Ochratoxin production and taxonomy of the yellow aspergilli (*Aspergillus* section *Circumdati*)

C.M. Visagie[1], J. Varga[2], J. Houbraken[1], M. Meijer[1], S. Kocsubé[2], N. Yilmaz[1], R. Fotedar[3], K.A. Seifert[4], J.C. Frisvad[5*], and R.A. Samson[1*]

[1]*CBS-KNAW Fungal Biodiversity Centre, Uppsalalaan 8, NL-3584 CT Utrecht, The Netherlands;* [2]*Department of Microbiology, Faculty of Science and Informatics, University of Szeged, H-6726 Szeged, Közép fasor 52, Hungary;* [3]*Biotechnology Center, Ministry of Environment, Doha, Qatar;* [4]*Biodiversity (Mycology), Agriculture and Agri-Food Canada, Ottawa, ON K1A0C6, Canada;* [5]*Department of Systems Biology, Building 221, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark*

*Correspondence: R.A. Samson, r.samson@cbs.knaw.nl; J.C. Frisvad, jcf@bio.dtu.dk

Abstract: *Aspergillus* section *Circumdati* or the *Aspergillus ochraceus* group, includes species with rough walled stipes, biseriate conidial heads, yellow to ochre conidia and sclerotia that do not turn black. Several species are able to produce mycotoxins including ochratoxins, penicillic acids, and xanthomegnins. Some species also produce drug lead candidates such as the notoamides. A polyphasic approach was applied using morphological characters, extrolite data and partial calmodulin, β-tubulin and ITS sequences to examine the evolutionary relationships within this section. Based on this approach the section *Circumdati* is revised and 27 species are accepted, introducing seven new species: *A. occultus*, *A. pallidofulvus*, *A. pulvericola*, *A. salwaensis*, *A. sesamicola*, *A. subramanianii* and *A. westlandensis*. In addition we correctly apply the name *A. fresenii* (≡ *A. sulphureus* (*nom. illeg.*)). A guide for the identification of these 27 species is provided. These new species can be distinguished from others based on morphological characters, sequence data and extrolite profiles. The previously described *A. onikii* and *A. petrakii* were found to be conspecific with *A. ochraceus*, whilst *A. flocculosus* is tentatively synonymised with *A. ochraceopetaliformis*, despite extrolite differences between the two species. Based on the extrolite data, 13 species of section *Circumdati* produce large amounts of ochratoxin A: *A. affinis*, *A. cretensis*, *A. fresenii*, *A. muricatus*, *A. occultus*, *A. ochraceopetaliformis* (*A. flocculosus*), *A. ochraceus*, *A. pseudoelegans*, *A. pulvericola*, *A. roseoglobulosus*, *A. sclerotiorum*, *A. steynii* and *A. westerdijkiae*. Seven additional species produce ochratoxin A inconsistently and/or in trace amounts: *A. melleus*, *A. ostianus*, *A. persii*, *A. salwaensis*, *A. sesamicola*, *A. subramanianii* and *A. westlandensis*. The most important species regarding potential ochratoxin A contamination in agricultural products are *A. ochraceus*, *A. steynii* and *A. westerdijkiae*.

Key words: *Ascomycetes*, *Eurotiales*, Mycotoxin, Food spoilage, Indoor environment.
Taxonomic novelties: New species: *Aspergillus occultus* Visagie, Seifert, Frisvad & Samson, *A. pallidofulvus* Visagie, Varga, Frisvad & Samson, *A. pulvericola* Visagie, Seifert, Frisvad & Samson, *A. salwaensis* Visagie, Houbraken, Fotedar, Frisvad & Samson, *A. sesamicola* Visagie, Frisvad & Samson, *A. subramanianii* Visagie, Frisvad & Samson, *A. westlandensis* Visagie, Varga, Meijer & Frisvad.

Published online 12 September 2014; http://dx.doi.org/10.1016/j.simyco.2014.07.001. Hard copy: June 2014.

INTRODUCTION

Aspergillus section *Circumdati* (Gams *et al.* 1985; *Aspergillus ochraceus* species group according to Raper & Fennell 1965) includes species with biseriate conidial heads in shades of yellow to ochre.

Some species of *Aspergillus* section *Circumdati* are economically important; for example, strains of *A. ochraceus* or *A. sclerotiorum* are used for biochemical transformation of steroids, alkaloids or phenazines (Chen *et al.* 1994), while some species, e.g. *A. sclerotiorum* and *A. melleus*, are important sources of proteolytic enzymes (Luisetti *et al.* 1991) and several exometabolites (Matsukuma *et al.* 1992). Sclerotia of several species contain anti-insect compounds (Whyte *et al.* 1996, Ooike *et al.* 1997). Several species produce diverse mycotoxins harmful for animals and humans including ochratoxin A, xanthomegnin and viomellein (Lai *et al.* 1970, Ciegler 1972, Hesseltine *et al.* 1972, Durley *et al.* 1975, Varga *et al.* 1996, Frisvad *et al.* 2004, Davolos & Pietrangeli 2014).

These moulds are also known for the production of asperga-mides, notoamides, norgeamides, stephacidins, avrainvillamides, among which are several promising anti-cancer compounds (Finefield *et al.* 2011). *Aspergillus westerdijkiae*, *A. melleus*, *A. ochraceus*, *A. steynii* and *A. subramanianii* are reported to be common from a wide range of habitats such as soil, agricultural and stored foods (Kozakiewicz 1989, Frisvad *et al.* 2004, Morello *et al.* 2007, Noonim *et al.* 2008, Gil-Serna *et al.* 2009a, 2011).

Aspergillus ochraceus and *A. sclerotiorum* have also been identified as human and animal pathogens causing onychomycosis (Feuilhade de Chauvin & de Bievre 1985), allergic bronchopulmonary aspergillosis (Novey & Wells 1978, Wierzbicka *et al.* 1997), otomycosis (Harima *et al.* 2004) and antromycosis in humans (Bassiouny *et al.* 1982), and mycotic placentitis in cow (Munoz *et al.* 1989). *Aspergillus persii* was isolated from several onychomycosis cases in Italy (Zotti & Corte 2002, Zotti *et al.* 2010). Several species are involved in nail infections, including *A. sclerotiorum*, *A. ochraceus* and *A. melleus* (Machetti *et al.* 2010). Another species, *A. ochraceopetaliformis*, was

Peer review under responsibility of CBS-KNAW Fungal Biodiversity Centre.

isolated from human skin lesions (Batista & Maia da Silva 1957), and recently found to cause onychomycosis (Brasch *et al.* 2009).

An early study of the Japanese yellow Aspergilli (Nehira 1949) was followed by the taxonomic treatment of section *Circumdati* by Raper & Fennell (1965) that included nine species (*A. ochraceus*, *A. fresenii*, *A. alliaceus*, *A. sclerotiorum*, *A. auricomus*, *A. petrakii*, *A. melleus*, *A. elegans* and *A. ostianus*). Christensen & Raper (1970, 1982) described *A. robustus*, *A. campestris* and *A. bridgeri* as members of this group, while Samson (1979) added four more species: *A. dimorphicus*, *A. insulicola*, *A. lanosus* and *A. ochraceoroseus*. Later another new species, *A. persii*, was assigned to this section (Zotti & Corte 2002). In a more recent paper, seven new species were described in section *Circumdati*: *A. cretensis*, *A. flocculosus*, *A. neobridgeri*, *A. pseudoelegans*, *A. roseoglobulosus*, *A. steynii* and *A. westerdijkiae* (Frisvad *et al.* 2004). A sexually reproducing ochratoxin producing species with a *Neopetromyces* teleomorph, *A. muricatus*, was also found to belong to this section (Varga *et al.* 2000a, Frisvad & Samson 2000).

Phylogenetic analysis of sequences of parts of the ribosomal RNA gene cluster indicated that *A. campestris* and *A. lanosus* belong to *Aspergillus* sections *Candidi* and *Flavi*, respectively, while *A. dimorphicus* and *A. sepultus* are members of section *Cremei* (Peterson 1995, Varga *et al.* 2000a). Two teleomorphic species previously assigned to this section, *Petromyces alliaceus* and *P. albertensis* were found to belong to *Aspergillus* section *Flavi* (Varga *et al.* 2000b).

In this study, we examined available strains of the species proposed to belong to section *Circumdati* and provide a monographic treatment on the section. We used a polyphasic approach to species delimitation, including sequence analysis of parts of the β-tubulin and calmodulin genes and the ITS region, macro- and micro-morphological analyses and examination of the extrolite profiles of the isolates.

Table 1. Strains used for phylogenetic analyses of *Aspergillus* section *Circumdati*.

Species	Culture collection number	Source and origin	GenBank accession nr.		
			ITS	*BenA*	*CaM*
A. affinis	CBS 129190T = IBT 32310 = ATCC MYA-4773	Decomposing leave litter, Italy	GU721090	GU721092	GU721091
A. auricomus	CBS 467.65T = NRRL 391 = IBT 14581 = ATCC 16890 = IMI 172277 = LCP 89.2596 = LSHBA 41 = WB 391	Unrecorded source	EF661411	EF661320	EF661379
	CBS 613.78 = NRRL 397 = IBT 13857 = QM 9809 = Thom 5479.A42 = WB 397	Unrecorded source	EF661412	EF661321	EF661380
	CBS 638.78 = NRRL 388 = IBT 13854 = DTO 139-E9	Soil, Wyoming, USA	FJ491575	KJ775049	FJ491529
A. bridgeri	CBS 350.81T = NRRL 13000 = IBT 13380 = ATCC 44562 = IMI 259098	Soil, Wyoming, USA	EF661404	EF661335	EF661358
	NRRL 35081 = NRRL A-20312 = o-1192	Soil, Utah, USA	EF661398	EF661334	EF661366
A. cretensis	CBS 112802T = NRRL 35672 = IBT 17505	Soil, Crete, Greece	FJ491572	AY819977	FJ491534
	CBS 112805 = NRRL 35673 = IBT 23283 = IMI 001177	*Citrus* sp., Israel	FJ491584	AY819978	FJ491533
A. elegans	CBS 102.14T = CBS 543.65 = NRRL 4850 = IBT 13505 = ATCC 13829 = ATCC 16886 = IFO 4286 = IMI 133962 = QM 8912 = QM 9373 = WB 4850	Unrecorded source, USA	EF661414	EF661349	EF661390
	CBS 310.70 = CBS 614.78 = NRRL 407 = NRRL 4813 = IBT 13861 = IFO 4354 = IMI 313490 = QM 8885 = QM 9810 = Thom 5400.1 = WB 4813	Unrecorded source	EF661413	EF661348	EF661383
	CBS 615.78 = NRRL 4820 = IFO 5443 = IMI 313485 = WB 4820	Unrecorded source, Japan	FM201287	FM995522	KJ775241
A. fresenii	CBS 550.65T = NRRL 4077 = ATCC 16893 = IMI 211397 = NRRL A-5355 = NRRL A-5520 = WB 4077	Soil, Mysore, India	EF661409	EF661341	EF661382
	NRRL 35092 = NRRL A-22634	Unrecorded source, India	EF661408	EF661342	EF661367
A. insulicola	CBS 382.75T = NRRL 6138 = ATCC 26220	Soil, Venezuela	EF661430	EF661353	EF661396
A. melleus	CBS 112786 = NRRL 386 = IBT 14265	Unrecorded source	FJ491567	AY819964	KJ834523
	CBS 112788 = IBT 23399	Soil in Gauguin garden, Taboga Island, Costa Rica	FJ491578	FJ491523	FJ491543
	CBS 546.65T = NRRL 5103 = IBT 13510 = IBT 13511 = IBT 13875 = ATCC 16889 = WB 5103	Soil, India	EF661425	EF661326	EF661391
	NRRL 35105 = NRRL A-23163	Peanut field soil, Turkey	EF661426	EF661327	EF661370
A. muricatus	CBS 112808T = NRRL 35674 = IBT 19374 = IMI 36852	Grassland soil, Philippines	EF661434	EF661356	EF661377
	NRRL 35071 = NRRL A-20270	Cotton field soil, Arizona, USA	EF661433	EF661355	EF661365
A. neobridgeri	CBS 559.82T = NRRL 13078 = IBT 14026	Soil, Nebraska, USA	EF661410	EF661345	EF661359

Table 1. (Continued).

Species	Culture collection number	Source and origin	GenBank accession nr.		
			ITS	*BenA*	*CaM*
A. occultus	CBS 137328 = DTO 267-B7	Indoor house dust, Kosrae Island, Micronesia	KJ775441	KJ775059	KJ775237
	CBS 137329 = IBT 32287 = IBT 32136 = DTO 231-A8	Air sample, Zwartewaal, Netherlands	KJ775442	KJ775060	KJ775238
	CBS 137330T = IBT 32285 = DTO 231-A7	Air sample, Zwartewaal, Netherlands	KJ775443	KJ775061	KJ775239
	DTO 303-E3 = PT 05-1	Sediment of saltern, Putian Fujian Province, China	KJ775450	KJ775062	KJ775247
A. ochraceopetaliformis	CBS 112784 = IBT 21104	Unknown source, Venezuela	FJ491571	AY819959	FJ491549
	CBS 112785T = NRRL 35668 = IBT 23121 (ex-type of *A. flocculosus*)	Saltern, Slovenia	EF661432	EF661352	EF661371
	CBS 112789 = IBT 22898	Internal infection of current grape, Peloponnese, Greece	FJ491579	AY819958	FJ491548
	CBS 112798 = NRRL 5224 = NRRL A-88 = IBT 21076	Soil, India	EU021616	EU014094	EF661394
	CBS 112799 = IBT 23406	Soil in Gauguin garden, Taboga Island, Costa Rica	FJ491582	AY819957	FJ491551
	CBS 123.55T = NRRL 4752 = IBT 14347 = ATCC 12066 = IMI 211804 = QM 6955 = WB 4752	Scalp lesion, Recife, Brazil	EF661429	EF661350	EF661388
	NRRL 35055 = NRRL A-17358 = WB 5569	Unrecorded source	EF661431	EF661351	EU014116
A. ochraceus	CBS 105.57 = IBT 13388 = ATCC 16885 = IMI 172291 = LCP 89.2586 = QM 8041 = WB 4369 = WB 4777 (ex-type of *A. petrakii*)	*Leptinotarsa decemlineata*, Hungary	FJ491565	AY819972	FJ491539
	CBS 108.08T = NRRL 398 = IBT 11952 = ATCC 1008 = CECT2093 = DSM 824 = HARVARD296 = IMI 16247 = NCTC 3889 = NRRL 1642 = QM 6731 = Thom 112 = WB 398	Unrecorded source	EF661419	EF661322	EF661381
	CBS 118.32 = DTO 022-C2 (submitted as *A. onikii* in CBS collection)	A. Blochwitz; *A. ochraceus* var. *pallida*	FJ491587	KJ775051	FJ491526
	CBS 624.78 = NRRL 419 = IBT 14027 = IMI 016265ii = IMI 16265 = IMI 313488 = LSHB AC.83 = NCTC 3895 = QM 9811 = Thom 4640.476	Unrecorded source, France	EU021609	EU021662	EU021680
	CBS 748.70 = IBT 14389 (ex-type of *Sterigmatocystis japonica*)	Unrecorded source, Japan	FJ491576	AY819971	FJ491540
	NRRL 35053	Unrecorded source	EF661420	EF661323	EF661363
A. ostianus	CBS 101.23 = NRRL 423 = NRRL 4762 = IBT 14017 = QM 8156 = Thom 4876.1 = WB 423 = WB 4762	Unrecorded source	EU021612	EU021661	EU021679
	CBS 103.07T = CBS 548.65 = IBT 13386 = NRRL 420 = ATCC 16887 = IMI 015960iii = IMI 15960 = LCP 89.2584 = LSHBA c .35 = NCTC 3788 = QM 7460 = Thom 4724.35 = WB 420	Unrecorded source	EF661421	EF661324	EF661385
	CBS 137323 = IBT 29245 = IBT 32818 = DTO 148-A5	Indoor air, Denmark	KJ775436	KJ775052	KJ775232
	CBS 311.80 = IBT 13387 = IMI 237221	Pulses, India	KJ775444	AY819969	KJ775240
	CBS 627.78 = NRRL 422 = IBT 13863 = IMI 313483 = QM 7398 = Thom 4640.471 = WB 422	Unrecorded source	EU021611	EU021660	EU021677
	NRRL 5225 = NRRL A-381 = IBT 13880	Peas, Ontario, Canada	EF661422	EF661325	EF661395
A. pallidofulvus	CBS 112790 = IBT 23097	Green coffee bean, India	FJ491568	FJ491524	FJ491541
	CBS 114.26 = IBT 13385	Unrecorded source	FJ491566	AY819967	FJ491544
	CBS 115.51 = NRRL 4748 = IBT 14019 = QM 8157	K. Kominami; *A. katsuobushi*, *A. petrakii*; unrecorded source	EU021613	EU014096	EF661387
	CBS 640.78T = NRRL 4789 = IBT 13871 = IFO 4095 = WB 4789	R. Nakazawae; *A. sulphureus* var. *minimus*; unrecorded source	EF661423	EF661328	EF661389
A. persii	CBS 112795T = NRRL 35669 = IBT 22660 = MUCL 41970	Toenail of patient, Italy	FJ491580	AY819988	FJ491559
A. pseudoelegans	CBS 112796T = NRRL 35670 = IBT 23402	Soil in Gauguin garden, Taboga Island, Costa Rica	FJ491590	AY819962	FJ491552
	CBS 112797 = NRRL 35671 = IBT 23403	Soil in Gauguin garden, Taboga Island, Costa Rica	KJ834521	AY819963	FJ491553

(*continued on next page*)

Table 1. (Continued).

Species	Culture collection number	Source and origin	GenBank accession nr.		
			ITS	*BenA*	*CaM*
A. pulvericola	CBS 137325 = DTO 267-F4	Indoor house dust, Kosrae Island, Micronesia	KJ775438	KJ775053	KJ775234
	CBS 137326 = DTO 267-E2	Indoor house dust, Kosrae Island, Micronesia	KJ775439	KJ775054	KJ775235
	CBS 137327T = DTO 267-C6	Indoor house dust, Kosrae Island, Micronesia	KJ775440	KJ775055	KJ775236
A. robustus	CBS 428.77T = NRRL 6362 = ATCC 36106 = IMI 216610 = NRRL A-17351 = WB 5286	Surface soil from thorn-forest, near Mombasa, Kenya	EF661176	EU014101	EF661357
	CBS 649.93 = NRRL 35097 = NRRL 5286 = IBT 14305 = IMI 216610 = WB 5286	Surface soil from thorn-forest, near Mombasa, Kenya	EF661435	EU014103	EU014114
A. roseoglobulosus	CBS 112800T = NRRL 4565 = IBT 14720	Decaying leaves, Little San Salvador Island, Bahamas	FJ491583	AY819984	FJ491555
A. salwaensis	DTO 297-B3T	Soil, Salwa Beach, Qatar	KJ775447	KJ775056	KJ775244
	DTO 297-B5	Soil, Salwa Beach, Qatar	KJ775445	KJ775057	KJ775245
	DTO 297-C1	Soil, Salwa Beach, Qatar	KJ775446	KJ775058	KJ775246
A. sclerotiorum	CBS 549.65T = NRRL 415 = IBT 11931 = ATCC 16892 = DSM 870 = IFO 7542 = IMI 056732 = IMI 56673 = LCP 89.2594 = QM 6732 = Thom 5351 = WB 415	Fruit of apple (*Malus sylvestris*), Oregon, USA	EF661400	EF661337	EF661384
	CBS 632.78 = NRRL 4901	Unrecorded source	FJ491574	AY819987	FJ491558
	NRRL 35024 = NRRL A-4072	Bronx Park, New York, USA	EF661401	EF661340	EF661361
A. sesamicola	CBS 137324T = IBT 29314 = DTO 148-B4	Sesame seed, Denmark	KJ775437	KJ775063	KJ775233
A. steynii	CBS 112812T = NRRL 35675 = IBT 23096	Internal infection of dried arabica green coffee bean, India	EF661416	EF661347	EF661378
	CBS 112814 = IBT 23792	Green coffee bean, India	FJ491564	AY819953	FJ491546
	NRRL 35100 = NRRL 269 = NRRL A-22878	Unrecorded source, Poland	EF661415	EF661346	EF661369
A. subramanianii	CBS 138228 = DTO 245-E4	House dust, Mexico	KJ775446	KJ775050	KJ775243
	CBS 138229 = NRRL 5170 = NRRL A-993 = QM 4911	Air, Panama	EF661402	EF661338	EF661392
	CBS 138230 = NRRL 6161T = ATCC 18413	Shelled brazil nuts, Canada	EF661403	EF661339	EF661397
A. tanneri	NRRL 62426T = NIH 1005	Human lung, Cystic Fibrosis patient, USA	JN853798	JN896582	JN896583
A. westerdijkiae	CBS 112791 = IBT 23783	Surface disinfected green coffee bean, India	FJ491570	AY819974	FJ491536
	CBS 112803T = NRRL 3174 = IBT 10738 = ATCC 22947 = IBT 10738 = MUCL 39539	*Andropogon sorghum*, South Africa	EF661427	EF661329	EF661360
	CBS 112804 = IBT 24389	Saltern, Slovenia	KJ834522	AY819975	FJ491535
	CBS 138175 = DTO 178-D7	House dust, Cape Town, South Africa	KJ775445	KJ775064	KJ775242
	NRRL 5175 = NRRL A-17098	Cotton seed, Texas, USA	EF661428	EF661330	EF661393
	CBS 123905 = IBT 29316 = DTO 031-F5 = IBT 29038	Air sample, Zwartewaal, Netherlands	KJ775433	KJ775065	KJ775229
	CBS 137321T = IBT 32139 = DTO 231-A9	Air sample, Zwartewaal, Netherlands	KJ775434	KJ775066	KJ775230
	CBS 137322 = IBT 32137 = DTO 231-B1	Air sample, Zwartewaal, Netherlands	KJ775435	KJ775067	KJ775231

MATERIALS AND METHODS

Strains

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

Morphological analysis

For macro-morphological observations, Czapek Yeast Autolysate agar (CYA), Malt Extract agar (MEA), Yeast Extract Sucrose agar (YES), Dichloran 18 % Glycerol agar (DG18), Oatmeal agar (OA) and Creatine agar (CREA), were used (Samson *et al.* 2010). The isolates were inoculated at three points on each plate of each medium and incubated at 25 °C in the dark, in boxes, for 7 d. Additional CYA plates were incubated at 30, 33 and 37 °C under similar conditions. For micro-morphological observations, microscopic mounts were made in lactic acid from MEA and DG18 colonies. Alcohol was used to remove excess conidia and prevent air bubbles. A Zeiss SteReo Discovery.V20 dissecting microscope and Zeiss

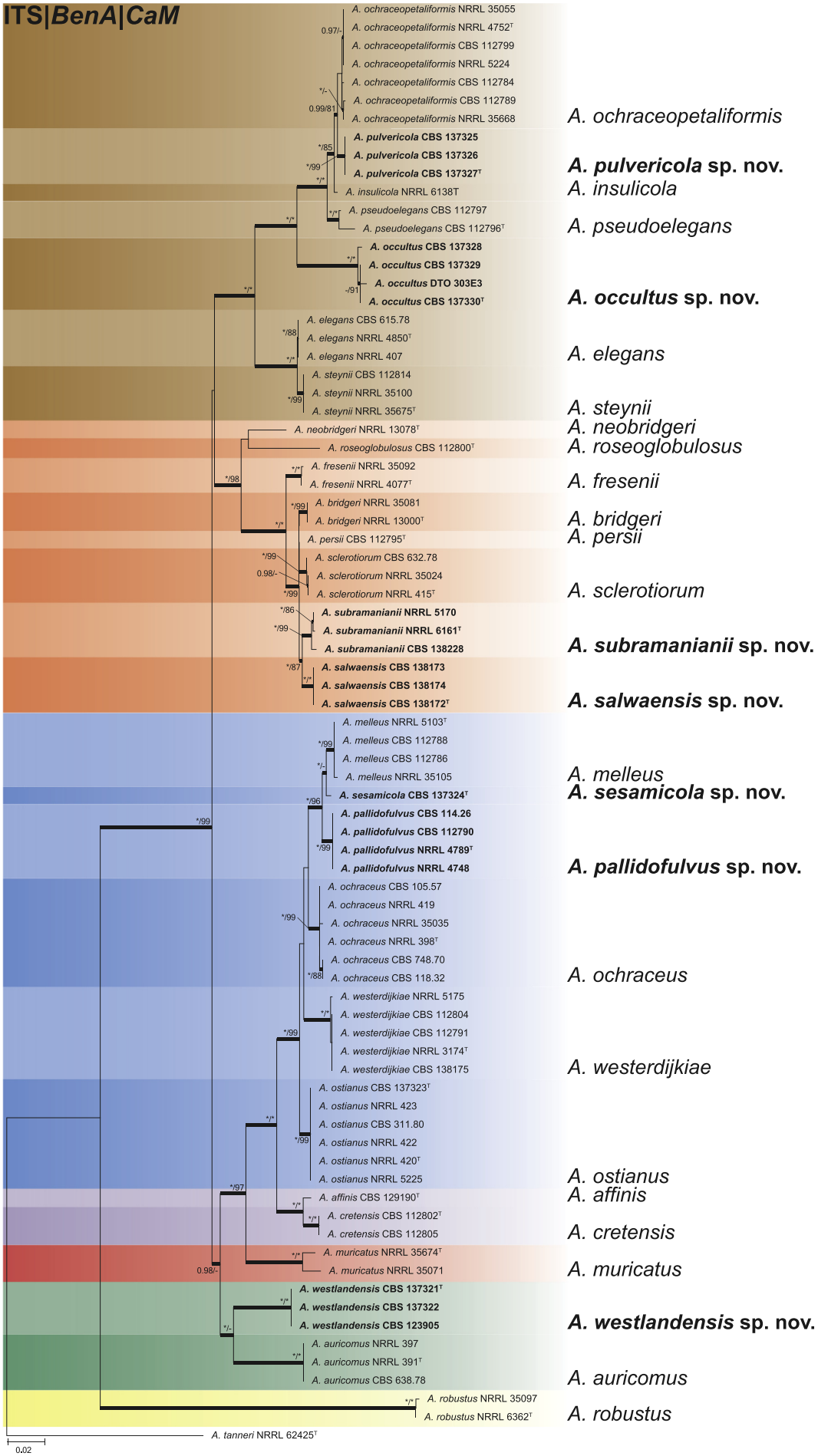

Fig. 1. Phylogenetic tree based on the concatenated ITS, *BenA* and *CaM*, showing the relationship of *Aspergillus* sect. *Circumdati* species. *Aspergillus tanneri* was chosen as outgroup. Thickened branches indicate bootstrap support in nodes above 80 % and/or posterior probabilities above 0.95 (^{T} = ex-type).

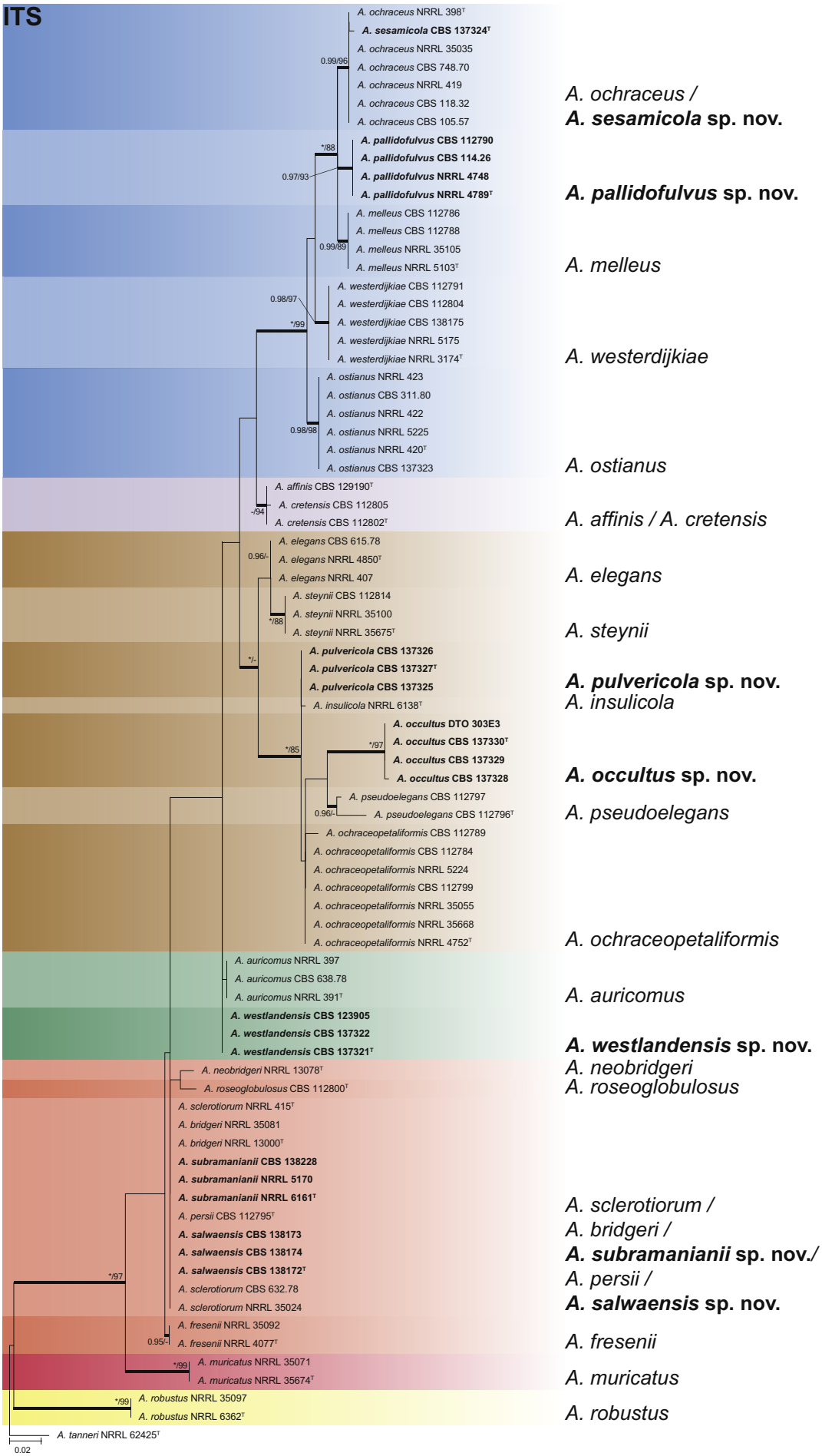

Fig. 2. Phylogenetic tree based on ITS, showing the relationship of *Aspergillus* sect. *Circumdati* species. *Aspergillus tanneri* was chosen as outgroup. Thickened branches indicate bootstrap support in nodes above 80 % and/or posterior probabilities above 0.95 (^{T} = ex-type).

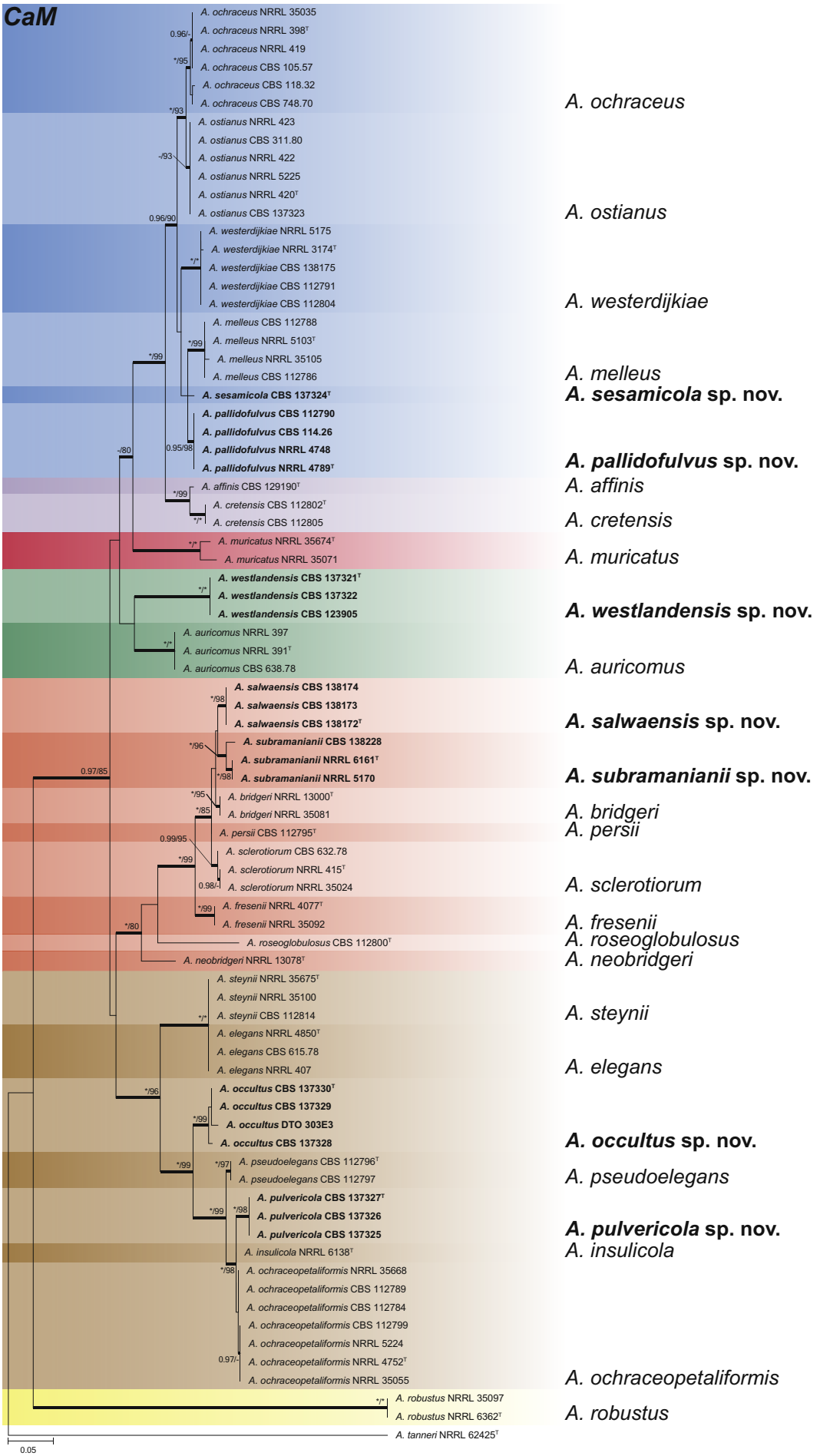

Fig. 3. Phylogenetic tree based on *CaM*, showing the relationship of *Aspergillus* sect. *Circumdati* species. *Aspergillus tanneri* was chosen as outgroup. Thickened branches indicate bootstrap support in nodes above 80 % and/or posterior probabilities above 0.95 (^{T} = ex-type).

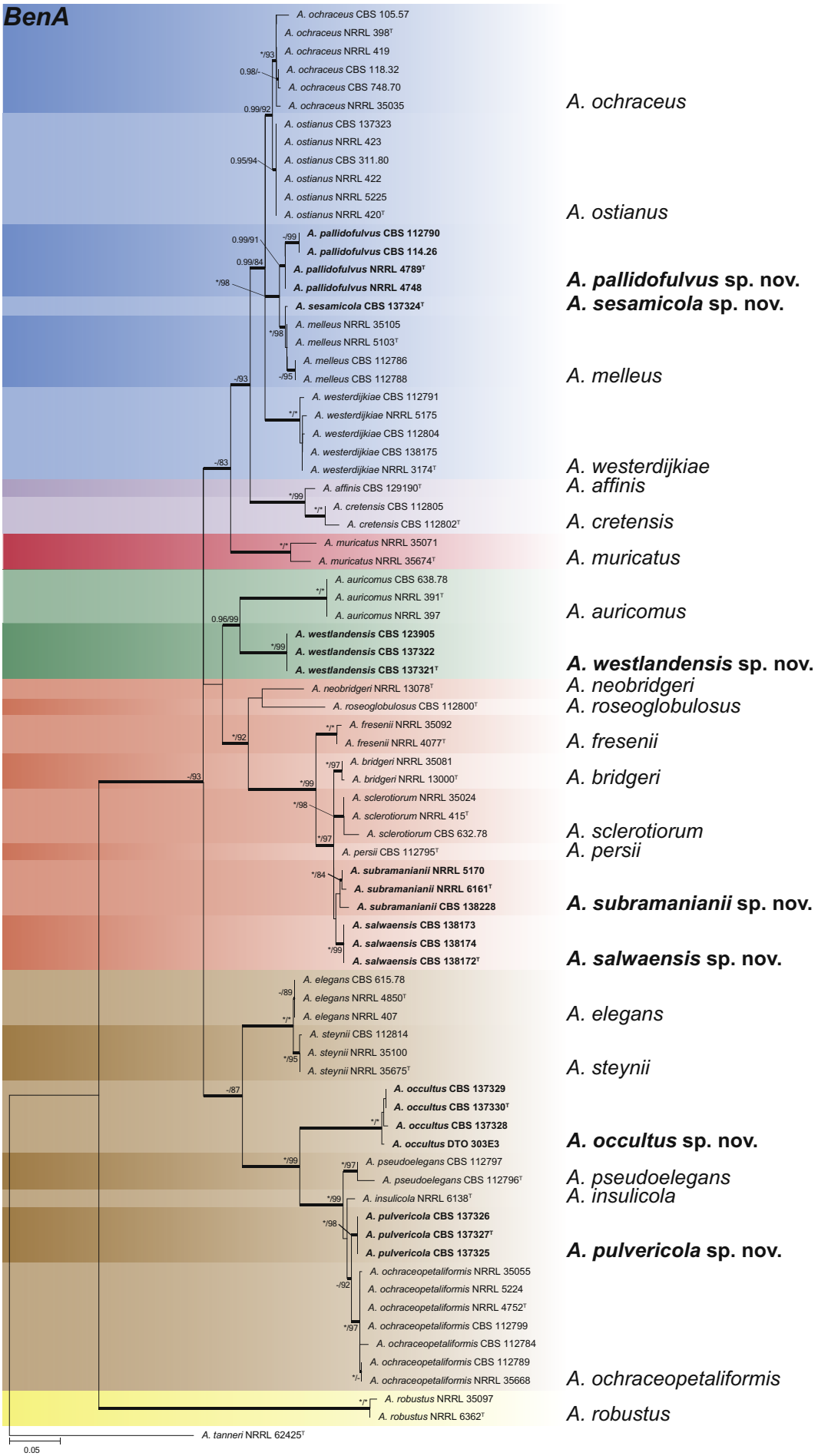

Fig. 4. Phylogenetic tree based on *BenA*, showing the relationship of *Aspergillus* sect. *Circumdati* species. *Aspergillus tanneri* was chosen as outgroup. Thickened branches indicate bootstrap support in nodes above 80 % and/or posterior probabilities above 0.95 (^{T} = ex-type).

Table 2. Growth rate comparison of *Aspergillus* section *Circumdati* species after 7 d (in mm).

	CYA				MEA	YES	DG18	OA	CREA
	25 °C	30 °C	33 °C	37 °C					
A. affinis	35–37	32–33	15–16	Microcolonies	34–35	52–55	47–48	22–25	Microcolonies
A. auricomus	40–50	35–45	No growth to microcolonies	No growth	35–42	58–70	45–55	25–35	10–16
A. bridgeri	46–48	55–56	43–44	30–31	40–42	65–66	42–44	33–34	22–23
A. cretensis	35–40	25–30	Microcolonies	No growth	29–32	49–51	48–55	21–25	5–6
A. elegans	32–45	31–40	18–23	No growth	30–40	50–60	45–50	26–35	13–15
A. fresenii	50–53	56–60	45–50	30–34	41–44	65–70	50–52	35–40	20–24
A. insulicola	38–45	42–47	35–40	16–20	35–40	60–65	52–56	33–36	15–19
A. melleus	49–60	50–55	43–48	15–20	36–45	68–70	45–55	30–40	9–10
A. muricatus	45–49	52–60	48–53	23–28	39–41	65–70	47–55	28–30	13–15
A. neobridgeri	37–40	52–56	55–58	38–42	43–45	70–75	54–56	39–41	20–21
A. occultus	24–30	23–30	12–18	No growth	20–22	34–36	35–42	20–25	9–12
A. ochraceopetaliformis	40–50	45–55	35–45	13–24	35–45	60–70	55–65	35–45	15–22
A. ochraceus	38–47	40–47	25–35	12–19, sometimes no growth	36–42	65–70	45–60	35–40	13–20
A. ostianus	46–53	35–44	18–22	No growth to microcolonies	40–45	65–70	50–60	40–45	14–25
A. pallidofulvus	45–60	45–60	35–45	20–30	47–60	65–75	55–65	42–45	20–28
A. persii	48–55	45–52	40–44	20–30	39–43	60–67	45–50	35–38	25–26
A. pseudoelegans	38–45	39–45	30–35	15–24	35–40	65–70	58–62	30–35	18–20
A. pulvericola	39–43	38–43	20–30	Microcolonies to 5	34–37	59–67	48–55	30–35	20–25
A. robustus	40–45	No growth	No growth	No growth	20–22	60–75	40–55	30–33	14–19
A. roseoglobulosus	48–57	50–57	40–45	15–24	43–50	65–72	45–60	40–50	20–25
A. salwaensis	54–56	63–65	57–58	30–32	42–43	70–72	48–50	42–45	30–35
A. sclerotiorum	54–57	56–64	46–50	28–32	41–45	70–72	40–50	38–42	25–30
A. sesamicola	32–34	40–41	30–31	19–20	30–31	47–50	38–39	35–36	11–12
A. steynii	40–50	30–40	7–30	No growth to 5 mm	36–45	60–70	52–60	31–35	15–16
A. subramanianii	52–60	60–67	55–60	35–45	44–48	65–72	40–50	40–45	28–30
A. westerdijkiae	49–55	35–42	12–18	No growth to 5 mm	38–44	68–70	60–65	40–45	15–25
A. westlandense	34–37	29–33	Microcolonies	No growth	30–31	46–50	44–47	25–30	12–15

AX10 Imager.A2 lightmicroscope equipped with AxioCam MRc5 cameras were used to capture digital images using the AxioVs40 v. 4.8.2.0 software package. Microscopic measurements were made using Nikon NIS-elements D v. 4.0 software.

Extrolite analysis

Isolates were grown on CYA and YES at 25 °C for 7 d. After incubation, five plugs of each agar medium were taken and pooled together in one vial for extraction with 0.75 ml ethyl acetate/dichloromethane/methanol (3:2:1) (v/v/v) with 1 % (v/v) formic acid. Extracts were filtered and analysed by HPLC using alkylphenone retention indices and diode array UV–VIS detection as described by Frisvad & Thrane (1987, 1993), with minor modifications as described by Smedsgaard (1997). The column used was a 50 × 2 mm Luna C-18 (II) reversed phase column (Phenomenex, CA, USA) fitted with a 2 × 2 mm guard column. Cultures examined after 2012 were examined using the UHPLC-DAD method described by Klitgaard *et al.* (2014).

Phylogenetic analysis

DNA extractions were made from 7 d old cultures grown on MEA, using the Ultraclean™ Microbial DNA isolation Kit (MoBio, Solana Beach, USA). DNA was stored at −20 °C. The ITS region and parts of the β-tubulin (*BenA*) and calmodulin (*CaM*) genes were amplified and sequenced as described previously (Varga *et al.* 2007a–c). The sequences were deposited in GenBank with accession numbers listed in Table 1.

Sequence contigs were assembled in SeqMan Pro v. 9.0.4 (DNASTAR). A sequence database was created using newly generated sequences and sequences obtained from GenBank, mainly from the Peterson (2008) study. The data sets were aligned using MAFFT v. 7.058b (Katoh & Standley 2013) using the L-INS-I option. Aligned data sets were analyzed in MEGA 5.2.2 (Tamura *et al.* 2011) using Maximum Likelihood (ML) and MrBayes v. 3.2.1 (Ronquist & Huelsenbeck 2003) used for Bayesian tree inference (BI).

For ML, the best-suited substitution model was selected using the model-test provided in the MEGA 5.2.2 software package based on the lowest Akaike information criterion (AIC) value. ML

Table 3. Most important colony characters for species recognition in *Aspergillus* section *Circumdati*.

	Sclerotia colour	Colour in mycelial areas on CYA 25 °C	Conidial colour CYA 25 °C	Reverse colour CYA 25 °C	Colour in mycelial areas on DG18	Reverse colour on DG18
A. affinis	White to yellow	White	Absent	Greyish orange (5B4) at centre, fading into yellow white (4A2) margin	White	Yellowish white (2A2)
A. auricomus	White to yellow to orange	Pale green to pale yellow	Very sparse	Greyish orange to brownish orange (5B4–C4)	Pale green to pale yellow	Greyish yellow (2C6) centrally, yellowish grey (2B2) elsewhere
A. bridgeri	Light yellow	Shade of brown	Light yellow (3A4–5)	Dull yellow to greyish yellow (3B3–4B3)	White to brown	Light yellow (3A4–5)
A. cretensis	White to yellow to orange	White	Yellow (3A6)	Greyish yellow (3A4–4A4)	White	Yellowish white to light yellow (4A2–4A4)
A. elegans	Cream to light brown	White to greyish yellow	White to greyish yellow (4B4)	Yellowish brown (5D5) at centre, yellowish white to greyish yellow (4A2–4B4) elsewhere	White to greyish yellow to pale yellow to light yellow	Pale yellow (2A3) at centre, yellowish white (2A2) elsewhere
A. fresenii	White to light orange to yellow	White	Very sparse, light yellow (4A4)	Light yellow (4A4–5)	White to greyish yellow	Light yellow to greyish yellow (1A5–B5–2B5)
A. insulicola	Absent	White	Light yellow (4A4) to brownish orange (5C4) to olive brown (4E6)	Brown (6D5–E5) to brownish orange (5C6) with pale margin	White to pale yellow	Light yellow to yellow (2A5–6) to white
A. melleus	White to yellow to brownish orange	White	Yellowish white (3A2–4A2)	Greyish orange to orange (6B6–7)	Greyish green	Olive (2F8) to greyish green (1D6)
A. muricatus	White to cream to yellow to orange	White	Orange white (5A2)	Brown (6E7) centrally, fading to greyish yellow greyish orange (4B5–5B5)	White	Light yellow (2A5–3A5)
A. neobridgeri	Yellow to brownish	White	Absent	Brown (6E5) centrally, brownish orange (5C4–6C4) elsewhere	White to yellowish white	Greyish yellow (2C5) centrally, fading into yellowish white (2A2)
A. occultus	White to yellow	White	Brown (5E4) to light yellow (4A4)	Pale yellow (3A3)	White	Yellowish white (2A2)
A. ochraceopetaliformis	Reddish brown sclerotium-like structures	White to greyish white	Light yellow to olive to brownish orange (3A4–3D4–5C4)	Range from greyish yellow to brownish orange to brown to dark brown (4B3–5C4–6C6–7D6–E8–F8)	White	Dark brown (6F4) centrally, olive brown to brown (4D6–5D6) to pale yellow (1A3) to yellowish white (1A2)
A. ochraceus	Pinkish to purplish brown	White	Pale yellow to light yellow (4A3–4)	Light brown to dark brown (5D6–7F6) areas, otherwise greyish yellow to greyish orange (4B4–5B4)	White	Generally olive (2F8–3F8) to olive yellow (2D6), when less dense sporulating, light yellow to brown (3A4–6E6) to white
A. ostianus	White to cream	White to yellowish grey to reddish grey	Light yellow to brown (4A4–5E5)	Light brown to brown (5D4–7E4) to olive (2E5–3E5), with some darker brown (5F5) areas, pale margin	Greyish yellow to olive	Greyish yellow to olive (2B4–3E8–F8)

Table 3. (Continued).

	Sclerotia colour	Colour in mycelial areas on CYA 25 °C	Conidial colour CYA 25 °C	Reverse colour CYA 25 °C	Colour in mycelial areas on DG18	Reverse colour on DG18
A. pallidofulvus	Yellow to pinkish to brown	White	Pale yellow to light yellow to greyish yellow (4A3–A5–B5)	Brown (5E5–6E5)	White	Brown (5E6) at centre, olive brown (4E6–F6) elsewhere, fading into pastel yellow (1A4) margin
A. persii	White to yellowish brown when present	White	Light yellow to pale orange (4A4–5A2)	Light yellow (3A5) to yellowish brown (5D6)	White	Light yellow (2A5) centrally, fading into pale yellow (2A3)
A. pseudoelegans	White to yellow to brown	White to yellowish white	Absent	Brownish orange (6C5) centrally, fading into greyish yellow to greyish orange (4B3–5B3)	White to light yellow to greenish yellow	Olive (3D3) at centre, pale yellow to light yellow (1A3–4) elsewhere
A. pulvericola	White to cream	White	Greyish yellow (4B5)	Brown (6D7)	White to pastel yellow	Yellowish white (1A3–2A2)
A. robustus	White to black	White	Light yellow (4A4)	Olive (2F7) centrally, olive yellow (2C7) and light yellow (3A5) elsewhere	White	Greenish grey to greyish yellow (1B2–3) to yellowish white (2A2)
A. roseoglobulosus	Yellow to pinkish to brown	Dull red	Very sparse, light yellow sporulation	Brownish orange (5C5–6C5) to light brown (7D6) to reddish brown (9D5) areas	Greyish yellow to olive	Olive (3F7) centrally, fading into greyish yellow (2B5) margin
A. salwaensis	White	White	Light yellow to yellow (3A5–6)	Light yellow to greyish yellow (4A4–B6)	White to cream	Orange yellow (4B7) near centre, fading into yellow (3A6) with white pale (2A2) margin
A. sclerotiorum	White to cream	White	Light yellow (3A4–4A4)	Light yellow greyish yellow (4A4–B5)	White	Greyish orange (5B6) at centre, greyish yellow (3B6) to yellowish white (2A2) elsewhere
A. sesamicola	Absent	White	Light yellow to orange (4A4–5)	Dark brown (6F8–9F8)	White	Orange yellow (4B7)
A. steynii	White to yellow	White to light grey	Light yellow (3A5–4A5)	Light brown (7D4) at centre, greyish yellow (3B5–4B5)	White	Greyish yellow (3B6) at centre, yellowish white to pale yellow (2A2–3) elsewhere
A. subramanianii	White to cream	White	Light yellow (3A5–4A5)	Light yellow (4A5)	White	Light yellow (3A3) to yellowish white (2A2)
A. westerdijkiae	White to yellow to pinkish	White to greyish yellow	Pale yellow to light yellow (3A3–5)	Light brown to dark brown (5D6–7F6) areas, otherwise greyish yellow to greyish orange (4B4–5B4), some isolates olive brown (4E7–F7) areas near margin	White	Orange grey to greyish orange (5B2–3), yellowish white (4A2) near margin
A. westlandense	Purple to reddish	White	Light yellow to orange (4A4–5)	Yellowish brown (5D6)	White to yellowish white	Yellowish white (4A2)

Colour codes refer to Kornerup & Wanscher 1967.

Table 4. Most important colony characters for species recognition in *Aspergillus* section *Circumdati*.

	Soluble pigment on CYA 25 °C	Soluble pigment on CYA 30 °C	Soluble pigment on CYA 33 °C	Soluble pigment on CYA 37 °C
A. affinis	Absent	Absent	Absent	Absent
A. auricomus	Orange brown	Orange brown	Absent	Absent
A. bridgeri	Absent	Absent	Absent	Absent
A. cretensis	Absent	Absent	Absent	Absent
A. elegans	Absent	Absent	Absent	Absent
A. fresenii	Yellow	Yellow	Yellow	Yellow
A. insulicola	Reddish, inconspicuous	Reddish, inconspicuous	Reddish brown inconspicuous	Yellowish orange (4A7)
A. melleus	Orange brown	Orange brown	Absent	Olive yellow to absent
A. muricatus	Yellowish brown to orange brown	Yellowish brown to orange brown	Yellowish brown to orange brown	Olive to yellow
A. neobridgeri	Reddish brown, inconspicuous	Reddish brown, inconspicuous	Reddish brown inconspicuous	Absent
A. occultus	Absent	Absent	Absent	Absent
A. ochraceopetaliformis	Reddish brown, inconspicuous in some isolates	Absent	Absent	Yellowish orange (4A7) in most isolates
A. ochraceus	Yellow, inconspicuous in some isolates	Yellow, inconspicuous in some isolates	Yellow, produced in degenerated strain	Yellowish orange (4A7)
A. ostianus	Absent	Absent	Absent	Absent
A. pallidofulvus	Absent	Absent	Absent	Absent
A. persii	Brownish orange	Brownish orange	Brownish orange	Brownish orange
A. pseudoelegans	Inconspicuously red	Inconspicuously red	Absent	Yellowish orange
A. pulvericola	Reddish to brown	Reddish to brown	Yellowish orange inconspicuous	Absent
A. robustus	Absent	Absent	Absent	Absent
A. roseoglobulosus	Absent	Absent	Absent	Absent
A. salwaensis	Yellowish orange	Yellowish orange	Yellowish orange	Yellowish brown
A. sclerotiorum	Yellow	Yellow	Yellow	Yellow
A. sesamicola	Absent	Absent	Absent	Absent
A. steynii	Absent	Absent	Absent	Absent to yellowish orange
A. subramanianii	Yellow, inconspicuous in some isolates	Yellow, inconspicuous in some isolates	Yellow	Yellow
A. westerdijkiae	Absent	Absent	Yellowish orange	Yellowish orange
A. westlandense	Reddish, inconspicuous	Absent	Absent	Absent

analyses were run with an initial tree calculated with the Bio-Neighbour-Joining (BioNJ) option and subsequent Heuristic search done with Nearest Neighbour Interchange (NNI). Statistical support in nodes was calculated running a bootstrap analysis of 1 000 replicates.

For BI, the best-suited substitution model was selected using MrModeltest v. 2.3 (Nylander *et al.* 2004) based on the lowest Akaike information criterion (AIC). BI analyses were run with two sets of four chains until the standard deviation of split frequencies reached 0.01. Sample frequency was set at 100, with 25 % of trees removed as burnin.

RESULTS AND DISCUSSION

Phylogeny

The aligned data sets of 79 strains was respectively 553, 571 and 465 bp long for ITS, *BenA* and *CaM*. The concatenated alignment was 1 589 bp long. The ML analysis was run with models determined from within the MEGA software package. The Tamura 3-parameter with gamma distributed (+G) and Invariant sites (+I) was used for the ITS phylogeny, Kimura 2-parameters (K2 + G + I) for *BenA* and K2 + G for both *CaM* and the combined phylogeny. For BI analyses, the general time reversible (GTR + G + I) model was used for the ITS and combined phylogeny, with HKY85 used for *BenA* and the symmetrical (SYM) model for *CaM*. Tree topology did not differ between ML and BI trees. As such, ML trees were used for presenting phylogenies, with both bootstrap values (>80 %) and posterior probabilities (>0.95) indicated above thickened branches (Figs 1–4).

Based on our results, we accept 27 species in section *Circumdati*, including the seven species described in this paper. Amongst the new species, we introduce *A. subramanianii* for NRRL 6161, incorrectly considered by Peterson (2008) to represent the type for *A. fresenii*. We reject *A. sulphureus* (Fresen.) Wehmer and correctly assign the strain IMI 211397 to *A. fresenii*.

Wehmer (1901) introduced the new combination, *Aspergillus sulphureus* (Fresen.) Wehmer, for *Sterigmatocystis sulphureus* Fresen. (1863). However, the epithet had already been used for the older name *Aspergillus sulphureus* Desm. (1831), a different species from that of Fresenius and only known from herbarium

Table 5. Most important micromorphological characters for species recognition in *Aspergillus* section *Circumdati*.

	Vesicle shape	Conidial shape	Conidial ornamentation	Conidial size, averages between brackets (in µm)
A. affinis	Globose	Subglobose to broadly ellipsoidal	Finely roughened	2.5–4 × 2.5–3.5 (3.2 ± 0.2 × 2.9 ± 0.2)
A. auricomus	Globose	Ellipsoidal	Roughened	3–4 × 2.5–3 (3.5 ± 0.2 × 2.5 ± 0.1)
A. bridgeri	Globose	Globose to subglobose	Smooth	2.5–3 × 2.5–3 (2.5 ± 0.1 × 2.5 ± 0.1)
A. cretensis	Globose, minor proportion spathulate	Broadly ellipsoidal	Smooth to finely roughened	2.5–4 × 2.5–3.5 (3.1 ± 0.3 × 2.6 ± 0.2)
A. elegans	Globose	Broadly ellipsoidal	Smooth to very finely roughened	3–4 × 2.5–3.5 (3.6 ± 0.2 × 3 ± 0.2)
A. fresenii	Globose, minor proportion elongated	Globose to subglobose	Smooth	2–3 × 2–3 (2.7 ± 0.3 × 2.6 ± 0.3)
A. insulicola	Globose	Globose to subglobose	Smooth	2–3 × 2–3 (2.5 ± 0.1 × 2.5 ± 0.1)
A. melleus	Globose	Globose to broadly ellipsoidal	Finely roughened	2.5–3.5 × 2.5–3.5 (3 ± 0.2 × 2.9 ± 0.2)
A. muricatus	Globose, sometimes elongated, especially on MEA	Globose to broadly ellipsoidal	Finely roughened to roughened	2.5–3 × 2.5–3 (2.8 ± 0.2 × 2.7 ± 0.1)
A. neobridgeri	Spathulate	Globose to subglobose	Smooth	2–3 × 2–2.5 (2.5 ± 0.2 × 2.3 ± 0.1)
A. occultus	Globose	Globose to subglobose	Smooth and finely roughened	2.5–3 (2.88 ± 0.15 × 2.81 ± 0.2)
A. ochraceopetaliformis	Globose to pyriform	Globose	Smooth	2–3 × 2–3 (2.7 ± 0.2 × 2.7 ± 0.2)
A. ochraceus	Globose, sometimes elongated on DG18	Globose to subglobose	Finely roughened	2.5–4 × 2.5–3.5 (3.1 ± 0.3 × 2.9 ± 0.3)
A. ostianus	Globose to spathulate	Broadly ellipsoid to pyriform	Smooth to finely roughened on dg18	4–5.5 × 3–4.5 (4.5 ± 0.3 × 3.8 ± 0.3)
A. pallidofulvus	Globose	Subglobose to ovoid to ellipsoidal	Smooth	3–4 × 2.5–3.5 (3.4 ± 0.3 × 3.1 ± 0.3)
A. persii	Globose	Globose to subglobose	Smooth	2.5–3 × 2.5–3 (2.6 ± 0.1 × 2.6 ± 0.1)
A. pseudoelegans	Globose to spathulate	Globose	Smooth	2–3 × 2–3 (2.6 ± 0.2 × 2.6 ± 0.2)
A. pulvericola	Globose	Globose to subglobose	Smooth, small proportion finely roughened	2.5–3 (2.55 ± 0.2 × 2.55 ± 0.2)
A. robustus	Globose	Ellipsoid	Roughened	3–4 × 2.5–3 (3.4 ± 0.3 × 2.9 ± 0.15)
A. roseoglobulosus	Globose	Globose to subglobose	Smooth to finely roughened	2–3 × 2–3 (2.4 ± 0.2 × 2.4 ± 0.2)
A. salwaensis	Globose to flattened at apex	Globose	Smooth	2.5–3 × 2.5–3 (2.7 ± 0.2 × 2.7 ± 0.2)
A. sclerotiorum	Globose	Globose to subglobose	Smooth	2–3.5 × 2–3.5 (2.69 ± 0.2 × 2.65 ± 0.2)
A. sesamicola	Globose	Ellipsoid	Smooth	3–3.5 × 2.5–3 (3.47 ± 0.15 × 2.89 ± 0.15)
A. steynii	Globose	Broadly ellipsoidal	Smooth to rough walled on DG18	2.5–4.5 × 2.5–4 (3.5 ± 0.4 × 3.1 ± 0.3)
A. subramanianii	Globose	Globose	Smooth	2.5–3 × 2.5–3 (2.5 ± 0.1 × 2.5 ± 0.1)
A. westerdijkiae	Globose to sometimes spathulate	Globose to subglobose	Finely roughened to rough	2.5–4 × 2.5–3.5 (3.1 ± 0.3 × 2.9 ± 0.3)
A. westlandense	Globose	Subglobose	Smooth	2.5–3.5 × 2.5–3 (2.99 ± 0.1 × 2.75 ± 0.1)

material (Desm. Pl. Crypt. exs. 554). As a result, Subramanian (1971) introduced the new name, *Aspergillus fresenii* Subram. for *A. sulphureus* (Fresen.) Wehmer. Because Subramanian (1971) failed to clearly designate a type strain, Samson & Gams (1985) neotypified *A. fresenii* with IMI 211397 (= CBS 550.65 = WB 4077). Based on Samson & Gams (1985), Kozakiewicz (1989) erroneously used *A. sulphureus* (Fresen.) Wehmer for the name of IMI 211397. This was also adopted in the 1993 "Names in Current Use" (NCU) for the *Trichocomaceae* (Pitt & Samson 1993) and the subsequent accepted species list of Pitt *et al.* (2000). These two lists did not accept *A. fresenii*. It is clear that the application of *A. sulphureus* Desm., is at present doubtful and that *Aspergillus fresenii* Subram. is the correct name for *Sterigmatocystis sulphureus* Fresen. (≡ *A. sulphureus* (Fresen.) Wehmer (nom. illeg.) ≡ *A. sulphureus* (Fresen.) Thom & Church (nom. illeg.)) (IMI 211397 = CBS 550.65 = NRRL 4077 = ATCC 16893). Peterson (2008) considered NRRL 6161 as the "type" strain for *A. fresenii* and informally "re-introduced" the name. Since IMI 211397 typifies *A. fresenii*, we introduce *Aspergillus subramanianii* for NRRL 6161.

As an identification marker ITS, the accepted DNA barcode for fungi (Schoch *et al.* 2012), performed respectably well (Fig. 2). Of the 27 species treated here in section *Circumdati*, 18 species could be identified using ITS, leaving nine species that could not be identified. *Aspergillus ochraceus* and *A. sesamicola*; *A. affinis* and *A. cretensis*; *A. bridgeri*, *A. persii*, *A. salwaensis*, *A. sclerotiorum* and *A. subramanianii* shared almost identical ITS sequences, meaning that an additional identification marker is necessary. *BenA* and *CaM* are good alternatives and *CaM* overall performs well for identification of *Aspergillus* strains (Peterson 2008, Jurjević *et al.* 2012, Visagie *et al.* 2014). In section *Circumdati*, *A. elegans* and *A. steynii* have identical *CaM* sequences and thus ITS or *BenA* is required for making a precise identification.

Based on our phylogenetic analysis, the 27 section *Circumdati* species are resolved in seven main clades. In some cases,

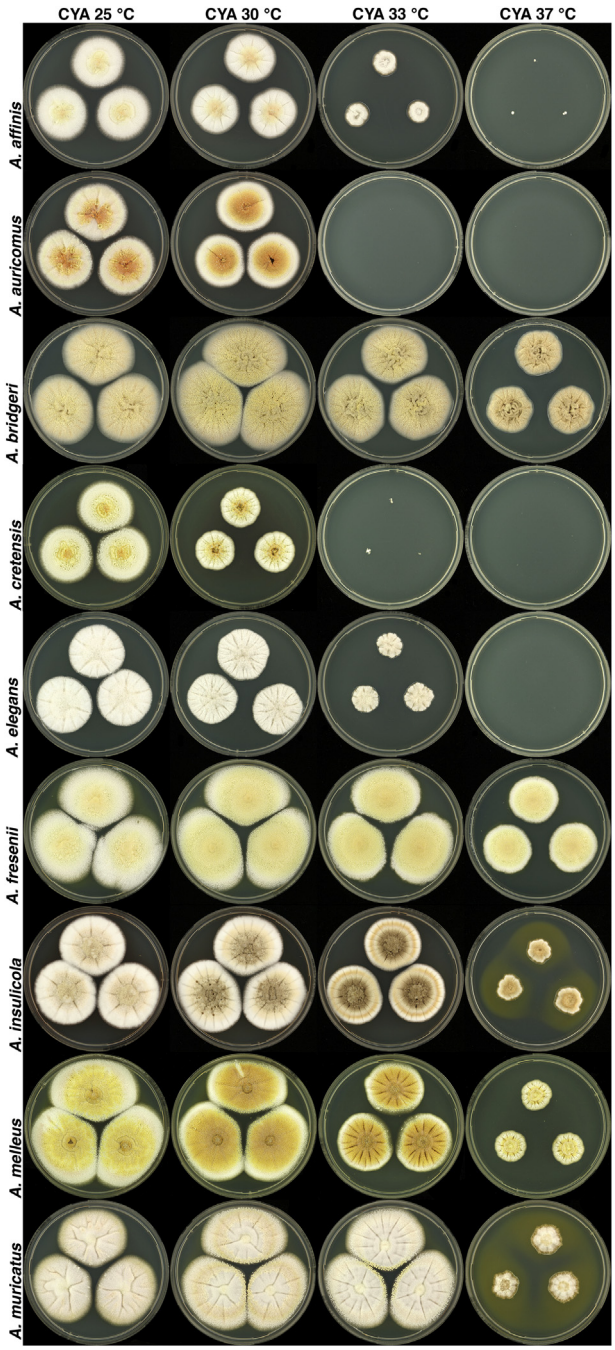

Fig. 5. Growth comparison of *Aspergillus* sect. *Circumdati* species on, from left to right, CYA at 25, 30, 33 and 37 °C.

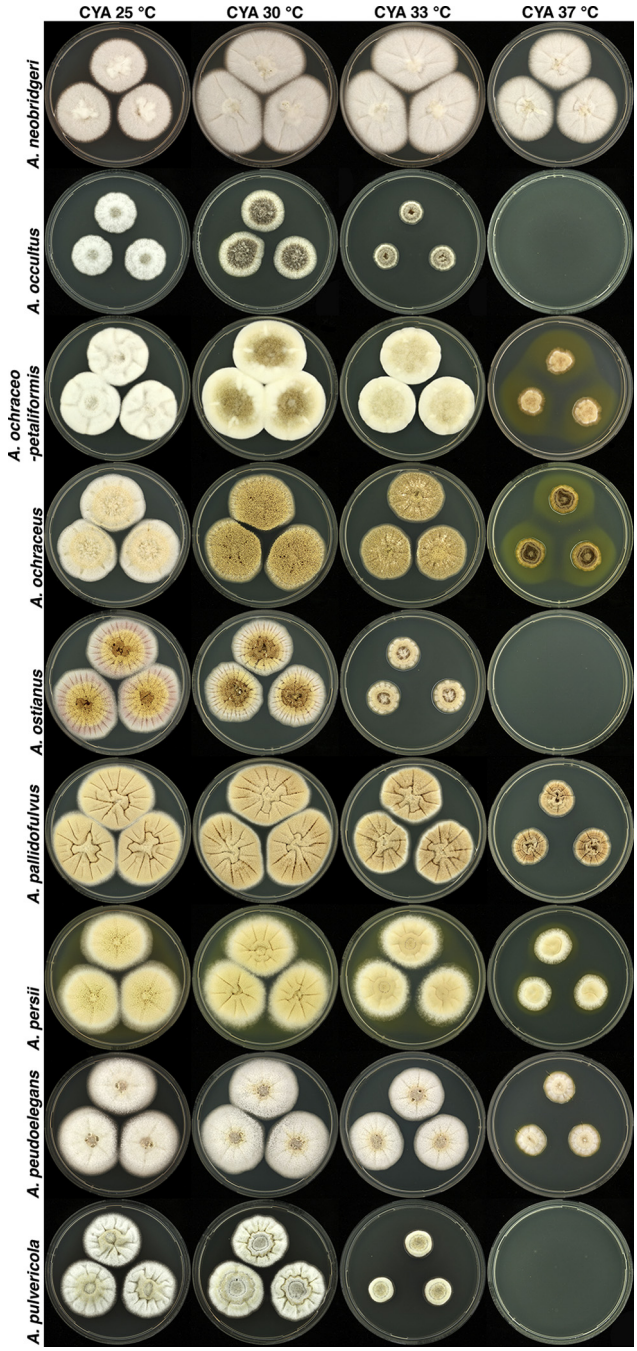

Fig. 6. Growth comparison of *Aspergillus* sect. *Circumdati* species on, from left to right, CYA at 25, 30, 33 and 37 °C.

these clades corresponded to the production of specific extrolites. The clades and their metabolites are discussed below.

The *A. fresenii* clade (Figs 1–4, orange box) includes *A. bridgeri*, *A. neobridgeri*, *A. persii*, *A. salwaensis*, *A. roseoglobulosus*, *A. sclerotiorum*, *A. subramanianii* and *A. fresenii*. These species are also closely related based on large subunit rRNA sequences (Peterson 2000), ITS (Varga *et al.* 2000a), *BenA* (Frisvad *et al.* 2004) and a combined phylogeny of *BenA*, *CaM*, ITS and *RPB2* (Peterson 2008). Peterson (2008) also showed that NRRL 35028 and NRRL 35056, previously identified as *A. sclerotiorum*, form a distinct clade. These strains were not examined here, but their sequences place them as a unique species within the *A. fresenii* clade.

The *A. ochraceopetaliformis* clade (Figs 1–4, brown box) includes *A. elegans*, *A. insulicola*, *A. occultus*, *A. ochraceopetaliformis*, *A. pseudoelegans*, *A. pulvericola*, and *A. steynii*. Strains previously identified as *A. flocculosus* also belong in this clade. Based on morphology and phylogenetic analyses, *A. flocculosus* could not be distinguished from *A. ochraceopetaliformis*. Peterson (2008) also noted this. As such, we place *A. flocculosus* as a tentative synonym of *A. ochraceopetaliformis*, although these two species are chemically distinct. Strain PT 05-1, previously identified as *A. flocculosus* (Zheng *et al.* 2013), was isolated from a saltern in China and was reported to produce ergosteroids and pyrrole derivatives. Morphologically and phylogenetically this strain is identical to *A. occultus*, a species we have isolated from house dust. *Aspergillus elegans* and *A. steynii* are resolved on a distinct branch, with both species producing cycloechinulin and TR-2, not observed in other species. *Aspergillus pseudoelegans*, *A. insulicola*, *A. pulvericola* and *A. ochraceopetaliformis* all produce asteltoxins.

Fig. 7. Growth comparison of *Aspergillus* sect. *Circumdati* species on, from left to right, CYA at 25, 30, 33 and 37 °C.

Aspergillus auricomus and the new species, *A. westlandensis*, are close relatives on a poorly supported branch in the *A. auricomus* clade (Figs 1–4, green box). *Aspergillus muricatus* (Figs 1–4, red box) is also resolved on a distinct branch, in its own clade. *Aspergillus affinis* and *A. cretensis* (Figs 1–4, purple box) are paired on a separate branch, closely related to the *A. ochraceus* clade.

The *A. ochraceus* clade (Figs 1–4, blue box) includes the remaining species of section *Circumdati*, *A. melleus*, *A. ochraceus*, *A. ostianus*, *A. pallidofulvus*, *A. sesamicola* and *A. westerdijkiae*. Sequences from multiple genes resolve the ex-type cultures of *A. onikii*, *A. petrakii* and *Sterigmatocystis japonica* in a clade with *A. ochraceus* and these names are thus placed in synonymy with the latter. *Aspergillus ochraceus* is closely related to *A. ostianus*, *A. melleus* and two species introduced here as *A. pallidofulvus* and *A. sesamicola.* The other species belonging to the *A. ochraceus* clade include *A. westerdijkiae*, *A. muricatus* and *A. cretensis*. *Aspergillus westerdijkiae* was described in 2004 as a new species with NRRL 3174 as the type strain (Frisvad *et al.* 2004). This particular strain was used in several previous studies dealing with various aspects of ochratoxin production (Davis *et al.* 1969, Trenk *et al.* 1971, Wei *et al.* 1971, Applegate & Chipley 1976). This species can be differentiated from *A. ochraceus* by several DNA based methods, including real time PCR (Morello *et al.* 2007, Gil-Serna *et al.* 2009a, 2009b), or sequence-based methods (Frisvad *et al.* 2004). However, it is difficult to distinguish these two sibling species using physiological or morphological methods. Yilmaz *et al.* (unpublished) showed that *A. westerdijkiae* colonies on CYA at 33 °C consistently produce yellowish orange soluble pigment, a character not observed for strains of *A. ochraceus*. The well supported branch including species of the *A. ochraceus* and *A. cretensis* clades and *A. muricatus* includes species producing aspochracins, mellamides, circumdatins and aspergamides. The *A. ochraceus* and *A. cretensis* clades have apparently lost the ability to produce aspochracins.

The *A. robustus* clade (Figs 1–4, yellow box) includes a single species, *A. robustus*, not closely related to any other species of section *Circumdati* and probably represents a unique section. *Aspergillus robustus* produces black sclerotia, phototropic conidiophores, are not able to grow on CYA at 30 °C and none of the extrolites usually found in species of section *Circumdati*. Similarly, *A. tanneri* was described and placed in section *Circumdati* by Sugui *et al.* (2012), and is phylogenetically closest to *A. robustus*. From the phylogenies it is clear that, in common with *A. robustus*, *A. tanneri* does not belong in section *Circumdati,* and its correct classification in *Aspergillus* will be considered in a future study.

Morphology

Morphological characters applicable to the identification of *Aspergillus* section *Circumdati* species are summarised in Tables 2–5. Colony growth rates on various media and incubated at various temperatures are taxonomically informative (on strictly standardised media, incubated under standardised growth conditions). In particular, growth rates and the production of coloured soluble pigments on CYA at 25, 30, 33 and 37 °C (Figs 5–7) are informative. As an example, *A. robustus* is the only species that does not grow on CYA at 30 °C. In addition, *A. westerdijkiae* generally does not grow at 37 °C and produces a yellowish orange soluble pigment only at 33 °C. The yellow haloes produced around colonies seem to be correlated with the production of neoaspergillic acids. Additional colony characters informative for identification include mycelia and colony reverse colour on CYA and DG18, as well as the colour of sclerotia produced. Microscopically, species are very similar. All conidiophores are biseriate. Most species have globose vesicles, with *A. cretensis*, *A. fresenii*, *A. muricatus*, *A. ochraceus*, *A. pseudoelegans* and *A. westerdijkiae* producing a minority of elongated or spathulate conidiophores. *Aspergillus neobridgeri* strictly produces spathulate conidiophores. Conidial shape and ornamentation is taxonomically informative, even though conidial sizes are similar for most species in section *Circumdati*. However, *A. ostianus* is the exception and produces larger conidia (4–5.5 × 3–4.5 µm) than all other species. In

Table 6. Presence–absence data for extrolites produced in *Aspergillus* section *Circumdati*.

	Antibiotic Y	Aspergamides	Aspochracin	Aspyrone	Asteltoxins	Aurantiamin	Circumdatins	Cycloechinulin	Cyclopenol	Destruxins	Insulicolides	Mellamide	Mellein	Mevinolin	Nethylepiamauromine	Neohydroxyaspergillic acid	Ochratoxin A	Ochrindols	Orthosporin	Penicillic acid	Petromurin	Preussin	Quinolactacin	Radarins	Sclerotides	Secalonicacid A	Secopenitrems	Sulphinines	TR – 2	Viomellein	Xanthomegnin
A. affinis	–	+	–	+	–	–	–	–	–	–	–	+	+	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–
A. auricomus	–	+	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	+
A. bridgeri	–	+	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	+	+	–	–	–	–	–	+	–	–	–	–
A. cretensis	–	–	–	+	–	–	–	–	–	–	–	+	+	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–
A. elegans	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+
A. fresenii	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	+	–	–	–	–	+	–	–	+	+	–	–	+
A. insulicola	–	–	+	+	+	–	–	–	–	–	+	–	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	+
A. melleus	–	+	–	+	–	–	+	–	–	–	–	–	+	–	–	–	–/w	–	+	+	–	–	–	–	–	–	–	–	–	–	+
A. muricatus	–	–	+	–	–	–	+	–	–	–	–	+	–	–	–	+	+	–	+	+	+	–	–	–	–	–	–	–	–	–	+
A. neobridgeri	–	–	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	–	–	+	–	–	–	–	+
A. occultus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	+	–	–	–	–	–	–	–	–
A. ochraceopetaliformis	–	–	–	+	+	–	–	–	–	–	+	–	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	+
A. ochraceopetaliformis (A. flocculosus)	–	–	–	+	+	–	–	–	–	–	–	–	+	–	–	+	+	–	+	+	–	–	–	–	–	–	–	–	–	–	+
A. ochraceus	–	+	–	+	–	–	+	–	–	–	–	–	+	–	–	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	+
A. ostianus	–	+	–	+	–	–	+	–	–	–	–	+	+	–	–	–	–/w	–	+	+	–	–	–	–	–	–	–	–	–	–	+
A. pallidofulvus	–	+	–	+	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	+
A. persii	–	+	+	–	–	+	–	–	+	–	–	+	–	+	–	+	–/w	–	–	+	+	–	–	–	–	–	–	–	–	–	+
A. pseudoelegans	+	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–
A. pulvericola	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	+	–	–	–	–	+	+
A. robustus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. roseoglobulosus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	+
A. salwaensis	–	+	+	–	–	–	–	–	–	–	+	–	–	–	–	–	w	–	–	+	–	–	–	–	–	–	–	–	–	–	–
A. sclerotiorum	–	+	+	–	–	–	–	–	+	–	–	+	–	–	–	–	w	–	–	+	+	–	–	–	+	–	–	–	–	–	+
A. sesamicola	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+
A. steynii	–	–	–	+	–	–	–	+	–	–	–	–	+	–	+	–	+	+	+	–	–	–	–	–	–	–	–	–	+	–	+
A. subramanianii	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	w	–	–	+	+	–	–	–	–	–	–	–	–	–	–
A. westerdijkiae	–	+	–	+	–	–	+	–	–	+	–	+	+	–	–	+	+	–	+	+	–	+	–	–	–	–	–	–	–	–	+
A. westlandense	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–/w	–	–	+	–	–	–	–	–	–	–	–	–	–	+

Table 7. Mycotoxins produced in section *Circumdati* (*++: strong production, +: medium production, w (weak): trace production, −: toxin not detected).

Species	Ochratoxin A production*	Penicillic acid	Xanthomegnin, viomellein, vioxanthin
A. affinis	+	++	−
A. auricomus	−	++	++
A. bridgeri	−	++	–
A. cretensis	+	++	−
A. elegans	−	−	++
A. fresenii	+	−	+
A. insulicola	−	++	++
A. melleus	w	++	++
A. muricatus	+	++	++
A. neobridgeri	−	++	++
A. occultus	++	++	−
A. ochraceopetaliformis	−	++	++
A. ochraceopetaliformis (*A. flocculosus*)	+	++	++
A. ochraceus	+	++	++
A. ostianus	w/−	++	++
A. pallidofulvus	−	++	++
A. persii	w/−	++	++
A. pseudoelegans	+	−	−
A. pulvericola	++	+	+
A. robustus	−	−	−
A. roseoglobulosus	++	++	++
A. salwaensis	w	+	−
A. sclerotiorum	w	+	+
A. sesamicola	w	−	++
A. steynii	++	−	++
A. subramanianii	w	+	−
A. westerdijkiae	++	++	++
A. westlandense	w	++	++

addition to Tables 2–5, we provide notes to facilitate identification of each species in the taxonomy section of this manuscript.

Extrolites

The extrolite profiles of species assigned to *Aspergillus* section *Circumdati* were recently studied intensively (Frisvad *et al.* 2004, Tables 6 & 7). Section *Circumdati* is generally characterised by the production of orthosporins, aspyrones, melleins, xanthomegnin, ochratoxins and penicillic acid, with insulicolin and petromurins being less frequently produced.

Overall, eleven of the accepted 27 species produce mellein, all except *A. robustus*, *A. elegans* and *A. steynii* produce penicillic acid and all except *A. cretensis*, *A. pseudoelegans*, *A. salwaensis*, *A. subramanianii* and *A. robustus* produce xanthomegnins. Mycotoxins produced by members of section *Circumdati* are summarised in Table 7. Eleven species produce large amounts of ochratoxin A: *A. cretensis*, *A. flocculosus*, *A. fresenii*, *A. muricatus*, *A. ochraceus*, *A. pseudoelegans*, *A. pulvericola*, *A. roseoglobulosus*, *A. sclerotiorum*, *A. steynii* and *A. westerdijkiae*. Ochratoxin production in these species has been confirmed using HPLC with diode array detection and by comparison to authentic standards. Seven further species produce ochratoxin A inconsistently and/or in trace amounts: *A. ostianus*, *A. melleus*, *A. persii*, *A. salwaensis*, *A. sclerotiorum*, *A. subramanianii* and *A. westlandensis*. The most important species regarding potential ochratoxin A production in coffee, rice, beverages and other foodstuffs are *A. ochraceus*, *A. westerdijkiae* and *A. steynii* (Frisvad & Samson 2000, Frisvad *et al.* 2004).

Among the newly described species, *A. pallidofulvus*, isolates produce aspergamide A, aspergamide B, notoamides, penicillic acid, mellein, 4-hydroxy mellein, xanthomegnin, viomellein, aspyrone, neoaspergillic acid, and metabolites OS, MM, O1, OI, OKI, OT, XME, AUX, SUW and CUR. Metabolite MM was until now only found in *A. pallidofulvus*. Additionally, one isolate (CBS 112790) also produces cycloechinulin, also consistently produced by isolates of *A. steynii* and *A. elegans*. *Aspergillus westlandensis* produces aspergamide A and B, penicillic acid, dehydropenicillic acid, xanthomegnin, viomellein and vioxanthin and traces of ochratoxin A. Petromurins were originally described from *A. muricatus* (Ooike *et al.* 1997), and were also identified in *A. sclerotiorum*, *A. flocculosus* and *A. pseudoelegans* (Table 6).

Although sequence data from 4 loci (*RPB2* data from Peterson 2000) suggest that *A. flocculosus* is a synonym of *A. ochraceopetaliformis*, extrolite data suggests *A. flocculosus* is quite different from both *A. ochaceopetaliformis* and *A. insulicola*, while *A. ochraceopetaliformis* is closer to *A. insulicola*. For example, *A. flocculosus* isolates produce ochratoxins and petromurins, in contrast with *A. ochraceopetaliformis* and *A. insulicola*, but do not produce insulicolides and several of the unknown characteristic metabolites (e.g. IN2, IN3, Met k, Pal2) produced by both of the other two species (Table 6). This is one of the few cases in *Aspergillus* when sequence data of four loci cannot distinguish among chemically quite distinct species. For the time being, *A. insulicola* and *A. ochraceopetaliformis* are accepted as distinct species, with *A. flocculosus* reduced to a synonym of the latter. Further sequence and physiological data are needed to solve this particular problem.

TAXONOMY

We accept the following species in *Aspergillus* section *Circumdati* (printed in bold). Included in the list are the seven new species described in this paper. *Aspergillus robustus* is also treated as part of the section for the time being, but see the discussion above. Descriptions for species follow the list with identifications table provided above.

Aspergillus affinis Davolos *et al.*, Int. J. Syst. Evol. Microbiol. 62: 1014. 2012. [MB517245]. — Herb.: ATCC MYA-4773. Ex-type: CBS 129190 = ATCC MYA-4773.

Aspergillus auricomus (Guég.) Saito, J. Ferment. Technol. 17: 3. 1939. [MB119950]. — Herb.: CBS H-9173. Ex-type: CBS 467.65 = NRRL 391 = ATCC 16890 = IMI 172277 = LCP 89.2596 = LSHBA 41 = WB 391.

Aspergillus bridgeri M. Chr., Mycologia 74: 210. 1982. [MB110494]. — Herb.: NY JB 26-1-2. Ex-type: CBS 350.81 = NRRL 13000 = ATCC 44562 = IMI 259098.

Aspergillus cretensis Frisvad & Samson, Stud. Mycol. 50: 33. 2004. [MB500002]. — Herb.: CBS H-13446. Ex-type: CBS 112802 = NRRL 35672 = IBT 17505.

Aspergillus elegans Gasperini, Atti Soc. Tosc. Sci. Nat. Pisa, Processi Verbali 8: 328. 1887. [MB212852]. — Herb.: CBS 102.14. Ex-type: CBS 102.14 = CBS

543.65 = NRRL 4850 = ATCC 13829 = ATCC 16886 = IFO 4286 = IMI 133962 = QM 8912 = QM 9373 = WB 4850.

Aspergillus fresenii Subram., Hyphomycetes (New Delhi): 552. 1971. [MB309222]. — Herb.: IMI 211397. Ex-type: CBS 550.65 = NRRL 4077 = ATCC 16893 = IMI 211397 = NRRL A-5355 = NRRL A-5520 = WB 4077.

Aspergillus flocculosus Frisvad & Samson, Stud. Mycol. 50: 33. 2004 = ***Aspergillus ochraceopetaliformis*** Bat. & Maia, Anais Soc. Biol. Pernambuco 15: 213. 1957. [MB500003]. — Herb.: CBS H-13435. Ex-type: CBS 112785 = NRRL 35668 = IBT 23121.

Aspergillus insulicola Montem. & A.R. Santiago, Mycopathologia 55: 130. 1975. [MB309225]. — Herb.: CBS 382.75. Ex-type: CBS 382.75 = NRRL 6138 = ATCC 26220.

Aspergillus melleus Yukawa, J. Coll. Agric. Imp. Univ. Tokyo 1: 358. 1911. [MB164593]. — Herb.: CBS 546.65. Ex-type: CBS 546.65 = NRRL 5103 = ATCC 16889 = WB 5103.

Aspergillus muricatus Udagawa, Uchiy. & Kamiya, Mycotaxon 52: 210. 1994. [MB362530]. — Herb.: CBM BF-42515. Ex-type: CBS 112808 = NRRL 35674 = IBT 19374.

Aspergillus neobridgeri Frisvad & Samson, Stud. Mycol. 50: 35. 2004. [MB500004]. — Herb.: CBS 559.82. Ex-type: CBS 559.82 = NRRL 13078.

Aspergillus occultus Visagie *et al.*, published here. [MB809198]. — Herb.: CBS H-21794. Ex-type: CBS 137330 = IBT 32285 = DTO 231-A7.

Aspergillus ochraceopetaliformis Bat. & Maia, Anais Soc. Biol. Pernambuco 15: 213. 1957. [MB292851]. — Herb.: no 270, Instituto de Micologia, Iniversidade do Recife. Ex-type: CBS 123.55 = NRRL 4752 = ATCC 12066 = IMI 211804 = QM 6955 = WB 4752.

Aspergillus ochraceus K. Wilh., Beitr. Kenntn. *Aspergillus*: 66. 1877. [MB190223]. — Herb.: IMI 16247iv. Ex-type: CBS 108.08 = NRRL 398 = ATCC 1008 = CECT2093 = DSM 824 = HARVARD296 = IMI 16247 = NCTC 3889 = NRRL 1642 = QM 6731 = Thom 112 = WB 398.

Aspergillus ostianus Wehmer, Bot. Centralbl. 80: 461. 1899. [MB179393]. — Herb.: IMI 15960. Ex-type: CBS 103.07 = CBS 548.65 = NRRL 420 = ATCC 16887 = IMI 015960iii = IMI 15960 = LCP 89.2584 = LSHBA c .35 = NCTC 3788 = QM 7460 = Thom 4724.35 = WB 420.

Aspergillus pallidofulvus Visagie *et al.*, published here. [MB809199]. — Herb.: CBS H-21796. Ex-type: CBS 640.78 = NRRL 4789 = IBT 13871 = IFO 4095 = WB 4789.

Aspergillus persii A.M. Corte & Zotti, Mycotaxon 83: 276. 2002. [MB374215]. — Herb.: MUCL 41970. Ex-type: CBS 112795 = NRRL 35669 = IBT 22660 = MUCL 41970.

Aspergillus pseudoelegans Frisvad & Samson, Stud. Mycol. 50: 35. 2004. [MB500005]. — Herb.: CBS H-13439. Ex-type: CBS 112796 = NRRL 35670 = IBT 23402.

Aspergillus pulvericola Visagie *et al.*, published here. [MB809200]. — Herb.: CBS H-21793. Ex-type: CBS 137327 = DTO 267-C6.

Aspergillus robustus M. Chr. & Raper, Mycologia 70: 200. 1978. [MB309241]. — Herb.: NY WB 5286. Ex-type: CBS 428.77 = NRRL 6362 = ATCC 36106 = IMI 216610 = NRRL A-17351 = WB 5286.

Aspergillus roseoglobulosus Frisvad & Samson, Stud. Mycol. 50: 30. 2004. [MB500001]. — Herb.: CBS H-13438. Ex-type: CBS 112800 = IBT 14720 = NRRL 4565.

Aspergillus salwaensis Visagie, *et al.*, published here. [MB809201]. — Herb.: BTC QF 001/14. Ex-type: CBS 138172 = DTO 297-B3.

Aspergillus sclerotiorum G.A. Huber, Phytopathology 23: 306. 1933. [MB277707]. — Herb.: IMI 56673. Ex-type: CBS 549.65 = NRRL 415 = ATCC 16892 = DSM 870 = IFO 7542 = IMI 056732 = IMI 56673 = LCP 89.2594 = QM 6732 = Thom 5351 = WB 415.

Aspergillus sesamicola Visagie *et al.*, published here. [MB809202]. — Herb.: CBS H-21792. Ex-type: CBS 137324 = IBT 29314 = DTO 148-B4.

Aspergillus steynii Frisvad & Samson, Stud. Mycol. 50: 39. 2004. [MB500006]. — Herb.: CBS H-13445. Ex-type: CBS 112812 = IBT 23096.

Aspergillus subramanianii Visagie *et al.*, published here. [MB809203]. — Herb.: CBS H-21791. Ex-type: CBS 138230 = NRRL 6161 = ATCC 18413.

Aspergillus westerdijkiae Frisvad & Samson, Stud. Mycol. 50: 30. 2004. [MB500000]. — Herb.: CBS H-13444. Ex-type: CBS 112803 = NRRL 3174 = ATCC 22947 = IBT 10738 = MUCL 39539.

Aspergillus westlandensis Visagie *et al.*, published here. [MB809204]. — Herb.: CBS H-21795. Ex-type: CBS 137321 = IBT 32139 = DTO 231-A9.

Aspergillus affinis Davolos *et al.*, Int. J. Syst. Evol. Microbiol. 62: 1014. 2012. MycoBank MB517245. Fig. 8.

Typus: **Italy**, Lazio, decomposing leave litter, isolated by D. Davolos, (ATCC MYA-4773, culture ex-type CBS 129190 = IBT 32310 = ATCC MYA-4773).

ITS barcode: GU721090. (alternative markers: *BenA* = GU721092; *CaM* = GU721091). This species has unique sequences for *BenA* and *CaM*, but share a similar ITS sequence with *A. cretensis*.

Colony diam, 7 d (in mm): CYA 35–37; CYA 30 °C 32–33; CYA 33 °C 15–16; CYA 37 °C microcolonies; MEA 34–35; YES 52–55; DG18 47–48; OA 22–25; CREA microcolonies.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; sclerotia white to yellow (2A3–3A4), dominate colony appearance; sporulation after prolonged incubation; soluble pigment absent; exudate clear to yellowish; reverse greyish orange (5B4) at centre, fading into yellow white (4A2) margin. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies crateriform, whitish to cream, sterile. CYA 37 °C, 7 d: Microcolonies white. MEA 25 °C, 7 d: Colony surface floccose; sclerotia white to pale yellow to light yellow (2A3–4A5), dominate colony appearance; soluble pigment absent; exudate clear to yellowish; reverse brown (6D8) at centre, greyish orange (5B6) near margin. YES 25 °C, 7 d: Colony surface floccose; sclerotia white to pale yellow to light yellow (2A3–3A4), dominate appearance; soluble pigment absent; exudate absent; reverse pale yellow to light yellow (4A3–5). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white to light yellow (3A2–3A4); soluble pigment absent; exudate absent; reverse yellowish white (2A2). OA 25 °C, 7 d: Colony surface floccose; sclerotia white to pale yellow to light yellow (2A3–3A4), dominate appearance; soluble pigment absent; exudate absent; reverse yellowish white (3A2). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, after 7 d only produced on DG18; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 730–2300 × 11–17 µm; Vesicles globose, 35–70 µm wide; Metulae 12.5–21.5 × 4.5–7 µm, covering 100 % of head; Phialides ampulliform, 9–11 × 3–4.5 µm; Conidia subglobose to broadly ellipsoidal, finely roughened, 2.5–4 × 2.5–3.5 µm (3.2 ± 0.2 × 2.9 ± 0.2, *n* = 44); Sclerotia white to pale yellow to light yellow, 133–675 µm.

Extrolites: aspergamides, aspyrones, mellamides, mellein, ochratoxins, penicillic acid.

Distinguishing characters: *Aspergillus affinis* sporulates poorly on most media after 7 d and its colony appearance is dominated by white to yellow sclerotia. In addition, the species produces microcolonies on CYA at 37 °C. Morphologically and phylogenetically, it is very similar to *A. cretensis*. However, *A. cretensis* produces microcolonies on CYA at 33 °C, compared to 15–16 mm diam colonies of *A. affinis*, and does not grow at 37 °C.

Aspergillus auricomus (Guég.) Saito, J. Ferment. Technol. 17: 3. 1939. MycoBank MB119950. Fig. 9.

≡ *Sterigmatocystis auricoma* Guég., Bull. Soc. mycol. Fr. 15: 186. 1899.

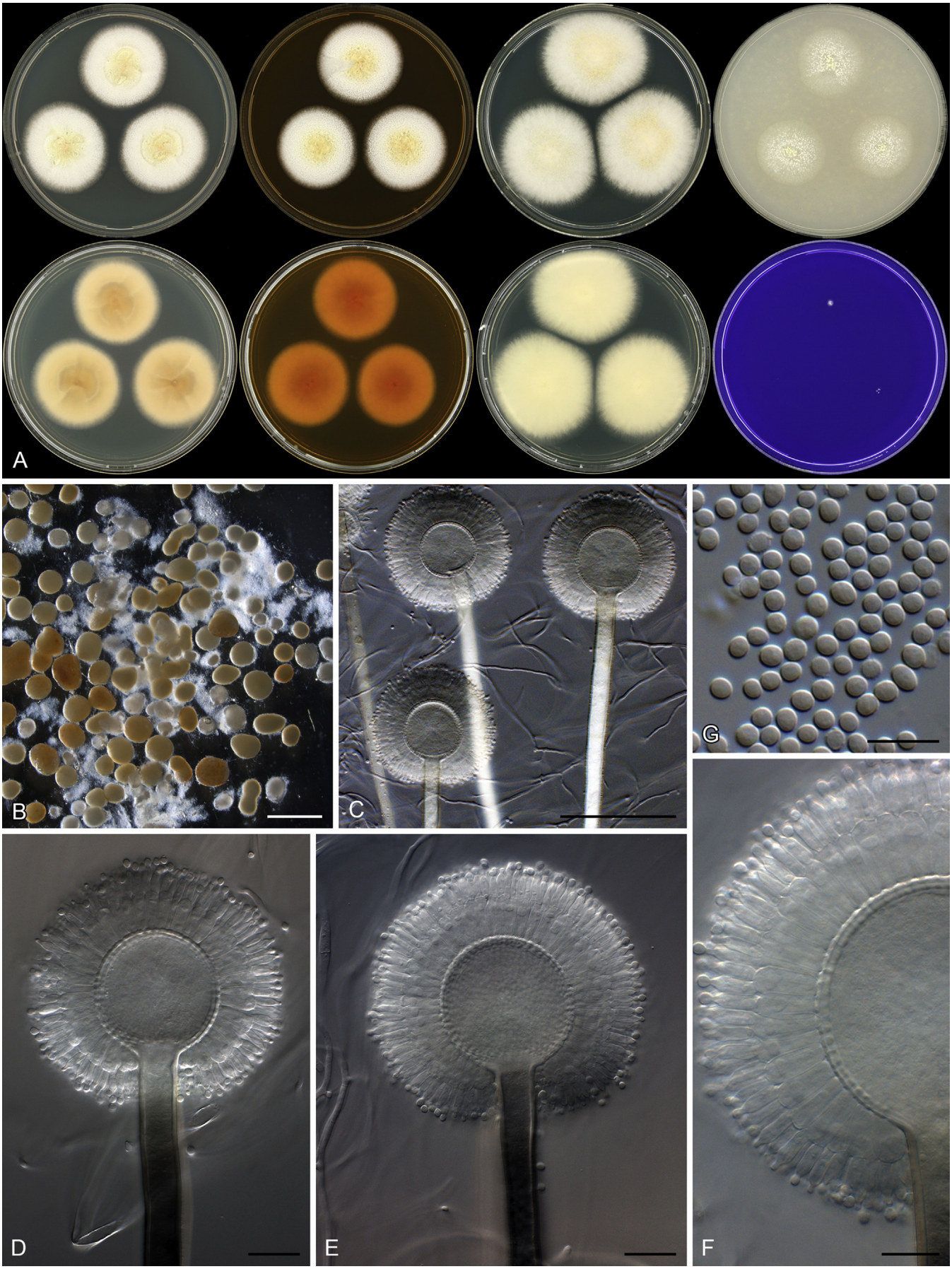

Fig. 8. *Aspergillus affinis*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C = 100 µm; D, E = 20 µm; F, G = 10 µm.

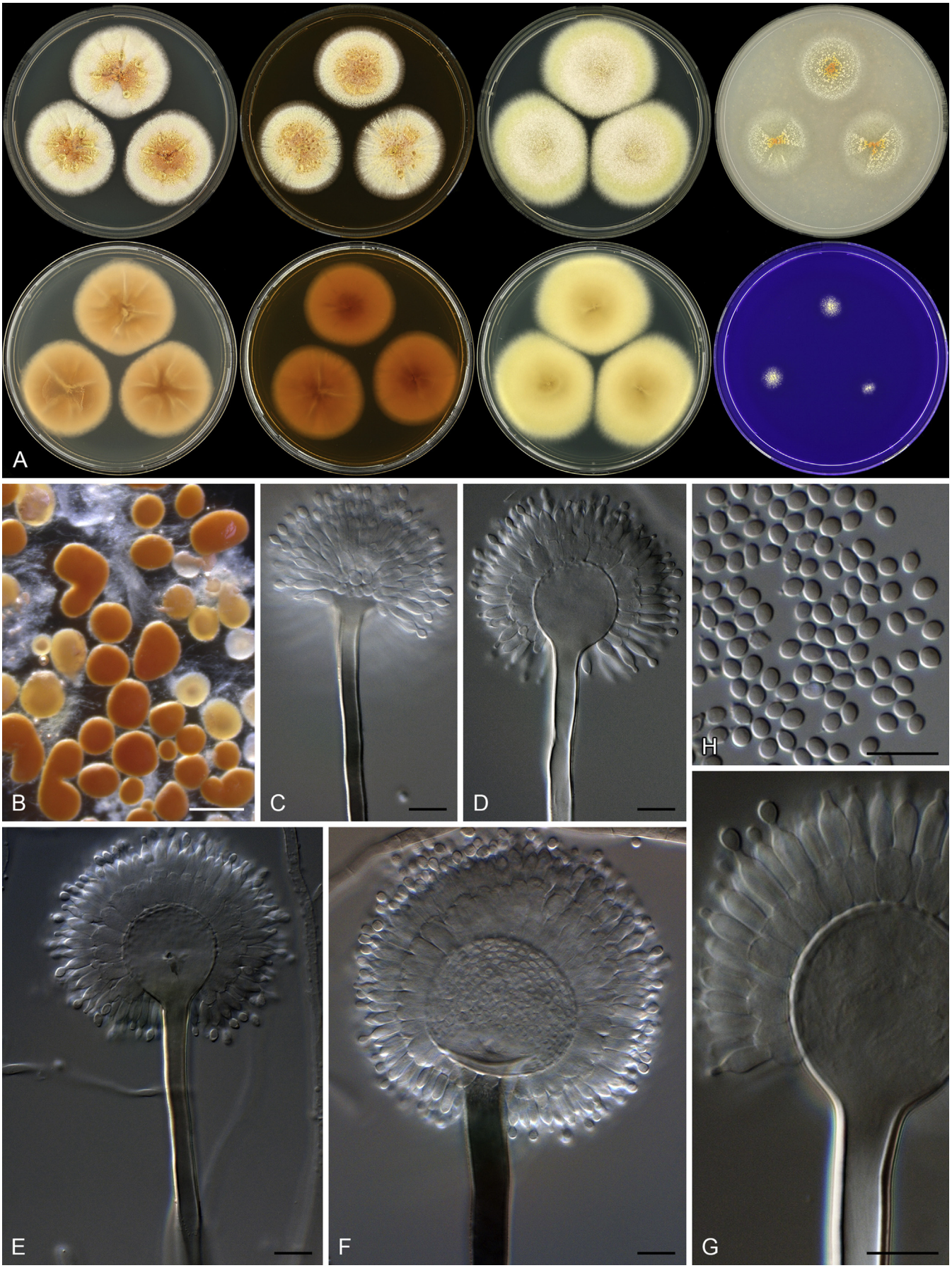

Fig. 9. *Aspergillus auricomus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C–H = 10 µm.

Typus: unrecorded source, isolated by P. Biourge (CBS H-9173, culture ex-type CBS 467.65 = NRRL 391 = IBT 14581 = ATCC 16890 = IMI 172277 = LCP 89.2596 = LSHBA 41 = WB 391).

ITS barcode: EF661411. (alternative markers: *BenA* = EF661320; *CaM* = EF661379). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 40–50; CYA 30 °C 35–45; CYA 33 °C no growth to microcolonies; CYA 37 °C no growth; MEA 35–42; YES 58–70; DG18 45–55; OA 25–35; CREA 10–16.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas pale green to pale yellow (30A3–1A3); sporulation very sparse after 7 d; sclerotia orange; soluble pigment orange brown; exudate yellow; reverse greyish orange to brownish orange (5B4–C4). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: No growth to microcolonies. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas pale green to pale yellow (30A3–1A3); sporulation very sparse after 7 d; sclerotia white to yellow to orange; soluble pigment absent; exudate yellow; reverse yellowish brown to light brown (5D5–6D6). YES 25 °C, 7 d: Colony surface floccose; mycelial areas pale green to pale yellow (30A2–1A2); sporulation absent; sclerotia white to orange; soluble pigment absent; exudate minute clear droplets; reverse brownish orange (5C5) centrally, light yellow (4A4) elsewhere. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas pale green to pale yellow (30A2–1A2); sporulation light yellow (4A2) after prolonged incubation; sclerotia white; soluble pigment absent; exudate absent; reverse greyish yellow (2C6) centrally, yellowish grey (2B2) elsewhere. OA 25 °C, 7 d: Colony surface velutinous; sporulation very sparse after 7 d; sclerotia white to yellow to orange, dominate colony appearance; soluble pigment inconspicuous, reddish brown; exudate absent; reverse white to light yellow (4A4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, sporulating poorly after 7 d; Conidiophores biseriate; Stipes hyaline to dark brown, rough walled, 190–1360 × 5–11 µm; Vesicles globose, 13–53 µm wide; Metulae 6.5–14.5 × 4–6 µm, covering 100 % of head; Phialides ampulliform, 7.5–10.5 × 3–4 µm; Conidia ellipsoidal, roughened, 3–4 × 2.5–3 µm (3.5 ± 0.2 × 2.5 ± 0.1, *n* = 39); Sclerotia white to yellow to orange, 200–720 µm.

Extrolites: aspergamides, mellein, neohydroxyaspergillic acids, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus auricomus* produces orange sclerotia on most media, grows poorly on CYA at 33 °C and colonies sporulate poorly after 7 d. When grown on CYA at 33 °C, *A. cretensis* and *A. westlandensis* (phylogenetically its closest relative) also produce microcolonies. *Aspergillus cretensis*, however, grows slower on MEA and DG18. *Aspergillus westlandensis* sporulates well on most media and produces purple to reddish sclerotia.

Aspergillus bridgeri M. Chr., Mycologia 74: 210. 1982. MycoBank MB110494. Fig. 10.

Typus: **USA**, Wyoming, soil, 1979, isolated by M. Christensen (NY JB 26-1-2, culture ex-type CBS 350.81 = NRRL 13000 = IBT 13380 = ATCC 44562 = IMI 259098).

ITS barcode: EF661404. (alternative markers: *BenA* = EF661335; *CaM* = EF661358). This species share identical ITS sequences with *A. subramanianii*, *A. persii*, *A. salwaensis* and *A. sclerotiorum*. *BenA* and *CaM* sequences for the species are unique.

Colony diam, 7 d (in mm): CYA 46–48; CYA 30 °C 55–56; CYA 33 °C 43–44; CYA 37 °C 30–31; MEA 40–42; YES 65–66; DG18 42–44; OA 33–34; CREA 22–23.

Colony characters: CYA 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (3A4–5), brownish underneath sporulating areas, giving colonies brownish appearance; sclerotia sparse light yellow; soluble pigment absent; exudate absent; reverse dull yellow to greyish yellow (3B3–4B3). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for reverse, olive brown to brown (4D4–5D4). CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C. MEA 25 °C, 7 d: Colony surface floccose to somewhat velutinous; mycelia white; sporulation light yellow (3A4–5); sclerotia sparse, light yellow; soluble pigment absent; exudate absent; reverse light brown to brown (5D7–6D7), greyish yellow (4B4) near margin. YES 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (3A4), greyish orange (5B4) underneath sporulating areas; soluble pigment absent; exudate absent; reverse greyish yellow (4B4). DG18 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (4A4), brownish to cream underneath sporulating areas; soluble pigment absent, exudate absent, reverse light yellow (3A4–5). OA 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (4A4); sclerotia sparse, light yellow; soluble pigment absent; exudate absent; reverse yellowish white (3A2). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to dark brown, rough walled, some smooth on DG18, 215–1700 × 4.5–11 µm; Vesicles globose, 12–36.5 µm wide; Metulae 6.5–10 × 3.5–5.5 µm, covering 100 % of head, with a minor proportion only 75 % covered; Phialides ampulliform, 6.5–9 × 2.5–3.5 µm; Conidia globose to subglobose, smooth, 2.5–3 × 2.5–3 µm (2.5 ± 0.1 × 2.5 ± 0.1, *n* = 40); Sclerotia light yellow, 115–550 µm.

Extrolites: aspergamides, aspochracins, insulicolins, orthosporin, penicillic acid, secalonic acid A (the latter only in IBT 14313).

Distinguishing characters: *Aspergillus bridgeri* is typically brownish beneath the light yellow sporulation, which gives colonies an overall brownish appearance. *Aspergillus bridgeri* is resolved in a clade together with *A. subramanianii*, *A. persii*, *A. salwaensis*, *A. sclerotiorum* and *A. fresenii*. In general, this group of species grows relatively well on CYA at 37 °C (colonies range from 25 to 45 mm). When compared to the other species in this clade, the degree of sporulation, conidial colour and brownish colonies make it recognisable.

Aspergillus cretensis Frisvad & Samson, Stud. Mycol. 50: 33. 2004. MycoBank MB500002. Fig. 11.

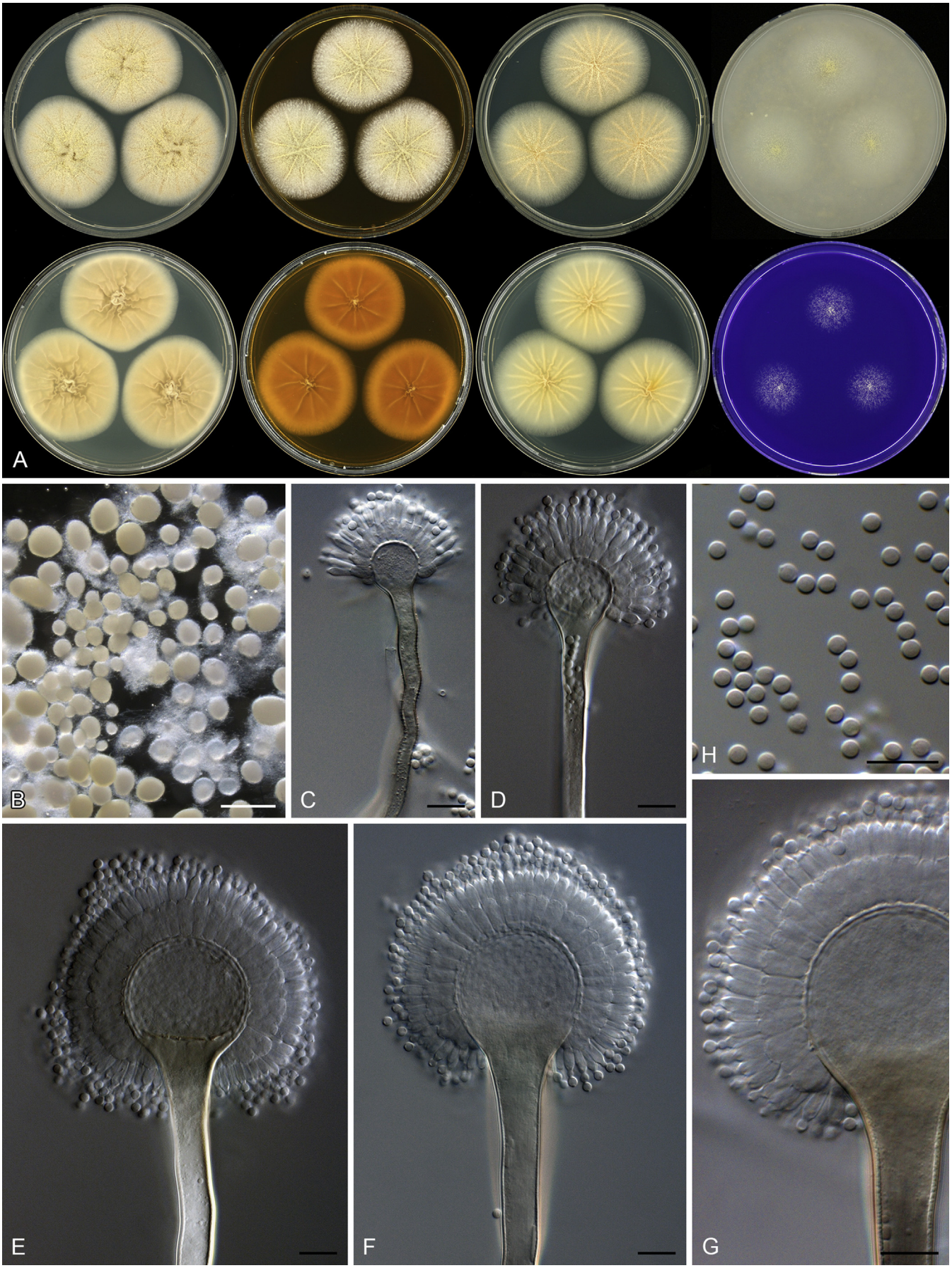

Fig. 10. *Aspergillus bridgeri*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C–H = 10 µm.

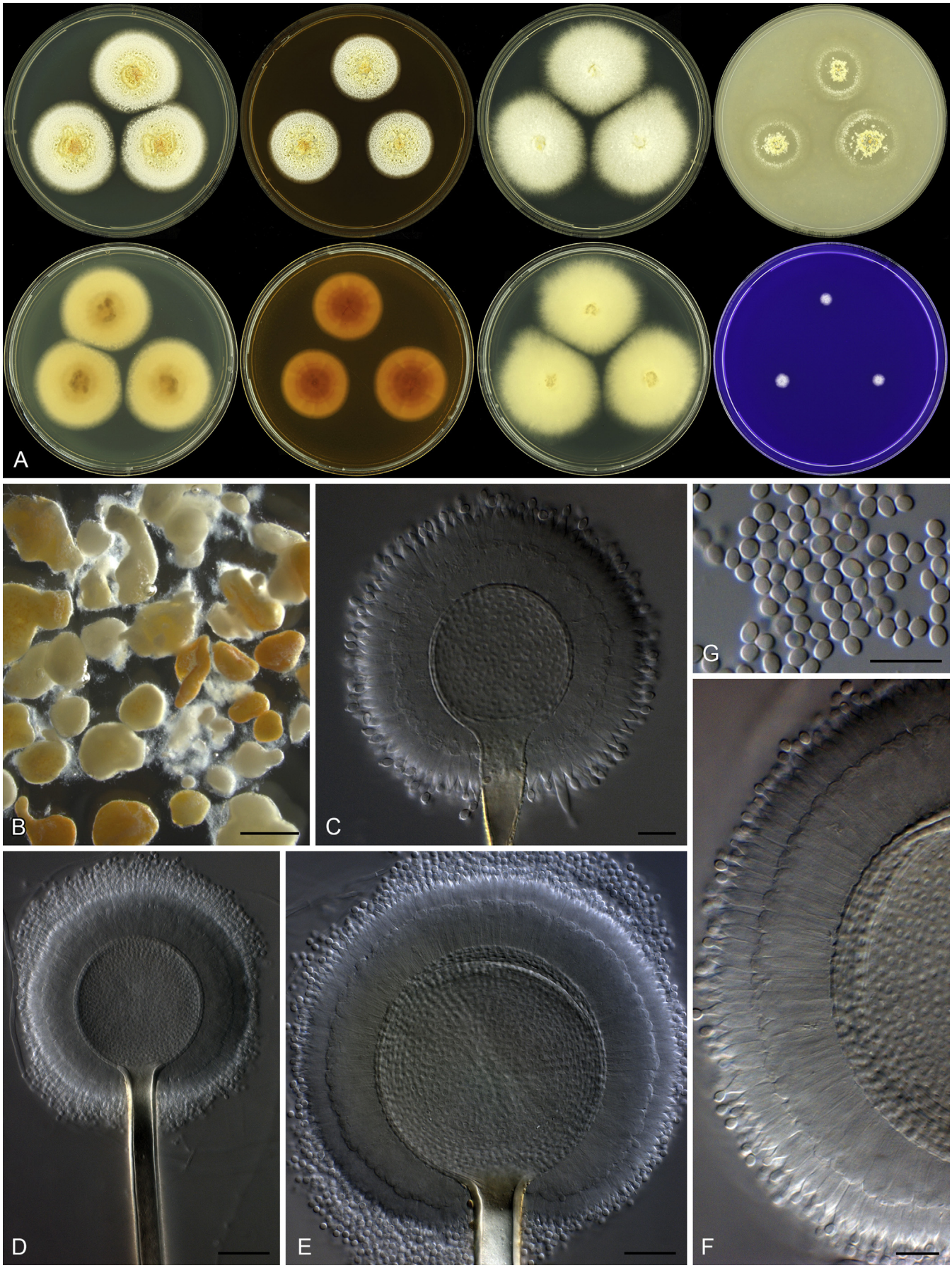

Fig. 11. *Aspergillus cretensis*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C, F, G = 10 µm; D, E = 20 µm.

Typus: **Greece**, Crete, soil, 1985, isolated by J.C. Frisvad (CBS H-13446, culture ex-type CBS 112802 = NRRL 35672 = IBT 17505).

ITS barcode: FJ491572. (alternative markers: *BenA* = AY819977; *CaM* = FJ491534). This species has unique sequences for *BenA* and *CaM*, but share a similar ITS sequence with *A. affinis*.

Colony diam, 7 d (in mm): CYA 35–40; CYA 30 °C 25–30; CYA 33 °C microcolonies; CYA 37 °C no growth; MEA 29–32; YES 49–51; DG18 48–55; OA 21–25; CREA 5–6.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellow (3A6); sclerotia white to yellow to orange, sparse in some isolates; soluble pigment absent; exudate absent; reverse greyish yellow (3B4–4B4). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Microcolonies white. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white (2A2) to light yellow (3A5); sclerotia white to yellowish to orange; soluble pigment absent; exudate clear, absent in some strains, reverse brown (6D7) at centre, greyish orange (5B5) near margin. YES 25 °C, 7 d: Colony surface floccose, mycelial areas white to light yellow (4A5); sporulates poorly; sclerotia white to yellow; soluble pigment absent; exudate absent; reverse light yellow (3A5–4A5). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to yellowish white; sporulation light yellow (3A2–3A4); soluble pigment absent; exudate absent; reverse yellowish white to light yellow (4A2–4A4). OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to light yellow (4A5); sclerotia white to yellow to orange; soluble pigment absent; exudate absent; reverse yellowish white (3A2). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 700–1600(–4000) × 9.5–19 µm; Vesicles globose, with a minor proportion spathulate, 35–65(–90) µm wide; Metulae 8–26 × 4–6.5 µm, covering 100 % of head; Phialides ampulliform, 8.5–11.5 × 3–4 µm; Conidia broadly ellipsoidal, smooth to finely roughened, 2.5–4 × 2.5–3.5 µm (3.1 ± 0.3 × 2.6 ± 0.2, *n* = 44); Sclerotia white to yellow to orange, 240–1340 µm.

Extrolites: aspyrones, mellamides, melleins, ochratoxins, penicillic acid.

Distinguishing characters: *Aspergillus cretensis* typically produces white to yellow sclerotia and produces only microcolonies on CYA at 33 °C. Microcolonies are also produced by *A. westlandensis* and *A. auricomus.* However, *A. westlandensis* produces purple to reddish sclerotia and *A. auricomus* grows faster on MEA and DG18. Phylogenetically, *A. affinis* is closely related to *A. cretensis*. However, *A. affinis* grows faster on CYA at 33 °C (15–16 mm) and produces microcolonies at 37 °C.

Aspergillus elegans Gasperini, Atti Soc. Tosc. Sci. Nat. Pisa, Processi Verbali 8: 328. 1887. MycoBank MB212852. Fig. 12.

Typus: **USA**, unrecorded source, 1914, isolated by A. Blochwitz (CBS 102.14, culture ex-type CBS 102.14 = CBS 543.65 = NRRL 4850 = IBT 13505 = ATCC 13829 = ATCC 16886 = IFO 4286 = IMI 133962 = QM 8912 = QM 9373 = WB 4850).

ITS barcode: EF661414. (alternative markers: *BenA* = EF661349; *CaM* = EF661390). This species share identical *CaM* sequences with *A. steynii*. ITS and *BenA* sequences are unique for the species.

Colony diam, 7 d (in mm): CYA 32–45; CYA 30 °C 31–40; CYA 33 °C 18–23; CYA 37 °C no growth; MEA 30–40; YES 50–60; DG18 45–50; OA 26–35; CREA 13–15.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation greyish yellow (4B4), beige underneath sporulating areas; sclerotia white to beige present; soluble pigment absent; exudate absent; reverse yellowish brown (5D5) at centre, yellowish white to greyish yellow (4A2–4B4) elsewhere. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies crateriform, whitish to cream, sterile. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to greyish yellow (4B4), beige underneath sporulating areas; sclerotia white to beige; soluble pigment absent; exudate minute clear droplets; reverse brown (6D8–E8), greyish orange (5B4) near margin. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to greyish yellow (4B4), beige underneath sporulating areas; sclerotia white to beige; soluble pigment absent; exudate absent; reverse brownish orange (5C5) at centre, pale yellow (4A3) near margin. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to greyish yellow to pale yellow to light yellow (4B3–A4–5); sporulation after prolonged incubation, light yellow; sclerotia cream to light brown, embedded in media after weeks of incubation; soluble pigment absent; exudate absent; reverse pale yellow (2A3) at centre, yellowish white (2A2) elsewhere. OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to light yellow (4A5); sclerotium-like structures present, white; soluble pigment absent; exudate absent; reverse light yellow (4A4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to brown, smooth to finely rough walled, 470–1800 × 7–13 µm; Vesicles globose, 21–53 µm wide; Metulae 6–11.5 × 3.5–5.5 µm, covering 75–100 % of head; Phialides ampulliform, 7–10.5 × 3–4 µm; Conidia broadly ellipsoidal, smooth to very finely roughened, 3–4 × 2.5–3.5 µm (3.6 ± 0.2 × 3 ± 0.2, *n* = 41); Sclerotia white to cream to light brown, 600–750(–1000) µm.

Extrolites: cycloechinuline, TR-2, melleins, orthosporins, xanthomegnins.

Distinguishing characters: *Aspergillus elegans* produces strongly floccose colonies that sporulate poorly. The species is not able to grow on CYA at 37 °C. Morphologically it resembles *A. steynii*, also phylogenetically its closest relative. However, *A. steynii* is more densely sporulating and grows faster on CYA at 25 °C, YES and DG18, and has longer metulae than *A. elegans*.

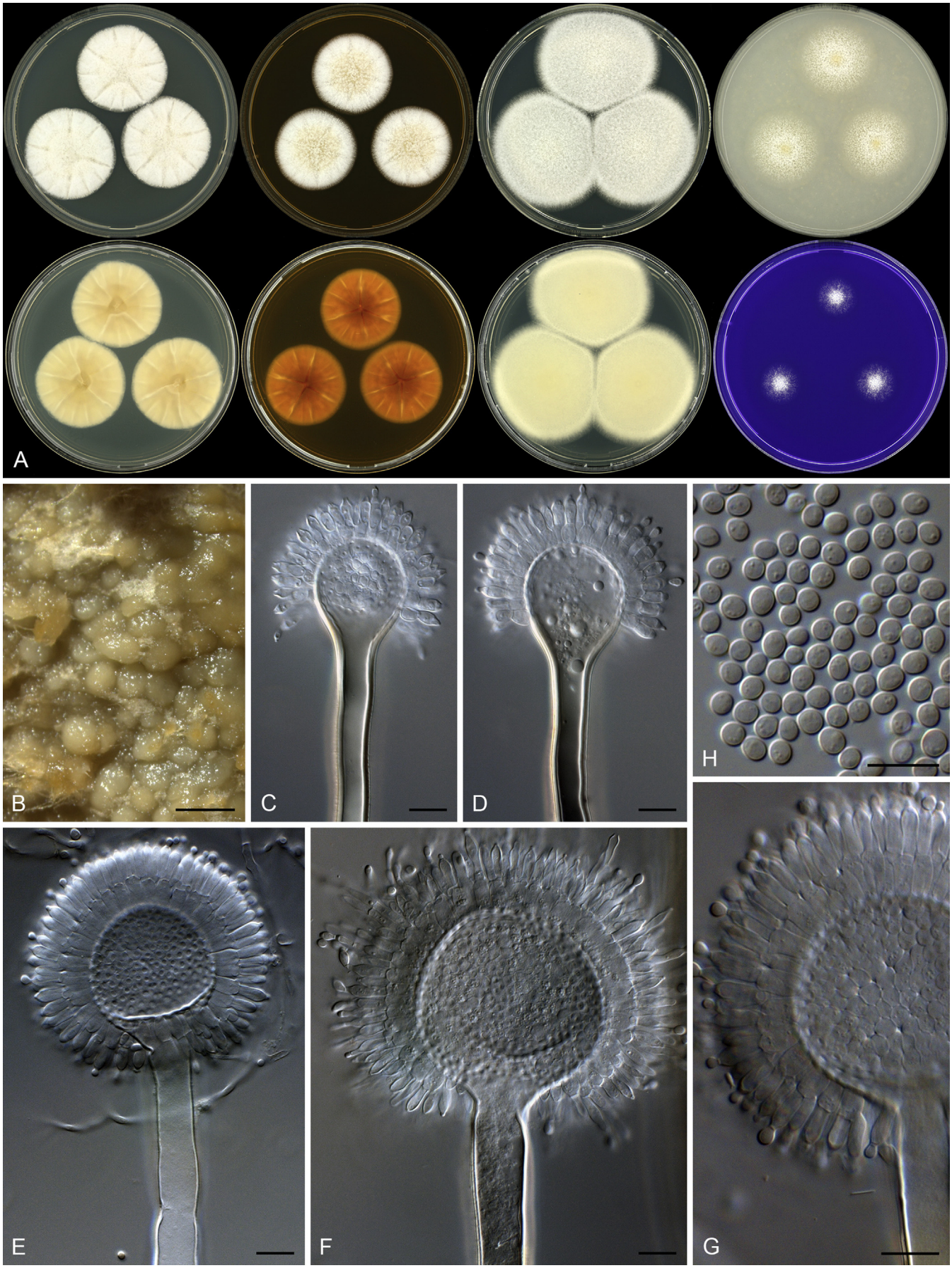

Fig. 12. *Aspergillus elegans*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Embedded sclerotia on DG18 after weeks. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm; C–H = 10 µm.

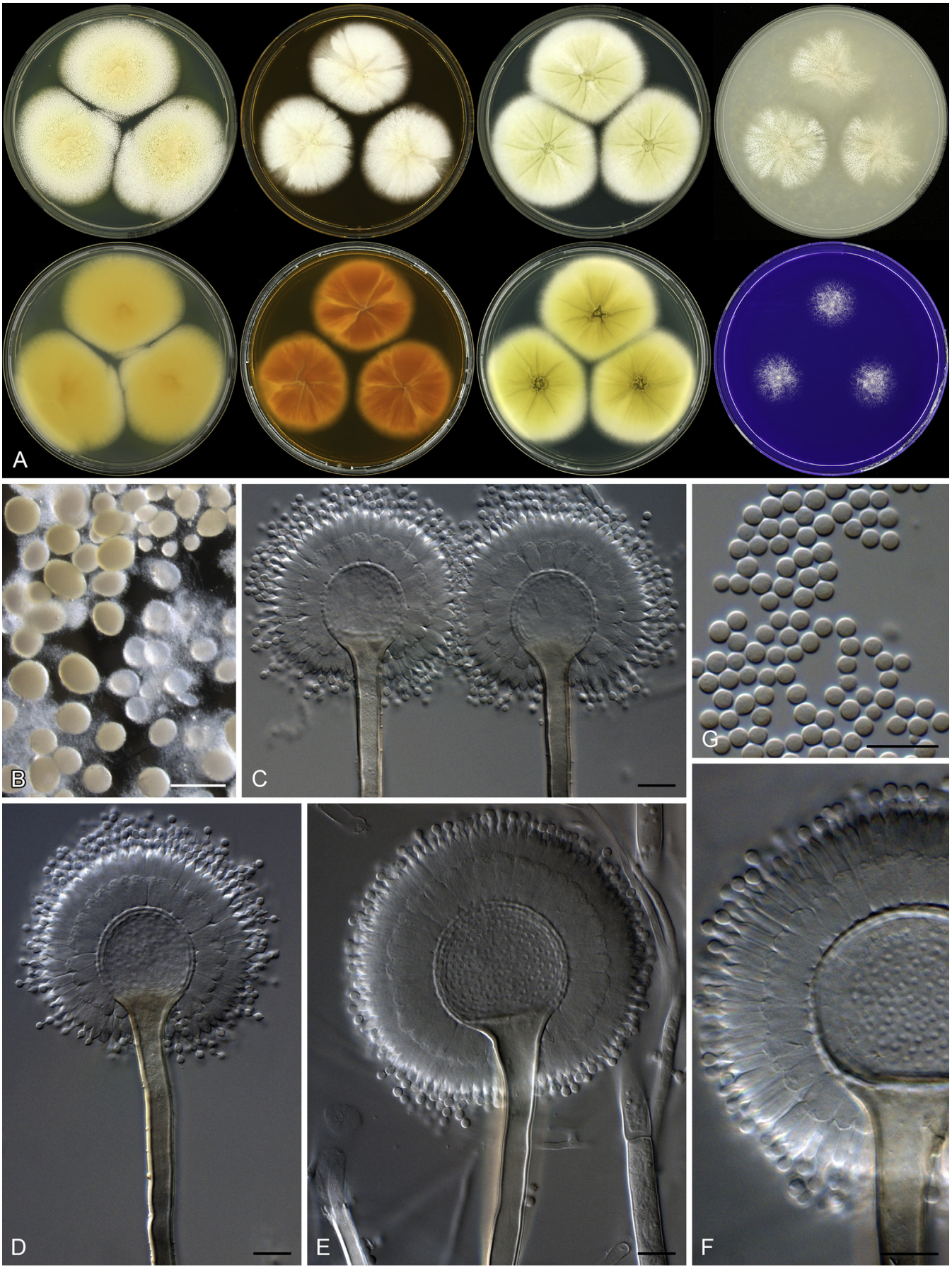

Fig. 13. *Aspergillus fresenii*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 µm; C–G = 10 µm.

Aspergillus fresenii Subram., Hyphomycetes (New Delhi): 552. 1971. MycoBank MB309222. Fig. 13.

≡ *Sterigmatocystis sulphurea* Fresen., Beitr. Mykol.: 83. 1863.
≡ *Aspergillus sulphureus* (Fresen.) Wehmer, Mem. Soc. Phys. Genève 33: 113. 1901.
= *Aspergillus sulphureus* (Fresen.) Thom & Church, The Aspergilli 185. 1926.

Typus: **India**, soil, isolated by E. Yuill (IMI 211397, culture ex-type CBS 550.65 = NRRL 4077 = ATCC 16893 = IMI 211397 = NRRL A-5355 = NRRL A-5520 = WB 4077).

ITS barcode: EF661409. (alternative markers: *BenA* = EF661341; *CaM* = EF661382). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 50–53; CYA 30 °C 56–60; CYA 33 °C 45–50; CYA 37 °C 30–34; MEA 41–44; YES 65–70; DG18 50–52; OA 35–40; CREA 20–24.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation very sparse; sclerotia white to light yellow (4A4), dominate colony appearance; soluble pigment yellow; exudate clear; reverse light yellow (4A4–5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C; soluble pigment inconspicuous, yellow. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation very sparse, pale yellow (3A3) after prolonged incubation; sclerotia light yellow (4A4), dominate colony appearance; soluble pigment absent; exudate clear; reverse brown (6E7), light yellow at margin (4A4). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation absent; sclerotia white to yellowish white (3A2), domenate colony appearance; soluble pigment absent; exudate absent; reverse light yellow (4A5) to slightly darker areas. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to greyish yellow (2B4); sporulation sparse, pale yellow (3A3) after prolonged incubation; sclerotia sparse, white; soluble pigment absent; exudate absent; reverse light yellow to greyish yellow (1A5–B5–2B5). OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation absent; sclerotia white to yellow to orange, dominate colony appearance; soluble pigment absent; exudate absent; reverse greyish yellow (1B5). CREA 25 °C, 7 d: Colony surface floccose, white to light yellow (4A4); acid not produced.

Micromorphology: Conidial heads radiating, produced after prolonged incubation; Conidiophores biseriate; Stipes hyaline to brown, finely rough to rough walled, 340–1310 × 6.5–9.5 µm; Vesicles globose, with a minor proportion elongated, 21–39 µm wide; Metulae 8–13.5 × 3.5–6 µm, covering 100 % of head, with a minor proportion only 75 % covered; Phialides ampulliform, 7.5–10 × 2.5–3.5 µm; Conidia globose to subglobose, smooth, 2–3 × 2–3 µm (2.7 ± 0.3 × 2.6 ± 0.3, *n* = 46); Sclerotia white to yellow to orange, 95–485 µm.

Extrolites: aspochracins, mellamides, ochratoxins, orthosporins, radarins, secopenitrems, sulphinines, xanthomegnins.

Distinguishing characters: *Aspergillus fresenii* colonies are poorly sporulating after 7 d and their appearance is dominated by the production of white to light yellow to light orange sclerotia, with bright greyish yellow mycelia dominating DG18 colonies. Sporulation is more abundant after prolonged incubation, and then colonies are pale yellow (3A3) in conidial areas. Yellow soluble pigments are produced on CYA at 25, 30, 33 and 37 °C. These characters distinguish it from the phylogenetically closely related *A. bridgeri*, *A. subramanianii*, *A. persii*, *A. salwaensis* and *A. sclerotiorum*.

Aspergillus insulicola Montem. & A. R. Santiago, Mycopathologia 55: 130. 1975. MycoBank MB309225. Fig. 14.

Typus: **Venezuela**, Aves Island, soil, 1975, isolated by L. Montemayor (CBS 382.75, culture ex-type CBS 382.75 = NRRL 6138 = ATCC 26220).

ITS barcode: EF661430. (alternative markers: *BenA* = EF661353; *CaM* = EF661396). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 38–45; CYA 30 °C 42–47; CYA 33 °C 35–40; CYA 37 °C 16–20; MEA 35–40; YES 60–65; DG18 52–56; OA 33–36; CREA 15–19.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4A4) to brownish orange (5C4) to olive brown (4E6); soluble inconspicuous, pigment reddish; exudate absent; reverse brown (6D5–E5) to brownish orange (5C6) with pale margin. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for more intense brown (5E5) sporulation in some areas. CYA 33 °C, 7 d: Colonies similar to CYA at 30 °C. CYA 37 °C, 7 d: Colonies crateriform, greyish yellow to light brown (4B4–6D5) colour; soluble pigment yellowish orange (4A7); exudate absent; reverse brown (5E6) with light yellow (4A5) margin. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light orange to greyish orange (5A4–B3); soluble pigment absent; exudate absent, in some strains yellow to brown; reverse brown to dark brown (5F6–6F6) centrally, (5D6) elsewhere, light yellow (4A4) margin. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white to greyish white; sporulation absent; soluble pigment absent; exudate absent; reverse light brown (5D4) centrally, yellowish white to dull yellow (3A2–B4) elsewhere. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to pale yellow (2A3); sporulation absent; soluble pigment absent; exudate absent; reverse light yellow to yellow (2A5–6) to white, dark olive (1F5) at centre in some isolates. OA 25 °C, 7 d: Colony surface floccose to somewhat velutinous; mycelial areas white; sporulation pale yellow to olive brown to brown (3A3–4D5–5D5); soluble pigment inconspicuous, reddish brown; exudate absent; reverse dull yellow (3B4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 250–600 × 6–8.5 µm; Vesicles globose, 15–30 µm wide; Metulae 7–12 × 3.5–5 µm, covering 100 % of head; Phialides ampulliform, 7–9.5 × 2.5–3 µm; Conidia globose to subglobose, smooth, 2–3 × 2–3 µm (2.5 ± 0.1 × 2.5 ± 0.1, *n* = 29); Sclerotia absent.

Extrolites: aspochracins, aspyrones, asteltoxins, insulicolins, melleins, penicillic acid, xanthomegnins.

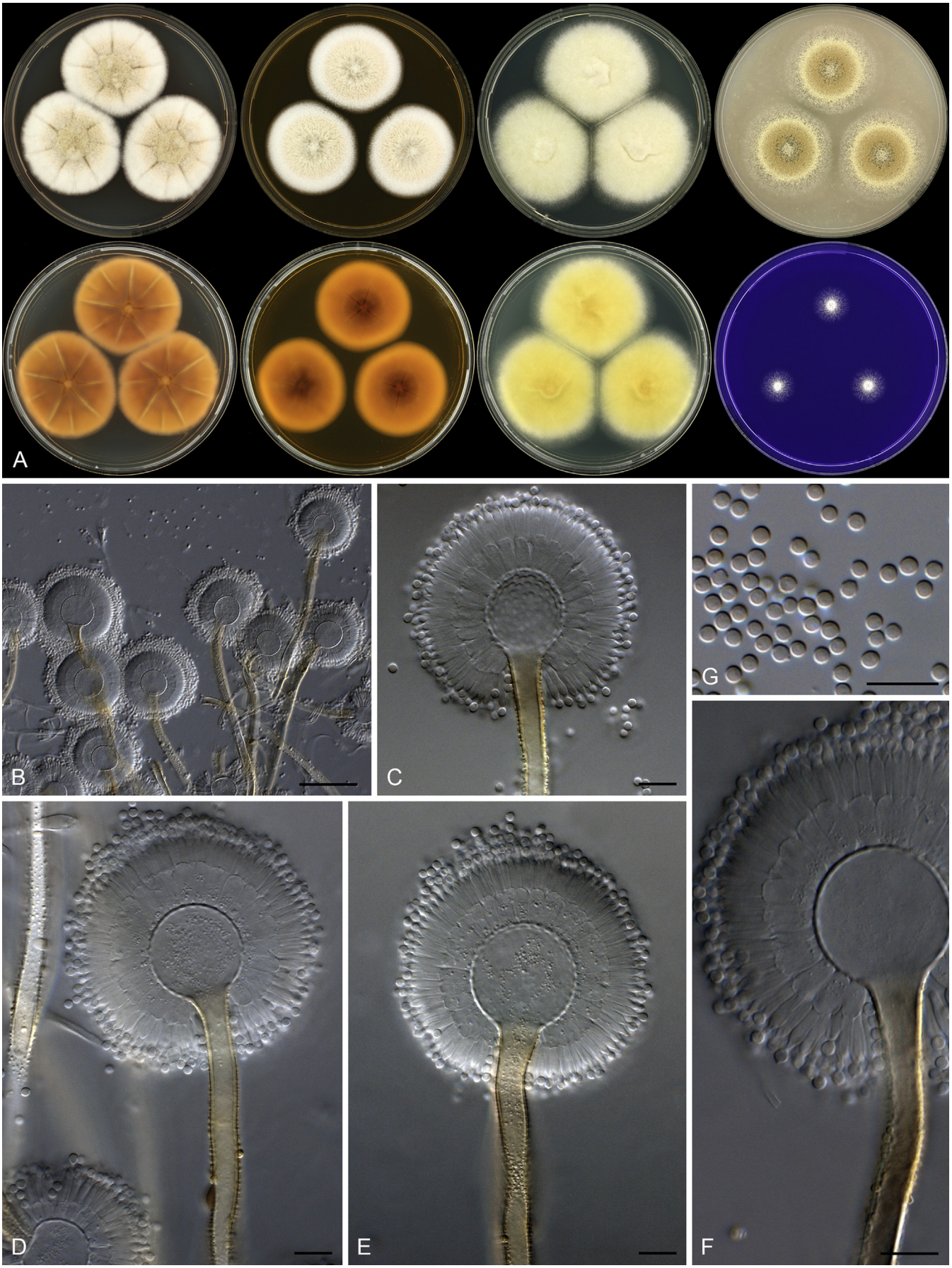

Fig. 14. *Aspergillus insulicola*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B–F. Conidiophores. G. Conidia. Scale bars: B = 50 µm; C–G = 10 µm.

Distinguishing characters: *Aspergillus insulicola* colonies are strongly floccose and have a light yellow to brownish orange (4A4–5C4) to olive brown (4E6) sporulation on CYA and light orange to greyish orange (5A4–B3) sporulation on MEA. Colonies on CYA and OA produce a reddish brown soluble pigment on CYA and OA. The reddish brown soluble pigment on CYA was also observed in *A. pulvericola*. The latter species has a more yellow sporulation and grows poorly on CYA at 37 °C. The phylogenies resolve it in a clade closely related to *A. ochraceopetaliformis*, *A. pulvericola* and *A. pseudoelegans*. However, all of these species readily produce sclerotia, which are absent in *A. insulicola*.

Aspergillus melleus Yukawa, J. Coll. Agric. Imp. Univ. Tokyo 1: 358. 1911. MycoBank MB164593. Fig. 15.

Typus: **India**, Allahabad, soil, isolated by B.S. Mehrotra (CBS 546.65, culture ex-type CBS 546.65 = NRRL 5103 = IBT 13510 = IBT 13511 = IBT 13875 = ATCC 16889 = WB 5103).

ITS barcode: EF661425. (alternative markers: *BenA* = EF661326; *CaM* = EF661391). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 49–60; CYA 30 °C 50–55; CYA 33 °C 43–48; CYA 37 °C 15–20; MEA 36–45; YES 68–70; DG18 45–55; OA 30–40; CREA 9–10.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation sparse, yellowish white (3A2–4A2); sclerotia white to yellow to brownish orange, dominate colony appearance; soluble pigment orange brown; exudate yellow; reverse greyish orange to orange (6B6–7). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for sclortia that is more brown. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C, lacks yellowish orange soluble pigments. CYA 37 °C, 7 d: Colonies crateriform; sclerotia white, dominate colony appearance; soluble pigment olive yellow in some isolates. MEA 25 °C, 7 d: Colony surface velutinous to floccose; mycelial areas white; sporulation greyish orange (6B3) to light yellow (4A4); sclerotia white to yellow greyish orange, dominate colony appearance; soluble pigment absent; exudate clear to yellow; reverse brown (6D7–E7). YES 25 °C, 7 d: Colony surface velutinous to floccose; mycelial areas white; sporulation yellow (3A6) to greyish orange (5B3) to pale green to pale yellow (30A2–1A2); sclerotia white to yellow to brownish orange; soluble pigment absent; exudate absent; reverse greyish yellow (4B4). DG18 25 °C, 7 d: Colony surface velutinous; sporulation yellow (3A6) to greyish orange (5B3) to greyish green (1C4), sclerotia yellowish to white to brownish orange; soluble pigment absent; exudate absent; reverse olive (2F8) to greyish green (1D6). OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4A2); sclerotia orange to greyish orange to white, dominate colony appearance; soluble pigment absent; exudate absent; reverse greyish yellow (3C5). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, diminutive conidiophores sometimes observed, especially on MEA; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 400–1225 × 4–12.5 µm; Vesicles globose, 9–46 µm wide; Metulae 6–22.5 × 3.5–8 µm, covering 100 % of head; Phialides ampulliform, 7.5–10.5 × 2.5–4 µm; Conidia globose to broadly ellipsoidal, finely roughened, 2.5–3.5 × 2.5–3.5 µm (3 ± 0.2 × 2.9 ± 0.2, *n* = 36); Sclerotia white to yellow to brownish orange, 115–420 µm.

Extrolites: aspergamides, aspyrones, circumdatins, melleins, ochratoxins (weak), orthosporins, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus melleus* colonies typically sporulate well and produce abundant white to yellow to brownish orange sclerotia. On DG18, colonies have a greyish green (1C4) colour in mycelial areas and an olive reverse. A similar olive reverse was observed in *A. pallidofulvus*, *A. ochraceus*, *A. ostianus* and *A. roseoglobulosus*. However, *A. melleus* lacks the dull red mycelia of *A. roseoglobulosus* on CYA, grows faster on CYA at 37 °C than *A. ostianus* (no growth to microcolonies), and grows faster than *A. ochraceus* (40–47 mm, 25–35 mm) on CYA at 30 and 33 °C. Compared to *A. pallidofulvus*, *A. melleus* has a more orange conidial colour on MEA, grows slower on MEA, DG18 and OA, and produces finely roughened conidia, which are smooth in *A. pallidofulvus*.

Aspergillus muricatus Udagawa *et al.*, Mycotaxon 52: 210. 1994. MycoBank MB362530. Fig. 16.

≡ *Neopetromyces muricatus* (Udagawa *et al.*) Frisvad & Samson, Stud. Mycol. 45: 204. 2004.

≡ *Petromyces muricatus* Udagawa *et al.*, Mycotaxon 52: 208. 1994.

Typus: **Philippines**, grassland soil, isolated by S. Udagawa (CBM BF-42515, culture ex-type CBS 112808 = NRRL 35674 = IBT 19374 = IMI 36852).

ITS barcode: EF661434. (alternative markers: *BenA* = EF661356; *CaM* = EF661377). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 45–49; CYA 30 °C 52–60; CYA 33 °C 48–53; CYA 37 °C 23–28; MEA 39–41; YES 65–70; DG18 47–55; OA 28–30; CREA 13–15.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation orange white (5A2); sclerotia cream; soluble pigment yellowish brown to orange brown; exudate clear; reverse brown (6E7) centrally, fading to greyish yellow to greyish orange (4B5–5B5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 30 °C. CYA 37 °C, 7 d: Colonies crateriform; mycelial areas white to grey; soluble pigment olive to yellow halo; exudate absent; reverse dark brown (5F7). MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation pale yellow (3A2); sclerotia pale yellow (3A2); soluble pigment absent; exudate clear, reverse brown (6E7–7E7). YES 25 °C, 7 d: Colony surface floccose, white to pale yellow (3A2) sparse sporulation, some areas a greyish orange; sclerotia pale yellow; soluble pigment absent; exudate absent; reverse light brown to brown (5D7–F7); some isolates brown (7D7–E7). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas yellowish white (2A2); sporulation very sparse; sclerotia white; soluble pigment absent; exudate absent; reverse light yellow (2A5–3A5). OA 25 °C, 7 d: Colony surface floccose; sclerotia white to yellow to greyish orange, dominate colony appearance; soluble pigment

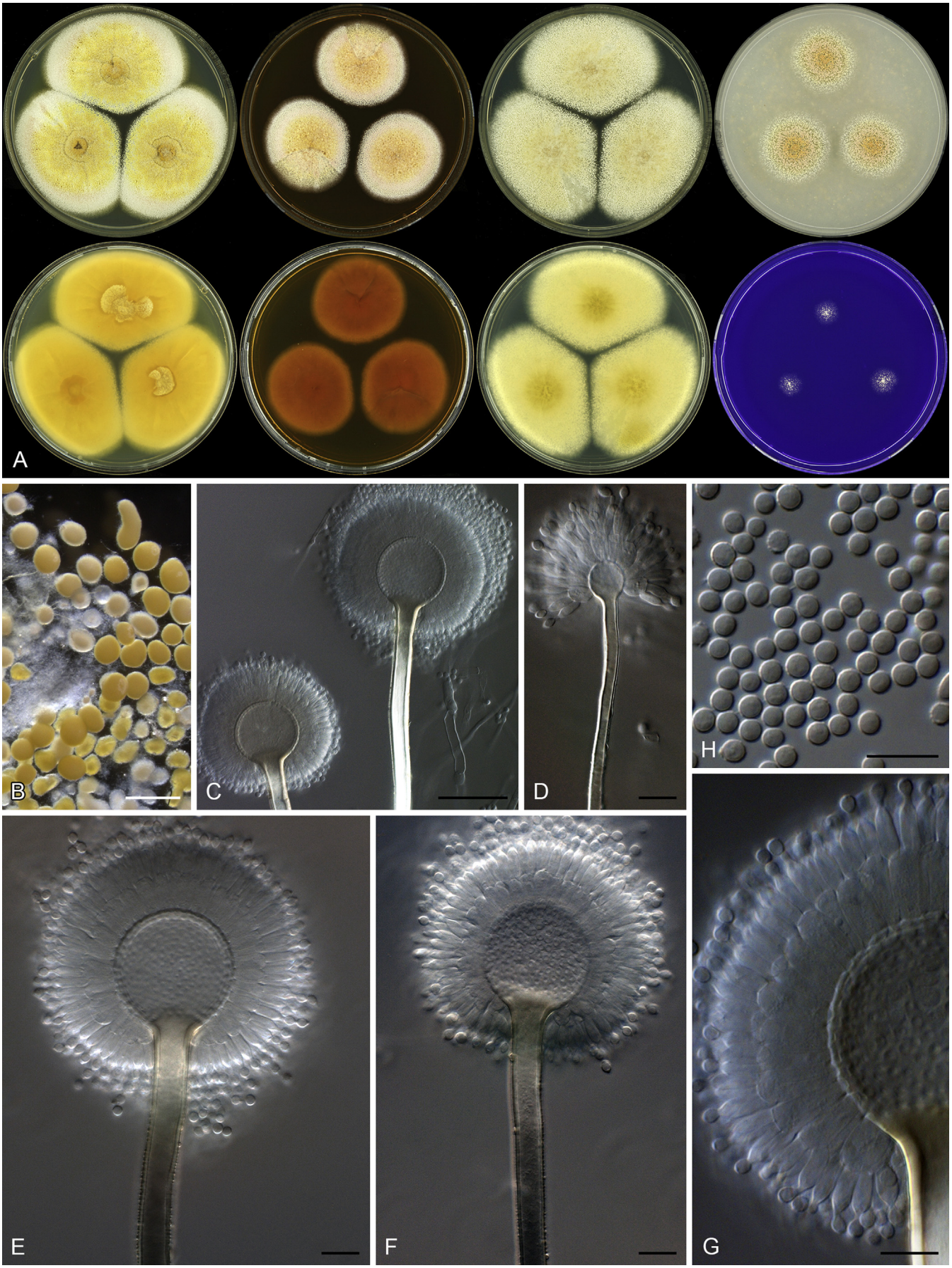

Fig. 15. *Aspergillus melleus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C = 50 µm; D–H = 10 µm.

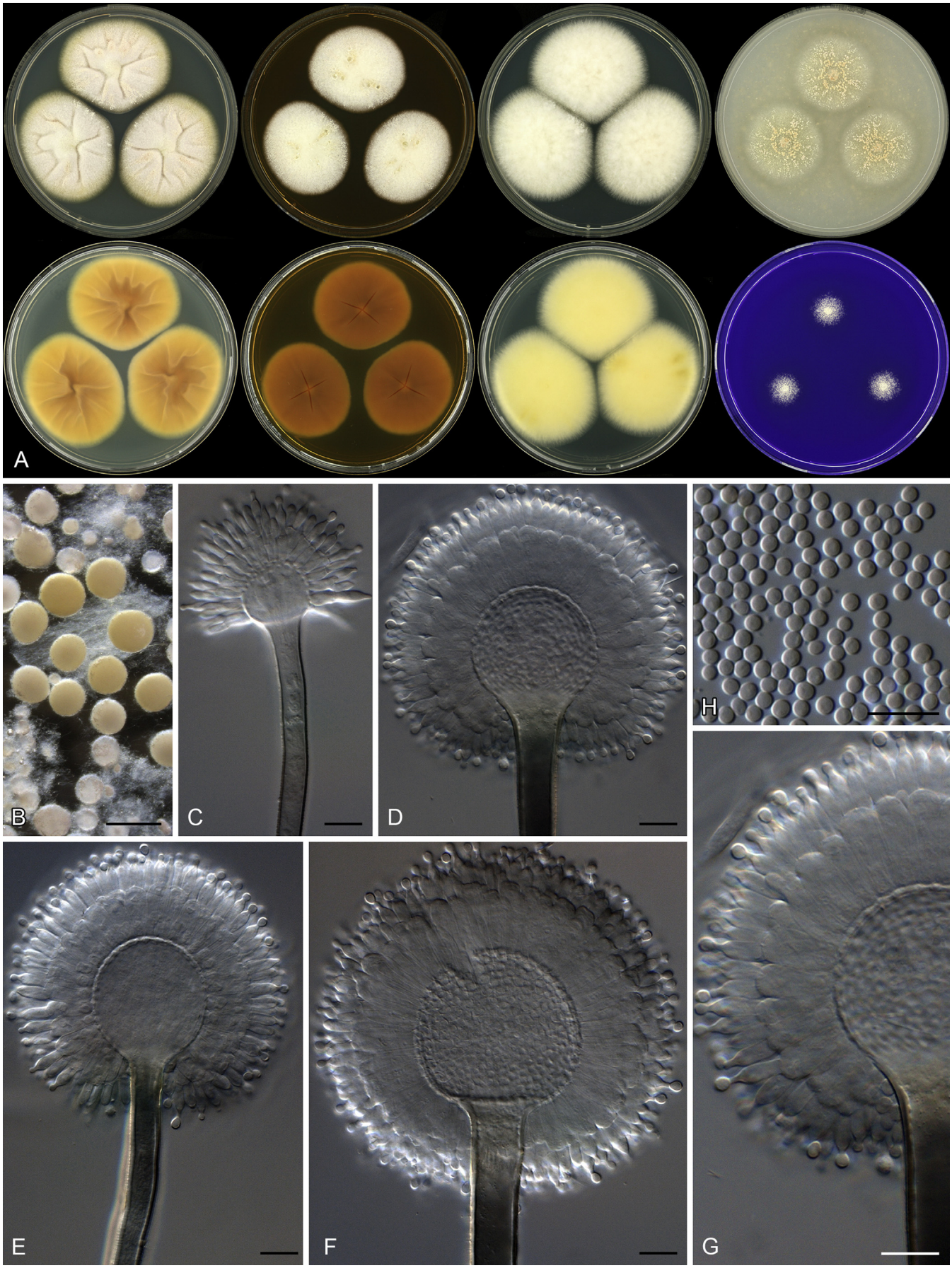

Fig. 16. *Aspergillus muricatus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C–H = 10 µm.

absent; exudate clear; reverse pale yellow (2A2). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Sporulation after two wk; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 290–1500 × 7–13.5 µm; Vesicles globose, sometimes elongated, especially on MEA, 11–52 µm wide; Metulae 7.5–19 × 3–7 µm, covering 75–100 % of head; Phialides ampulliform, 7–9.5 × 2.5–4 µm; Conidia globose to broadly ellipsoidal, finely roughened to rough, 2.5–3 × 2.5–3 µm (2.8 ± 0.2 × 2.7 ± 0.1, *n* = 34); Sclerotia white to yellow to greyish orange, 95–600 µm.

Extrolites: aspochracins, circumdatins, mellamide, neohydroxyaspergillic acids, ochratoxins, orthosporins, penicillic acid, petromurins, xanthomegnins.

Distinguishing characters: Colonies of *A. muricatus* sporulate poorly and are dominated by the production of white to cream to yellow to orange sclerotia. The species grows well on CYA at 37 °C and produces yellow soluble pigments on CYA at 25, 30, 33 and 37 °C. Growth rates and yellow soluble pigments resemble colonies of *A. subramanianii*, *A. persii*, *A. salwaensis* and *A. fresenii*, However, *A. muricatus* has finely roughened to roughened conidia, compared to the smooth conidia observed in these species. The phylogenies resolve strains in a clade distinct from other species in the section. A *Neopetromyces* sexual state was previously described for this species, but was not observed in this study.

Aspergillus neobridgeri Frisvad & Samson, Stud. Mycol. 50: 35. 2004. MycoBank MB500004. Fig. 17.

Typus: **USA**, Nebraska, soil, 1982, isolated by M. Christensen (CBS 559.82, culture ex-type CBS 559.82 = NRRL 13078 = IBT 14026).

ITS barcode: EF661410. (alternative markers: *BenA* = EF661345; *CaM* = EF661359). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 37–40; CYA 30 °C 52–56; CYA 33 °C 55–58; CYA 37 °C 38–42; MEA 43–45; YES 70–75; DG18 54–56; OA 39–41; CREA 20–21.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation absent; sclerotia yellow to brownish, embedded in media; soluble pigment inconspicuous, reddish brown; exudate absent; reverse brown (6E5) centrally, brownish orange (5C4–6C4) elsewhere. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C, lacks soluble pigments. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation absent, light yellow after prolonged incubation; soluble pigment absent; exudate absent; reverse brown (7D7–E6), margin pale. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white to brownish orange (7C5); sporulation absent; soluble pigment absent; exudate absent; reverse light brown (7D5) centrally, light yellow to light orange (4A4–5A4) elsewhere. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to yellowish white (1A2); sporulation absent, light yellow after prolonged incubation; soluble pigment absent; exudate absent; reverse greyish yellow (2C5) centrally, fading into yellowish white (2A2). OA 25 °C, 7 d: Colony surface floccose, mycelia submerged at margin; mycelial areas white; sporulation absent; soluble pigment absent; exudate absent; reverse pale yellow (3A3). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Sporulation after at least two wk; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 300–1800 × 7–12 µm; Vesicles spathulate, (21–)30–40 µm wide; Metulae 6.5–18(–21) × 3.5–5.5 µm, covering 100 % of head; Phialides ampulliform, (5.5–)8–9 × 2–3 µm; Conidia globose to subglobose, smooth, 2–3 × 2–2.5 µm (2.5 ± 0.2 × 2.3 ± 0.1, *n* = 40); Sclerotia yellow to brownish, 260–600 µm.

Extrolites: aspochracins, insulicolins, penicillic acid, secalonic acid A, xanthomegnins.

Distinguishing characters: *Aspergillus neobridgeri* typically produces fast growing colonies on CYA at 37 °C (38–42 mm) and conidiophores have spathulate vesicles. *Aspergillus subramanianii* produces similarly fast growing colonies on CYA at 37 °C (35–45 mm), but its conidiophores have globose vesicles. *Aspergillus neobridgeri* is not phylogenetically closely related to any other species.

Aspergillus occultus Visagie, Seifert, Frisvad & Samson, **sp. nov.** MycoBank MB809198. Fig. 18.

Etymology: Latin, *occultus*, meaning concealed, in reference to aerial mycelia masking sporulating areas.

Typus: **Netherlands**, Zwartewaal, air sample, 2012, isolated by M. Meijer (holotype CBS H-21794, culture ex-type CBS 137330 = IBT 32285 = DTO 231-A7).

ITS barcode: KJ775443. (alternative markers: *BenA* = KJ775061; *CaM* = KJ775239). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 24–29; CYA 30 °C 23–29; CYA 33 °C 12–18; CYA 37 °C no growth; MEA 20–22; YES 34–36; DG18 35–42; OA 20–25; CREA 9–12.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation brown (5E4) to light yellow (4A4); sclerotia white to yellow underneath mycelial and sporulating areas; soluble pigment absent; exudate absent; reverse pale yellow (3A3). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for bigger sclerotia produced and better sporulation. CYA 33 °C, 7 d: Colonies crateriform, similar colours to CYA at 25 °C. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white to orange grey (5B2), often masking light yellow (4A4) sporulating areas; soluble pigment absent; exudate absent; reverse brown (6E6). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white (4A2); soluble pigment absent; exudate absent; reverse light yellow (4A2). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light

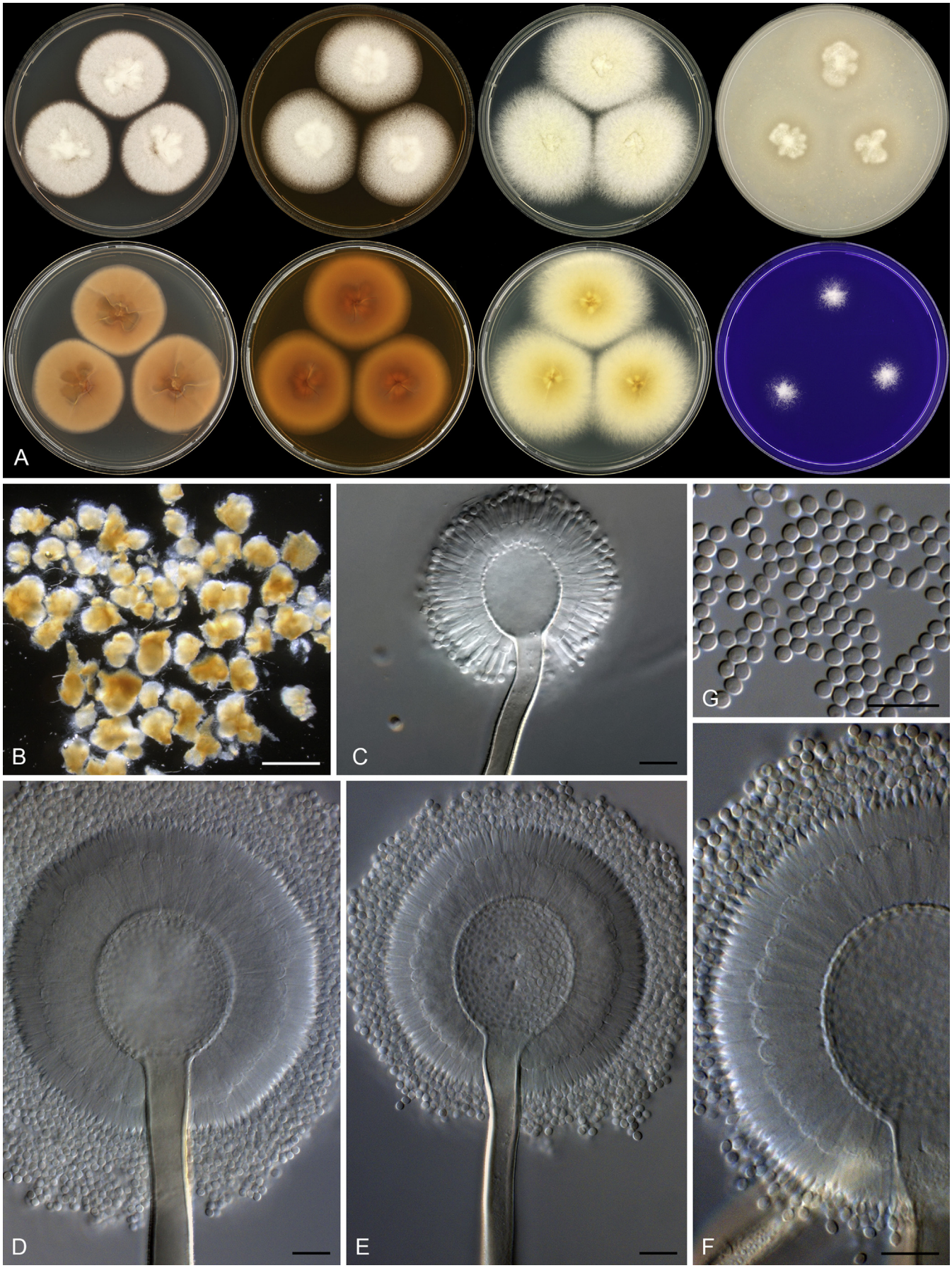

Fig. 17. *Aspergillus neobridgeri*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia structures. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 µm; C–G = 10 µm.

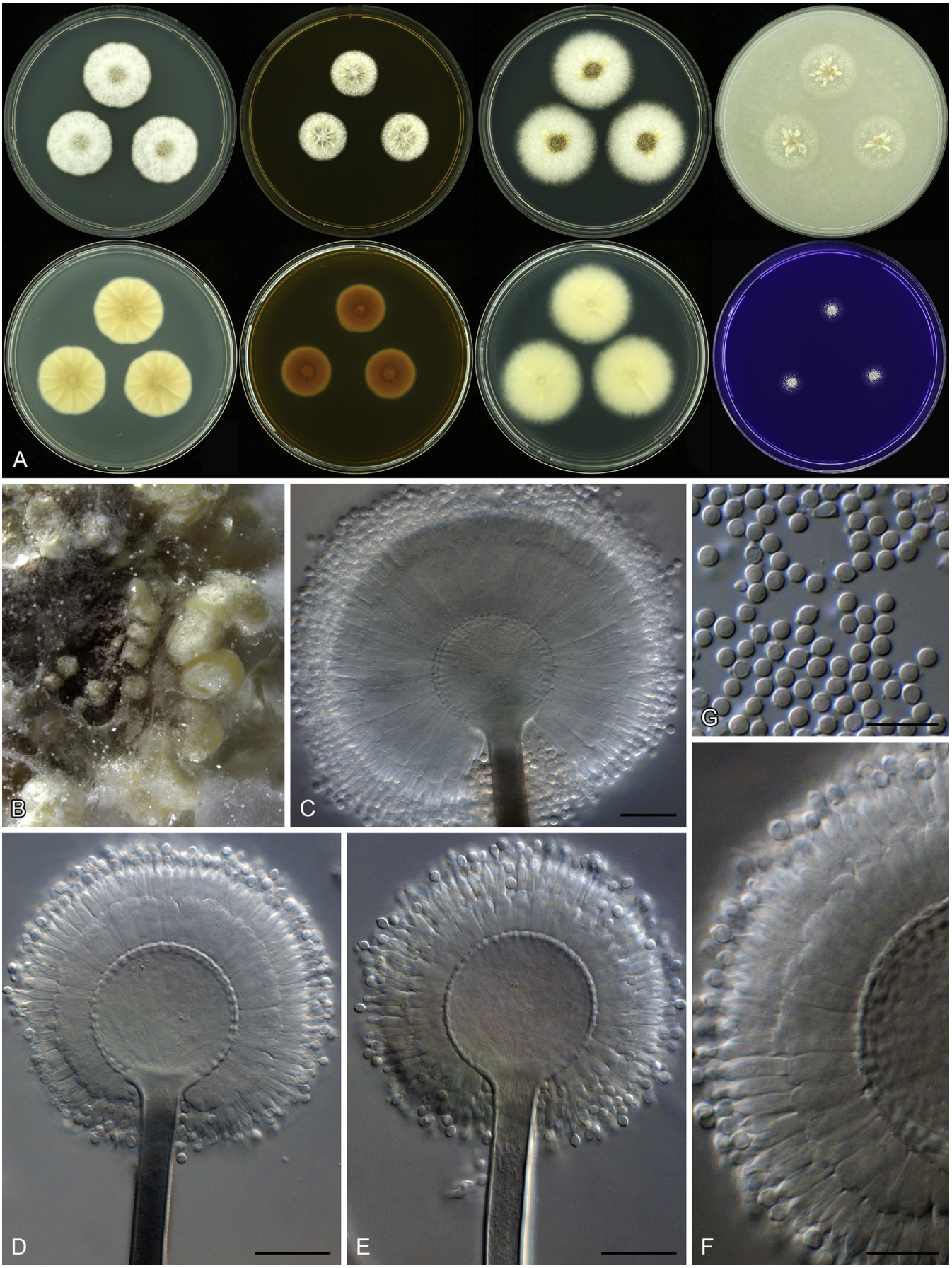

Fig. 18. *Aspergillus occultus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: C–E = 20 µm; F, G = 10 µm.

yellow (4A4) to olive brown (4E4); soluble pigment absent; exudate absent; reverse yellowish white (2A2). OA 25 °C, 7 d: Colony surface floccose to velutinous; mycelial areas white; sporulation olive brown (4E4); soluble pigment absent; exudate absent; reverse white. CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes brownish, hyaline also present, finely rough walled, 435–1270 × 8.5–14 µm; Vesicles globose, sometimes less, 28–60 µm wide; Metulae 10–16(–38 on DG18) × 4–7.5 µm, covering 100 % of head; Phialides ampulliform, 8–10.5 × 2.5–4 µm; Conidia globose to subglobose, smooth and finely roughened, 2.5–3 µm (2.88 ± 0.15 × 2.81 ± 0.2, *n* = 45); Sclerotia white to yellow, 450–1650 µm.

Extrolites: ochratoxins, penicillic acid, quinolactacin-derivatives.

Distinguishing characters: *Aspergillus occultus*, in common with *A. robustus*, grows restrictedly on MEA. However, *A. occultus* does not produce the typical black sclerotia observed in *A. robustus*. *Aspergillus occultus* is closely related to *A. elegans*, *A. steynii*, *A. pseudoelegans*, *A. insulicola*, *A. ochraceopetaliformis* and *A. pulvericola*. In addition to growth rate on MEA, *A. occultus* grows more restricted on all media used in this study.

Aspergillus ochraceopetaliformis Bat. & Maia, Anais Soc. Biol. Pernambuco 15: 213. 1957. MycoBank MB292851. Fig. 19.

= *Aspergillus flocculosus* Frisvad & Samson, Stud. Mycol. 50: 33. 2004.

Typus: **Brazil**, Recife, scalp lesion, isolated by A.C. Batista (no 270, Instituto de Micologia, Iniversidade do Recife, culture ex-type CBS 123.55 = NRRL 4752 = IBT 14347 = ATCC 12066 = IMI 211804 = QM 6955 = WB 4752).

ITS barcode: EF661429. (alternative markers: *BenA* = EF661350; *CaM* = EF661388). This species has unique sequences for all genes studied, allhtough very similar to *A. insulicola* and *A. pulvericola*.

Colony diam, 7 d (in mm): CYA 40–50; CYA 30 °C 45–55; CYA 33 °C 35–45; CYA 37 °C 13–24; MEA 35–45; YES 60–70; DG18 55–65; OA 35–45; CREA 15–22.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white to greyish white; sporulation light yellow to olive to brownish orange (3A4–3D4–5C4); sclerotium-like structures embedded in media, reddish brown; soluble pigment inconspicuous in some isolates, reddish brown; exudate absent to yellowish olive; reverse range from greyish yellow to brownish orange to brown to dark brown (4B3–5C4–6C6–7D6–E8–F8). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C; soluble pigment absent. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C; soluble pigment inconspicuous, yellowish orange. CYA 37 °C, 7 d: Colonies crateriform, greyish yellow to brown (4B4–5D4); soluble pigment yellowish orange (4A7), absent in some isolates. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white, aerial mycelia often mask sporulating areas; sporulation dull yellow (3B4) to olive brown to brown (4D6–5D6); sparse sporulation in some isolates, reddish brown sclerotium-like structures sparsely produced in some isolates, embedded in medium, soluble pigment absent, exudate absent, reverse dark brown (6F8) centrally in some isolates, elsewhere range from light brown to brown (5D8–6D8–E8). YES 25 °C, 7 d: Colony surface floccose, somewhat velutinous in some isolates; mycelial areas white; sporulation greyish yellow (2B5) to light yellow to greyish yellow (3A5–3B6); sclerotium-like structures sparsely produced in some isolates, which are embedded in mycelia and media, reddish brown; soluble pigment inconspicuous, reddish brown; exudate absent; reverse brown to greyish brown (5F3–7F3) centrally in some isolates, elsewhere ranges from pale yellow to greyish orange to brownish orange to light brown to brown (4A3–5B5–6C6–7D7–7E7). DG18 25 °C, 7 d: Colony surface floccose, dense white sterile aerial mycelia generally produced, less dense in some isolates; sporulation pale yellow to olive brown to yellowish brown (3A3–4D5–5D5); soluble pigment absent; exudate absent; reverse dark brown (6F4) centrally, olive brown to brown (4D6–5D6) to pale yellow (1A3) to yellowish white (1A2). OA 25 °C, 7 d: Colony surface floccose, sterile aerial mycelia that mask sporulating areas, some isolates velutinous; mycelial areas white; sporulation pale yellow to greyish yellow to brownish orange (4A3–B4–5C4); soluble pigment absent; exudate absent; reverse olive brown (4F8) centrally, elsewhere ranges between white to pale yellow to olive yellow (3A2–D6). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 260–1300 × 8–10 µm; Vesicles globose to pyriform, 25–45 µm wide; Metulae 10–20(–28) × 3.5–6 µm, covering 100 % of head; Phialides ampulliform, 7.5–9(–12) × 2–3 µm; Conidia globose, smooth, 2–3 × 2–3 µm (2.7 ± 0.2 × 2.7 ± 0.2, *n* = 41). Sclerotium-like structures reddish brown, 350–650 µm.

Extrolites: (*A. ochraceopetaliformis*) aspyrones, asteltoxins, insulicolins, melleins, penicillic acid, xanthomegnins; (*A. floccosus*) aspyrones, asteltoxins, melleins, neohydroxyaspergillic acid, ochratoxins, orthosporins, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus ochraceopetaliformis* colony appearance is typically dominated by white mycelia. The mycelia masks the dull yellow to olive brown to brown conidia produced, a colour not observed in other species of the section. The species is phylogenetically closely related to *A. insulicola*, *A. pseudoelegans* and *A. pulvericola*. In addition to the conidial colour, all strains of *A. ochraceopetaliformis* produced faster growing colonies on CYA at 30 °C than at 25 °C. For other species in the clade, growth rates did not vary between these two temperatures.

Aspergillus ochraceus K. Wilh., Beitr. Kenntn. *Aspergillus*: 66. 1877. MycoBank MB190223. Fig. 20.

= *Aspergillus petrakii* Vörös, Sydowia, ser. 2, Beih., 1: 62. 1957.
= *Aspergillus onikii* Okun. not published (Raper & Fennell 1965, p. 592. name applied to culture in the CBS collection, but was never described. Blochwitz cites it in Ann. Mycol. 33: 240 (1935) as *A. ochraceus*)
= *Sterigmatocystis japonica* Aoki *et al.*, J. Seric. Sci. Japan: 273–382. 1951.

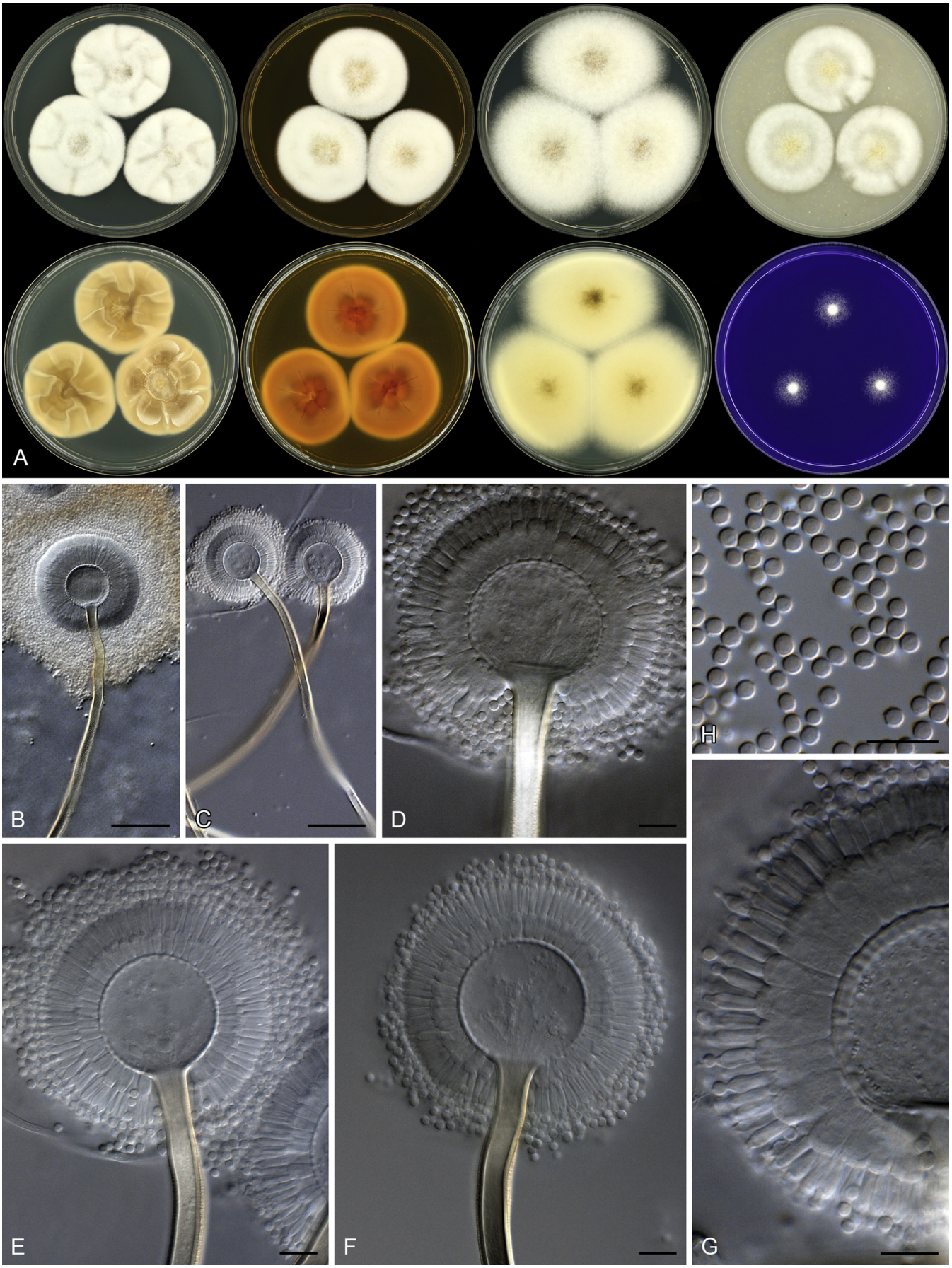

Fig. 19. *Aspergillus ochraceopetaliformis*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B–G. Conidiophores. H. Conidia. Scale bars: B, C = 50 µm; D–H = 10 µm.

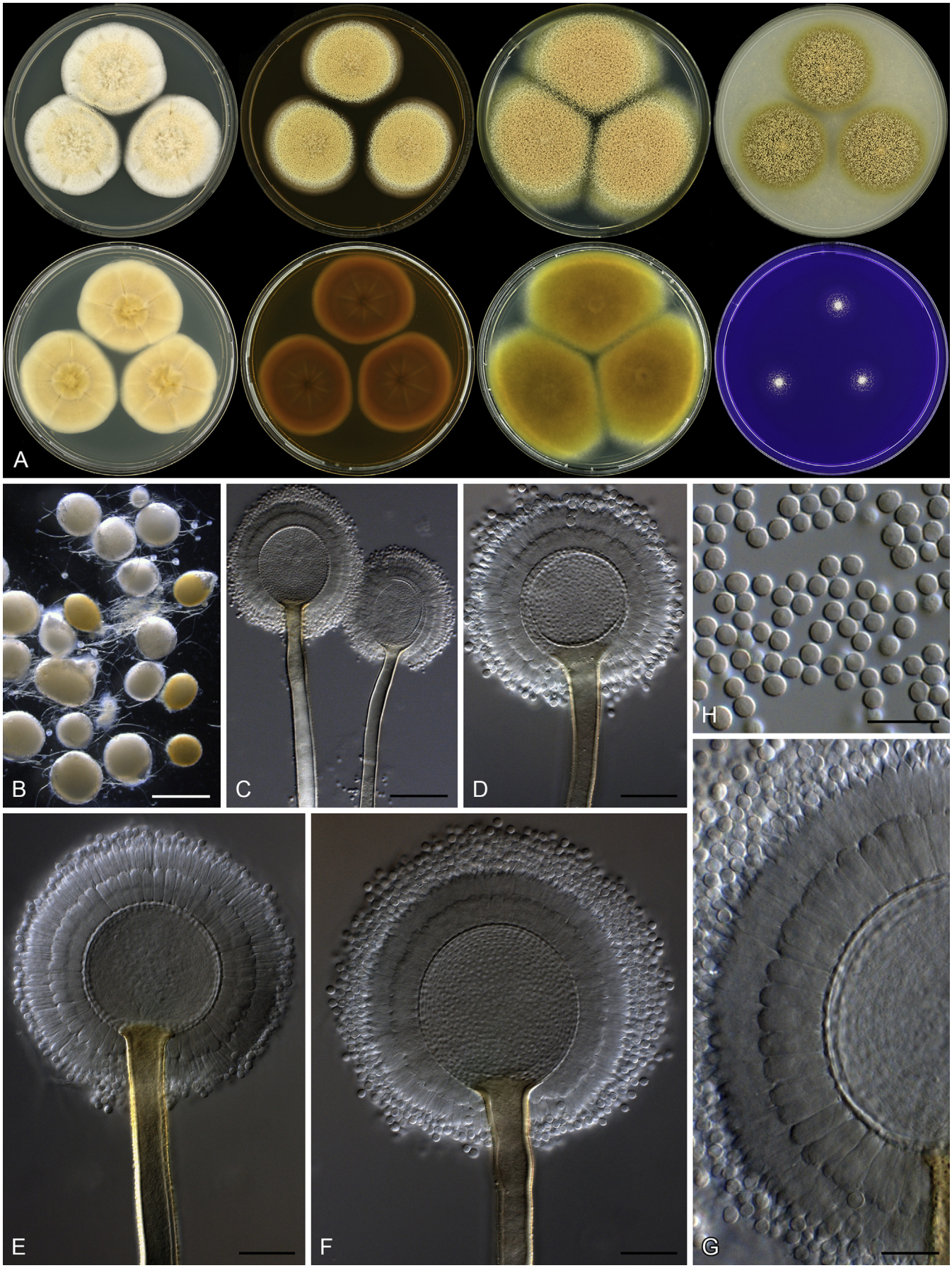

Fig. 20. *Aspergillus ochraceus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm; C = 50 µm; D–F = 20 µm; G, H = 10 µm.

Typus: unrecorded source, isolated by K.B. Raper (IMI 16247iv, culture ex-type CBS 108.08 = NRRL 398 = IBT 11952 = ATCC 1008 = CECT2093 = DSM 824 = HARVARD296 = IMI 16247 = NCTC 3889 = NRRL 1642 = QM 6731 = Thom 112 = WB 398).

ITS barcode: EF661419. (alternative markers: *BenA* = EF661322; *CaM* = EF661381). This species has some variation in the ITS gene, which is similar to the ITS sequence of *A. sesamicola*. *BenA* and *CaM* are unique for the species.

Colony diam, 7 d (in mm): CYA 38–47; CYA 30 °C 40–47; CYA 33 °C 25–35; CYA 37 °C 12–19, sometimes no growth; MEA 36–42; YES 65–70; DG18 45–60; OA 35–40; CREA 13–20.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose, some isolates are light brown underneath sporulating areas; mycelial areas white; sporulation pale yellow to light yellow (4A3–4); soluble pigment inconspicuous, yellow, absent in some isolates; exudate absent; reverse light brown to dark brown (5D6–7F6), some areas greyish yellow to greyish orange (4B4–5B4). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for more greyish yellow conidia (4B5) and more abundant pinkish to purplish brown sclerotia; soluble pigment absent to yellow in some isolates. CYA 33 °C, 7 d: Colonies similar to CYA at 30 °C, only ex-type strain producing yellow soluble pigment. CYA 37 °C, 7 d: Colonies ranging from generally purplish to whitish to light yellow to brownish red to brownish grey (4A4–8C6–F2); soluble pigment yellowish orange (4A7); exudate absent; reverse greyish yellow to brownish orange to dark brown (4B6–5C6–6F8). MEA 25 °C, 7 d: Colony surface velutinous with some floccose areas, white sterile aerial mycelia present; sporulation light yellow to greyish yellow (4A5–B5); soluble pigment absent; exudate absent; reverse brown to dark brown (6E8–7F8) near centre, brown (6D7–8) elsewhere. YES 25 °C, 7 d: Colony surface floccose, sometimes having an olive (2E6) colour underneath sporulating areas; mycelial areas white; sporulation pale yellow to light yellow (4A3–5); sclerotia pinkish brown colour in some isolates; soluble pigment absent; exudate absent; reverse generally olive to olive brown (2F8–4F8) to light yellow (4A4) at margin, in less sporulating areas, light yellow to greyish yellow (3A4–4C5) to brown (6E6). DG18 25 °C, 7 d: Colony surface velutinous, sterile white aerial mycelia present, sometimes olive (2E6) underneath sporulating areas; sporulation greyish orange to brownish orange (5B5–C5), light yellow (4A5) in isolates that sporulate less dense; soluble pigment absent; exudate absent; reverse generally olive (2F8–3F8) to olive yellow (2D6), when less dense sporulating, light yellow to brown (3A4–6E6) to white. OA 25 °C, 7 d: Colony surface velutinous, sometimes white sterile aerial mycelia present, some isolates have an olive (3E6) colour underneath sporulating areas; sporulation pale yellow to light yellow (4A3–4A5); soluble pigment absent; exudate absent; reverse greyish yellow to olive (2B5–3F6). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 420–2000(–2350) × 10–18 µm; Vesicles globose, sometimes elongated on DG18, 34–65 µm wide; Metulae 8–17 × 3.5–6 µm, covering 100 % of head; Phialides ampulliform, 9–11.5 × 2.5–4 µm; Conidia globose to subglobose, finely roughened, 2.5–4 × 2.5–3.5 µm (3.1 ± 0.3 × 2.9 ± 0.3, *n* = 58); Sclerotia pinkish to purplish brown, 260–1020 µm.

Extrolites: aspergamides, aspyrones, circumdatins, melleins, ochratoxins, orthosporin, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus ochraceus* is characterised by densely sporulating colonies with the production of pinkish to purplish brown sclerotia. Morphologically it is most similar to *A. westerdijkiae*. However, *A. ochraceus* grows faster on CYA at 33 °C (25–35 mm) compared to *A. westerdijkiae* (12–18 mm) and produces an olive reverse on DG18. *Aspergillus westerdijkiae* also produces a yellow orange soluble pigment on CYA at 33 °C, which was observed only in a degraded strain of *A. ochraceus*. The olive reverse on DG18 is also present in *A. melleus*, *A. pallidofulvus*, *A. ostianus* and *A. roseoglobulosus*. However, *A. ochraceus* lacks the dull red mycelial colour of *A. roseoglobulosus* on CYA, grows faster on CYA 33 °C than *A. ostianus* (no growth to microcolonies), and grows slower than *A. melleus* (50–55 mm, 43–48 mm) on CYA at 30 and 33 °C. *Aspergillus pallidofulvus* grows faster on MEA and OA (47–60 mm, 42–45 mm) compared to *A. ochraceus*.

Aspergillus ostianus Wehmer, Bot. Centralbl. 80: 461. 1899. MycoBank MB179393. Fig. 21.

Typus: unrecorded source, isolated by R. Westling (IMI 15960, culture ex-type CBS 103.07 = CBS 548.65 = IBT 13386 = NRRL 420 = ATCC 16887 = IMI 015960iii = IMI 15960 = LCP 89.2584 = LSHBA c .35 = NCTC 3788 = QM 7460 = Thom 4724.35 = WB 420).

ITS barcode: EF661419. (alternative markers: *BenA* = EF661322; *CaM* = EF661381). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 46–53; CYA 30 °C 35–44; CYA 33 °C 18–22; CYA 37 °C no growth to microcolonies; MEA 40–45; YES 65–70; DG18 50–60; OA 40–45; CREA 14–25.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white to yellowish grey to reddish grey (4B2–8B2); sporulation light yellow to brown (4A4–5E5); soluble pigment absent; exudate yellowish to brown; reverse light brown to brown (5D4–7E4) to olive (2E5–3E5), with some darker brown (5F5) areas, pale margin. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C; sclerotia white to cream. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: No growth to microcolonies. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow to brownish orange (4A4–5C5), becomes brown with age; soluble pigment absent; exudate yellowish to orange to brown; reverse light brown to brown (5D7–E8–6D8). YES 25 °C, 7 d: Colony surface floccose; mycelial areas yellowish grey to reddish grey (4B2–8B2) and greyish yellow (1B6) to olive (3D6) in some strains; sporulation white to greyish orange to brownish orange (5B5–C5); soluble pigment absent; exudate absent; reverse brown (5E6) to olive (1F8–3F8). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas greyish yellow to olive (2C5–E7–3D6); sporulation white to light yellow to orange (4A4–5–5A5); soluble pigment absent; exudate absent; reverse greyish yellow to olive

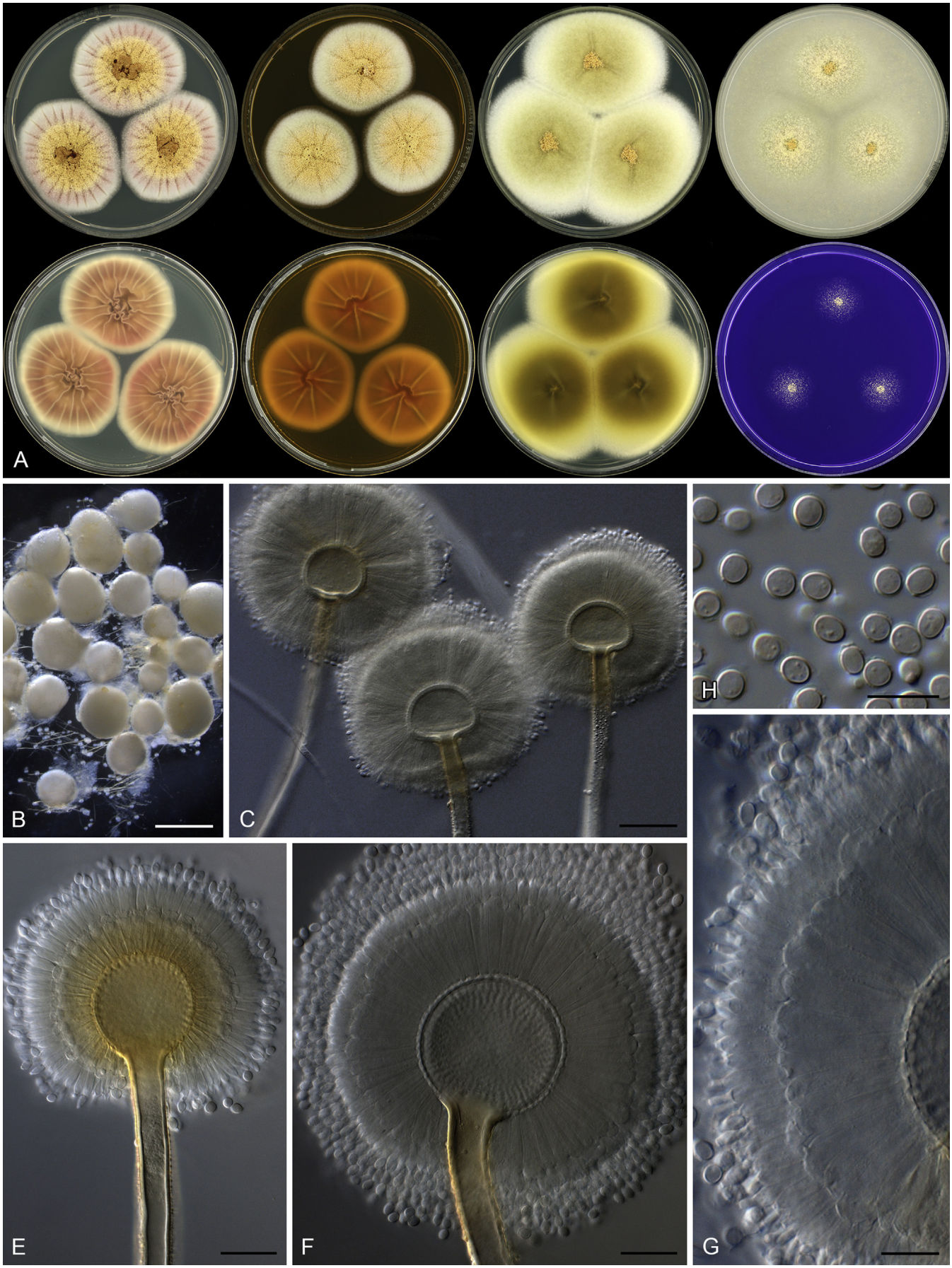

Fig. 21. *Aspergillus ostianus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm; C = 50 µm; D, E = 20 µm; G, H = 10 µm.

(2B4–3E8–F8). OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to light yellow to light orange (4A4–5A4); soluble pigment absent; exudate absent; reverse pale yellow to greyish yellow (1A3–4C4) to brownish orange (5C6). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 450–2000 × 8–16.5 µm; Vesicles globose to flattened at apex, 25–60 µm wide; Metulae 8–25(–38.5) × 4–7.5 µm, covering 100 % of head; Phialides ampulliform, 7.5–11.5(–14) × 2.5–4 µm; Conidia broadly ellipsoidal to pyriform, smooth, finely roughened on DG18, 4–5.5 × 3–4.5 µm (4.5 ± 0.3 × 3.8 ± 0.3, *n* = 47); Sclerotia white to cream, 330–750 µm.

Extrolites: aspergamices, aspyrones, circumdatins, mellamide, melleins, ochratoxins (weak to absent), orthosporins, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus ostianus* colonies on DG18 are olive in mycelial areas and in the reverse, and also produce large broadly ellipsoidal conidia (4–5.5 × 3–4.5 µm). Its conidial size distinguishes it from all other species in the section.

Aspergillus pallidofulvus Visagie, Varga, Frisvad & Samson, **sp. nov.** MycoBank MB809199. Fig. 22.

= *Aspergillus sulphureus* var. *minimus* Nakazawa *et al.*, J. Agric. Chem Soc., Japan 1932.

Etymology: Latin, *pallidofulvus*, meaning light amber-coloured to light brown.

Typus: unrecorded source, isolated by R. Nakazawae (holotype CBS H-21796, culture ex-type CBS 640.78 = NRRL 4789 = IBT 13871 = IFO 4095 = WB 4789).

ITS barcode: EF661423. (alternative markers: *BenA* = EF661328; *CaM* = EF661389). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 45–60; CYA 30 °C 45–60; CYA 33 °C 35–45; CYA 37 °C 20–30; MEA 47–60; YES 65–75; DG18 55–65; OA 42–45; CREA 20–28.

Colony characters: CYA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation pale yellow to light yellow to greyish yellow (4A3–A5–B5), some isolates greyish orange (5B3); soluble pigment absent; exudate clear to brown; reverse brown (5E5–6E5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colony surface floccose to velutinous, crateriform; mycelial areas light brown (5D4); sporulation light yellow (4A4); soluble pigment absent; exudate absent; reverse brown to dark brown (5F6–6F6). MEA 25 °C, 7 d: Colony surface velutinous to somewhat floccose; mycelial areas white; sporulation light yellow (4A2–4); soluble pigment absent; exudate absent; reverse brown to dark brown (6D8–F8). YES 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation yellowish white to light yellow (4A2–4); sclerotia yellow to pinkish in some isolates; soluble pigment absent; exudate absent; reverse brownish orange to brown (5C6–E6). DG18 25 °C, 7 d: Colony surface velutinous, olive colour underneath sporulation in some isolates; mycelial areas white; sporulation light yellow to light orange (4A4–5A5); soluble pigment absent; exudate absent; reverse brown (5E6) at centre, olive brown (4E6–F6) elsewhere, fading into pastel yellow (1A4) margin. OA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation pale yellow to light yellow (4A3–5); sclerotia brown present in some isolates; soluble pigment absent; exudate minute clear droplets; reverse olive (2E5) at centre, greyish yellow (2B4) elsewhere, some isolates have a more yellowish to orange colour. CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 350–1500 × 7–15 µm; Vesicles globose, (15–)30–50 µm wide; Metulae (6.5–)10–15(–18) × 4–7 µm, covering 100 % of head; Phialides ampulliform, 8–10 × 2.5–3.5 µm; Conidia subglobose to ovoid to ellipsoidal, smooth, 3–4 × 2.5–3.5 µm (3.4 ± 0.3 × 3.1 ± 0.3, *n* = 38); Sclerotia yellow to pinkish to brown, 160–820 µm.

Extrolites: aspergamides, aspyrones, insulicolins (only NRRL 405), melleins, penicillic acid, xanthomegnins.

Distinguishing characters: *Aspergillus pallidofulvus* produces densely sporulating colonies with sclerotia abundant on YES and OA. Colonies on DG18 have an olive brown reverse, which is similar to *A. melleus*, *A. ochraceus*, *A. ostianus* and *A. roseoglobulosus*. However, *Aspergillus pallidofulvus* lacks the dull red mycelia of *A. roseoglobulosus* on CYA; grows faster on CYA at 37 °C than *A. ostianus* (no growth to microcolonies); and grows faster than *A. ochraceus* on CYA at 25, 30, 33 and 37 °C, MEA, DG18 and OA. It also grows faster on CYA at 37 °C, MEA, DG18 and OA compared to *A. melleus* and produces smooth walled conidia compared to the latter that have finely roughened conidia.

Aspergillus persii A.M. Corte & Zotti, Mycotaxon 83: 276. 2002. MycoBank MB374215. Fig. 23.

Typus: **Italy**, toenail of patient, 1999, isolated by A. Persi (MUCL 41970, culture ex-type CBS 112795 = NRRL 35669 = IBT 22660 = MUCL 41970).

ITS barcode: FJ491580. (alternative markers: *BenA* = AY819988; *CaM* = FJ491559). This species share identical ITS sequences with *A. bridgeri*, *A. subramanianiii*, *A. salwaensis* and *A. sclerotiorum*. *BenA* and *CaM* sequences are unique for the species.

Colony diam, 7 d (in mm): CYA 48–55; CYA 30 °C 45–52; CYA 33 °C 40–44; CYA 37 °C 20–30; MEA 39–43; YES 60–67; DG18 45–50; OA 35–38; CREA 25–26.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow to pale orange (4A4–5A2); sclerotia white to yellowish brown, absent in some strains; soluble pigment brownish orange to absent; exudate clear; reverse light yellow (3A5) to yellowish brown (5D6). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d:

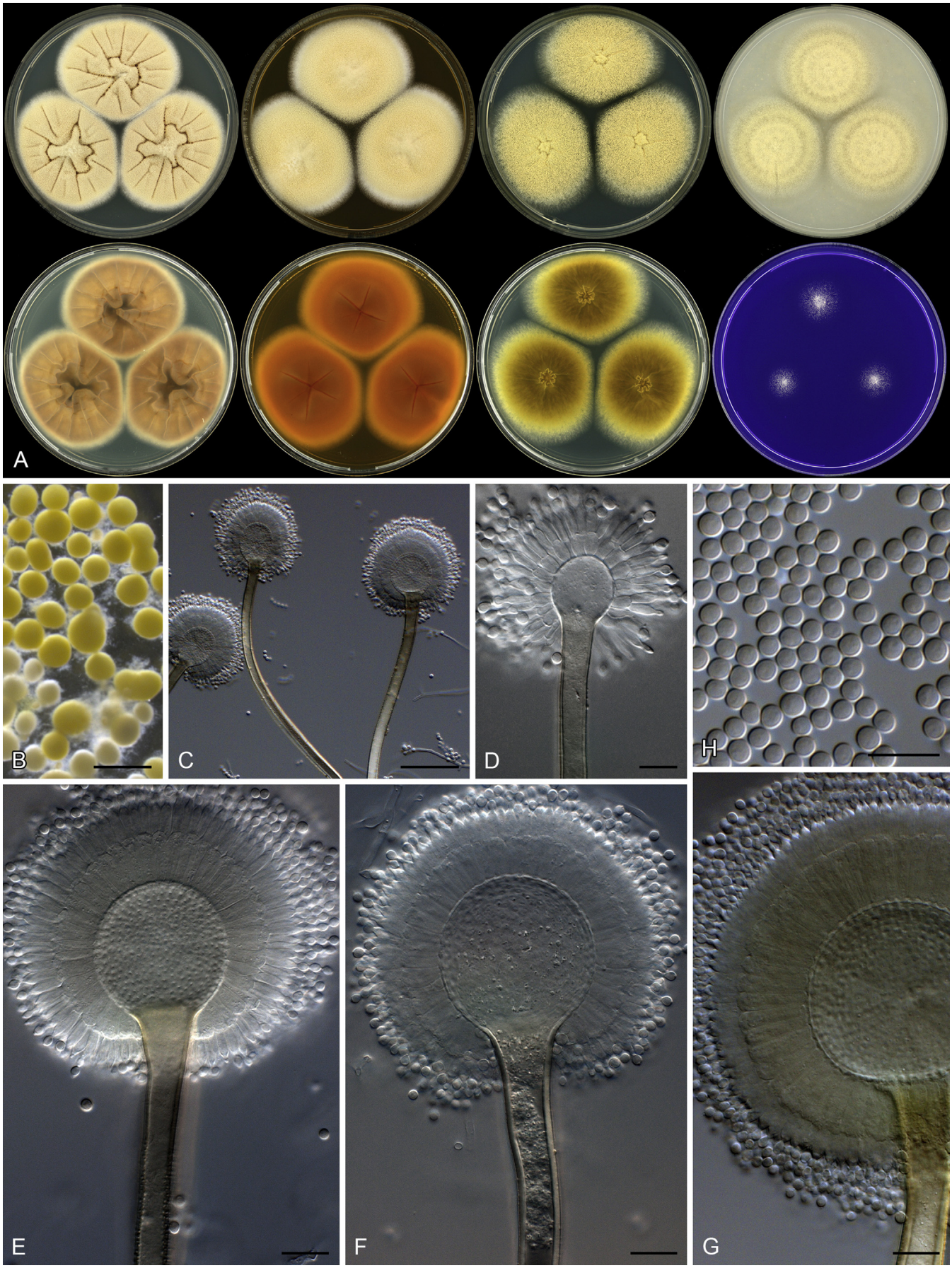

Fig. 22. *Aspergillus pallidofulvus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm; C = 50 µm; D–H = 10 µm.

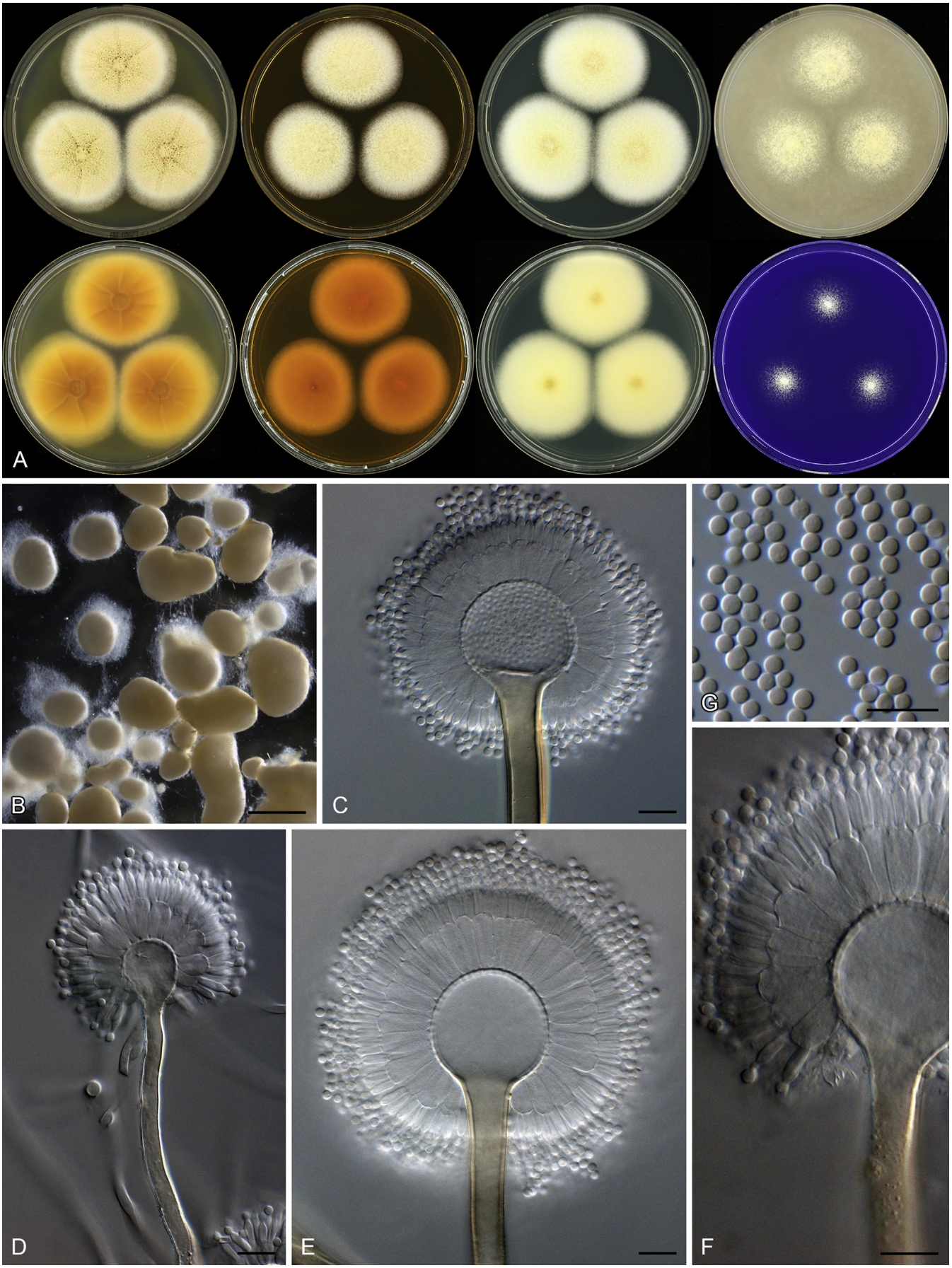

Fig. 23. *Aspergillus persii*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B–F Conidiophores. G. Conidia. Scale bars: B = 1 mm; C–G = 10 µm.

Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (3A5); soluble pigment absent; exudate absent; reverse brown (6D8). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white to light yellow (3A2–A5); soluble pigment absent; exudate absent; reverse greyish orange (5B6) centrally, fading into light yellow (4A5). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation pale yellow to light yellow (2A3–3A4); soluble pigment absent; exudate absent; reverse light yellow (2A5) centrally, fading into pale yellow (2A3). OA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white (2A2); soluble pigment inconspicuous, reddish brown; exudate absent; reverse light yellow (2A4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 225–960 × 5.5–10.5 µm; Vesicles globose, with minor proportion flattened at the apex, 15–30.5 µm wide; Metulae 9–17.5 × 4–7.5 µm, covering 75–100 % of head; Phialides ampulliform, 7.5–9.5 × 2.5–3.5 µm; Conidia globose, minor proportion subglobose, smooth, 2.5–3 × 2.5–3 µm (2.6 ± 0.1 × 2.6 ± 0.1, *n* = 41); Sclerotia white to yellowish brown, 160–1335 µm.

Extrolites: aspergamices, aspochracins, aurantiamin, cyclopenols, mellamide, mevinolin, neohydroxyaspergillic acids, ochratoxin (weak to absent) penicillic acid, petromurins, xanthomegnins.

Distinguishing characters: *Aspergillus persii* colonies sporulate well, grow well on CYA at 37 °C (25–30 mm) and produce a yellow soluble pigment on CYA at 25, 30, 33 and 37 °C. *Aspergillus persii* is closely related to *A. bridgeri*, *A. subramanianii*, *A. salwaensis*, *A. sclerotiorum* and *A. fresenii*. However, *A. bridgeri* produces brown colonies on CYA, *A. subramanianii* and *A. salwaensis* grows faster on CYA at 30, 33 and 37 °C, *A. sclerotiorum* has paler conidia on CYA and generally grows faster at higher temperatures and *A. fresenii* has greyish yellow mycelia on DG18.

Aspergillus pseudoelegans Frisvad & Samson, Stud. Mycol. 50: 35. 2004. MycoBank MB500005. Fig. 24.

Typus: **Costa Rica**, Taboga Island, soil, 2000, isolated by M. Christensen (CBS H-13439, culture ex-type CBS 112796 = NRRL 35670 = IBT 23402).

ITS barcode: FJ491590. (alternative markers: *BenA* = AY819962; *CaM* = FJ491552). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 38–45; CYA 30 °C 39–45; CYA 33 °C 30–35; CYA 37 °C 15–24; MEA 35–40; YES 65–70; DG18 58–62; OA 30–35; CREA 18–20.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white to yellowish white (2A2); sporulation only after prolonged incubation; sclerotia brownish orange to greyish brown (5C3–D3); soluble pigment inconspicuous, red; exudate absent; reverse brownish orange (6C5) centrally, fading into greyish yellow to greyish orange (4B3–5B3). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C, lacks the greyish brown centre; sclerotia white; soluble pigment yellowish orange. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white to light yellow (4A4); sporulation only after prolonged incubation; sclerotia white to yellow; soluble pigment absent; exudate clear to yellowish; reverse brown (6E7) centrally, brownish orange (5C6) elsewhere. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white with some greenish yellow (1A6) areas; sporulation absent; sclerotia white; soluble pigment absent; exudate absent; reverse brownish orange (6C5–7C5). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to light yellow to greenish yellow (1A5–7); sporulation absent; sclerotia white; soluble pigment absent; exudate absent; reverse olive (3D3) at centre, pale yellow to light yellow (1A3–4) elsewhere. OA 25 °C, 7 d: Colony surface floccose; white mycelial areas; sporulation only after prolonged incubation; sclerotia pale yellow to greyish orange (2A3–5B4), dominate colony appearance; soluble pigment absent; exudate clear; reverse greyish yellow (4B4) centrally, greyish orange (5B3) elsewhere. CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, scarcely sporulating on MEA, described from CYA, MEA and OA; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 365–730(–1200) × 7–12.5 µm; Vesicles globose to spathulate, 23–51 µm wide; Metulae 7.5–22.5 × 4–7 µm, covering 100 % of head; Phialides ampulliform, 7–10.5 × 2.5–3.5 µm; Conidia globose, smooth, 2–3 × 2–3 µm (2.6 ± 0.2 × 2.6 ± 0.2, *n* = 29); Sclerotia white to yellow to greyish orange, 120–900 µm.

Extrolites: antibiotic Y, aspyrones, melleins, ochratoxins, petromurins.

Distinguishing characters: *Aspergillus pseudoelegans* produces strongly floccose colonies that sporulate poorly and produces abundant white to brownish orange to brown sclerotia. Mycelial areas on DG18 are bright light yellow to greenish yellow (1A5–7). These characters distinguish it from the phylogenetically closely related *A. insulicola*, *A. pulvericola* and *A. ochraceopetaliformis*.

Aspergillus pulvericola Visagie, Seifert, Frisvad & Samson, **sp. nov.** MycoBank MB809200. Fig. 25.

Etymology: Latin, *pulvericola*, meaning living in dust, in reference to ex-type strain isolated from dust.

Typus: **Micronesia**, Kosrae Island, Malem, house dust, 2009, isolated by E. Whitfield and K. Mwange (holotype CBS H-21793, culture ex-type CBS 137327 = DTO 267-C6).

ITS barcode: KJ775440. (alternative markers: *BenA* = KJ775055; *CaM* = KJ775236). This species has unique sequences for all genes studied.

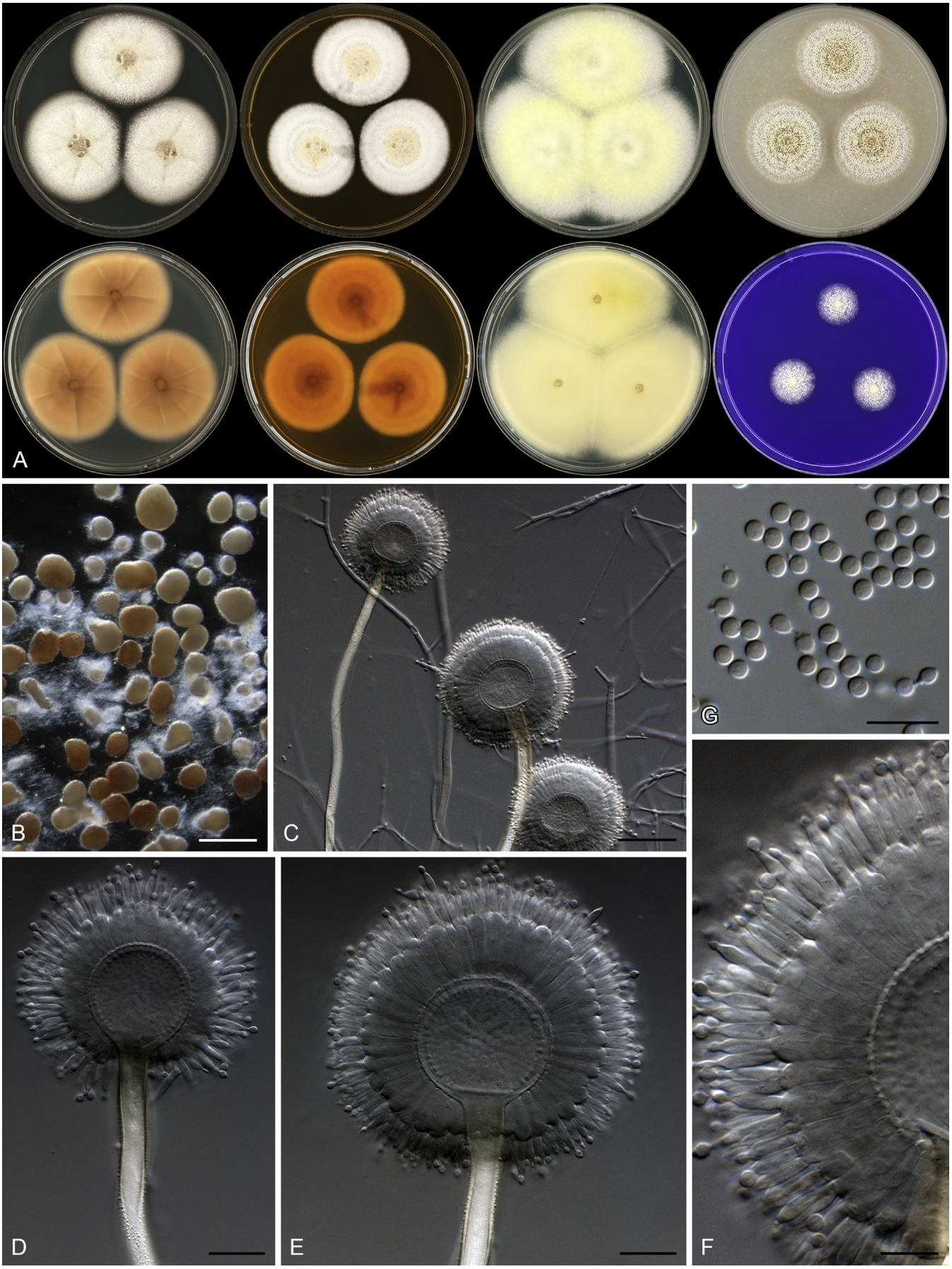

Fig. 24. *Aspergillus pseudoelegans*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C = 20 µm; D–G = 10 µm.

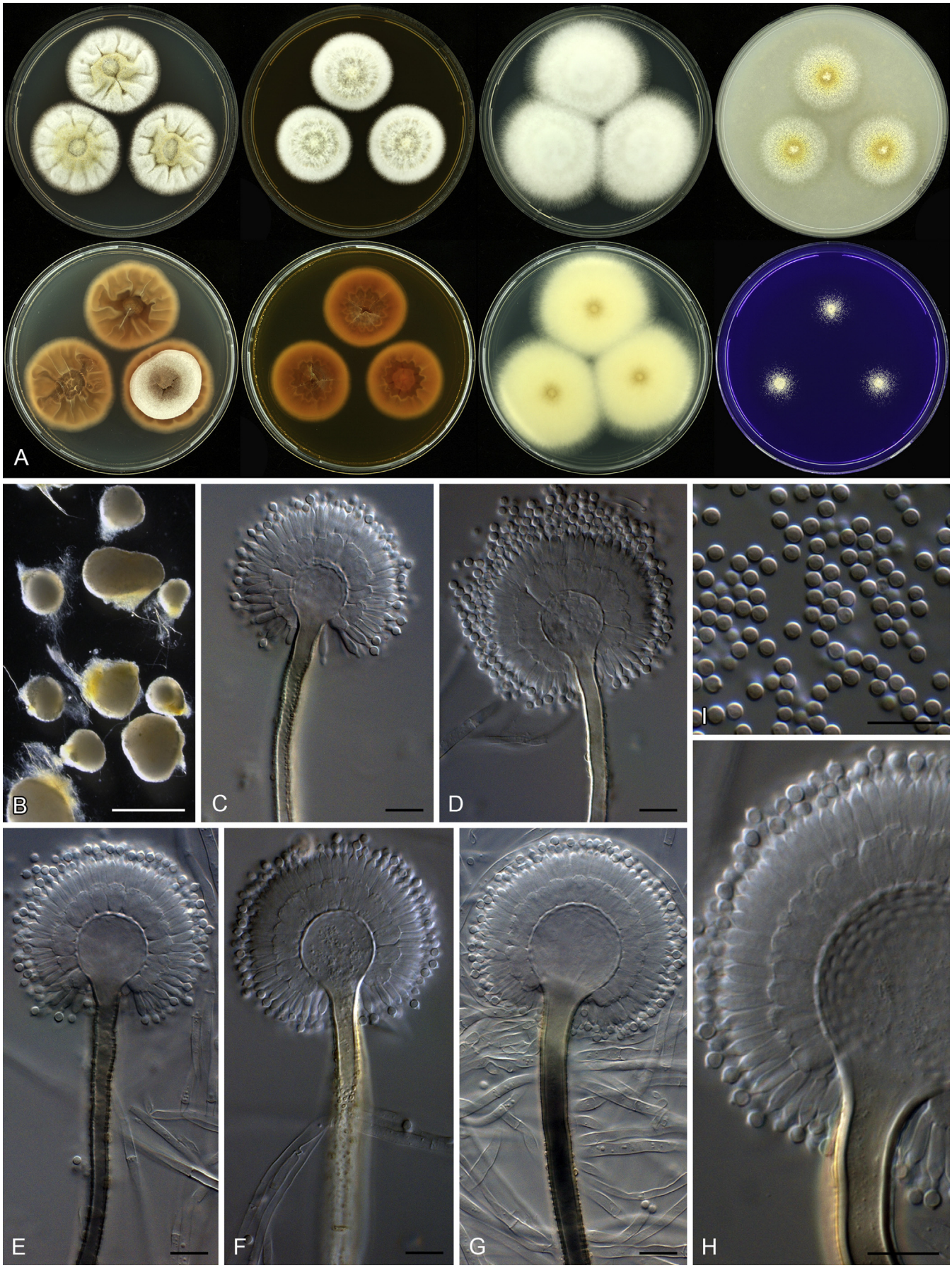

Fig. 25. *Aspergillus pulvericola*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–H. Conidiophores. I. Conidia. Scale bars: B = 1 mm; C–I = 10 µm.

Colony diam, 7 d (in mm): CYA 39–43; CYA 30 °C 38–43; CYA 33 °C 20–30; CYA 37 °C microcolonies to 5; MEA 34–37; YES 59–67; DG18 48–55; OA 30–35; CREA 20–25.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation greyish yellow (4B5); soluble pigment reddish to brown; exudate absent; reverse brown (6D7). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies crateriform, similar colours to CYA at 25 °C. CYA 37 °C, 7 d: Mostly no growth, some isolates microcolonies. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white (4A2); sclerotia sometimes present underneath mycelial areas, white to cream; soluble pigment absent; exudate absent; reverse brown (6D5). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation yellowish white (4A2); soluble pigment absent; exudate absent; reverse brownish orange (6C8). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to pastel yellow (1A4); sporulation sparse, yellowish, masked by aerial mycelia; soluble pigment absent; exudate absent; reverse yellowish white (1A3–2A2). OA 25 °C, 7 d: Colony surface floccose to velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse greyish yellow (2B4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes brownish, some hyaline, rough walled on MEA, minor proportion smooth walled on DG18, 190–1000 × 5–9 µm; Vesicles globose, 15–53 µm wide; Metulae 5.5–16.5 × 3.5–7 µm, covering 100 % of head, a minor proportion less; Phialides ampulliform, 7.5–10 × 2.5–3 µm; Conidia globose, sometimes subglobose, smooth, small proportion finely roughened, 2.5–3 µm (2.55 ± 0.2 × 2.55 ± 0.2, *n* = 49); Sclerotia white to cream, 250–510 µm.

Extrolites: ochratoxin A & B, aspochracin, sclerotiotides, penicillic acid, viomellein, xanthomegnin.

Distinguishing characters: *Aspergillus pulvericola* colonies are strongly floccose and have greyish yellow (4B5) sporulating areas. Colonies on CYA produce a reddish brown soluble pigment, also observed in *A. insulicola*. *Aspergillus pulvericola* is closely related to *A. insulicola*, *A. ochraceopetaliformis* and *A. pseudoelegans*. However, these species all grow moderately well on CYA at 37 °C compared to the poor growth of *A. pulvericola*.

Aspergillus robustus M. Chr. & Raper, Mycologia 70: 200. 1978. MycoBank MB309241. Fig. 26.

Typus: Kenya, Mombasa, thorn forest soil, 1966, isolated by D.B. Prest (NY WB 5286, culture ex-type CBS 428.77 = NRRL 6362 = ATCC 36106 = IMI 216610 = NRRL A-17351 = WB 5286).

ITS barcode: EF661176. (alternative markers: *BenA* = EU014101; *CaM* = EF661357). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 40–45; CYA 30 °C no growth; CYA 33 °C no growth; CYA 37 °C no growth; MEA 20–22; YES 60–75; DG18 40–55; OA 30–33; CREA 14–19.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose, overall having a deep green to dark green (30E8–F8) colour; mycelial areas white; sporulation light yellow (4A4), after prolonged incubation; sclerotia black, white when young; soluble pigment absent; exudate abundant, yellow; reverse olive (2F7) centrally, olive yellow (2C7) and light yellow (3A5) elsewhere. CYA 30 °C, 7 d: No growth. CYA 33 °C, 7 d: No growth. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface floccose, overall having a deep green to dark green (30E8–F8) colour; mycelial areas white; sporulation light yellow (4A4); sclerotia black; soluble pigment absent; exudate abundant yellow; reverse brown to dark brown (6E8–F8). YES 25 °C, 7 d: Colony surface floccose, overall having a deep green to dark green (30E8–F8) colour; mycelial areas white; sporulation light yellow (4A4); sclerotia black, white when young; soluble pigment absent; exudate abundant, yellow; reverse greyish yellow (4B6–C6) centrally, yellowish white to orange white (3A2–5A2) elsewhere. DG18 25 °C, 7 d: Colony surface floccose, overall having an olive brown to brown (4F4–5F4) colour; mycelial areas white; sporulation light yellow (4A4); sclerotia black, white to brownish when young; soluble pigment absent; exudate absent; reverse greenish grey to greyish yellow (1B2–3) to yellowish white (2A2). OA 25 °C, 7 d: Colony surface floccose, overall having a deep green to dark green (30E8–F8) colour; mycelial areas white; sporulation light yellow (4A4); black sclerotia produced centrally, white when young; soluble pigment absent; exudate yellow; reverse olive (3E7) centrally, fading into light yellow (3A4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, underdeveloped on MEA after 7 d, maturing after prolonged incubation; Conidiophores biseriate; Stipes hyaline to brown, smooth, 400–5000 × 3.5–12.5 µm; Vesicles globose, (8–)30–55 µm, after two wk up to 100 µm wide; Metulae 6.5–16(–23) × 4–7.5 µm, covering 100 % of head; Phialides ampulliform, 6.5–8.5 × 3–4 µm; Conidia ellipsoidal, roughened, 3–4 × 2.5–3 µm (3.4 ± 0.3 × 2.9 ± 0.15, *n* = 51); Sclerotia white to black, 155–820 µm.

Extrolites: No known extrolites.

Distinguishing characters: Slow growth on MEA (20–22 mm), no growth on CYA at 30 °C or higher, black sclerotia on most media and phototrophic conidiophores distinguish *A. robustus* from other species in the section.

Aspergillus roseoglobulosus Frisvad & Samson, Stud. Mycol. 50: 30. 2004. MycoBank MB500001. Fig. 27.

Typus: Bahamas, Little San Salvador Island, decaying leaves, 1992, isolated by B. Rassing (CBS H-13438, culture ex-type CBS 112800 = NRRL 4565 = IBT 14720).

ITS barcode: FJ491583. (alternative markers: *BenA* = AY819984; *CaM* = FJ491555). This species has unique sequences for all genes studied.

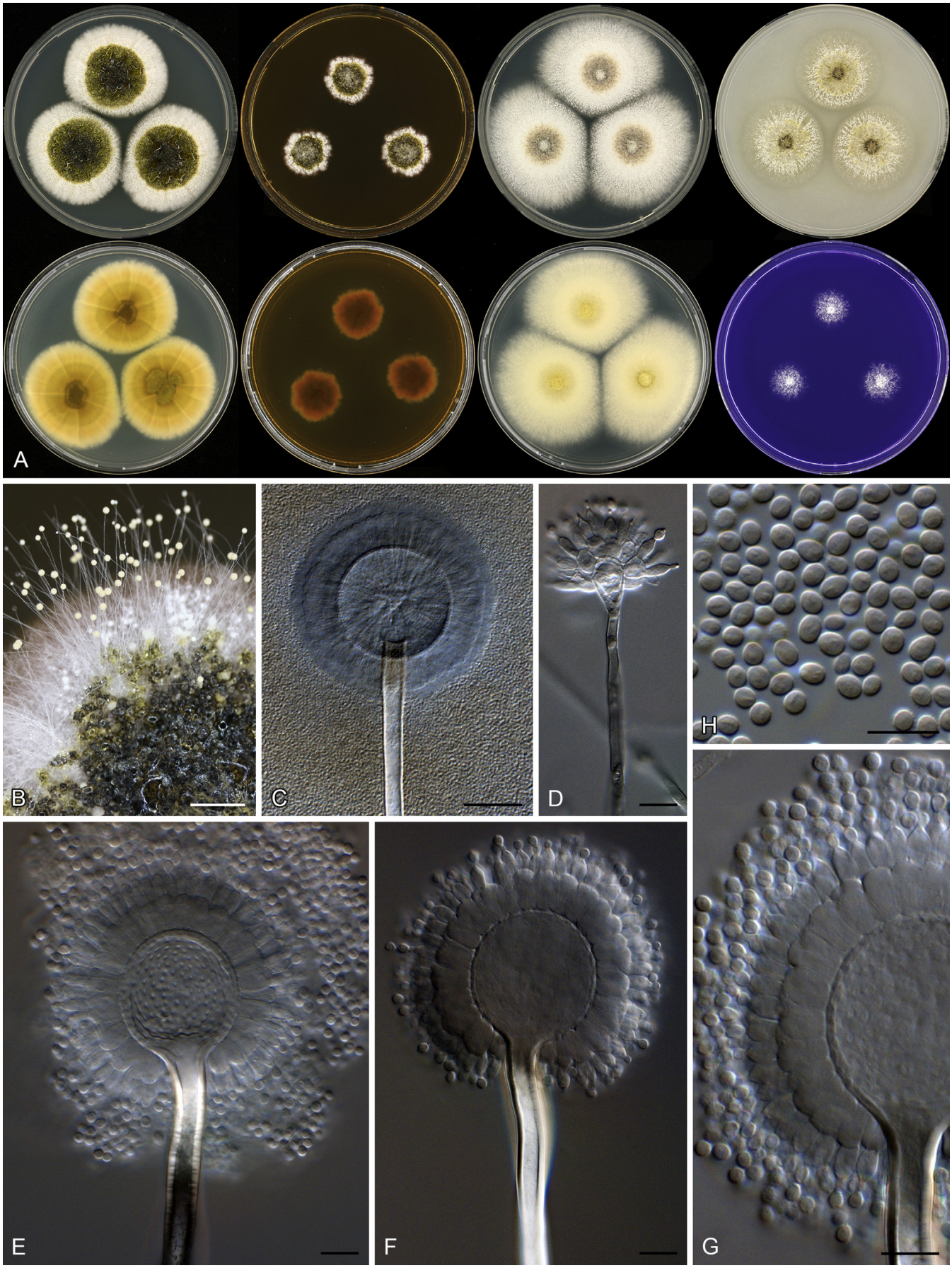

Fig. 26. *Aspergillus robustus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia and conidiophores. C–G. Conidiophores. H. Conidia. Scale bars: B = 500 µm; C = 50 µm; D–H = 10 µm.

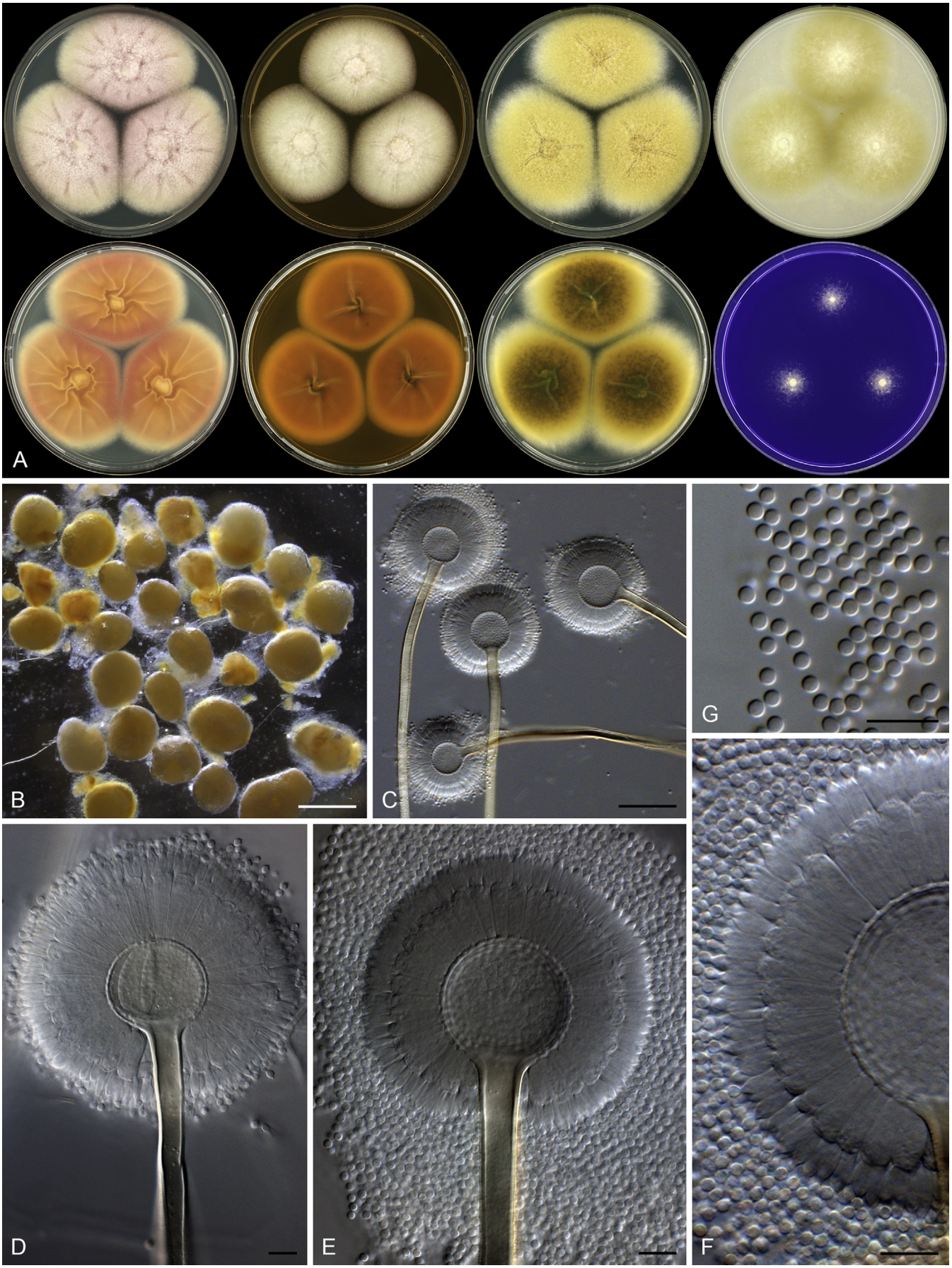

Fig. 27. *Aspergillus roseoglobulosus*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm; C = 50 µm; D–G = 10 µm.

Colony diam, 7 d (in mm): CYA 48–57; CYA 30 °C 50–57; CYA 33 °C 40–45; CYA 37 °C 15–24; MEA 43–50; YES 65–72; DG18 45–60; OA 40–50; CREA 20–25.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas dull red (10B3–4); sporulation very sparse, light yellow; soluble pigment absent; exudate absent; reverse brownish orange (5C5–6C5) to light brown (7D6) to reddish brown (9D5) areas. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for more intense red colour. CYA 33 °C, 7 d: Colonies similar to CYA at 30 °C. CYA 37 °C, 7 d: Colonies crateriform, characters similar to CYA at 25 °C; soluble pigment yellow in DTO 304E8. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white to greenish grey (1B2); sporulation light yellow to yellow (4A46); sclerotia sparse, brown after prolonged incubation; soluble pigment absent; exudate absent; reverse yellowish brown to brown (5D6–E6) with some dark brown (6F6) areas centrally. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white to yellowish grey (4B2), greenish white (30A2) near margin; sporulation sparse, light yellow; sclerotia yellow to pinkish, produced in some isolates; soluble pigment absent; exudate absent; reverse olive brown (4F7) fading into light yellow (3A4) margin. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas greyish yellow to olive (3C5–D5); sporulation sparse, light yellow; soluble pigment absent; exudate absent; reverse olive (3F7) centrally, fading into greyish yellow (2B5) margin. OA 25 °C, 7 d: Colony surface floccose, greyish yellow (2B4) underneath mycelial areas; mycelial areas white; sporulation absent to very sparse, light yellow; sclerotia white; soluble pigment absent; exudate absent; reverse pastel yellow (1A4) at centre, greyish yellow (2B4) elsewhere. CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 500–1500 × 8.5–11.5 µm; Vesicles globose, (23–)30–42 µm wide; Metulae 11.5–18(–25) × 4.5–5.5(–7) µm, covering 100 % of head; Phialides ampulliform, 8–10 × 2.5–3.5 µm; Conidia globose to subglobose, smooth to finely roughened, 2–3 × 2–3 µm (2.4 ± 0.2 × 2.4 ± 0.2, *n* = 39); Sclerotia yellowish to pinkish brown, 230–1375 µm.

Extrolites: ochratoxins, penicillic acid, xanthomegnins.

Distinguishing characters: The dull red mycelial areas and reddish reverse on CYA at all temperatures make *A. roseoglobulosus* easily recognizable. Phylogenetically it is not closely related to any other species.

Aspergillus salwaensis Visagie, Houbraken, Fotedar, Frisvad & Samson, **sp. nov.** MycoBank MB809201. Fig. 28.

Etymology: Latin, *salwaensis*, named in reference to Salwa Beach, Qatar, where the species was isolated.

Typus: **Qatar**, Salwa, soil, 2013, isolated by J. Houbraken (holotype QCC F001/14, culture ex-type CBS 138172 = DTO 297-B3).

ITS barcode: KJ775447. (alternative markers: *BenA* = KJ775056; *CaM* = KJ775244). This species has identical ITS sequences with *A. bridgeri*, *A. subramanianii*, *A. persii,* and *A. sclerotiorum*. *BenA* and *CaM* sequences are unique for this species.

Colony diam, 7 d (in mm): CYA 54–56; CYA 30 °C 63–65; CYA 33 °C 57–58; CYA 37 °C 30–32; MEA 42–43; YES 70–72; DG18 48–50; OA 42–45; CREA 30–35.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose to somewhat velutinous; mycelial areas white; sporulation light yellow to yellow (3A5–6); sclerotia sometimes present, white; soluble pigment yellowish orange; exudate clear minute droplets; reverse light yellow to greyish yellow (4A4–B6). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for sparse white sclerotia produced in some isolates. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies crateriform; mycelial areas white to pastel yellow (2A4); sporulation light yellow (3A4); soluble pigment yellowish brown; exudate absent; reverse orange (5A6) to light yellow (4A4). MEA 25 °C, 7 d: Colony surface floccose to somewhat velutinous; mycelial areas white; sporulation light yellow (3A4–4A4–5); soluble pigment absent; exudate minute clear droplets; reverse brown (6D8–E8). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white to cream; sporulation light yellow (3A4–5); soluble pigment absent; exudate absent; reverse light yellow to greyish yellow (4A4–B4–B6). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white to cream; sporulation light yellow (3A4–5); soluble pigment absent; exudate absent; reverse orange yellow (4B7) near centre, fading into yellow (3A6) with white pale (2A2) margin. OA 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (3A4–5); soluble pigment reddish brown; exudate minute clear droplets; reverse olive yellow to olive (3C6–E6). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow, rough walled, finely roughened on DG18, 250–1275 × 8–10.5 µm; Vesicles globose to flattened at apex, 27–45 µm wide; Metulae 8–21 × 3.5–6 µm, covering 100 % of head; Phialides ampulliform, 7.5–9 × 2–3 µm; Conidia globose, smooth, 2.5–3 × 2.5–3 µm (2.7 ± 0.2 × 2.7 ± 0.2, *n* = 41); Sclerotia white, 200–715 µm.

Extrolites: low ochratoxin A, penicillic acid, cf. aurantiamin, aspergamides, insulicolide, aspochracin.

Distinguishing characters: *Aspergillus salwaensis* is characterized by fast growth on CYA at 30 and 33 °C and often has conidiophores with vesicles that are flattened at the apex. The only species with comparable growth is *A. subramanianii* (60–67 mm, 55–60 mm).

Aspergillus sclerotiorum G.A. Huber, Phytopathology 23: 306. 1933. MycoBank MB277707. Fig. 29.

Typus: **USA**, Oregon, *Malus sylvestris* fruit, isolated by G.A. Huber (IMI 56673, culture ex-type CBS 549.65 = NRRL 415 = IBT 11931 = ATCC 16892 = DSM 870 = IFO 7542 = IMI 056732 = IMI 56673 = LCP 89.2594 = QM 6732 = Thom 5351 = WB 415).

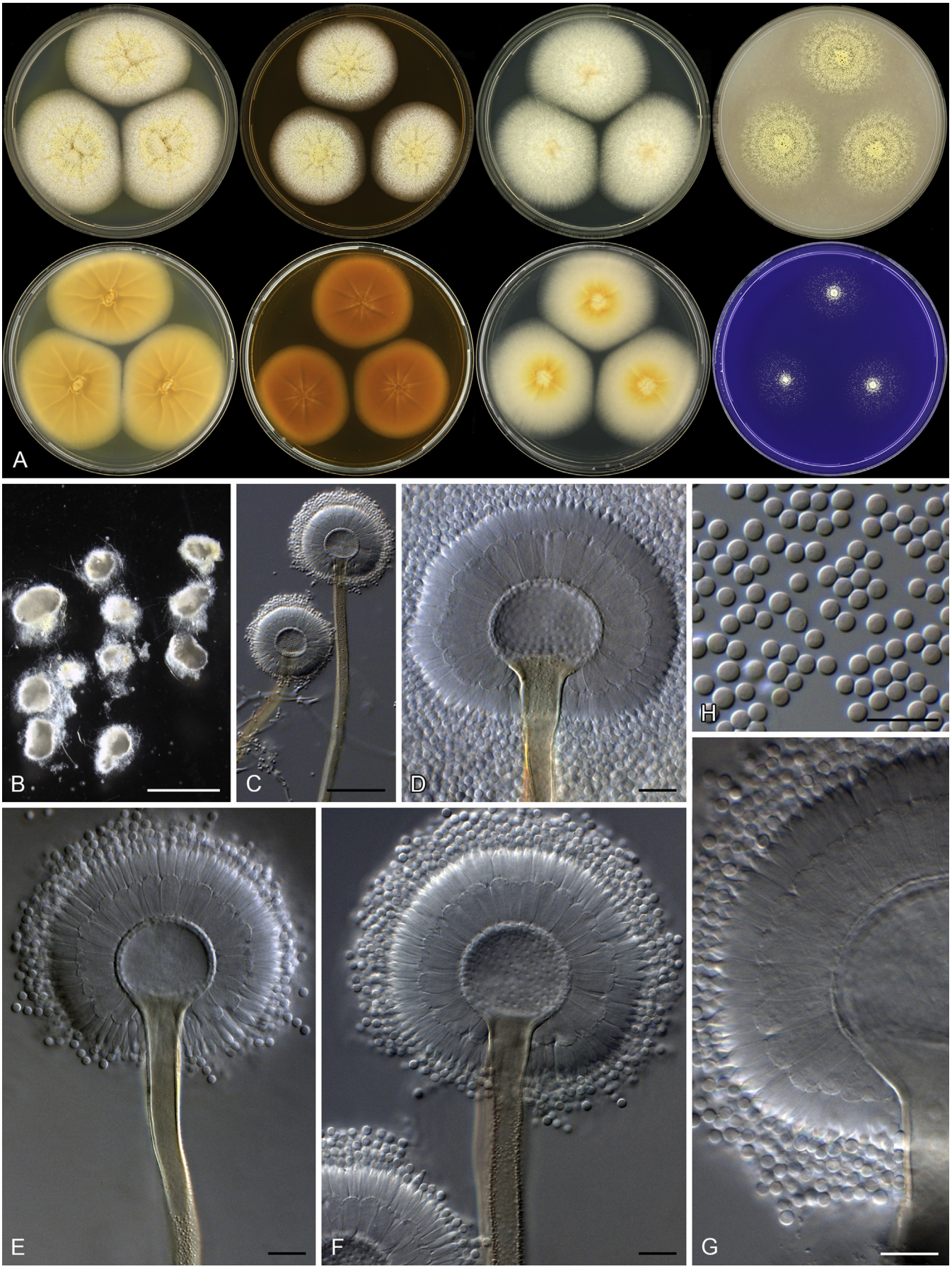

Fig. 28. *Aspergillus salwaensis*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: B = 1 mm, C = 50 µm; D–H = 10 µm.

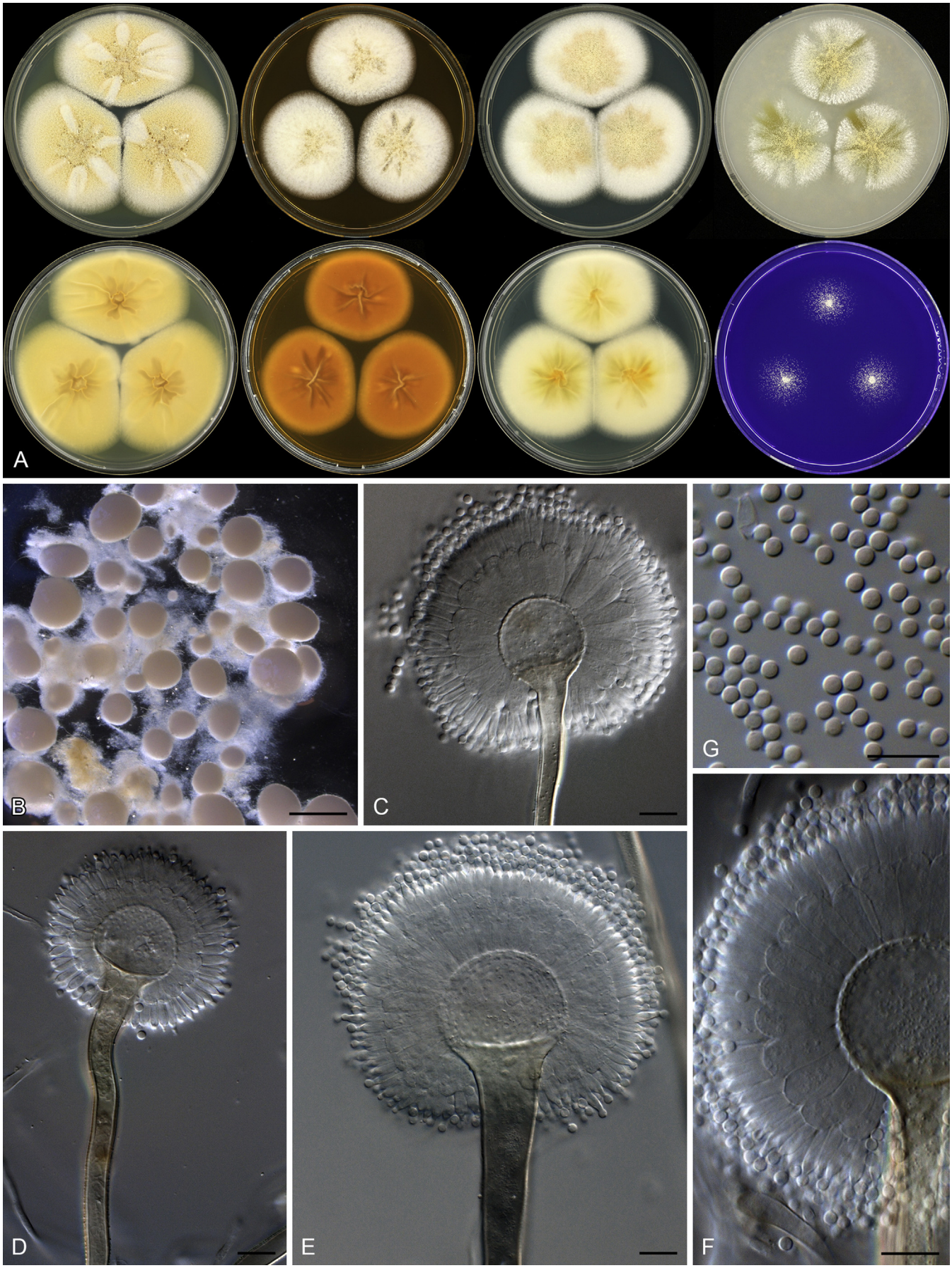

Fig. 29. *Aspergillus sclerotiorum*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C–G = 10 µm.

ITS barcode: EF661400. (alternative markers: *BenA* = EF661337; *CaM* = EF661384). This species share identical ITS sequences with *A. bridgeri*, *A. subramanianii*, *A. persii* and *A. salwaensis*. *BenA* and *CaM* sequences are unique for the species.

Colony diam, 7 d (in mm): CYA 54–57; CYA 30 °C 56–64; CYA 33 °C 46–50; CYA 37 °C 28–32; MEA 41–45; YES 70–72; DG18 40–50; OA 38–42; CREA 25–30.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (3A4–4A4); sclerotia white to cream; soluble pigment yellow; exudate clear; reverse light yellow greyish yellow (4A4–B5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C; soluble pigment inconspicuous, yellow. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (3A5); sclerotia white to cream; soluble pigment absent; exudate absent, in some strains yellow to brown; reverse brown (6D8). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4A5); sclerotia white to cream; soluble pigment absent; exudate absent; reverse light brown (5D4) near centre, light yellow (3A4) elsewhere. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4A5); sclerotia white to cream; soluble pigment absent; exudate absent; reverse greyish orange (5B6) at centre, greyish yellow (3B6) to yellowish white (2A2) elsewhere. OA 25 °C, 7 d: Colony surface floccose, olive colour underneath sporulating areas; mycelial areas white; sporulation light yellow (4A4); sclerotia white to cream; soluble pigment absent; exudate absent; reverse greyish yellow (3C4) to yellowish white (2A2). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 440–1100 × 5–12.5 µm; Vesicles globose, 19–36 µm wide; Metulae 8–16 × 4.5–7 µm, covering 75–100 % of head; Phialides ampulliform, 7–9.5 × 2.5–3.5 µm; Conidia globose to subglobose, smooth, 2–3.5 × 2–3.5 µm (2.69 ± 0.2 × 2.65 ± 0.2, *n* = 36); Sclerotia white to cream, 130–1160 µm.

Extrolites: aspergamides, aspochracins, cyclopenols, mellamides, ochratoxins (weak), penicillic acid, petromurins, sclerotides, secalonic acid A, xanthomegnins.

Distinguishing characters: *Aspergillus sclerotiorum* produces colonies dominated by areas of white to cream sclerotia and light yellow sporulation. It grows well on CYA at 37 °C (29–32 mm) and produces a yellow soluble pigment on CYA at 25, 30, 33 and 37 °C. The species is resolved in a clade closely related to *A. bridgeri*, *A. subramanianii*, *A. persii*, *A. salwaensis* and *A. fresenii*. The white to cream sclerotia and yellow soluble pigments resembles colonies of *A. subramanianii*. However, the latter species grows much faster at 33 and 37 °C.

Aspergillus sesamicola Visagie, Frisvad & Samson, **sp. nov.** MycoBank MB809202. Fig. 30.

Etymology: Latin, *sesamicola*, meaning living on sesame, in reference to the substrate of the ex-type strain.

Typus: **Denmark**, sesame seed, (holotype CBS H-21792, culture ex-type CBS 137324 = IBT 29314 = DTO 148-B4).

ITS barcode: KJ775437. (alternative markers: *BenA* = KJ775063; *CaM* = KJ775233). This species shares a similar ITS sequence to that of *A. ochraceus*. *BenA* and *CaM* are unique for this species.

Colony diam, 7 d (in mm): CYA 32–34; CYA 30 °C 40–41; CYA 33 °C 30–31; CYA 37 °C 19–20; MEA 30–31; YES 47–50; DG18 38–39; OA 35–36; CREA 11–12.

Colony characters: CYA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate small orange droplets; reverse dark brown (6F8–9F8). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C, except for more abundant exudates. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colony surface velutinous; sporulation greyish yellow (3B5) to olive (3E6); soluble pigment absent; exudate absent; reverse olive brown (4F8). MEA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse dark brown (6F8–8F8). YES 25 °C, 7 d: Colony surface velutinous; mycelial areas white to yellowish white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse olive brown to brown (4F8–5F8). DG18 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse orange yellow (4B7). OA 25 °C, 7 d: Colony surface velutinous, olive underneath sporulating areas; mycelial areas white to yellowish white; sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse olive brown (4E8–F8). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes brownish yellow, sometimes hyaline, rough walled, 150–355 × 7–10.5 µm; Vesicles globose, 22.5–41 µm wide; Metulae 9.5–15.5 × 4–6.5 µm, covering 100 % of head; Phialides ampulliform, 9–11.5 × 3–3.5 µm; Conidia ellipsoidal, smooth, 3–3.5 × 2.5–3 µm (3.47 ± 0.15 × 2.89 ± 0.15, *n* = 41); Sclerotia absent.

Extrolites: aspergamides, ochratoxins (trace), xanthomegnins.

Distinguishing characters: *Aspergillus sesamicola* produces densely sporulating colonies on most media, does not produce sclerotia and has conidiophores with short stipes (up to 355 µm). Its most striking feature, however, is the dark brown (6F8–9F8) reverse produced on CYA and MEA. This is not observed for any other species in the section.

Aspergillus steynii Frisvad & Samson, Stud. Mycol. 50: 39. 2004. MycoBank MB500006. Fig. 31.

Typus: **India**, Giris, dried arabica green coffee, isolated by J.C. Frisvad (CBS H-13445, culture ex-type CBS 112812 = NRRL 35675 = IBT 23096).

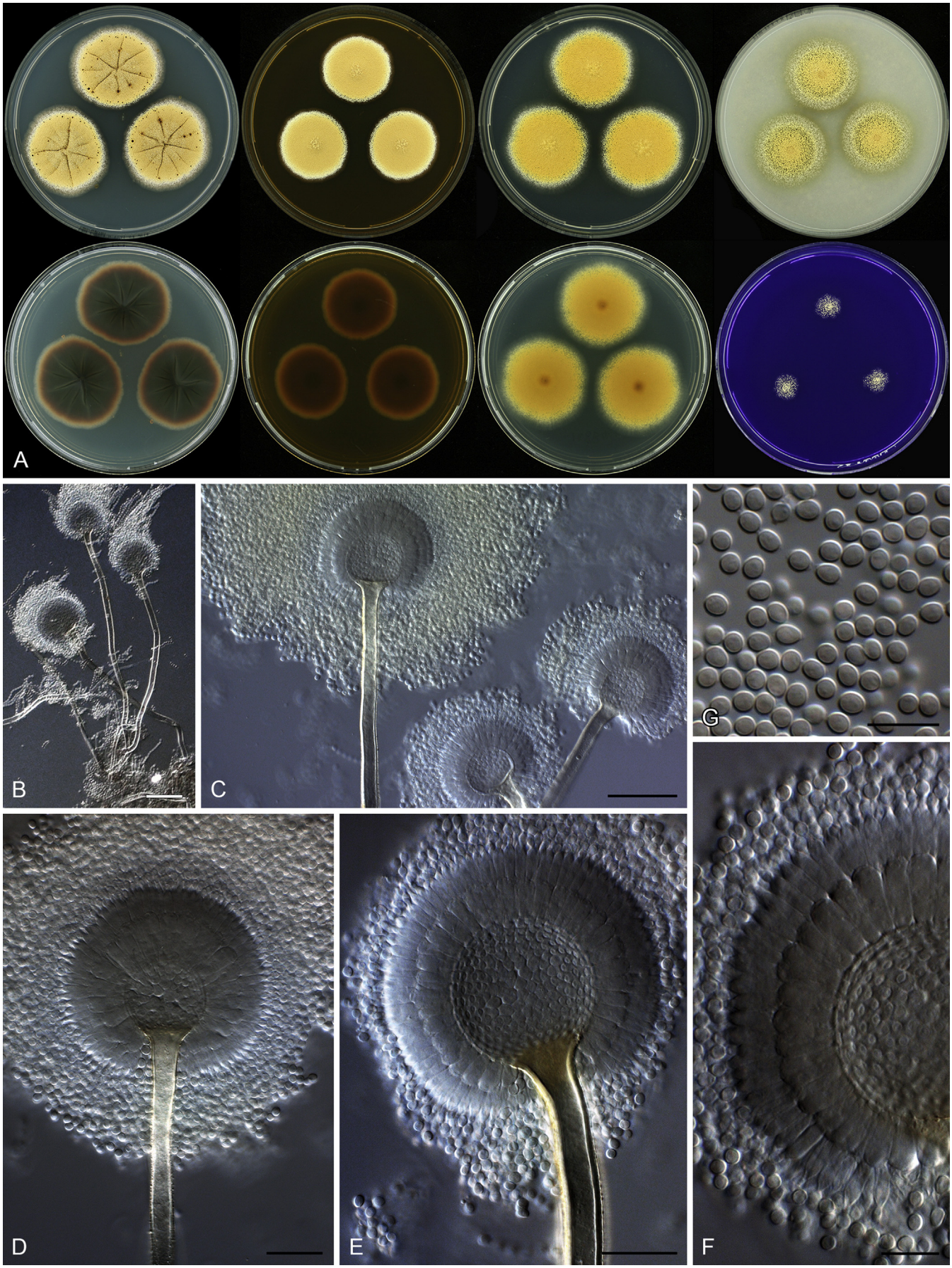

Fig. 30. *Aspergillus sesamicola*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B–F. Conidiophores. G. Conidia. Scale bars: B, C = 50 µm; D, E = 20 µm; F, G = 10 µm.

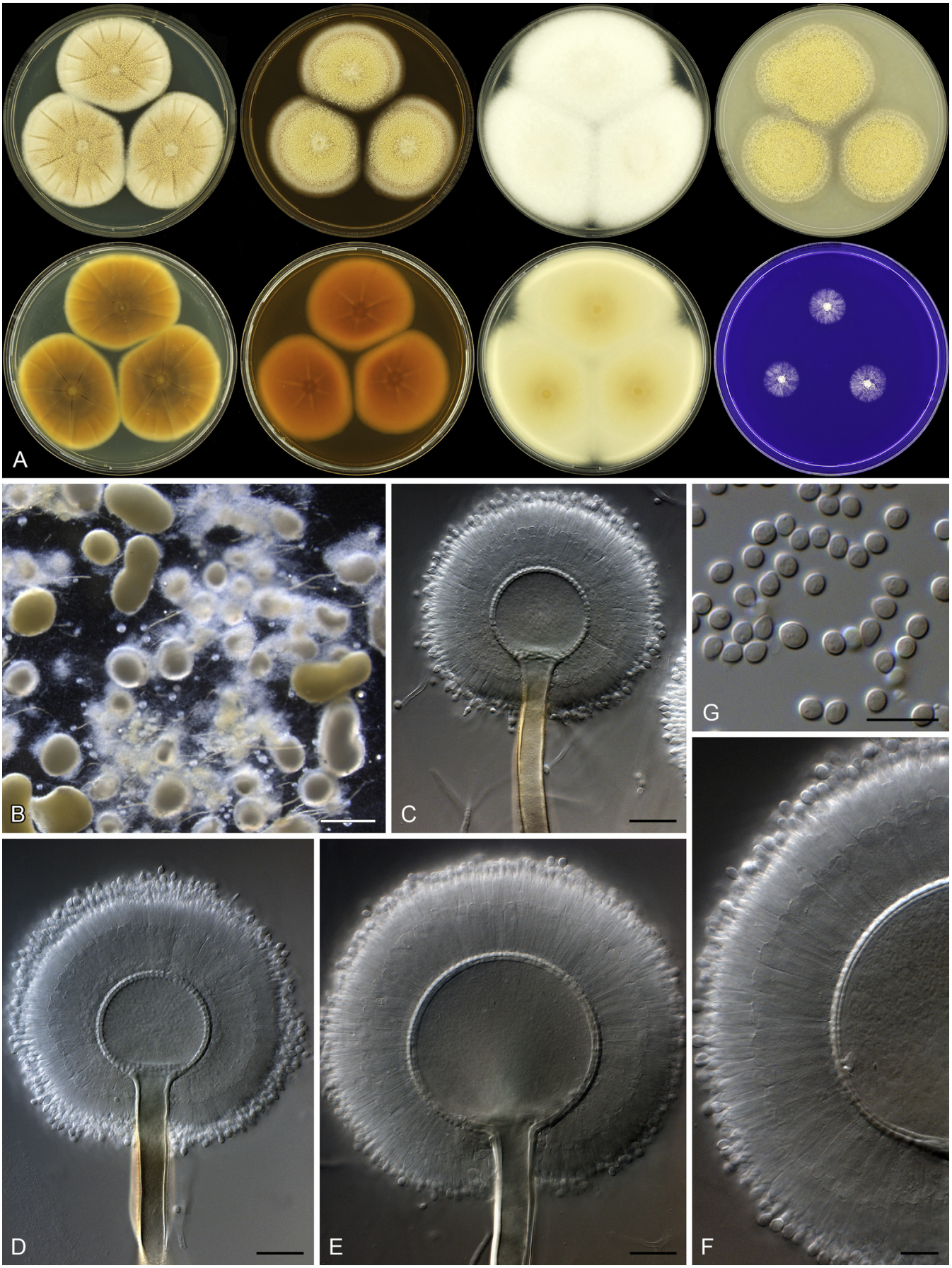

Fig. 31. *Aspergillus steynii*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C–E = 20 µm; F, G = 10 µm.

ITS barcode: EF661416. (alternative markers: *BenA* = EF661347; *CaM* = EF661378). This species share identical *CaM* sequences with *A. elegans*. ITS and *BenA* sequences are unique for the species.

Colony diam, 7 d (in mm): CYA 40–50; CYA 30 °C 30–40; CYA 33 °C 7–30; CYA 37 °C no growth to 5 mm; MEA 36–45; YES 60–70; DG18 52–60; OA 31–35; CREA 15–16.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white to light grey; sporulation light yellow (3A5–4A5); sclerotia white to yellow; soluble pigment absent; exudate clear in some isolates; reverse light brown (7D4) at centre, greyish yellow (3B5–4B5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C; sclerotia produced in some strains, yellowish green. CYA 33 °C, 7 d: Microcolonies; mycelial areas white; reverse bright orange. CYA 37 °C, 7 d: No growth to microcolonies, with deep yellow soluble pigment. MEA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4A5); sclerotia white to yellow; soluble pigment absent; exudate absent; reverse brown (6E8) at centre, brownish orange (5C6) near margin. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4B5); soluble pigment absent; exudate absent; reverse brown (5F8) at centre, pale yellow (4A3) elsewhere. DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (4B5); soluble pigment absent; exudate absent; reverse greyish yellow (3B6) at centre, yellowish white to pale yellow (2A2–3) elsewhere. OA 25 °C, 7 d: Colony surface velutinous; sporulation light yellow (3A5); soluble pigment absent; exudate absent; reverse light yellow (3A4). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, size varying between strains; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 500–3000 × 11.5–20.5 µm; Vesicles globose, 36–92 µm wide; Metulae 11–26 × 3.5–6 µm, covering 100 % of head; Phialides ampulliform, 9.5–12 × 2.5–4 µm; Conidia broadly ellipsoidal, smooth to rough walled, especially on DG18, 2.5–4.5 × 2.5–4 µm (3.5 ± 0.4 × 3.1 ± 0.3, *n* = 53); Sclerotia white to yellow, 140–890 µm.

Extrolites: aspyrones, cycloechinulin, melleins, N-methylepiamauromine, ochratoxins, ochrindols, orthosporins, TR-2, xanthomegnins.

Distinguishing characters: *Aspergillus steynii* produces strongly floccose colonies that sporulate densely at colony centres. The species grow poorly on CYA at 37 °C. Morphologically it resembles *A. elegans*, also phylogenetically its closest relative. However, *A. elegans* sporulate poorly and generally grow slower on CYA at 25 °C and slower on YES and DG18.

Aspergillus subramanianii Visagie, Frisvad & Samson, **sp. nov.** MycoBank MB809203. Fig. 32.

Etymology: Latin, *subramanianii*, named after C.V. Subramanian.

Typus: **Canada**, shelled Brazil nuts (holotype CBS H-21791, culture ex-type CBS 138230 = NRRL 6161 = ATCC 18413).

ITS barcode: EF661403. (alternative markers: *BenA* = EF661339; *CaM* = EF661397). This species has identical ITS sequences with *A. bridgeri*, *A. persii*, *A. salwaensis* and *A. sclerotiorum*. *BenA* and *CaM* sequences are unique for this species.

Colony diam, 7 d (in mm): CYA 52–60; CYA 30 °C 60–67; CYA 33 °C 55–60; CYA 37 °C 35–45; MEA 44–48; YES 65–72; DG18 40–50; OA 40–45; CREA 28–30.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation light yellow (3A5–4A5); sclerotia white; soluble pigment yellow, sometimes absent; exudate clear to yellow; reverse light yellow (4A5). CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C; sclerotia white to cream. CYA 33 °C, 7 d: Colonies similar to CYA at 25 °C. CYA 37 °C, 7 d: Colonies similar to CYA at 25 °C, in some isolates no sporulation. MEA 25 °C, 7 d: Colony surface floccose to somewhat velutinous; mycelial areas white; sporulation light yellow (4A5); soluble pigment absent; exudate absent; reverse light brown to brown (5D7–6D7). YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation white to light yellow (4A4); sclerotia white to cream; soluble pigment absent; exudate clear; reverse light yellow (3A5). DG18 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation pale yellow to light yellow (4A3–5); sclerotia white to cream; soluble pigment absent; exudate absent; reverse light yellow (3A3) to yellowish white (2A2). OA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow (3A5–4A5); soluble pigment inconspicuous, reddish brown; exudate absent; reverse greyish yellow (3C3). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating, not produced on DG18; Conidiophores biseriate; Stipes hyaline to brown, rough walled, 370–1300 × 6.5–10 µm; Vesicles globose, 21.5–36 µm wide; Metulae 9–14 × 4–6.5 µm, covering 100 % of head, minor proportion only 75 %; Phialides ampulliform, 7.5–11 × 2.5–3.5 µm; Conidia globose, smooth, 2.5–3 × 2.5–3 µm (2.5 ± 0.1 × 2.5 ± 0.1, *n* = 36); Sclerotia white to cream, 200–900 µm.

Extrolites: low ochratoxin A, aspergamides, aspochracin, penicillic acid, cf. aurantiamin, petromuirin.

Distinguishing characters: *Aspergillus subramanianii* produces fast growing colonies on CYA at 37 °C (35–45 mm), which distinguish it from its phylogenetic close relatives *A. bridgeri*, *A. persii*, *A. salwaensis*, *A. sclerotiorum* and *A. fresenii*. *Aspergillus neobridgeri* also produces fast growing colonies on CYA at 37 °C (43–45 mm), but its conidiophores have spathulate vesicles compared to the globose vesicles observed in *A. subramanianii*.

Aspergillus westerdijkiae Frisvad & Samson, Stud. Mycol. 50: 30. 2004. MycoBank MB500000. Fig. 33.

Typus: **South Africa**, *Andropogon sorghum*, isolated by D.B. Scott (CBS H-13444, culture ex-type CBS 112803 = NRRL 3174 = IBT 10738 = ATCC 22947 = IBT 10738 = MUCL 39539).

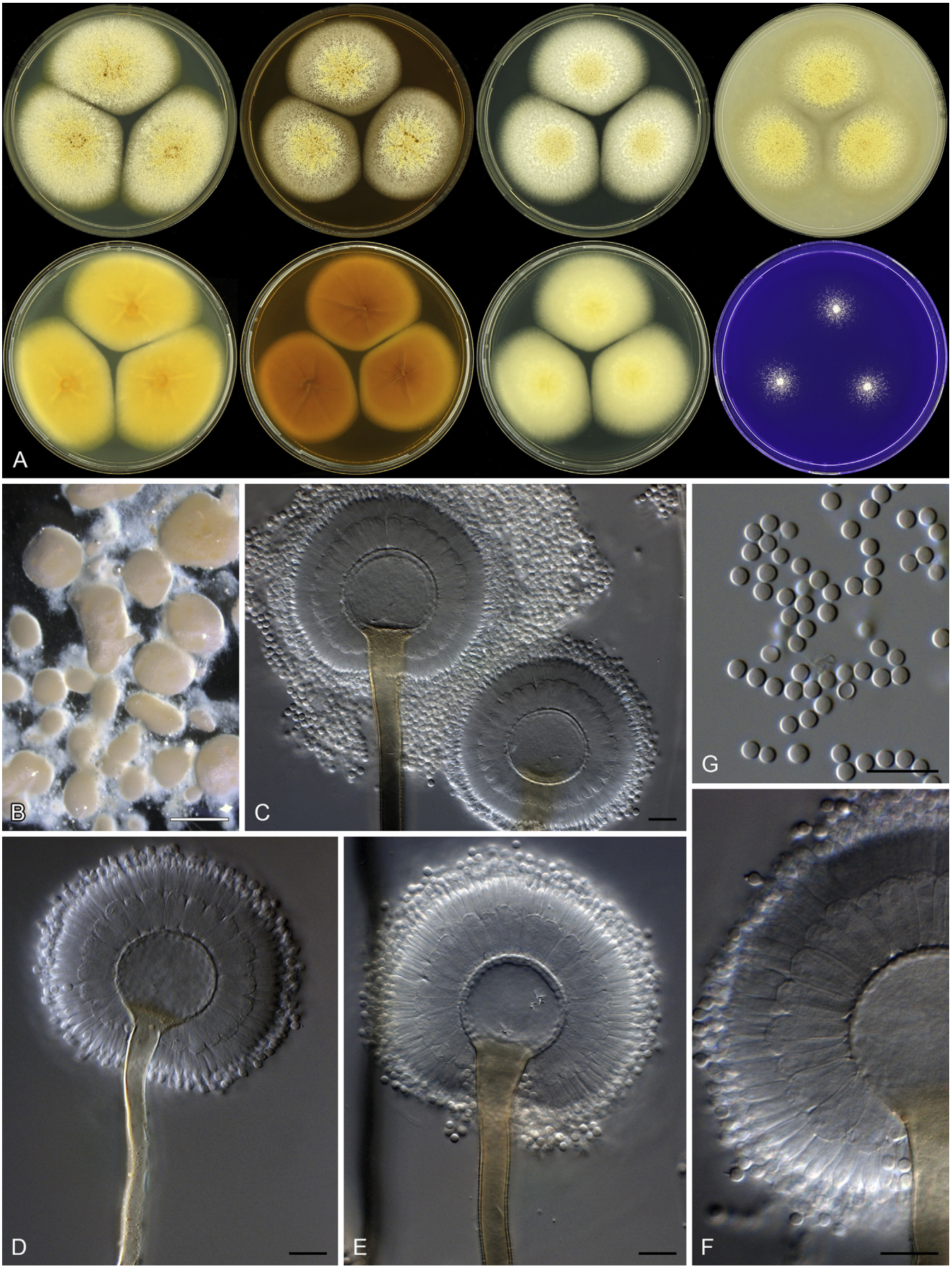

Fig. 32. *Aspergillus subramanianii*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 µm; C–G = 10 µm.

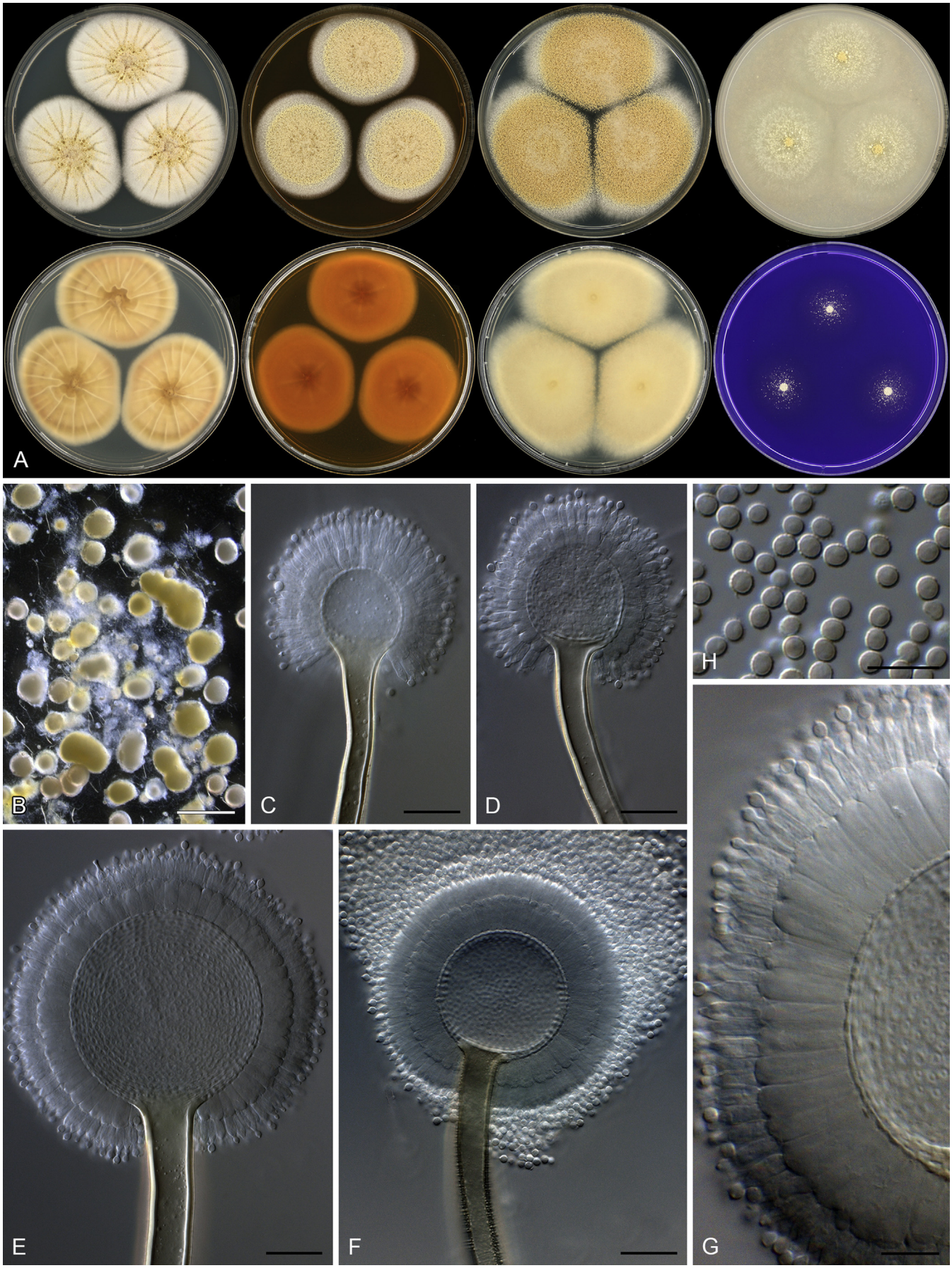

Fig. 33. *Aspergillus westerdijkiae*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–F. Conidiophores. G. Conidia. Scale bars: B = 1 mm; C–F = 20 µm; G, H = 10 µm.

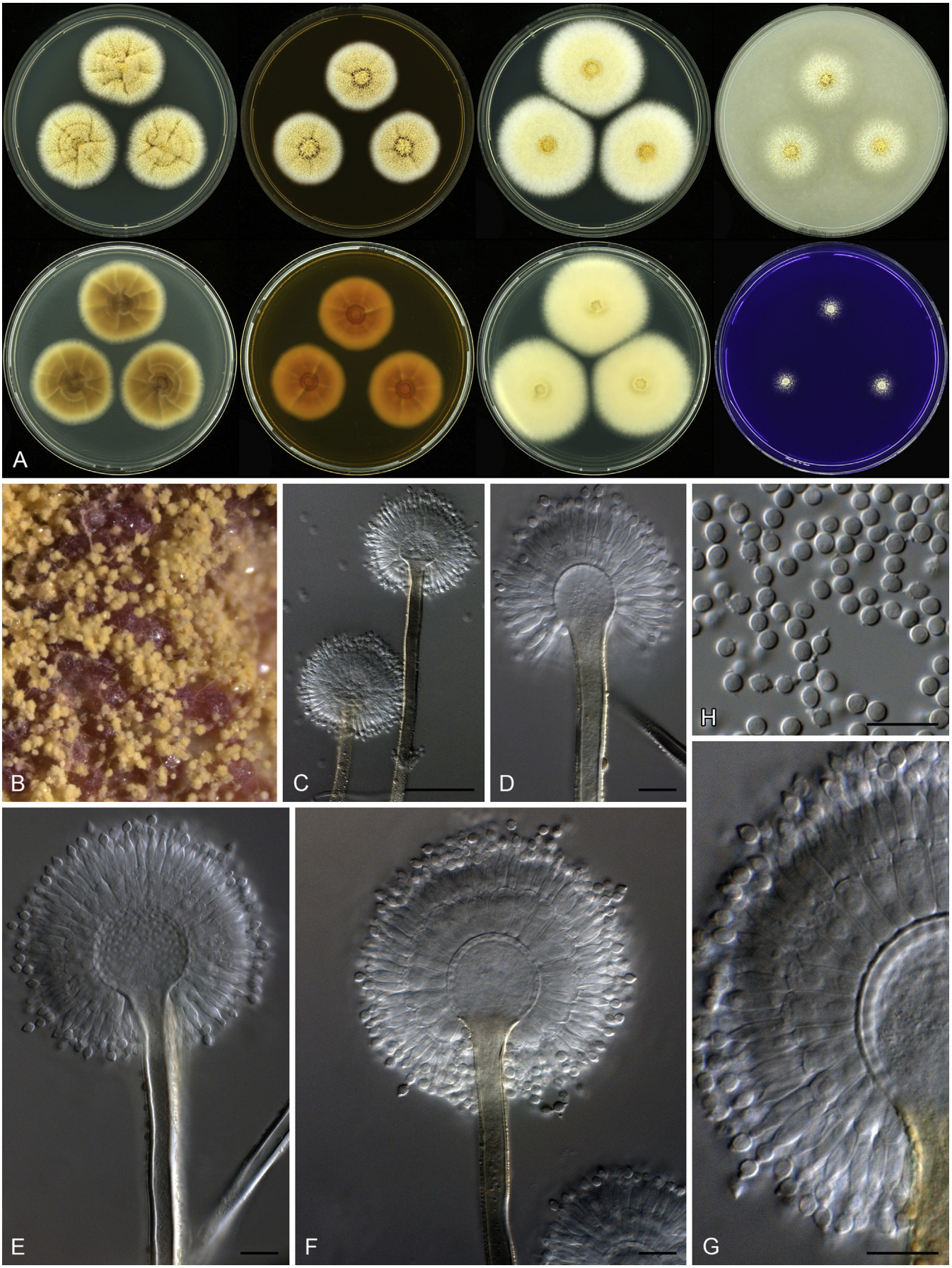

Fig. 34. *Aspergillus westlandensis*. A. Colonies: top row left to right, obverse CYA, MEA, DG18 and OA; bottom row left to right, reverse CYA, MEA, DG18 and obverse CREA. B. Sclerotia. C–G. Conidiophores. H. Conidia. Scale bars: C = 50 µm; D–H = 10 µm.

ITS barcode: EF661427. (alternative markers: *BenA* = EF661329; *CaM* = EF661360).

Colony diam, 7 d (in mm): CYA 49–55; CYA 30 °C 35–42; CYA 33 °C 12–18; CYA 37 °C no growth to 5 mm; MEA 38–44; YES 68–70; DG18 60–65; OA 40–45; CREA 15–25.

Colony characters: CYA 25 °C, 7 d: Colony surface floccose; mycelial areas white to greyish yellow; sporulation pale yellow to light yellow (3A3–5); sclerotia white to yellow; soluble pigment absent; exudate yellow, sometimes absent; reverse light brown to dark brown (5D6–7F6) areas, otherwise greyish yellow to greyish orange (4B4–5B4), some isolates olive brown (4E7–F7) areas near margin. CYA 30 °C, 7 d: Colonies similar to CYA at 25 °C; sclerotia white to yellow to pinkish; soluble pigment inconspicuous, yellow, absent in some isolates. CYA 33 °C, 7 d: Colonies crateriform, white to brownish orange (7C3); soluble pigment yellowish orange. CYA 37 °C, 7 d: Colonies, when growth observed, having a yellowish orange (4A7) reverse in some isolates. MEA 25 °C, 7 d: Colony surface velutinous with some floccose areas; mycelial areas white; sporulation light yellow to greyish yellow (4A5–B5); soluble pigment absent; exudate absent; reverse brown to dark brown (6E8–7F8) near centre, brown (6D7–8) elsewhere. YES 25 °C, 7 d: Colony surface floccose; mycelial areas white; sporulation greyish yellow (3B5–4B5); sclerotia white to pinkish; soluble pigment absent; exudate absent; reverse olive to olive brown (2F8–4F7), brown (5E7) in some isolates, yellowish (4A2) white near margin. DG18 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation greyish yellow to greyish orange (4B5–5B5); soluble pigment absent; exudate absent; reverse orange grey to greyish orange (5B2–3), yellowish white (4A2) near margin. OA 25 °C, 7 d: Colony surface floccose to velutinous, olive yellow (2D6) underneath sporulating areas; mycelial areas white; sporulation light yellow (4A5); sclerotia yellowish to pinkish in some isolates; soluble pigment absent; exudate absent; reverse greyish yellow to olive yellow (2B6–D8). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes hyaline to yellow to brown, rough walled, 260–1200 × 6.5–17.5 µm; Vesicles globose to sometimes spathulate, 22–75 µm wide; Metulae 8–21 × 4.5–7 µm, covering 100 % of head; Phialides ampulliform, 9–11 × 2.5–4 µm; Conidia globose to subglobose, finely roughened to rough, 2.5–4 × 2.5–3.5 µm (3.1 ± 0.3 × 2.9 ± 0.3, *n* = 69); Sclerotia white to yellow to pinkish, 140–715 µm.

Extrolites: aspergamides, aspyrones, circumdatins, destruxins, mellamides, melleins, neohydroxyaspergillic acids, ochratoxins, orthosporins, penicillic acid, preussin, xanthomegnins.

Distinguishing characters: *Aspergillus westerdijkiae* produces a yellowish orange soluble pigment on CYA at 33 °C and most strains do not grow at 37 °C. At 25 and 30 °C these soluble pigments are not produced. Other species producing soluble pigments at 33 °C in a shade of yellow include *A. pulvericola*, *A. sclerotiorum*, *A. fresenii*, *A. muricatus* and the degenerated strain of *A. ochraceus* (CBS 108.81). However, these species also all produce the soluble pigment at different temperatures. *Aspergillus ochraceus* can also be distinguished by its pinkish to purplish brown sclerotia compared to the generally white to yellow (somewhat pinkish at 30 °C) sclerotia. Furthermore, strains of *A. ochraceus* grows faster on CYA at 33 °C (25–35 mm) than *A. westerdijkiae* (12–18 mm) and produces an olive reverse on DG18.

Aspergillus westlandensis Visagie, Varga, Meijer & Frisvad, **sp. nov.** MycoBank MB809204. Fig. 34.

Etymology: Latin, *westlandensis*, in reference to the town of Zwartewaal, located in the Westland region of the Netherlands, where the strains were isolated.

Typus: **Netherlands**, Zwartewaal, air sample, 2012, isolated by M. Meijer (holotype CBS H-21795, culture ex-type: CBS 137321 = IBT 32139 = DTO 231-A9).

ITS barcode: KJ775434. (alternative markers: *BenA* = KJ775066; *CaM* = KJ775230). This species has unique sequences for all genes studied.

Colony diam, 7 d (in mm): CYA 34–37; CYA 30 °C 29–33; CYA 33 °C microcolonies; CYA 37 °C no growth; MEA 30–31; YES 46–50; DG18 44–47; OA 25–30; CREA 12–15.

Colony characters: CYA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); soluble pigment inconspicuous, red; exudate clear to orange droplets; reverse yellowish brown (5D6). CYA 30 °C, 7 d: Colony surface velutinous; sporulation light yellow to orange (4A4–5), sclerotia purple to reddish; soluble pigment absent; exudate reddish; reverse yellowish brown (5D6). CYA 33 °C, 7 d: Microcolonies white. CYA 37 °C, 7 d: No growth. MEA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); sclerotia purple to reddish in some isolates; soluble pigment absent; exudate clear; reverse light brown (5D7). YES 25 °C, 7 d: Colony surface velutinous; mycelial areas white to greyish yellow (4B4); sporulation light yellow to orange (4A4–5); soluble pigment absent; exudate absent; reverse olive brown (4E8–F8). DG18 25 °C, 7 d: Colony surface velutinous; mycelial areas white to yellowish white (4A2); sporulation light yellow to orange (4A4–7); soluble pigment absent; exudate absent; reverse yellowish white (4A2). OA 25 °C, 7 d: Colony surface velutinous; mycelial areas white; sporulation light yellow to orange (4A4–5); sclerotia purple to reddish; soluble pigment absent; exudate absent; reverse olive (4C5). CREA 25 °C, 7 d: Acid not produced.

Micromorphology: Conidial heads radiating; Conidiophores biseriate; Stipes brownish yellow, sometimes hyaline, rough walled, 200–1050 × 7–10 µm; Vesicles globose, 18.5–30 µm wide; Metulae 7.5–14 × 3.5–6.5 µm, covering 100 % of head; Phialides ampulliform, 8.5–11 × 2.5–3.5 µm; Conidia subglobose, smooth, 2.5–3.5 × 2.5–3 µm (2.99 ± 0.14 × 2.75 ± 0.13, *n* = 46); Sclerotia purple to reddish, 300–575 µm.

Extrolites: aspergamides, ochratoxins (trace), penicillic acids, xanthomegnins.

Distinguishing characters: The species typically produces purple to reddish sclerotia. Also, it produces only microcolonies on CYA at 33 °C, similar to *A. cretensis*. *Aspergillus cretensis*, however, sporulate poorly on most media after 7 d and produces white to yellow to orange sclerotia, compared to the dense sporulation and purple to reddish sclerotia of *A. westlandensis*. These characters also distinguish the latter from its phylogenetic close relative *A. muricatus*, which sporulates poorly and produces white to orange sclerotia.

ACKNOWLEDGEMENTS

This research was supported by grants from the Alfred P. Sloan Foundation Program on the Microbiology of the Built Environment. A research grant (Grant NPRP 6-647-1-127) from the Qatar National Research Fund (a member of Qatar Foundation) supported R. Fotedar, which resulted in the description of *A. salwaensis*. We would like to thank Dr Weiming Zhu for depositing strain PT 05-1, which is now described as *A. occultus*, into the DTO collection housed at CBS-KNAW. Furthermore we like to acknowledge Dr Uwe Braun who provided nomenclatural assistance for this manuscript.

REFERENCES

Applegate KL, Chipley JR (1976). Production of ochratoxin A by *Aspergillus ochraceus* NRRL 3174 before and after exposures to ^{60}Co irradiation. *Applied and Environmental Microbiology* **31**: 349–353.

Bassiouny A, Maher A, Bucci TJ, *et al*. (1982). Non invasive antromycosis (diagnosis and treatment). *Journal of Laryngology and Otology* **96**: 215–228.

Batista AC, Maia da Silva H (1957). Alguns *Aspergillus* contaminantes de culturas. *Anais da Sociedade de Biologia de Pernambuco* **15**: 181–237 [in Portuguese].

Blochwitz A (1935). Die Gattung Aspergillus. IV. Neue Arten. Synonyme. Varianten und Mutanten. *Annales Mycologici* **33**: 238–250.

Brasch J, Varga J, Jensen JM, *et al*. (2009). Nail infection by *Aspergillus ochraceopetaliformis*. *Medical Mycology* **47**: 658–662.

Chen KC, Yin WS, Tiu C, *et al*. (1994). 11-α-hydroxylation of progesterone using modified alginate-immobilized cells. *Enzyme and Microbial Technology* **16**: 551–555.

Christensen M, Raper KB (1970). *Aspergillus robustus*, a new species in the *Aspergillus ochraceus* group. *Mycologia* **70**: 200–205.

Christensen M, Raper KB (1982). The *Aspergillus ochraceus* group: two new species from western soils and a synoptic key. *Mycologia* **74**: 210–225.

Ciegler A (1972). Bioproduction of ochratoxin A and penicillic acid by members of the *Aspergillus ochraceus* group. *Canadian Journal of Microbiology* **18**: 631–636.

Davis ND, Searcy JW, Diener UL (1969). Production of ochratoxin A by *Aspergillus ochraceus* in a semisynthetic medium. *Applied Microbiology* **17**: 742–744.

Davolos D, Pietrangeli B (2014). A molecular and bioinformatic study on the ochratoxin A (OTA)-producing *Aspergillus affinis* (section *Circumdati*). *Mycotoxin Research* **30**: 113–122.

Durley RC, Macmillan J, Simpson TJ, *et al*. (1975). Fungal products. Part XIII. Xanthomegnin, viomellein, rubrosulphin, and viopurpurin, pigments from *Aspergillus sulphureus* and *Aspergillus melleus*. *Journal of the Chemical Society, Perkin Transactions 1* **1975**: 163–169.

Feuilhade de Chauvin M, de Bievre C (1985). Onyxis et perionyxis a *Aspergillus sclerotiorum*. *Bulletin Francaise de Mycologie Medicale* **14**: 77–79 [in French].

Finefield JM, Frisvad JC, Sherman DH, *et al*. (2011). Fungal origins of the bicyclo[2.2.2]diazaoctane ring system of prenylated indole alkaloids. *Journal of Natural Products* **75**: 812–833.

Frisvad JC, Frank JM, Houbraken J, *et al*. (2004). New ochratoxin producing species of *Aspergillus* section *Circumdati*. *Studies in Mycology* **50**: 23–43.

Frisvad JC, Samson RA (2000). *Neopetromyces* gen. nov. and an overview of teleomorphs of *Aspergillus* subg. *Circumdati*. *Studies in Mycology* **45**: 201–207.

Frisvad JC, Thrane U (1987). Standardized high performance liquid chromatography of 182 mycotoxins and other fungal metabolites based on alkylphenone retention indices and UV-VIS spectra (diode array detection). *Journal of Chromatography A* **404**: 195–214.

Frisvad JC, Thrane U (1993). Liquid column chromatography of mycotoxins. In: *Chromatography of mycotoxins. Techniques and applications. Journal of Chromatography Library 54* (Betina V, ed). Elsevier, Amsterdam, Netherlands: 253–372.

Gams W, Christensen M, Onions AH, *et al*. (1985). Infrageneric taxa of *Aspergillus*. In: *Advances in* Penicillium *and* Aspergillus *systematics* (Samson RA, Pitt JI, eds). Plenum Press, New York: 55–62.

Gil-Serna J, González-Salgado A, González-Jaén MA, *et al*. (2009a). ITS-based detection and quantification of *Aspergillus ochraceus* and *Aspergillus westerdijkiae* in grapes and green coffee beans by real-time quantitative PCR. *International Journal of Food Microbiology* **131**: 162–167.

Gil-Serna J, Vázquez C, Sardiñas N, *et al*. (2009b). Discrimination of the main ochratoxin A-producing species in *Aspergillus* section *Circumdati* by specific PCR assays. *International Journal of Food Microbiology* **136**: 83–87.

Gil-Serna J, Vázquez C, Sardiñas N, *et al*. (2011). Revision of ochratoxin a production capacity by the main species of *Aspergillus* section *Circumdati*. *Aspergillus steynii* revealed as the main risk of OTA contamination. *Food Control* **22**: 343–345.

Harima N, Inoue T, Kubota T, *et al*. (2004). A case of otomycosis caused by *Aspergillus sclerotiorum*. *Journal of Dermatology* **31**: 949–950.

Hesseltine CW, Vandegraft EE, Fennel DI, *et al*. (1972). Aspergilli as ochratoxin producers. *Mycologia* **64**: 539–550.

Jurjević Ž, Peterson SW, Horn BW (2012). *Aspergillus* section *Versicolores*: nine new species and multilocus DNA sequence based phylogeny. *IMA Fungus* **3**: 59–79.

Katoh K, Standley DM (2013). MAFFT multiple sequence alignment software version 7: improvements in performance and usability. *Molecular Biology and Evolution* **30**: 772–780.

Kornerup A, Wanscher JH (1967). *Methuen Handbook of Colour*. Methuen & Co Ltd., Copenhagen, 243 p.

Kozakiewicz Z (1989). *Aspergillus* species on stored products. *Mycological Papers* **161**: 1–188.

Klitgaard A, Iversen A, Andersen MR, *et al*. (2014). Aggressive dereplication using UHPLC-DAD-QTOF: screening extracts for up to 3000 fungal secondary metabolites. *Analytical and Bioanalytical Chemistry* **406**: 1933–1945.

Lai M, Semeniuk G, Hesseltine CW (1970). Conditions for production of ochratoxin A by *Aspergillus* species in a synthetic medium. *Applied Microbiology* **19**: 542–544.

Luisetti M, Piccioni PD, Dyne K, *et al*. (1991). Some properties of the alkaline proteinase from *Aspergillus melleus*. *International Journal of Tissue Reactions* **13**: 187–192.

Machetti M, Di Piazza S, Persi A, *et al*. (2010). Non-dermatophytic moulds causing onychomycosis in a 40 cases study. In: *Proceedings of the 9th International Mycological Congress, Edinburgh, 1–6 August 2010, P4.279*.

Matsukuma S, Ohtsuka T, Kotaki H, *et al*. (1992). A new series of natural antifungals that inhibit P450 lanosterol C-14 demethylase. I. Taxonomy, fermentation, isolation and structural elucidation. *Journal of Antibiotics* **45**: 151–159.

Morello LG, Sartori D, de Oliveira Martinez AL, *et al*. (2007). Detection and quantification of *Aspergillus westerdijkiae* in coffee beans based on selective amplification of beta-tubulin gene by using real-time PCR. *International Journal of Food Microbiology* **119**: 270–276.

Munoz MC, Gonzalez M, Alvarez E (1989). Placentitis micotica y aborto por *Aspergillus ochraceus* en una vaca. *Revista de Salud Animal* **11**: 190–195 [in Spanish].

Nehira T (1949). A taxonomic study of the genus *Aspergillus* (2): The yellow spored aspergilli in Japan. *The Society for Biotechnology, Japan* **27**: 26–32.

Noonim P, Mahakarnchanakul W, Nielsen KF, *et al*. (2008). Isolation, identification and toxigenic potential of ochratoxin A-producing *Aspergillus* species from coffee beans grown in two regions of Thailand. *International Journal of Food Microbiology* **128**: 197–202.

Novey HS, Wells ID (1978). Allergic bronchopulmonary aspergillosis caused by *Aspergillus ochraceus*. *American Journal of Clinical Pathology* **70**: 840–843.

Nylander AJJ, Ronquist F, Huelsenbeck JP, *et al*. (2004). Bayesian phylogenetic analysis of combined data. *Systematic Biology* **53**: 47–67.

Ooike M, Nozawa K, Udagawa SI, *et al*. (1997). Bisindolylbenzenoids from ascostromata of *Petromyces muricatus*. *Canadian Journal of Chemistry* **75**: 625–628.

Peterson SW (1995). Phylogenetic analysis of *Aspergillus* sections *Cremei* and *Wentii*, based on ribosomal DNA sequences. *Mycological Research* **99**: 547–554.

Peterson SW (2000). Phylogenetic relationships in *Aspergillus* based on rDNA sequence analysis. In: *Integration of modern taxonomic methods for* Penicillium *and* Aspergillus *classification* (Samson RA, Pitt JI, eds). Harwood Academic Publishers, Amsterdam: 323–355.

Peterson SW (2008). Phylogenetic analyses of *Aspergillus* species using DNA sequences from four loci. *Mycologia* **100**: 205–226.

Pitt JI, Samson RA (1993). Species names in current use in the *Trichocomaceae* (Fungi, Eurotiales). In: *Names in current use in the families* Trichocomaceae, Cladoniaceae, Pinaceae, *and* Lemnaceae (Greuter W, ed), *Regnum Vegetabile*, **vol. 128**. Koeltz Scientific Books, Königstein: 13–57.

Pitt JI, Samson RA, Frisvad JC (2000). List of accepted species and their synonyms in the family *Trichocomaceae*. In: *Integration of modern taxonomic methods for* Penicillium *and* Aspergillus *classification* (Samson RA, Pitt JI, eds). Harwood Academic Publishers, Amsterdam: 9–79.

Raper KB, Fennell DI (1965). *The genus* Aspergillus. Williams & Wilkins, Baltimore.

Ronquist F, Huelsenbeck JP (2003). MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* **19**: 1572–1574.

Samson RA (1979). A compilation of the Aspergilli described since 1965. *Studies in Mycology* **18**: 1–38.

Samson RA, Gams W (1985). Typification of the species of *Aspergillus* and associated teleomorphs. In: *Advances in* Penicillium *and* Aspergillus *systematics* (Samson RA, Pitt JI, eds). Plenum Press, New York: 31–54.

Samson RA, Houbraken J, Frisvad JC, *et al*. (2010). *Introduction to food- and airborne fungi*, 7th ed. CBS-KNAW Fungal Biodiversity Centre, Utrecht.

Schoch CL, Seifert KA, Huhndorf S, *et al*. (2012). Nuclear ribosomal internal transcribed spacer (ITS) region as a universal DNA barcode marker for Fungi. *PNAS* **109**: 6241–6246.

Smedsgaard J (1997). Micro-scale extraction procedure for standardized screening of fungal metabolite production in cultures. *Journal of Chromatography A* **760**: 264–270.

Subramanian CV (1971). *Hyphomycetes*. ICAR, New Delhi.

Sugui JA, Peterson SW, Clark LP, *et al*. (2012). *Aspergillus tanneri* sp. nov., a new pathogen that causes invasive disease refractory to antifungal therapy. *Journal of Clinical Microbiology* **50**: 3309–3317.

Tamura K, Peterson D, Peterson N, *et al*. (2011). MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution* **28**: 2731–2739.

Trenk HL, Butz ME, Chu FS (1971). Production of ochratoxins in different cereal products by *Aspergillus ochraceus*. *Applied Microbiology* **21**: 1032–1035.

Varga J, Due M, Frisvad JC, *et al*. (2007c). Taxonomic revision of *Aspergillus* section *Clavati* based on molecular, morphological and physiological data. *Studies in Mycology* **59**: 89–106.

Varga J, Frisvad JC, Samson RA (2007b). Polyphasic taxonomy of *Aspergillus* section *Candidi* based on molecular, morphological and physiological data. *Studies in Mycology* **59**: 75–88.

Varga J, Kevei E, Rinyu E, *et al*. (1996). Ochratoxin production by *Aspergillus* species. *Applied and Environmental Microbiology* **62**: 4461–4464.

Varga J, Kocsubé S, Tóth B, *et al*. (2007a). *Aspergillus brasiliensis* sp. nov., a biseriate black *Aspergillus* species with world-wide distribution. *International Journal of Systematic and Evolutionary Microbiology* **57**: 1925–1932.

Varga J, Tóth B, Kevei É, *et al*. (2000b). Analysis of genetic variability within the genus *Petromyces*. *Antonie van Leeuwenhoek* **77**: 83–89.

Varga J, Tóth B, Rigó K, *et al*. (2000a). Phylogenetic analysis of *Aspergillus* section *Circumdati* based on sequences of the internal transcribed spacer regions of the 5.8 S rRNA gene. *Fungal Genetics and Biology* **30**: 71–80.

Visagie CM, Hirooka Y, Tanney J, *et al*. (2014). *Aspergillus*, *Penicillium* and *Talaromyces* species occurring in house dust samples collected around the world. *Studies in Mycology* **78**: 63–139.

Wehmer C (1901). Die Pilzgattung *Aspergillus*. *Memoires de la Société de physique et d'histoire naturelle de Genève* **33**: 64–153.

Wei RD, Strong FM, Smalley EB (1971). Incorporation of chlorine-36 into ochratoxin A. *Applied Microbiology* **22**: 276–277.

Whyte AC, Gloer JB, Wicklow DT, *et al*. (1996). Sclerotiamide: a new member of the paraherquamide class with potent antiinsectan activity from the sclerotia of *Aspergillus sclerotiorum*. *Journal of Natural Products* **59**: 1093–1095.

Wierzbicka M, Podsiadło B, Janczarski M (1997). Invasive pulmonary aspergillosis caused by *Aspergillus ochraceus*. *Pneumonologia Alergologia Polska* **65**: 254–260 [in Polish].

Zheng J, Wang Y, Wang J, *et al*. (2013). Antimicrobial ergosteroids and pyrrole derivatives from halotolerant *Aspergillus flocculosus* PT05-1 cultured in a hypersaline medium. *Extremophiles* **17**: 963–971.

Zotti M, Corte AM (2002). *Aspergillus persii*: a new species in *Circumdati* section. *Mycotaxon* **83**: 269–278.

Zotti M, Machetti M, Perotti M, *et al*. (2010). A new species, *Aspergillus persii*, as an agent of onychomycosis. *Medical Mycology* **48**: 656–660.