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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* 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 *Bacillispori*, *Helici*, *Islandici*, *Purpurei*, *Subinflati*, *Talaromyces* and *Trachyspermi*. 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*, Ascospores, Single name nomenclature, *Talaromyces marneffei*, Food spoilage, Biotechnology.
Taxonomic novelties: New sections: *Talaromyces* section *Helici* Yilmaz, Frisvad & Samson, *Talaromyces* section *Bacillispori* 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. & Pěčková) Yilmaz, Frisvad & Samson, *Talaromyces liani* (Kamyschko) Yilmaz, Frisvad & Samson, *Talaromyces cinnabarinus* (S.C. Jong & E.E. Davis) Yilmaz, Samson & Frisvad.

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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 ascocarps 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 asci, limiting *Talaromyces* to species producing asci 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*, *Merimbla*, *Paecilomyces* and *Penicillium* (Pitt *et al.* 2000). *Merimbla* was shown to belong to a monophyletic 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 *Byssochlamys* in the *Thermoascaceae*. 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. byssochlamydoides*, *T. eburneus* and *T. emersonii*, belong in the genus *Rasamsonia* and were renamed as *R. byssochlamydoides*, *R. eburnea* 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. udagawae* 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

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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* 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. piceus* 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. amestolkiae* 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. stipitatus*, *T. trachyspermus* and *T. wortmannii,* and cause spoilage of pasteurised juices and other fruit based products (Pitt & Hocking 1997, Dijksterhuis 2007). Some species also produce mycotoxins in food products. Rubratoxin is a potential hepatotoxin (Engelhardt & Carlton 1991) and is produced by *T. purpurogenus* (Yilmaz *et al.* 2012). A teenaged boy needed an immediate liver transplant after drinking rhubarb-wine, which was contaminated with *T. purpurogenus* and contained a high concentration of rubratoxin (Sigler *et al.* 1996, Richer *et al.* 1997). *Talaromyces islandicus* is one of the most destructive and harmful fungi affecting rice in storage, causing the yellowing of rice (Saito *et al.* 1971, Sakai *et al.* 2005, Oh *et al.* 2008) and also produces mycotoxins such as cyclochlorotine, islanditoxin, erythroskyrine and luteoskyrin, which are hepatotoxic agents and carcinogenic (Uraguchi *et al.* 1961, 1972, Uraguchi 1962, Ueno & Ishikawa 1969, Bouhet *et al.* 1976, Stark *et al.* 1978). *Talaromyces islandicus*, *T. radicus*, *T. rugulosus* and *T. wortmannii* produce rugulosin and skyrin. Rugulosin is a bis-anthraquinoid pigment (Breen *et al.* 1955) with a specific antibacterial effect against *Staphylococcus aureus* (Yamazaki *et al.* 2010a, b, c) and was also shown to be moderately active against *Pythium* (Ueno *et al.* 1980). Studies have shown that rugulosin could also be a hepatocarcinogen (Ueno *et al.* 1980). Even though they have been classified as mycotoxins, extrolites such as erythroskyrin have also been reported to be antitumour agents (Kenkyusho 1983). Species in *Talaromyces* generally produce yellow, orange and red pigments in the mycelium or as diffusing pigments. Azaphilone polyketide pigments like the mitorubrins (mitorubrin, mitorubrinol, mitorubrinol acetate and mitorubrinic acid) (Büchi *et al.* 1965) and the *Monascus* red pigments (N-glutaryl monascorubramin, N-glutarylrubropunctamin, monascorubramine, monascin, PP-R and others (Mapari *et al.* 2009)) are responsible for the red pigments and are produced in different ratios and amounts between different isolates and species (Samson *et al.* 1989, Frisvad *et al.* 1990a, b, van Reenen-Hoekstra *et al.* 1990, Samson *et al.* 2011). *Talaromyces purpurogenus*, *T. marneffei*, *T. albobiverticillius*, *T. minioluteus* and *T. atroroseus* produce large volumes of mitorubrins (Yilmaz *et al.* 2012, Frisvad *et al.* 2013). However, only *T. atroroseus* consistently produces the azaphilone biosynthetic families mitorubrins and *Monascus* pigments without any 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 (Fahima & 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* (endoglucanase, cellulase; Pol *et al.* 2012), *T. funiculosus* (cellulase; Maeda *et al.* 2013) and *T. cellulolyticus* (*Acremonium cellulolyticus* = *T. pinophilus*), which is reported as an important cellulose-degrading fungus used for biomass degradation (Fujii *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 sucrose 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	IBT 132626	Soil in secondary forest, Brazil
	CBS 289.48^{T}	ATCC 10409 = IMI 040588 = NRRL 2129 = NRRL A-1474	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^{T}	BDUN 276 = IMI 105412	Debris, United Kingdom
Talaromyces albobiverticillius	CBS 133440^{T}	DTO 166-E5 = BCRC 34774 = IBT 31667	Decaying leaves of a broad-leaved tree, Taiwan
	CBS 133441	DTO 166-E6 = BCRC 34775 = IBT 31668	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^{T}	CBS 304.63 = ATCC 15067 = NRRL 3397 = FRR 3397 = IBT 3926 = IBT 10824	Cultivated soil, Allahabad, India
Talaromyces amestolkiae	CBS 132696^{T}	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^{T} = DTO 303-E2	Dried roots of *Angelica gigas*, Pyeongchang, Korea
Talaromyces apiculatus	CBS 101366		Soil, Hong Kong, China
	CBS 312.59^{T}	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^{T}		Soil, Egypt
	CBS 645.80	FRR 1966 = IFO 31750 = IMI 198365	Type of *T. gossypii*, *Gossypium*, India
Talaromyces atricola	CBS 255.31^{T}	NRRL 1052 = FRR 1052 = Thom 4640.439 = ATCC 52257	Unknown
Talaromyces atroroseus	CBS 133442^{T}	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^{T}	ATCC 13216 = IMI 099722 = NRRL 3398	Soil, Georgia
Talaromyces austrocalifornicus	CBS 644.95^{T}	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^{T}	ATCC 10126 = IMI 040045 = NRRL 1025	Leaf, New York, USA
Talaromyces bohemicus	CBS 545.86^{T}	CCF 2330 = IAM 14789	Peloids for balneological purposes, Czech Republic
Talaromyces boninensis	CBS 650.95^{T}	IBT 17516	Lawn soil, Japan
Talaromyces brunneus	CBS 227.60^{T}	ATCC 18229 = FRR 646 = IFO 6438 = IHEM 3907 = IMI 078259 = MUCL 31318	Milled rice imported into Japan, Thailand
Talaromyces calidicanius	CBS 112002^{T}		Soil, Nantou County, Taiwan
Talaromyces cecidicola	CBS 101419^{T}	DAOM 233329	Cynipid insect galls on *Quercus pacifica* twigs, Oregon, USA
Talaromyces chloroloma		DAOM 241016^{T}	Fynbos soil, Western Cape, South Africa

(*continued on next page*)

Table 1. (Continued).

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 cnidii		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, Loisiana, 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	Unindentified 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 040579ii = NRRL 2121	Leather, USA
		DTO 133-A7	House dust, Thailand
		DTO 133-E4	House dust, Thailand
		DTO 133-I6	Lotus tea, produced in Vietnam, imported to the Netherlands
		DTO 244-E6	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	Soil, Yokohama, Japan
Talaromyces flavovirens	CBS 102801^T	IBT 27044	Dead leaves of *Quercus ilex*, Parque del Retiro, Madrid, Spain
		DAOM 236381	Leaves of *Quercus suber*, port de la Selva, Girona, Spain
		DAOM 236382	Leaves of *Quercus suber*, Selva de Mar, Girona, Spain
		DAOM 236383	Leaves of *Quercus suber*, Barraca d'en Rabert, Paau, Girona, Spain
		DAOM 236384	Leaves of *Quercus suber*, Xóvar, 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 hachijoensis		IFM 53624^T = PF 1174	Soil, Hachijojima, 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 335.48^T	ATCC 10451 = DSM 3705 = IMI 040593 = NRRL 2106	Soil, Sweden
	CBS 550.72A		Saline soil, Vallée de la Seille, France
Talaromyces indigoticus	CBS 100534^T	IBT 17590 = SUM 3010	Soil, Japan
Talaromyces intermedius	CBS 152.65^T	BDUN 267 = IFO 31752 = IMI 100874	Allauvial pasture and swamp soil, Nottingham, England
Talaromyces islandicus	CBS 117284	DTO 002-C7	Wheat flour, the Netherlands
	CBS 338.48^T	ATCC 10127 = IMI 040042 = MUCL 31324 = NRRL 1036	Unknown, Cape Town, South Africa
	CBS 394.50	DTO 093-B9	Kapok fibre, unkown
	CBS 165.81	ATCC 42240; IMI 253796	Type of *P. aurantioflammiferum*, 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 225.66^T	ATCC 18325 = ATCC 18331 = IMI 098480 = NRRL 3380 = VKM F-301	Soil, China
		DTO 058-F2	Heat tretaed corn kernels, the Netherlands
Talaromyces loliensis	CBS 172.91	DTO 105-E9	Soil, New Zealand
	CBS 643.80^T	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^T	FRR 404 = IMI 197478	Apple juice, Stellenbosch, South Africa
	CBS 353.72		Tentage, New Guinea
		DTO 077-C5	Pine apple concentrate, the Netherlands
		DTO 105-C4	Unknown
Talaromyces marneffei	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 388.87^T	ATCC 18224 = CBS 334.59 = IMI 068794ii = IMI 068794iii	Bamboo rat (*Rhizomys sinensis*), Vietnam
	CBS 549.77	ATCC 24100	Man spleen, unknown
Talaromyces mimosinus	CBS 659.80^T	FRR 1875 = IMI 223991	Soil from creek bank, New South Wales
Talaromyces minioluteus	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 642.68^T	IMI 089377 = MUCL 28666 = NRRL 1714	Unknown
Talaromyces muroii	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 756.96^T	PF 1153	Soil, Taiwan
	CBS 889.96		Dung of sheep, Papua New Guinea
Talaromyces oumae-annae	CBS 138207	DTO 180-B4	House dust, South Africa
	CBS 138208^T	DTO 269-E8	House dust, South Africa
Talaromyces palmae	CBS 442.88	IMI 343640	*Chrysalidocarpus lutescens* seed, Wageningen, the Netherlands
Talaromyces panamensis	CBS 128.89^T	IMI 297546	Soil, Barro Colorado Island, Panama
Talaromyces paucisporus		PF 1150^T = 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	Pectin, unknown
	CBS 137377	DTO 178-F3	House dust, South Africa

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Table 1. (Continued).

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		Type of *Penicillium korosum*, Rhizosphere, India
		DTO 183-I6	*Protea repens* infructescense, Struisbaai, South Africa
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 31321 = 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 *Hylocichla fuscescens*, Minnesota, USA
Talaromyces ptychoconidium		DAOM 241017^T = DTO 180-E7	Fynbos soil, Malmesbury, South Africa
		DTO 180-E9	Fynbos soil, Malmesbury, South Africa
		DTO 180-F1	Fynbos soil, Malmesbury, South Africa
Talaromyces purpureus	CBS 475.71^T	ATCC 24069 = ATCC 52513 = FRR 1731 = IMI 181546	Soil, France
Talaromyces purpurogenus	CBS 122434	NRRL 1059 = ATCC 10064 = IBT 10612 = IBT 3560 = DTO 049-F7	Unknown
	CBS 132707	IMI 136128 = IBT 3658 = IBT 3560 = DTO 189-A1	Moulded field corn, Wisconsin, USA
	CBS 184.27	IMI 094165 = FRR 1057 = NRRL 1057	Soil, Lousiana, USA
	CBS 286.36^T	IMI 091926 = Thom 17	Parasitic on a culture of *Aspergillus oryzae*, Japan
Talaromyces rademirici	CBS 140.84^T	CECT 2771 = IMI 282406 = IMI 327870	Air under willow tree, Valladolid, Spain
Talaromyces radicus	CBS 100488	DTO 037-F6	Wheat root, New South Wales
	CBS 100489^T	FRR 4718 = IBT 14379	Root seadling, New South Wales
	CBS 100490	DTO 037-F8	Wheat root, New South Wales
	CBS 137382	DTO 181-D5	Fynbos soil, South Africa
		DTO 181-D4	Fynbos soil, South Africa
		DTO 181-D7	Fynbos soil, South Africa
Talaromyces ramulosus		DAOM 241660^T = DTO 184-B8	Soil, Malmesbury, South Africa
		DTO 181-E3	Mite, Stellenbosch, South Africa
		DTO 181-F6	*Protea repens* infructescense, Stellenbosch, South Africa
		DTO 182-A3	*Protea repens* infructescense, Stellenbosch, South Africa
		DTO 182-A6	Air, Malmesbury, South Africa
		DTO 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	DTO 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
Talaromyces rubicundus	CBS 342.59^T	ATCC 13217 = IMI 099723 = NRRL 3400	Soil, Georgia
Talaromyces rugulosus	CBS 137366	DTO 061-E8	Type of *P. chrysitis*, air sample, beer producing factory, Kaulille, Belgium
	CBS 344.51	IFO 6016	Type of *P. echinosporum* Nehira, unknown, Japan
	CBS 371.48^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
		NRRL 1073 = FRR 1073 = IMI 040034 = ATCC 10503 = Thom 4640.444	Type of *P. tardum* & *P. elongatum*, decaying twigs, France
Talaromyces ryukyuensis		NHL 2917^T = DTO 176-I6	Soil, Naha, Japan
Talaromyces sayulitensis	CBS 138204^T	DTO 245-H1	House dust, Mexico
	CBS 138205	DTO 245-H2	House dust, Mexico
	CBS 138206	DTO 245-H3	House dust, Mexico
Talaromyces scorteus	CBS 233.60	NRRL203 = IMI 78256 = FRR 203 = ATCC 18481 = IFO 6437	Type of *T. phialosporus*, milled Californian rice, Japan
	CBS 340.34^T	NRRL 1129 = FRR 1129	Military equipment, Japan
	CBS 499.75		Unknown, Nigeria
	CBS 500.75		Unknown, Sierra Leone
		DTO 270-A6	House dust, Thailand
Talaromyces siamensis	CBS 475.88^T	IMI 323204	Forest soil Thailand
		DTO 269-I3	House dust, Thailand
Talaromyces solicola	CBS 133445^T	DAOM 241015 = CV 2800 = DTO 180D4	Soil, Malmesbury, South Africa
	CBS 133446		Soil, Malmesbury, South Africa
Talaromyces stipitatus	CBS 375.48^T	ATCC 10500 = NRRL 1006 = IMI 39805	Decaying wood, Louisiana, USA
Talaromyces stollii	CBS 169.91	NRRL 1033	Unknown substrate, South Africa
	CBS 265.93		Bronchoalveolar lavage of patient after lung transplantation (subclinical), France
	CBS 408.93^T		AIDS patient, the Netherlands
	CBS 581.94		Unknown
	CBS 624.93		*Ananas camosus* cultivar, Martinique
Talaromyces subinflatus	CBS 652.95^T	IBT 17520	Copse soil, Japan
Talaromyces tardifaciens	CBS 250.94^T	SUM 3017 = IBT 14986	Paddy soil, Bhaktapur, Nepal
Talaromyces thailandensis	CBS 133147^T	KUFC 3399	Soil, Thailand
Talaromyces trachyspermus	CBS 116556		Pasteurised canned strawberries, Germany
	CBS 118437		Soil, Marocco
	CBS 118438		Soil, Marocco
	CBS 373.48^T	ATCC 10497 = IMI 040043 = NRRL 1028	Unknown, USA
Talaromyces tratensis	CBS 133146^T	KUFC 3383	Soil, Trat, Thailand
	CBS 137400	DTO 270-F5	House dust, Mexico
	CBS 137401	NRRL1013 = FRR 1013	Carbonated beverage, Washington D.C., USA
Talaromyces ucrainicus	CBS 127.64		Type of *T. ohiensis*, soil treated with cyanamide, Germany
	CBS 162.67^T	ATCC 22344 = FRR 3462 = NHL 6086	Unknown
	CBS 583.72A	IFO 8395	Soil, Japan
	CBS 583.72C	IFO 8891	Soil, Japan
Talaromyces udagawae	CBS 579.72^T	FRR 1727 = IMI 197482	Soil, Misugimura, Japan
Talaromyces unicus	CBS 100535^T	CCRC 32703 = IBT 18385 = FRR 4436	Soil, Taiwan
Talaromyces varians	CBS 386.48^T	ATCC 10509 = IMI 040586 = NRRL 2096	Cotton yarn, England
Talaromyces verruculosus	CBS 254.56	IBT 5047	Unknown, Yangambi, Zaire
	CBS 388.48^T	ATCC 10513 = DSM 2263 = IMI 040039 = NRRL 1050	Soil, Texas, USA
		DTO 129-H4	House dust, Thailand
		DTO 129-H5	House dust, Thailand
Talaromyces viridis	CBS 114.72^T	ATCC 22467 = NRRL 5575	Soil, Australia
Talaromyces viridulus	CBS 252.87^T	FRR 1863 = IMI 288716	Soil from bank of creek floading into Little river, New South Wales

(*continued on next page*)

Table 1. (Continued).

Species name	CBS no.	Other collections	Substrate and origin
Talaromyces wortmannii	CBS 137376	PF 1130	Type of *T. sublevisporus*, soil, Japan
	CBS 319.63	DTO 108-A4	Unknown
	CBS 385.48	IMI 40040 = NRRL 1048 = FRR 1048 = ATCC 10508 = IFO 6111	Type of *T. variabilis*, coconut matting, Johannesburg, South Africa
	CBS 391.48^{T}	NRRL 1017 = IMI 040047 = FRR 1017 = ATCC 10517 = IFO 7738 = Thom 4733.126.1 = IBT 4838	Soil, Denmark
	CBS 895.73	ATCC 20201 = IFO 4683 = BCRC 31677	Unkown, Japan
		NRRL 2125 = FRR 2125 = DTO 278-E7	Weathering canvas, Panama
Talaromyces yelensis	CBS 138209	DTO 268-E5	House dust, Micronesia
	CBS 138210^{T}	DTO 268-E7	House dust, Micronesia

al. 2010), using 90 mm Petri dishes. Plates were incubated for 7 d at 25 °C in darkness. Additional CYA plates were incubated at 30 and 37 °C, while additional MEA plates were incubated at 30 °C. After 7 d of incubation, colony diameters were recorded. The degree of sporulation, obverse and reverse colony colours and the production of soluble pigments were noted. Colony colour codes used in descriptions refer to Kornerup & Wanscher (1967). For ascoma production, OA, MEA and hay infusion agar (HAY) plates were incubated for up to four weeks.

Microscope preparations were made from 1 to 2 wk old colonies grown on MEA, with OA and HAY used when sporulation was absent on MEA. OA was used for observing ascomata, asci and ascospores. Lactid acid (60 %) was used as mounting fluid. Characters were captured using a Zeiss SteReo Discovery.V20 dissecting microscope and Zeiss AX10 Imager.A2 compound microscope. The microscopes are equipped with AxioCam MRc5 cameras and uses AxioVs40 v. 4.8.2.0 software. Microscopic measurements were made using Nikon NIS-elements D v. 4.0. Photo plates were prepared in Adobe® Photoshop® CS6.

DNA extraction, PCR amplification and sequencing

DNA extractions were made from 1 to 2 wk old colonies grown on MEA using the Ultraclean™ Microbial DNA isolation Kit (MoBio, Solana Beach, USA) with extracts stored at −20 °C. PCR reactions were prepared as described in Houbraken & Samson (2011). 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 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

literature. Authentic standards of the different extrolites were available for most of the *Talaromyces* compounds (Klitgaard *et al.* 2014).

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, Houbraken & 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 1 368 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 bohemica*, 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 (GCPSR; 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 derxii* 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. aerocephalum* 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 *Biveriticillium*. 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* Biourge 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., Matsush. 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 monoverticillate or with solitary phialides. *Stipes* usually hyaline, terminating in a whorl of *metulae* of 3–10, appearing symmetrical in face view. *Conidiogenous cells* phialidic, approximately equal length to metulae, typically acerose, rarely flask-shaped. *Conidia* aseptate, green *en masse*, in basipetal chains, usually ellipsoidal to fusiform, rarely globose to subglobose or ovoidal. *Ascomata* cleistothecial 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, ellipsoidal to globose, rarely smooth-walled, but often with spines and/or less commonly ridges, hyaline to yellow, occasionally red.

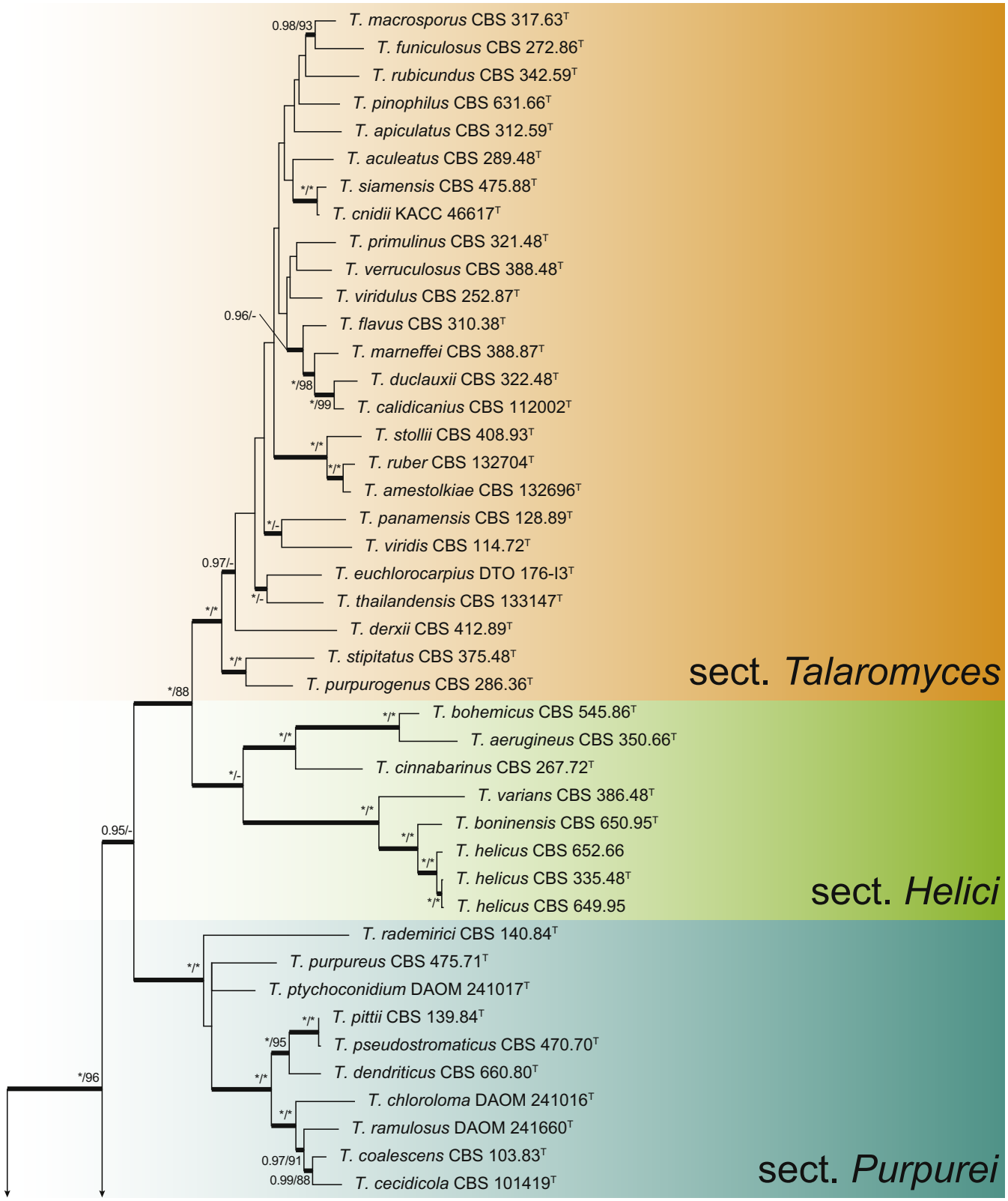

Fig. 1. Combined phylogeny of the ITS, *BenA* and *RPB2* gene regions of species from *Talaromyces*. *Trichocoma paradoxa* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by posterior probabilities (BI analysis) of 0.95 and higher and/or bootstrap values (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.

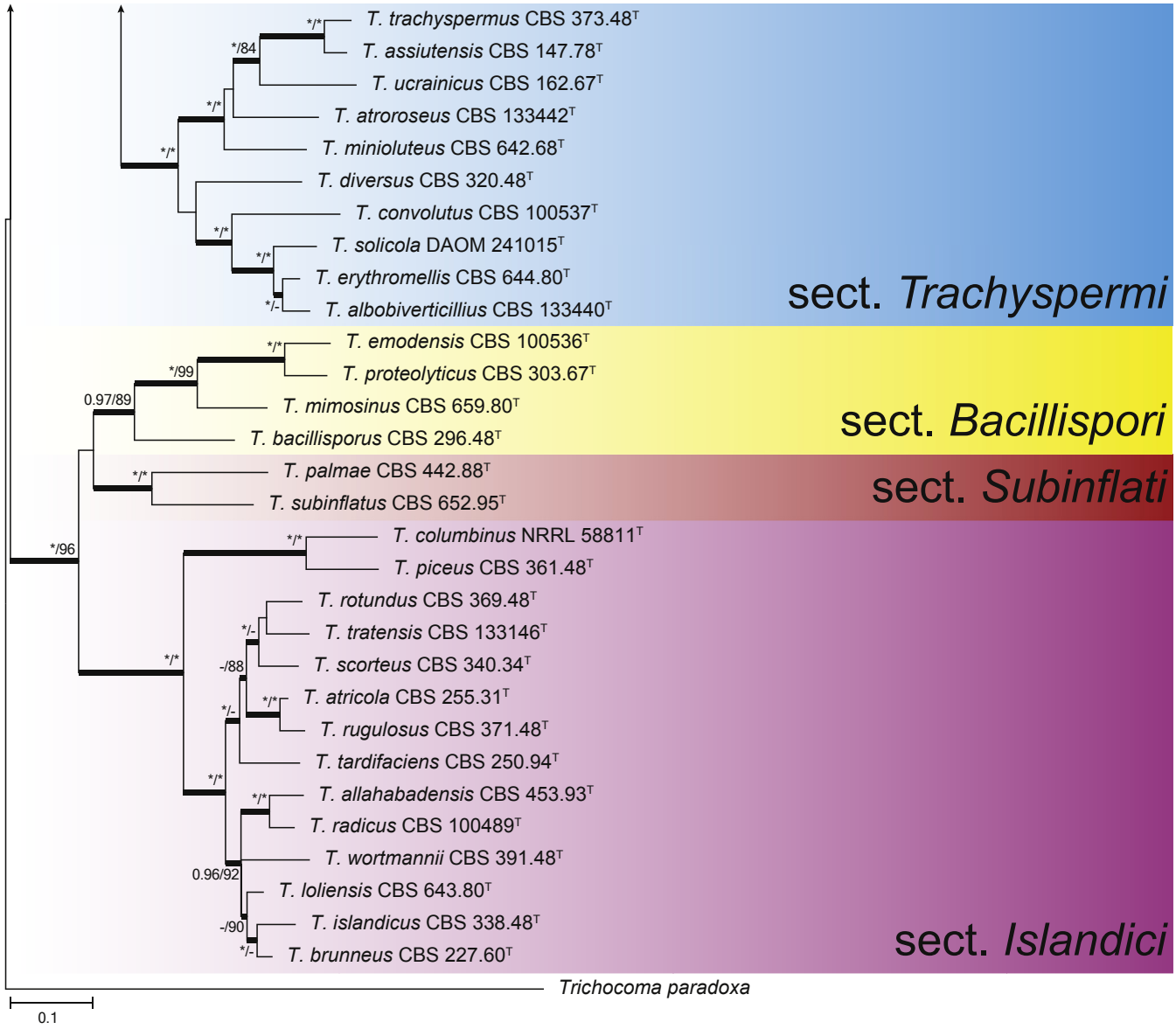

Fig. 1. (Continued).

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 infrageneric classification of *Talaromyces*. Ubiquinone Q-10(H_2) was found in the majority of *Talaromyces* species; however, they found a mixture of ubiquinone Q-10(H_2) and ubiquinone Q-10(H_4) 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.

= *Penicillium* subgenus *Biverticillium* section *Simplicium* series *Minioluteae* 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

Table 2. Overview of sectional classification in different studies of *Talaromyces*.

Stolk & Samson (1972)		Pitt (1980)		Current study	
Section	**Type species**	**Section/Series**	**Type species**	**Section**	**Type species**
Talaromyces sect. *Emersonii*	*T. emersonii*	*Penicillium* subgenus *Biverticillium* sect. *Coremigenum* ser. *Dendritica*	*P. dendriticum*	sect. *Bacillispori*	*T. bacillisporus*
Talaromyces sect. *Purpurea*	*T. purpureus*	*Penicillium* subgenus *Biverticillium* sect. *Coremigenum* ser. *Duclauxii*	*P. duclauxii*	sect. *Helici*	*T. helicus*
Talaromyces sect. *Talaromyces*	*T. flavus* (=*T. vermiculatus*)	*Talaromyces* sect. *Purpureus* ser. *Purpurei*	*T. purpureus*	sect. *Islandici*	*T. islandicus*
Talaromyces sect. *Thermophila*	*T. thermophilus*	*Penicillium* sect. *Simplicium* ser. *Islandica*	*P. islandicum*	sect. *Purpurei*	*T. purpureus*
		Penicillium sect. *Simplicium* ser. *Miniolutea*	*P. minioluteum*	sect. *Subinflati*	*T. subinflatus*
		Talaromyces sect. *Talaromyces* ser. *Flavi*	*T. flavus*	sect. *Talaromyces*	*T. flavus*
		Talaromyces sect. *Talaromyces* ser. *Lutei*	*T. luteus*	sect. *Trachyspermi*	*T. trachyspermus*
		Talaromyces sect. *Talaromyces* ser. *Trachyspermi*	*T. trachyspermus*		
		Talaromyces sect. *Thermophilus* ser. *Thermophili*	*T. thermophilus*		

have yellow ascospores. Conidiophores are usually of the biverticillate-symmetrical type, with some species that have reduced conidiophores with solitary phialides. Phialides are usually acerose, 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. purpurogenus*. *Talaromyces purpurogenus* produces rubratoxin, which is a well-known hepa-carcinogenic toxin (Burnside *et al.* 1957, Kihara *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 cellulolyticus* (strains Y-94), an important cellulose-degrading species (Fujii *et al.* 2013). However, based on their sequence data (ITS: AB474749 and *BenA*: AB773823) we do not consider this 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. versatilis* (IMI 378536) as a "basionym" of *Penicillium funiculosum* (≡ *T. funiculosus*). Even though *T. versatilis* 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. [MB560639]. — 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* = KM023271).

Talaromyces amestolkiae Yilmaz *et al.*, Persoonia 29: 48. 2012. [MB801358]. — Herb.: CBS H-21050. Ex-type: CBS 132696 = DTO 179-F5. ITS barcode: JX315660. (Alternative markers; *BenA* = JX315623; *CaM* = KF741937; *RPB1* = JX315679; *RPB2* = JX315698).

Talaromyces angelicus S.H. Yu, T.-J. An & H. Sang, J. Microbiol. 51: 707. 2013. [MB804807]. — Herb.: KACC 46611. Ex-type: KACC 46611. ITS barcode: KF183638. (Alternative markers; *BenA* = KF183640; *CaM* = KJ885259; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces apiculatus Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 174. 2011. [MB560641]. — Herb.: CBS H-20755. Ex-type: CBS 312.59 = ATCC 18315 = FRR 635 = IMI 068239. ITS barcode: JN899375. (Alternative markers; *BenA* = KF741916; *CaM* = KF741950; *RPB1* = JN680293; *RPB2* = KM023287).

Talaromyces aurantiacus (J.H. Mill., Giddens & A.A. Foster) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560642]. — Herb.: No. 1736 (A.A. Foster). Ex-type: CBS 314.59 = ATCC 13216 = IMI 099722 = NRRL 3398. ITS barcode: JN899380. (Alternative markers; *BenA* = KF741917; *CaM* = KF741951; *RPB1* = KC202951; *RPB2* = n.a.).

Talaromyces calidicanius (J.L. Chen) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560645]. — Herb.: CFC-7 (isotype TNM F12246). Ex-type: CBS 112002. ITS barcode: JN899319. (Alternative markers; *BenA* = HQ156944; *CaM* = KF741934; *RPB1* = JN899305; *RPB2* = KM023311).

Talaromyces cnidii S.H. Yu, T.-J. An & H. Sang, J. Microbiol. 51: 707. 2013. [MB804809]. — Herb.: KACC 46617. Ex-type: KACC 46617. ITS barcode: KF183639. (Alternative markers; *BenA* = KF183641; *CaM* = KJ885266; *RPB1* = n.a.; *RPB2* = KM023299).

Talaromyces derxii Takada & Udagawa, Mycotaxon 31: 418. 1988. [MB133755]. — Herb.: NHL 2980. Ex-type: CBS 412.89 = NHL 2981. ITS barcode: JN899327. (Alternative markers; *BenA* = JX494305; *CaM* = KF741959; *RPB1* = JN680306; *RPB2* = KM023282).

Talaromyces duclauxii (Delacr.) Samson *et al.*, Stud. Mycol. 71: 175. 2011. [MB560650]. — Herb.: IMI 24312. 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; *RPB1* = JN121643; *RPB2* = JN121491).

Talaromyces euchlorocarpius Yaguchi, Somaya & Udagawa, Mycoscience 40: 133. 1999. [MB460481]. — Herb.: PF 1203. Ex-type: PF 1203 = DTO 176-I3 = DTO 176-I4. ITS barcode: AB176617. (Alternative markers; *BenA* = KJ865733; *CaM* = KJ885271; *RPB1* = n.a.; *RPB2* = KM023303).

Talaromyces flavovirens (Durieu & Mont.) Visagie, Llimona & Seifert, Mycotaxon 122: 404. 2012. [MB800438]. — Herb.: Lectotype PC 0088796; Epitype BCC 473 = BCN 473. Ex-type: CBS 102801 = IBT 27044. ITS barcode: JN899392. (Alternative markers; *BenA* = JX091376; *CaM* = KF741933; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces flavus (Klöcker) Stolk & Samson, Stud. Mycol. 2: 10. 1972. [MB324416]. — Herb.: CBS H-7820. Ex-type: CBS 310.38 = IMI 197477 = NRRL 2098. ITS barcode: JN899360. (Alternative markers; *BenA* = JX494302; *CaM* = KF741949; *RPB1* = JN121639; *RPB2* = JF417426).

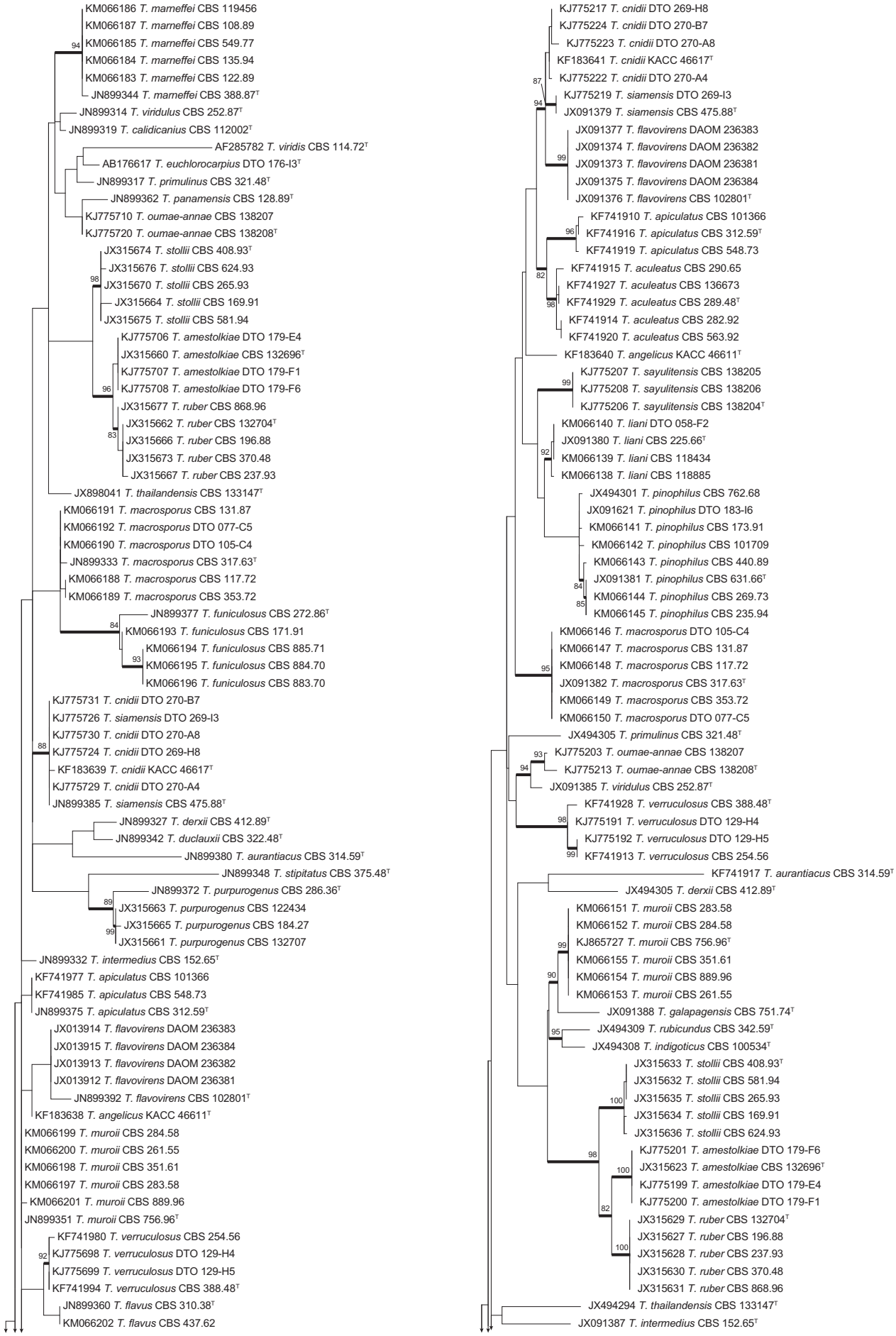

Fig. 2. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Talaromyces*. *Talaromyces dendriticus* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: Tamura 3-parameter (T92) +G+I for ITS, K2+G for *BenA*, alignment 537 (ITS) and 458 (*BenA*) bp.

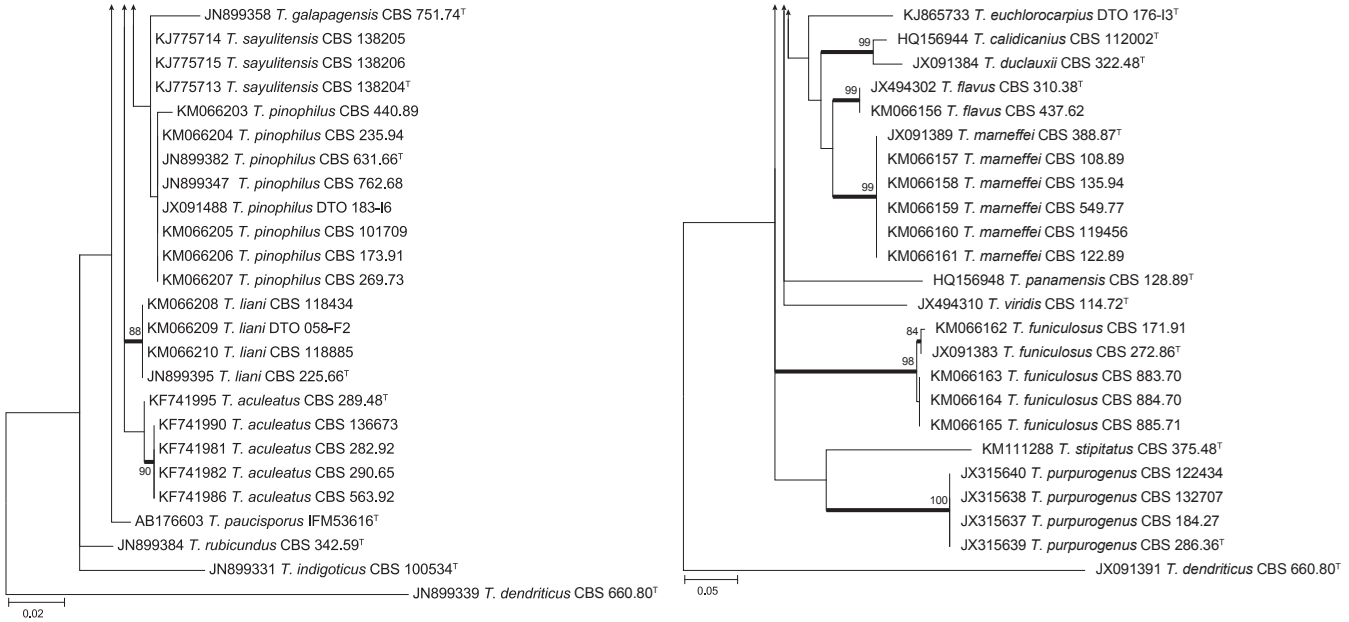

Fig. 2. (Continued).

Talaromyces funiculosus (Thom) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560653]. — Herb.: IMI 193019. Ex-type: CBS 272.86 = IMI 193019. ITS barcode: JN899377. (Alternative markers; *BenA* = JX091383; *CaM* = KF741945; *RPB1* = JN680288; *RPB2* = KM023293).

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* = JN680321; *RPB2* = n.a.).

Talaromyces indigoticus Takada & Udagawa, Mycotaxon 46: 129. 1993. [MB359290]. — Herb.: CBM SUM-3010. Ex-type: CBS 100534 = IBT 17590. ITS barcode: JN899331. (Alternative markers; *BenA* = JX494308; *CaM* = KF741931; *RPB1* = JN680323; *RPB2* = n.a.).

Talaromyces intermedius (Apinis) Stolk & Samson, Stud. Mycol. 2: 21. 1972. [MB324418]. — Herb.: CBS H-7828. Ex-type: CBS 152.65 = BDUN 267 = IFO 31752 = IMI 100874. ITS barcode: JN899332. (Alternative markers; *BenA* = JX091387; *CaM* = KJ885290; *RPB1* = JN680276; *RPB2* = n.a.).

Talaromyces liani (Kamyschko) Yilmaz, 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* = JN680280; *RPB2* = n.a.).

Talaromyces macrosporus (Stolk & Samson) Frisvad, Samson & Stolk, Antonie van Leeuwenhoek 57: 186. 1990. [MB126704]. — Herb.: CBS H-7822. Ex-type: CBS 317.63 = FRR 404 = IMI 197478. ITS barcode: JN899333. (Alternative markers; *BenA* = JX091382; *CaM* = KF741952; *RPB1* = JN680296; *RPB2* = KM023292).

Talaromyces marneffei (Segretain, Capponi & Sureau) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560656]. — Herb.: IMI 68794iii. Ex-type: CBS 388.87 = ATCC 18224 = CBS 334.59 = IMI 068794ii = IMI 068794iii. ITS barcode: JN899344. (Alternative markers; *BenA* = JX091389; *CaM* = KF741958; *RPB1* = JN899298; *RPB2* = KM023283).

Talaromyces muroii Yaguchi, Someya & Udagawa, Mycoscience 35: 252. 1994. [MB362930]. — Herb.: CBM PF-1153. Ex-type: CBS 756.96 = PF 1153. ITS barcode: JN899351. (Alternative markers; *BenA* = KJ865727; *CaM* = KJ885274; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces oumae-annae Visagie *et al.*, Stud. Mycol. 78: 130. 2014. [MB809187]. — Herb.: CBS H-21797. Ex-type: CBS 138208 = DTO 269-E8. ITS barcode: KJ775720. (Alternative markers; *BenA* = KJ775213; *CaM* = KJ775425; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces panamensis (Samson, Stolk & Frisvad) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560659]. — Herb.: CBS 128.89. Ex-type: CBS 128.89 = IMI 297546. ITS barcode: JN899362. (Alternative markers; *BenA* = HQ156948; *CaM* = KF741936; *RPB1* = JN899291; *RPB2* = KM023284).

Talaromyces paucisporus (Yaguchi, Someya & Udagawa) Samson & Houbraken, Stud. Mycol. 71: 176. 2011. [MB560684]. — Herb.: PF 1150. Ex-type: PF 1150 = IFM 53616. ITS barcode: AB176603. (Alternative markers; *BenA* = n.a.; *CaM* = n.a.; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces pinophilus (Hedgc.) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560662]. — Herb.: IMI 114933. Ex-type: CBS 631.66 = ATCC 36839 = CECT 2809 = DSM 1944 = IAM 7013 = IMI 114933. ITS barcode: JN899382. (Alternative markers; *BenA* = JX091381; *CaM* = KF741964; *RPB1* = JN680313; *RPB2* = KM023291).

Talaromyces primulinus (Pitt) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. [MB560664]. — Herb.: IMI 040031. Ex-type: CBS 321.48 = ATCC 10438 = CBS 439.88 = FRR 1074 = IMI 040031 = MUCL 31321 = MUCL 31330 = NRRL 1074. ITS barcode: JN899317. (Alternative markers; *BenA* = JX494305; *CaM* = KF741954; *RPB1* = JN680298; *RPB2* = KM023294).

Talaromyces purpurogenus (Stoll) Samson *et al.*, Stud. Mycol. 71: 177. 2011. [MB560667]. — Herb.: IMI 091926. Ex-type: CBS 286.36 = IMI 091926. ITS barcode: JN899372. (Alternative markers; *BenA* = JX315639; *CaM* = KF741947; *RPB1* = JN680271; *RPB2* = JX315709).

Talaromyces ruber (Stoll) Yilmaz *et al.*, Persoonia 29: 48. 2012. [MB801360]. — Herb.: CBS H-21052. Ex-type: CBS 132704 = DTO 193-H6 = IBT 10703 = CBS 113137. ITS barcode: JX315662. (Alternative markers; *BenA* = JX315629; *CaM* = KF741938; *RPB1* = JX315681; *RPB2* = JX315700).

Talaromyces rubicundus (J.H. Mill., Giddens & A.A. Foster) Samson *et al.*, Stud. Mycol. 71: 177. 2011. [MB560671]. — Herb.: No. 2531 (A.A. Foster). Ex-type: CBS 342.59 = ATCC 13217 = IMI 099723 = NRRL 3400. ITS barcode: JN899384. (Alternative markers; *BenA* = JX494309; *CaM* = KF741956; *RPB1* = JN680301; *RPB2* = KM023296).

Talaromyces sayulitensis Visagie *et al.*, Stud. Mycol. 78: 132. 2014. [MB809188]. — Herb.: CBS H-21798. Ex-type: CBS 138204 = DTO 245-H1. ITS barcode: KJ775713. (Alternative markers; *BenA* = KJ775206; *CaM* = KJ775422; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces siamensis (Manoch & C. Ramírez) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. [MB560674]. — Herb.: CBS 475.88. Ex-type: CBS 475.88 = IMI 323204. ITS barcode: JN899385. (Alternative markers; *BenA* = JX091379; *CaM* = KF741960; *RPB1* = n.a.; *RPB2* = KM023279).

Talaromyces stipitatus (Thom) C.R. Benj., Mycologia 47: 684. 1955. [MB306722]. — Herb.: CBS H-7835. Ex-type: CBS 375.48 = ATCC 10500 = NRRL 1006 = IMI 39805. ITS barcode: JN899348. (Alternative markers; *BenA* = KM111288; *CaM* = KF741957; *RPB1* = JN680303; *RPB2* = KM022380).

Talaromyces stollii Yilmaz *et al.*, Persoonia 29: 52. 2012. [MB801359]. — Herb.: CBS H-21053. Ex-type: CBS 408.93. ITS barcode: JX315674.

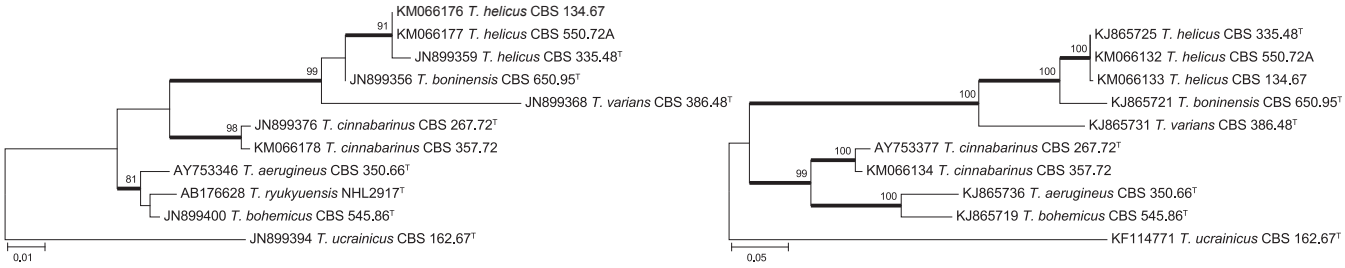

Fig. 3. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Helici*. *Talaromyces ucrainicus* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: T92+G for ITS, K2+I for *BenA*, alignment 463 (ITS) and 510 (*BenA*) bp.

(Alternative markers; *BenA* = JX315633; *CaM* = JX315646; *RPB1* = JX315693; *RPB2* = JX315712).

Talaromyces thailandensis Manoch, Dethoup & Yilmaz, Mycoscience 54: 339. 2013. [MB801737]. — Herb.: CBS H-21075. Ex-type: CBS 133147 = KUFC 3399. ITS barcode: JX898041. (Alternative markers; *BenA* = JX494294; *CaM* = KF741940; *RPB1* = JX898043; *RPB2* = KM023307).

Talaromyces verruculosus (Peyronel) Samson *et al.*, Stud. Mycol. 71: 177. 2011. [MB560678]. — Herb.: IMI 040039. Ex-type: CBS 388.48 = ATCC 10513 = DSM 2263 = IMI 040039 = NRRL 1050. ITS barcode: KF741994. (Alternative markers; *BenA* = KF741928; *CaM* = KF741944; *RPB1* = n.a.; *RPB2* = KM023306).

Talaromyces viridis (Stolk & G.F. Orr) Arx, Persoonia 13: 2821. 1987. [MB132097]. — 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. [MB560679]. — Herb.: FRR 1863. Ex-type: CBS 252.87 = FRR 1863 = IMI 288716. ITS barcode: JN899314. (Alternative markers; *BenA* = JX091385; *CaM* = KF741943; *RPB1* = JN680284; *RPB2* = JF417422).

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 350.66 = BDUN 276 = IMI 105412. ITS barcode: AY753346. (Alternative markers; *BenA* = KJ865736; *CaM* = KJ885285; *RPB1* = n.a.; *RPB2* = JN121502).

Talaromyces bohemicus (Fassat. & Pěčková) Yilmaz, Frisvad & Samson, (this study). [MB809554]. — Herb.: unknown. Ex-type: CBS 545.86 = CCF 2330 = IAM 14789. ITS barcode: JN899400. (Alternative markers; *BenA* = KJ865719; *CaM* = KJ885286; *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: JN899356. (Alternative markers; *BenA* = KJ865721; *CaM* = KJ885263; *RPB1* = JN680319; *RPB2* = KM023276).

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: JN899376. (Alternative markers; *BenA* = AY753377; *CaM* = KJ885256; *RPB1* = n.a.; *RPB2* = JN121477).

Talaromyces helicus (Raper & Fennel) C.R. Benj., Mycologia 47: 684. 1955. [MB306715]. — Herb.: IMI 040593. Ex-type: CBS 335.48 = ATCC 10451 = DSM 3705 = IMI 040593 = NRRL 2106. ITS barcode: JN899359. (Alternative markers; *BenA* = KJ865725; *CaM* = KJ885289; *RPB1* = JN680300; *RPB2* = KM023273).

Talaromyces ryukyuensis (S. Ueda & Udagawa) Arx, Persoonia 13: 282. 1987. [MB132096]. — Herb.: unknown. Ex-type: NHL 2917 = DTO 176-I6. ITS barcode: AB176628. (Alternative markers; *BenA* = n.a.; *CaM* = n.a.; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces varians (G. Sm.) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. [MB560677]. — Herb.: IMI 040586. Ex-type: CBS 386.48 = ATCC 10509 = IMI 040586 = NRRL 2096. ITS barcode: JN899368. (Alternative markers; *BenA* = KJ865731; *CaM* = KJ885284; *RPB1* = JN680305; *RPB2* = KM023274).

Talaromyces section *Purpurei* 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: 57. 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 *Purpurei* includes species that generally produce synnemata after two to three weeks of incubation, the exceptions being *T. rademirici*, *T. purpureus* and *T. ptychoconidium* (Fig. 4). Pitt (1980) used synnemata production as a defining character for his section *Coremigenum* (type species *Talaromyces dendriticus* ≡ *P. dendriticum*), which we synonomise here with section *Purpurei*. In general, this group of species produces biverticillate conidiophores that have additional subterminal branches. *Talaromyces purpureus* is the exception, which

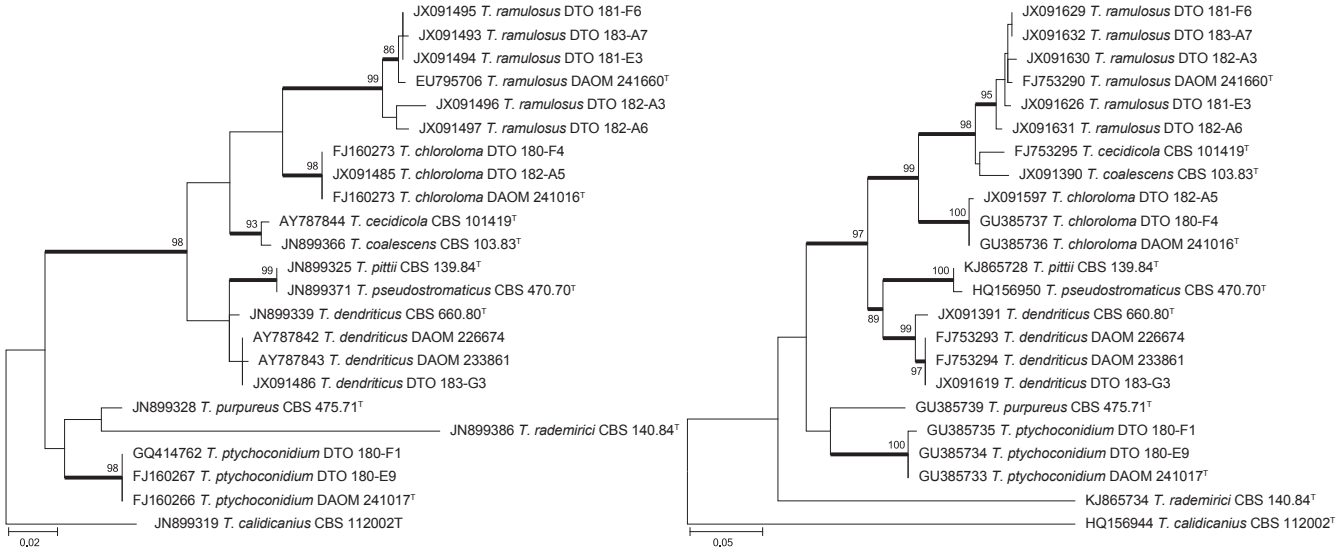

Fig. 4. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Purpurei*. *Talaromyces calidicanius* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: T92+G for ITS, K2+G for *BenA*, alignment 521 (ITS) and 376 (*BenA*) bp.

produces conidiophores that can be monoverticillate or have solitary phialides. A number of species seems to be associated with very specific habitats. *Talaromyces cecidicola* 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* infructescences 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 cecidicola (Seifert, Hoekstra & Frisvad) Samson *et al.*, Stud. Mycol. 71: 175. 2011. [MB560646]. — Herb.: DAOM 233329. Ex-type: CBS 101419 = DAOM 233329. ITS barcode: AY787844. (Alternative markers; *BenA* = FJ753295; *CaM* = KJ885287; *RPB1* = n.a.; *RPB2* = KM023309).

Talaromyces chloroloma Visagie & K. Jacobs, Persoonia 28: 18. 2012. [MB564326]. — Herb.: PREM 60033. Ex-type: DAOM 241016 = CV 2802. ITS barcode: FJ160273. (Alternative markers; *BenA* = GU385736; *CaM* = KJ885265; *RPB1* = n.a.; *RPB2* = KM023304).

Talaromyces coalescens (Quintan.) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560647]. — Herb.: CBS 103.83. Ex-type: CBS 103.83. ITS barcode: JN899366. (Alternative markers; *BenA* = JX091390; *CaM* = KJ885267; *RPB1* = n.a.; *RPB2* = KM023277).

Talaromyces dendriticus (Pitt) Samson *et al.*, Stud. Mycol. 71: 175. 2011. [MB560648]. — Herb.: IMI 216897. Ex-type: CBS 660.80 = IMI 216897. ITS barcode: JN899339. (Alternative markers; *BenA* = JX091391; *CaM* = KF741965; *RPB1* = JN121714; *RPB2* = KM023286).

Talaromyces pittii (Quintan.) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560663]. — Herb.: CBS 139.84. Ex-type: CBS 139.84 = IMI 327871. ITS barcode: JN899325. (Alternative markers; *BenA* = KJ865728; *CaM* = KJ885275; *RPB1* = JN680274; *RPB2* = KM023297).

Talaromyces pseudostromaticus (Hodges, G.M. Warner & Rogerson) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560666]. — Herb.: Warner 18 (NY). Ex-type: CBS 470.70 = ATCC 18919 = FRR 2039. ITS barcode: JN899371. (Alternative markers; BenA = HQ156950; CaM = KJ885277; RPB1 = JN899300; RPB2 = KM023298).

Talaromyces ptychoconidium Visagie & K. Jacobs, Persoonia 28: 18. 2012. [MB564327]. — Herb.: PREM 60041. Ex-type: DAOM 241017 = CV 2808 = DTO 180-E7. ITS barcode: FJ160266. (Alternative markers; *BenA* = GU385733; *CaM* = JX140701; *RPB1* = n.a.; *RPB2* = KM023278).

Talaromyces purpureus (E. Müll. & Pacha-Aue) Stolk & Samson, Stud. Mycol. 2: 57. 1972. [MB324420]. — Herb.: CBS H-7832 (isotype). Ex-type: CBS 475.71 = ATCC 24069 = ATCC 52513 = FRR 1731 = IMI 181546. ITS barcode: JN899328. (Alternative markers; *BenA* = GU385739; *CaM* = KJ885292; *RPB1* = JN121687; *RPB2* = JN121522).

Talaromyces rademirici (Quintan.) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. [MB560668]. — Herb.: CBS 140.84. Ex-type: CBS 140.84 = CECT 2771 = IMI 282406 = IMI 327870. ITS barcode: JN899386. (Alternative markers; *BenA* = KJ865734; *CaM* = n.a.; *RPB1* = n.a.; *RPB2* = KM023302).

Talaromyces ramulosus (Visagie & K. Jacobs) Samson *et al.*, Stud. Mycol. 71: 177. 2011. [MB560670]. — Herb.: PREM 59947. Ex-type: DAOM 241660 = CV 2837 = DTO 184-B8. ITS barcode: EU795706. (Alternative markers; *BenA* = FJ753290; *CaM* = JX140711; *RPB1* = n.a.; *RPB2* = KM023281).

Talaromyces* section *Trachyspermi Yaguchi & Udagawa [as '*trachyspermus*'], Mycoscience 37: 57. 1996. MycoBank MB538978. Figs 1, 5.

Typus: *Talaromyces trachyspermus* (Shear) Stolk & Samson, Stud. Mycol. 2: 32. 1972.

Description: Restricted growth on CYA, YES and DG18, growing slightly faster on MEA, no growth to poor growth on CREA. Some species produce abundant red pigments. Conidiophores are generally biverticillate and some species produce creamish white or yellow ascomata.

Talaromyces section *Trachyspermi* includes species that generally grow restrictedly on CYA, YES and DG18, and slightly faster on MEA. This group of species also grows poorly on CREA and some species produce colonies with abundant red pigments. Conidiophores are generally biverticillate and ascomata, when produced, have a creamish white or yellow colour. *Talaromyces atroroseus*, *T. minioluteus* and *T. albobiverticillius* are biotechnologically important, with their pigments used as colourants in the food industry (Frisvad *et al.* 2013).

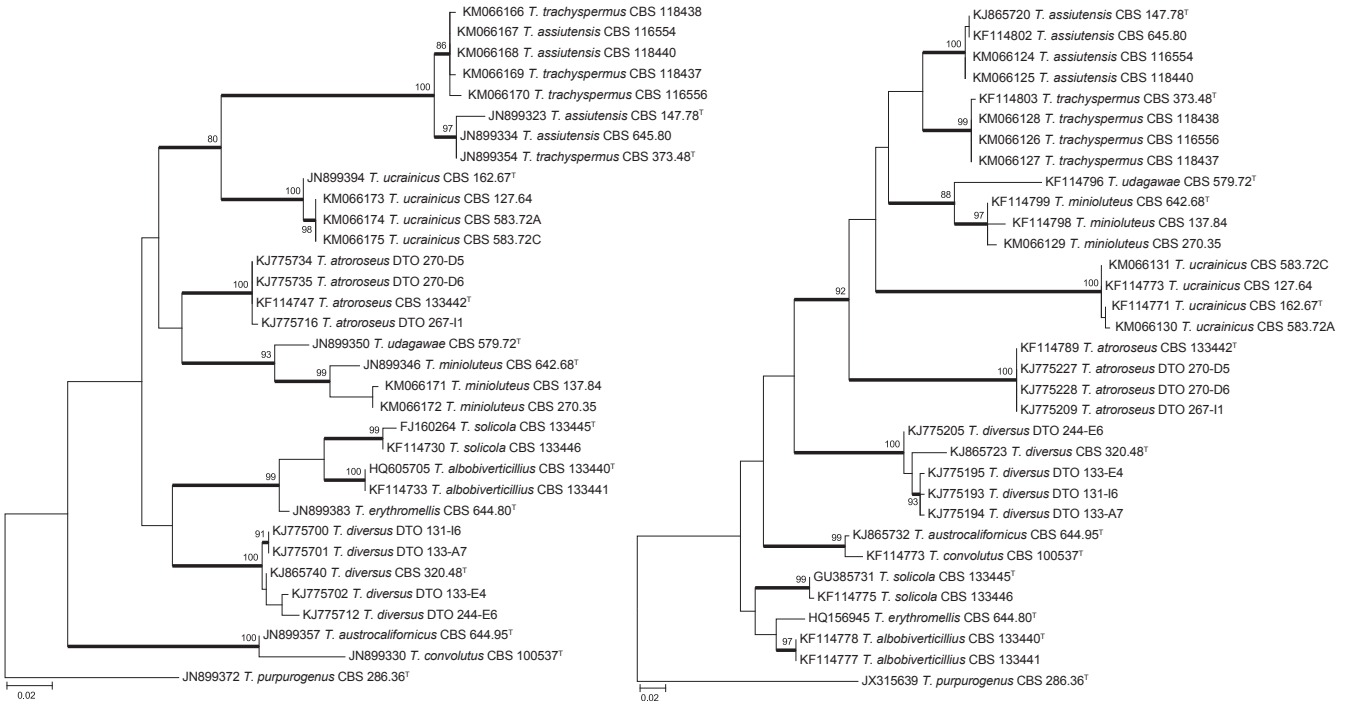

Fig. 5. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Trachyspermi*. *Talaromyces purpurogenus* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: T92+G+I for ITS, K2+G for *BenA*, alignment 495 (ITS) and 376 (*BenA*) bp.

Accepted species:

Talaromyces albobiverticillius (H.-M. Hsieh, Y.M. Ju & S.Y. Hsieh) Samson *et al.*, Stud. Mycol. 71: 174. 2011. [MB560683]. — Herb.: BCRC 34774. Ex-type: CBS 133440 = DTO 166-E5 = YMJ 1292. ITS barcode: HQ605705. (Alternative markers; *BenA* = KF114778; *CaM* = KJ885258; *RPB1* = n.a.; *RPB2* = KM023310).

Talaromyces assiutensis Samson & Abdel-Fattah, Persoonia 9: 501. 1978. [MB324414]. — Herb.: CBS 147.78. Ex-type: CBS 147.78. ITS barcode: JN899323. (Alternative markers; *BenA* = KJ865720; *CaM* = KJ885260; *RPB1* = JN680275; *RPB2* = KM023305).

Talaromyces atroroseus Yilmaz *et al.*, PLoS ONE 8: e84102-page 8. 2013. [MB804901]. — Herb.: CBS H-21790. Ex-type: CBS 133442 = IBT 32470 = DTO 178-A4. ITS barcode: KF114747. (Alternative markers; *BenA* = KF114789; *CaM* = KJ775418; *RPB1* = n.a.; *RPB2* = KM023288).

Talaromyces austrocalifornicus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 245. 1993. [MB361182]. — Herb.: CBM-PF 1117. Ex-type: CBS 644.95 = IBT 17522. ITS barcode: JN899357. (Alternative markers; *BenA* = KJ865732; *CaM* = KJ885261; *RPB1* = JN680316; *RPB2* = n.a.).

Talaromyces convolutus Udawaga, Mycotaxon 48: 141. 1993. [MB360474]. — Herb.: CBM SUM-3018. Ex-type: CBS 100537 = IBT 14989. 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 040579. Ex-type: CBS 320.48 = ATCC 10437 = DSM 2212 = IMI 040579 = IMI 040579ii = NRRL 2121. ITS barcode: KJ865740. (Alternative markers; *BenA* = KJ865723; *CaM* = KJ885268; *RPB1* = JN680297; *RPB2* = KM023285).

Talaromyces erythromellis (A.D. Hocking) Samson *et al.*, Stud. Mycol. 71: 175. 2011. [MB560652]. — Herb.: IMI 216899. Ex-type: CBS 644.80 = FRR 1868 = IMI 216899. ITS barcode: JN899383. (Alternative markers; *BenA* = HQ156945; *CaM* = KJ885270; *RPB1* = JN680315; *RPB2* = KM023290).

Talaromyces minioluteus (Dierckx) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560657]. — Herb.: CBS 642.68. Ex-type: CBS 642.68 = IMI 089377 = MUCL 28666. ITS barcode: JN899346. (Alternative markers; *BenA* = KF114799; *CaM* = KJ885273; *RPB1* = JN121709; *RPB2* = JF417443).

Talaromyces solicola Visagie & K. Jacobs, Persoonia 28: 20. 2012. [MB564328]. — Herb.: PREM 60037. Ex-type: DAOM 241015 = CV 2800 = DTO 180-D4. ITS barcode: FJ160264. (Alternative markers; *BenA* = GU385731; *CaM* = KJ885279; *RPB1* = n.a.; *RPB2* = KM023295).

Talaromyces trachyspermus (Shear) Stolk & Samson, Stud. Mycol. 2: 32. 1972. [MB324421]. — Herb.: IMI 040043. Ex-type: CBS 373.48 = ATCC 10497 = IMI 040043 = NRRL 1028. ITS barcode: JN899354. (Alternative markers; *BenA* = KF114803; *CaM* = KJ885281; *RPB1* = JN121664; *RPB2* = JF417432).

Talaromyces ucrainicus (Panas.) Udagawa, Trans. Mycol. Soc. Japan 7: 94. 1966. [MB449587]. — Herb.: unknown. Ex-type: CBS 162.67 = ATCC 22344 = FRR 3462 = NHL 6086. ITS barcode: JN899394. (Alternative markers; *BenA* = KF114771; *CaM* = KJ885282; *RPB1* = JN680277; *RPB2* = KM023289).

Talaromyces udagawae Stolk & Samson, Stud. Mycol. 2: 36. 1972. [MB324424]. — Herb.: CBS H-7841. Ex-type: CBS 579.72 = FRR 1727 = IMI 197482. ITS barcode: JN899350. (Alternative markers; *BenA* = KF114796; *CaM* = n.a.; *RPB1* = JN680310; *RPB2* = n.a.).

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

Typus: *Talaromyces bacillisporus* (Swift) C.R. Benj., [as '*bacillosporus*'], Mycologia 47: 682. 1955.

Description: Restricted growth on CYA, DG18, YES and CREA. Some species produce creamish white to yellow ascomata. Conidiophores mono- to biverticillate.

The section is introduced for *T. bacillisporus* and its closely related species. Species typically produce creamish white to yellow ascomata 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.

Accepted species:

Talaromyces bacillisporus (Swift) C.R. Benj. [as '*bacillosporus*'], Mycologia 47: 682. 1955. [MB118745]. — Herb.: CBS H-7813 (Isotype). Ex-type: CBS 296.48 = ATCC 10126 = IMI 040045 = NRRL 1025. ITS barcode: KM066182. (Alternative markers; *BenA* = AY753368; *CaM* = KJ885262; *RPB1* = JN121634; *RPB2* = JF417425).

Talaromyces emodensis Udagawa, Mycotaxon 48: 146. 1993. [MB360476]. — Herb.: CBM SUM-3025. Ex-type: CBS 100536 = IBT 14990. ITS barcode:

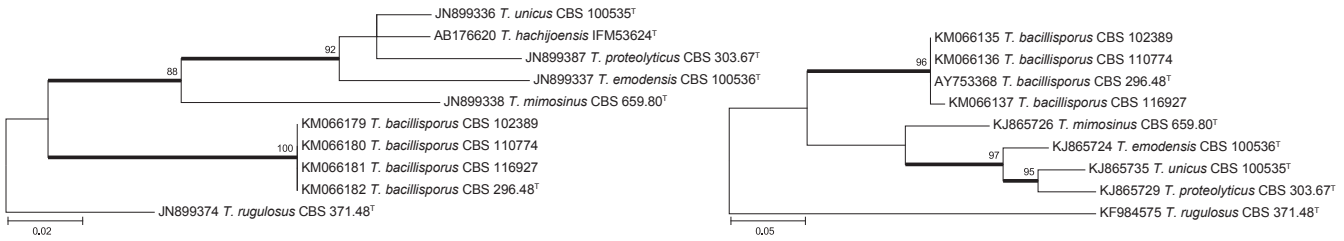

Fig. 6. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Bacillispori*. *Talaromyces rugulosus* was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: T92+G for ITS, K2+G for *BenA*, alignment 457 (ITS) and 469 (*BenA*) bp.

JN899337. (Alternative markers; *BenA* = KJ865724; *CaM* = KJ885269; *RPB1* = JN121552; *RPB2* = JN121552).

Talaromyces hachijoensis Yaguchi, Someya & Udagawa, Mycoscience 37: 157. 1996. [MB416016]. — Herb.: PF 1174. Ex-type: PF 1174 = IFM 53624. ITS barcode: AB176620. (Alternative markers; *BenA* = n.a.; *CaM* = n.a.; *RPB1* = n.a.; *RPB2* = n.a.).

Talaromyces mimosinus A.D. Hocking, The genus *Penicillium*: 507. 1980. [MB116382]. — Herb.: IMI 223991. Ex-type: CBS 659.80 = FRR 1875 = IMI 223991. ITS barcode: JN899338. (Alternative markers; *BenA* = KJ865726; *CaM* = KJ885272; *RPB1* = JN899302; *RPB2* = n.a.).

Talaromyces proteolyticus (Kamyschko) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. [MB560665]. — Herb.: CBS 303.67. Ex-type: CBS 303.67 = ATCC 18326 = NRRL 3378. ITS barcode: JN899387. (Alternative markers; *BenA* = KJ865729; *CaM* = KJ885276; *RPB1* = JN680292; *RPB2* = KM023301).

Talaromyces unicus Tzean, J.L. Chen & S.H. Shiu, Mycologia 84: 739. 1992. [MB360172]. — Herb.: PPH 16; Holotype Nat. Taiwan Univ. Ex-type: CBS 100535 = CCRC 32703 = IBT 18385. ITS barcode: JN899336. (Alternative markers; *BenA* = KJ865735; *CaM* = KJ885283; *RPB1* = JN680324; *RPB2* = n.a.).

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 343640. ITS barcode: JN899396. (Alternative markers; *BenA* = HQ156947; *CaM* = KJ885291; *RPB1* = JN680308; *RPB2* = KM023300).

Talaromyces subinflatus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 249. 1993. [MB361184]. — Herb.: CBM PF-1113. Ex-type: CBS 652.95 = IBT 17520. ITS barcode: JN899397. (Alternative markers; *BenA* = KJ865737; *CaM* = KJ885280; *RPB1* = JN680301; *RPB2* = KM023308).

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 *Pencillium*: 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 ascomata.

The section is introduced for *Penicillium* sect. *Simplicium* ser. *Islandica* Pitt. Species typically produce restrictedly growing colonies and have prominent yellow mycelia. A four-gene phylogeny, morphology and extrolite data revealed that *T. variabilis*, *P. concavorugulosum* and *T. sublevisporus* are synonymous with *T. wortmannii* (Yilmaz *et al.* unpubl.). Section *Islandici* 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, Petruccioli *et al.* 1999, Horré *et al.* 2001, de Vos *et al.* 2009, Peterson & Jurjević 2013).

Accepted species:

Talaromyces allahabadensis (B.S. Mehrotra & 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* = JN680309; *RPB2* = KF985006).

Talaromyces atricola S.W. Peterson & Jurjevic, PLoS ONE 8: e78084-page 8. 2013. [MB804733]. — Herb.: unknown. Ex-type: CBS 255.31 = NRRL 1052 = FRR 1052 = Thom 4640.439 = ATCC 52257. ITS barcode: KF984859. (Alternative markers; *BenA* = KF984566; *CaM* = KF984719; *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 18229 = FRR 646 = IFO 6438 = IHEM 3907 = IMI 078259 = MUCL 31318. ITS barcode: JN899365. (Alternative markers; *BenA* = KJ865722; *CaM* = KJ885264; *RPB1* = JN680281; *RPB2* = KM023272).

Talaromyces columbinus S.W. Peterson & Jurjevic, PLoS ONE 8: e78084-page 6. 2013. [MB804732]. — Herb.: BPI 892668. Ex-type: NRRL 58811. ITS barcode: KJ865739. (Alternative markers; *BenA* = KF196843; *CaM* = KJ885288; *RPB1* = n.a.; *RPB2* = KM023270).

Talaromyces islandicus (Sopp) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560654]. — Herb.: IMI 040042. Ex-type: CBS 338.48 = ATCC 10127 = IMI 040042 = MUCL 31324 = NRRL 1036. ITS barcode: KF984885. (Alternative markers; *BenA* = KF984655; *CaM* = KF984780; *RPB1* = JN121648; *RPB2* = KF985018).

Talaromyces loliensis (Pitt) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. [MB560655]. — Herb.: IMI 216901. Ex-type: CBS 643.80 = ATCC 52252 = FRR 1798 = IMI 216901 = MUCL 31325. ITS barcode: KF984888. (Alternative markers; *BenA* = KF984658; *CaM* = KF984783; *RPB1* = JN680314; *RPB2* = KF985021).

Talaromyces piceus (Raper & Fennell) Samson *et al.*, Stud. Mycol. 71: 176. 2011. [MB560661]. — Herb.: IMI 040038. Ex-type: CBS 361.48 = ATCC 10519 = IMI 040038 = NRRL 1051. ITS barcode: KF984792. (Alternative markers; *BenA* = KF984668; *CaM* = KF984680; *RPB1* = n.a.; *RPB2* = KF984899).

Talaromyces radicus (A.D. Hocking & Whitelaw) 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 040589. Ex-type: CBS 369.48 = ATCC 10493 = IMI

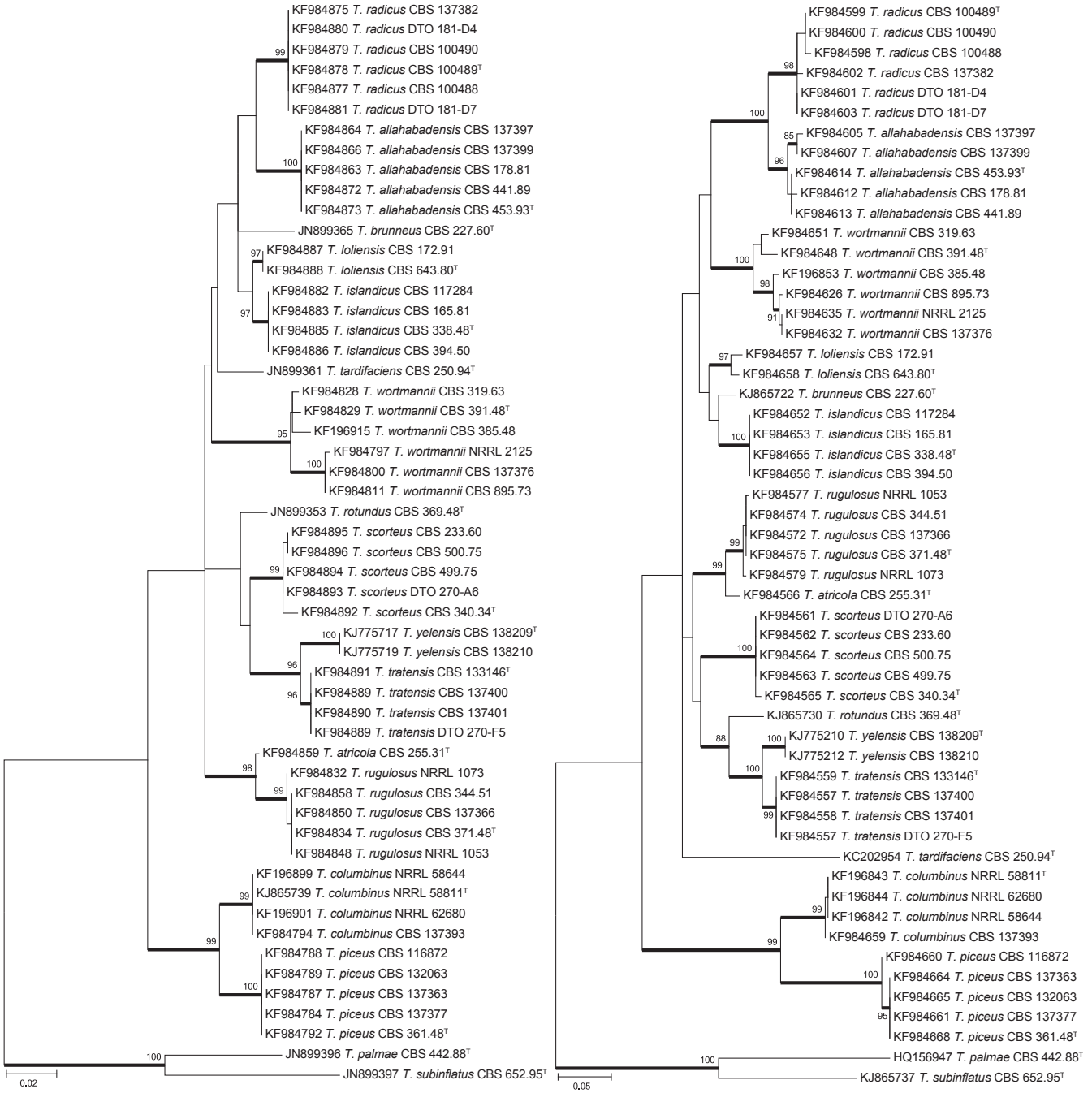

Fig. 7. ML phylogenies of ITS (left) and *BenA* (right) for species classified in *Talaromyces* sect. *Islandici*. *Talaromyces palmae* and *T. subinflatus* (*Talaromyces* sect. *Subinflati*) were chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. T = ex type. Model selected: GTR+G for ITS, K2+G for *BenA*, alignment 584 (ITS) and 398 (*BenA*) bp.

040589 = NRRL 2107. ITS barcode: JN899353. (Alternative markers; *BenA* = KJ865730; *CaM* = KJ885278; *RPB1* = n.a.; *RPB2* = KM023275).

Talaromyces rugulosus (Thom) Samson *et al.*, Stud. Mycol. 71: 177. 2011. [MB560672]. — Herb.: IMI 040041. Ex-type: CBS 371.48 = ATCC 10128 = IMI 040041 = MUCL 31201 = NRRL 1045. ITS barcode: KF984834. (Alternative markers; *BenA* = KF984575; *CaM* = KF984702; *RPB1* = JN680302; *RPB2* = KF984925).

Talaromyces scorteus (Nakazawa, Takeda & Suematsu) S.W. Peterson & Jurjevic PLoS ONE 8: e78084-page 8. 2013. [MB492647]. — Herb.: unknown. Ex-type: CBS 340.34 = NRRL 1129 = FRR 1129. ITS barcode: KF984892. (Alternative markers; *BenA* = KF984565; *CaM* = KF984684; *RPB1* = n.a.; *RPB2* = KF984916).

Talaromyces tardifaciens Udagawa, Mycotaxon 48: 150. 1993. [MB360478]. — Herb.: CBM SUM 3017. Ex-type: CBS 250.94. ITS barcode: JN899361. (Alternative markers; *BenA* = KC202954; *CaM* = KF984682; *RPB1* = JN680283; *RPB2* = KF984908).

Talaromyces tratensis Manoch, Dethoup & Yilmaz, Mycoscience 54: 337. 2013. [MB801738]. — Herb.: CBS H-21074. Ex-type: CBS 133146 = KUFC 3383. ITS barcode: KF984891. (Alternative markers; *BenA* = KF984559; *CaM* = KF984690; *RPB1* = JX898042; *RPB2* = KF984911).

Talaromyces wortmannii (Klöcker) C.R. Benj., Mycologia 47: 683. 1955. [MB344294]. — Herb.: IMI 040047. Ex-type: CBS 391.48 = ATCC 10517 = IMI 040047 = NRRL 1017. ITS barcode: KF984829. (Alternative markers; *BenA* = KF984648; *CaM* = KF984756; *RPB1* = JN121669; *RPB2* = KF984977).

Talaromyces yelensis Visagie *et al.*, Stud. Mycol. 78: 134. 2014. [MB809189]. — Herb.: CBS H-21799. Ex-type: CBS 138209 = DTO 268-E5. ITS barcode: KJ775717. (Alternative markers; *BenA* = KJ775210; *CaM* = n.a.; *RPB1* = n.a.; *RPB2* = n.a.).

Phylogenetic species recognition

The ITS rDNA region was recently accepted as the official DNA barcode for fungi (Schoch *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 *Trachyspermi* (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, Visagie *et al.* 2009, Visagie & Jacobs 2012, Yilmaz *et al.* 2012, Frisvad *et al.* 2013). In our study, *BenA* easily distinguished between all species, also allowing for some infraspecies 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 Bt2a and Bt2b or Bt2f 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 *Trachyspermi* 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 contains 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 macromorphological 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 *Trachyspermi* 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 *Trachyspermi* 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. allahabadensis* produces acid in contrast to *T. radicus*, which lacks acid production. Species of medical importance includes *T. amestolkiae*, *T. marneffei*, *T. helicus*, *T. piceus* and *T. stollii* (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. derxii*, *T. euchlorocarpius*, *T. viridis* and *T. aerugineus* 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 monoverticillate (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. derxii*, *T. euchlorocarpius* and *T. viridis*) or creamish white ascomata (*T. assiutensis* and *T. trachyspermus*). Size, shape and ornamentation of ascospores are also useful for distinguishing between species. Ascospores are generally spiny. Ascospores of *T. stipitatus* have single equatorial ridges, *T. udagawae* has numerous ornamented ridges on ascospores and *T. helicus* has smooth ascospores. In most species, ascospores are broadly ellipsoidal, but *T. bacillisporus* and *T. rotundus* have spiny, globose ascospores and *T. tardifaciens* produces smooth globose ascospores.

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 conidioma (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. calidicanius* 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. albobiverticillius*, *T. atroroseus*, *T. marneffei, T. minioluteus* and *T. purpurogenus* typically produce these pigments. Table 7

Table 3. Overview of macromorphological 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 (7D4–7D5) at the centre fading into greyish yellow (4A3–4B3)	Absent	Floccose to funiculose	Weak
T. aerugineus	Absent	26–27	35	49–50	Dark green (26F5) centre fading into greyish green (26B5–26B5)	Absent	Loosely funiculose to velvety	Absent (no growth)
T. albobiverticillius	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. amestolkiae	Absent	30–32	8–15	30–45	Violet brown (11E8–11F8)	Very weak brownish red, in some strains absent	Floccose and overlaying funiculose	Weak
T. angelicus	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. assiutensis	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*)

Table 3. (Continued)

Species name	Ascomata	Growth rate (mm)			CYA reverse	CYA soluble pigment	MEA colony texture	Acid production on CREA
		CYA	CYA (37 °C)	MEA				
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. derxii	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. duclauxii	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 (8C8–8D8)	Absent	Floccose	Absent
T. erythromellis	Absent	10–11	No growth	10–11	Dark red to brownish red (10C8–10D8)	Absent	Loosely funiculose	Absent
T. euchlorocarpius	Present	15–18	No growth	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 (7E6) 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 (5C6) 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	Dark 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 yellow to light orange (4A4–5A4)	Absent	Velvety and lossely funiculose	Present
T. liani	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. loliensis	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. macrosporus	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 brownish 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)

Table 3. (Continued)

Species name	Ascomata	Growth rate (mm)			CYA reverse	CYA soluble pigment	MEA colony texture	Acid production on CREA
		CYA	CYA (37 °C)	MEA				
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. oumae-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 14 d)	No growth	19–20 (after 14 d)	Violet brown (11E8)	Violet brown	Velvety to tomentose	Unknown
T. piceus	Absent	20–27	30–35	25–27	Brown (6E6)	Light brown	Loosely funiculose to floccose	Absent
T. pinophilus	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 (8C6)	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 (no growth)
T. purpureus	Present	2–4	No growth	15–16	Creamish beige	Absent	Floccose	Absent (no growth)
T. purpurogenus	Absent	20–25	16–25	30–45	Dark brown to violet brown (9F8–11F8)	Red	Velvety and floccose	Absent
T. rademirici	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	Loosely funiculose to floccose	Absent
T. ramulosus	Absent	32–40	5–8	45–48	Dark brown (6F4–6F7)	Absent	Funiculose 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	Velvety	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

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Table 3. (Continued)

Species name	Ascomata	Growth rate (mm)			CYA reverse	CYA soluble pigment	MEA colony texture	Acid production on CREA
		CYA	CYA (37 °C)	MEA				
T. ryukyuensis	Present	Unknown	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. scorteus	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. solicola	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 lossely funiculose	Present
T. subinflatus	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 (4A5–4A6) 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 (1F6–4E5–5C5)	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)	Pale red to reddish brown	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

Table 4. Overview of micromorphological characters for the identification of *Talaromyces* species.

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 × 3–3.5
T. aerugineus	Solitary phialides to monoverticillate	Smooth	Subglobose to ellipsoidal to fusiform	3–8.5 × 2.5–5
T. albobiverticillius	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Globose to subglobose	2–3.5(–4) × 1.5–2.5
T. allahabadensis	Biverticillate	Smooth	Ellipsoidal to fusiform	2.5–4.5 × 1.7–2.5
T. amestolkiae	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Ellipsoidal	2–3 × 1.5–2.5
T. angelicus	Mono- to biverticillate	Finely rough	Subglobose to ellipsoidal	2.5–3.5 × 2–3
T. apiculatus	Biverticillate	Rough to echinulate	Globose	3–4(–5.5) × 3–4(–5)
T. assiutensis	Mono- to biverticillate	Smooth	Ovoidal to ellipsoidal	2–4 × 1.5–2.5
T. atricola	Biverticillate having symmetrical subterminal branches	Smooth	Ellipsoidal to fusiform	2–5 × 2–5
T. atroroseus	Biverticillate, minor proportion with subterminal branches	Finely rough to rough	Ellipsoidal	2–3.5 × 1.5–2.5
T. aurantiacus	Biverticillate	Smooth	Cylindirical to ellipsoidal	3–5 × 1.5–2.5
T. austrocalifornicus	Biverticillate	Smooth	Subglobose	1.5–3 × 1.5–2.5
T. bacillisporus	Mono- to biverticillate	Smooth	Cylindrical, rod shaped to ellipsoidal	3–5(–6.5) × 1–2
T. bohemicus	Monoverticillate, subterminal branching sometimes present	Encrusted cell walls	Fusiform	7–9 × 2.6–3
T. boninensis	Biverticillate	Smooth	Ellipsoidal to fusiform	2–4 × 1.5–2.5
T. brunneus	Biverticillate, minor proportion with subterminal branches	Smooth	Globose to subglobose	3–4(–7) × 2–4
T. calidicanius	Biverticillate, minor proportion with subterminal branches	Finely rough to rough with spiral striations	Ellipsoidal to fusiform	2.5–4.5 × 2–3
T. cecidicola	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Ellipsoidal	2.5–4 × 1.5–3
T. chloroloma	Biverticillate, minor proportion with subterminal branches	Smooth	Ellipsoidal	2.5–4(–6) × 1.5–2.5
T. cinnabarinus	Biverticillate	Smooth	Cylindirical	5.4–7.2 × 1.5–2
T. cnidii	Biverticillate, minor proportion with subterminal branches	Smooth	Ellipsoidal	2.5–4 × 2–2.5
T. coalescens	Biverticillate, minor proportion with subterminal branches	Smooth	Ellipsoidal to fusiform	2.5–3.5(–5.5) × 1.5–3
T. columbinus	Biverticillate	Smooth	Ellipsoidal	2.5–3.5 × 3–4.5
T. convolutus	Mono- to biverticillate	Smooth	Ellipsoidal	(2–)3–4 × 1.5–2(–3)
T. dendriticus	Biverticillate	Smooth	Subglobose to ellipsoidal	2.5–3.5 × 2–2.5
T. derxii	Mono- to biverticillate	Smooth	Cylindrical to ellipsoidal, sometimes curved and fusiform	4–8 × 1.5–3
T. diversus	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Subglobose to ellipsoidal	2–3(–5) × 2–3(–3.5)
T. duclauxii	Biverticillate	Smooth to finely rough	Ellipsoidal	3–4 × 1.5–3.5(–4)
T. emodensis	Monoverticillate, minor proportion with subterminal branches	Smooth	Ovoidal to ellipsoidal	3–4 × 1.5–3
T. erythromellis	Biverticillate having symmetrical subterminal branches	Smooth	Subglobose to ellipsoidal	2–3.5 × 1.5–2.5
T. euchlorocarpius	Biverticillate	Smooth	Subglobose to ellipsoidal	2–4 × 2–3
T. flavovirens	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Ellipsoidal	2.5–3.5(–5.5) × 2–2.5(–4)

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Table 4. (Continued)

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	Ovoidal to ellipsoidal	2.5–5 × 1.5–3
T. hachijoensis	Absent	Absent	Absent	Absent
T. helicus	Mono- to biverticillate	Smooth	Globose to subglobose	2.5–3.5(–4.5) × 2.2–3.5
T. indigoticus	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. liani	Mono- to biverticillate	Smooth	Ellipsoidal	2.5–4(–4.5) × 2–3.5
T. loliensis	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. marneffei	Mono- to biverticillate	Smooth	Subglobose	2.5–4 × 2–3
T. mimosinus	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. muroii	Mono- to biverticillate, minor proportion with subterminal branches	Smooth	Globose to subglobose	2–3 × 1.5–3
T. oumae-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. pinophilus	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

Table 4. (Continued)

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 symmentrical 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. stollii	Biverticillate, minor proportion with subterminal branches	Smooth to finely rough	Ellipsoidal	2.5–4 × 2–2.5
T. subinflatus	Biverticillate	Smooth	Ellipsoidal to fusiform	2.5–4 × 1.5–2
T. tardifaciens	Solitary phialides and monoverticillate	Smooth	Cylindrical to ellipsoidal	3–6 × 1.5–2.5
T. thailandensis	Biverticillate	Smooth	Broadly ellipsoidal to ovoidal	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 ovoidal	2–2.5 × 3–3.5
T. ucrainicus	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. viridis	Solitary phialides	Smooth	Fusiform to ellipsoidal	2.5–3.5(–4) × 1.5–2
T. viridulus	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

Table 5. Morphological characters distinguishing *Talaromyces* species producing ascoma.

Species name	Ascoma colour	Ascospores				Conidiophore branching	Growth rate (mm)	
		Ridges	Ornamentation	Shape	Size (µm)		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	Absent	Finely spiny	Broadly ellipsoidal	2.5–3.5 × 2–2.5	Biverticillate	10–11	16–18
T. bacillisporus	Creamish white to pastel orange	Absent	Spiny	Globose	3.5–5 × 3.5–5	Mono- to biverticillate	10–15	15–20
T. boninensis	Grayish green	Absent	Spiny	Broadly ellipsoidal	(2.5–)3.5–4(4.5) × 2–3	Biverticillate	28	30
T. cinnabarinus	Yellowish orange to orange red	Present	Ornamented by irregular ridges	Broadly ellipsoidal, thick walled	4–5.5(–6) × 3–3.5	Biverticillate	Unknown	Unknown
T. convolutus	Sulphur yellow	Absent	Spiny	Globose to subglobose	3–3.5 × 2.5–3(–3.5)	Mono- to biverticillate	10–12	13–15
T. derxii	Greyish green to dark bluish green	Absent	Spiny	Ellipsoidal	3.5–5 × 2.5–3	Mono- to biverticillate	38–40	48–50
T. emodensis	Creamish white to sulphur yellow	Absent	Spiny	Globose to subglobose	2.5–4 × 2.5–3.5	Monoverticillate, subterminal branching sometimes present	8–10	8–10
T. euchlorocarpius	Deep green	Absent	Spiny	Ellipsoidal	3.5–5 × 2.5–3	Biverticillate	15–18	38–40
T. flavovirens	Golden yellow with a reddish pigment	Absent	Spiny	Ellipsoidal, thick walled	(4–)4.5–6(–7) × 3–4	Biverticillate, minor proportion with subterminal branches	19–20	37–38
T. flavus	Deep yellow	Absent	Spiny	Broadly ellipsoidal, thick walled	4–5.5 × 3–3.5	Monoverticillate	9–10	31–32
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 sinous 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. liani	Yellow to orange red	Absent	Spiny	Broadly ellipsoidal	4–6 × 2.5–4	Mono- to biverticillate	20–30	35–45
T. macrosporus	Yellow	Absent	Spiny	Subglobose to boradly 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 sinous 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 boradly 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	4–5.5 × 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

Table 5. (Continued)

Species name	Ascoma colour	Ascospores				Conidiophore branching	Growth rate (mm)	
		Ridges	Ornamentation	Shape	Size (µm)		CYA	MEA
T. subinflatus	Sulphur yellow	Absent	Spiny	Broadly ellipsoidal	3–4(–5.5) × 2–3(–5)	Biverticillate	3–4	14–15
T. tardifaciens	Creamish white to white yellow	Absent	Smooth	Broadly ellipsoidal	3–3.5 × 2–3	Solitary phialides and monoverticillate	9–10	13–15
T. thailandensis	Yellow	Absent	Spiny	Broadly ellipsoidal, thick walled	4–6 × 2.5–4.5	Biverticillate	33–35	30–35
T. trachyspermus	Creamish white	Absent	Spiny	Broadly ellipsoidal	3.5–5 × 2–3	Mono- to biverticillate	13–24	17–25
T. tratensis	Yellow	Absent	Spiny	Broadly globose to ovoidal	3.5–5.0 × 2.5–3.5	Biverticillate	10–12	15–20
T. ucrainicus	Yellow	Present	Ornamented with thin, somewhat jagged, irregular, mostly longitudinal ridges	Broadly ellipsoidal	3–5 × 2–3	Mono- to biverticillate	10–20	18–24
T. udagawae	Yellow	Present	Ornamented with 3 to 5 regular, nearly parallel, transverse ridges, often spirally arranged	Ellipsoidal	3.5–6 × 2.5–3.5	Biverticillate	6–8	10–11
T. unicus	Pastel yellow to yellow	Present	Roughened to spiny, usually with a single ridge	Ellipsoidal	3.3–6.7 × 2.8–4.2	Mono- to biverticillate, minor proportion with subterminal branches	10.5–16	15–19.5
T. viridis	Dark green	Present	Finely ornamented with ridges	Ellipsoidal	3.7–4.5 × 2.5–3	Solitary phialides	9	15
T. wortmannii	Yellow to orange	Absent	Smooth to spiny	Broadly ellipsoidal, thick walled	3.5–6.0 × 2.5–4	Biverticillate, minor proportion with subterminal branches	18–28	15–25

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	After 7 d	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. pseudostromaticus	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 morpholgical characters distinguishing soluble red pigment producers in the genus *Talaromyces*.

Species name	Growth rate (mm)			MEA texture	Acid CREA
	CYA	CYA (37 °C)	MEA		
T. albobiverticillius	15–20	No growth	25–28	Velvety	Absent
T. amestolkiae	30–32	8–15	30–45	Floccose and overlaying funiculose	Weak
T. atroroseus	28–40	23–25	30–35	Velvety and floccose	Absent
T. cnidii	25–30	20–28	38–40	Velvety and floccose	Absent
T. coalescens	32–34	2–4	43–45	Funiculose	Very weak
T. marneffei	13–25	5–10	15–27	Loosely funiculose and floccose	Absent
T. minioluteus	17–18	No growth	21–22	Loosely funiculose and floccose	Absent
T. pittii	34–36	No growth	42–44	Yeast like slimy colonies, after 2 wk floccose and synnematous	Absent
T. purpurogenus	20–25	16–25	30–45	Velvety and floccose	Absent
T. ruber	20–35	14–18	35–40	Velvety	Absent
T. stollii	38–45	25–35	45–50	Floccose and lossely funiculose	Present

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	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)	Brownish orange (5C6)
T. apiculatus	38–41	35–45	25–35	40–42	Weak	Light brown (7D5) to brownish grey (7E2)	Brownish orange (5C6)
T. diversus	7–10	6–10	5–8	25–35	Absent	Light yellow (4A5–5A5)	Brownish yellow (5C7–5C8)
T. solicola	12–13	13–15	No growth	22–23	No growth	Reddish brown to dark brown (9E6–9F6)	Centre dark brown (7F7), fading into brown (7E7)
T. verruculosus	32–35	37–38	25–26	35–36	Weak	Greyish orange (5B5)	Greyish orange (5C6)

Table 9. Overview of growth rates on CYA at 37 °C for *Talaromyces* species.

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. cecidicola	2–3	*T. macrosporus*	28–35
T. coalescens	2–4	*T. piceus*	30–35
T. rademirici	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. derxii*	35–38
T. diversus	5–8	*T. funiculosus*	38–50
T. ramulosus	5–8	*T. columbinus*	42–43
T. marneffei	5–10	*T. albobiverticillius*	No growth
T. ptychoconidium	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. amestolkiae	8–15	*T. euchlorocarpius*	No growth
T. islandicus	8–17	*T. hachijoensis*	No growth
T. austrocalifornicus	10–11	*T. intermedius*	No growth
T. oumae-annae	10–11	*T. loliensis*	No growth
T. viridis	10–11	*T. minioluteus*	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. indigoticus	20–22	*T. rotundus*	No growth
T. liani	20–25	*T. rugulosus*	No growth
T. cnidii	20–28	*T. scorteus*	No growth
T. allahabadensis	23–25	*T. solicola*	No growth
T. atroroseus	23–25	*T. subinflatus*	No growth
T. galapagensis	25–26	*T. tardifaciens*	No growth
T. yelensis	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. stollii	25–35	*T. ryukyuensis*	Unknown
T. pinophilus	25–40	*T. boninensis*	Unknown (growth was reported, but no diam)

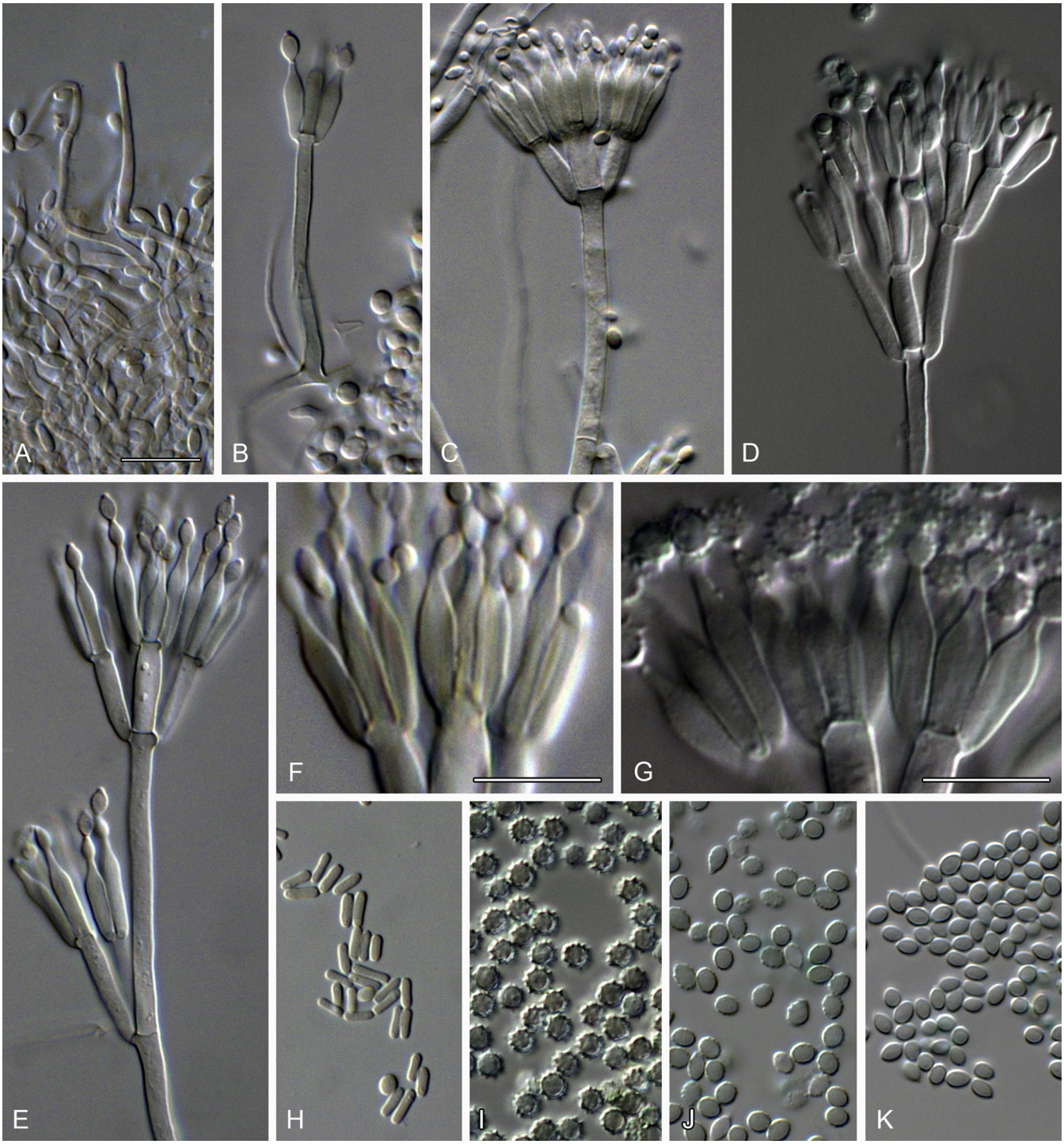

Fig 8. Micromorphological features of *Talaromyces*. A–E. Condiophore branching: A. Solitary phialides. B. Monoverticillate. C. Biverticillate. D–E. Biverticillate with extra subterminal branching. F. Acerose phialides G. Flask-shaped phialides. H–K. Shapes of conidia: H. Cylindrical and rod-shaped.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

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. *Trachyspermi*). 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).

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	Alternariol	Apiculides	Asperphenamate	Austin	Bacillisporin	Botryodiploidin*	Cyclochlorotine & Islanditoxin*	Duclauxin	Epi-Austdiol	Falconensis	Glauconic/Glaucanic acid	Luteoskyrin*	Mitorubrins	Penicillides/Purpactins/Vermixocins	Penisimlissin	Pentacecilides/Thailandolides	Prugusenes/Ukulactones	Rubratoxins*	Rubropunctatin and other monascus pigments	Rugulosin*	Skyrin*	Rugulovasine*	Secalonic acid D & F*	Stipitatic acid	Vermicellin	Vermiculin	Vermistatin & Funicones	Wortmannilactones (F-H)	Wortmannin
T. aculeatus	+	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. albobiverticillius	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
T. allahabadensis	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−	+	−	−	−	−	−−	−	−	−	−
T. apiculatus	+	+	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. assiutensis	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. atricola	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
T. atroroseus	−	−	−	−	−	−	−	−	−	−	+	−	+	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
T. austrocalifornicus	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. bacillisporus	−	−	−	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. brunneus	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	-	−	+	−	−	−	−	−	−	−	−	−
T. calidicanius	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. cecidicola	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−
T. coalescens	−	−	−	−	−	+	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. columbinus	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
T. convolutus	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	-	−	−	−	−	−	−	−	−	−	−	−
T. dendriticus	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−	−	−	+	−	−	+	−	−	−
T. diversus	+	−	−	+	−	-	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−−	−	−	−
T. duclauxii	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. emodensis	−	−	−	−	−	−	−	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. erythromellis	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
T. flavovirens	−	+	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−
T. flavus	−	+	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−
T. funiculosus	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	+(?)	−	−
T. galapagensis	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. hachiojensis	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. helicus	+	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. islandicus	−	−	−	−	−	−	+	−	−	−	−	+	+	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
T. loliensis	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−
T. macrosporus	−	−	−	−	−	−	−	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. marneffei	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
T. mimosinus	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. minioluteus	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−
T. palmae	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−
T. panamensis	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−
T. piceus	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
T. pinophilus	−	−	−	+	−	−	−	−	−	−	−	−	+	+	+	−	−	−	+	−	−	−	−	−	+	+	+	−	−
T. primulinus	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
T. pseudostromaticus	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−
T. purpurogenus	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	−	+	+	−	−	+	−	−	−	+	−	−	−

(*continued on next page*)

Table 10. (Continued).

Species name	Alternariol	Apiculides	Asperphenamate	Austin	Bacillisporin	Botryodiploidin*	Cyclochlorotine & Islanditoxin*	Duclauxin	Epi-Austdiol	Falconensis	Glauconic/Glaucanic acid	Luteoskyrin*	Mitorubrins	Penicillides/Purpactins/Vermixocins	Penisimlissin	Pentacecilides/Thailandolides	Prugusenes/Ukulactones	Rubratoxins*	Rubropunctatin and other monascus pigments	Rugulosin*	Skyrin*	Rugulovasine*	Secalonic acid D & F*	Stipitatic acid	Vermicellin	Vermiculin	Vermistatin & Funicones	Wortmannilactones (F-H)	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 descriptions (see Taxonomy). Mitorubrins, penicillides, purpactins and vermixocins 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. funiculosus*, *T. minioluteus*, *T. pseudostromaticus*, *T. siamensis* and *T. stipitatus*). Red pigment producers such as, *T. marneffei*, *T. albobiverticillius*, *T. purpurogenus*, *T. albobiverticillius* 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*). Glauconic acid and glaucanic acid are specific for section *Trachyspermi*.

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.

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; *RPB2* = 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 (5C6). YES

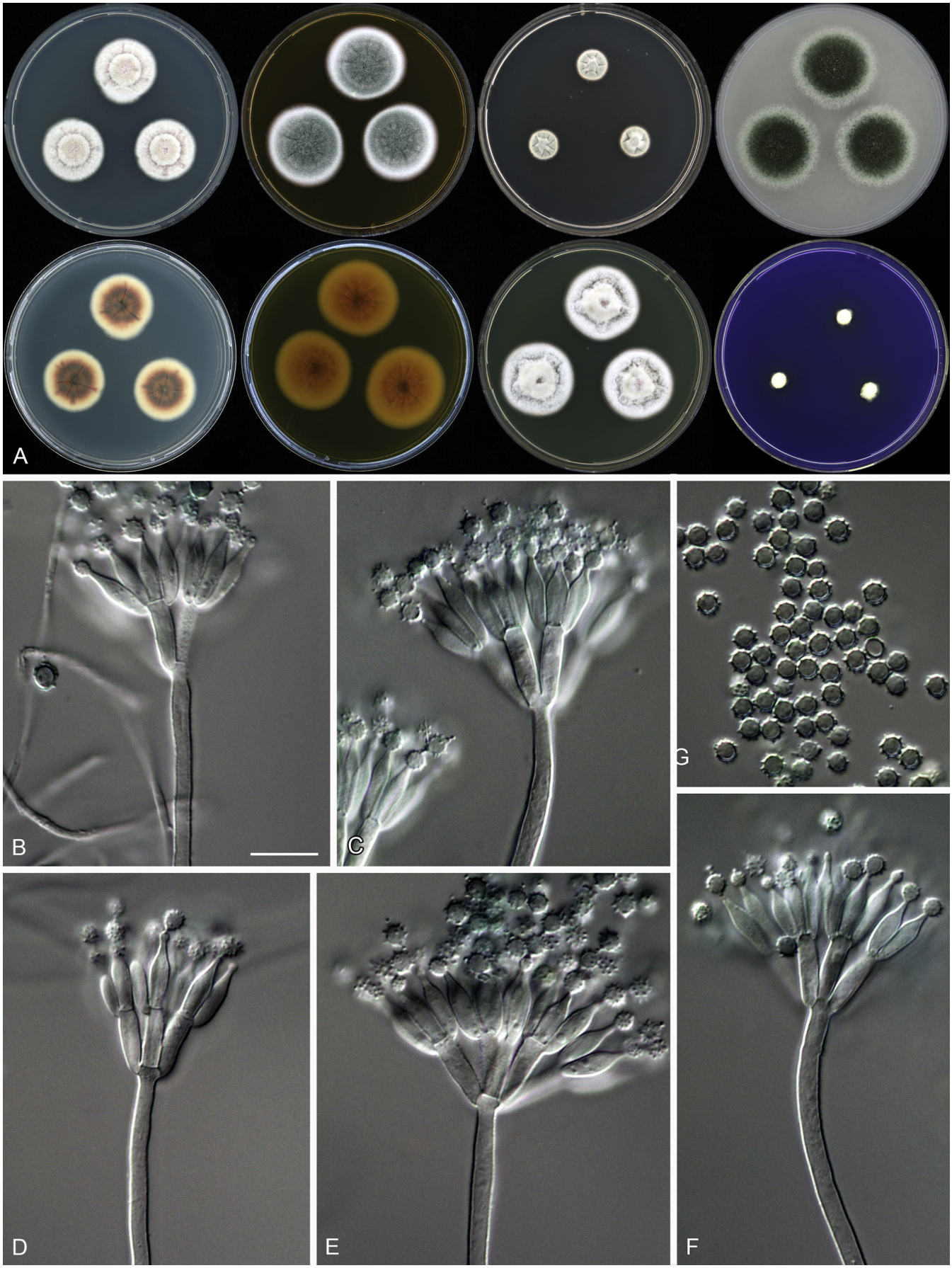

Fig. 9. Morphological characters of *Talaromyces aculeatus* (CBS 289.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

25 °C, 7 d: Colonies moderately deep, irregularly sulcate, raised at centre; margins low, narrow, entire; mycelia white, yellow, red; texture floccose to lightly funiculose; sporulation absent to sparse, conidia *en masse* greyish green (27D5–27E5); 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 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* = KJ885285; *RPB2* = JN121502)

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 funiculose; sporulation absent; soluble pigments absent; exudates absent; reverse dark green (26F5) centre fading into greyish green (26B5–26B5). MEA 25 °C, 7 d: Colonies low, sulcate, sterile white mycelia; margins low, plane, entire (1 mm); mycelia white; sporulation absent; texture loosely funiculose to velvety; soluble pigments absent; exudates absent; reverse greyish orange (5B5–5B6). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate, green and orange appearance; margins low, plane, entire (1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse light yellow (4A4) with light orange (5A6) circle. DG18 25 °C, 7 d: Colonies raised, plane; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* dull green (25D4–26D4); soluble pigments absent; exudates absent; reverse olive (1F3–1F4). OA 25 °C, 7 d: Colonies low, plane, green (because of the reverse); margins low, plane, entire (3–5 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse greyish green to dull green (at 30 °C greyish green (25E6)). CREA 25 °C, 7 d: No growth.

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.
≡ *Penicillium albobiverticillium* H.-M. Hsieh, Y.M. Ju & S.Y. Hsieh, Fungal Sci. 25: 26. 2010.

In: *Talaromyces* section *Trachyspermi*

Typus: BCRC 34774, culture ex-type CBS 133440 = DTO 166-E5 = YMJ 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 the ex-type strain, and for the other isolates greyish green (25D5–26D5); 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:

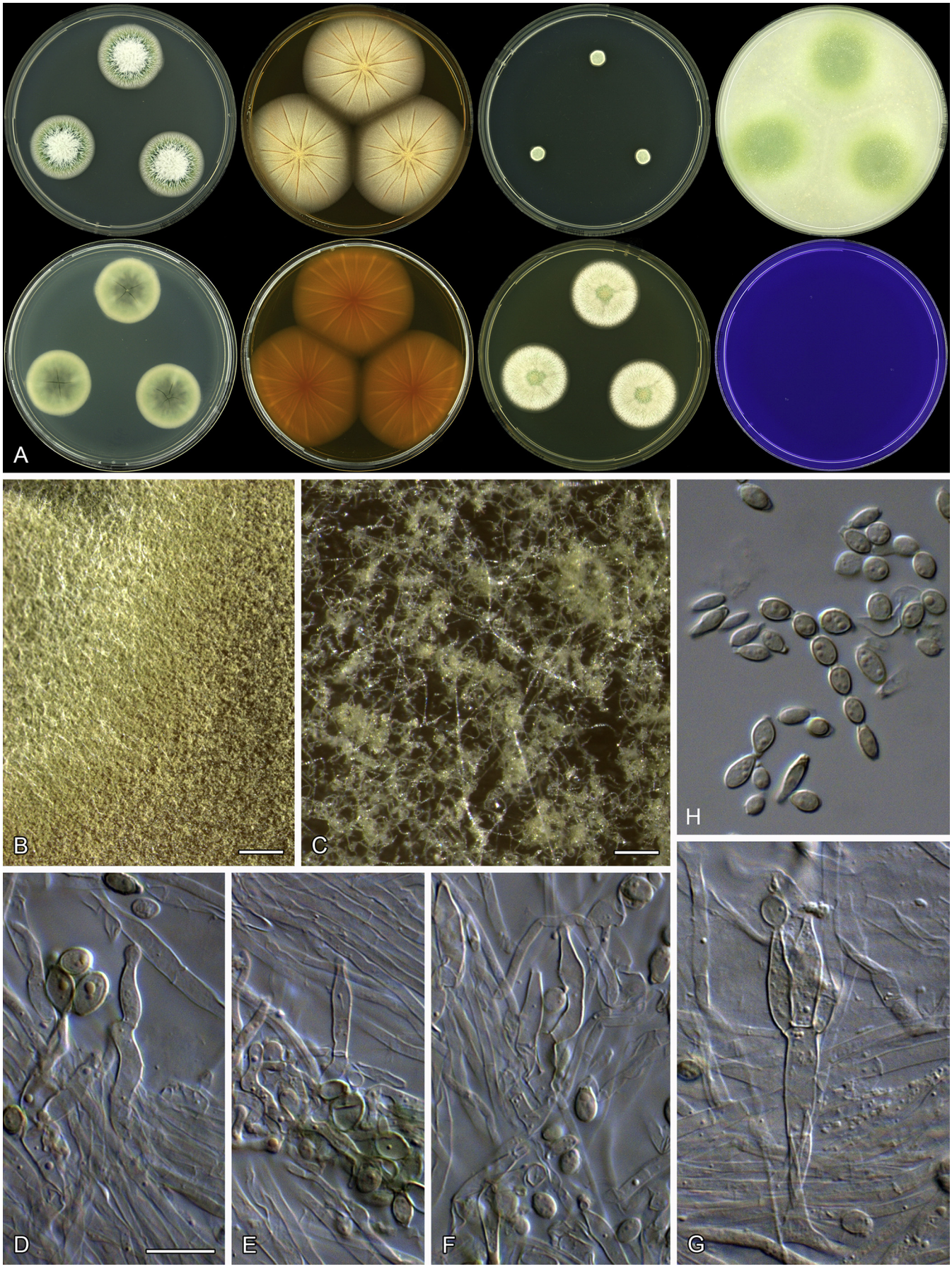

Fig. 10. Morphological characters of *Talaromyces aerugineus* (CBS 350.66^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B, C. Colony texture on MEA after 2 wk incubation. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 µm; D = 10 µm, applies to E–H.

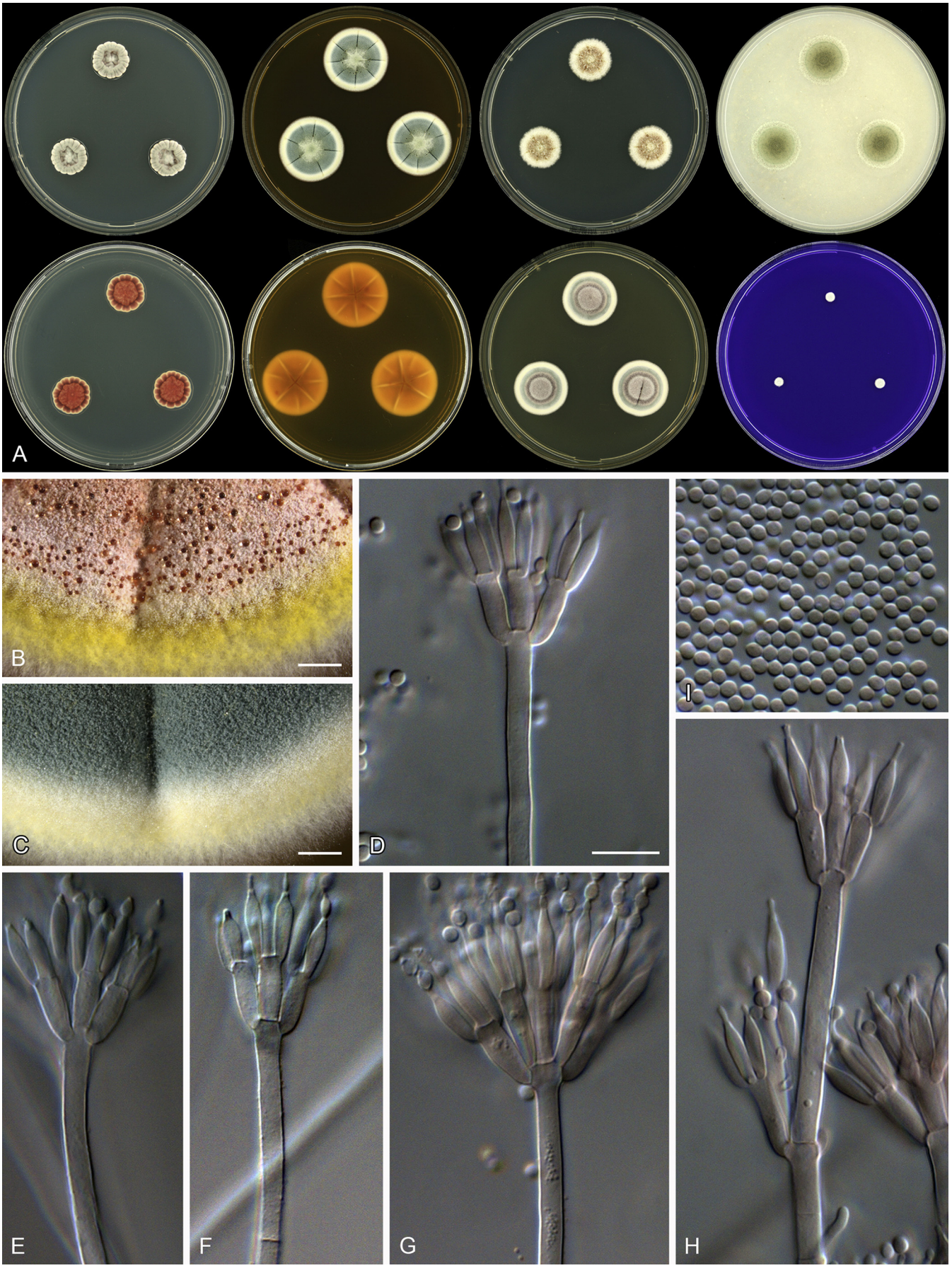

Fig. 11. Morphological characters of *Talaromyces albobiverticillius* (CBS 206.89). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 1 wk incubation (CBS 113442^{T}). C. Colony texture on MEA after 1 wk 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 greenish grey 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 reddish orange (7A8) centre fading into orange (6A8) and in some isolates dull yellow (3B4) centre fading into pale yellow (3A3). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia only in type white, pastel yellow and pastel red, in other strains white; 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 dull green (26D4); soluble pigments in some isolates red, generally absent; exudates absent; reverse in some isolates dark red, in some lack of red reverse and pale 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.

Extrolites: *Talaromyces albobiverticillius* produces mitorubrin, mitorubrinic acid, mitorubrinol, monascin, monascorubramin, 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. Ramírez & A.T. Martínez, 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 orange to 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, 2.5–4.5 × 1.7–2.5 µm. Ascomata not observed.

Extrolites: *Talaromyces allahabadensis* produces prugosenes/ukulactones (Lang *et al.* 2007, Mori *et al.* 2011) and several azaphilones: mitorubrin, mitorubrinol, mitorubrinol acetate, mitorubrinic acid, 6′-hydroxy-3′-methoxy-mitorubrin, 4′-hydroxy-3′-methoxy-(S)-mitorubrin and monomethyl-(S)-mitorubrin. Three isolates, IBT 12688, CBS 137397, 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 extrolite production at 25 °C. *Talaromyces allahabadensis*

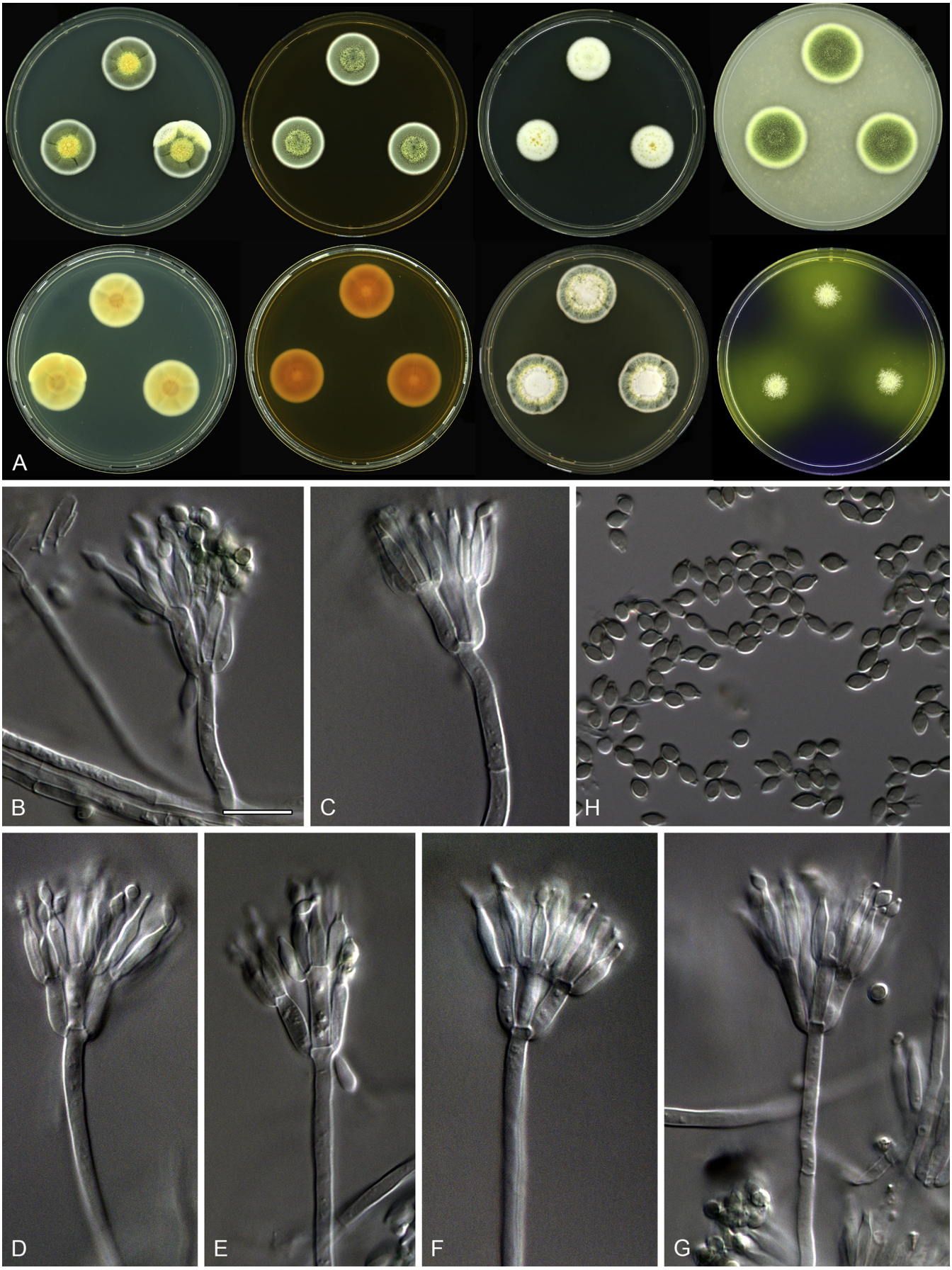

Fig. 12. Morphological characters of *Talaromyces allahabadensis* (CBS 453.93^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale Bar: B = 10 µm, applies to C–H.

shares prugosenes with *T. rugulosus* and the three latter mitorubrins 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, mitorubrin, mitorubrinic acid, mitorubrinol, *Monascus* red azaphilone 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

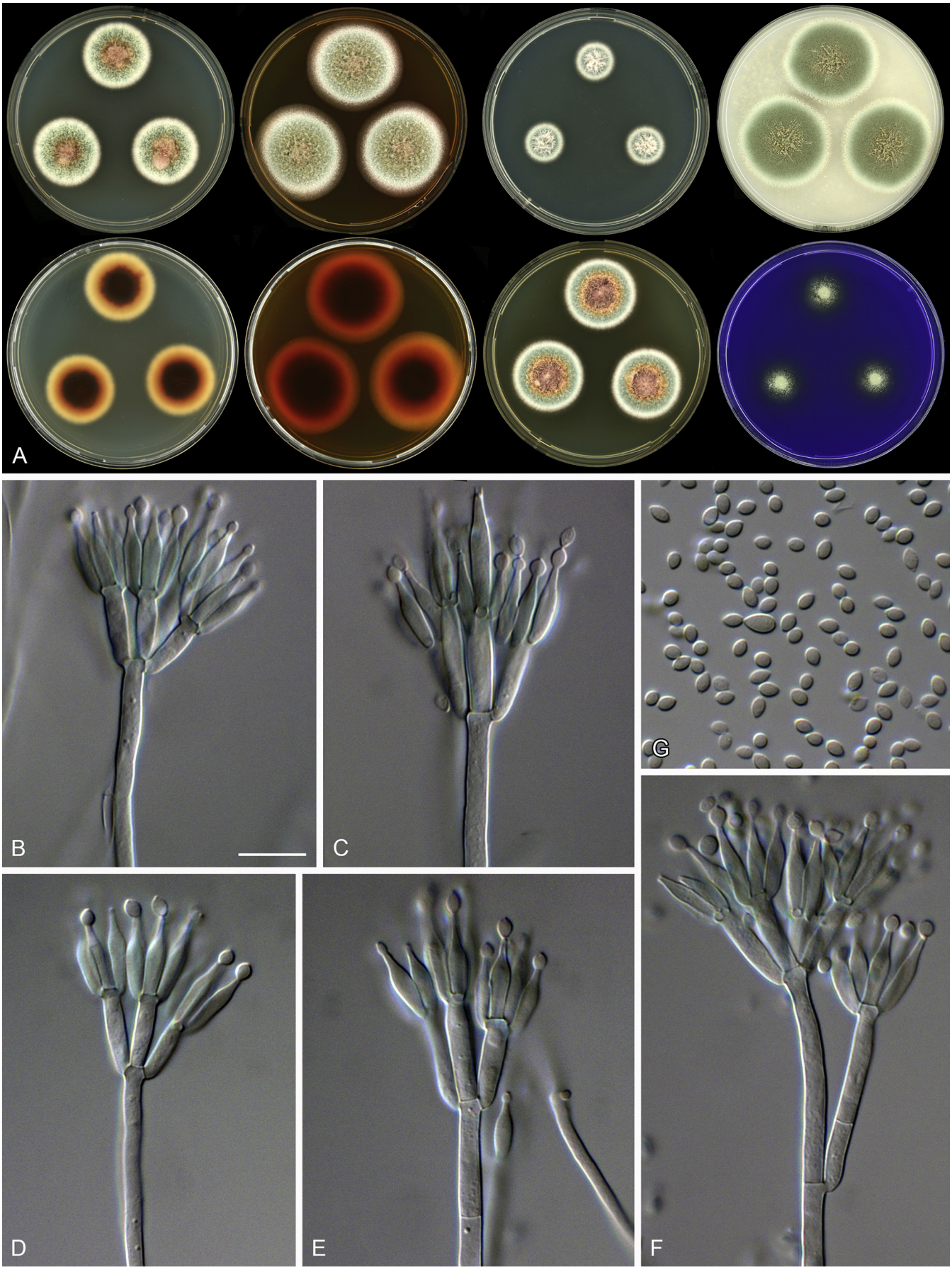

Fig. 13. Morphological characters of *Talaromyces amestolkiae* (CBS 132696^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

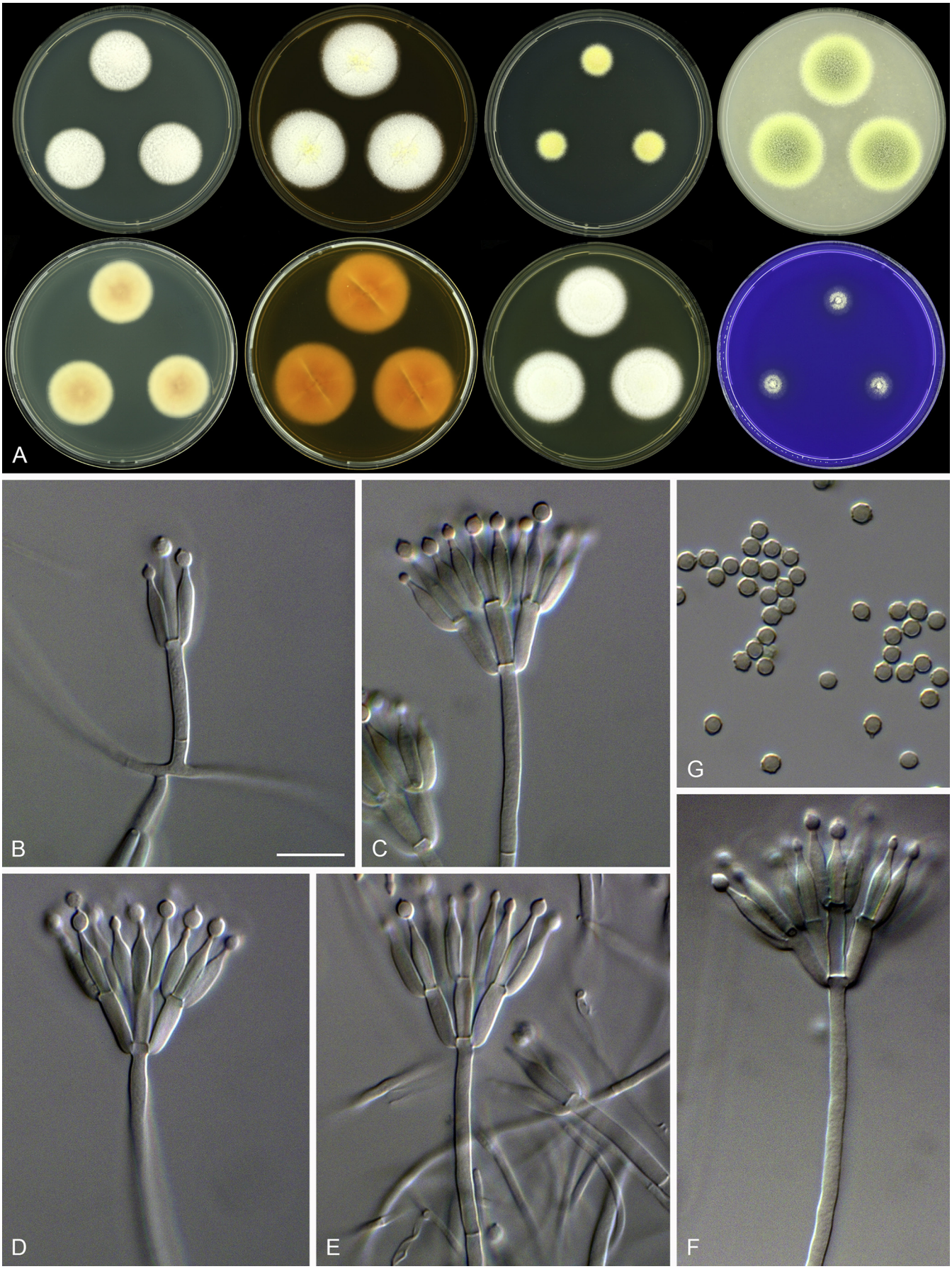

Fig. 14. Morphological characters of *Talaromyces angelicus* (KACC 46611^T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A5–5A6) centre fading into pastel yellow to light 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 also sometimes monoverticillate; stipes smooth walled, 15–120 × 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 roughed, subglobose to ellipsoidal, 2.5–3.5 × 2–3 µm. Ascomata not observed.

Distinguishing characters: *Talaromyces angelicus* 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 ascomata. Morphologically, *T. angelicus* 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* = KF741950; *RPB2* = KM023287)

Colony diam, 7 d (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; sporulation 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; conidioge sporulation nesis sparse 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; sporulation 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.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, (100–)150–350 × 2.5–3 µm; metulae four to eight, divergent, 7.5–11 × 2.5–3.5; phialides flask-shaped, tapering into very thin neck, three to five per metulae, 9–11 × 2.5–3.5 µm; conidia echinulate, globose with a minor proportion apiculate, 3–4(–5.5) × 3–4(–5) µm. Ascomata not observed.

Extrolites: *Talaromyces apiculatus* produces the macrocyclic polylactones ("apiculides") NG-011 and NG-012 (Ito *et al.* 1992a, b), BK223-A (=NG-012), BK-223B, BK-223C (Breinholt *et al.* 1993), 15G256β, and 15G256α-2 (Gao *et al.* 2013). The latter five extrolites have been reported as antifungal (Breinholt *et al.* 1993, Schlingmann *et al.* 2002), while NG-011 and NG-012 are potentiators 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, prenpenicillide 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, purpactins, vermicillin. Decalpenic 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 ≡ *Talaromyces 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 d (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; sporulation absent to sparse, conidia *en masse* greenish grey (28B2); soluble pigments absent; exudates absent; reverse

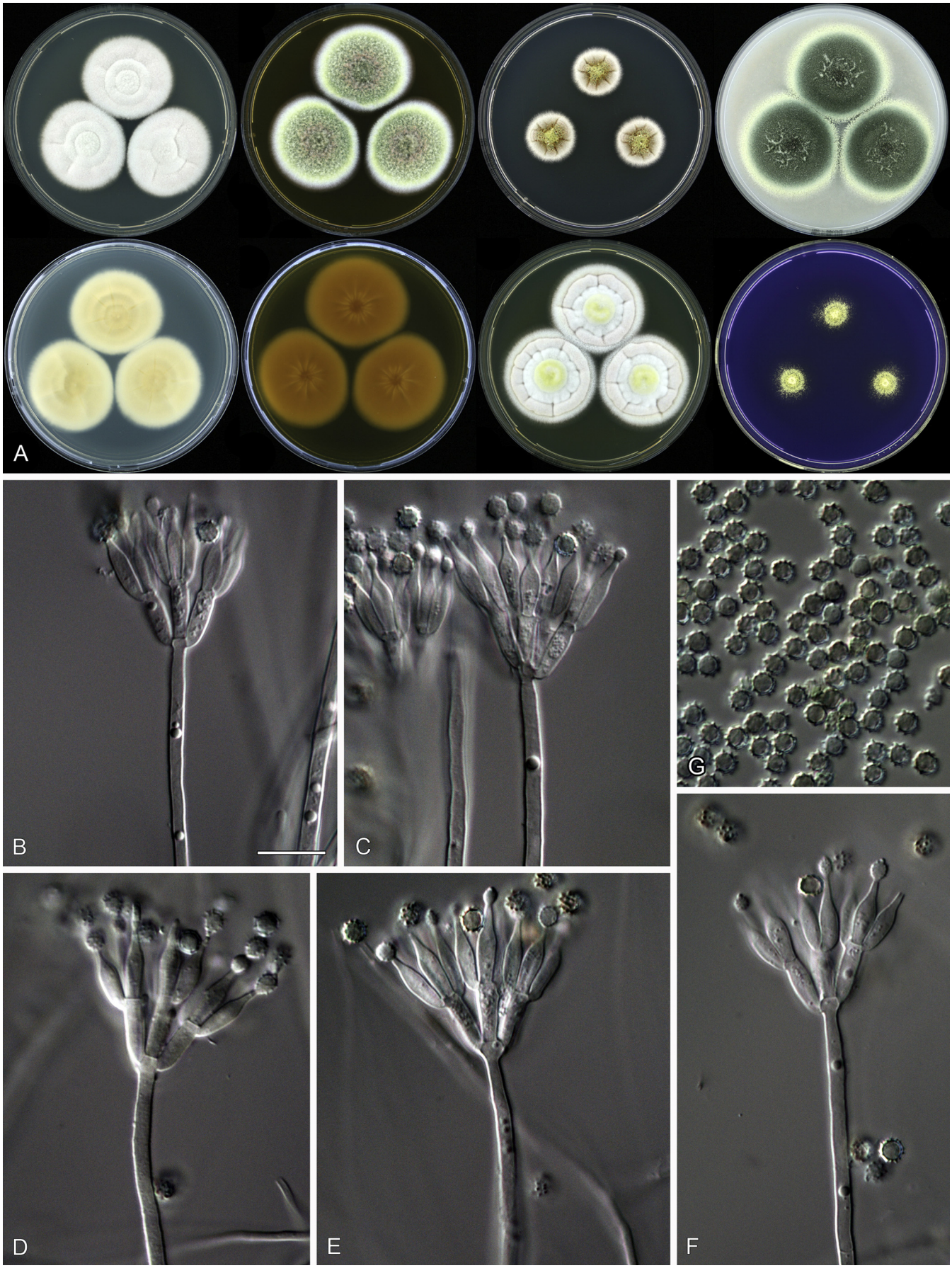

Fig. 15. Morphological characters of *Talaromyces apiculatus* (CBS 312.59^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

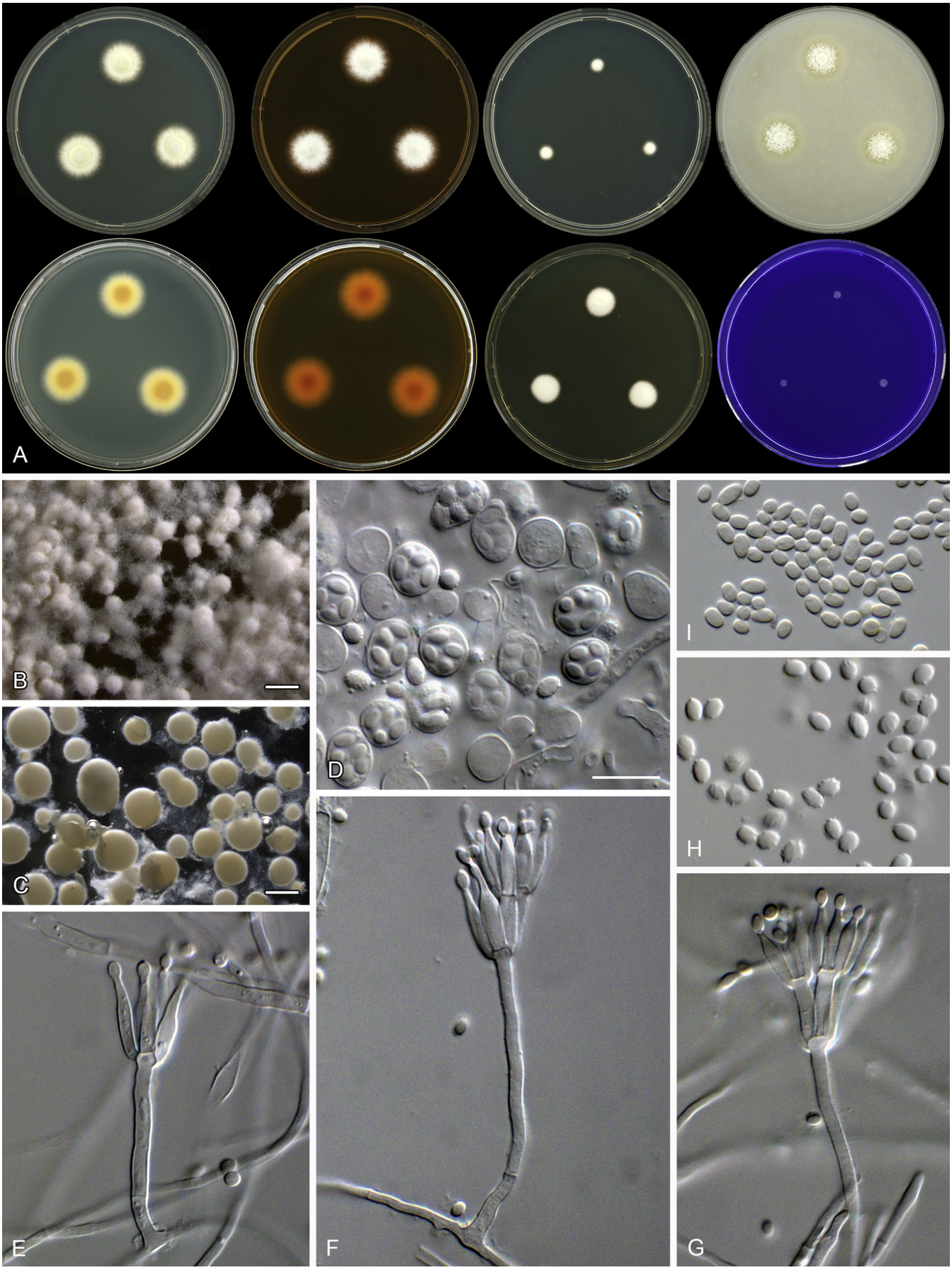

Fig. 16. Morphological characters of *Talaromyces assiutensis* (CBS 116554) A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on OA after 2 wk incubation. C. Ascomata D. Asci and ascopsores. E–G. Conidiophores. H. Ascospores. 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 (28B2); soluble pigments absent; exudates absent; reverse brownish yellow to brown (5C8–5E7). 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 (28B2); 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 yellowish white (2A2). OA 25 °C, 7 d: Colonies low, plane, young ascomata visible; margins subsurface, wide, entire (3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent, in some orange coloured inside media in colony periphery; exudates absent; reverse pale yellow to light orange (1A3–5A4). CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate and also sometimes monoverticillate; 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, ovoidal to ellipsoidal, 2–4 × 1.5–2.5 µm. Ascomata 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, asci 7–11 × 5.5–8.5 µm, ascospores ellipsoidal, spiny, 3.5–5 × 2–3 µm.

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

Distinguishing characters: *Talaromyces assiutensis* produces creamish white ascomata with spiny, ellipsoidal ascospores (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, ascospores 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: e78084-page 8. 2013. MycoBank MB804733. Fig. 17.

≡ *Penicillium rugulosum* var. *atricolum* Thom, Penicillia: 474. 1930.

In: *Talaromyces* section *Islandici*

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 raised at centre, slightly sulcate; margins narrow (<1 mm), low, entire, plane; mycelium white; sporulation absent to sparse; exudates absent; soluble pigment absent; reverse yellowish white to yellowish grey (4A2–4A3). MEA 25 °C, 7 d: Colonies low, plane; margins narrow (1 mm), low, entire, plane; mycelium white; sporulation sparse to dense; texture floccose; conidia *en masse* greyish green to dull green (26C3–26D3); exudates absent; soluble pigment absent; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins narrow (<1 mm), low, entire, plane; mycelium white; sporulation absent; exudates absent; soluble pigment absent; reverse light orange to greyish orange (5A5–5B5). DG18 25 °C, 7 d: Colonies low, plane; margins narrow (<1 mm), low, entire, plane; mycelium white; sporulation sparse to dense; texture floccose; conidia *en masse* greyish green to dull green (26C3–26D3); exudates absent; soluble pigment absent; reverse yellowish white to yellowish grey (4A2–4A3). OA 25 °C, 7 d: Colonies low, plane; margins narrow (2 mm), low, entire, plane; mycelium white; sporulation sparse to dense; texture floccose; conidia *en masse* greyish green to dull green (26C3–26D3); exudates absent; soluble pigment absent; reverse beige. CREA, 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate often having symmetrical subterminal branches; stipes smooth walled, 20–200 × 2.0–3.0 µm; with extra branches 10–30 µm; metulae three to six, divergent, 6–13 × 1.5–3.0 µm; phialides acerose, three to six per metulae, 8–11 × 2–3 µm; conidia smooth, ellipsoidal, with one end connection to sometimes fusiform, 2–5 × 2–5 µm. Ascomata not observed.

Extrolites: *Talaromyces atricola* produces questin, rugulosin A, skyrin, mitorubrin, mitorubrinol, mitorubrinol acetate, 6′-hydroxy-3′-methoxy-mitorubrin, 4′-hydroxy-3′-methoxy-(S)-mitorubrin and monomethyl-(S)-mitorubrin.

Distinguishing characters: *Talaromyces atricola* is characterised by restricted growth on most media and produces floccose colonies that sporulate poorly (Fig. 17). It is most similar to *T. rugulosus*. However, the floccose colonies and poor sporulation is in contrast to the velvety and well sporulating colonies of *T. rugulosus*. In addition, conidia of *T. atricola* are more ellipsoidal than those of *T. rugulosus* and colonies generally grow more restrictedly.

Talaromyces atroroseus Yilmaz *et al.*, PLoS ONE 8: e84102-page 8. 2013. MycoBank MB804901. Fig. 18.

In: *Talaromyces* section *Trachyspermi*

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

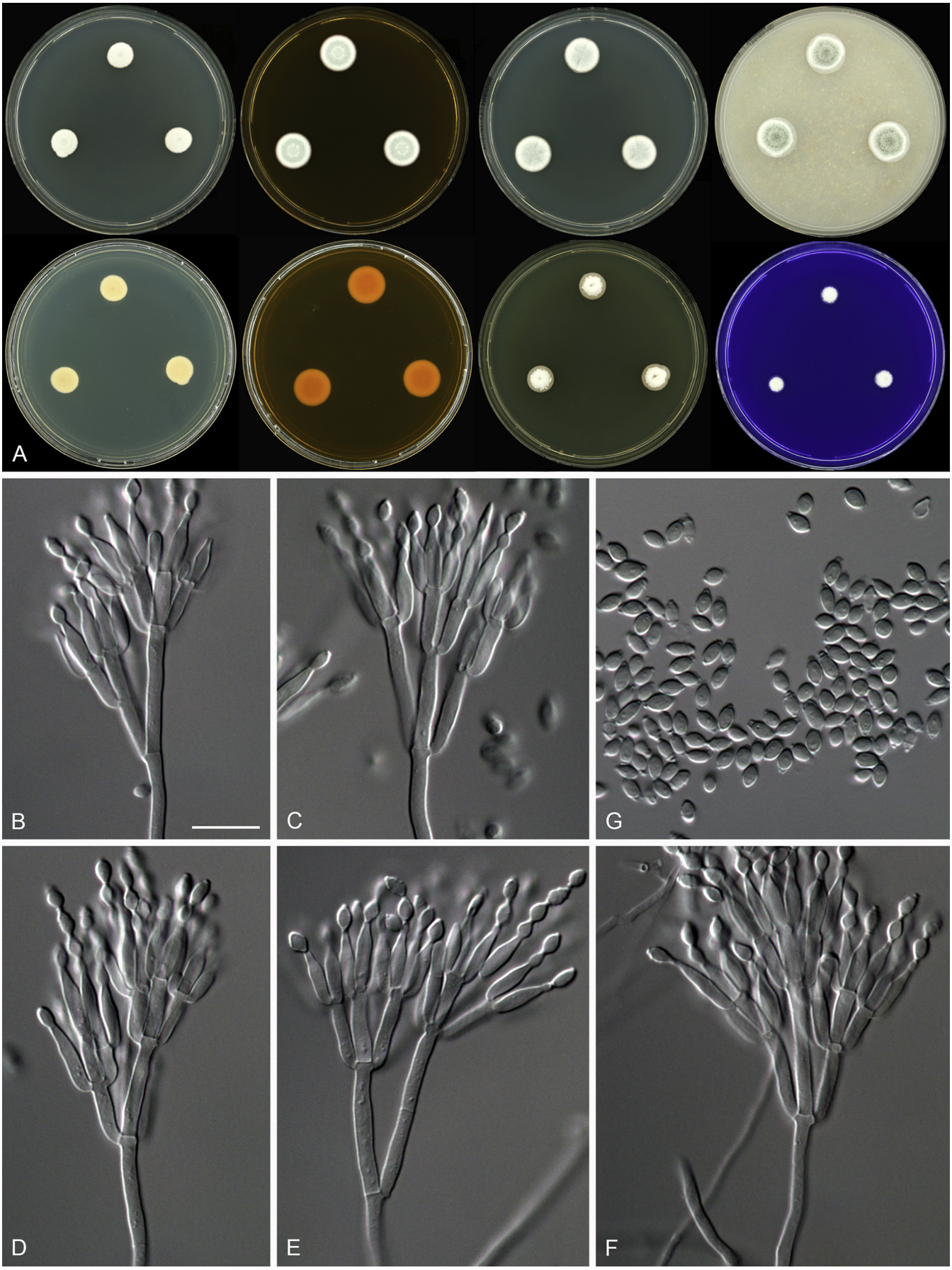

Fig. 17. Morphological characters of *Talaromyces atricola* (CBS 255.31^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

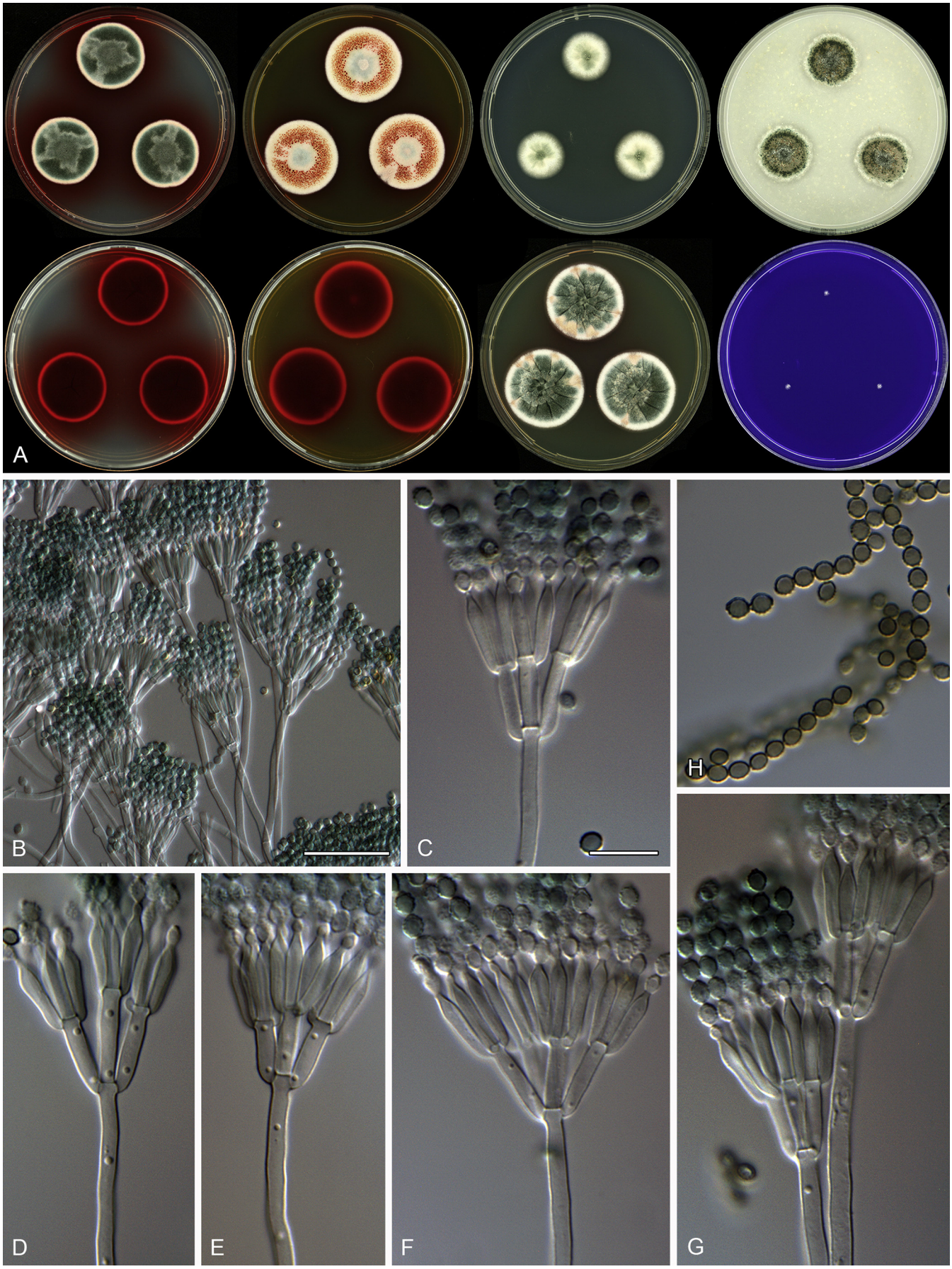

Fig. 18. Morphological characters of *Talaromyces atroroseus* (CBS 133442^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bars: B = 50 µm; C = 10 µm, applies to D–H.

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 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 atroroseus* produces glauconic acid, glaucanic acid, Monascus red azaphilone pigments, purpactins A-C, purpuride, purpurogenone and ZG-1494α (Frisvad *et al.* 2013).

Distinguishing characters: *Talaromyces atroroseus* is characterised by soluble red pigment and very dark green conidia on OA (Fig. 18). *Talaromyces atroroseus* produces glauconic acid, purpuride and ZG-1494α (Frisvad *et al.* 2013). Other species producing soluble red pigment include *T. minioluteus*, *T. purpurogenus* and *T. albobiverticillius*. *Talaromyces atroroseus* grows well on CYA at 37 °C, in contrast to poor growth for *T. albobiverticillius* and *T. minioluteus*. *Talaromyces atroroseus* resembles *T. purpurogenus*, 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 white (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. auriantiacus*.

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)

Colony diam, 7 d (mm): CYA 10–11; CYA 30 °C 10–11; CYA 37 °C 10–11; MEA 16–18; MEA 30 °C 23–24; DG18 8; CYAS No growth; OA 25; CREA No growth; YES 18–20.

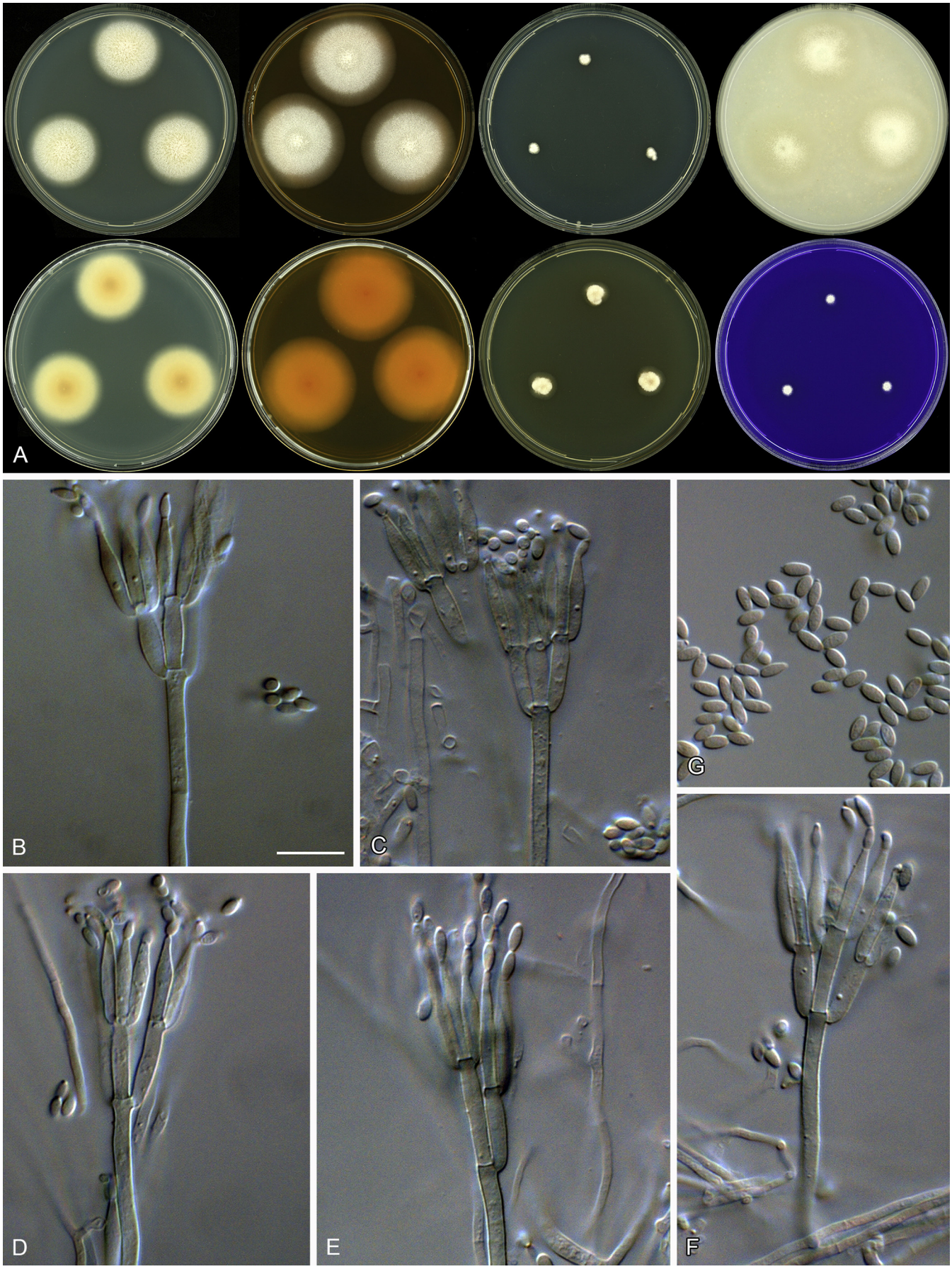

Fig. 19. Morphological characters of *Talaromyces aurantiacus* (CBS 314.59^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

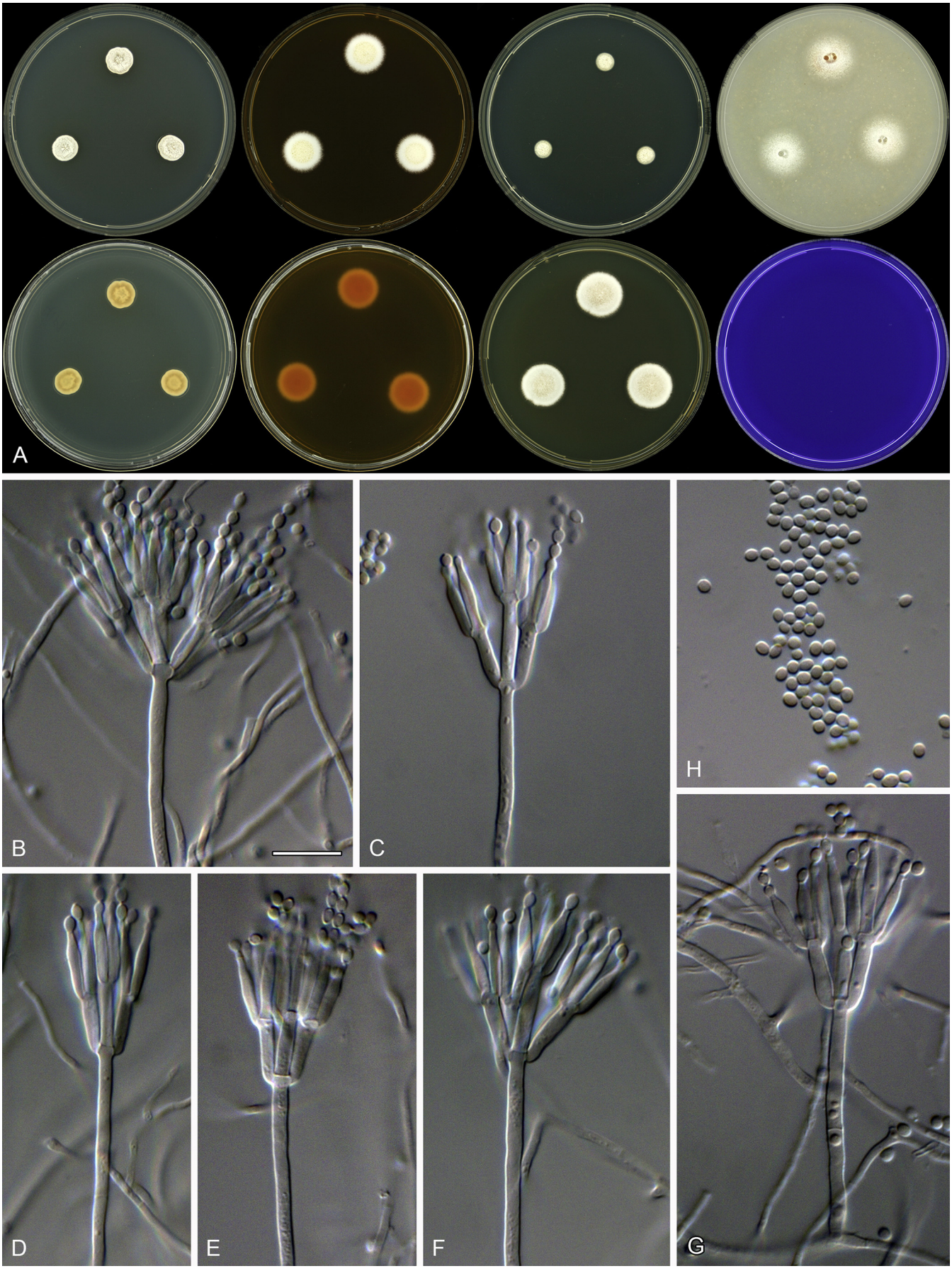

Fig. 20. Morphological characters of *Talaromyces austrocalifornicus* (CBS 645.95^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

Colony 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 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange to light orange (5A3–5A4). DG18 25 °C, 7 d: Colonies raised at centre, plane; 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 acerose, 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, asci 6–8 × 5–6 µm, ascospores broadly ellipsoidal, finely spiny, 2.5–3.5 × 2–2.5 µm.

Extrolites: *Talaromyces austrocalifornicus* produces altenuene, mitorubrin, mitorubrinic 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 ascopores and biverticillate conidiophores producing smooth subglobose conidia (Fig. 20). All these characters differentiate *T. austrocalifornicus* from other species that produce yellow ascomata wth 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 '*bacillosporus*'], 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: KM066182 (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 caramel brown (6C6) and at 30 °C reverse dark green (25F4). YES 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, 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 small clear droplets; reverse dark brown centre and at 30 °C very dark green reverse. CREA 25 °C, 7 d: Generally no growth colonies up to 3 mm acid production absent.

Micromorphology: Conidiophores mostly monoverticillate and biverticillate with a minor proportion having subterminal branches; stipes rough-walled, 20–60 × 2–3.5 µm; branches 15–25 µm; metulae three to six, divergent, 9.5–13 × 3–3.5 µm; phialides acerose, two to five per metulae, 7–12 × 2–4 µm; conidia cylindrical, rod-shaped, occasionally ellipsoidal, 3–5(–6.5) × 1–2 µm (2.5–4 × 1.5–2.5 µm). Ascomata maturing after 1–2 wk of incubation on OA at 25 °C and abundantly at 30 °C, creamish white and longer incubation pastel orange, globose to subglobose, 80–150 µm, asci 8–12 × 9–14 µm, ascospores globose, spiny, 3.5–5 × 3.5–5 µm.

Extrolites: *Talaromyces bacillisporus* produces pinselin and bacillisporin 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 bohemica* 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* = KJ865719; *CaM* = KJ885286, *RPB2* = JN121532)

Colony diam, 10 d (mm): *Fide* Fassatiová & Pěčková (1990), MEA 40 mm.

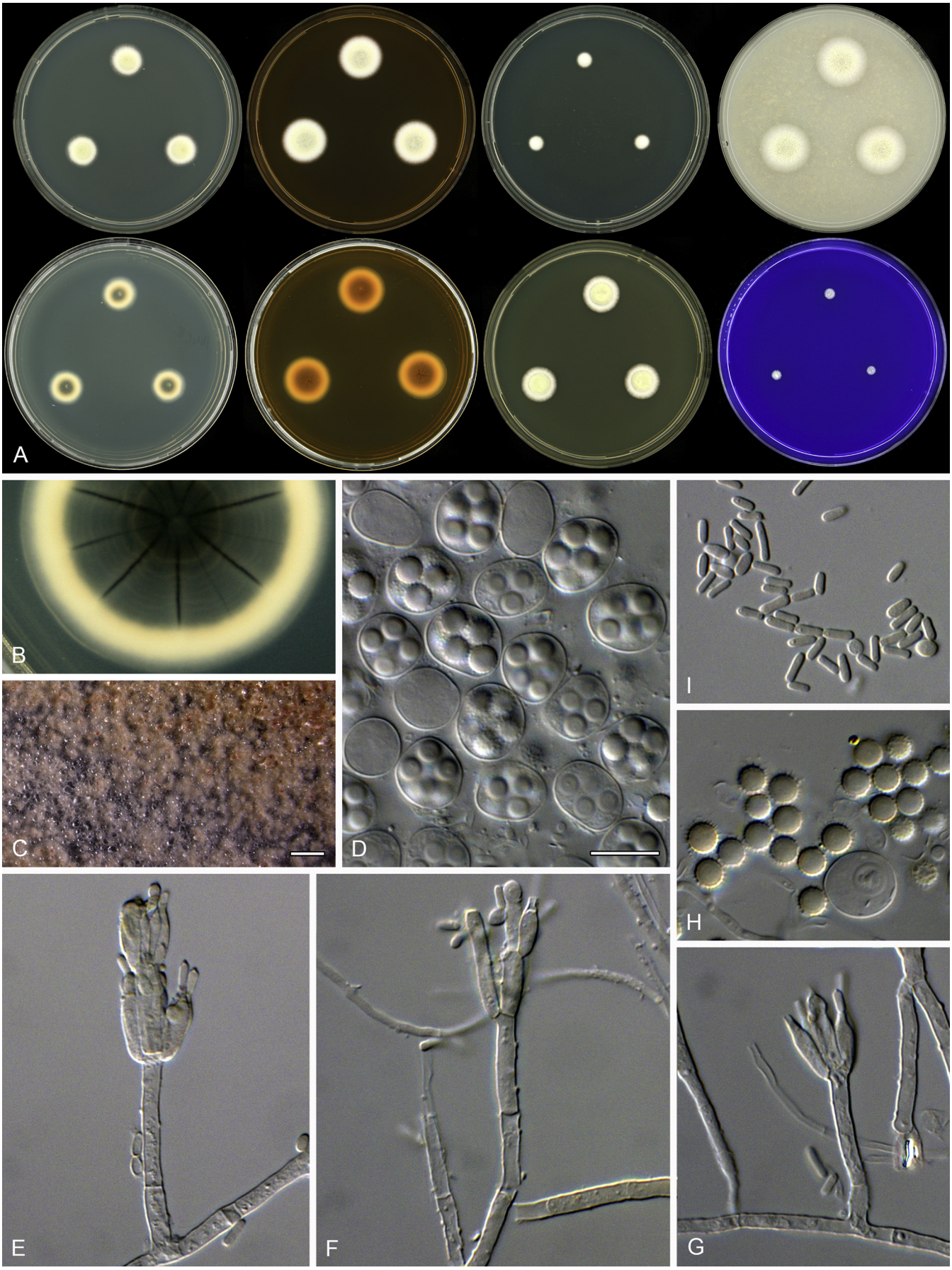

Fig. 21. Morphological characters of *Talaromyces bacillisporus* (CBS 298.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B Colony reverse on CYA after 1 wk incubation at 30 °C. C. Colony texture and ascomata on OA after 2 wk incubation. D. Asci and ascopsores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: C = 500 µm; D = 10 µm, applies to E–I.

Colony characters: *Fide* Fassatiová & Pêčková (1990) after 10 d of cultivation on MEA the colonies reach 4 cm diam., are very low and thin, mycelium is light brown, later cinnamon brown. The colonies grow in concentric zones. The centre of the colony is later tomentose, forming pink brown to red brown hyphae joining into narrow funicles. Three to four weeks later a heavy sporulation, grey green conidia; reverse at first red brown and later diffusing into surrounding agar conspicuously colourating it.

Micromorphology: *Fide* Fassatiová & Pêčková (1990), monoverticillate with extra branching up to 20 µm; phialides acerose, 13–25(–30) × 2.5–3 µm; conidia fusiform, encrusted cell wall, 7–9 × 2.6–3 µm.

Notes: The ex-type strain of *Talaromyces bohemicus* was not in good condition and could not be studied. The description is based on Fassatiová & Pêčková (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 (28A6–28B6); 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 grayish green (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, acerose, 10–15 × 2–3.5 µm; conidia ellipsoidal to fusiform, sometimes globose, smooth, 2–4 × 1.5–2.5 µm. Ascomata ripening 14–21 d, grayish green, globose to subglobose, 280–550 × 240–480 µm; asci 8–10(–12) × 7–8 µm; ascospores broadly ellipsoidal, spiny, (2.5–)3.5–4(4.5) × 2–3 µm.

Extrolites: *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 macrmorphology is smilar to *T. helicus* (Yaguchi *et al.* 1992), but 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 25–28 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. 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* = KJ885264; *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 (5B5). 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,

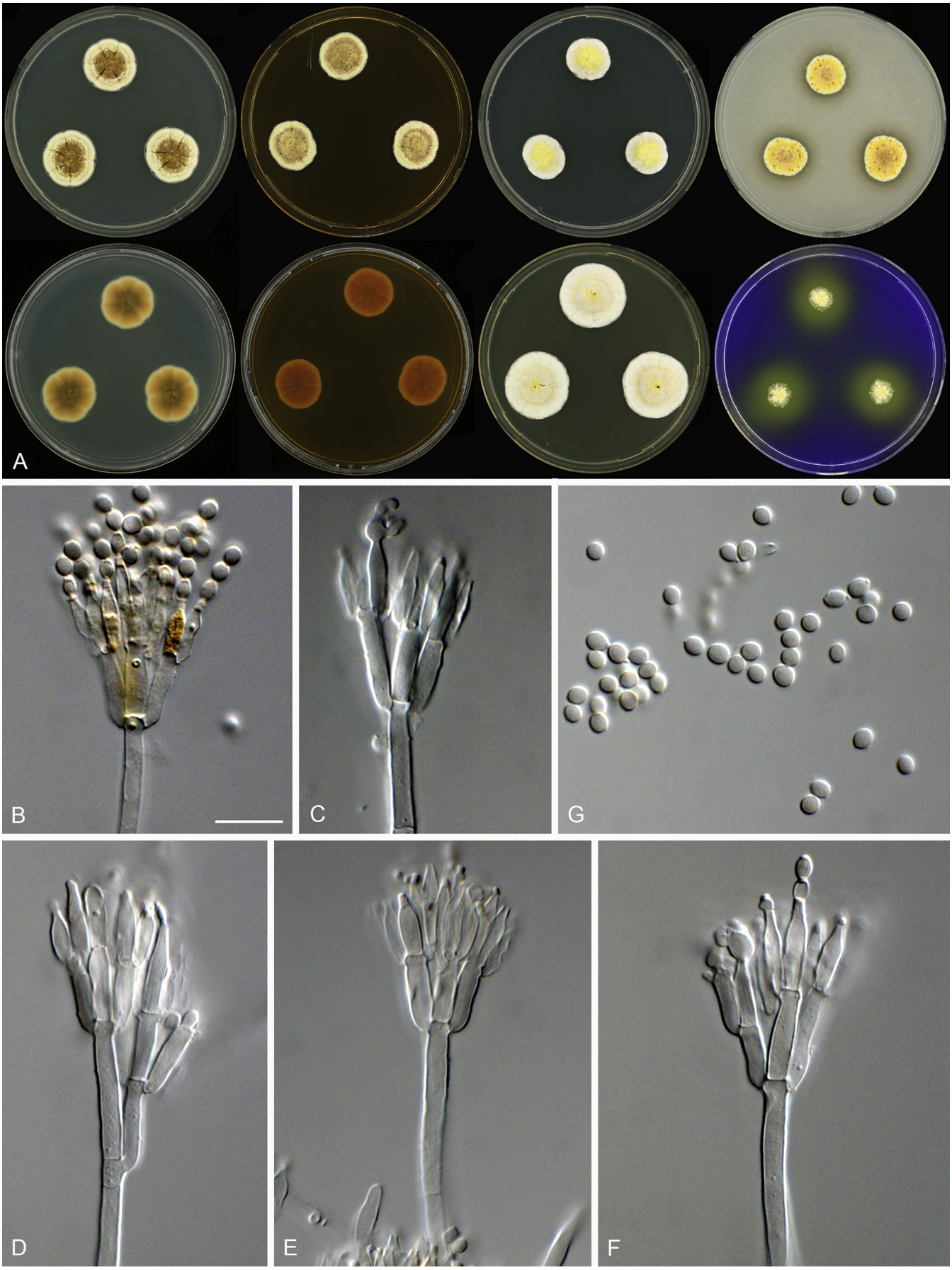

Fig. 22. Morphological characters of *Talaromyces brunneus* (CBS 227.60^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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 mitorubrinol 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 producton 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 other *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, sulcate, young synnemata produced; margins low, plane, entire (<1 mm); mycelia white and pastel yellow; texture funiculose and floccose; sporulation moderately dense, conidia *en 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, sulcate, synnemata at centre sporulate, and young synnemata at margins; margins low, plane, entire (3 mm); mycelia white; texture synnematous, loosely funiculose to floccose; sporulation sparse to moderately dense, conidia *en masse* dark green (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, sulcate, young synnemata formation; margins low, plane, entire (2 mm); mycelia white and yellow; texture funiculose; sporulation moderately dense, conidia *en 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, sulcate; margins low, plane, entire (<1 mm); mycelia white; texture velvety; sporulation dense, conidia *en masse* greyish green (26E5–27E5); 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 6 000 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 cecidicola (Seifert, Hoekstra & Frisvad) Samson *et al.*, Stud. Mycol. 71: 175. 2011. MycoBank MB560646. Fig. 24.

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

In: *Talaromyces* section *Purpurei*

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

ITS barcode: AY787844 (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 floccose and strongly funiculose; sporulation moderately dense, conidia *en 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 funiculose 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 dark brown (7F8–8F8). YES 25 °C, 7 d: Colonies low, centrally raised surrounded by sunken in ridge; margins low, wide, entire (3 mm); mycelia white; texture funiculose, with some floccose areas; sporulation moderately dense, conidia *en masse* greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent; reverse very dark red at

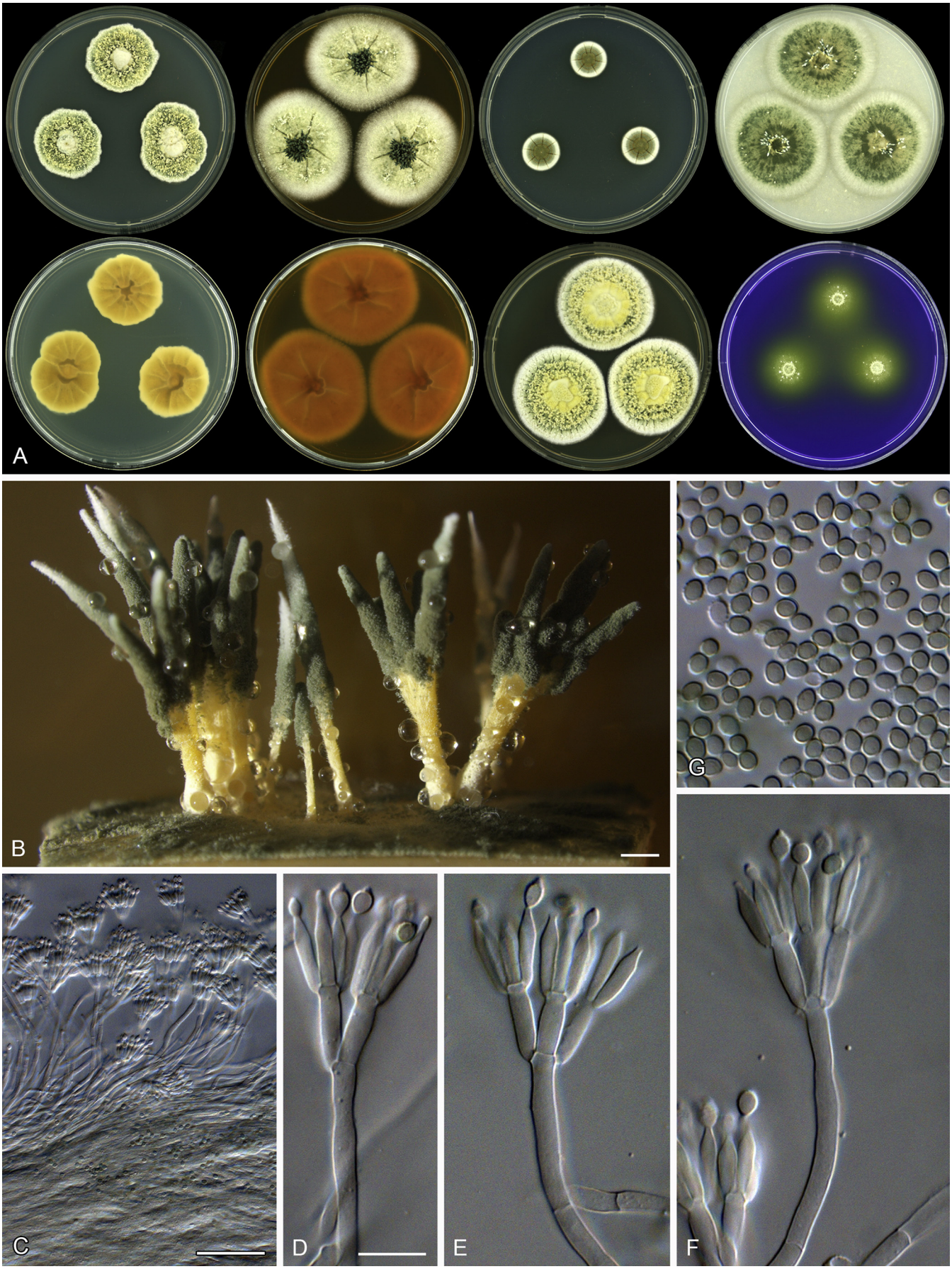

Fig. 23. Morphological characters of *Talaromyces calidicanius* (CBS 112002^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 1000 µm; C = 50 µm; D = 10 µm, applies to E–G.

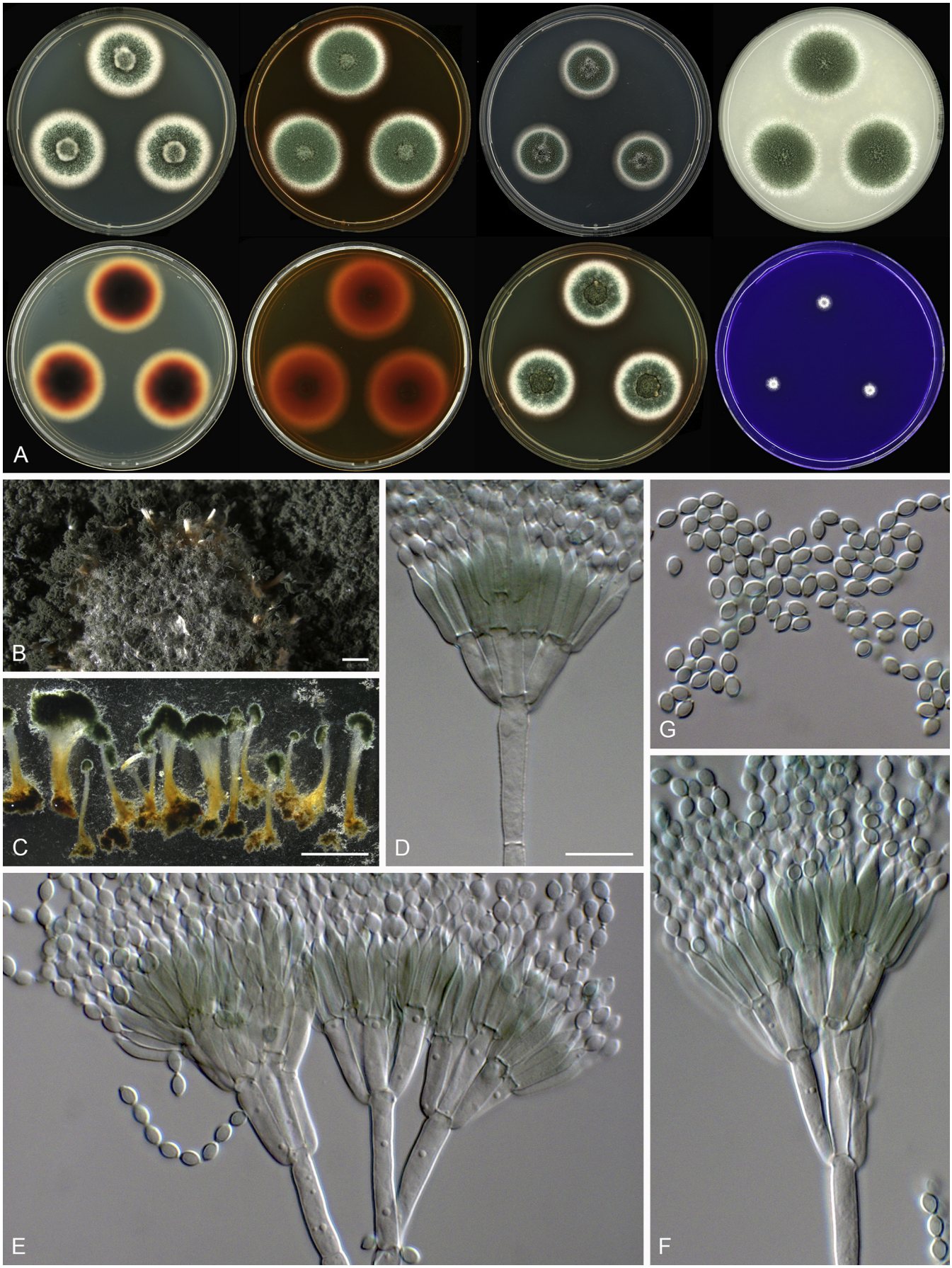

Fig. 24. Morphological characters of *Talaromyces cecidicola* (CBS 101419^T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C. Synnemata. D–F. Conidiophores. G. Conidia. 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 funiculose; 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 funiculose, 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 subterminal 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. Ascomata not observed.

Distinguishing characters: *Talaromyces cecidicola* is characterised by colonies with dark red reverses and synnemata up to 1 250 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 funiculose (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 funiculose; 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 funiculose; 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 subterminal 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. Ascomata not observed.

Distinguishing characters: *Talaromyces chloroloma* grows rapidly on most media and produces synnemata after 2–3 wk, up to 1 250 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. choloroloma* from *T. ramulosus*.

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 2673.

ITS barcode: JN899376 (alternative markers: *BenA* = AY753377; *CaM* = KJ885256; *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 immatured.

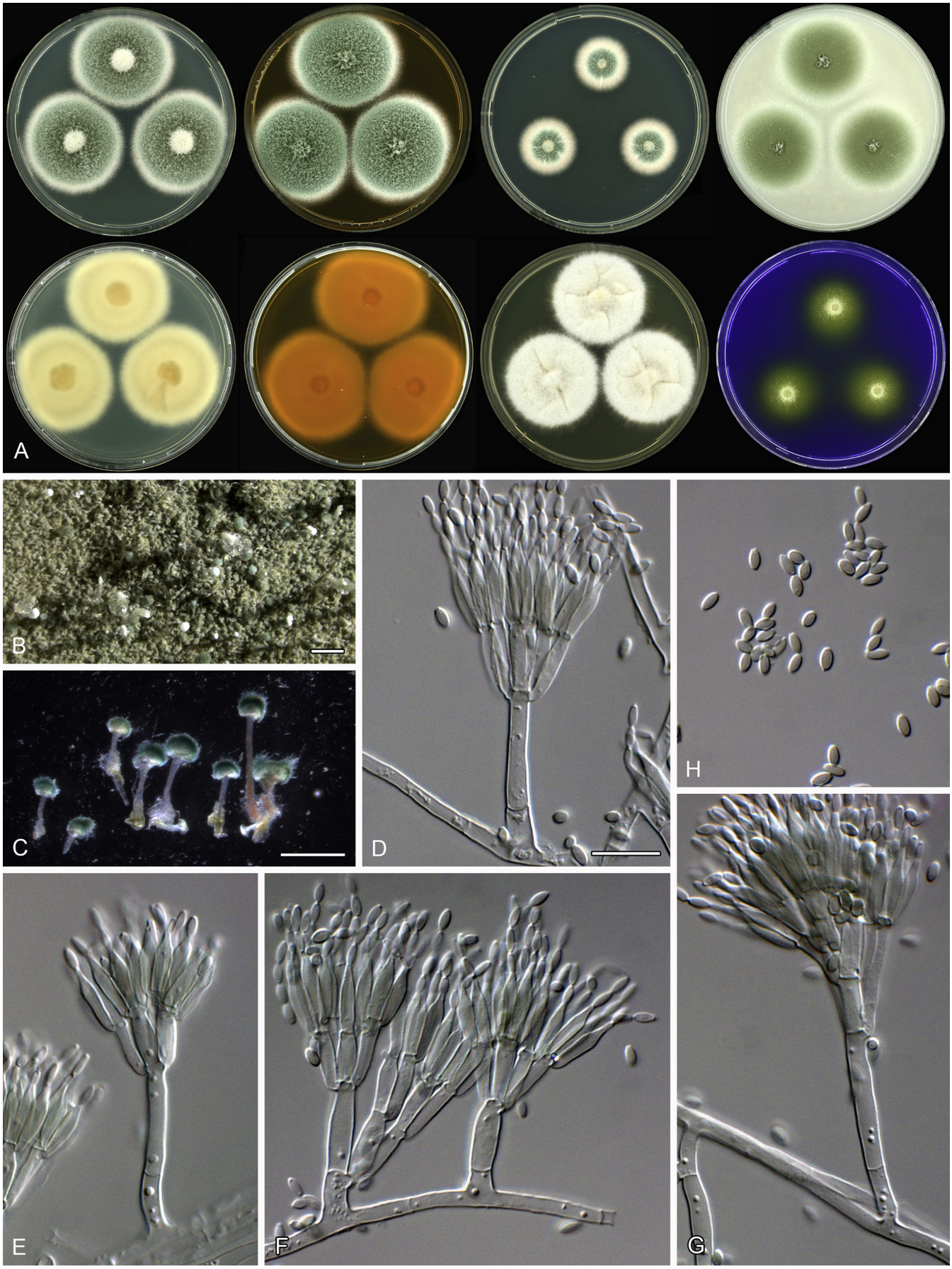

Fig. 25. Morphological characters of *Talaromyces chloroloma* (DAOM 241016^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. 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; asci 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 asci, 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) neotypified the species with CBS 267.72. However, this strain produced a *Paecilomyces* anamorph, which was described by Jong & Davis (1975) as *Paecilomyces cinnabarinus*, whereas Zukal's original description and illustrations clearly describes the structures of a *Chrysosporium* anamorph (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 results 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. *macrosporus* 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 cnidii 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-I2) 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 acerose, 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 cnidii* 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 cnidii* 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*

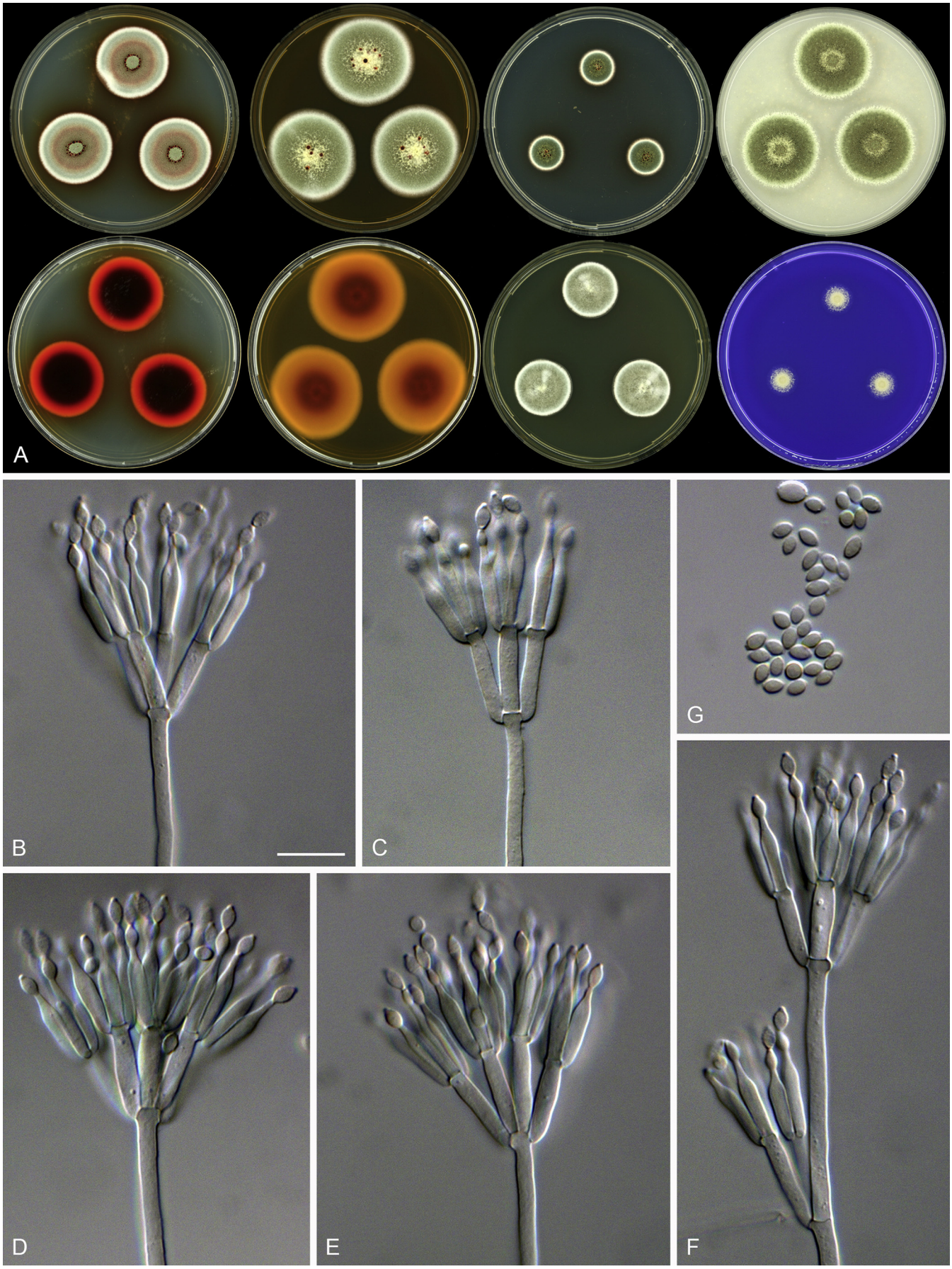

Fig. 26. Morphological characters of *Talaromyces cnidii* (KACC 46617^T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

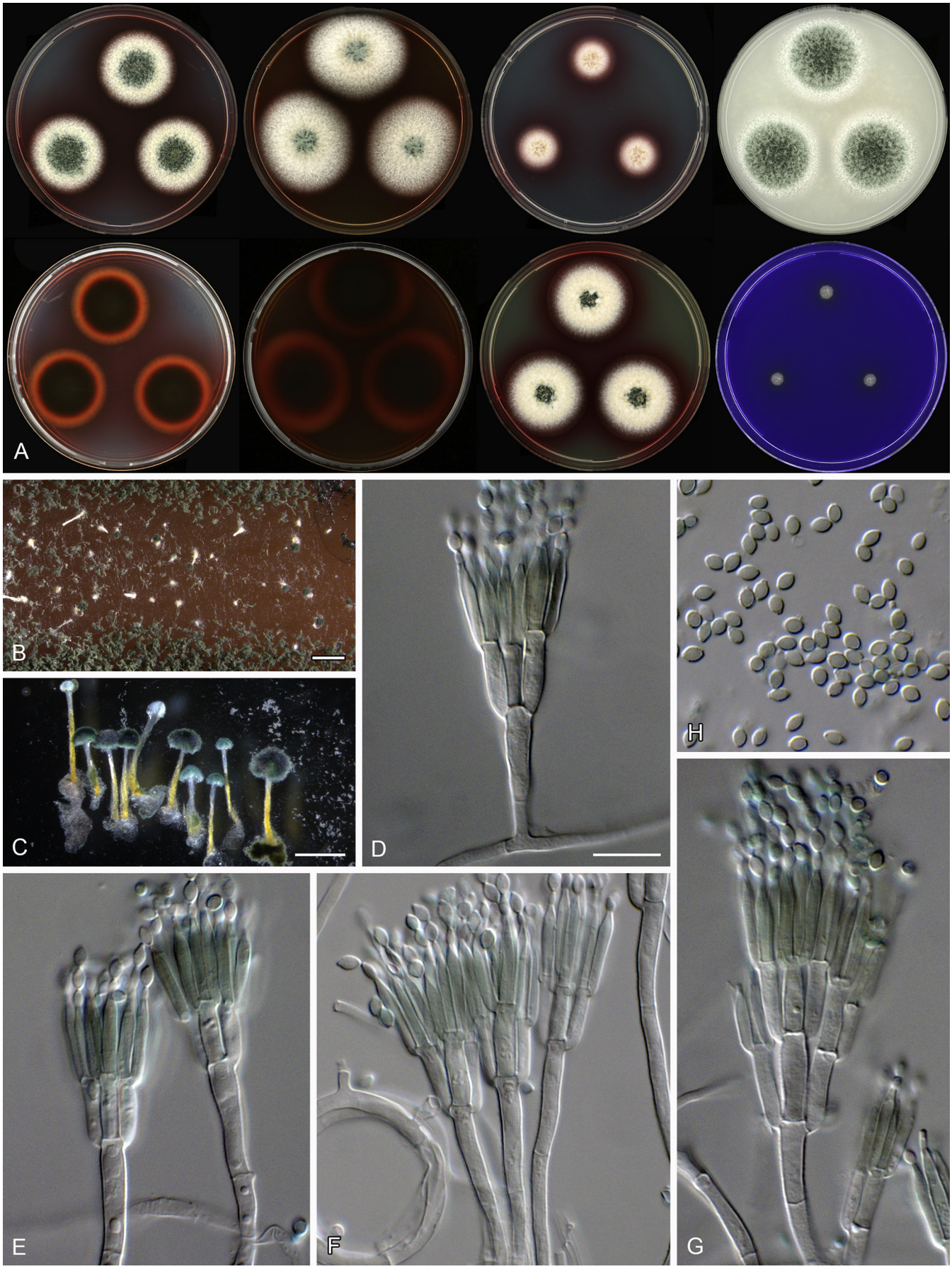

Fig. 27. Morphological characters of *Talaromyces coalescens* (CBS 103.83^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 µm; D = 10 µm, applies to E–H.

Typus: CBS 103.83, culture ex-type CBS 103.83.

ITS barcode: JN899366 (alternative markers: *BenA* = JX091390; *CaM* = KJ885267; *RPB2* = KM023277)

Colony 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.

Colony 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 funiculose; 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 funiculose; 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 funiculose, 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 funiculose; 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 funiculose, 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 acerose, 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.

Extrolites: *Talaromyces coalescens* produces (−) botryodiploidin and related compounds (Cabedo *et al.* 2007). Botryodiploidin 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 glauconic acid.

Distinguishing characters: *Talaromyces coalescens* produces colonies with dark red reverses with abundant red soluble pigment (Fig. 27). Synnemata, up to 1 200 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*

Typus: BPI 892668, culture ex-typus NRRL 58811.

ITS barcode: KJ865739 (alternative markers: *BenA* = KF196843; *CaM* = KJ885288; *RPB2* = KM023270)

Colony 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.

Colony 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 acerose, three to six per metulae, 7–12 × 1.5–2.2 µm; conidia smooth, ellipsoidal, 2.5–3.5 × 3–4.5 µm.

Extrolites: *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 convolutus Udawaga, Mycotaxon 48: 141. 1993. MycoBank MB360474. Fig. 29.

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

In: *Talaromyces* section *Trachyspermi*

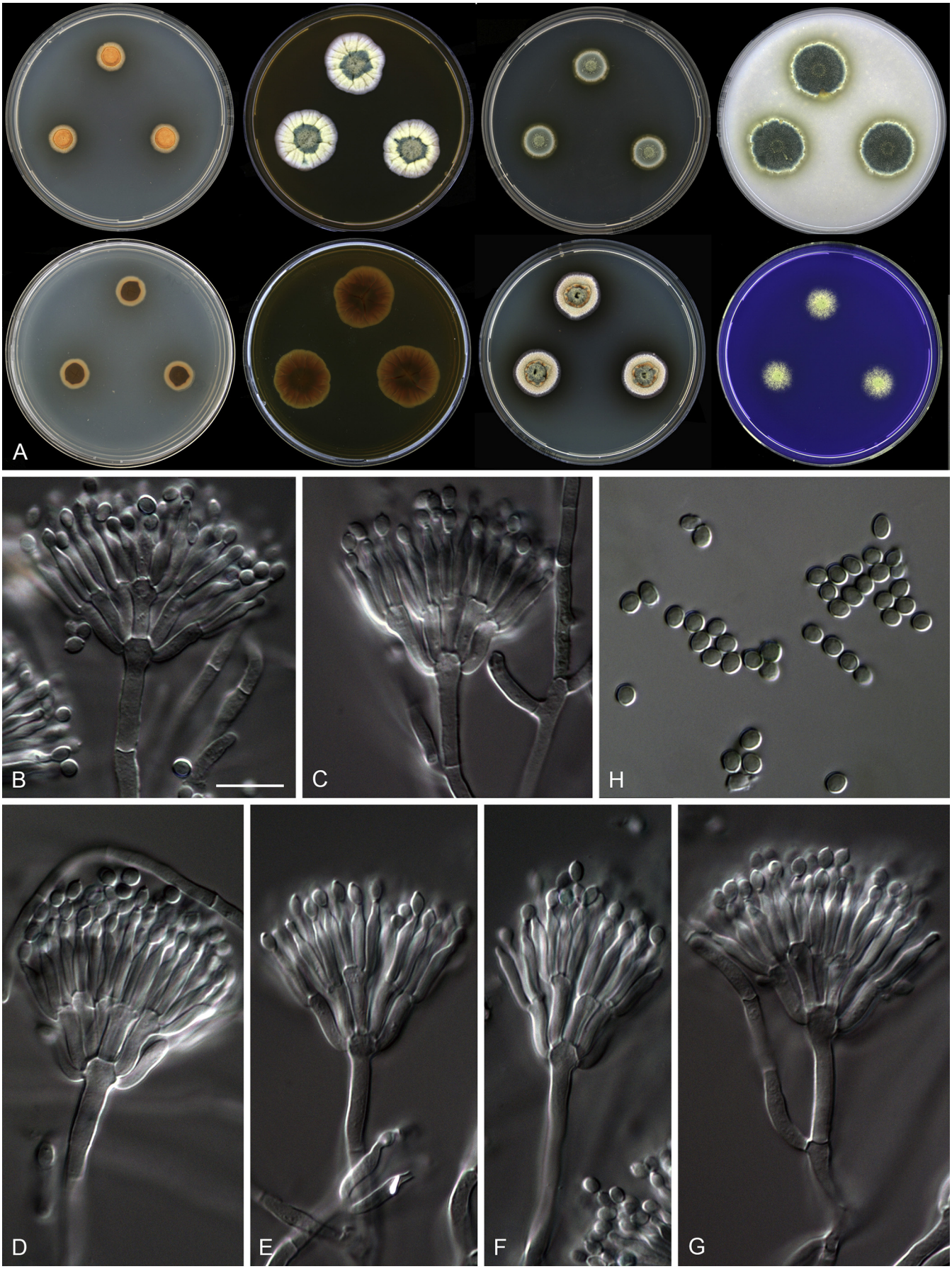

Fig. 28. Morphological characters of *Talaromyces columbinus* (CBS 137393). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

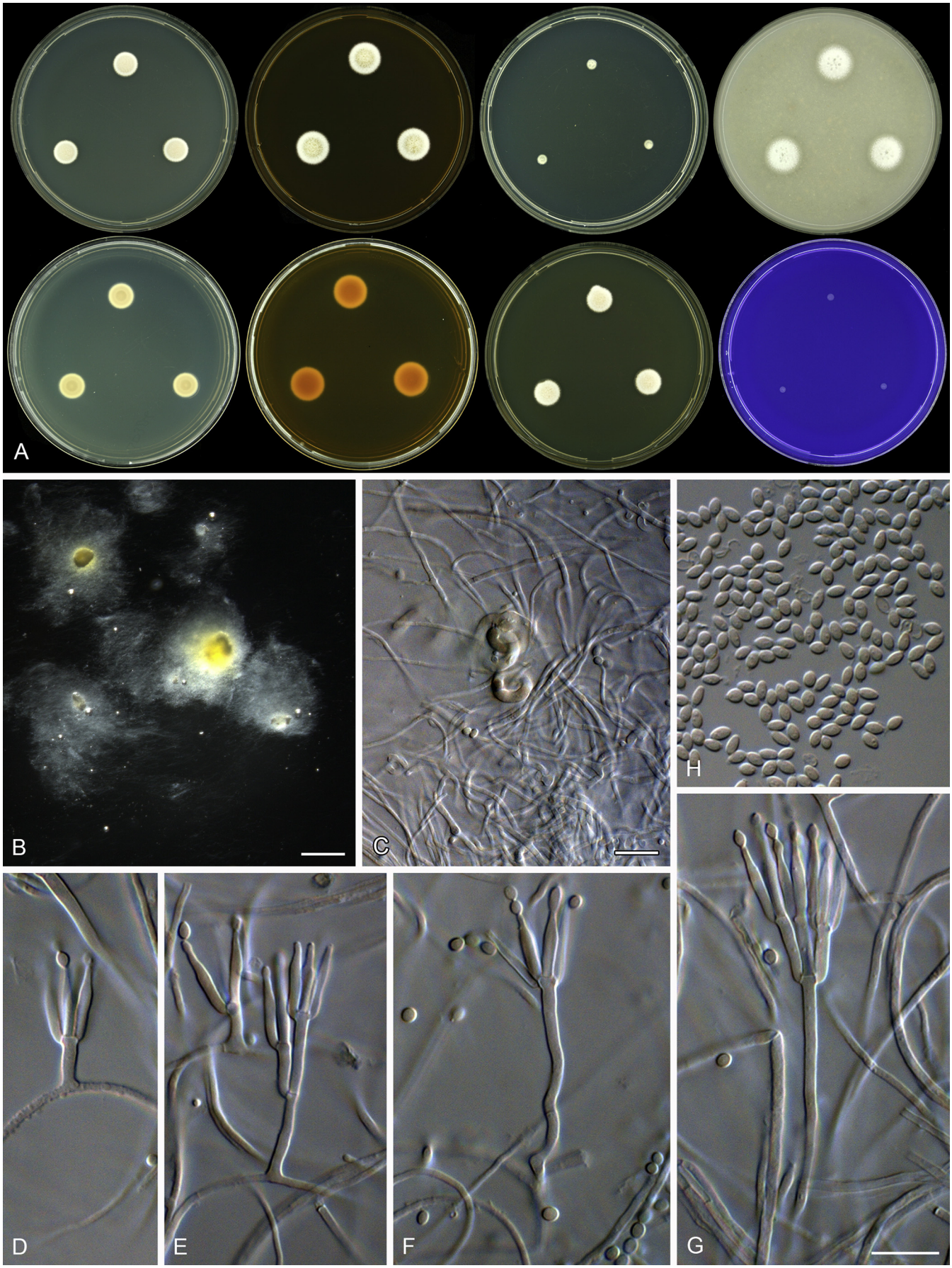

Fig. 29. Morphological characters of *Talaromyces convolutus* (CBS 100537^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Ascomata from OA after 3 wk incubation. C. Initials. D–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C = 10 µm; D = 10 µm, applies to E–H.

ITS barcode: JN899330 (alternative markers: *BenA* = KF114773; *RPB2* = JN121414)

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; sporulation absent; soluble pigments absent; exudates absent (at 37 °C clear droplets); 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; sporulation absent; soluble pigments absent; exudates clear droplets (at 30 °C bigger yellow droplets); reverse brownish orange (5B6). YES 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, white sterile appearance; margins low, plane, entire (1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange (5A3). DG18 25 °C, 7 d: Colonies low, plane, slimy yeast like colony appearance; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent; 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; sporulation absent; soluble pigments absent; exudates clear droplets; reverse beige. 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 convolutus* produces talaroconvolution A-D and ZG-1494α (Suzuki *et al.* 2000) and (−)-mitorubrinal, (−)-mitorubrinic acid and anhydroflavomannin-9,10-quinone-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 *Trachyspermi*. 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.

Talaromyces dendriticus (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; *RPB2* = KM023286)

Colony diam, 7 d (mm): CYA 23–26; CYA 30 °C 15–16; CYA 37 °C 5–6; MEA 35–36; MEA 30 °C 20; DG18 12–20; CYAS No growth; OA 30–37; CREA 6–8; YES 15–27.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly radially sulcate; margins low, plane, entire (2–3 mm); mycelia white and yellow; texture velvety and loosely funiculose; sporulation moderately dense in the centre, conidia *en masse* greyish green to dark green (27E4–27F4); soluble pigments absent; exudates absent; reverse centre dark brown (6F6), fading into light brown (6D6) and light yellow (2A5). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia yellow and white; texture loosely funiculose (colonies dominated with young yellow synnemata without sporulation); sporulation sparse to moderately dense (in the centre), conidia *en masse* greyish green to dark green (27E4–27F4); soluble pigments absent; exudates absent; reverse centre dark brown (8F6) fading into reddish brown (8D5–8E5) and brownish orange (5C5–5C6). YES 25 °C, 7 d: Colonies slightly raised at centre, slightly radially sulcate; margins low, plane, entire (2–3 mm); mycelia white and yellow; texture velvety and loosely funiculose; sporulation moderately dense, conidia *en masse* greyish green to dark green (27E4–27F4); soluble pigments absent; exudates absent; reverse centre dark brown (6F6), fading into light brown (6D6) and light yellow (2A5). DG18 25 °C, 7 d: Colonies slightly raised in the centre, slightly radially sulcate; margins low, plane, entire (3–4 mm); mycelia white and pale yellow; texture velvety; sporulation sparse to moderately dense in the centre, conidia *en masse* dark green (26F5–26F6); soluble pigments absent; exudates absent; reverse centre dark green (28F3), fading into pale yellowish white (2A2) to beige. OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire; mycelia white and yellow; texture velvety (colonies dominated with young yellow synnemata without sporulation); sporulation sparse to moderately dense in the centre, conidia *en masse* dark green (26F5–26F6); soluble pigments absent; exudates absent; reverse light brown centre, fading into light yellow. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Synnemata up to 5 000 µm long after 2 wk. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 20–200 × 2.5–4 µm; branches 12–20 µm; metulae four to six, divergent, 9.5–16 × 2–3.5 µm; phialides acerose, three to eight per metulae, 9.5–14 × 2–2.5 µm; conidia smooth, subglobose to ellipsoidal, 2.5–3.5 × 2–2.5 µm. Ascomata not observed.

Extrolites: *Talaromyces dendriticus* produces mitorubrinic acid, secalonic acid D (Samson *et al.* 1989) in addition to a purpactin and nonadrides related to glauconic acid.

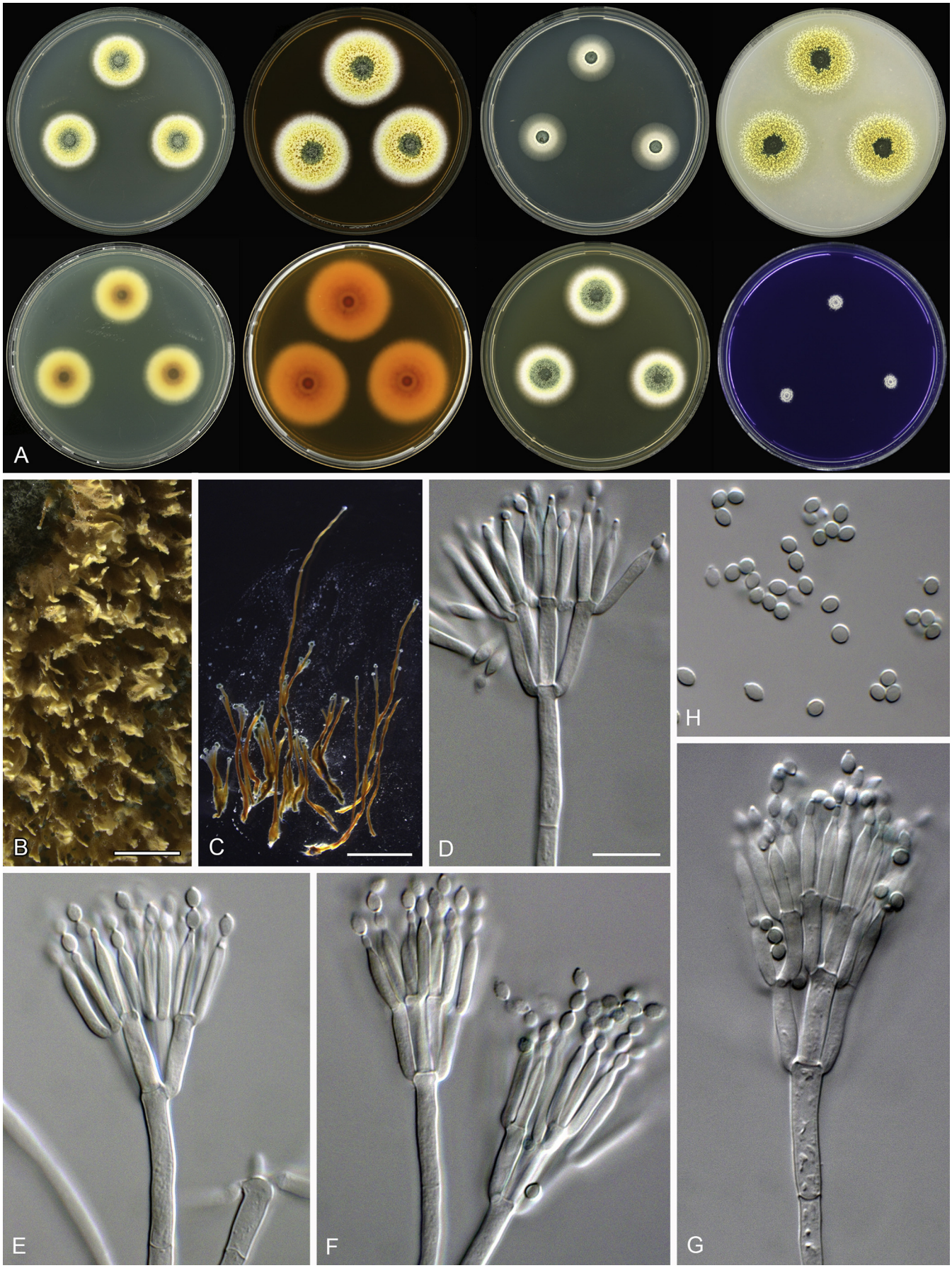

Fig. 30. Morphological characters of *Talaromyces dendriticus* (DTO 183-G3). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 2000 µm; D = 10 µm, applies to E–H.

Distinguishing characters: *Talaromyces dendriticus* is recognised by colonies producing synnemata up 5 000 µm long after 1–2 wk of incubation. This species seems to be associated with *Eucalyptus*. *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* Takata & 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 (25B3–26B3); 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 (25B3–26B3); 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 moderately dense, conidia *en masse* greyish green (25C5–25D5); soluble pigments absent; exudates absent; reverse in some isolates (CBS 412.89^{T}) centre 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.

Micromorphology: Conidiophores biverticillate and monoverticillate; stipes smooth walled, (15–)30–60(–125) × 2.5–3.5 µm; metulae two to five, divergent, 10–20(–30) × 2–4 µm; phialides acerose, three to six per metulae, 10–20(–25) × 2–3.5 µm; conidia smooth, cylindrical to ellipsoidal and sometimes curved and fusiform, 4–8 × 1.5–3 µm. Ascomata not observed in our culture but *fide* Takada & Udagawa (1993) heterothallic. Superficial, maturing within 1–2 wk at 37 °C, greyish green to dark bluish green, globose to subglobose, asci 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-typus CBS 320.48 = ATCC 10437 = DSM 2212 = IMI 040579 = IMI 040579ii = NRRL 2121.

ITS barcode: KJ865740 (alternative markers: *BenA* = KJ865723; *CaM* = KJ885268; *RPB2* = KM023285)

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 blond 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

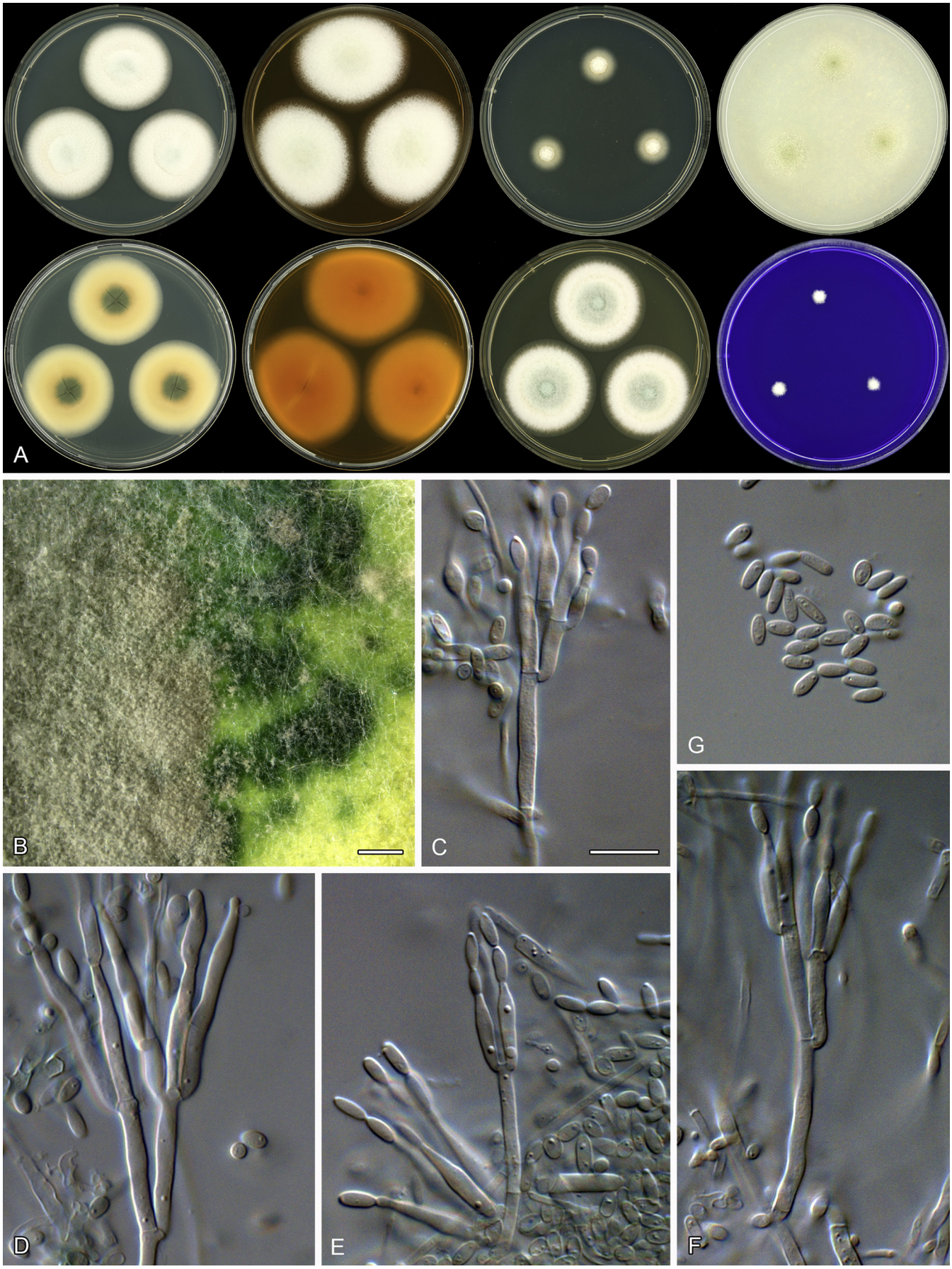

Fig. 31. Morphological characters of *Talaromyces derxii* (CBS 412.89^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. b. Colony texture of on OA after 2 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 µm; C = 10 µm, applies to D–G.

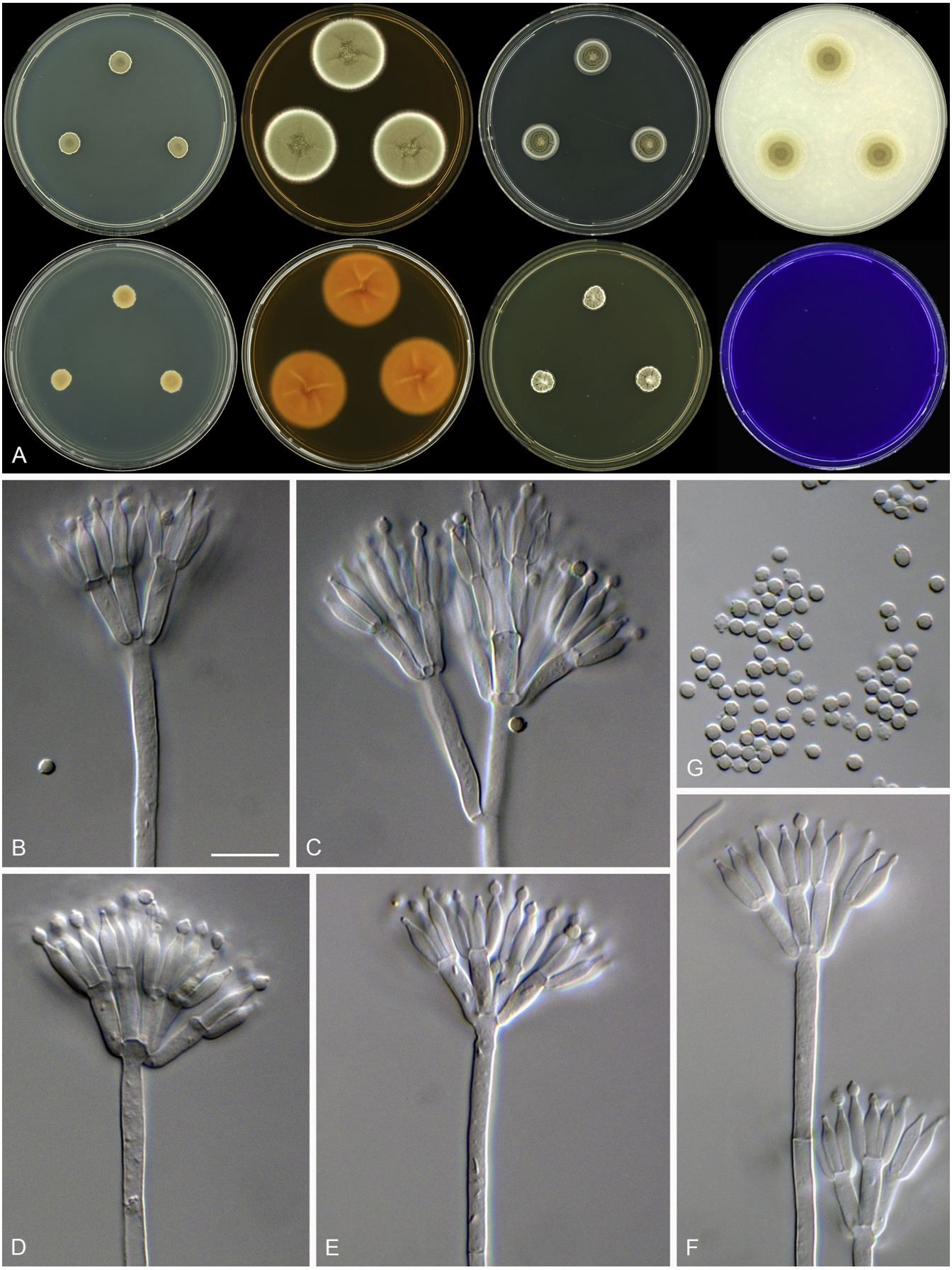

Fig. 32. Morphological characters of *Talaromyces diversus* (CBS 320.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

(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 acerose, 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.

Extrolites: *Talaromyces diversus* have been reported to produce diversonol, α- and β-diversonol esters, isoaustin, austinol, alternariol monomethyl ether and lichexanthone (Turner 1978, Simpson *et al.* 1982, Holker *et al.* 1983). We have detected the alternariol monomethyl ether, diversonol, austins and mitorubrinic 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. erythromellis* and *T. primulinus*, 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, synnematous; sporulation absent to sparse, conidia *en masse* difficult to determine; soluble pigments yellow; exudates absent; reverse olive brown (4E8) 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 (25B5–25C5); 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 synnemateus; 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 × 3–4(–5.5) µm; metulae two to six, divergent, 8.5–15 × 2.5–5 µm; phialides acerose, 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.

Extrolites: *Talaromyces duclauxii* produces duclauxin, xenoglaucin and crypptoclauxin and related compounds (Shibata *et al.* 1965, Ogihara *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 5 000 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 (5B5–5C5). 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;

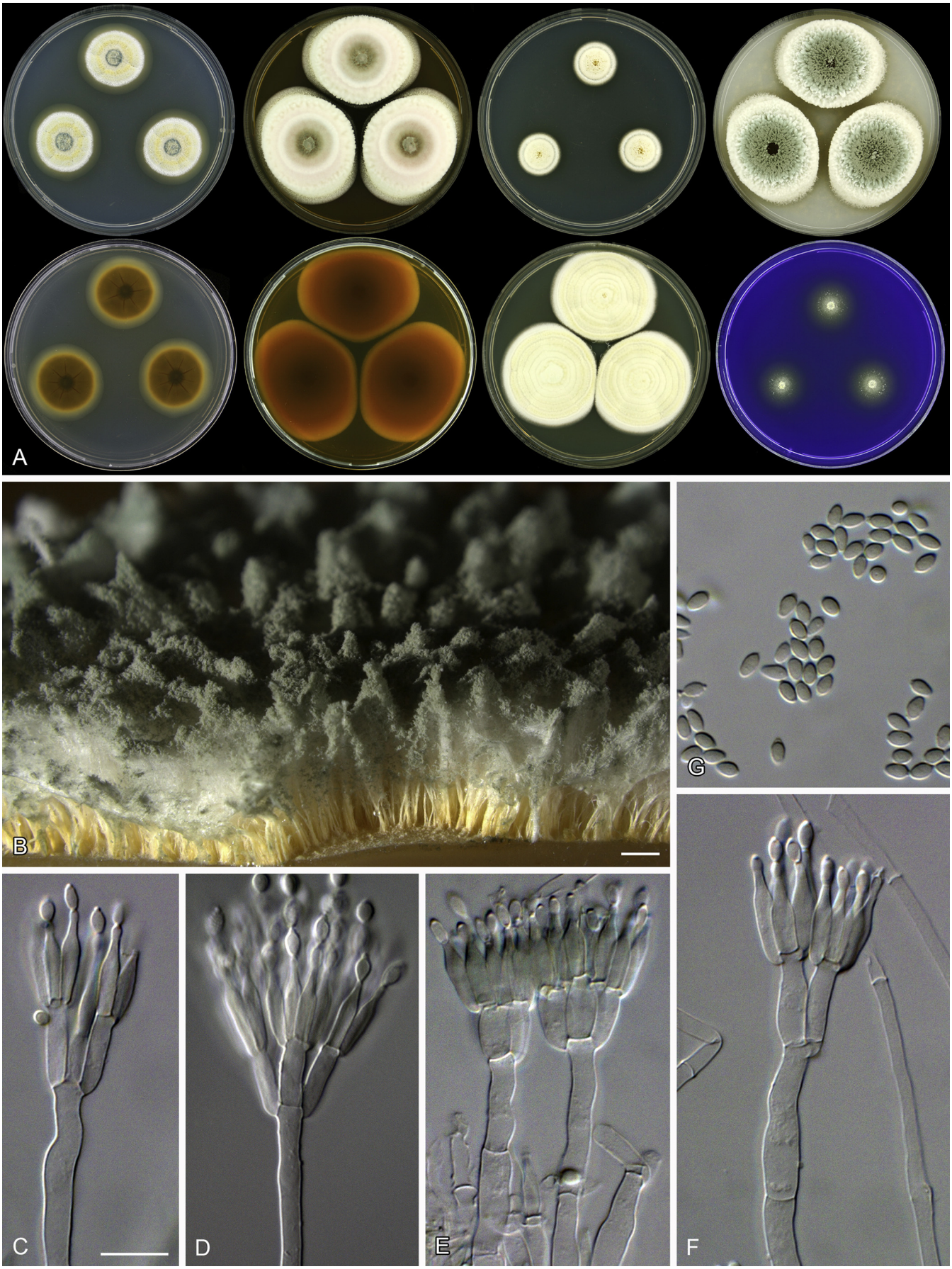

Fig. 33. Morphological characters of *Talaromyces duclauxii* (CBS 322.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 1000 µm; C = 10 µm, applies to D–G.

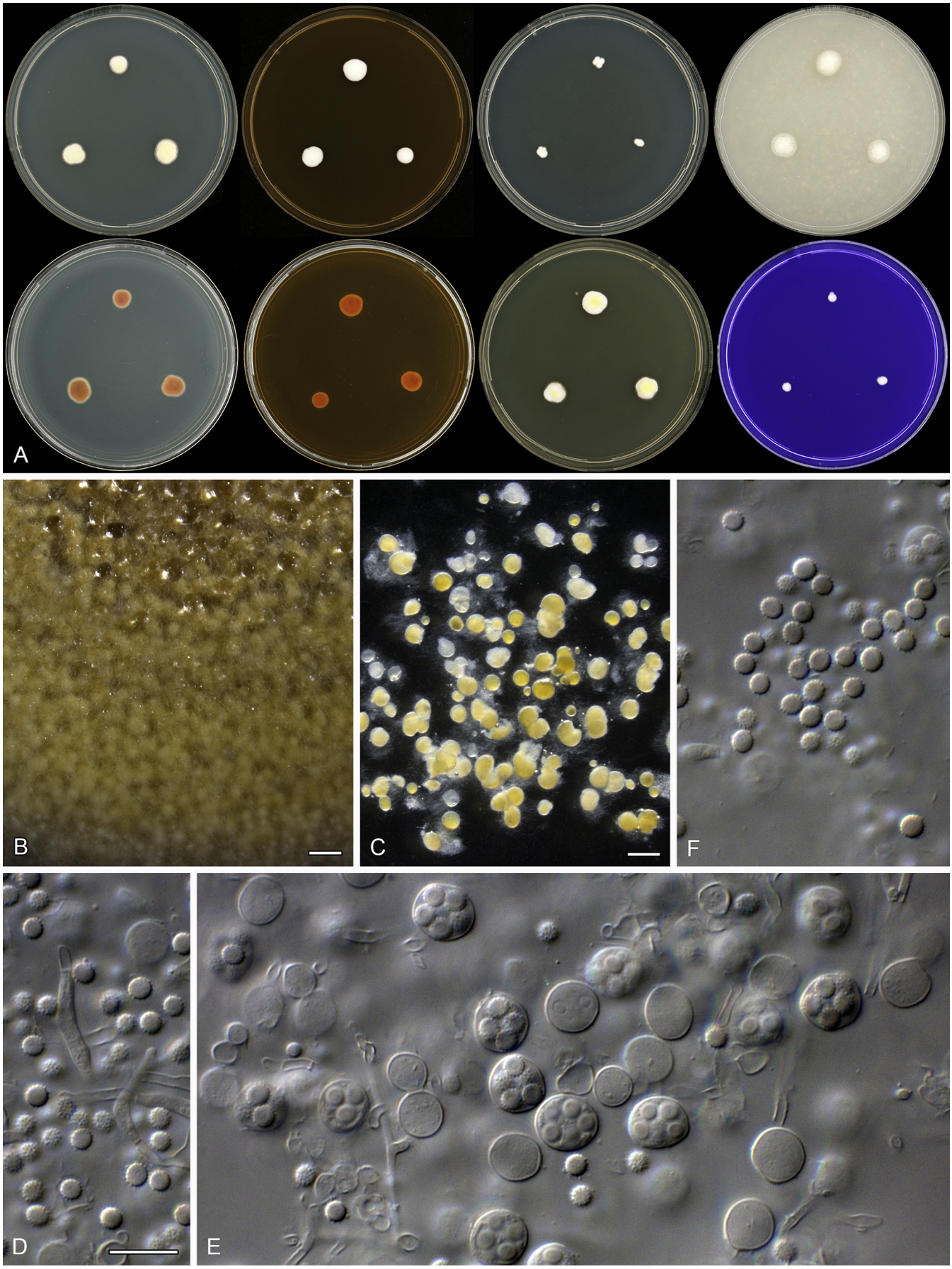

Fig. 34. Morphological characters of *Talaromyces emodensis* (CBS 100536^T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D–E. Asci and ascospores F. Ascospores. 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 × 1.5–3 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 8–11 × 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 medium, 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 ascopsores. The typical characters of *T. emodensis* distinguish it from other species that produce globose to subglobose, spiny ascospores such as *T. bacillisporus* and *T. rotundus*. The asexual state was not observed in our study.

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

≡ *Penicillium erythromellis* A.D. Hocking, The genus *Penicillium*: 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, sulcate; margins low, plane, entire (<1 mm); mycelia white; texture loosely funiculose; 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, sulcate, 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 symmetrical 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, 2–3.5 × 1.5–2.5 µm. Ascomata not observed.

Extrolites: *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.

≡ *Penicillium 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* = KJ865733; *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, sulcate, 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 sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture loosely funiculose 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 (9B7) dots. YES 25 °C, 7 d: Colonies raised at centre, sulcate; 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

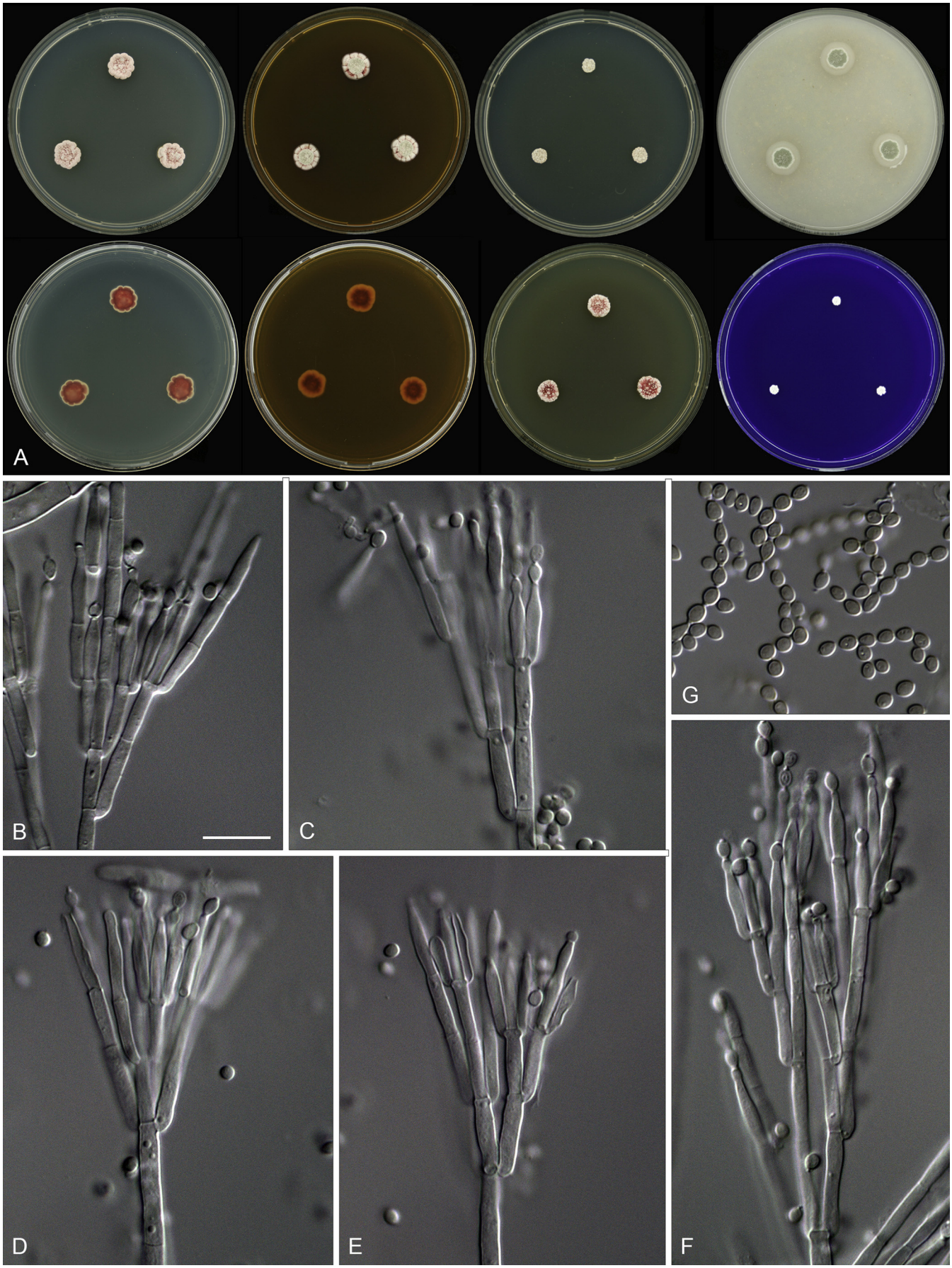

Fig. 35. Morphological characters of *Talaromyces erythromellis* (CBS 644.80^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

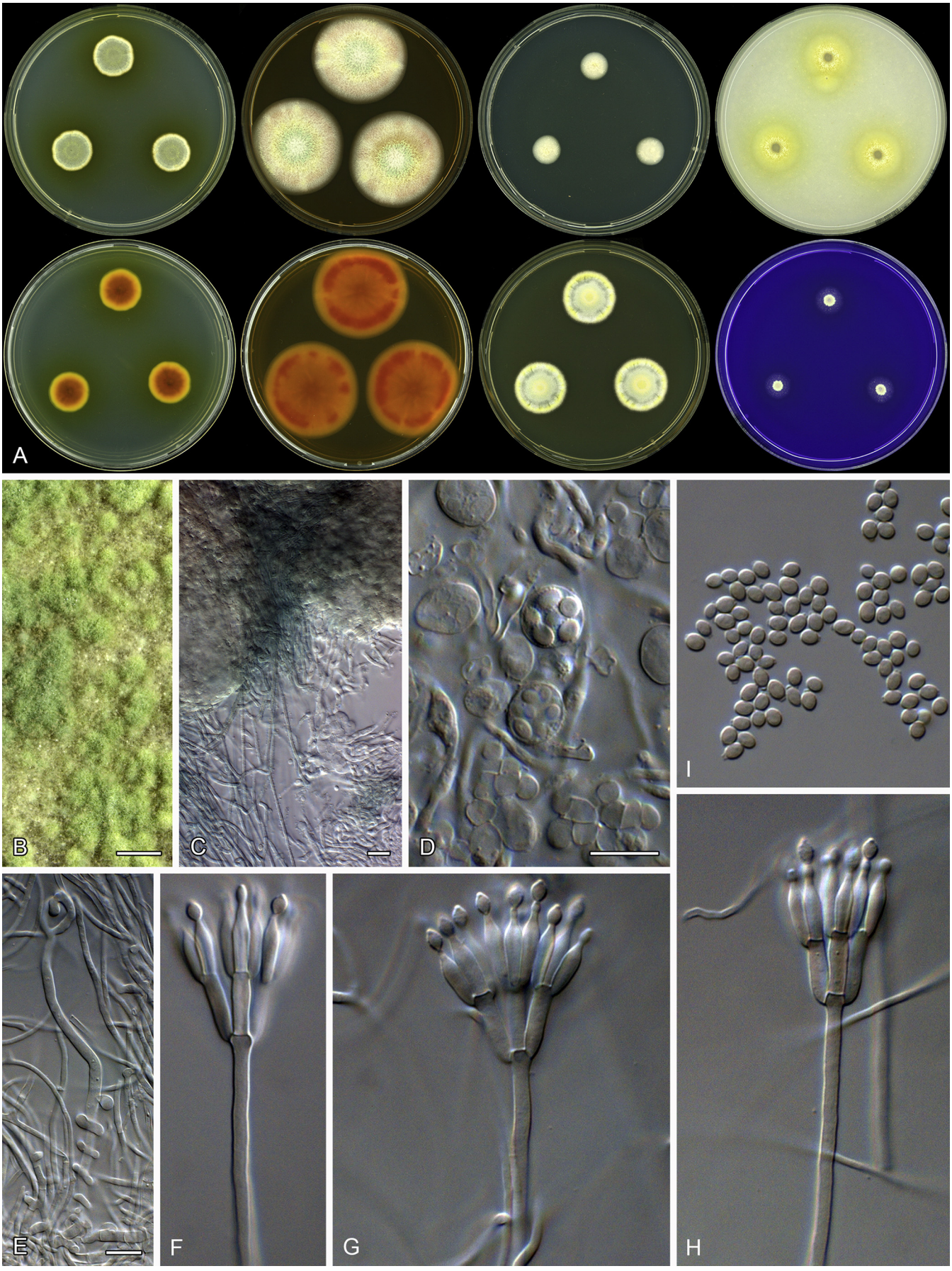

Fig. 36. Morphological characters of *Talaromyces euchlorocarpius* (PF 1203^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on Hay infusion agar after 1 wk incubation. C. Ascomata. D. Asci and ascospores. E. Initials. F–H. Conidiophores. I. Conidia. Scale bars: B = 500 µm; C = 10 µm; E = 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 ellipsoidal, 2–4 × 2–3 µm. Ascomata 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 ellipsoidal, spiny, 3.5–5 × 2.5–3 µm.

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

Talaromyces flavovirens (Durieu & Mont.) Visagie, Llimona & Seifert, Mycotaxon 122: 404. 2012. MycoBank MB800438. Fig. 37.

≡ *Lasioderma flavovirens* 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* greyish turquoise (24D4–25D4); soluble pigments yellow; exudates absent; reverse brown (7E6) centre fading into greyish yellow (2B6). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; texture velvety after 2 wk of incubation covered with yellow mycelia layer; sporulation dense, conidia *en masse* dull green (26D3–27D3); 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 velvety; sporulation dense, conidia *en masse* dull green (26D4–26E4); soluble pigments absent; exudates absent; reverse dark brown (6F6) centre fading into brownish yellow (5C7) and mustard yellow (3B6) and greyish green (1C5). DG18 25 °C, 7 d: Colonies sunken at centre, low, 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, ellipsoidal, 2.5–3.5(–5.5) × 2–2.5(–4) µm. Ascomata production was reported by Visagie *et al.* (2012) from burned *Quercus suber* leaf litter. Ascomata golden yellow with a reddish pigment, only produced on *Quercus suber* leaf litter in nature, globose to subglobose, 150–380 µm, asci absent, ascospores ellipsoidal, thick walled, spiny, (4–)4.5–6(–7) × 3–4 µm.

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

Distinguishing characters: *Talaromyces flavovirens* produces yellow ascomata with spiny, ellipsoidal ascospores on *Quercus suber* and rarely on *Q. ilex* and *Cistus salviifolius* leaf litter and all cultures originate from Catalonia, Spain. No ascomata 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. flavovirens*, 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. Benj., 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 = NRRL 2098.

ITS barcode: JN899360 (alternative markers: *BenA* = JX494302; *CaM* = KF741949; *RPB2* = J417426)

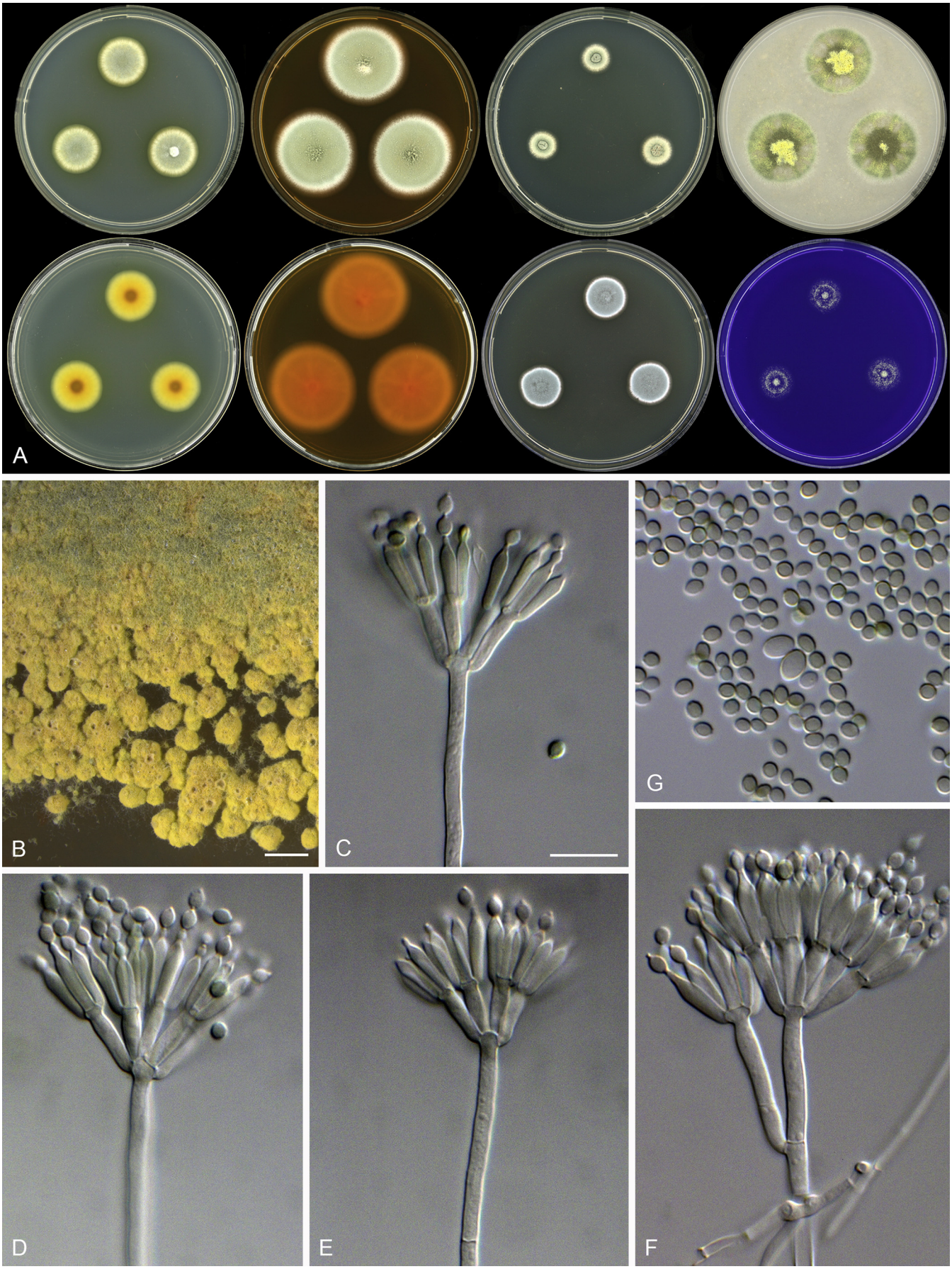

Fig. 37. Morphological characters of *Talaromyces flavovirens* (CBS 1102801^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 3 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 µm; C = 10 µm, applies to D–G.

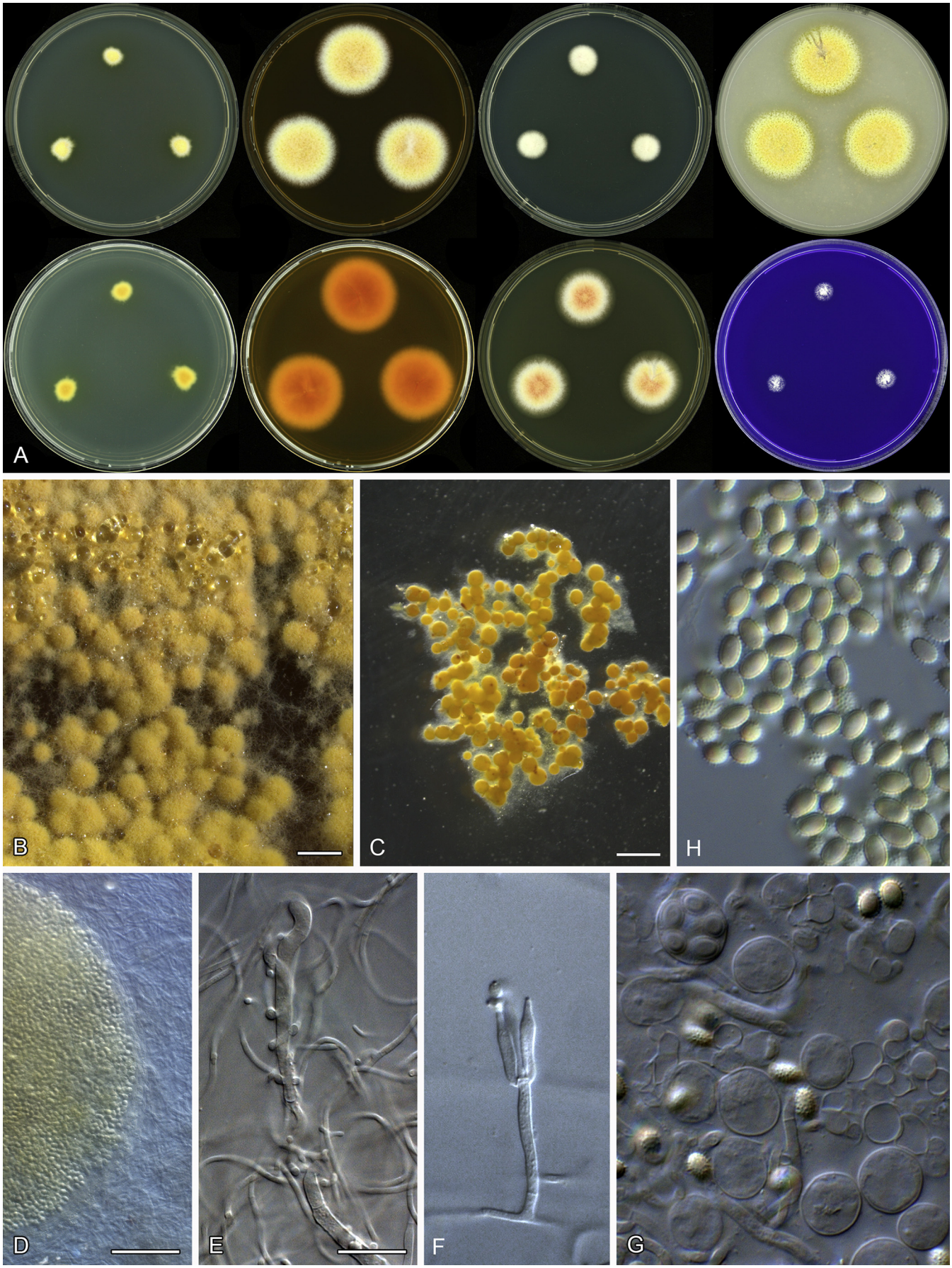

Fig. 38. Morphological characters of *Talaromyces flavus* (CBS 310.38^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Ascomata and asci. E. initials. F. 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 (5B6–6B6). 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 monoverticillate; stipes smooth walled, 15–20 × 1.9–20 µm; phialides acerose, 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.

Extrolites: *Talaromyces flavus* produces 3-hydroxymethyl-6,8-dimethoxycoumarin, 2,5-dimethyl-7-hydroxychromone, (−)-*trans*-2,3-epoxysuccinic acid, fosfonochlorin, 2-methylsorbic acid, 4,6-dihydroxy-5-methylphthalide, funiculosic acid, hydroxyfuniculosic acid, vermistatin = fijiensin and related compounds, altenusin, dehydroaltenusin, desmethyldehydroaltenusin, talaroflavon, deoxytalaroflavon, (−)-mitorubrin, (−)-mitorubrinol, (−)-mitorubrinic acid, (−)-diazaphilonic acid, vermixocin A (= penicillide) & vermixocin B (= purpac tin A), vermilutin, vermiculine, vermiculinic acid, 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 monoverticillate 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.

≡ *Penicillium funiculosum* Thom, U.S.D.A. Bur. Animal Industr. Bull. 118: 69. 1910.

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.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, sulcate; 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 (5B5–5C5) 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, sulcate; 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 (1C4–1D4) sometimes with light orange (5A5) circle; in some isolates light orange (5A5); in some isolates dark brown (6F6) centre fading into melon yellow (5A6). OA 25 °C, 7 d: Colonies in some isolates low, in some isolates moderately deep, plane; margins low, plane, entire (2–3 mm); mycelia white; texture funiculose and in some isolates loosely funiculose to velvety; sporulation dense, conidia *en masse* greyish green to dull green

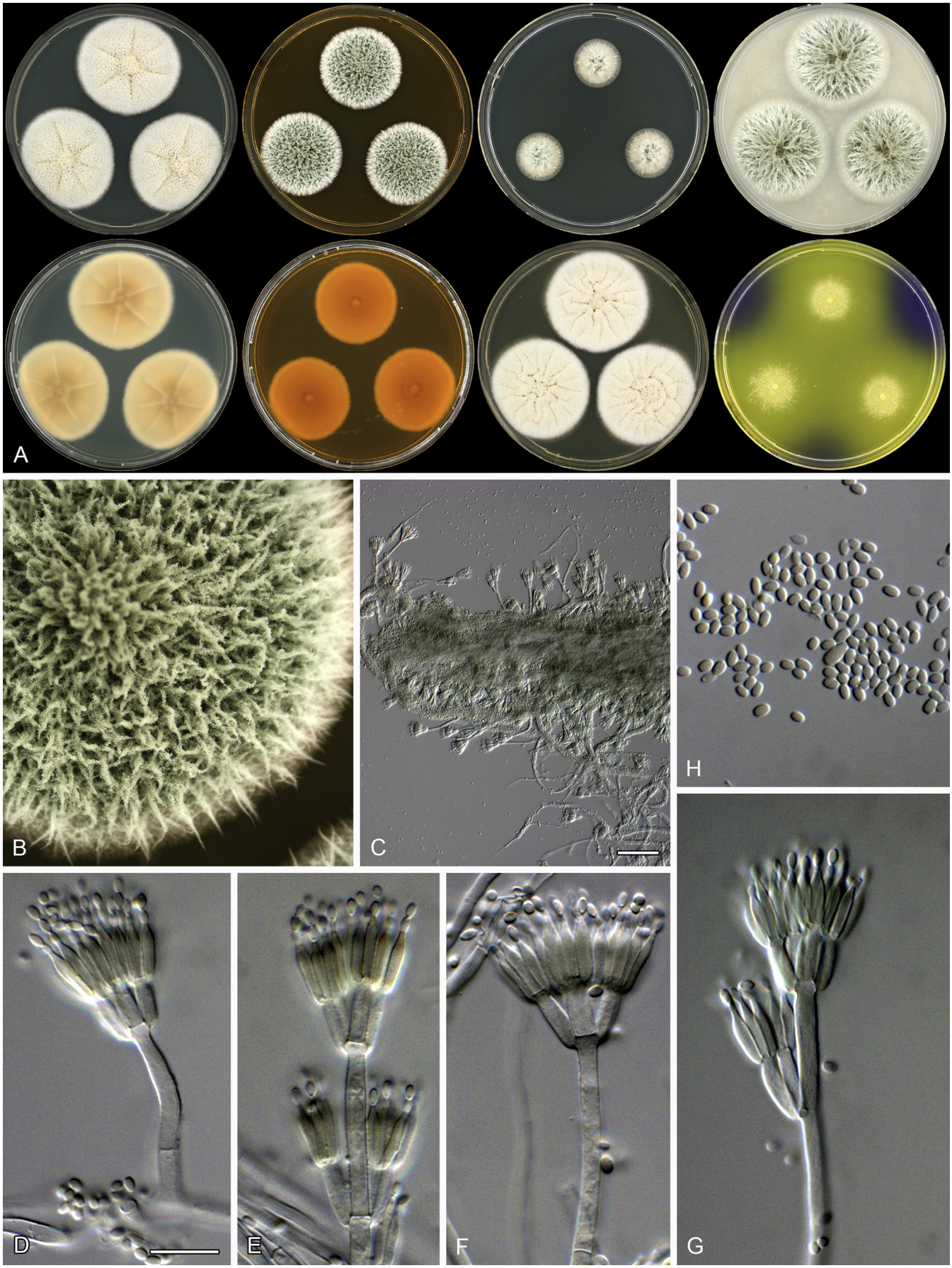

Fig. 39. Morphological characters of *Talaromyces funiculosus* (CBS 883.70). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 1 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: C = 50 µm; D = 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.

Extrolites: 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 extrolite, 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 galapagense* 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, sulcate; 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, sulcate; 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, sulcate, 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 (5C3). 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 monoverticillate; 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.

Extrolites: 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 ascomata.

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

In: *Talaromyces* section *Proteolytcius*

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, conisisting of a compact basal felt, producing abundant ascomata 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, conisisting of a thick basal felt; mycelia white to light yellow (2A5); ascomata 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 sulcate, more or less zonate, consisting of a thin basal felt with funiculose aerial hyphae, granular due to abundant production of ascomata 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. Ascomata 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 sinous 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

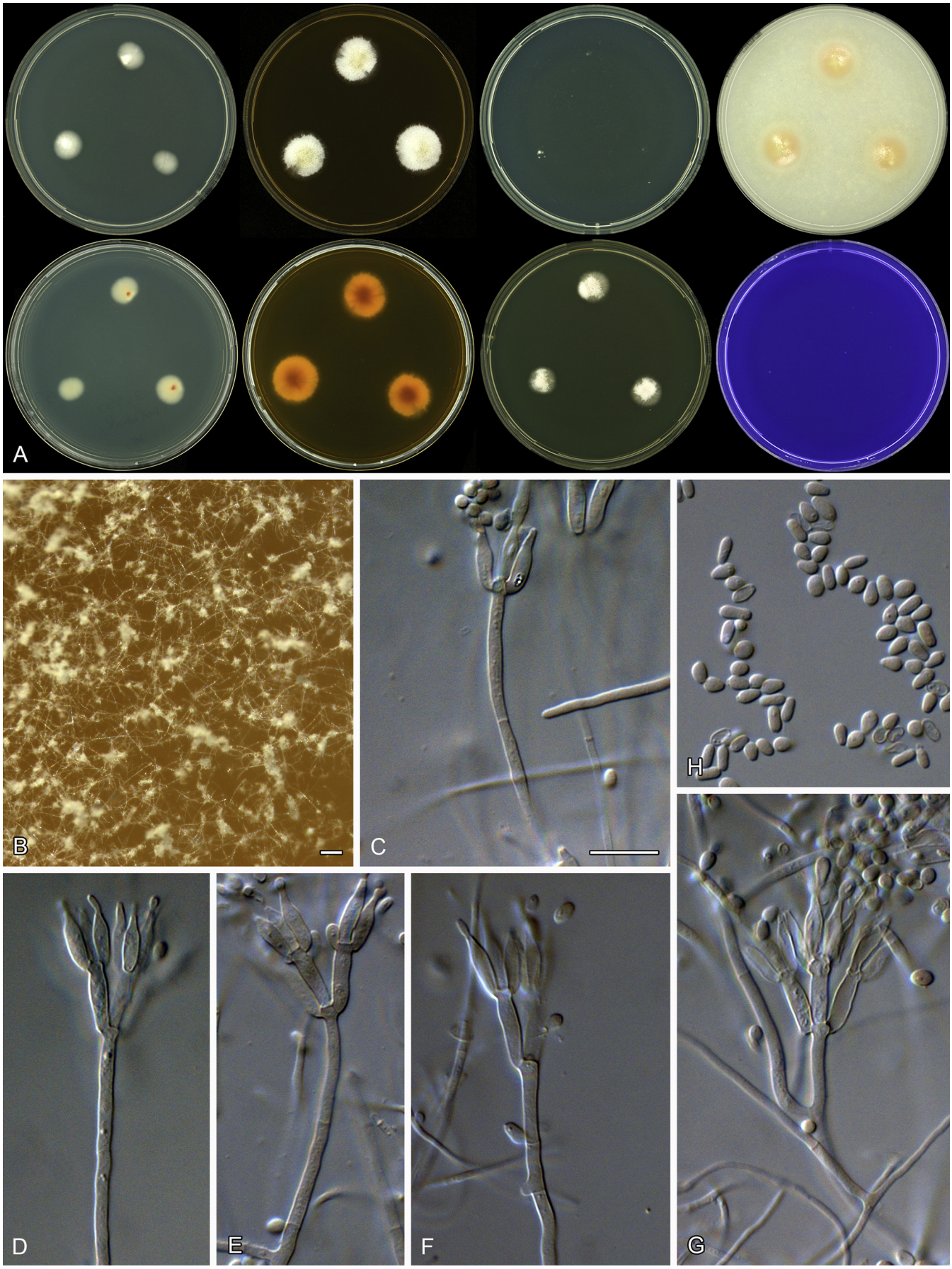

Fig. 40. Morphological characters of *Talaromyces galapagensis* (CBS 751.74^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: B = 100 µm; C = 10 µm, applies to D–H.

ascomata with ellipsoidal, striate ornamentated ascospores and absence of conidiophores.

Talaromyces helicus (Raper & Fennel) 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 barcinensis* Yaguchi & Udagawa Trans. Mycol. Soc. Japan 34: 15. 1993 ≡ *Penicillium barcinense* 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; *CaM* = 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 (5E4) centre fading into greyish orange (5B3) and yellowish white (4A2). 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 metulae, 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 barcinensis* (CBS 649.95) and *T. helicus* var. *major* (CBS 652.66) are phylogenetically identical to *T. helicus* (Fig. 1) and are considered synonyms.

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

≡ *Penicillium indigoticum* Takada & Udagawa, (simultaneously published).

In: *Talaromyces* section *Talaromyces*

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

ITS barcode: JN899331 (alternative markers: *BenA* = JX494308; *CaM* = 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 brownish red (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 pale 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;

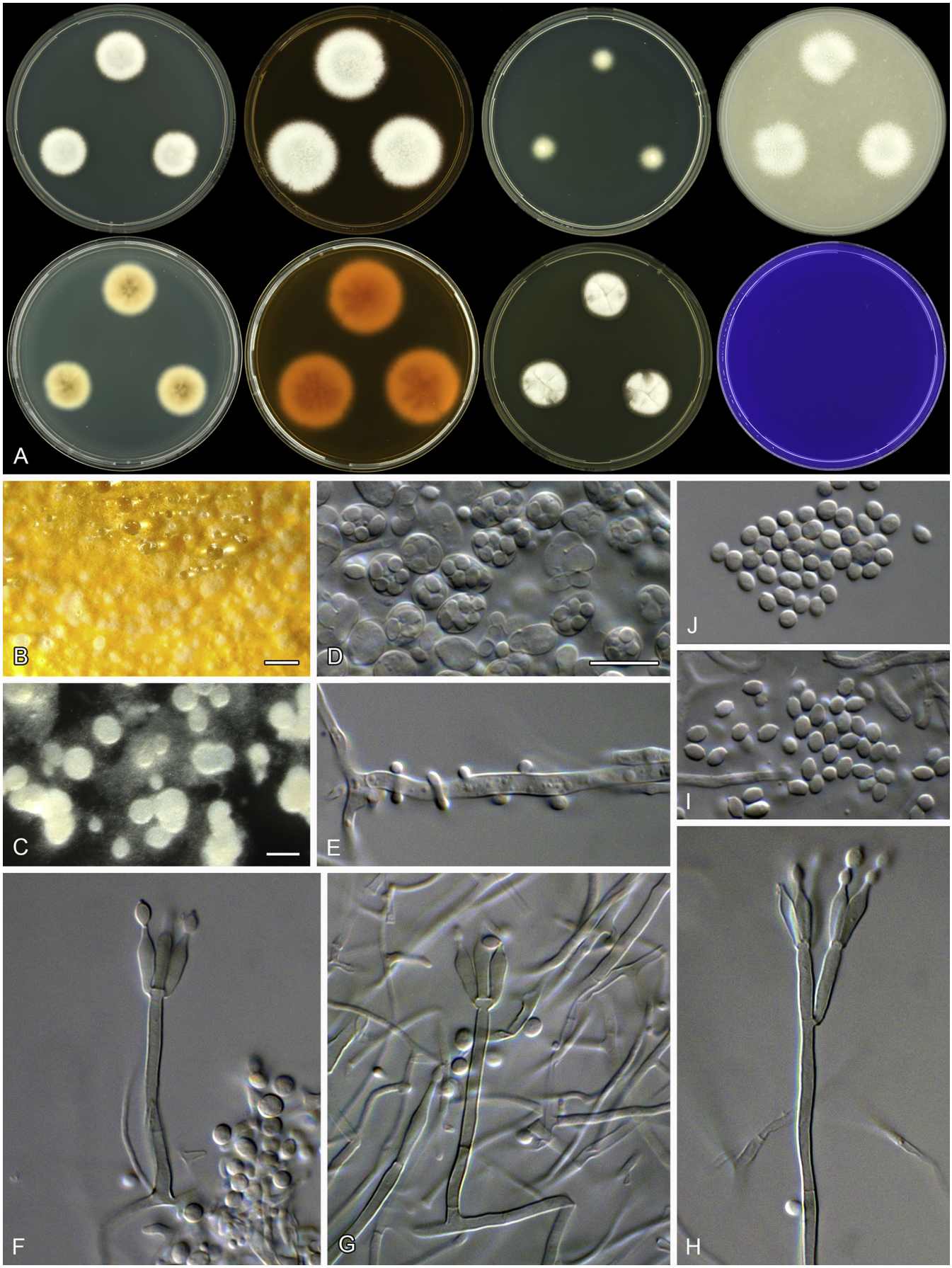

Fig. 41. Morphological characters of *Talaromyces helicus* (CBS 335.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascopsores. E. Initials. F–H. Conidiophores. I. Ascospores. J. Conidia. Scale bars: B = 500 µm; C = 250 µm; D = 10 µm, applies to E–J.

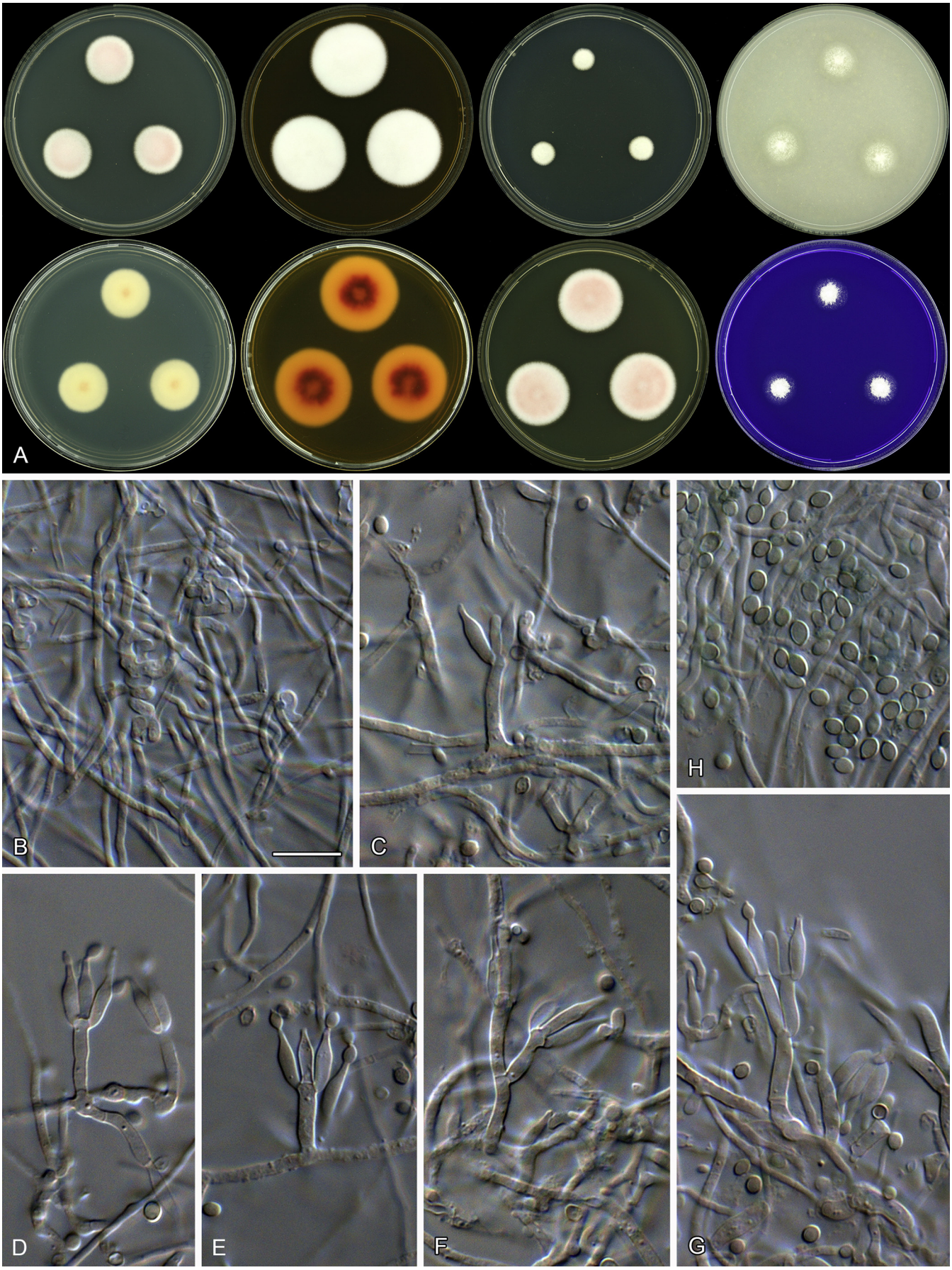

Fig. 42. Morphological characters of *Talaromyces indogoticus* (CBS 100534^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Initials. C–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

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 acerose, three to five per metulae, 8–14.5 × 2–3 µm; conidia smooth, ovoidal to ellipsoidal, 2.4–4 × 2–3.2 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, asci 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 (5A5) 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 acerose, 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, asci 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 aurantioflammiferum* C. Ramírez, A.T. Martínez & 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; *RPB2* = 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^{T}). 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 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 raised at centre, crateriforme; margins narrow (1–2 mm), low, entire, plane; mycelium white, red 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

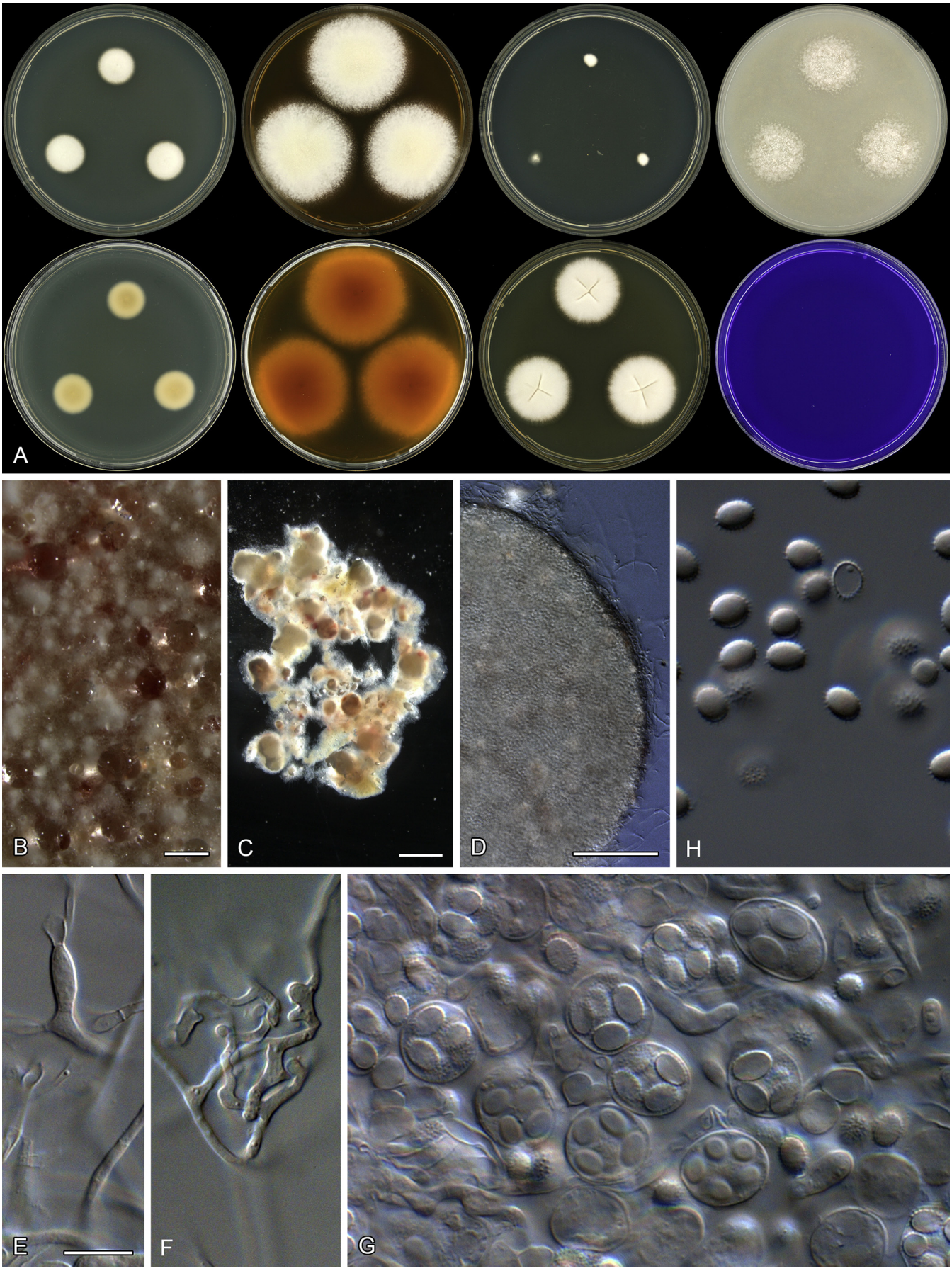

Fig. 43. Morphological characters of *Talaromyces intermedius* (CBS 152.65^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C–D. Ascomata. E. Conidiophores. F. Initials. G. Asci and ascospores. H. Ascospores. Scale bars: B, C = 500 µm; D = 100 µm; E = 10 µm, applies to F–H.

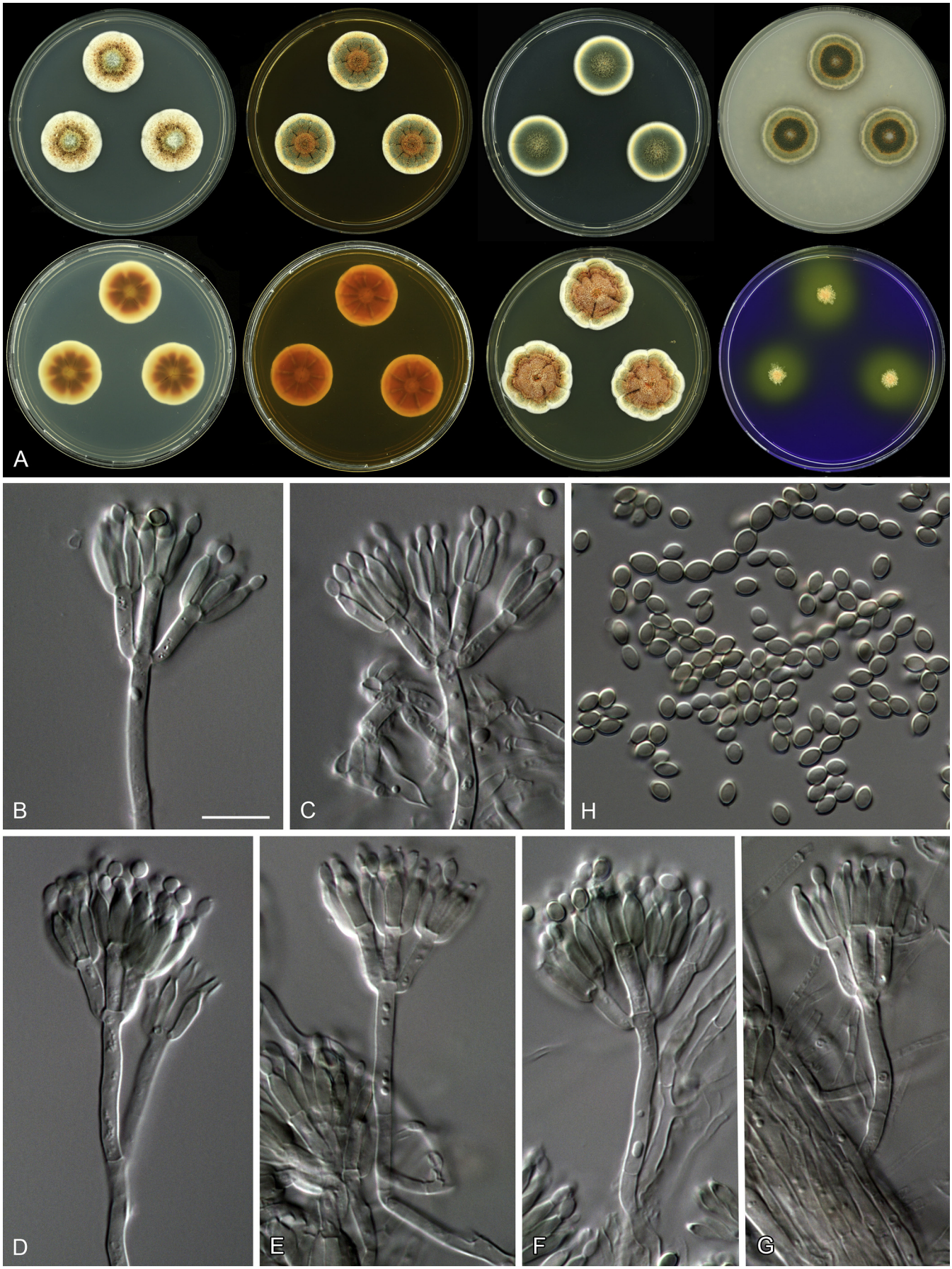

Fig. 44. Morphological characters of *Talaromyces islandicus* (CBS 338.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

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 (8E5) in the centre fading into golden yellow (5B7) to light yellow (4A5). 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.

Extrolites: 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); iridoskyrin and (−)-rubroskyrin (Howard & Raistrick 1954b, Takeda *et al.* 1973), endocrocin (Gatenbeck 1959), emodin (Gatenbeck 1958, Sankawa *et al.* 1973, Kawai *et al.* 1984); (−)-luteoskyrin (Yamamoto *et al.* 1956, Ueno & Ishikawa 1969, Takeda *et al.* 1973, Ghosh *et al.* 1978a); (−)-rugulosin (Takeda *et al.* 1973); erythroskyrine (Howard & Raistrick 1954b, Shoji *et al.* 1965, Shibata *et al.* 1966, Kenkyusho 1983); 1,4,7,8-tetrahydroxy-2-anthraquinone, chrysophanol, catenarin and dimers of those and emodin and islandicin: dianhydrorugulosin, dicatenarin, roseoskyrin, auroskyrin, rhodoislandicin A & B, punicoskyrin, aurantioskyrin, oxyskyrin, 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); cyclochlorotine = islanditoxin = chlorine containing peptide = chloropeptide and simatoxin (Marumo & Sumiki 1955, Uraguchi *et al.* 1961, 1972, Ghosh *et al.* 1978b). Extrolites detected in this study (in CBS 338.48^{T}; NRRL 1036; CBS 165.81; IBT 12697; IBT 15605; FRR 3445; FRR 3606; CBS 189.68 and CBS 117284): erythroskyrin, islandicin, luteoskyrin, mitorubrinic acid and other special mitorubrins, rugulosin & skyrin. UV spectra indicated that *T. islandicus* can also produce wortmannilactone E-H, in addition to some extrolites 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. aurantioflammiferum* (CBS 165.81) is identical to *T. islandicus* (Fig. 7) and is considered a synonym.

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 thermocitrinus* Subrahm. & Gopalkr., Ind. Bot. Reporter 35: 35. 1984 [as '*thermocitrinum*'].

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* = KJ885257)

Colony 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.

Colony 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 into 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 centre between deep yellow and deep orange (4A8–5A8) fading into 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 monoverticillate 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 × 2–3.5 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.

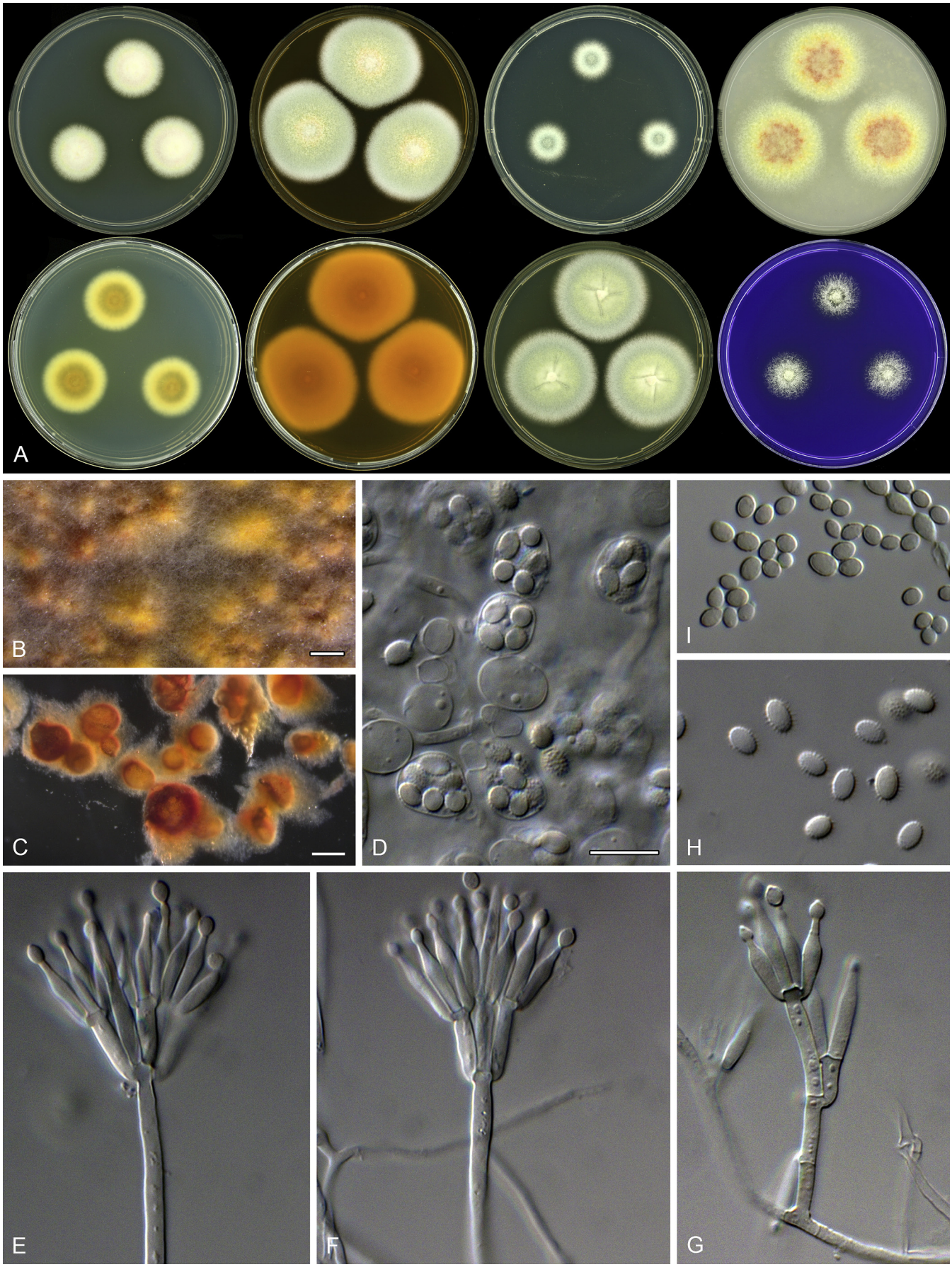

Fig. 45. Morphological characters of *Talaromyces liani* (CBS 118885). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascopsores. E–G. Conidiophores. 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 ascospores, similar to those of *T. flavus*, *T. convolutus*, *T. austrocalifornicus*, *T. flavovirens*, *T. tratensis*, *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. macroporus*. *Talaromyces liani* have ellipsoidal ascospores, whereas *T. macrosporus* has more subglobose to broadly ellipsoidal ascospores. *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. thermocitrinus* 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 sulcate; 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 sulcate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; sporulation absent to sparse; texture floccose and loosely funiculose; conidia *en masse* greyish green to dark green (28D4–28F4); 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 sulcate; 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 sulcate; 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 (28D4–28F4); 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 × 2.4–3.5 µm.

Extrolites: *Talaromyces loliensis* produces mitorubrins and skyrin. 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. tratensis*, however, *T. tratensis* 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)

≡ *Talaromyces flavus* var. *macrosporus* Stolk & Samson Stud. Mycol. 2: 15. 1972.

In: *Talaromyces* section *Talaromyces*

Typus: CBS H-7822, culture ex-type CBS 317.63 = FRR 404 = IMI 197478.

ITS barcode: JN899333 (alternative markers: *BenA* = JX091382; *CaM* = KF741952; *RPB2* = KM023292)

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, sulcate, 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, sulcate, 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

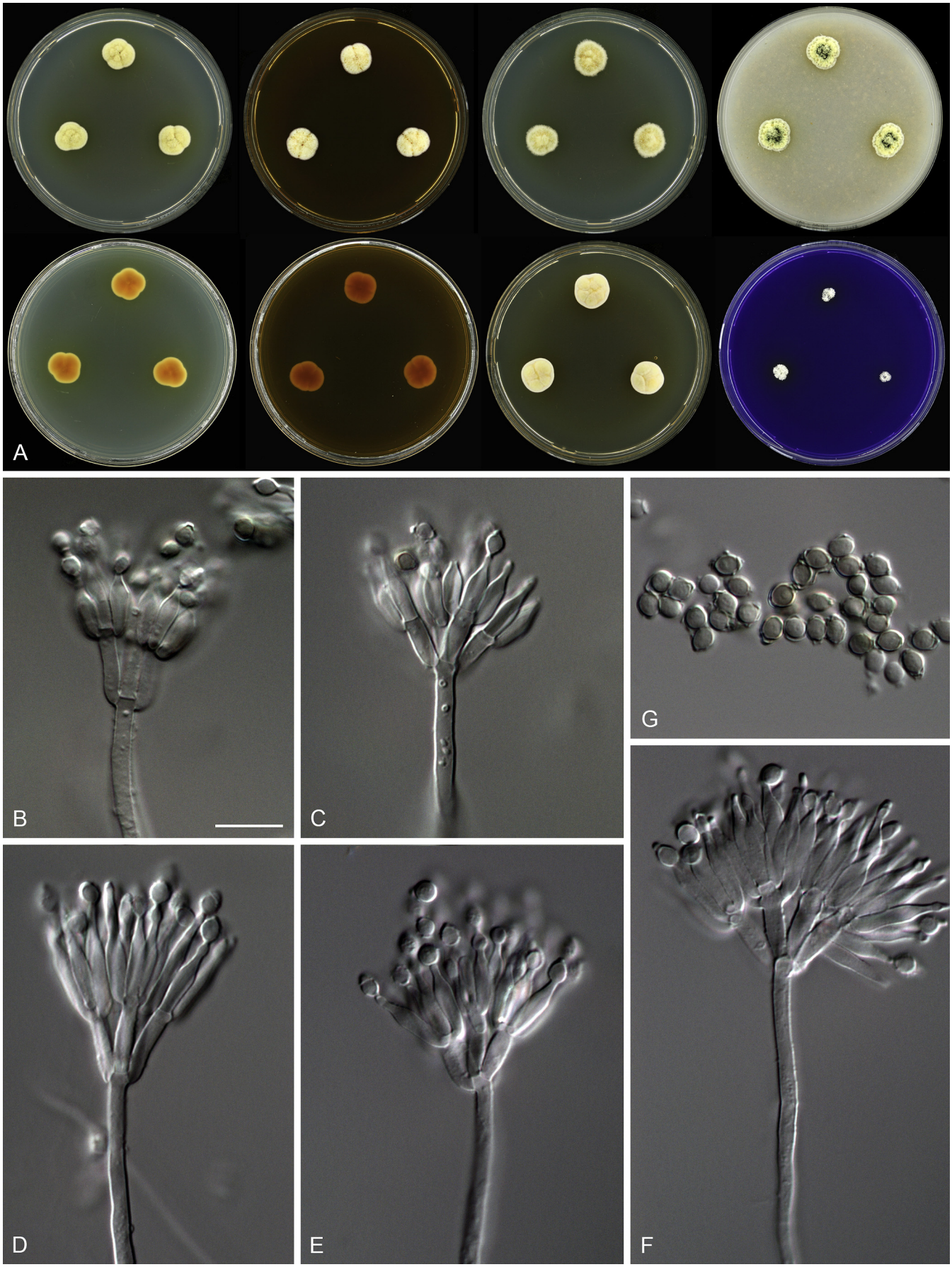

Fig. 46. Morphological characters of *Talaromyces loliensis* (CBS 643.80^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

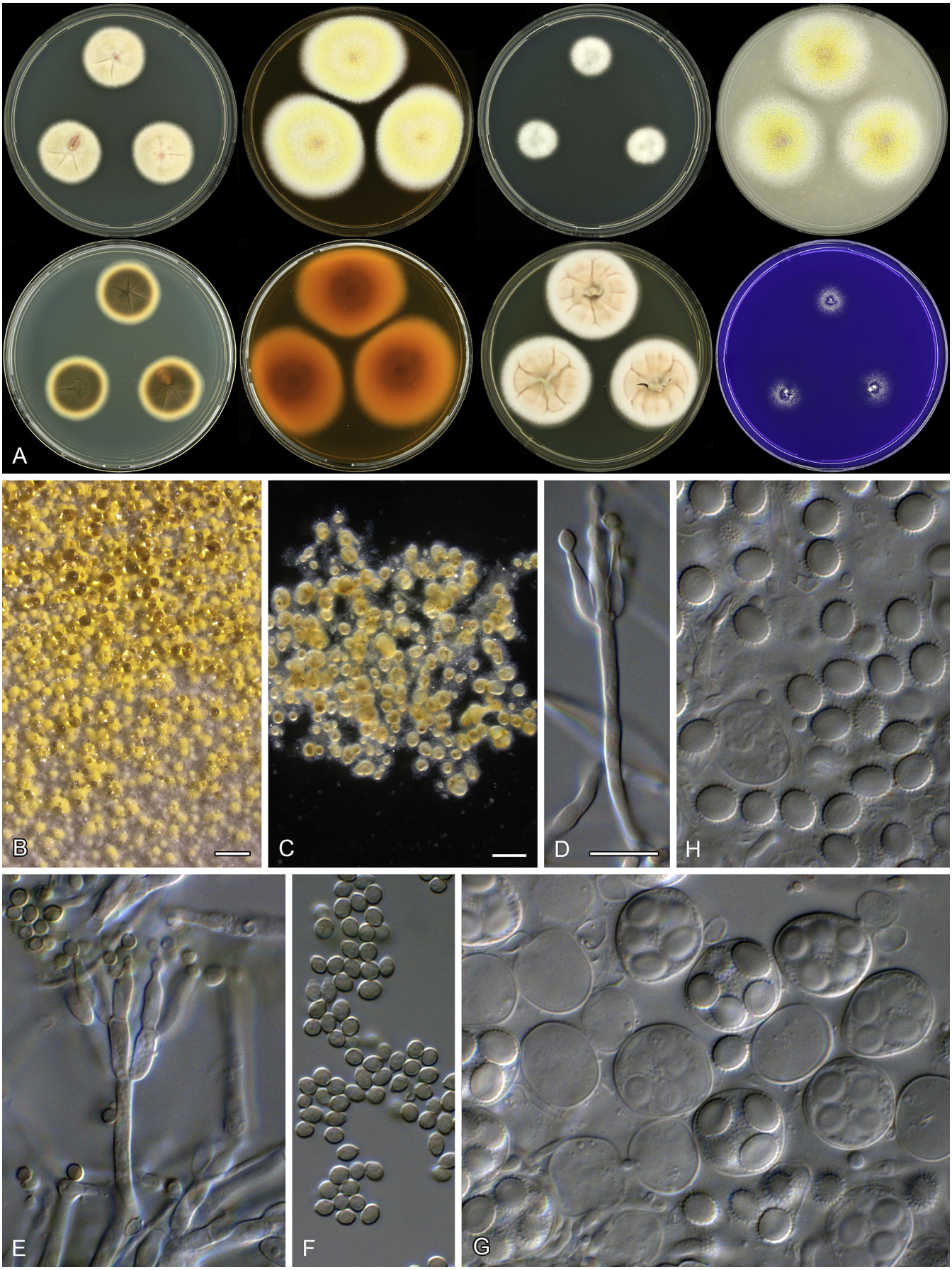

Fig. 47. Morphological characters of *Talaromyces macrosporus* (CBS 317.63^{T}). a. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D, E. Conidiophores. F. Conidia. 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 monoverticillate; stipes smooth walled, 15–50 × 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, 5–6.5 × 4.5–5.5 µm.

Extrolites: *Talaromyces macrosporus* produces duclauxin and mitorubrinic 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. muroii* and *T. liani*. *Talaromyces muroii* and *T. liani* colonies sporulate better on MEA compared to *T. macrosporus*. *Talaromyces muroii* does not grow on CREA. *Talaromyces liani* produces yellow to orange red ascomata, whereas *T. macrosporus* produces only yellow ascomata. Additionally, *T. 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. muroii* (3.5–6 × 3–4 µm). The species is a well-known heat-resitant 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 68794iii, 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* dull 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.

Micromorphology: 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.

Extrolites: *Talaromyces marneffei* produces *Monascus* red pigments including rubropunctatin, monascin, mitorubrin, mitorubrinol, 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.

ITS barcode: JN899338 (alternative markers: *BenA* = KJ865726; *CaM* = KJ885272)

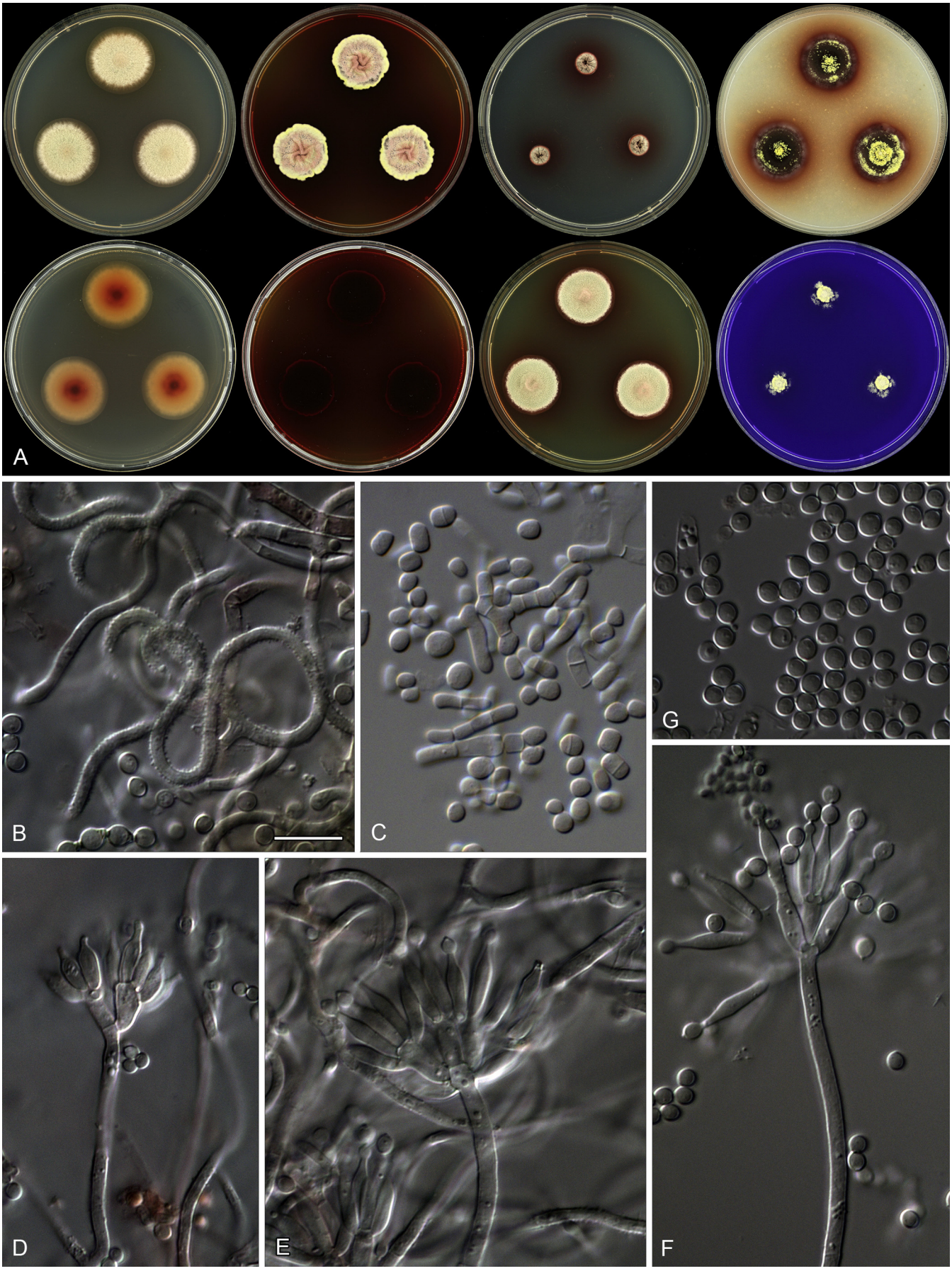

Fig. 48. Morphological characters of *Talaromyces marneffei* (CBS 549.77). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Mycelia. C. Yeast phase. D–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

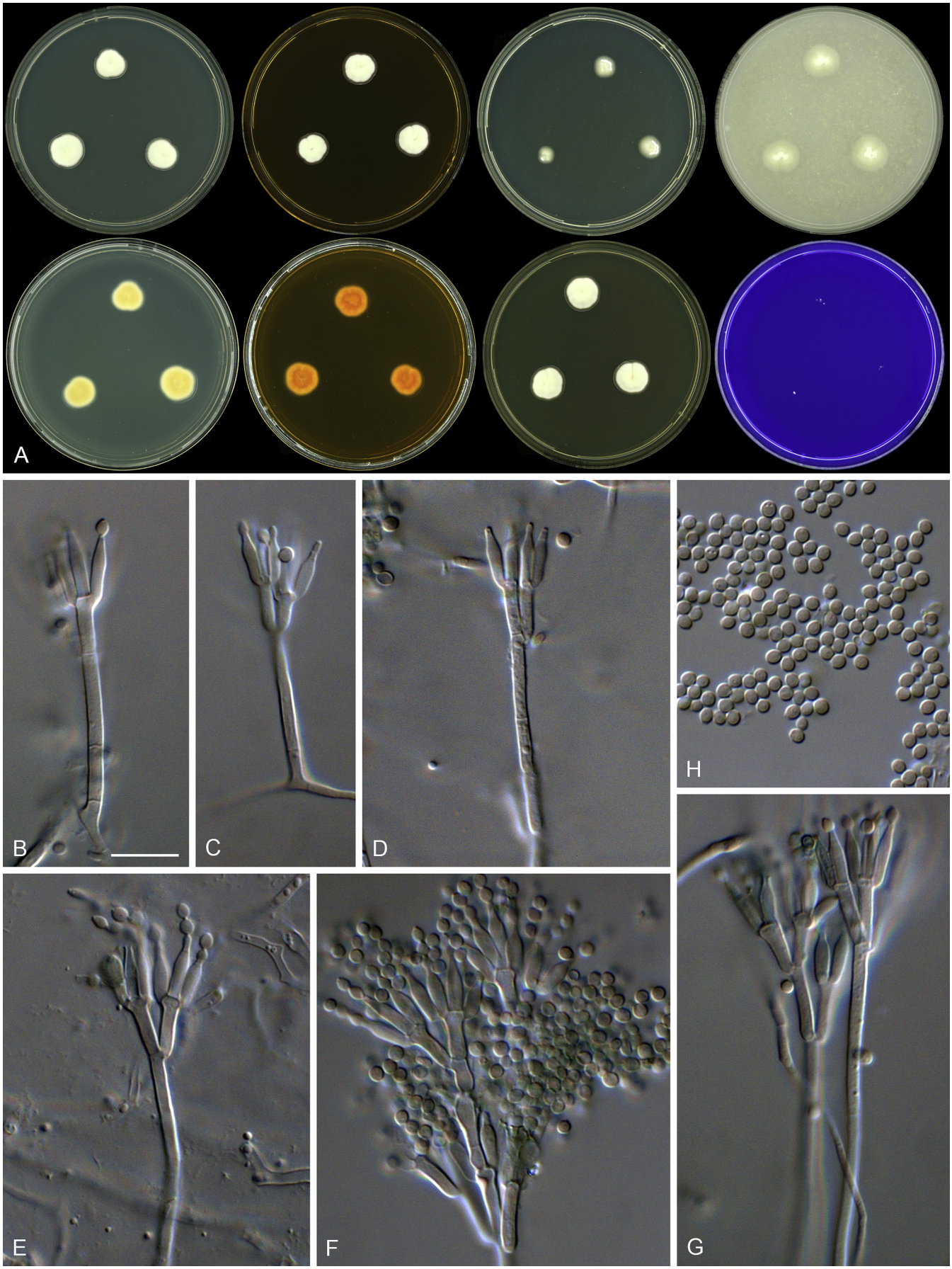

Fig. 49. Morphological characters of *Talaromyces mimosinus* (CBS 659.80^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

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; CYAS 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 (5A5–5A6). YES 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 maize yellow (4A6). DG18 25 °C, 7 d: Colonies low, plane, slimy yeast like; margins low, plane, entire (<1 mm); mycelia white; 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; 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 monoverticillate 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 × 2–2.5 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 sinous ridges about 0.5 µm high, 7–8 × 6–7 µm.

Extrolites: *Talaromyces mimosinus* produces some mitrorubrin-like extrolites.

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. Ramírez & A.T. Martínez, Mycopathologia 74: 165. 1981.

= *Penicillium purpurogenum* var. *rubrisclerotium* 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; *RPB2* = 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 (27E4–27E6); soluble pigments absent; exudates absent; reverse brownish orange (7C8). YES 25 °C, 7 d: Colonies raised at centre, sulcate, crateriform; margins low, plane, entire (1 mm); mycelia white; texture velvety; 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; sporulation absent to sparse; soluble pigments absent; exudates clear droplets; reverse brownish orange (7C8) centre fading into orange (7B8). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 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.

Extrolites: *Talaromyces minioluteus* produces mitorubrin, mitorubrinic acid, a purpactin, secaslonic acid D and vermicellin. It has also been reported to produce minioluteic acid and spiculisporic acid (Birkinshaw & Raistrick 1934), 22-epoxyberkeleydione, miniolutelide A & B (Iida *et al.* 2008), HY558-1 (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. *rubisclerotiorum* 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

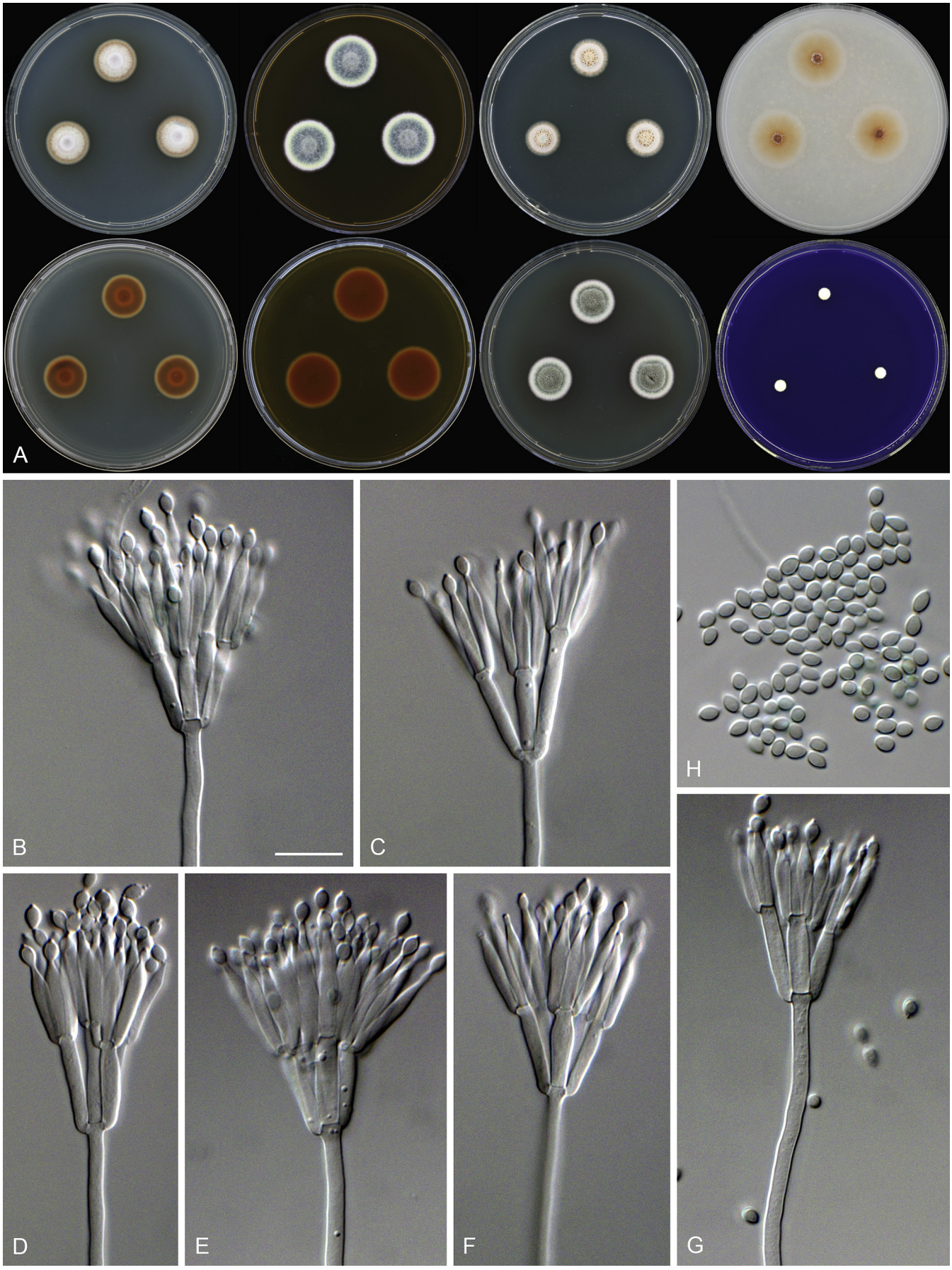

Fig. 50. Morphological characters of *Talaromyces minioluteus* (CBS 642.68^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

phylogenetically identical to *T. minioluteus* (Fig. 5) and are considered synonyms.

Talaromyces muroii Yaguchi, Someya & Udagawa, Mycoscience 35: 252. 1994. MycoBank MB362930. Fig. 51.

= *Penicillium victoriae* Szilvinyi, 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 (5C6) 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 abundat 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 monoverticillate 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 subglobose 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 (26E5–27E5); 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

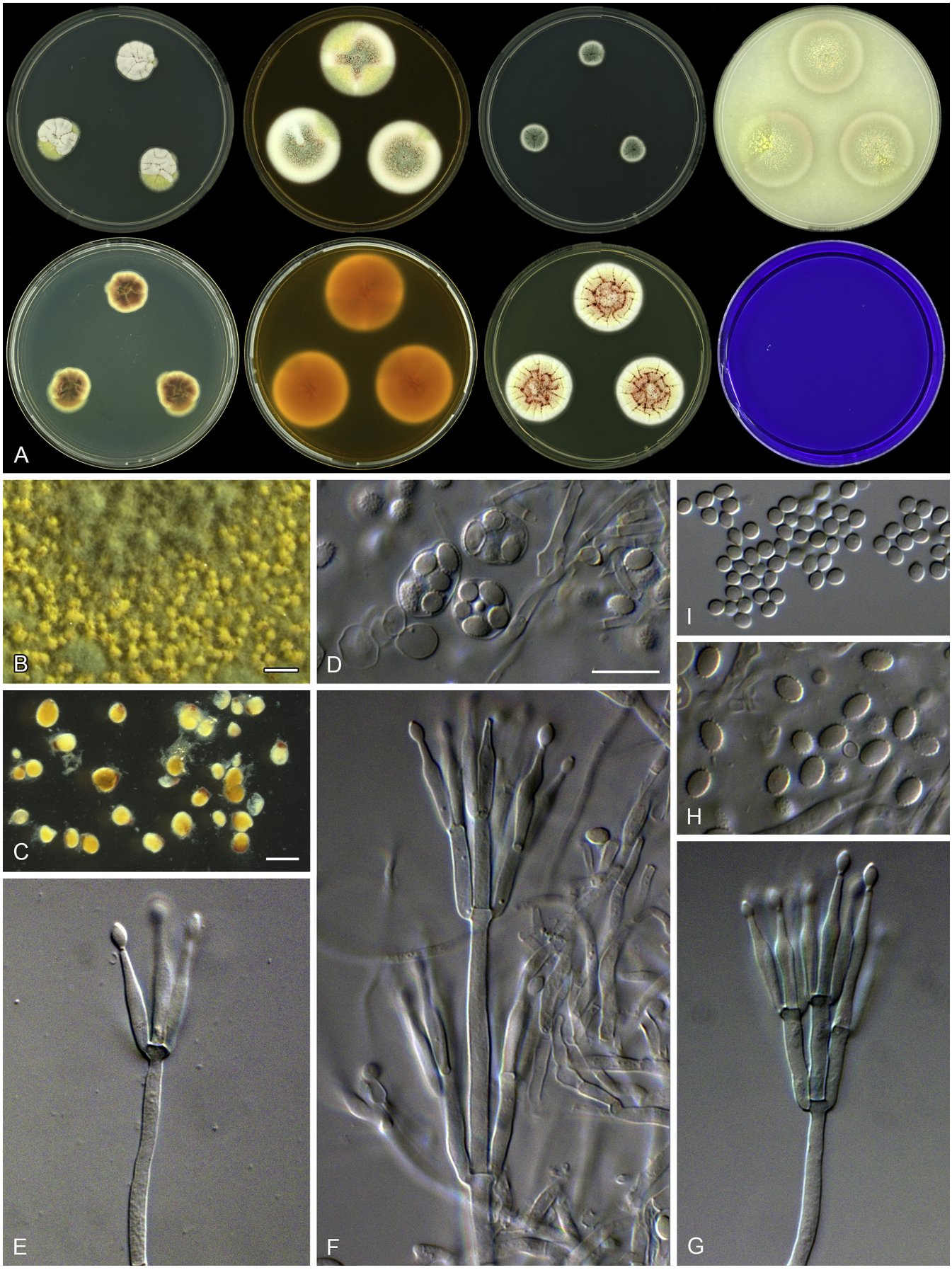

Fig. 51. Morphological characters of *Talaromyces muroii* (CBS 756.96^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascopsores. E–G. Conidiophores. 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.

≡ *Penicillium palmae* Samson, Stolk & Frisvad, Stud. Mycol. 31: 135. 1989.

In: *Talaromyces* section *Subinflati*

Typus: CBS 442.88, culture ex-typue CBS 442.88 = IMI 343640.

ITS barcode: JN899396 (alternative markers: *BenA* = HQ156947; *CaM* = KJ885291; *RPB2* = KM023300)

Colony diam, 7 d (mm): CYA 20–25; CYA 30 °C 20–22; CYA 37 °C No growth; MEA 22–26; MEA 30 °C 25–27 mm; DG18 4–5; CYAS No growth; OA 25–27; CREA 7–11; YES 25–26.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, crateriforme; margins low, plane, entire (1 mm); mycelia white and yellow; texture velvety; 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 synnemata 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 synnemata 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 absent; 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 synnemata 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: Synnemata 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.

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

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

≡ *Penicillium panamense* Samson, Stolk & Frisvad, Stud. Mycol. 31: 136. 1989.

In: *Talaromyces* section *Talaromyces*

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

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

Colony diam, 7 d (mm): CYA 23–24; CYA 30 °C 20–21; CYA 37 °C No growth; MEA 28–30; MEA 30 °C 27–28; DG18 10–11; CYAS 2–3; OA 33–35; CREA 22–25; YES 30–32.

Colony characters: CYA 25 °C, 7 d: 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, synnemata at centre sporulate; margins low, plane, entire (1 mm); mycelia white, yellow and orange; texture synnematous; sporulation sporulation only on synnemata 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 (6E7) 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* greyish green (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 synnemata at centre and young synnemata at margins; margins low, plane, entire (2–3 mm); mycelia white, yellow, orange; texture synnematous; sporulation only on synnemata 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: Synnemata formed after 7 d on MEA 1 800–5 000 µm long and on OA 800–6800 µm long.

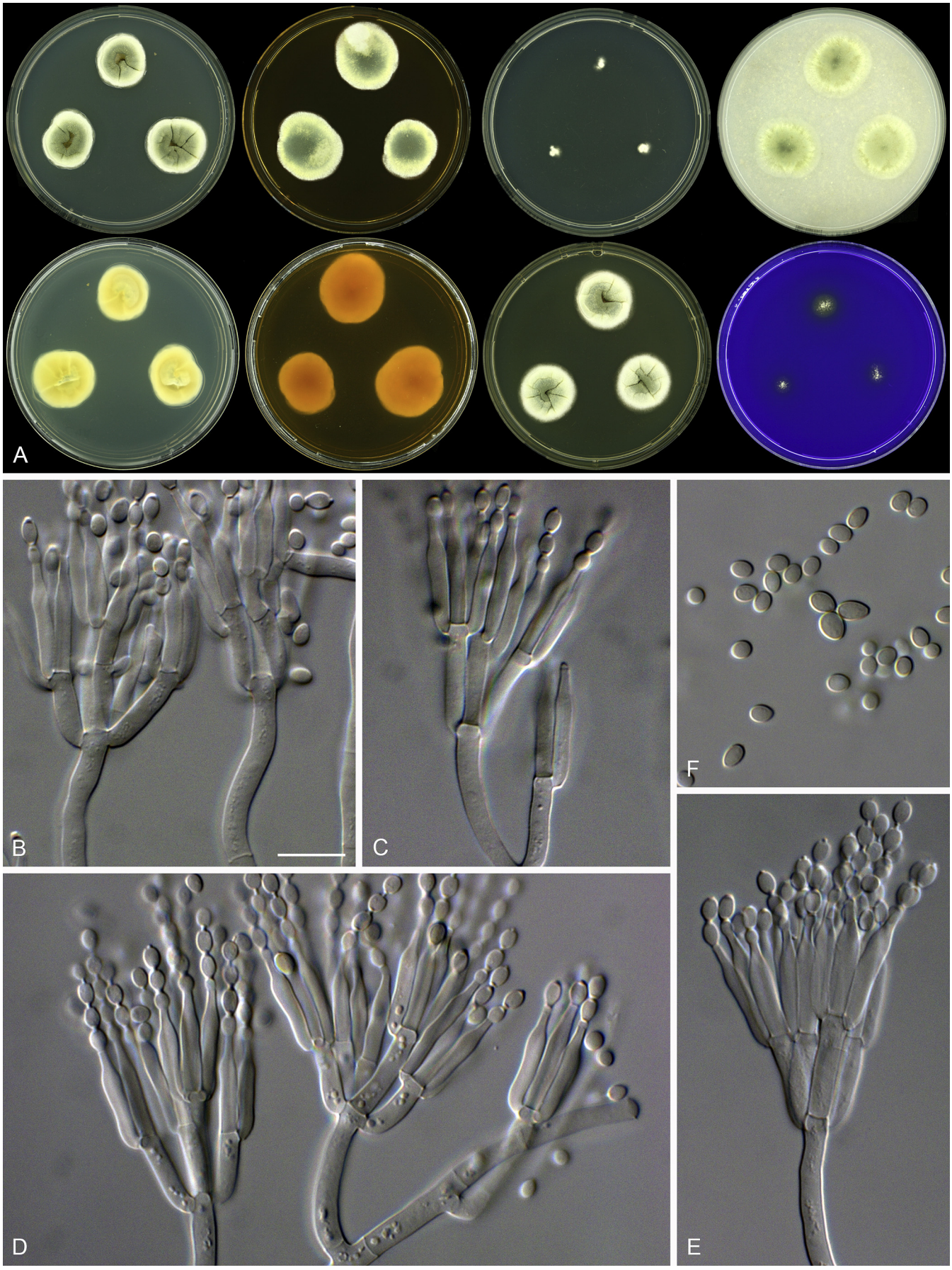

Fig. 52. Morphological characters of *Talaromyces palmae* (CBS 442.88^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–E. Conidiophores. F. Conidia. Scale bar: B = 10 µm, applies to C–F.

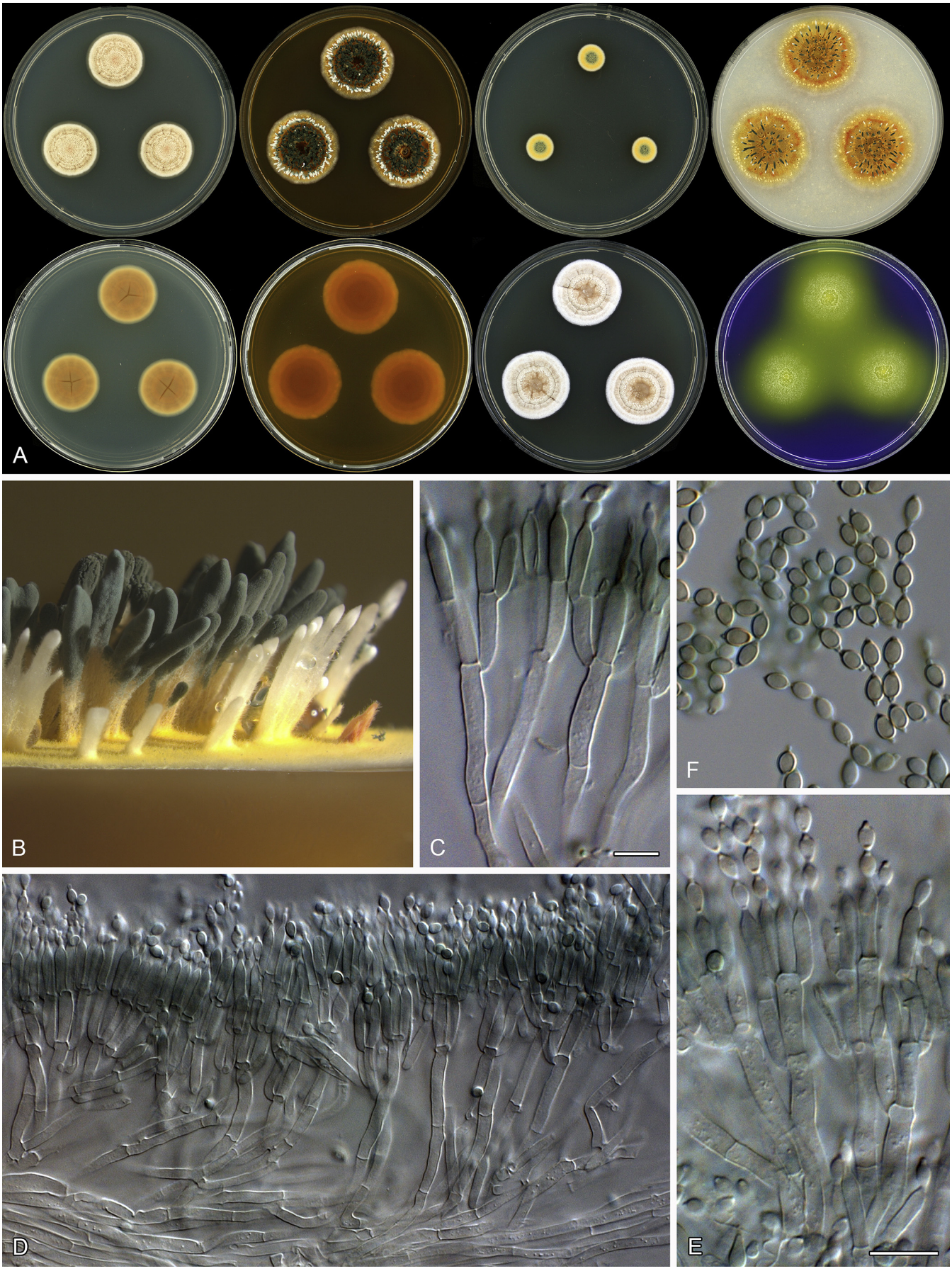

Fig. 53. Morphological characters of *Talaromyces panamensis* (CBS 128.89^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C–E. Conidiophores. F. Conidia. Scale bar: C = 10 µm, applies to D–F.

Conidiophores biverticillate with a minor proportion having subterminal 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 acerose, 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.

Extrolites: *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 *Talaromyces*

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 agar growing restrictedly, attaning 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; asci 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.

Extrolites: *Talaromyces paucisporus* produces monodictyphenone and purpactins.

Notes: *Erythrogymnotheca paucispora* was described by Yaguchi *et al.* (1994) introducing the new genus *Erythrogymnotheca*. It produces asci that have one to two and sometimes four ascospores, whereas *Talaromyces* generally produces asci 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 micromophological 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.

In: *Talaromyces* section *Islandici*

ITS barcode: KF984792 (alternative markers: *BenA* = KF984668; *CaM* = KF984680; *RPB2* = KF984899)

Typus: IMI 040038, culture ex-type CBS 361.48 = ATCC 10519 = IMI 040038 = NRRL 1051 = QM 7609 = IBT 4460.

Colony diam, 7 d (mm): CYA 20–27; CYA 30 °C 28–33; CYA 37 °C 30–35; MEA 25–27; MEA 30 °C 30–33; DG18 15–20; CYAS 7–15; OA 20–27; CREA 11–20; YES 15–20.

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* grayish 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* grayish 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;

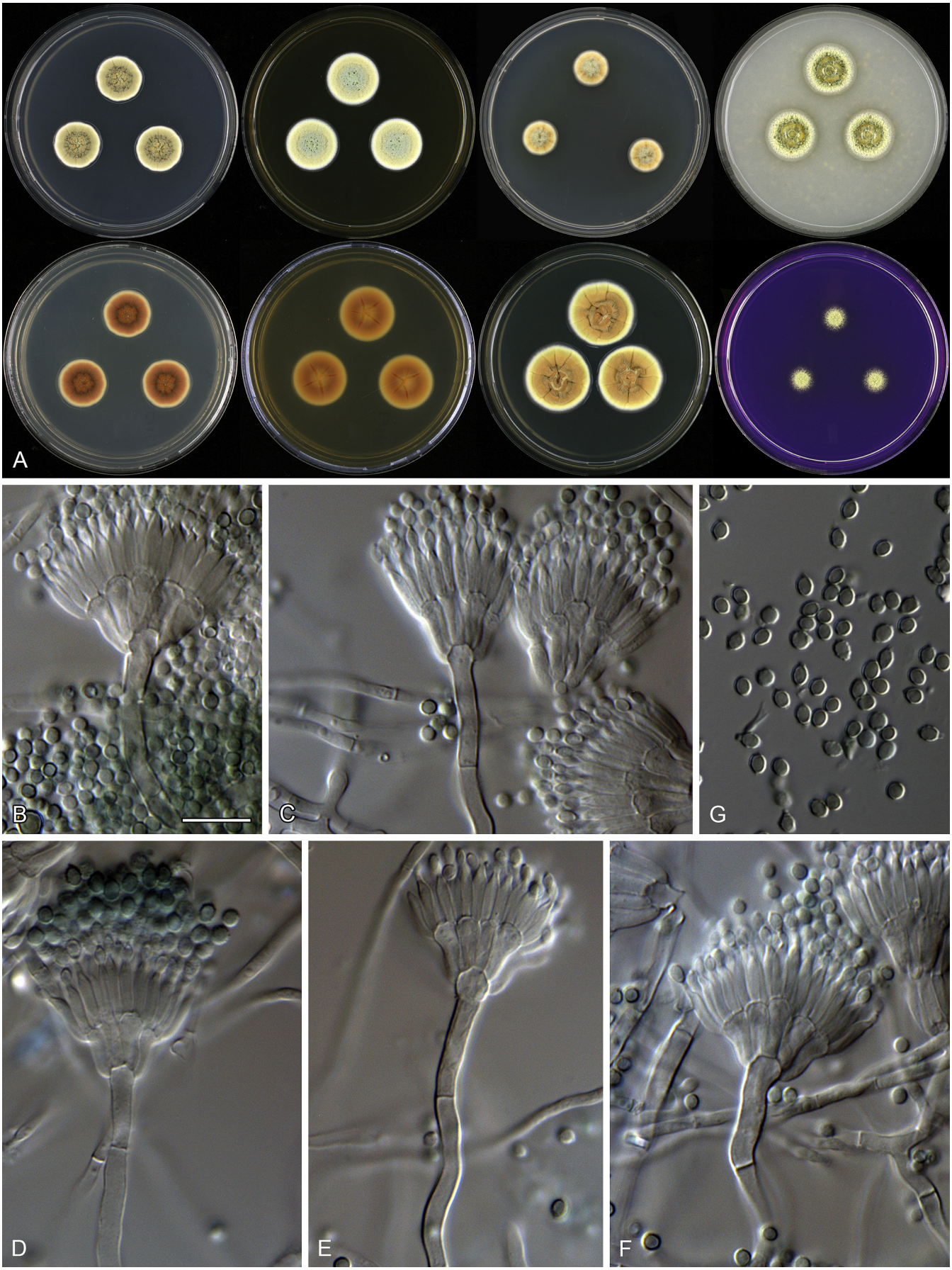

Fig. 54. Morphological characters of *Talaromyces piceus* (CBS 137377). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

margins narrow (1–2 mm), low, entire, plane; mycelium white and yellow; texture velvety to loosely funiculose; sporulation sparse to dense; conidia *en masse* grayish 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 acerose, 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, mitorubrinol, rugulosin A and other rugulosins, and skyrin. It also produces diverse other anthraquinones and extrolites with chromophores suggesting tetracyclic compounds, citreoisocoumarin 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 Industr. Bull. 118: 37. 1910.
= *Penicillium korosum* J.N. Rai, Wadhwani & J.P. Tewari, Antonie van Leeuwenhoek 35: 430. 1969.
= *Acremonium cellulolyticus nom. nud.*, Japanese patent, 1317660. 1985; US Patent 4562150. 1985.
= *Talaromyces cellulolyticus* 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; *RPB2* = KM023291)

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, sulcate; 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 weak 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 sulcate; 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, sulcate; 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 golden 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 acerose, 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 secopenicillide 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.* 2011), 3-O-methylfunicone and 3-O-methyl-5,6-epoxyfunicone (de Stefano *et al.* 1999a, b). We have found mitorubrin, mitorubrinic acid, vermicillin, a purpactin, penicillide, 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 macromorphologically 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,

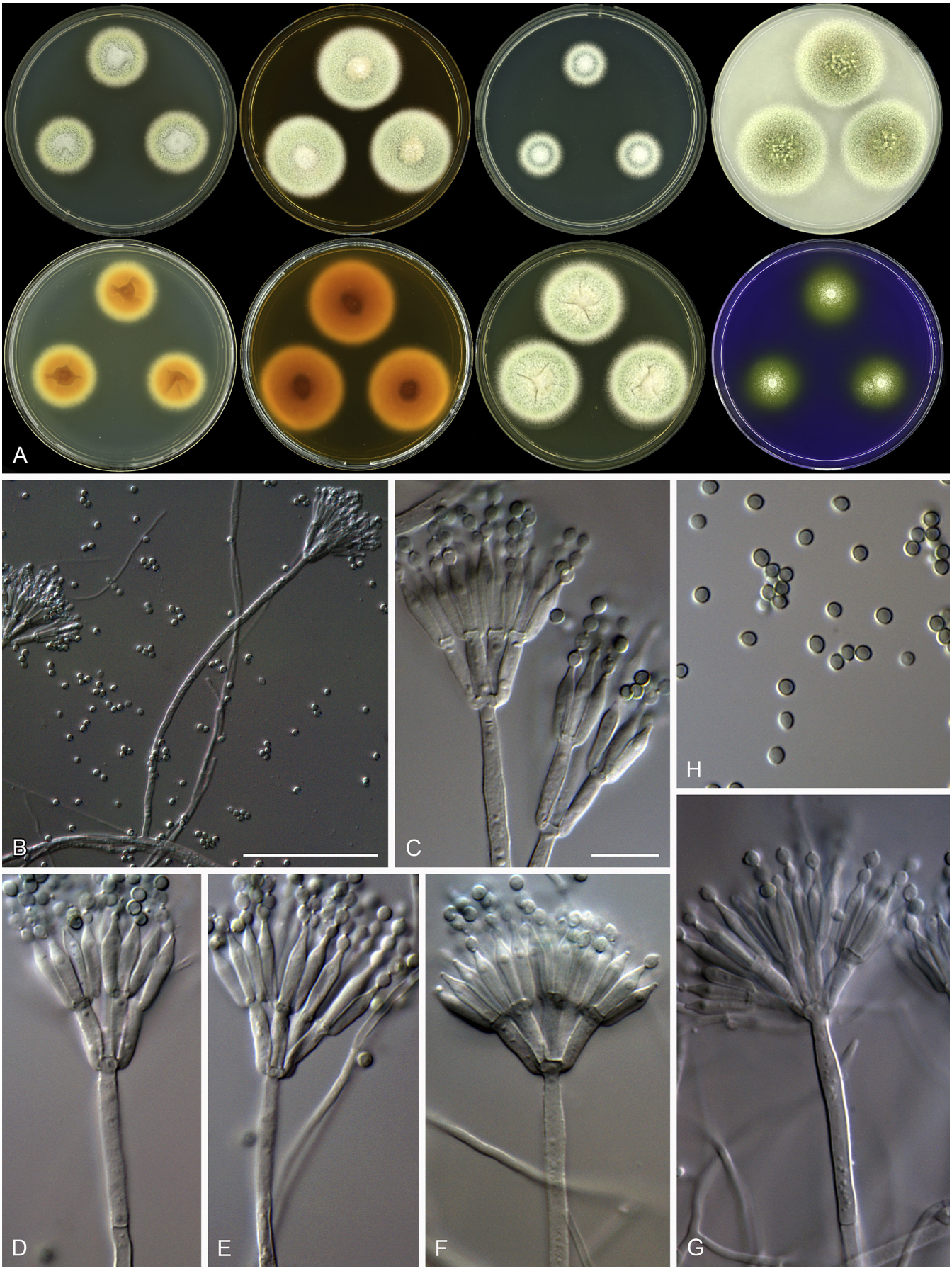

Fig. 55. Morphological characters of *Talaromyces pinophilus* (DTO 183-I6). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bars: B = 50 µm; C = 10 µm, applies to D–H.

since Visagie *et al.* (2014) introduced the phylogenetically distinct, but morphologically almost identical, *T. sayulitensis*.

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. Fujii *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): CYA 34–36; CYA 30 °C 38–40; CYA 37 °C No growth; MEA 42–44; MEA 30 °C 48–50; DG18 21–23; CYAS No growth; OA 35–36; CREA 4–5; YES 33–35.

Colony characters: CYA 25 °C, 7 d: Colonies low, raised at centre, plane, yeast-like appearance at centre, this character is not observed at 30 °C; margins low, narrow, entire (1 mm); mycelia white; texture velvety, after 2 wk of incubation floccose and synnematous, indeterminate synnemata produced centrally; sporulation moderately dense, conidia *en masse* greyish green (25C4); soluble pigments red; exudates clear to light red; reverse reddish brown (8E7) at centre, fading into brownish red (8C6). MEA 25 °C, 7 d: Colonies brownish red to reddish brown (8D6–8E8) yeast-like slimy colonies; sporulation absent; soluble pigments red; reverse brownish red to reddish brown (8C8–8D8). YES 25 °C, 7 d: Colonies yellowish grey (3B2–4B2) yeast-like slimy colonies; sporulation absent; soluble pigments absent; reverse yellowish grey (3B2–4B2). DG18 25 °C, 7 d: Colonies yellowish grey (3B2) yeast-like slimy colonies; sporulation absent; soluble pigments absent; reverse pale (3A2). 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* greyish green (25C4); soluble pigments absent; exudates absent; reverse reddish brown (9E7). CREA 25 °C, 7 d: Acid production absent.

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 acerose, 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.

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).

≡ *Penicillium primulinum* Pitt, The genus *Penicillium*: 455. 1980.

In: *Talaromyces* section *Talaromyces*

Typus: IMI 040031, culture ex-type CBS 321.48 = ATCC 10438 = CBS 439.88 = FRR 1074 = IMI 040031 = MUCL 31321 = MUCL 31330 = NRRL 1074.

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

Colony diam, 7 d (mm): CYA 5–6; 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: CYA 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose and velvety; sporulation sparse to dense, conidia *en masse* greyish green (27E5–28E5) (on DTO 270-F3); soluble pigments absent; exudates absent; reverse in some isolates brownish orange to reddish brown (7C5–8C5) (DTO 250-F2) and in some isolates greenish grey to greyish green (1D2–1D3) (DTO 250-F3). MEA 25 °C, 7 d: Colonies slightly raised at centre, sunken at centre, sulcate, degraded, white and dull red appearance; margins low, plane, entire (1–2 mm); mycelia white and dull red; texture floccose and after 2 wk of incubation colonies covered with yellow mycelia; sporulation absent; soluble pigments absent; exudates absent; reverse violet brown (10E7) centre fading into greyish orange (5B5). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose (DTO 250-F2) and velvety (DTO 250-F3); sporulation moderately dense to dense, conidia *en masse* dull green (26D3) (DTO 250-F2) and greyish green (25E5–26E5) (DTO 250-F3); soluble pigments absent; exudates absent; reverse olive (2F5) (DTO 250-F3) and light orange to greyish orange (5A5–5B5) (DTO 250-F2). DG18 25 °C, 7 d: Colonies raised at centre, plane; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia *en masse* greyish green (28B5) (DTO 250-F3); soluble pigments absent; exudates absent; reverse greyish green (1C5) centre fading into greyish yellow (1B5) (DTO 250-F3) and in some isolates yellowish white (4A2) (DTO 250-F2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white and in some isolates pastel yellow as well (DTO 250-F3); texture velvety; sporulation moderately dense, conidia *en masse* greyish green (25C4 for DTO 250-F2 and for DTO 250-F3 26E5–27E5); soluble pigments absent; exudates absent; reverse dull reddish brown (DTO 250-F2) and olive green (DTO 250-F3). CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, 70–200 × 1.5–3 µm, slightly vesiculate; branches 15 µm; metulae three to eight, divergent, 6–12 × 2–3.5; phialides

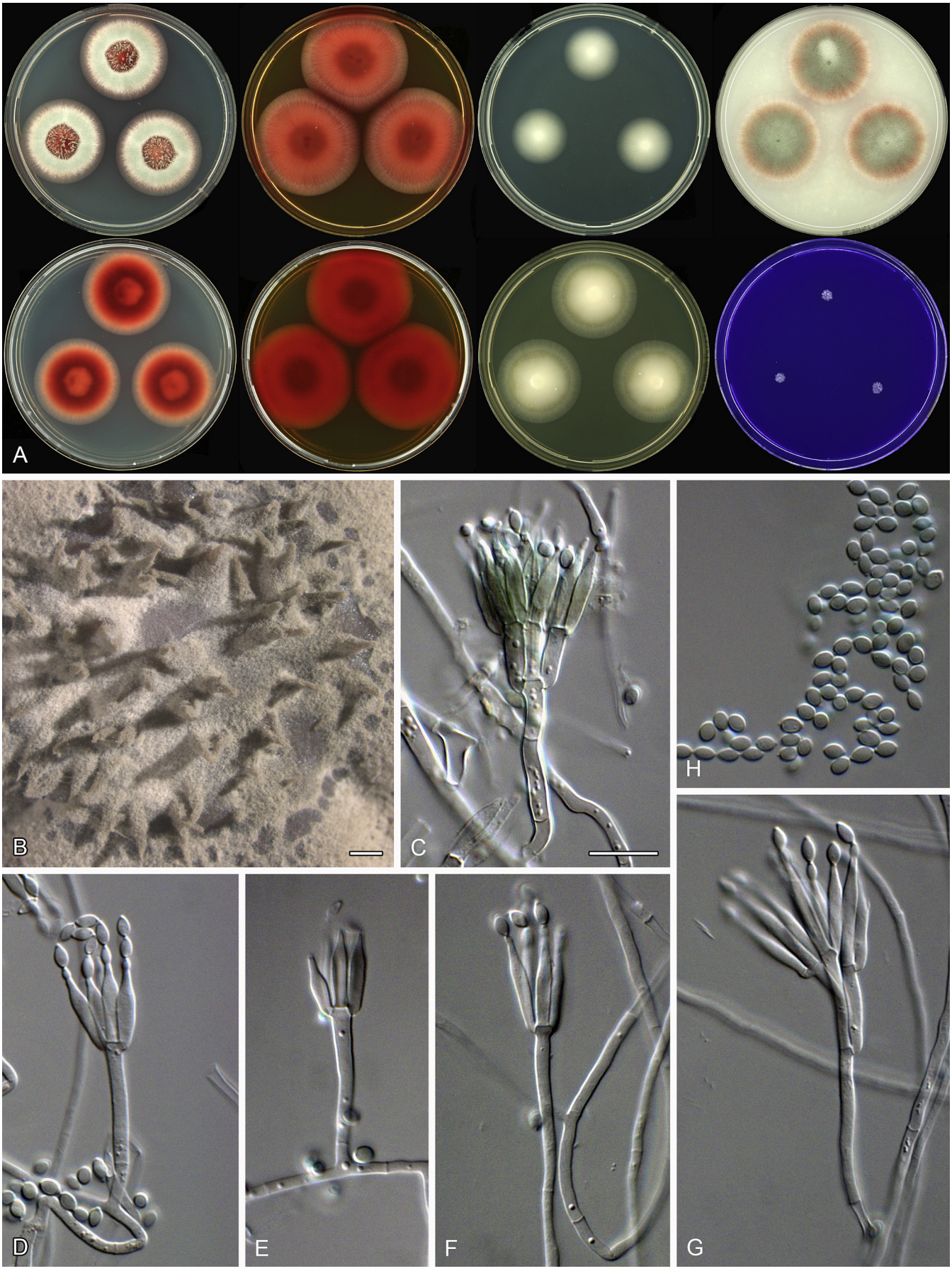

Fig. 56. Morphological characters of *Talaromyces pittii* (CBS 139.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 3 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: B = 1000 µm; C = 10 µm, applies to D–H.

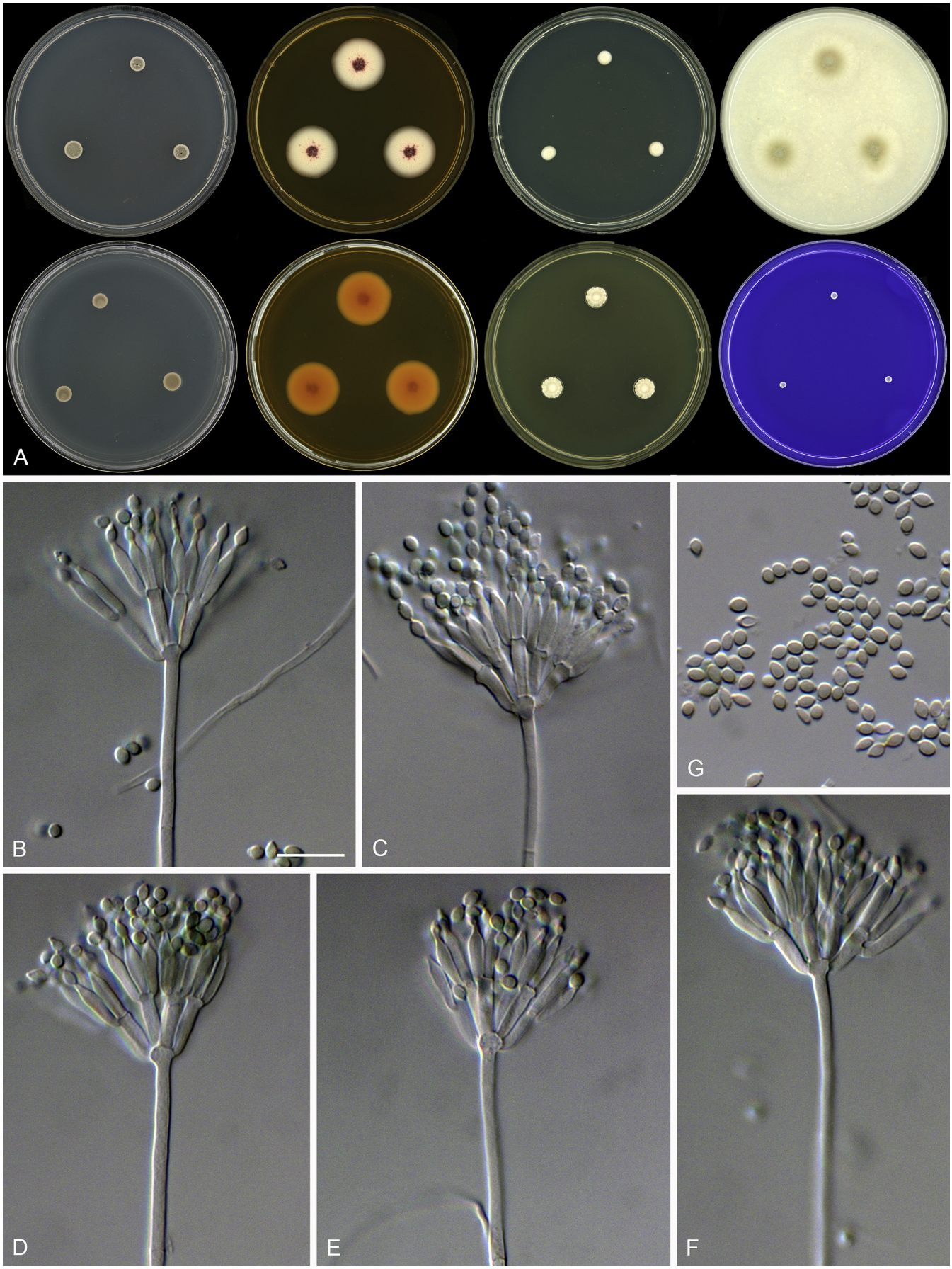

Fig. 57. Morphological characters of *Talaromyces primulinus* (CBS 321.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

acerose, three to eight per metulae, 7.5–12 × 1.5–2.5 µm; conidia smooth to finely roughed, ellipsoidal to fusiform, 2–4 × 1.5–3 µm.

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

Distinguishing characters: *Talaromyces primulinus* grows restrictedly 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. flavovirens* and *T. marneffei*. However, *T. marneffei* grows at 37 °C as a yeast form and *T. flavovirens* grows faster on all media. The restricted growth of *T. primulinus* on CYA resembles *T. rademirici*, *T. diversus* and *T. erythromellis. Talaromyces primulinus* differs from *T. erythromellis* 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.

≡ *Penicillium proteolyticum* Kamyschko, Nov. Sist. niz. Rast. Sist. niz. Rast. 14: 227. 1961.

In: *Talaromyces* section *Bacillispori*

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

ITS barcode: JN899387 (alternative markers: *BenA* = KJ865729; *CaM* = KJ885276; *RPB2* = 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 red (9B5) fading into between light yellow (4A4) and light orange (5A4). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white and pastel yellow; texture floccose; sporulation sparse, conidia *en masse* pastel green (25B4–26B4); soluble pigments absent; exudates absent; reverse greyish orange to brownish orange (5B6–5C6). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate, fluffy appearance; margins low, plane, entire (1 mm); mycelia white and pale pastel yellow; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A5) with pastel red (8A5) circle close to margins. DG18 25 °C, 7 d: Colonies raised at centre, pale, fluffy white appearance with sterile aerial hyphae; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent; 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; 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.

Micromorphology: 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 acerose, 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.

Extrolites: We detected monorden and compounds with the same chromophore as emodin, herqueinone and neosartorin 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.

≡ *Penicillium pseudostromaticum* Hodges, G.M. Warner & Rogerson, Mycologia 62: 1106. 1970.

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; *RPB2* = 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 (26E4); soluble pigments absent; exudates absent; reverse dark brown (7F8–8F8). MEA 25 °C, 7 d: Colonies low, slightly raised at centre, plane, red colour underneath sporulating areas; margins low, narrow, entire (2 mm); mycelia white, some yellow present; texture velvety, funicles present, after 2 wk of incubation synnemata produced; sporulation moderately dense, conidia *en masse* greyish green (25E5–25E6); soluble pigments absent; exudates absent; reverse dark brown (7F8–8F8). YES 25 °C, 7 d: Colonies low, slightly raised at centre, red colour underneath sporulating areas; margins low, narrow, entire (2–3 mm); mycelia white, yellow and pink; texture velvety, some loose funicles present; sporulation moderately dense, conidia *en masse* greyish green (25E5); soluble pigments red; exudates absent; reverse very dark red at centre, dark brown to violet brown (8F8–10F8) elsewhere. DG18 25 °C, 7 d:

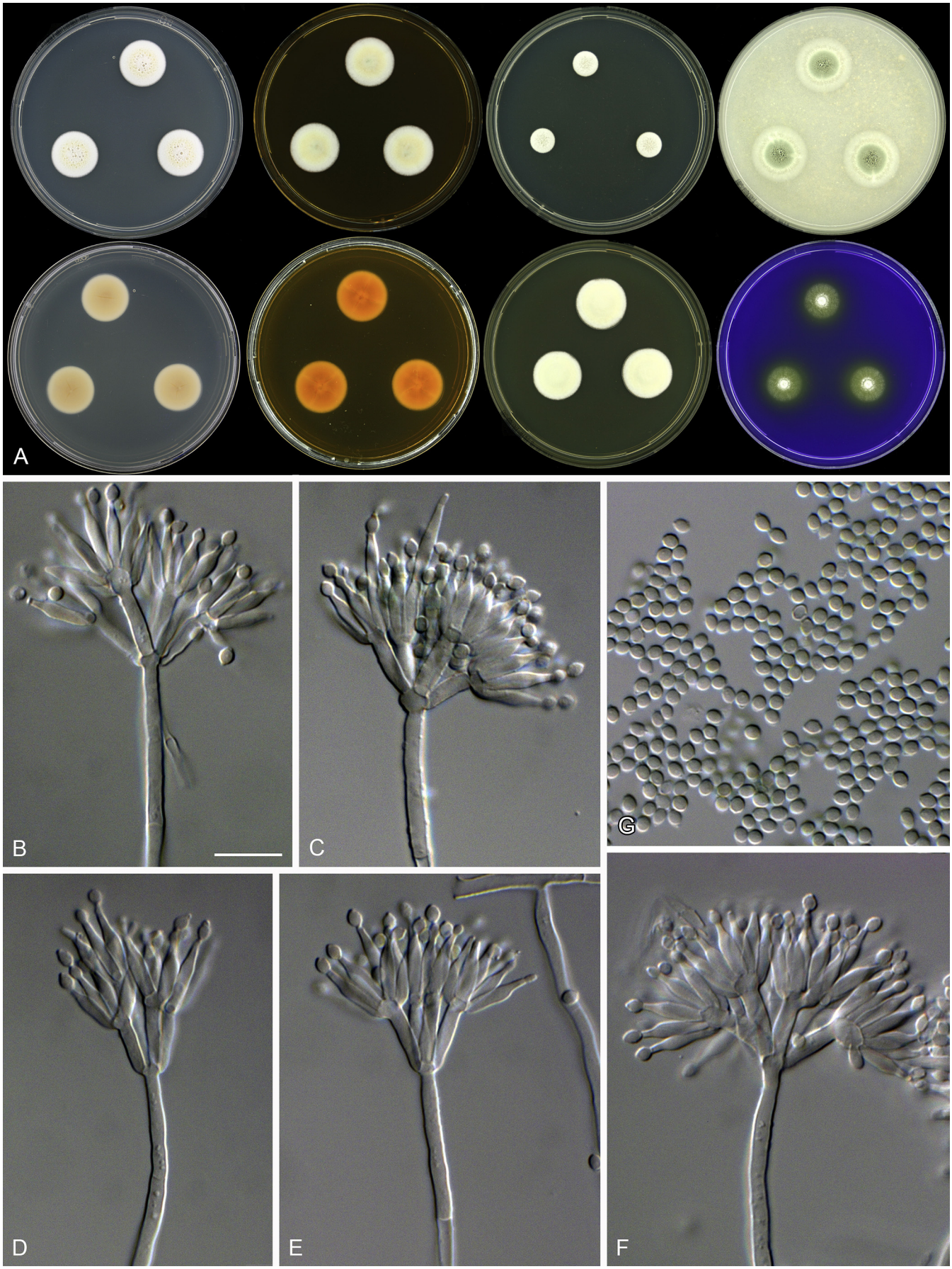

Fig. 58. Morphological characters of *Talaromyces proteolyticus* (CBS 303.67^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

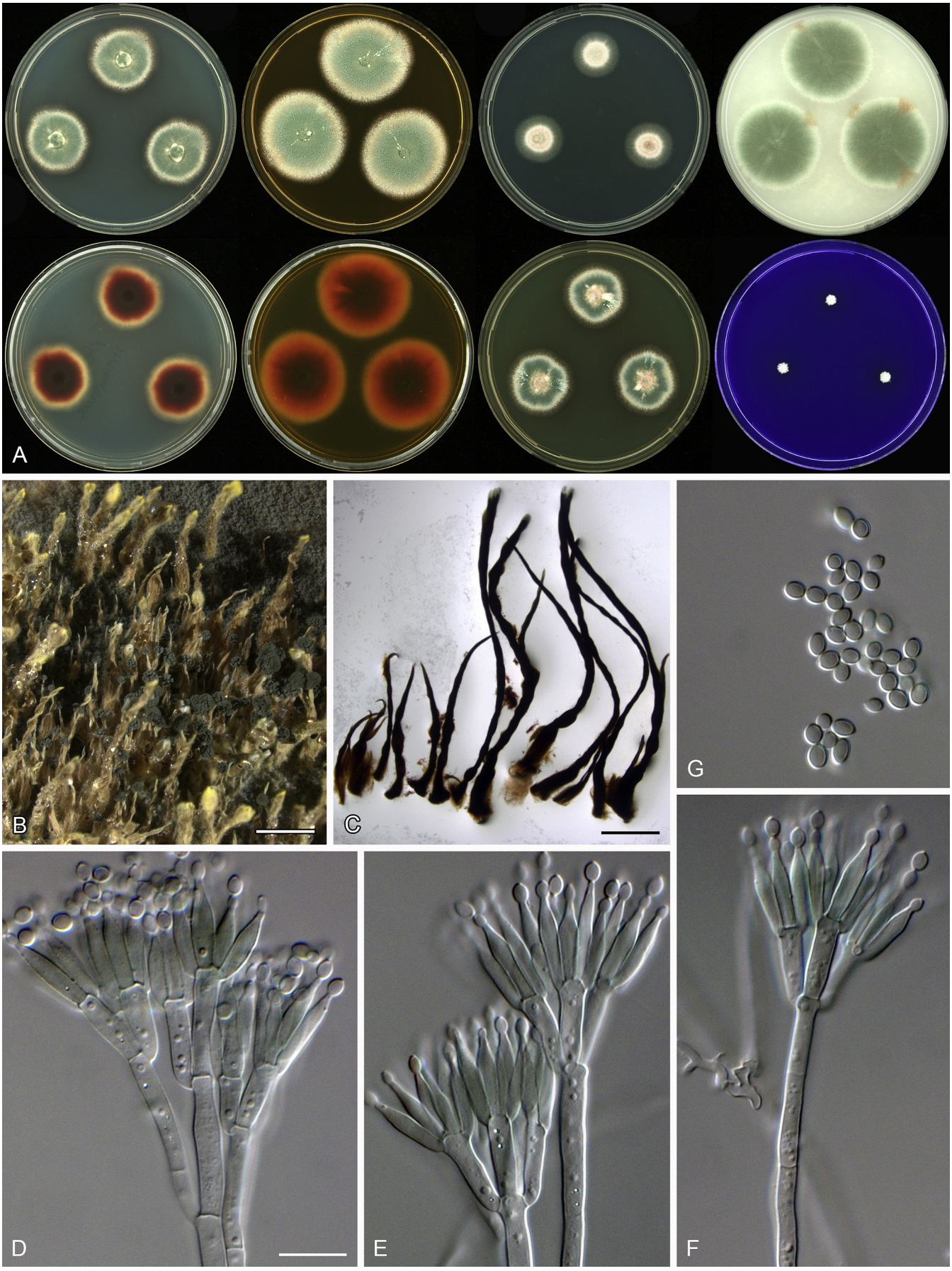

Fig. 59. Morphological characters of *Talaromyces pseudostromaticus* (CBS 470.70^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–F. Conidiophores. G. 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 pseudostromaticus* produces mitorubrinic acid and secalonic acid D (Samson *et al.* 1989). It also produces a *Monascus* red pigment (azaphilone).

Distinguishing characters: *Talaromyces pseudostromaticus* grows relatively fast on general media, but does not grow on CYA at 37 °C. It produces reddish brown to dark brown reverses on general media (Fig. 59). After 2–3 wk of incubation, it produces determinate, phototropic synnemata up to 8 000 µm long. These characters easily distinguish *T. pseudostromaticus* from other synnemata producers.

Talaromyces ptychoconidium Visagie & K. Jacobs, Persoonia 28: 18. 2012. MycoBank MB564327. Fig. 60.

In: *Talaromyces* section *Purpurei*

Typus: PREM 60041, culture ex-type DAOM 241017 = CV 2808 = DTO 180-E7.

ITS barcode: FJ160266 (alternative markers: *BenA* = GU385733; *CaM* = JX140701; *RPB2* = KM023278)

Colony diam, 7 d (mm): CYA 8–16; CYA 30 °C 15–20; CYA 37 °C 5–12; MEA 12–23; MEA 30 °C 30–35; DG18 6–12; CYAS No growth; OA 18–30; CREA No growth; YES 8–16.

Colony characters: CYA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture loosely funiculose, abundant aerial hyphae produced at colony centre; sporulation sparse, conidia *en masse* greyish green (30D4–30E4); soluble pigments absent; exudates very small clear droplets; reverse centre light brown (5D4) fading into light yellow (3A5). MEA 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire (1–2 mm); mycelia white; texture loosely funiculose and especially in the centre conidiophores born from sterile aerial hyphae; sporulation sparse to moderately dense, conidia *en masse* dull green (26E4); soluble pigments absent; exudates slimy, clear and yellow droplets; reverse centre raw umber (5F8) and the rest brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies low, slightly radially sulcate; margins low, narrow, entire (1 mm); mycelia white; texture loosely funiculose and especially in the centre conidiophores born from sterile aerial hyphae; sporulation sparse to moderately dense, conidia *en masse* dull green (26E4); soluble pigments absent; exudates small, clear droplets; reverse centre olive (2F5) fading into pastel yellow (2A4). DG18 25 °C, 7 d: Colonies slightly raised in the centre, plane; margins low, narrow, entire; mycelia white; sporulation absent to sparse (difficult to determine); soluble pigments absent; exudates clear and yellow droplets; reverse light yellow (4A5). OA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (3–6 mm); mycelia yellow and white; texture velvety and loosely floccose especially in the centre conidiophores born from aerial mycelia; sporulation moderately dense to dense, conidia *en masse* dull green to dark (26E6–26F6); soluble pigments absent; exudates small clear droplets; reverse light pale brown. CREA 25 °C, 7 d: No growth.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, green pigmented, 40–95 × 2.5–3.5 µm; metulae three to six, divergent, 10–12.5 × 2–2.5 µm; phialides acerose, three to six per metulae, 10–12 × 2–2.5 µm; conidia rough with spiral ridges, ellipsoidal to apiculate, 3–4.5(–5) × 2–3 µm. Ascomata not observed.

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* = JN121522)

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 germinating but sterile. MEA 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire (2 mm); mycelia white in the margins, red in the centre; colony is red appearance; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse reddish brown to dark brown (8F8–9F8). YES 25 °C, 7 d: Colonies germinating but sterile. DG18 25 °C, 7 d: Colonies germinating but sterile. OA 25 °C, 7 d: Colonies low, plane;

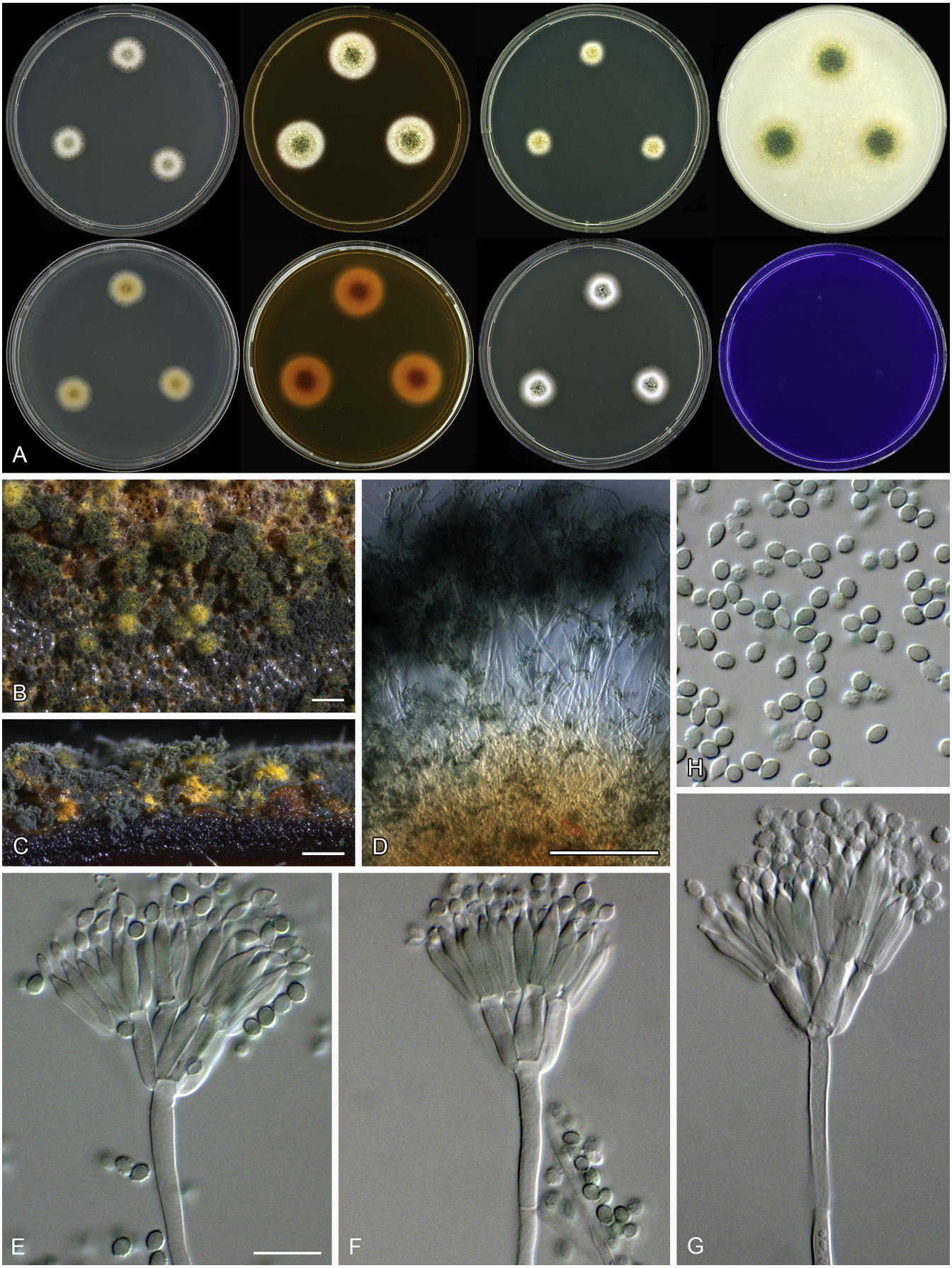

Fig. 60. Morphological characters of *Talaromyces ptychoconidium* (DAOM 241017^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B, C. Colony texture on MEA after 2 wk incubation. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 µm; D = 100 µm; E = 10 µm, applies to F–H.

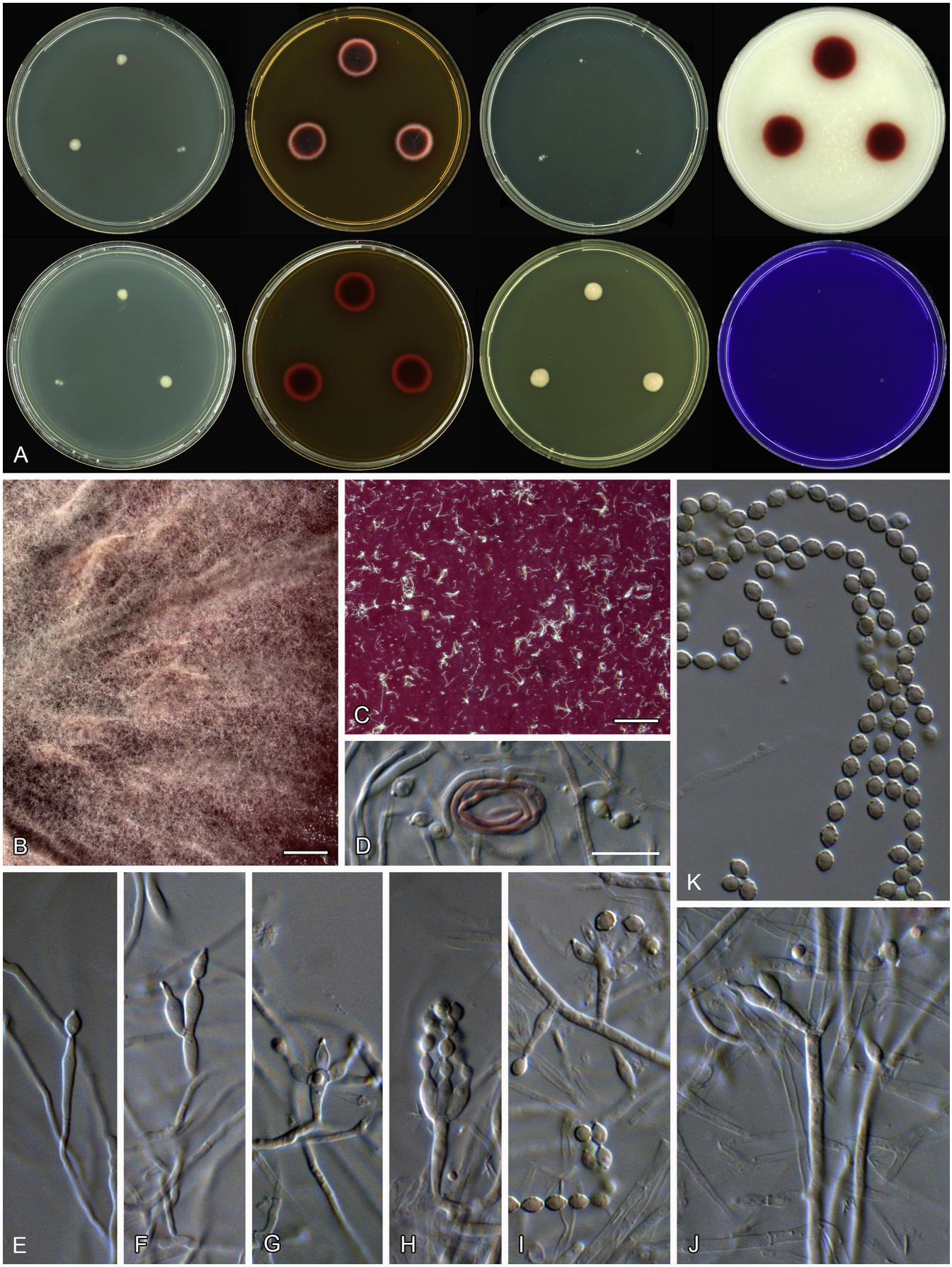

Fig. 61. Morphological characters of *Talaromyces purpureus* (CBS 475.71^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C. Colony texture on OA after 2 wk incubation. D. Initials. E–J. Conidiophores. K. Conidia. Scale bars: B = 500 µm; C = 100 µm; D = 10 µm, applies to E–K.

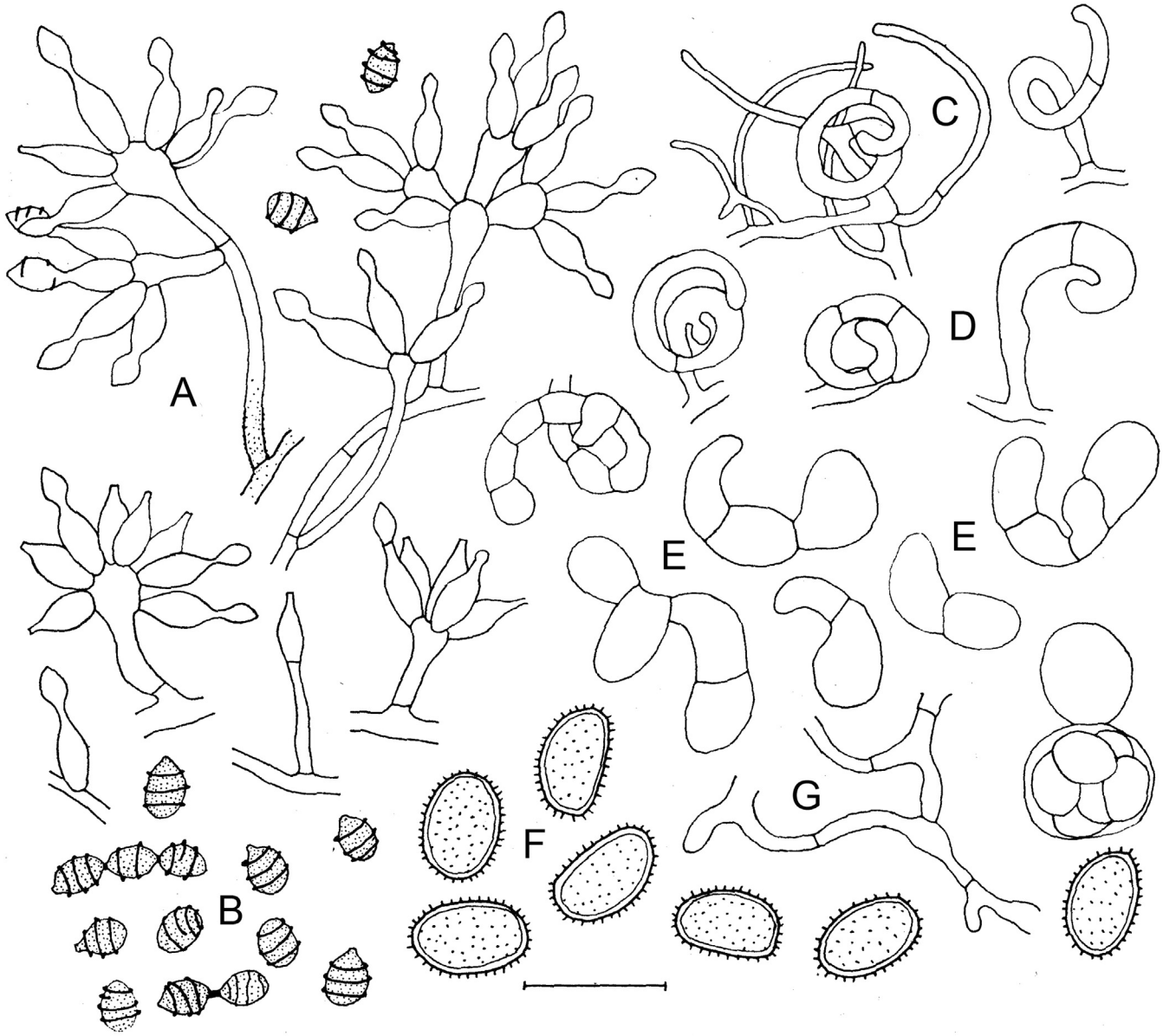

Fig. 62. Micromorphological characters of *Talaromyces purpureus* (CBS 475.71^T) from Stolk & Samson (1972). A. Conidiogenous structures. B. Conidia. C. Initials surrounded by thin hyphae. D. Initials. E. Asci produced in chains. F. Ascospores. G. Loosely branched hyphae covering ascoma. Scale bar 10 µm.

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 *fide* Stolk & Samson (1972) maturing after 3 wk of incubation on MEA at 30 °C, yellow, globose to subglobose 20–60 µm, asci 9–12 µm, ascospores ellipsoidal, thick walled, spiny over their entire surface, 6.5–8 × 4.5–5.5 µm.

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)

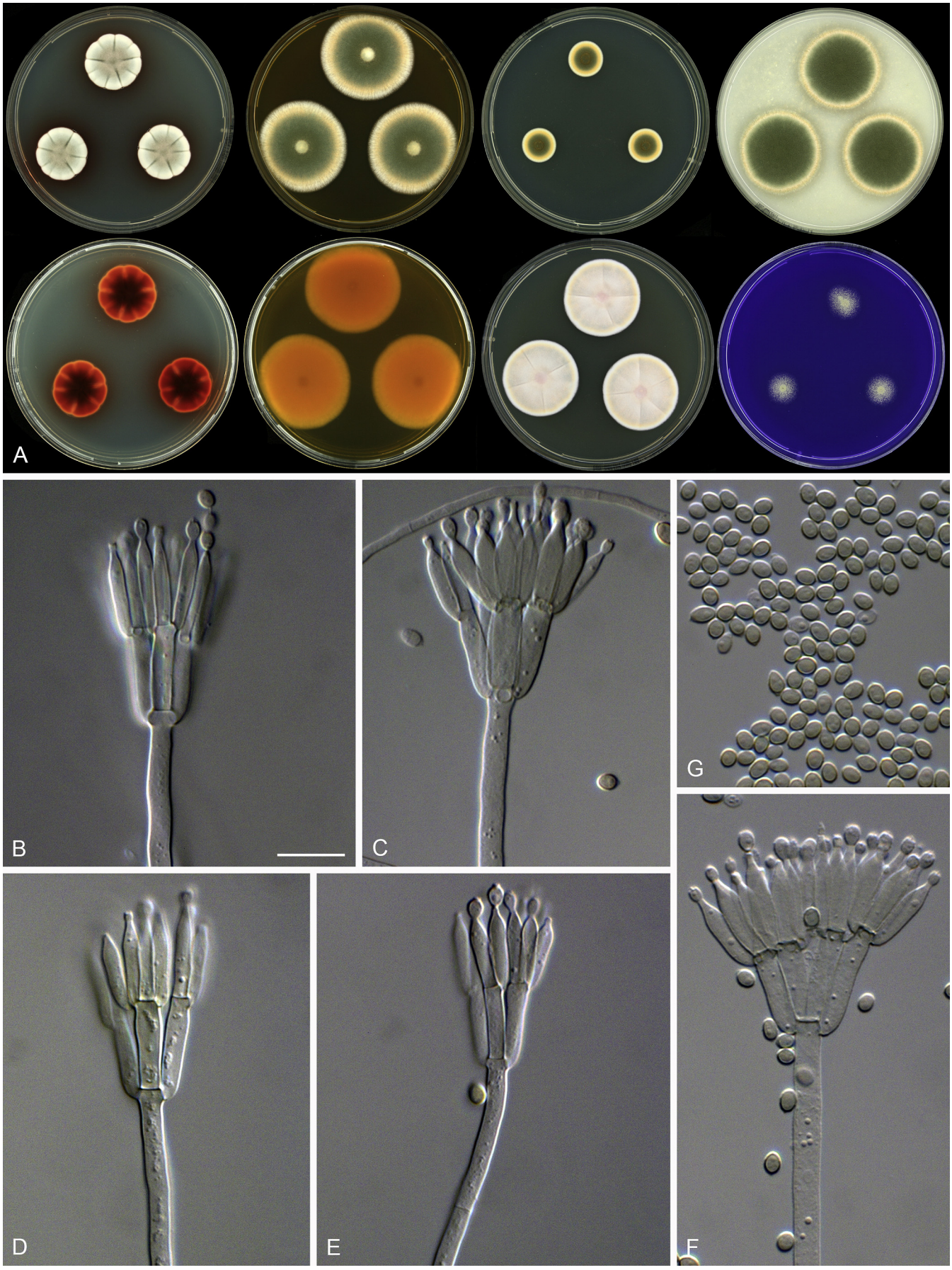

Fig. 63. Morphological characters of *Talaromyces purpurogenus* (CBS 132707). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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 (4A5), 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 to 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 biverticillate; 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 × 2–2.5 µm. Ascomata not observed.

Extrolites: *Talaromyces purpurogenus* produces rugulovasine A & B, rubratoxin A & B, spiculisporic acid, mitorubrin, mitorubrinic acid, mitorubrinol, 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 biverticillate 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 biverticillate 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*

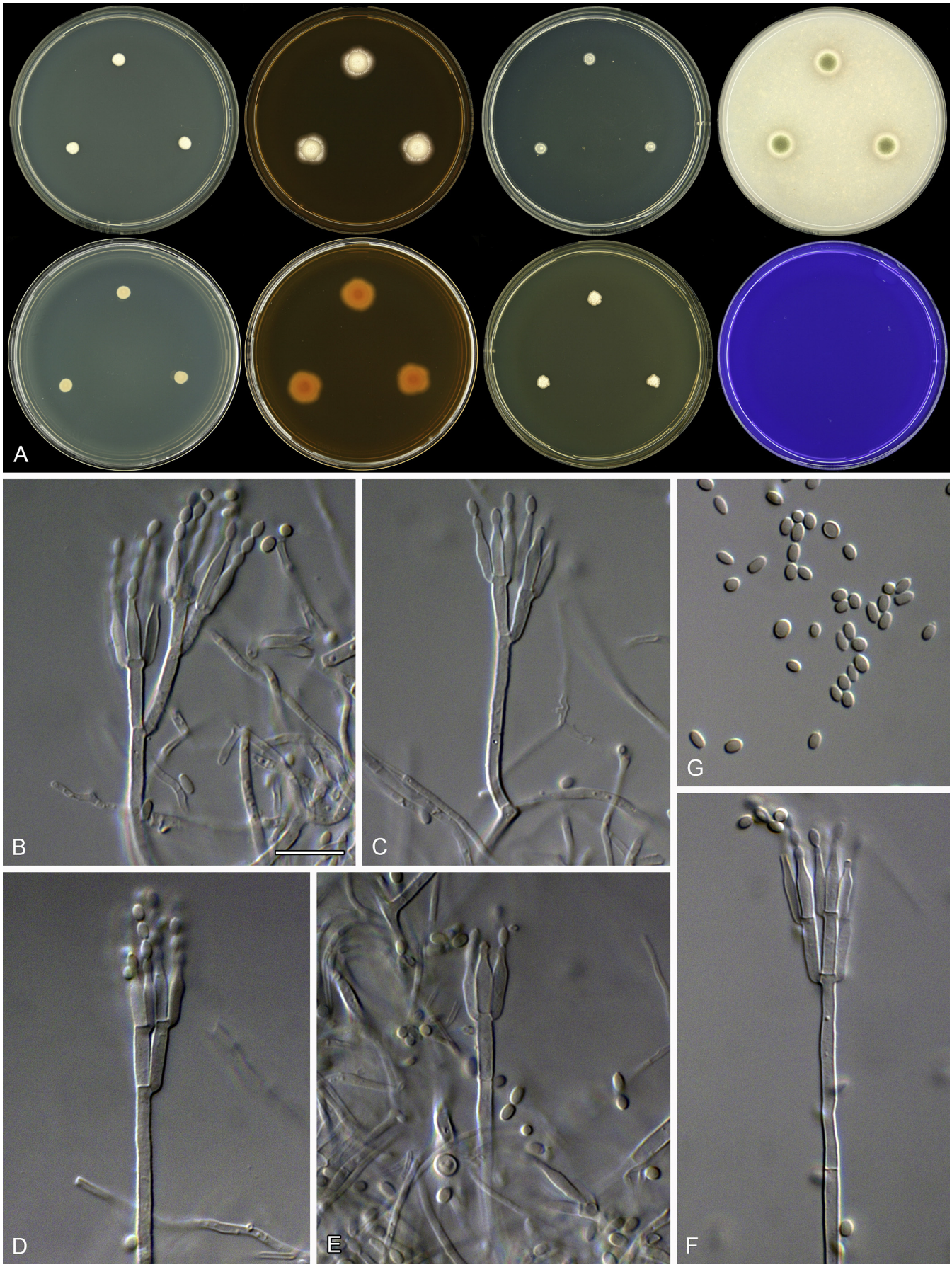

Fig. 64. Morphological characters of *Talaromyces rademirici* (CBS 140.84^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

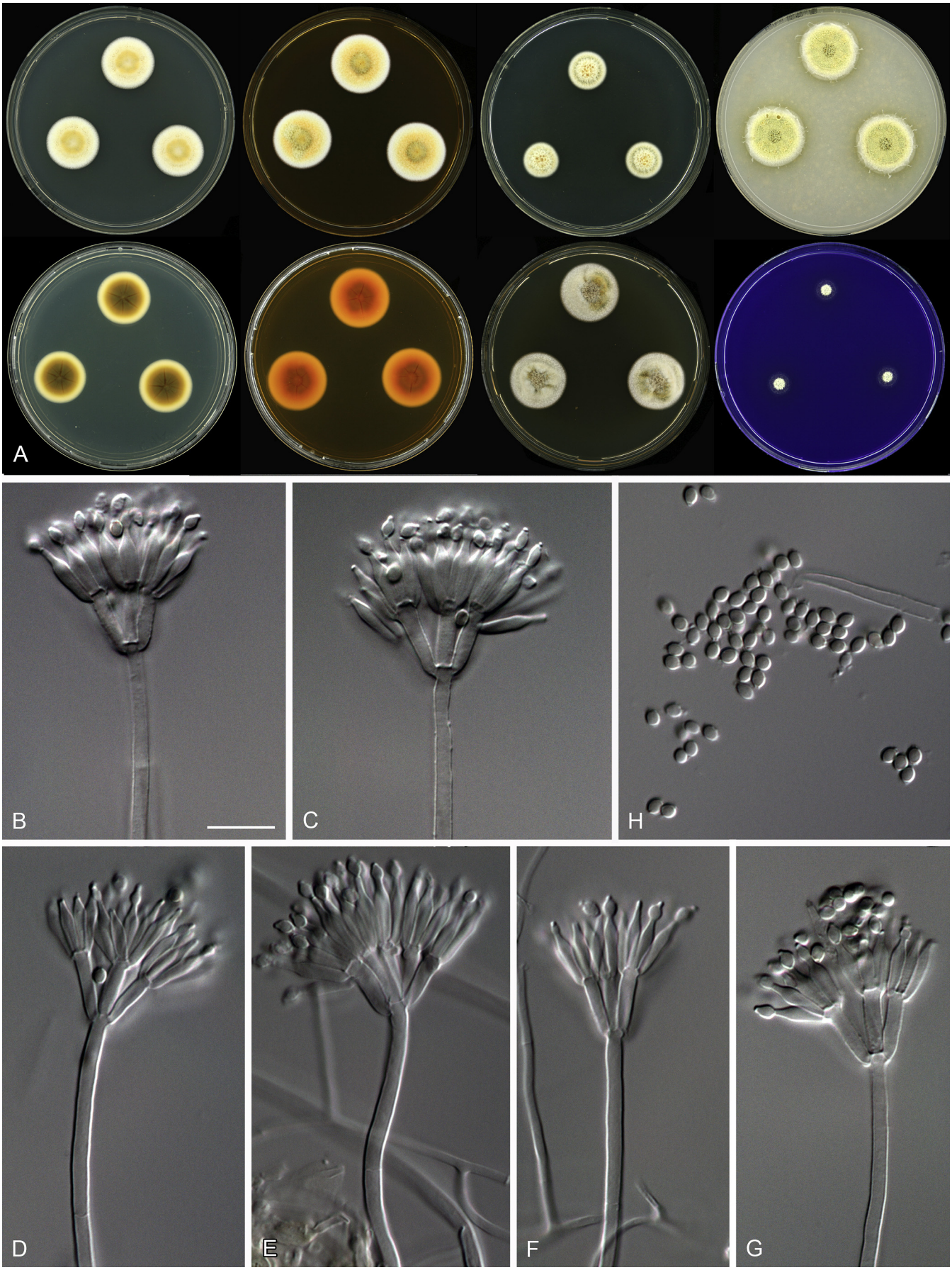

Fig. 65. Morphological characters of *Talaromyces radicus* (CBS 100489^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 µm, applies to C–H.

Typus: DAR 72374, culture ex-type CBS 100489 = FRR 4718 = IBT 14379.

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

Colony 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; CYAS 14–20; OA 15–22; CREA 4–8; YES 22–25.

Colony morphology: CYA 25 °C, 7 d: Colonies low, slightly sulcate; 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); exudates 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 sulcate; 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) exudates in some colonies clear small droplets; soluble pigment absent; reverse yellowish brown (5F5) centre. YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; 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); exudates 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); exudates 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); exudates 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 biverticillate with a minor proportion 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 acerose, 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-mitorubrin, 4′-hydroxy-3′-methoxy-(S)-mitorubrin and monomethyl-(S)-mitorubrin in agreement with Yamazaki *et al.* (2010b). Furthermore CBS 137382 produced traces of one of the ukulactones. 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-mitorubrin is a potentiator 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. Phylogenetically 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* = KM023281)

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

In: *Talaromyces* section *Purpurei*

Colony 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; CYAS 15–18; OA 40–45; CREA 10–14; YES 40–43.

Colony characters: CYA 25 °C, 7 d: Colonies low, slightly raised at centre, radially sulcate; margins low, plane, entire (3–5 mm); mycelia white and in some isolates orange to red; texture funiculose and floccose; sporulation sparse to moderately dense, conidia *en masse* greyish green (25D5–25E5); soluble pigments absent; exudates 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); mycelia 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; exudates 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 sulcate; margins low, narrow, entire (3 mm); mycelia white and in some isolates orange red centre; texture floccose and funiculose; sporulation sparse to moderately dense, conidia *en masse* greyish green to dark green (26E5–26F5); soluble pigments absent; exudates 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); mycelia 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; exudates 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); mycelia white, especially in the centre synnemata like aerial hyphae growing, and there is an exudate in the centre makes a structure like synnemata; texture velvety and funiculose; sporulation dense, conidia *en masse* greyish green to dark green (26E5–26F5);

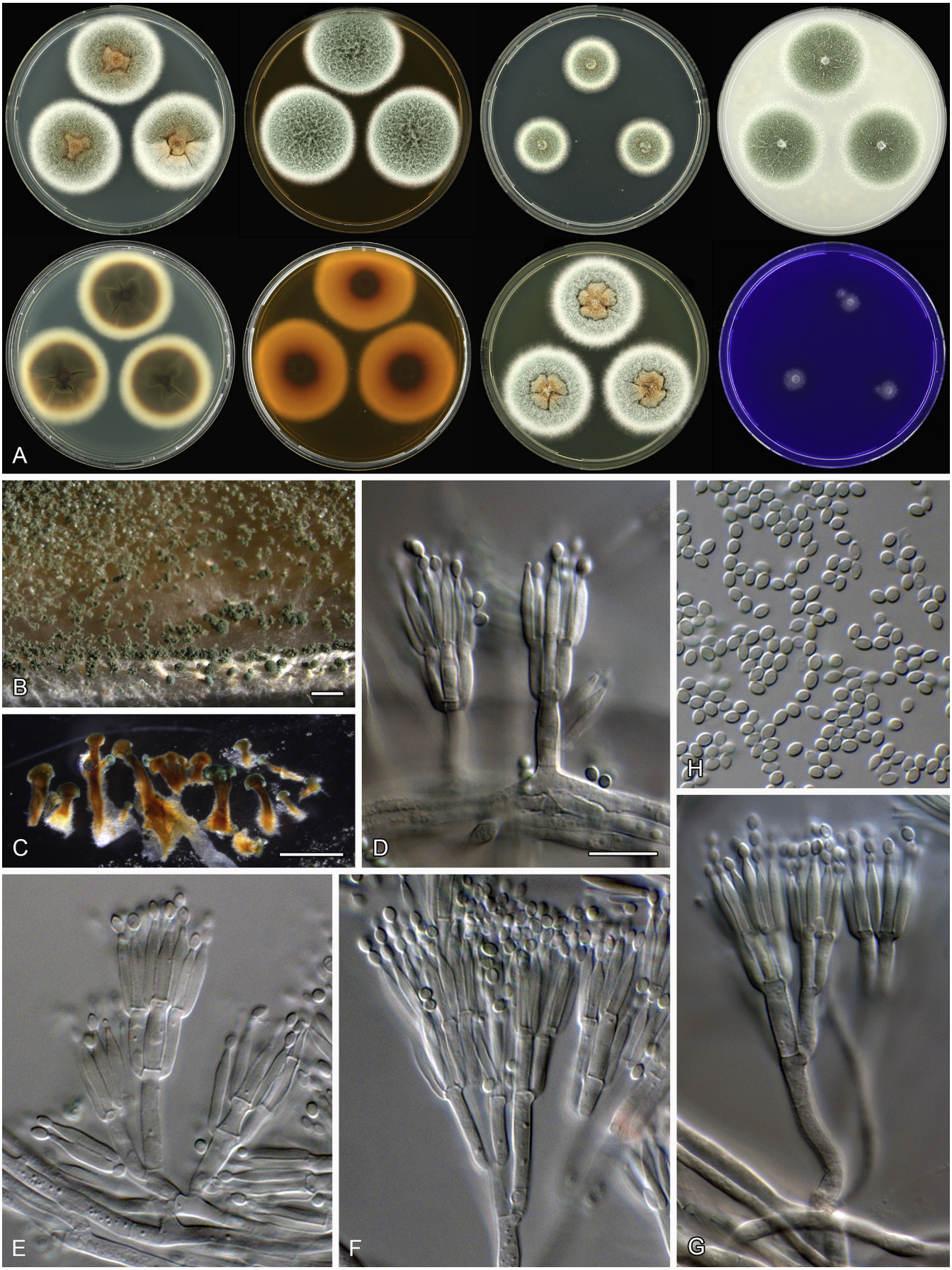

Fig. 66. Morphological characters of *Talaromyces ramulosus* (DAOM 241660^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 3 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. 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*. However, the latter two species produce longer synnemata. *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. stollii*. 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 sphaerum* Pitt, Gen. Penicil.: 494. 1980.

In: *Talaromyces* section *Islandici*

Typus: IMI 040589, culture ex-typus CBS 369.48 = IMI 040589 = NRRL 2107 = FRR 2107 = ATCC 10493 = IBT 4829.

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, sulcate; 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 sulcate; 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, sunked at centre, sulcate; 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, sulcate; margins low, plane, entire (<1 mm); mycelia white; texture yeast like slimy hyphae; sporulation absent; soluble pigments absent; exudate 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 × 4–5.5 µm.

Extrolites: *Talaromyces rotundus* produces emodin, rugulosin and an extrolite 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 ascoma 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.

Talaromyces ruber (Stoll) Yilmaz *et al.*, Persoonia 29: 48. 2012. MycoBank MB801360. Fig. 68.

≡ *Penicillium rubrum* Stoll, Beitr. Morph. Biol. Char. Penicill.: 35. 1904.

In: *Talaromyces* section *Talaromyces*

Typus: CBS H-21052, culture ex-type CBS 132704 = DTO 193-H6 = IBT 10703 = CBS 113137.

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, sulcate; 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 (8E8–8F8). 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, sulcate; 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;

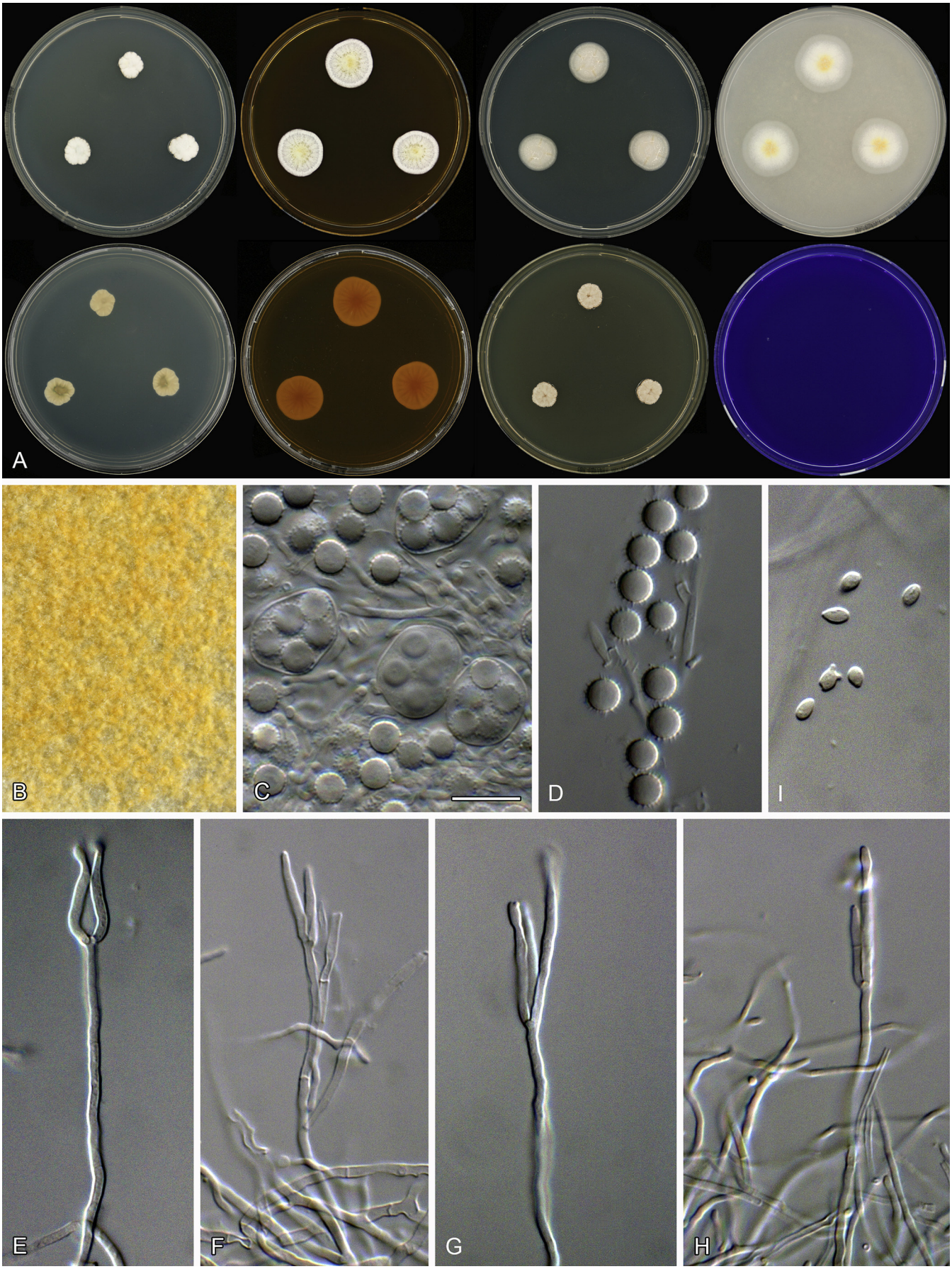

Fig. 67. Morphological characters of *Talaromyces rotundus* (CBS 369.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Texture an ascomata on OA after 2 wk incubation. C. Asci and ascospores. D. Ascospores. E–H. Conidiophores. I. Conidia. Scale bar: C = 10 µm, applies to D–I.

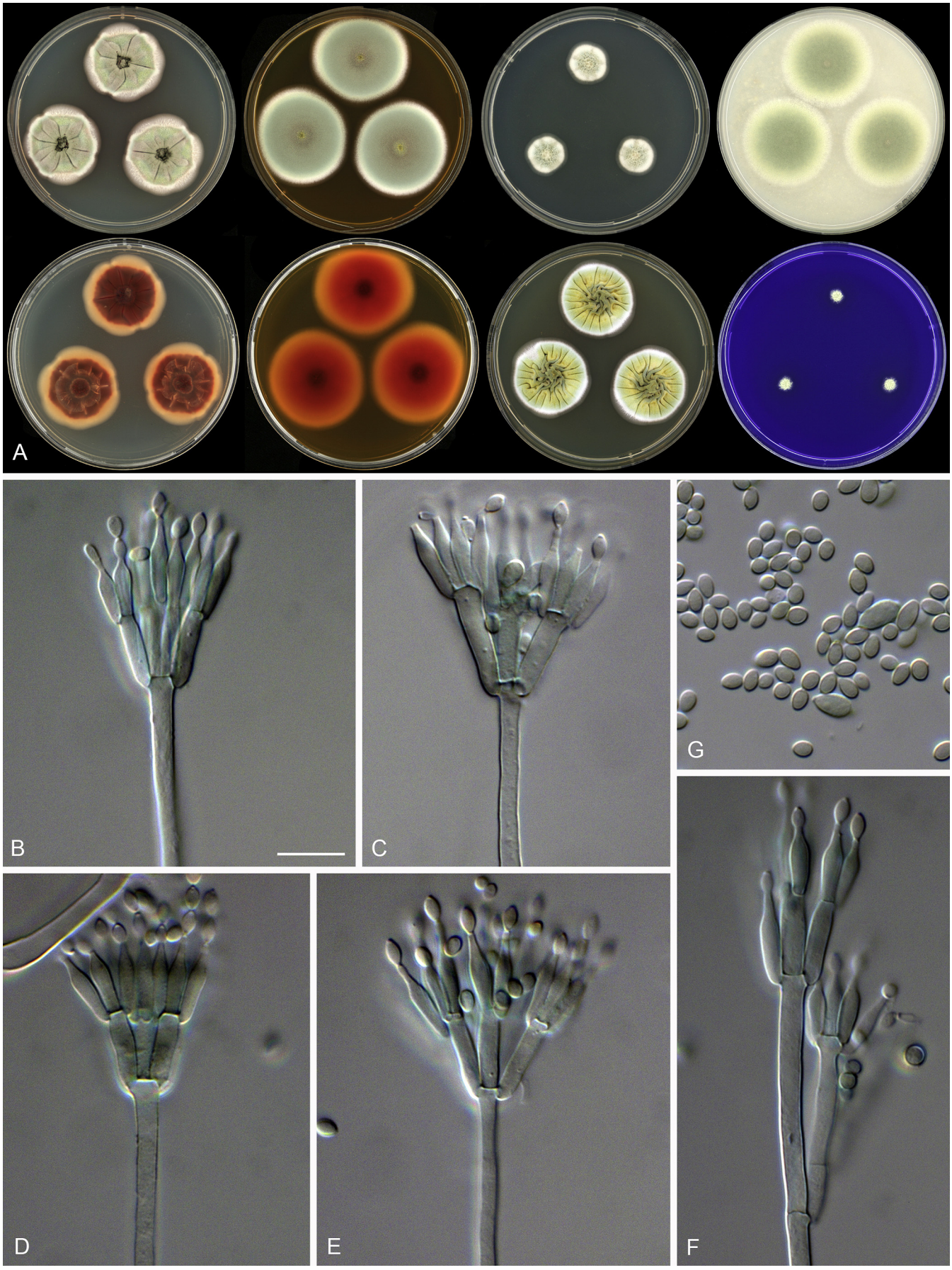

Fig. 68. Morphological characters of *Talaromyces ruber* (CBS 132704^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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* dull green (27D4); soluble pigments generally absent in some isolates orange soluble pigments around colony; exudates absent; 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.

Extrolites: *Talaromyces ruber* produces austin, berkelic acid, mitorubrin, mitorubrinic acid, *Monascus* red azaphilone pigments (not diffusing into agar), pestalacin A, a purpactin and vermicillin (Yilmaz *et al.* 2012).

Distinguishing characters: *Talaromyces ruber* grows rapidly on general media, produces red colony reverses and velvety texture on MEA (Fig. 68). These characters distinguish *T. ruber* from other species.

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)

Colony 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.

Colony characters: CYA 25 °C, 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 clear droplets; reverse coffee brown (5F7) centre fading into brownish orange (6C6). 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. aurantiacus* as synonyms of *T. funiculosus*. However, *T. funiculosus* 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. aurantiacus* 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 1901).
≡ *Penicillium rugulosum* Thom, U.S.D.A. Bur. Animal Industr. Bull. 118: 60. 1910.
= *Penicillium chrysitis* Biourge, 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)

Colony 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.

Colony 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, DTO 180-A4, DTO 254-A2, DTO 179-I3, DTO 278-E9) and in some pale light orange (14A2);

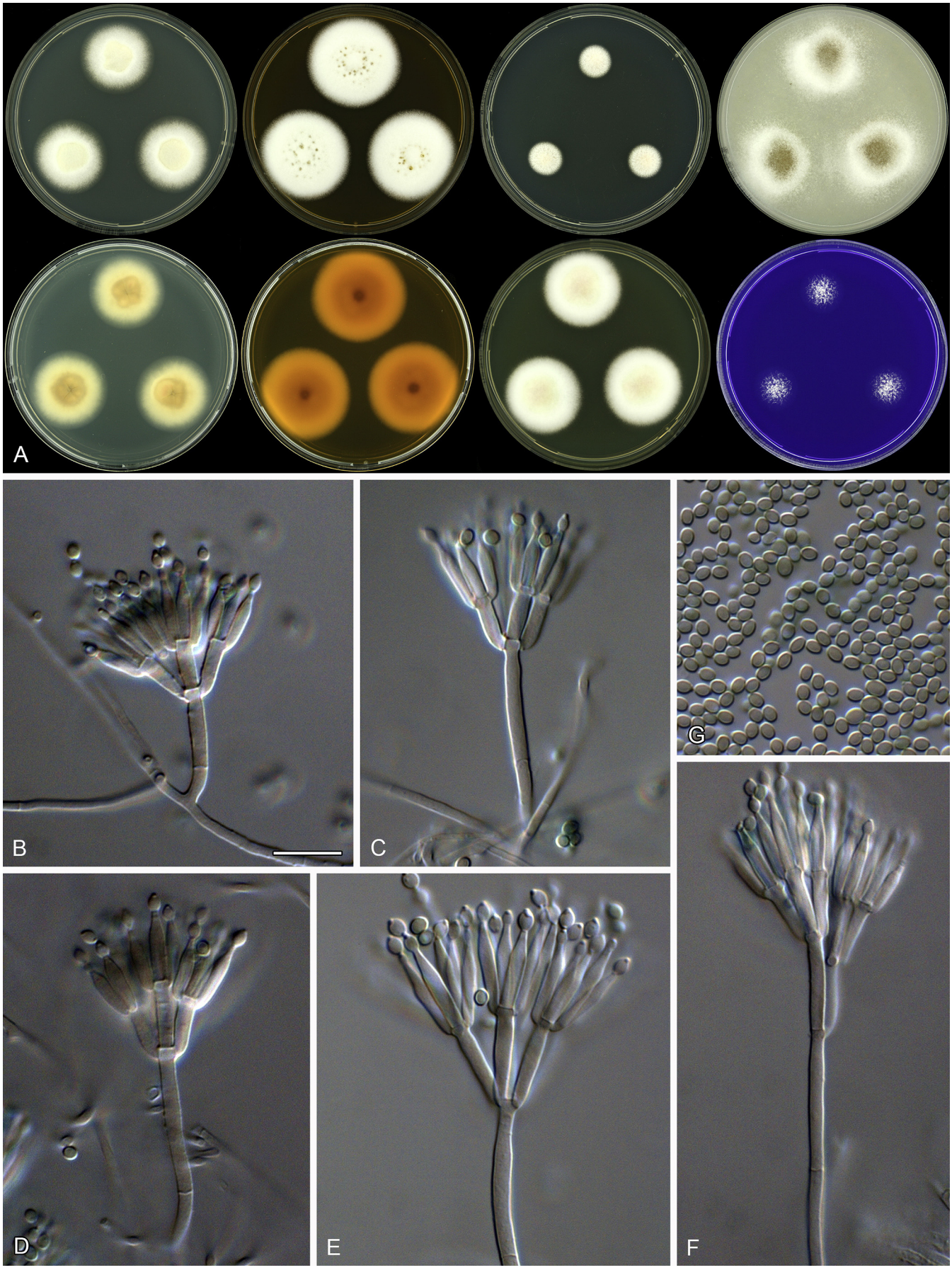

Fig. 69. Morphological characters of *Talaromyces rubicundus* (CBS 342.59^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

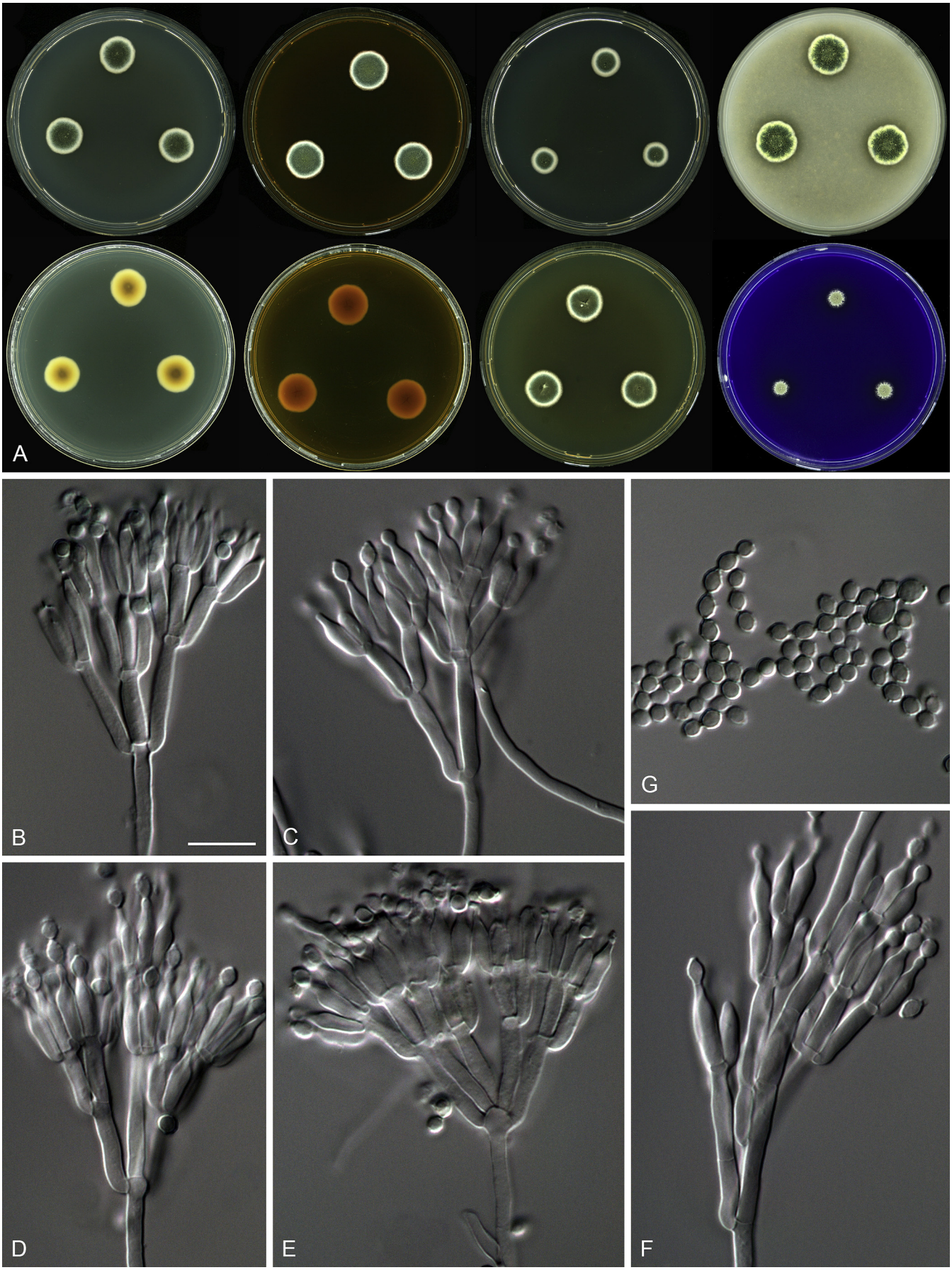

Fig. 70. Morphological characters of *Talaromyces rugulosus* (DTO 180-A4). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

texture velvety; sporulation dense; conidia *en masse* dull green to dark green (26E4–26F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E4–5F4) fading into light yellow to greyish yellow (2A5–2B5 to 1A5–1B5). MEA 25 °C, 7 d: Colonies low, plane; margins narrow (1 mm), low, entire, plane; mycelium in margins white, in centre aerial yellow; texture velvety; sporulation dense; conidia *en masse* dull green to dark green (26E4–26F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E6–6E6). YES 25 °C, 7 d: Colonies, slightly raised at centre, some isolates crateriforme and some isolates slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium generally only white, in some isolates in 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 (26E4–26F4); exudates absent; soluble pigment absent; reverse centre orange (6B7–6B8) fading into pastel yellow to 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 sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white; texture velvety; sporulation dense; conidia *en masse* dull green to dark green (26E4–26F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E4–5F4) 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 (26E4–26F4); exudates clear, yellow and orange droplets; soluble pigment absent; reverse yellowish green and in some isolates brownish orange centre. CREA, 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 flask-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, endocrocin 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 synonomous 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 ascomata 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 ascomata, 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); ascomata 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, usulally rough sometimes smooth, cylindrical to fusiform, ellipsoidal or ovoidal, 3.5–12(–15) × 2.5–3.5 µm. Ascomata ripening within 2 to 3 wk, deep reddish, globose to subglobose, 80–350 µm in diam; asci 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 (4A5). 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 × 2–2.5.

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; *RPB2* = 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 yellowish 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 (3E5–3F5). DG18 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 (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 to floccose; conidia *en masse* greyish green (29D4–29E4); exudates absent (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.

Extrolites: *Talaromyces scorteus* produced mitorubrin 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

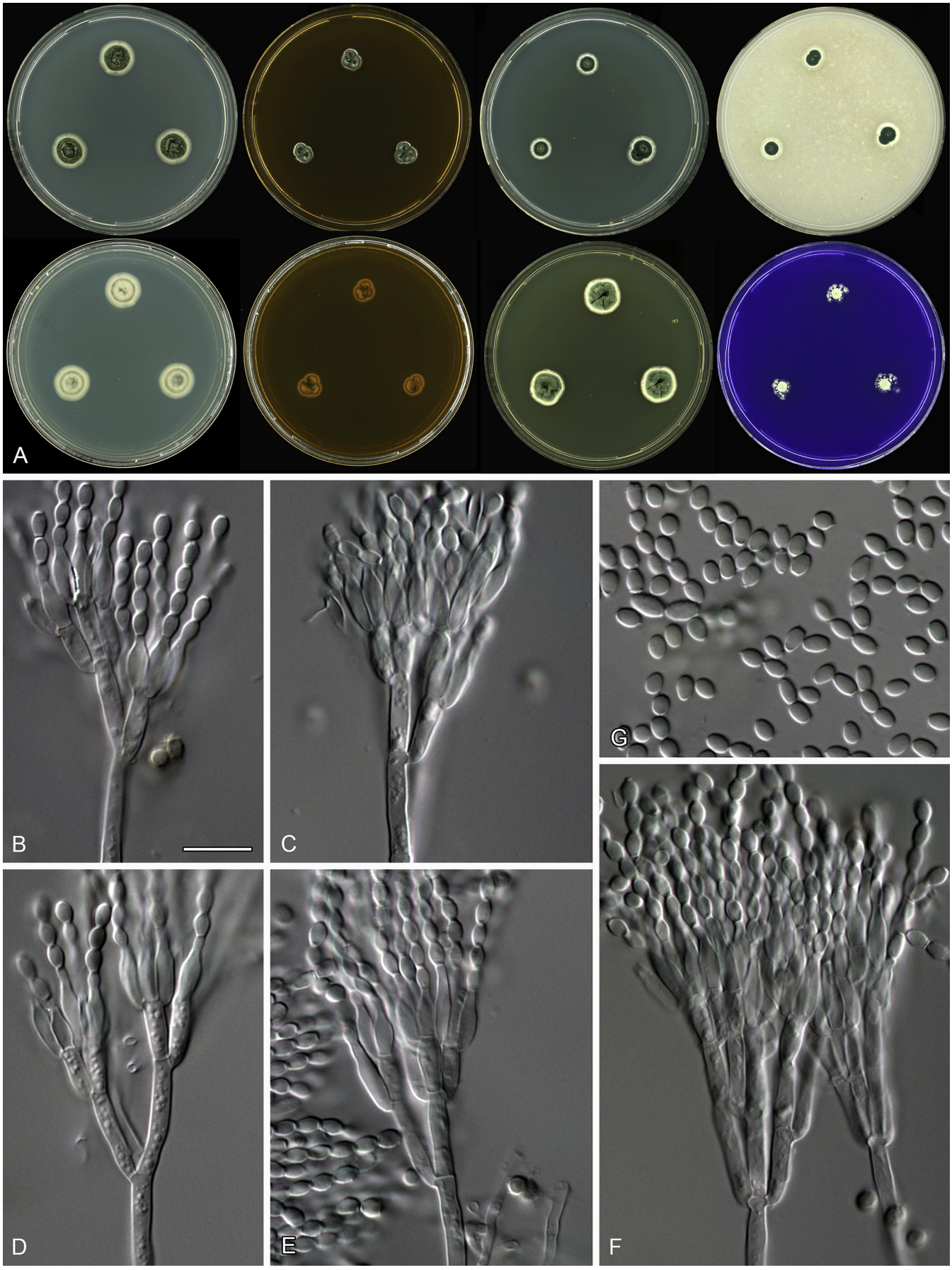

Fig. 71. Morphological characters of *Talaromyces scorteus* (CBS 233.60). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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. phialosporus* (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.

≡ *Penicillium 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; *RPB2* = 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 blond to greyish yellow (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 1988). *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 compare 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 DAOM 241015 = CV 2800 = CBS 133445 = DTO 180-D4.

ITS barcode: FJ160264 (alternative markers: *BenA* = GU385731; *CaM* = KJ885279; *RPB2* = 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, entire (1 mm); mycelia white and red; texture floccose; sporulation sparse, conidia *en masse* greyish green (25C5); soluble pigments absent; exudates clear 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 (5A2). 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 subglobose, 2–3.5 × 2–2.5 µm. Ascomata not observed.

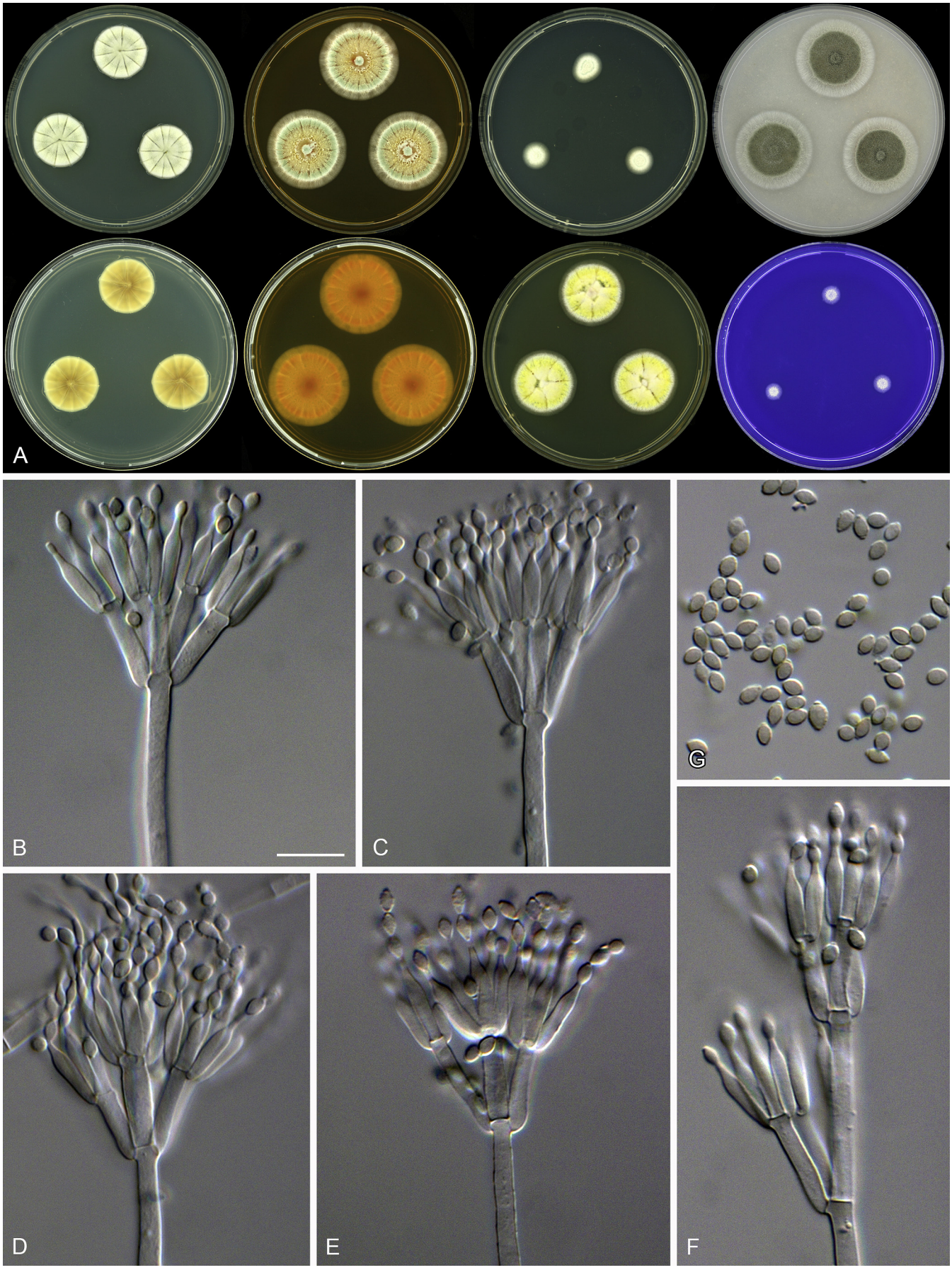

Fig. 72. Morphological characters of *Talaromyces siamensis* (CBS 475.88^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

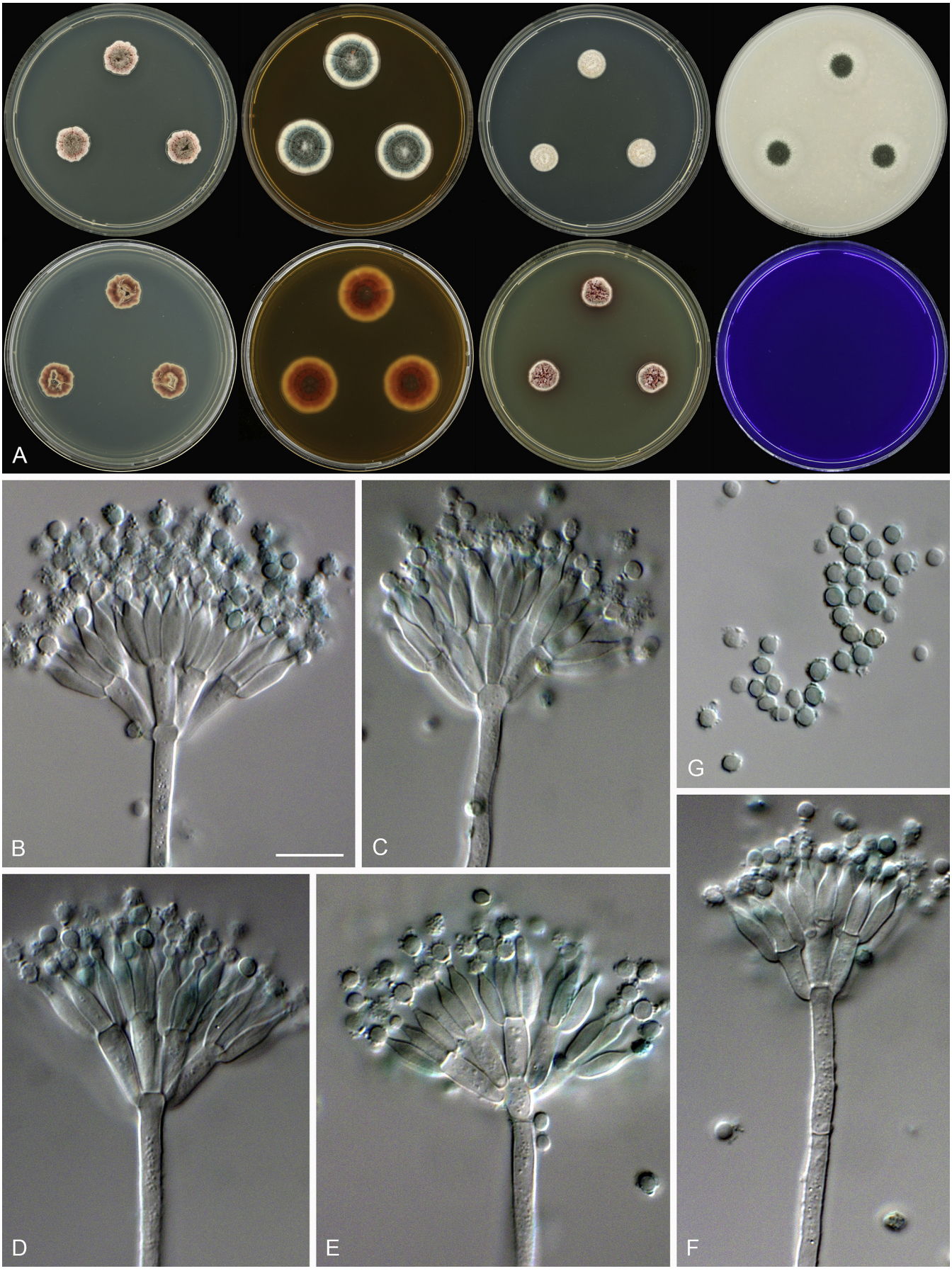

Fig. 73. Morphological characters of *Talaromyces solicola* (CBS 133445^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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. verruculosus*, *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; *CaM* = KF741957; *RPB2* = 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 light yellow ascomata (at 30 °C more abundant); margins low, plane, entire (2–3 mm); mycelia light 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 (4A7). 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 (30D5); 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 white; 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-epiaustdiol, 8-methoxy-epiaustdiol, duclauxin (Kuhr *et al.* 1973), compounds related to glauconic acid or rubratoxins, secalonic acid A, skyrin, stipitalide, stipitatic acid, stipitatonic 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; *CaM* = JX315646; *RPB2* = 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, conidia *en masse* 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 masse* 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 masse* 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

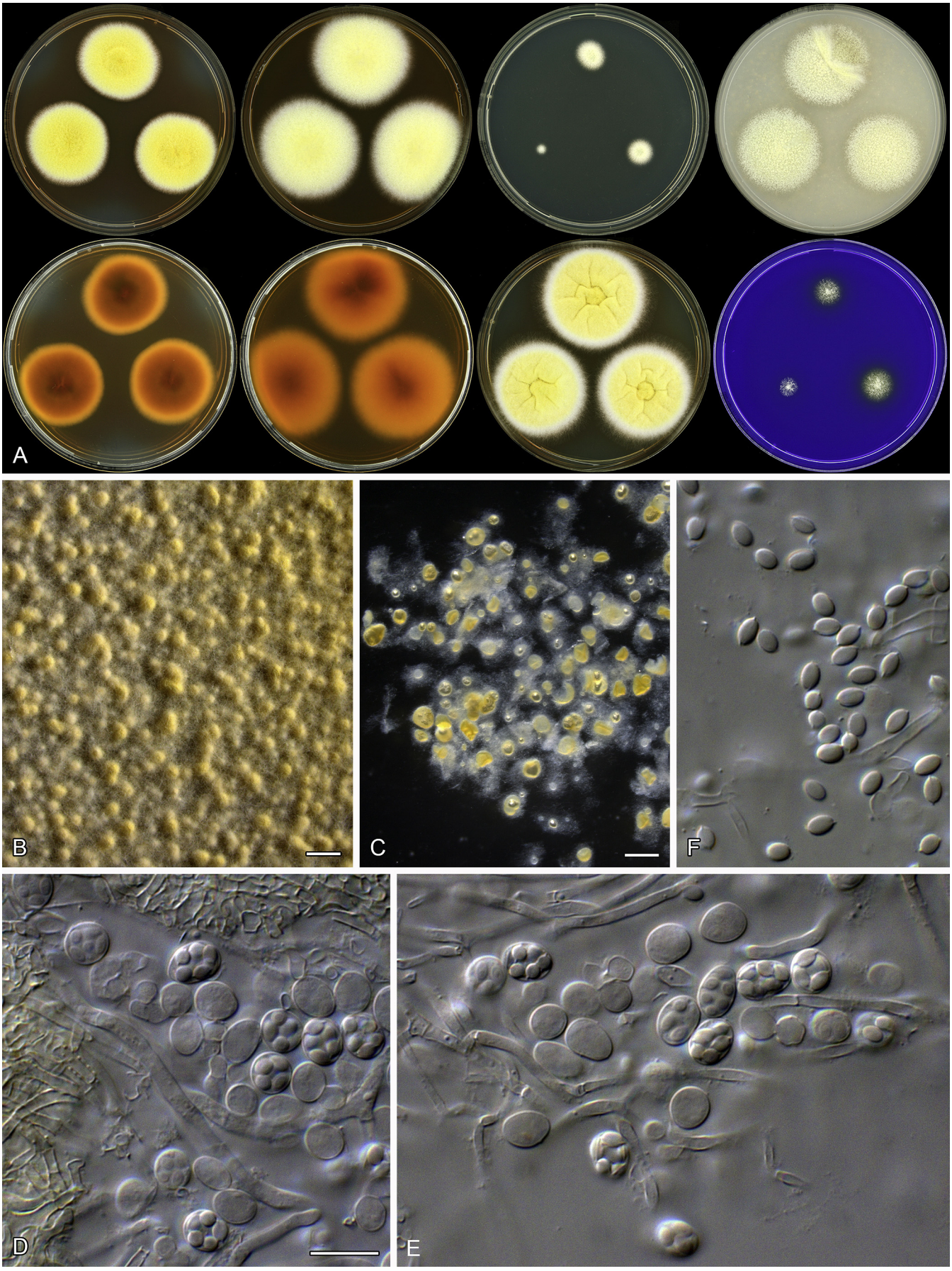

Fig. 74. Morphological characters of *Talaromyces stipitatus* (CBS 236.60). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D, E. Asci and ascospores. F. Ascospores. Scale bars: B = 1000 µm; C = 500 µm; D = 10 µm, applies to E, F.

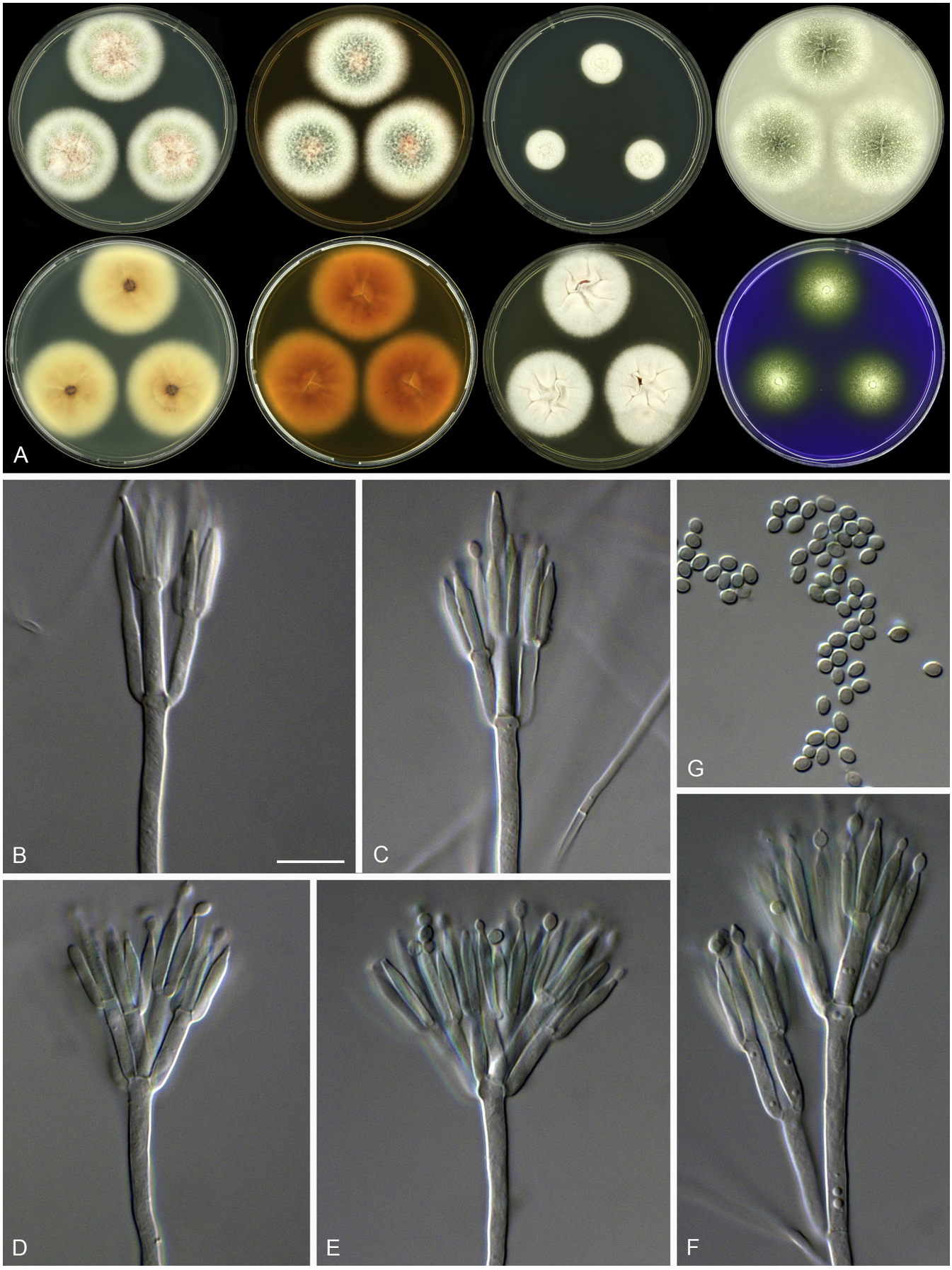

Fig. 75. Morphological characters of *Talaromyces stollii* (CBS 408.93^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

from aerial hyphae and overgrowing the ascomata, stipes 90–250 × 3–4.5 µm; metulae three to five, divergent 11–15 × 2–3.5 µm; phialides acerose, three to six per metulae, 13–17 × 2.0–2.5 µm; conidia, smooth to finely rough, ellipsoidal, 2.5–4 × 2–2.5 µm.

Extrolites: *Talaromyces stollii* produces austins (Yilmaz *et al.* 2012).

Distinguishing characters: *Talaromyces stollii* is characterised by fast growth on general media and colonies with floccose or loosely funiculose textures on MEA, with white, yellow and red mycelia (Fig. 75). These characters resemble *T. angelicus*, *T. aculeatus*, *T. apiculatus*, *T. verruculosus*, *T. amestolkiae* and *T. pinophilus*. *Talaromyces aculeatus*, *T. apiculatus* and *T. verruculosus* produce rough-walled, globose conidia and flask-shaped phialides, which distinguish them from *Talaromyces stollii. Talaromyces angelicus* differs from *T. stollii* by the lack of acid production on CREA. *Talaromyces amestolkiae* produces red colony reverses on CYA and MEA, black sclerotioa after 2 wk of incubation and grows more restrictedly on CYA at 37 °C, when compared to *T. stollii*. *Talaromyces stollii* micro- and macromorphologically most closely resembles *T. pinophilus* and *T sayulitensis.* However, *T. stollii* grows slightly faster than both these species on CYA. Sequence data is, however, recommended for reliable identification.

Talaromyces subinflatus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 249. 1993. MycoBank MB361184. Fig. 76.

≡ *Penicillium subinflatum* Yaguchi & Udagawa, (simultaneously published).

In: *Talaromyces* section *Subinflati*

Typus: CBM PF-1113, culture ex-type CBS 652.95 = IBT 17520.

ITS barcode: JN899397 (alternative markers: *BenA* = KJ865737; *CaM* = KJ885280; *RPB2* = KM023308)

Colony diam, 7 d (mm): CYA 3–4; CYA 30 °C 3–4; CYA 37 °C No growth; MEA 14–15; MEA 30 °C 10–11; DG18 No growth; CYAS No growth; OA 13–15; CREA No growth; YES 3–4.

Colony characters: CYA 25 °C, 7 d: Colonies low, 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, plane, fluffy; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse centre is dark brown (6F5) fading into brownish orange (5B5–5B6). YES 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pastel yellow (3A4). DG18 25 °C, 7 d: Colonies No growth. OA 25 °C, 7 d: Colonies raised, plane, fluffy; margins low, plane, entire (<1 mm) it does not have the transparent zone; mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pale pastel yellow. CREA 25 °C, 7 d: No growth.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, 150–350 × 2–2.5 µm; metulae two to five, divergent, 7.5–10.5 × 2.5–3 µm; phialides acerose, two to five per metulae, 7.5–11 × 2–3 µm; conidia smooth, ellipsoidal to fusiform, 2.5–4 × 1.5–2 µm. Ascomata not observed in our culture however, *fide* Yaguchi *et al.* (1993) maturing after 2–3 wk of incubation, sulphur yellow, globose to subglobose, 300–480 µm, asci 7–9.5 × 6.5–8 µm, ascospores broadly ellipsoidal, spiny, 3–4(–5.5) × 2–3(–5) µm.

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 *Merimbla*-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 *Merimbla*-like conidiophores or ascomata.

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

≡ *Penicillium tardifaciens* 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 9–10 mm, slightly raised in the centre, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white; sporulation absent; exudates very small clear droplets; soluble pigment absent; reverse centre light orange (5A5–5A6) fading into greyish yellow (4C4). MEA, 25 °C, 7 d: Colonies 13–15 mm, slightly raised in the centre, plane; margins very narrow (1 mm), low, not entire, plane; mycelium white; texture floccose; sporulation absent; exudates absent; soluble pigment absent; reverse centre golden 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.

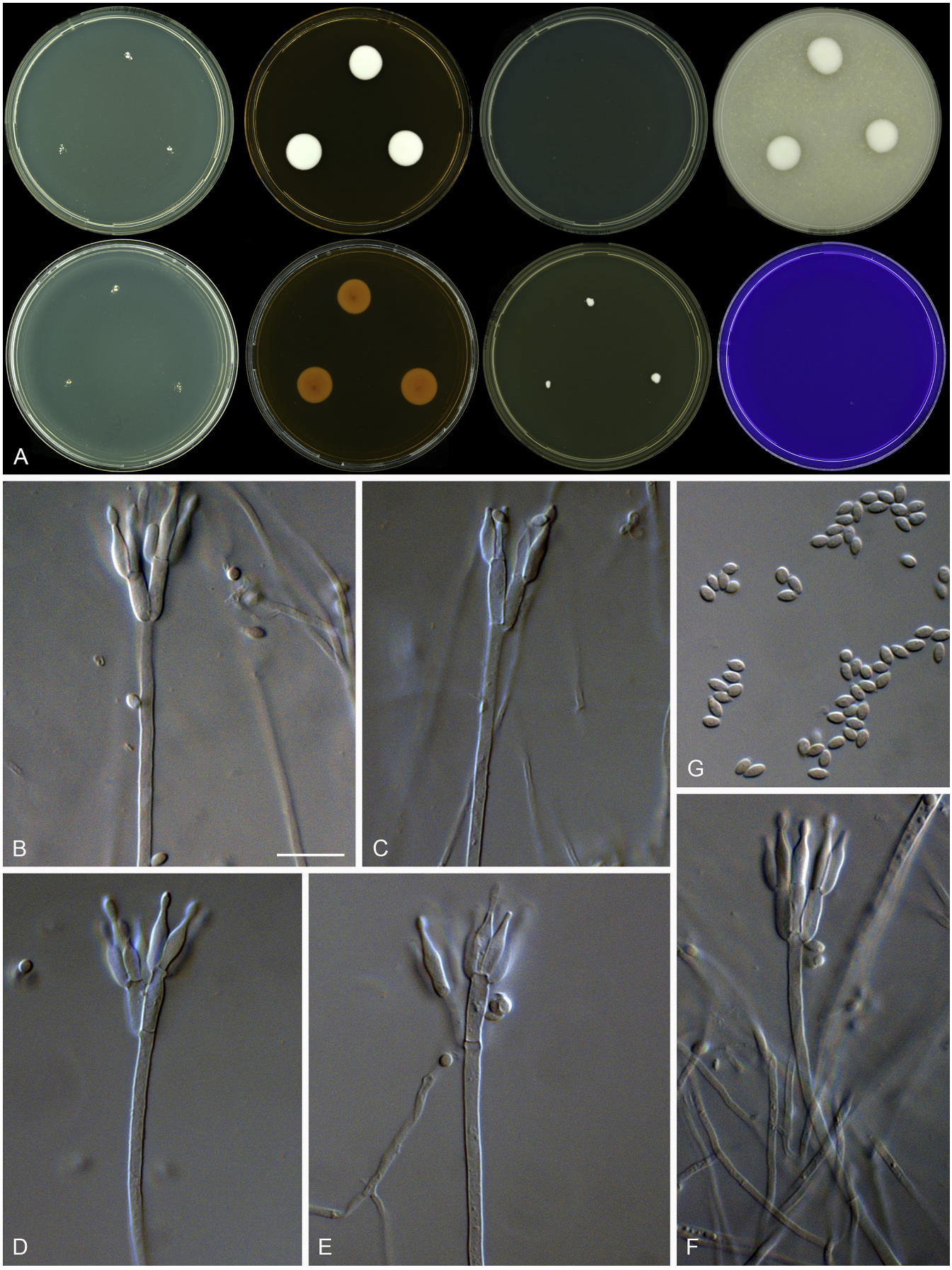

Fig. 76. Morphological characters of *Talaromyces subinflatus* (CBS 652.95^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

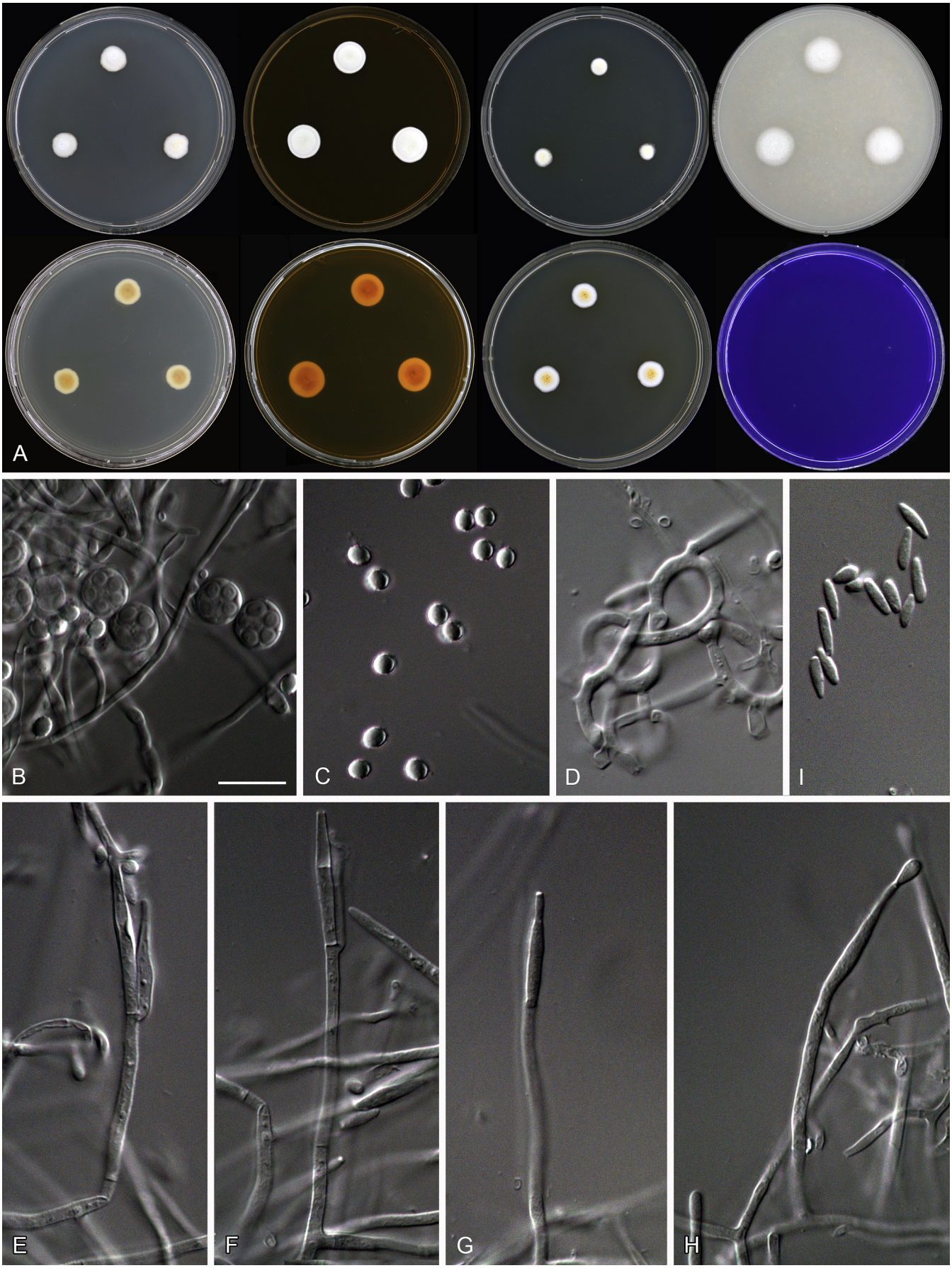

Fig. 77. Morphological characters of *Talaromyces tardifaciens* (CBS 250.94^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Asci. C. Ascospores. D. Initials. E–H. Conidiophores. I. Conidia. Scale bar: B = 10 µm, applies to 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. Asci broadly globose to ovoidal, 6–8 × 6–7 µm. Ascospores, broadly ovoidal, smooth walled, 3–3.5 × 2–3 µm.

Extrolites: *Talaromyces tardifaciens* produces skyrin, 6′-hydroxy-3′-methoxy-mitorubrin related extrolites, and some extrolites 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 *T. tardifaciens* by 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 µm).

Talaromyces thailandensis Manoch, Dethoup & Yilmaz, Mycoscience 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 (9B7) dots. MEA 25 °C, 7 d: Colonies low, plane, entire; margins low, plane, entire (1 mm); mycelia dominantly yellow and also white; texture floccose; sporulation sparse to moderately dense, conidia *en masse* greyish green (25D5); 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 (25D5); 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).

Micromorphology: 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, asci 10–13.5 × 8.5–11 µm, ascospores broadly ellipsoidal, thick walled, spiny, 4–6 × 2.5–4.5 µm.

Extrolites: *Talaromyces thailandensis* produces asperphenamate, thailandolide A & B, 3-methyl-6-hydroxy-8-methoxy-3,4-dihydroisocoumarin, penisimplicissin, vermistatin and hydroxydihydrovermistatin (Dethoup *et al.* 2007). We found mitorubrin, mitorubrinol, mitorubrinic acid, a purpactin, 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. muroii*, *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 spiculisporum* Lehman, Mycologia 12: 268. 1920 ≡ *Talaromyces spiculisporus* (Lehman) C.R. Benj., Mycologia 47: 683. 1955.

= *Talaromyces trachyspermus* var. *macrocarpus* J.E. Wright & Loewenb., Bol. Soc. Argent. Bot. 15: 100. 1973.

≡ *Penicillium lehmani* Pitt, 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

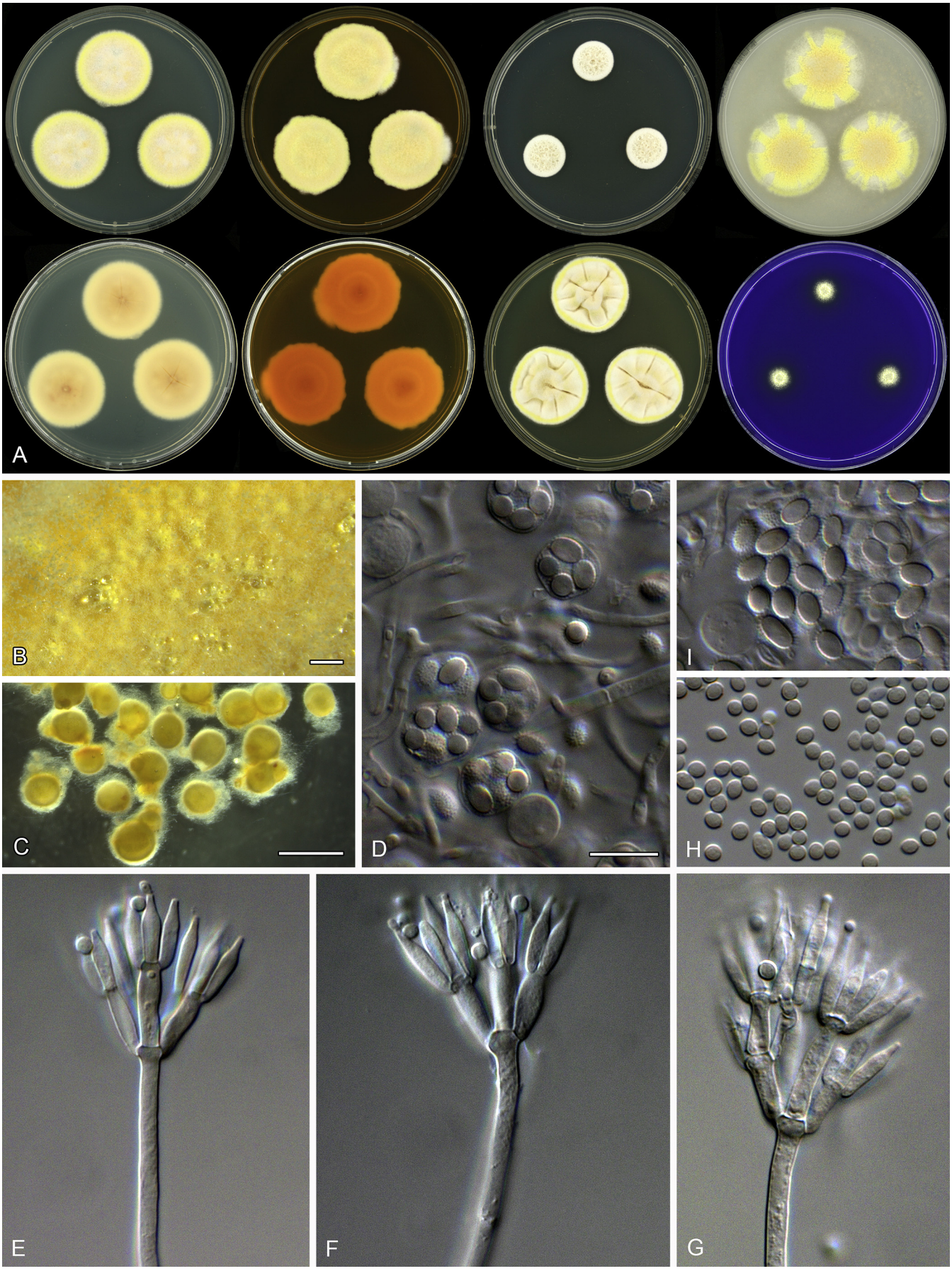

Fig. 78. Morphological characters of *Talaromyces thailandensis* (CBS 133147^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Asci and ascospores. E–G. Conidiophores. H. Conidia. I. Ascospores. Scale bars: B, C = 1000 µm; D = 10 µm, applies to E–I.

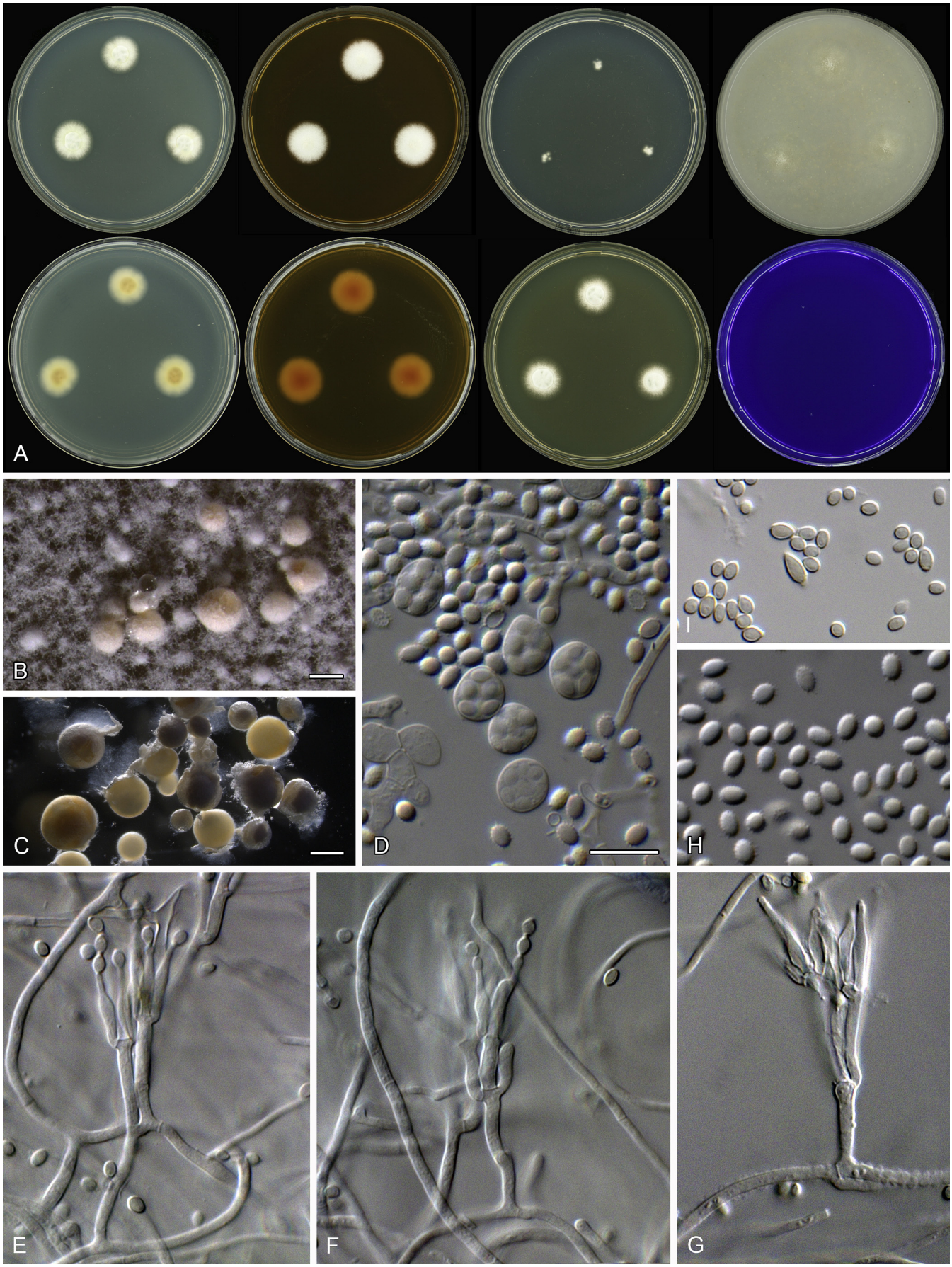

Fig. 79. Morphological characters of *Talaromyces trachyspermus* (CBS 373.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Asci and ascospores. E–G. 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 (5A5) 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; 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, asci 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), spiculisporic acid (Clutterbuck *et al.* 1931) and glauconic acid.

Distinguishing characters: *Talaromyces trachyspermus* produces creamish white ascomata with spiny, ellipsoidal ascospores (Fig. 79) and closely resembles *T. intermedius* and *T. assiutensis*. *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 morpohologically, *T. assiutensis* is very similar to *T. trachyspermus*, with them having identical ITS sequences. However, *T. trachyspermus* grows slightly faster than *T. assiutensis* on CYA at 37 °C and both species have unique *BenA* sequences.

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

Talaromyces tratensis Manoch, Dethoup & Yilmaz, Mycoscience 54: 337. 2013. MycoBank MB801738. Fig. 80.

In: *Talaromyces* section *Islandici*

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

ITS barcode: KF984891 (alternative markers: *BenA* = KF984559; *CaM* = KF984690; *RPB2* = 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^{T}); 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 predominately 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; asci 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 tratensis* produces mitorubrin, mitorubrinol, mitorubrinic acid, rugulosin, skyrin, vermicillin, wortmannin and a tetracyclic compound.

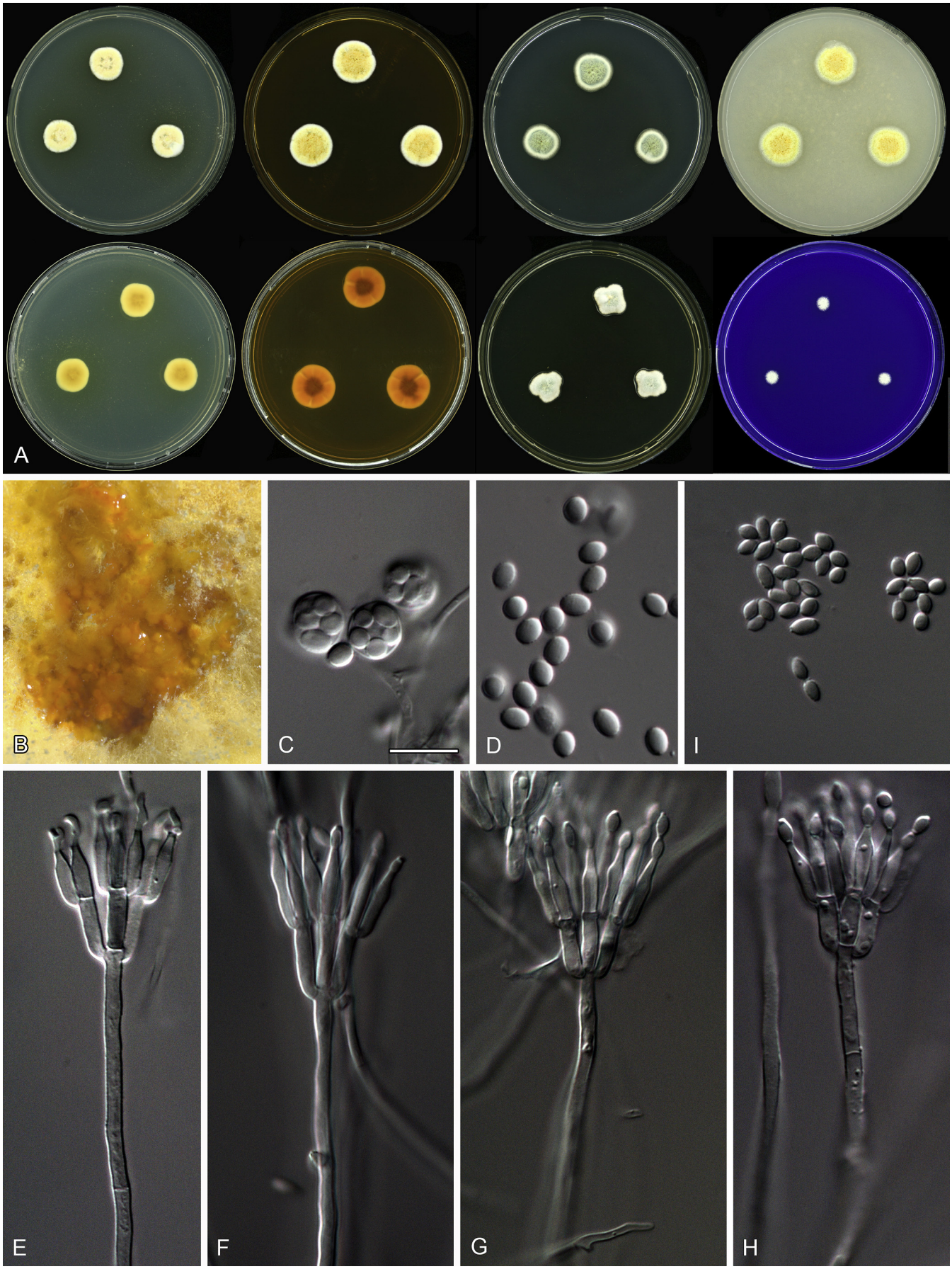

Fig 80. Morphological characters of *Talaromyces tratensis* (CBS 113146^{T}) a. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Texture and ascomata on OA after 2 wk incubation. C. Asci and ascospores. D. Ascospores. E–H. Conidiophores. 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. austrocalifornicus* and *T. convolutus.* On MEA, *T. flavus* grows slighty faster than *T. tratensis*. *Talaromyces tratensis* ascopore 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. austrocalifornicus*.

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

= *Penicillium ucrainicum* Panas., Mycologia 56: 59. 1964.
= *Penicillium ohiense* Pitt, The genus *Penicillium*: 502. 1980 ≡ *Talaromyces ohiensis* Pitt, The genus *Penicillium*: 502. 1980.
= *Talaromyces panasenkoi* Pitt, The genus *Penicillium*: 482. 1980 ≡ *Penicillium panasenkoi* Pitt, The genus *Penicillium*: 482. 1980.

In: *Talaromyces* section *Trachyspermi*

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

ITS barcode: JN899394 (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 (1F6–4E5–5C5). 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* turquoise 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 biverticillate and monoverticillate; stipes 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.

Extrolites: *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 biosurfectant (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. ohiensis* (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, (simultaneously published).

In: *Talaromyces* section *Trachyspermi*

Typus: 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; CREA 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.

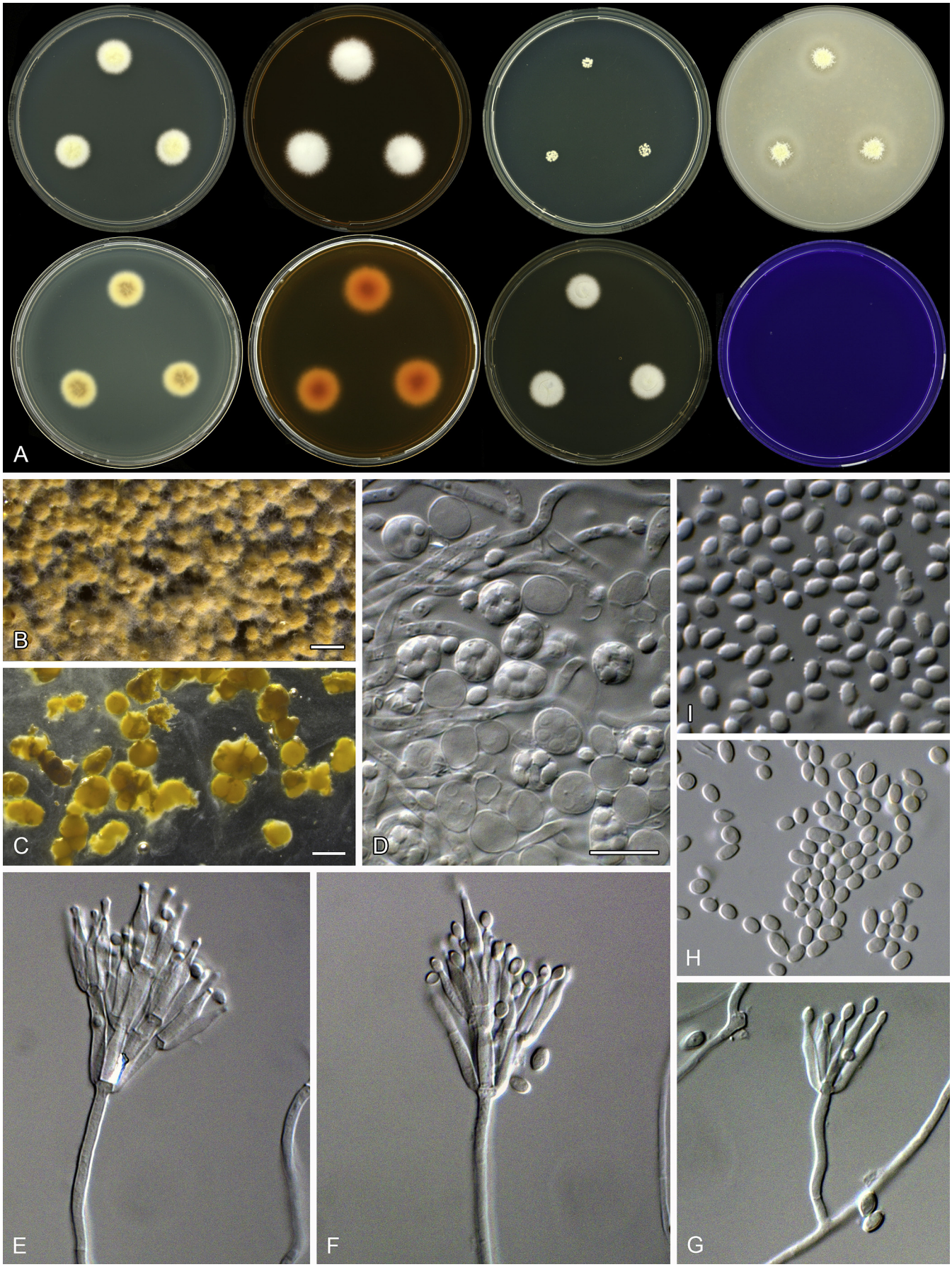

Fig. 81. Morphological characters of *Talaromyces ucrainicus* (CBS 583.72C). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascospores. E–G. Conidiophores. H. Conidia. I. Ascospores. Scale bars: B, C = 500 µm; D = 10 µm, applies to E–I.

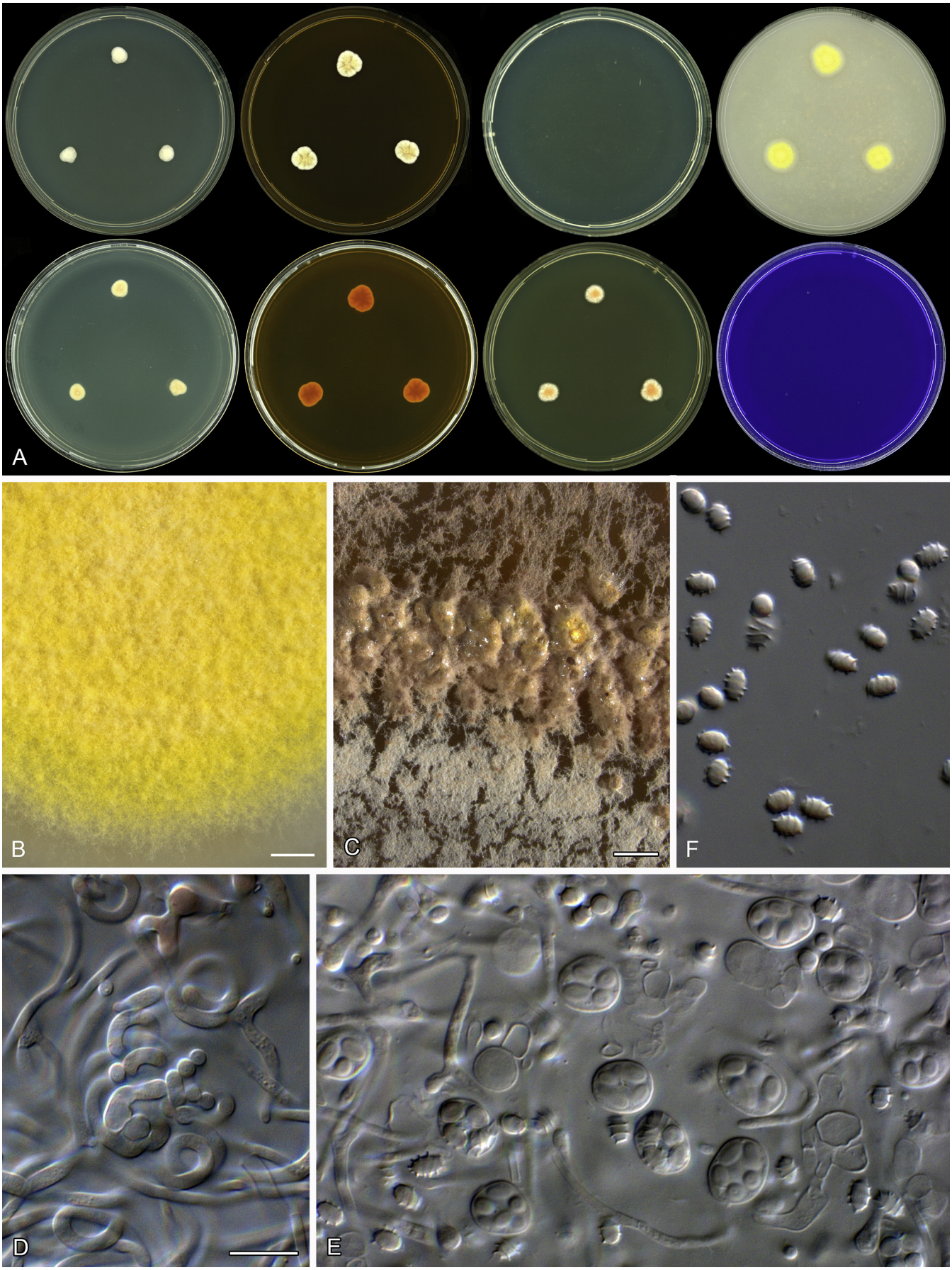

Fig. 82. Morphological characters of *Talaromyces udagawae* (CBS 579.72^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on OA after 1 wk incubation. C. Colony texture and ascomata on OA after 3 wk incunation. 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; conidia 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, mitorubrinol 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 restrictedly 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* that does 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 MB360172.

≡ *Penicillium unicum* Tzean, J.L. Chen & S.H. Shiu, (simultaneously published).

In: *Talaromyces* section *Bacillispori*

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 fibrillous; mycelium whte 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, abundant 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 chromophore similar to talaroderxine.

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,

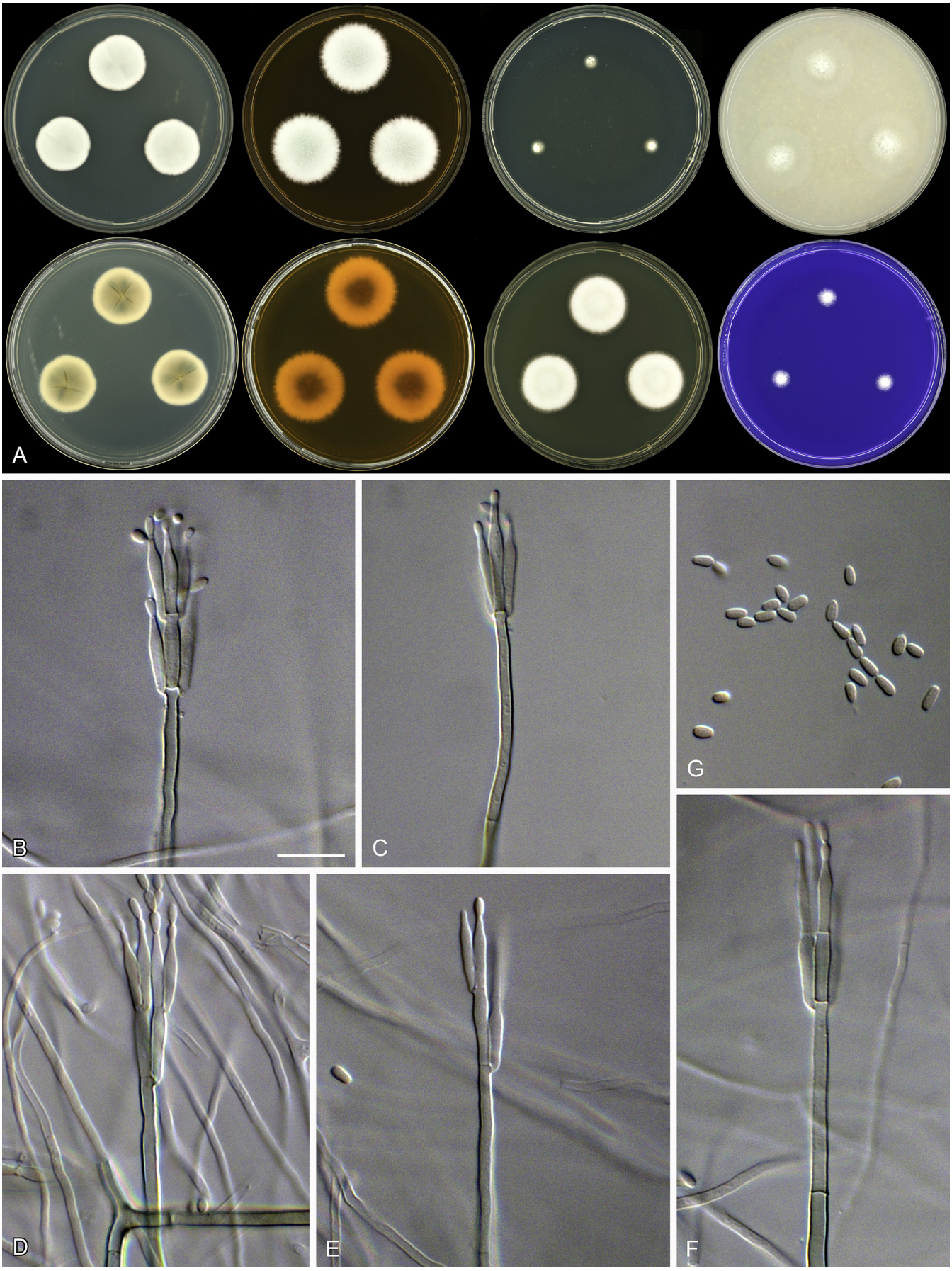

Fig. 83. Morphological characters of *Talaromyces varians* (CBS 386.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

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 metulae, 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 sulcate; 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 funiculose 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 sulcate, 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 × 2.5–3.5 µm; conidia echinulate, globose, 3–3.5 × 3–3.5 µm.

Extrolites: Altenuene, altenusin, alternariol, berkelic acid, hypomiltin, MC-141, mitorubrin, mitorubrinic acid, penicillide, pestalacin 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 = NRRL 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 sulcate; 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, sulcate, with a soily 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, sulcate; 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, sulcate, 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 ascomata (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

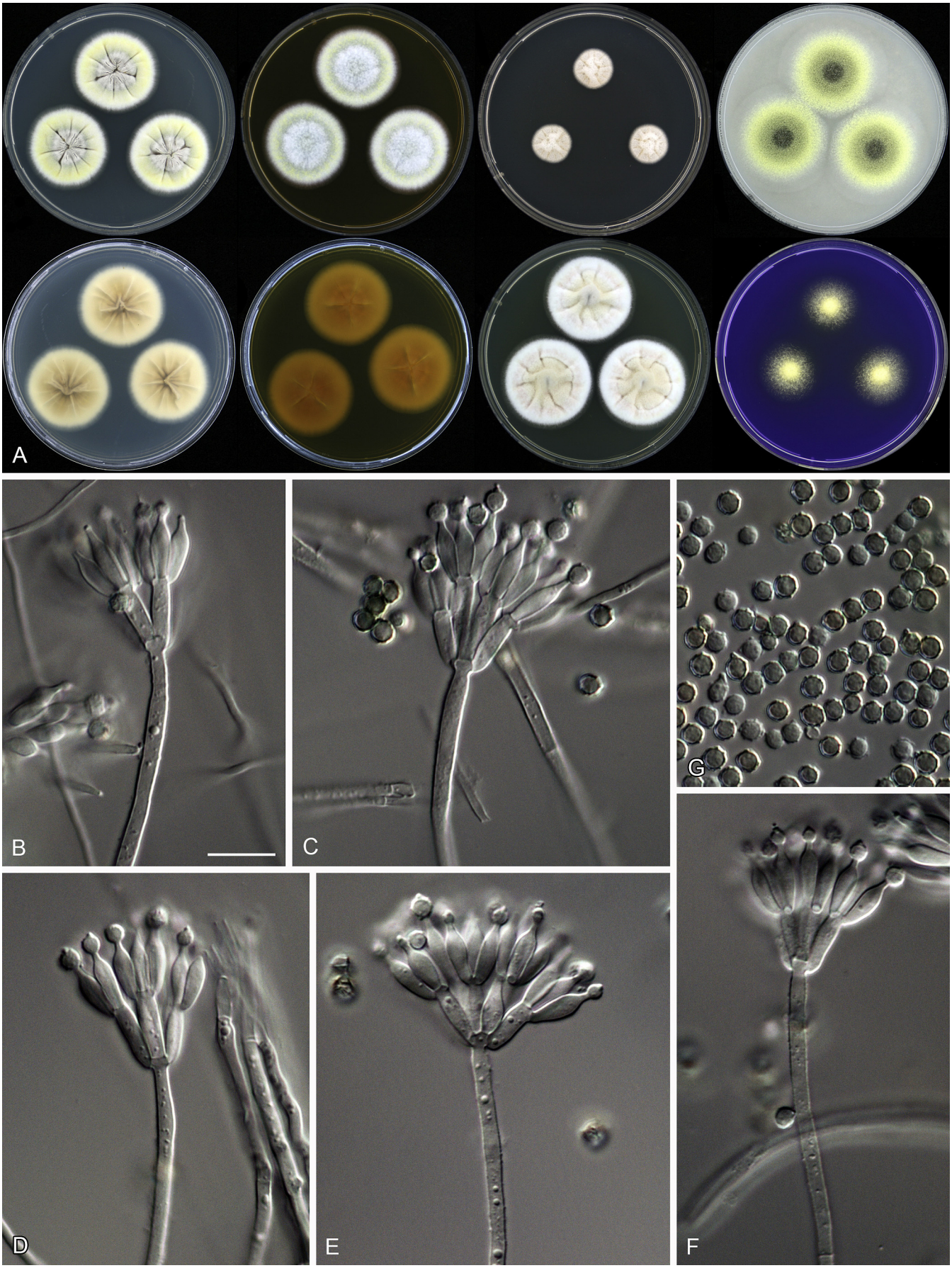

Fig. 84. Morphological characters of *Talaromyces verruculosus* (CBS 388.48^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

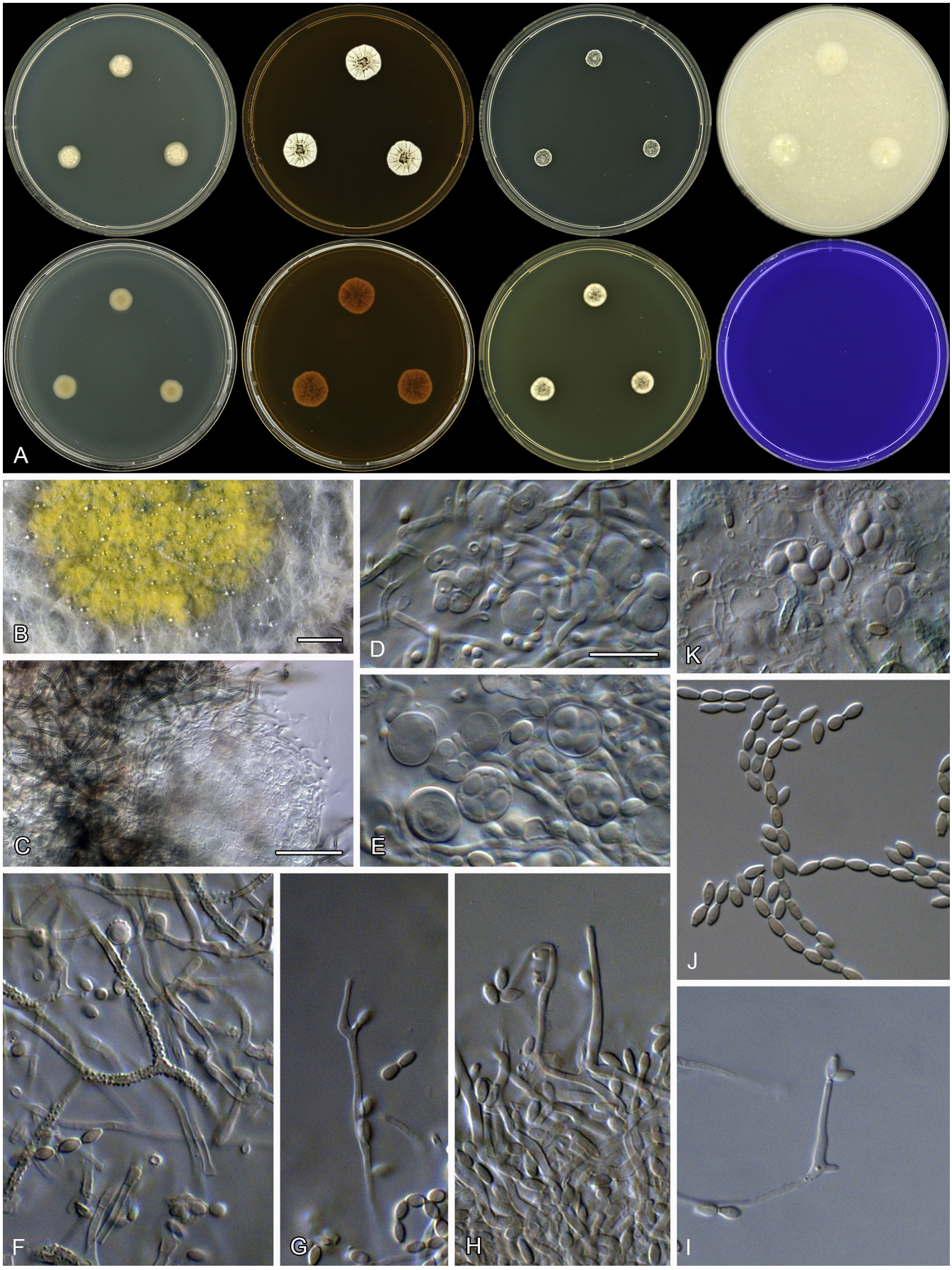

Fig. 85. Morphological characters of *Talaromyces viridis* (CBS 114.72^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Ascomata. D–E. Asci and ascospores. F. Peridial 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. Peridial hyphae brownish green, thick walled, richly branched 8–35 × 1–1.5 µm, asci 7.5–8 × 6–8.5 µm, ascospores ellipsoidal, finely ridges, 3.5–4.5 × 2.5–3 µm.

Extrolites: *Talaromyces viridis* (IBT 31150 = CBS 114.72) produces a purpactin and several extrolites only found in *Talaromyces*.

Distinguishing characters: *Talaromyces viridis* grows restrictedly on general media and does not grow on CREA. It produces dark green ascomata, which are covered with rough-walled, brownish green peridial hyphae (Fig. 85). Ascospores of *T. viridis* are finely striate and ellipsoidal. It produces reduced conidiophores consisting of solitary phialides. These features can easily distinguish *T. viridis* from other *Talaromyces* species.

Talaromyces viridulus Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. MycoBank MB560679. Fig. 86.

≡ *Geosmithia viridis* Pitt & A.D. Hocking, Mycologia 77: 822. 1985.
= *Penicillium viride* (Pitt & A.D. Hocking) Frisvad, Samson & Stolk, Persoonia 14: 229. 1990 (*nom. illegit.* Art. 53) (non Fres. 1851 nec Rivera 1873 nec Sopp 1912 nec (Matr.) Biourge 1923; non *Talaromyces viridis* (Stolk & G.F. Orr) Arx, Persoonia 13: 2821. 1987).

ITS barcode: JN899314 (alternative markers: *BenA* = JX091385; *CaM* = KF741943; *RPB2* = JF417422)

Typus: FRR 1863, culture ex-type CBS 252.87 = FRR 1863 = IMI 288716.

In: *Talaromyces* section *Talaromyces*

Colony diam, 7 d (mm): CYA 12–15; CYA 30 °C 16–18; CYA 37 °C 6–7; MEA 37–38; MEA 30 °C 39–41; DG18 16–17; CYAS No growth; OA 35–38; CREA 2–4; 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; sporulation absent; soluble pigments absent; exudates absent; reverse brownish red (9C7) centre fading into pale yellow (3A3). MEA 25 °C, 7 d: Colonies deep, plane, sterile white, pastel yellow and pastel red appearance; margins low, plane, entire (2–3 mm); mycelia white, pastel yellow and pastel red; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange 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; sporulation absent; soluble pigments absent; exudates absent; 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 (9E8) centre 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 restrictedly 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 variabile* Sopp, Skr. Vidensk.-Selsk. Christiania, Math.-Naturvidensk. Kl. 11: 169. 1912.
= *Penicillium concavorugulosum* S. Abe, J. Gen. Appl. Microbiol., 2: 127. 1956 (nom. inval., Art. 36).

In: *Talaromyces* section *Islandici*

Typus: IMI 040047, culture ex-type CBS 391.48 = ATCC 10517 = IMI 040047 = NRRL 1017 = IBT 4838.

ITS barcode: KF984829 (alternative markers: *BenA* = KF984648; *CaM* = KF984756; *RPB2* = KF984977)

Colony diam, 7 d (mm): CYA 18–28; CYA 30 °C 18–26; CYA 37°C Generally no growth, in some isolates colonies up to 7; MEA 15–25; MEA 30 °C 17–27; DG18 13–18; CYAS 10–12; OA 20–25; CREA 5–15; YES 20–30.

Colony characters: CYA 25 °C, 7 d: Colonies 18–28 mm, slightly raised at centre, sulcate; margins narrow (up to 2 mm), low, entire, plane; mycelium generally only white, in some isolates yellow dominant (CBS 100258; CBS 293.53, CBS 319.63, CBS 391.48^T, CBS 137376); texture velvety; sporulation absent (CBS 391.48^T, CBS 319.63, CBS 293.53), moderately dense to dense; conidia *en masse* greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent; reverse in some isolates centre brown (6E6–6E7) fading into in some isolates reddish yellow (4A6), in some isolates greyish orange to orange (6B6–6B7) (NRRL 2125; CBS 293.53), in some isolates centre yellowish brown (5F5) fading into in some isolates olive (3D5–3E5) and in some isolates greyish yellow (3B4–3C4) (CBS 100258; DTO 67-G1; DTO 189-D9; CBS 137384; DTO 127-I4) in some isolates yellow (3A6) with dark blonde (5D4) dots in centre (CBS 137376, CBS 319.63). MEA 25 °C, 7 d: Colonies 15–25 mm, in some isolates low, in some isolates slightly raised at centre, sulcate; margins very narrow (up to 1 mm), low, entire, plane; mycelium generally only white, in some isolates yellow dominant (CBS 100258; CBS 319.63, CBS 391.48^T, CBS 137376); texture velvety; sporulation absent (CBS 391.48^T, CBS 293.53), sparse (CBS 137376) to dense; conidia *en masse*

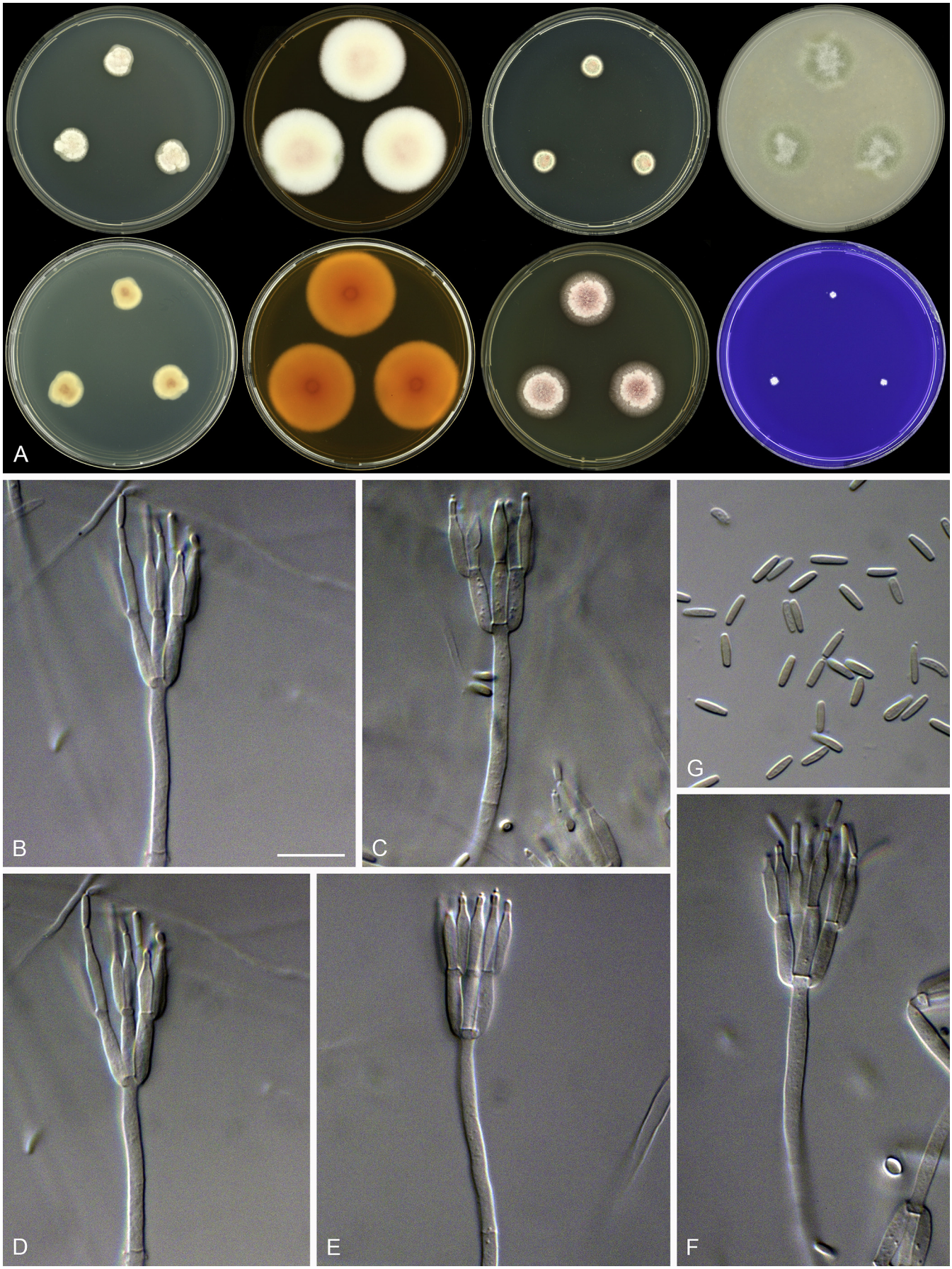

Fig. 86. Morphological characters of *Talaromyces viridulus* (CBS 252.87^{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 µm, applies to C–G.

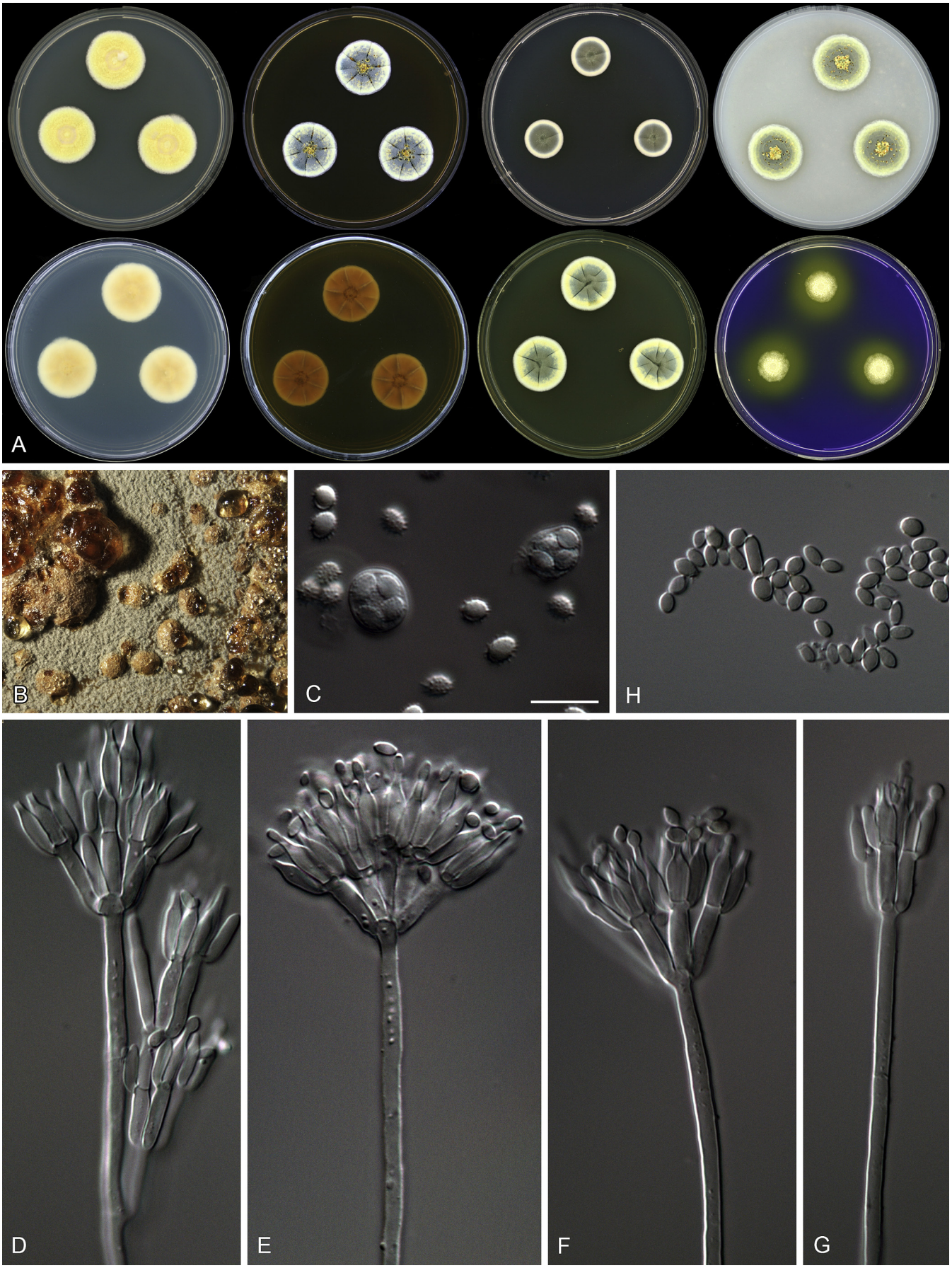

Fig. 87. Morphological characters of *Talaromyces wortmannii* (CBS 319.63). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on MEA after 2 wk incubation. C. Asci and ascopsores. D–G. Conidiophores. H. 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 brown (6E5) 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 crateriforme 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 391.48^T, CBS 137376); texture velvety and crusty; sporulation absent (CBS 293.53, CBS 391.48^T) to dense; conidia *en masse* greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent; reverse in some isolates centre light yellow to greyish orange (4A5–5B6) fading into greyish yellow to olive (2C4–2D4) (DTO 127-I4, DTO 189-D9, DTO 67-G1, CBS 137384, NRRL 2125), in some isolates olive (2F4) in the centre fading into greyish yellow to olive (2C4–2D4) (CBS 100258, CBS 137394), in some isolates centre orange to golden 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 391.48^T, CBS 293.53) to dense; conidia *en masse* greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent (except CBS 100258, CBS 137376, CBS 319.63 yellow); reverse in some isolates centre orange (5B8) fading into greyish green (26B3–26C3) (NRRL 2125, CBS 137384, DTO 127-I4), in some isolates centre pale yellow (1A3) centre fading into greyish yellow (1B3) (DTO 189-D9, DTO 67-G1), in some isolates yellowish white to yellow to vivid yellow (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 391.48^T). 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 391.48^T, CBS 137376); texture velvety in some isolates centre floccose; sporulation sparse (CBS 137376, CBS 391.48^T, 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 391.48^T; CBS 293.53); exudates in some isolates 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 391.48^T, 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 × 12.5–4.0 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 wortmannilactones E-H (Dong *et al.* 2009), closely related to the prugosins/prugosenes/ukulactones produced by *T. allahabadense* and *T. rugulosus*. Furthermore it produces rugulovasine A and B (Abe *et al.* 1969, Yamatodani *et al.* 1970, Zhelifonova *et al.* 2006, 2010, Antipova *et al.* 2008), chanoclavine-I (Abe *et al.* 1969); wortmannilactones A-D (Dong *et al.* 2006); mitorubrinol acetate (Suzuki *et al.* 1999); β-caryophyllene (Yamagiwa *et al.* 2011); Talaromin A and B (Bara *et al.* 2013); atrovirin B1 and B2 (Gill & Morgan 2004); We detected rugulosin, skyrin, rugulovasine A, wortmannilactones E, F, G, H, mitorubrin, mitorubrinol, mitorubrinol 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 ascomata 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. tratensis*. However, *T. tratensis* 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 *RPB2* phylogenies, *P. concavorugulosum*, *T. sublevisporus* (CBS 137376) and *T. variabilis* (CBS 385.48) form a coherent clade with *T. wortmannii* (Yilmaz *et al.*, unpubl.).

Talaromyces yelensis 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 low, narrow, entire; mycelia white to yellow to orange; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2) to greyish orange (5B5). DG18 25 °C, 7 d: Colonies deep, plane; margins low, 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 yellow (3A2–3A6). OA 25 °C, 7 d: Colonies moderately deep, plane; margins low, 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, subglobose 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 ascomata and produces subglobose to broadly ellipsoid conidia that have rough walls. For an illustration of the species, readers are referred to Visagie *et al.* (2014).

DOUBTFUL SPECIES LIST

Penicillium guizhouanum H.Z. Kong, Mycosystema 19: 1. 2000. [MB464324]. — Herb.: HMAS 74529. Ex-type: AS 3.5215. Note: Sequence data from Visagie *et al.* (2014) show that this species is a synonym of *T. funiculosus*, which we follow here.

Penicillium krugeri C. Ramirez, Mycopathologia 110: 23. 1990. [MB126186]. — Herb.: TISTR3377. Ex-type: No culture data available. Note: Culture was described from South Africa, but no type material is available.

Penicillium mirabile Beliakova & Milko, Mikol. Fitopatol. 6: 145. 1972. [MB319286]. — Herb.: VKM F-1328. Ex-type: CBS 624.72 = CCRC 31665 = FRR 1959 = IMI 167383 = LCP 72.2193 = MUCL 31206 = VKM F-1328. Note: The ex-type culture for this species (obtained from CBS and NRRL) is contaminated and additional work is needed to determine its exact taxonomic position.

Penicillium oblatum Pitt & A. D. Hocking, Mycologia 77: 819. 1985. [MB104603]. — Herb.: FRR 2234. Ex-type: CBS 258.87 = FRR 2234. Note: Samson *et al.* (2011) published sequence data showing a close relationship with *T. dendriticus*. In our opinion CBS 258.87 is contaminated and not representing the ex-type culture.

Penicillium pachmariensis A.K. Gupta & S. Chauhan, Indian For. 122: 1182. 1996. [MB459628]. — Herb.: IMI 278556. Ex-type: IMI 278556. Note: According to the IMI, the species is synonymous with *Talaromyces purpurogenus*. However, we were not able to examine this strain.

Penicillium pascuum (Pitt & A. D. Hocking) Frisvad *et al.*, Persoonia 14: 229. 1990 ≡ *Paecilomyces pascuus* Pitt & A. D. Hocking, Mycologia 77: 822. 1985. [MB492634]. — Herb.: Unknown. Ex-type: CBS 253.87 = FRR 1925. Note: Samson *et al.* (2011) published sequence data showing a close relationship with *T. dendriticus*. In our opinion CBS 253.87 is contaminated and not representing the ex-type culture.

Penicillium resedanum McLennan & Ducker, Aust. J. Bot. 2: 360. 1954. [MB302422]. — Herb.: IMI 062877. Ex-type: CBS 181.71 = ATCC 22356 = 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 lagunensis Udagawa, Uchiy. & Kamiya, Mycoscience 35: 403. 1994 ≡ *Penicillium lagunense* Udagawa, Uchiy. & Kamiya, Mycoscience 35: 403. 1994. [MB414250]. — Herb.: CBM BF-49341. Ex-type: Unknown. Note: We have not examined authentic material for this species and did not treat species in this 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 & Kaori Osada, Trans. Mycol. Soc. Japan 34: 9. 1993 ≡ *Penicillium retardatum* Udagawa, Kamiya & Kaori Osada, Trans. Mycol. Soc. Japan 34: 9. 1993. [MB360062]. — Herb.: CBM BF-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 & Buddie nom. inval., Art. 38.1(a). Note: *Talaromyces versatilis* was never published. However, Delmas *et al.* (2014) 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 species has an ITS sequence (EU004812) identical to *T. assiutensis* and *T. trachyspermus*. No strain is available for examination and thus its correct classification cannot be determined.

EXCLUDED SPECIES LIST

Penicillium emersonii Stolk, Antonie van Leeuwenhoek 31: 262. 1965 ≡ *Talaromyces emersonii* Stolk, Antonie van Leeuwenhoek 31: 262. 1965 ≡ ***Rasamsonia emersonii*** (Stolk) Houbraken & Frisvad, Antonie van Leeuwenhoek 101: 417. 2011. [MB335725]. — Herb.: CBS H-7817. Ex-type: CBS 393.64 = ATCC 16479 = CECT 2607 = IFO 31232 = IMI 116815 = IMI 116815ii.

Penicillium lignorum Stolk, Antonie van Leeuwenhoek 35: 264. 1969. [MB335743]. — Herb.: CBS H-7505. Ex-type: CBS 709.68 = ATCC 22051 = FRR 804 = IMI 151899 = UPSC 3184. Note: A preliminary phylogenetic analysis indicates that this species does not belong to *Talaromyces* and might represent a new genus (Samson *et al.* 2011).

Penicillium sabulosum Pitt & A.D. Hocking in Mycologia 77: 818. 1985 ≡ *Talaromyces sabulosus* (Pitt & A.D. Hocking) Samson, Yilmaz & Frisvad, Stud. Mycol. 70: 177. 2011. [MB104604]. — Herb.: FRR 2743. Ex-type: CBS 261.87 = FRR 2743. Note: This species was incorrectly transferred to *Talaromyces* by Samson *et al.* (2011) and belongs in *Penicillium* section *Exilicaulis*.

Penicillium striatum Raper & Fennell, Mycologia 40: 521. 1948 ≡ *Talaromyces striatus* (Raper & Fennell) C. R. Benj., Mycologia 47: 682. 1955 ≡ ***Hamigera striata*** (Raper & Fennell) Stolk & Samson, Persoonia 6: 347. 1971. [MB289109]. — Herb.: IMI 039741. Ex-type: CBS 377.48 = ATCC 10501 = IFO 6106 = IMI 039741 = NRRL 717 = QM 1857 = VKM F-2044.

Talaromyces avellaneus (Thom & Turesson) C.R. Benj. Mycologia 47: 682. 1955 ≡ *Penicillium avellaneum* Thom & Turesson, Mycologia 7: 284. 1915 ≡ ***Hamigera avellanea*** (Thom & Turesson) Stolk & Samson, Stud. Mycol. 6: 345. 1971. [MB306712]. — Herb.: IMI 040230. Ex-type: CBS 295.48 = ATCC 10414 = CECT 2265 = DSM 2208 = IMI 040230 = NRRL 1938.

Talaromyces brevicompactus Kong, Mycosystema 18: 9. 1999 ≡ *Merimbla brevicompacta* Kong, Mycosystema 18: 9. 1999. [MB460109]. — Herb.: HMAS 62770. Ex-type: CBS 102661 = AS 3.4676. Note: Molecular data show that this species belongs to the *Hamigera* clade and not *Talaromyces* (Houbraken & Samson 2011).

Talaromyces byssochlamydoides Stolk & Samson, Stud. Mycol. 2: 45. 1972 ≡ *Paecilomyces byssochlamydoides* Stolk & Samson, Stud. Mycol. 2: 45. 1972 ≡ ***Rasamsonia byssochlamydoides*** (Stolk & Samson) Houbraken

& Frisvad, Antonie van Leeuwenhoek 101: 415. 2011. [MB324415]. — Herb.: CBS H-7816. Ex-type: CBS 413.71 = IMI 178524 = JCM 12813 = NRRL 3658.

Talaromyces cejpii Milko in Novosti Sist. Nizš: Rast.: 208. 1964 ≡ *Dichotomomyces cejpii* (Milko) D.B. Scott in Trans. Brit. Mycol. Soc. 55: 313. 1970 ≡ ***Aspergillus cejpii*** (Milko) Samson *et al.*, Stud. Mycol. 78: 141. MycoBank MB809582.— Herb.: CBS H-7011. Ex-type: CBS 157.66. 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.*, Mycoscience 35: 249. 1994 ≡ *Geosmithia eburnea* Yaguchi *et al.* ≡ ***Rasamsonia eburnea*** (Yaguchi *et al.*) Houbraken & Frisvad, Antonie van Leeuwenhoek 101: 416. 2011. [MB362928]. — Herb.: CBM PF-1151. Ex-type: CBS 100538 = IBT 17519.

Talaromyces emersonii Stolk, Antonie van Leeuwenhoek 31: 262. 1965 ≡ *Penicillium emersonii* Stolk, Antonie van Leeuwenhoek 31: 262. 1965 ≡ ***Rasamsonia emersonii*** (Stolk) Houbraken & Frisvad, Antonie van Leeuwenhoek 101: 417. 2011. [MB339920]. — Herb.: CBS H-7817. Ex-type: CBS 393.64 = ATCC 16479 = CECT 2607 = IFO 31232 = IMI 116815 = IMI 116815ii.

Talaromyces leycettanus H.C. Evans & Stolk, Trans. Brit. Mycol. Soc. 56: 45. 1971 ≡ *Penicillium leycettanus* H.C. Evans & Stolk ≡ *Paecilomyces leycettanus* (H.C. Evans & Stolk) Stolk *et al.*, Persoonia 6: 342. 1971. [MB324419]. — Herb.: CBS 398.68. Ex-type: CBS 398.68 = ATCC 22469 = IMI 178525 = JCM 12814. Note: Houbraken & Samson (2011) showed that this species is phylogenetically unrelated to *Talaromyces* and belongs in the *Hamigera* clade.

Talaromyces luteus (Zukal) C.R. Benj., Mycologia 47: 681. 1955 ≡ *Penicillium luteum* Zukal, Sitzungsber Kaiserl. Akad. Wiss. Math-Naturwiss. C1., Abt. 1, 98: 561. 1890. [MB306716]. — Herb.: IMI 89305. Ex-type: CBS 348.51 = CECT 2950 = IFO 31753 = IMI 089305 = LSHB BB228. Note: Although the morphological characters of this species resemble species of *Talaromyces*, Houbraken *et al.* (2014) showed that this species is basal to *Thermomyces* and probably represents a distinct genus.

Talaromyces ocotl Bills & Heredia, Mycologia 90: 533. 1998 ≡ ***Sagenomella ocotl*** (Bills & Heredia) Samson *et al.*, Stud. Mycol. 71: 179. 2011. [MB467796]. — Herb.: GB 6125. Ex-type: CBS 102855.

Talaromyces spectabilis Udagawa & Suzuki, Mycotaxon 50: 82. 1994 ≡ *Byssochlamys spectabilis* (Udagawa & Suzuki) Houbraken & Samson, Appl. Environ. Microbiol. 74: 1618. 2008 = ***Paecilomyces variotii*** Bainier Bull. Soc. Mycol. Fr. 23: 27. 1907. [MB361677]. — Herb.: CBM SUM-3030. Ex-type: CBS 101075 = ATCC 90900 = FRR 5219 = JCM 12815.

Talaromyces striatus (Raper & Fennell) C.R. Benj., Mycologia 47: 682. 1955 ≡ *Penicillium striatum* Raper & Fennell, Mycologia 40: 521. 1948 ≡ *Byssochlamys striata* (Raper & Fennell) Arx, Mycotaxon 26: 120. 1986 ≡ ***Hamigera striata*** (Raper & Fennell) Stolk & Samson, Persoonia 6: 347. 1971. [MB306723]. — Herb.: IMI 039741. Ex-type: CBS 377.48 = ATCC 10501 = IFO 6106 = IMI 039741 = NRRL 717 = QM 1857 = VKM F-2044.

Talaromyces thermophilus Stolk, Antonie van Leeuwenhoek 31: 268. 1965 ≡ ***Thermomyces dupontii*** (Griffon & Maublanc) Houbraken & Samson, Adv. Appl. Microbiol. 86: 218. 2014. [MB805186]. — Herb.: CBS 236.58. Ex-type: CBS 236.58 = ATCC 10518 = ATCC 16461 = ATCC 52514 = FRR 2155 = IFO 31798 = IMI 048593 = NRRL 2155 = QM 1851 = VKM F-2043.

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