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Polyphasic taxonomy of *Aspergillus* section *Fumigati* and its teleomorph *Neosartorya*

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Abstract: The taxonomy of *Aspergillus* section *Fumigati* with its teleomorph genus *Neosartorya* is revised. The species concept is based on phenotypic (morphology and extrolite profiles) and molecular (β-tubulin and calmodulin gene sequences) characters in a polyphasic approach. Four new taxa are proposed: *N. australensis N. ferenczii, N. papuaensis* and *N. warcupii*. All newly described and accepted species are illustrated. The section consists of 33 taxa: 10 strictly anamorphic *Aspergillus* species and 23 *Neosartorya* species. Four other *Neosartorya* species described previously were not available for this monograph, and consequently are relegated to the category of doubtful species.

Taxonomic novelties: *Neosartorya australensis*, *N. ferenczii*, *N. papuaensis*, *N. warcupii*.
Key words: *Aspergillus* section *Fumigati*, extrolite profiles, *Neosartorya*, phylogenetics, polyphasic taxonomy.

INTRODUCTION

Aspergillus section *Fumigati* includes species characterised by uniseriate aspergilli, columnar conidial heads in shades of green and flask shaped vesicles (Raper & Fennell 1965). Teleomorphic species belonging to the "*Aspergillus fischeri* series" of the *A. fumigatus* group (Raper & Fennell 1965) were placed in the genus *Neosartorya* (family Trichocomaceae) by Malloch & Cain (1972). Section *Fumigati* includes more than 20 *Neosartorya* species and 10 anamorphic species (Pitt *et al.* 2000; Samson 2000; Horie *et al.* 2003; Hong *et al.* 2005, 2006, 2007).

Aspergillus fumigatus Fresenius is an ubiquitous filamentous fungus in the environment, and also an important human pathogen (Raper & Fennell 1965). Several *Neosartorya* species have been described as causal agents of human diseases including invasive aspergillosis, osteomyelitis, endocarditis and mycotic keratitis (Coriglione *et al.* 1990; Summerbell *et al.* 1992; Padhye *et al.* 1994; Lonial *et al.* 1997; Jarv *et al.* 2004; Balajee *et al.* 2005, 2006). All of the *Neosartorya* species produce heat-resistant ascospores that are frequently encountered in different food products (Gomez *et al.* 1994; Samson 1989; Tournas 1994). The several mycotoxins produced by these species may cause serious health hazard (Fujimoto *et al.* 1993; Frisvad & Samson 1990; Larsen *et al.* 2007). Some species also have valuable properties for mankind; e.g. *N. fischeri* strains produce fiscalins which effectively inhibit the binding of substance P to the human neurokinin receptor (Wong *et al.* 1993), while *A. fumigatus* strains produce pyripyropenes, potent inhibitors of acyl-CoA:cholesterol acyltransferase (Tomoda *et al.* 1994), the immunosuppressant restrictocins (Müllbacher & Eichner 1984), ribotoxins (Lin *et al.* 1995) and fumagillin that has amebicidal activity (McCowen *et al.* 1951). *Neosartorya spinosa* can be used for the complete enzymatic recovery of ferulic acid from corn residues (Shin *et al.* 2006).

Here we present an overview of the species belonging to *Aspergillus* section *Fumigati* based on analysis of macro- and micromorphology, extrolite profiles and β-tubulin, calmodulin, ITS and actin gene sequences of the isolates. We also describe four new homothallic *Neosartorya* species found in soil samples in Australia and Papua New Guinea using this polyphasic approach and list synonymies.

MATERIALS AND METHODS

Source of microorganisms

The fungi examined included type strains or representatives of all species available for examination in *Aspergillus* section *Fumigati*. Some atypical isolates collected in Australia and Papua New-Guinea were also examined to clarify their taxonomic status (Table 1).

Morphology and physiology

The strains (Table 1) were grown for 7 d as 3-point inoculations on Czapek agar, Czapek yeast autolysate agar (CYA), oat meal agar (OA) and malt extract agar (MEA) plates at 25 °C, and on CYA at 37 °C. For *Neosartorya* species Hay infusion agar and SNA agar have also been used for inducing the anamorphs (medium compositions in Samson *et al*. 2004). In some species e.g. *N. tatenoi* the anamorph could only be produced when growing the cultures at 30 or 37 °C on MEA + 40 % sucrose.

Table 1. *Aspergillus* section *Fumigati* isolates used in this study.

Species	Isolate No.*	Source
A. brevipes	CBS 118.53 T	Soil, Australia
A. duricaulis	CBS 481.65T	Soil, Buenos Aires, Argentina
A. fumigatiaffinis	IBT12703T	Soil, U.S.A.
A. fumigatus	CBS 133.61T = NRRL 163	Chicken lung, U.S.A.
A. fumisynnematus	IFM 42277T	Soil, Venezuela
A. lentulus	CBS 117887T = NRRL 35552 = KACC 41940	Man, U.S.A.
A. novofumigatus	IBT 16806T	Soil, Ecuador
A. unilateralis	CBS 126.56T	Rhizosphere, Australia
A. viridinutans	CBS 127.56T	Rabbit dung, Australia
A. turcosus	KACC 42090 = IBT 27920	Air conditioner, Inchen,Korea
	KACC 42091T = IBT 27921	Air conditioner, Seoul, Korea
	KACC 41955 = CBS 117265= IBT 3016	Car air conditioner, Seoul, Korea
N. assulata	KACC 41691T	Tomato soil, Buyeo, Korea
N. aurata	CBS 466.65T	Jungle soil, Brunei
N. aureola	CBS 105.55T	Soil, Tafo, Ghana
N. australensis sp. nov	CBS 112.55T = NRRL 2392 = IBT 3021	Garden soil, Adelaide, Australia
N. coreana	KACC 41659T = NRRL 35590 = CBS 121594	Tomato soil, Buyeo, Korea
N. denticulata	CBS 652.73T = KACC 41183	Soil under *Elaeis guineensis*, Suriname
	CBS 290.74 = KACC 41175	*Acer pseudoplatanus*, Netherlands
N. fennelliae	CBS 598.74T	Eye ball of *Oryctolagus cuniculus*, U.S.A.
	CBS 599.74	Eye ball of *Oryctolagus cuniculus*, U.S.A.
N. ferenczii **sp. nov.**	CBS 121594T = IBT 27813 = NRRL 4179	Soil, Australia
N. fischeri	CBS 544.65T = NRRL 181	Canned apples
N. galapagensis	CBS 117522T = IBT 16756 = KACC 41935	Soil, Ecuador
	CBS 117521 = IBT 16763 = KACC 41936	Soil, Ecuador
N. glabra	CBS 111.55T	Rubber scrab from old tire, Iowa, U.S.A.
N. hiratsukae	CBS 294.93T	Aloe juice, Tokyo, Japan
N. laciniosa	KACC 41657T = NRRL 35589 = CBS 117721	Tomato soil, Buyeo, Korea
N. multiplicata	CBS 646.95T = IBT 17517	Soil, Mouli, Taiwan
N. nishimurae	IFM 54133 = IBT 29024	Forest soil, Kenya
N. nishimurae	CBS 116047	Cardboard, Netherlands
N. papuensis **sp. nov.**	CBS 841.96T = IBT 27801	Bark of *Podocarpus* sp. (Podocarpaceae), bark, Myola, Owen Stanley Range, Northern Province, Papua New Guinea
N. pseudofischeri	NRRL 20748T = CBS 208.92	Human vertebrate, U.S.A.
N. quadricincta	CBS 135.52T = NRRL 2154	Cardboard, York, U.K.
	CBS 107078	Soil, Korea
	CBS 100942	Fruit juice, Netherlands
	CBS 253.94	Canned oolong tea beverage, Japan (type strain of *N. primulina*)
N. spathulata	CBS 408.89T	Soil under *Alocasia macrorrhiza*, Taiwan
N. spinosa	CBS 483.65T	Soil, Nicaragua
N. stramenia	CBS 498.65T	Soil from maple-ash-elm forest, Wisconsin, U.S.A.
N. tatenoi	CBS 407.93T	Soil of sugarcane, Timbauba, Brazil
	CBS 101754	Fruit, Yunnan, China (type strain of *N. delicata*)
N. udagawae	CBS 114217T	Soil, Brazil
	CBS 114218	Soil, Brazil
N. warcupii **sp. nov.**	NRRL 35723 T	Arid soil, Finder"s Range, Australia

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Analysis for extrolites

Extrolites were analysed using the HPLC-diode array detection method of Frisvad & Thrane (1987, 1993) as modified by Smedsgaard (1997). Extrolites were analyzed from cultures grown on CYA, OA and YES agar using three agar plugs (Smedsgaard 1997).

Isolation and analysis of nucleic acids

Isolates used for the molecular studies were grown on 2 mL of malt peptone broth [10 % (v/v) malt extract (Brix 10) and 0.1 % (w/v) bacto peptone (Difco)], in 15 mL tubes. The cultures were incubated at 25 °C for 7 d. DNA was extracted from the cells using the Masterpure™ yeast DNA purification kit (Epicentre Biotechnol.) following the instructions of the manufacturer. Fragments containing the ITS region were amplified using primers ITS1 and ITS4 as described (White *et al.* 1990). Amplification of partial β-tubulin gene was performed using the primers Bt2a and Bt2b and methods of Glass & Donaldson (1995). Amplifications of the partial calmodulin and actin genes were as described (Hong *et al.* 2005, 2007). Sequencing reactions were performed with the Big Dye Terminator Cycle Sequencing Ready Reaction Kit and carried out for both strands. All the sequencing reactions were purified by gel filtration through Sephadex G-50 (Amersham Pharmacia Biotech, Piscataway, NJ) equilibrated in double-distilled water and analyzed on the ABI PRISM 310 Genetic Analyzer (Applied Biosystems). The complementary sequences were corrected with the MT Navigator software (Applied Biosystems). Unique ITS, β-tubulin, actin and calmodulin sequences were deposited in GenBank (http://www.ncbi.nlm.nih.gov) with accession numbers DQ534140, DQ534141 and EU20279–EU220287.

Data analysis

Sequence alignments were performed using CLUSTAL-X (Thompson *et al.* 1997) and improved manually. The neighbour-joining (NJ) method was used for the phylogenetic analysis. For NJ analysis, the data were first analysed using the Tamura–Nei distance calculation with gamma-distributed substitution rates (Tamura & Nei 1993), which were then used to construct the NJ tree with MEGA v. 3.1 (Kumar *et al.* 2004). A bootstrap analysis was performed with 1 000 replications to determine the support for each clade,.

PAUP v. 4.0 b10 software was used for parsimony analysis (Swofford 2002). Alignment gaps were treated as a fifth character state and all characters were unordered and of equal weight. Maximum parsimony analysis was performed for all data sets using the heuristic search option with random addition order (100 reps) and tree bisection-reconnection (TBR) branch-swapping algorithm. Branches of zero length were collapsed and all multiple, equally parsimonious trees were saved. The robustness of the trees obtained was evaluated by 1 000 bootstrap replications (Hillis & Bull 1993). Sequences from an *A. clavatus* isolate were used as outgroups in these experiments.

RESULTS AND DISCUSSION

Phylogenetic analysis

We examined the phylogenetic relatedness of species belonging to *Aspergillus* section *Fumigati* using sequence analysis of partial β-tubulin, calmodulin and actin genes including sequences of all known species. ITS sequences were determined from the new species and the species most closely related to them in the β-tubulin tree. The partial β-tubulin gene alignment included 453 characters. Among the polymorphic sites, 102 were found to be phylogenetically informative. The Neighbour-joining tree based on partial β-tubulin genes sequences is shown in Fig. 1. The topology of the tree is the same as one of the 419 maximum parsimony trees constructed by the PAUP programME (length: 465 steps, consistency index: 0.6710, retention index: 0.6467). The calmodulin data set included 549 characters with 85 parsimony informative characters. The Neighbour-joining tree shown in Fig. 2 has the same topology as one of the 9 maximum parsimony trees (tree length: 323, consistency index: 0.7585, retention index: 0.6422). The actin data set included 390 characters with 104 parsimony informative characters. The Neighbour joining tree shown in Fig. 3 has the same topology as one of the 312 maximum parsimony trees (tree length: 397, consistency index: 0.6675, retention index: 0.7130). The ITS data set included 501 characters with 26 parsimony informative characters. The Neighbour joining tree shown in Fig. 4 has the same topology as one of the 57 maximum parsimony trees (tree length: 77, consistency index: 0.7532, retention index: 0.7765).

The four *Neosartorya* isolates representing new species were found to be different from all known species of *Aspergillus* section *Fumigati* based on either their β-tubulin, calmodulin or actin gene sequences. However, one of them (NRRL 4179) had identical ITS sequences with *N. denticulata* (Fig. 4). This isolate was found to be closely related to a clade including *N. fennelliae* and *N. denticulata* on all other trees.

Possible synonymies of some species described previously have also been examined during this study. Based on multilocus sequence analyses Hong *et al.* (2007) discussed the synonymy of *N. botucatensis, N. paulistensis* and *N. takaki* with *N. spinosa* (Raper & Fennell) Kozak. (1972). *N. spinosa* and the synonyms have roughly circular arrangements of projections on the ascospore convex walls. *N. spinosa* produces echinulate ascospores with spines ranging from < 0.5 µm up to 5(–7) µm long with verruculose and small triangular projections or sometimes with circularly arranged projections.

N. otanii Takada, Y. Horie & Abliz (2001) was described on the basis of its rapid growth on Czapek and malt extract agars, lenticular ascospores with two widely separated equatorial crests, tuberculate or lobate-reticulate convex surface, and globose to broadly ellipsoidal conidia with a microtuberculate wall. The morphology of *N. otanii* resembles *N. fennelliae*, although Takada *et al.* (2001) reported small differences of the ascospore ornamentation, which was not confirmed in our SEM studies. The β-tubulin gene sequences of *N. otanii* (GenBank accession numbers AB201363 and AB201362) were identical with *N. fennelliae* (KACC 42228) (Fig. 5A). These *N. fennelliae* isolates produced ascospores after mating with the *N. fennelliae* type strains (data not shown). *N. otanii* is probably synonymous with *N. fennelliae,* but mating experiments with *N. fennelliae* and *N. otanii* are needed for its confirmation.

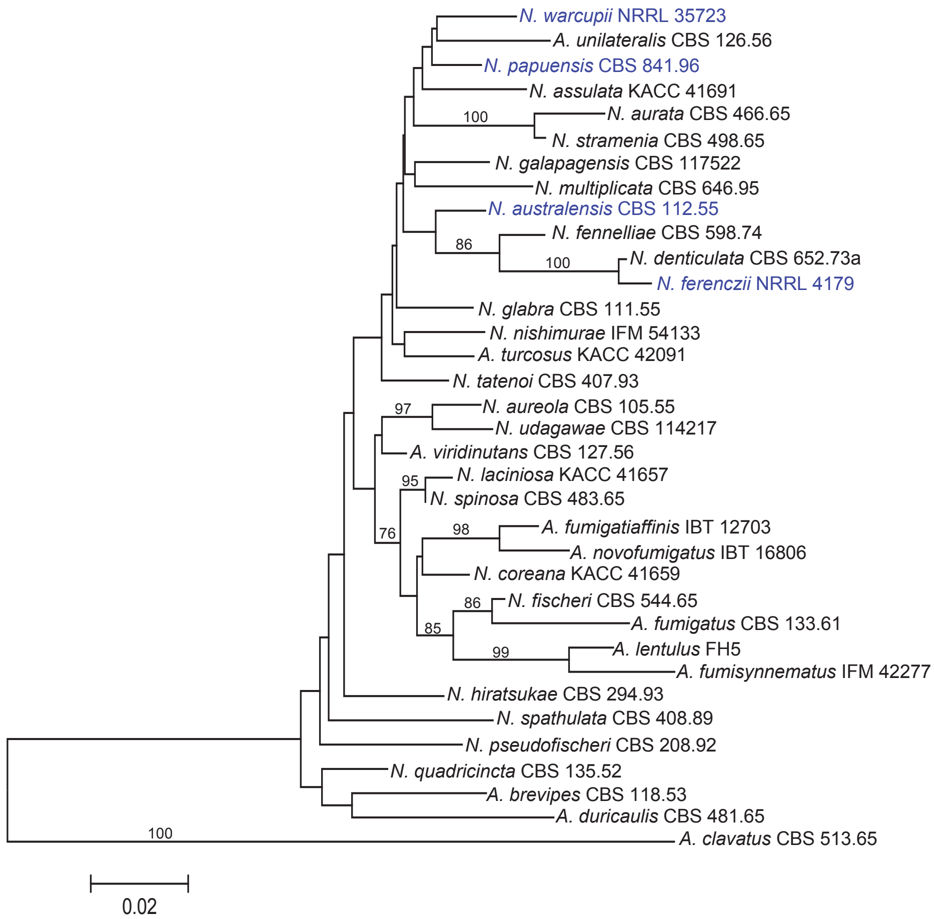

Fig. 1. Neighbour-joining tree based on β-tubulin sequence data of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

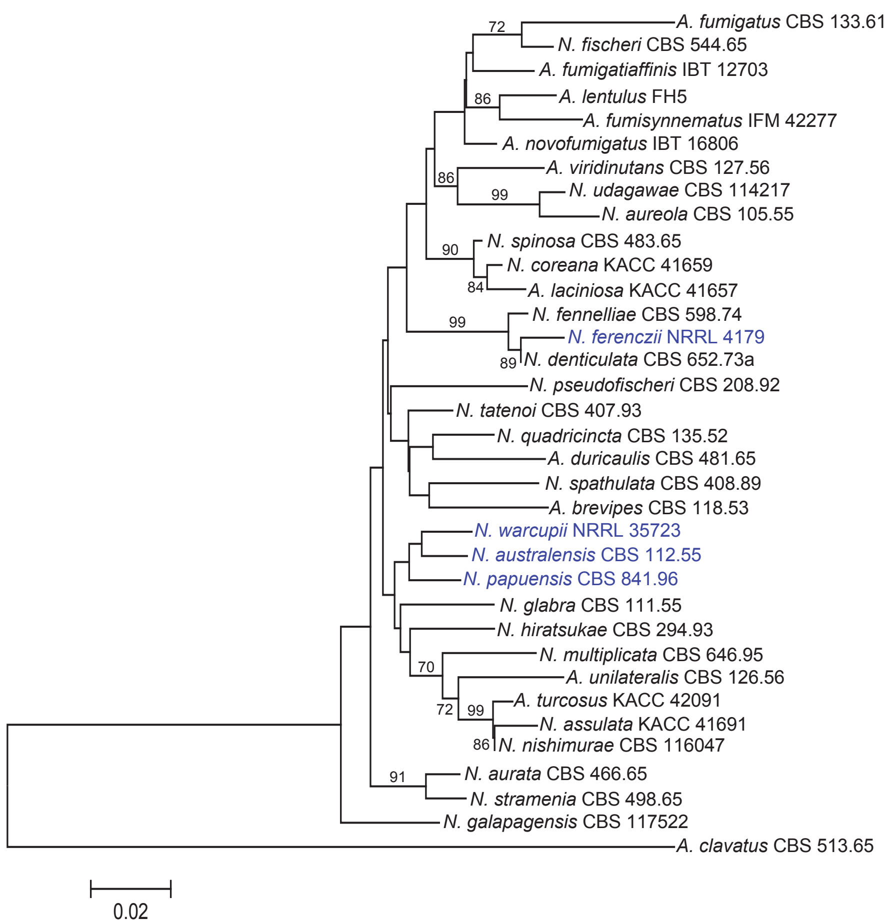

Fig. 2. Neighbour-joining tree based on calmodulin sequence data of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

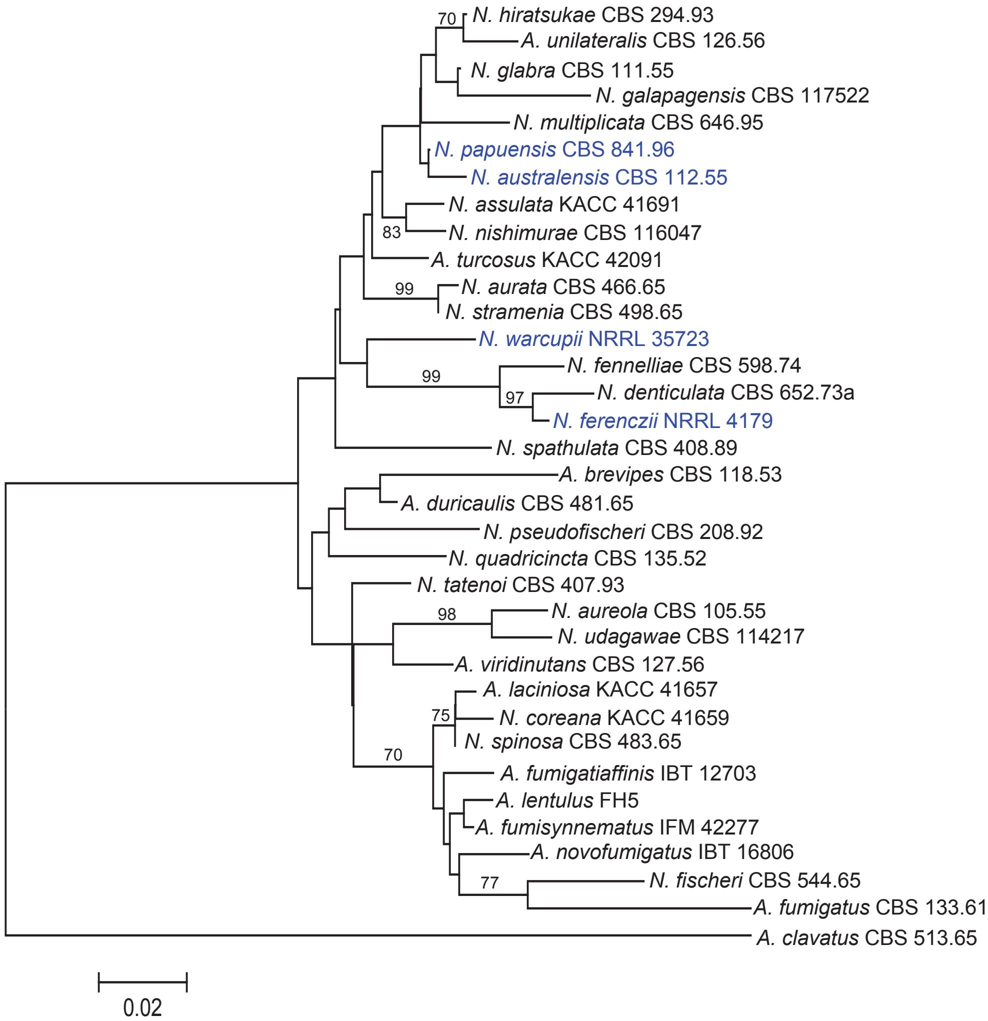

Fig. 3. Neighbour-joining tree based on actin sequence data of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

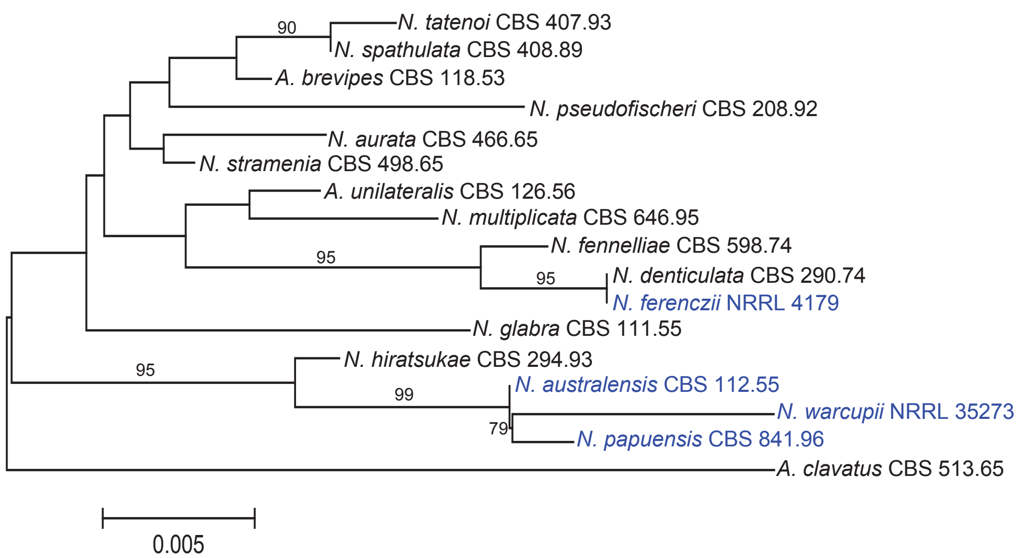

Fig. 4. Neighbour-joining tree based on ITS sequence data of selected species of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

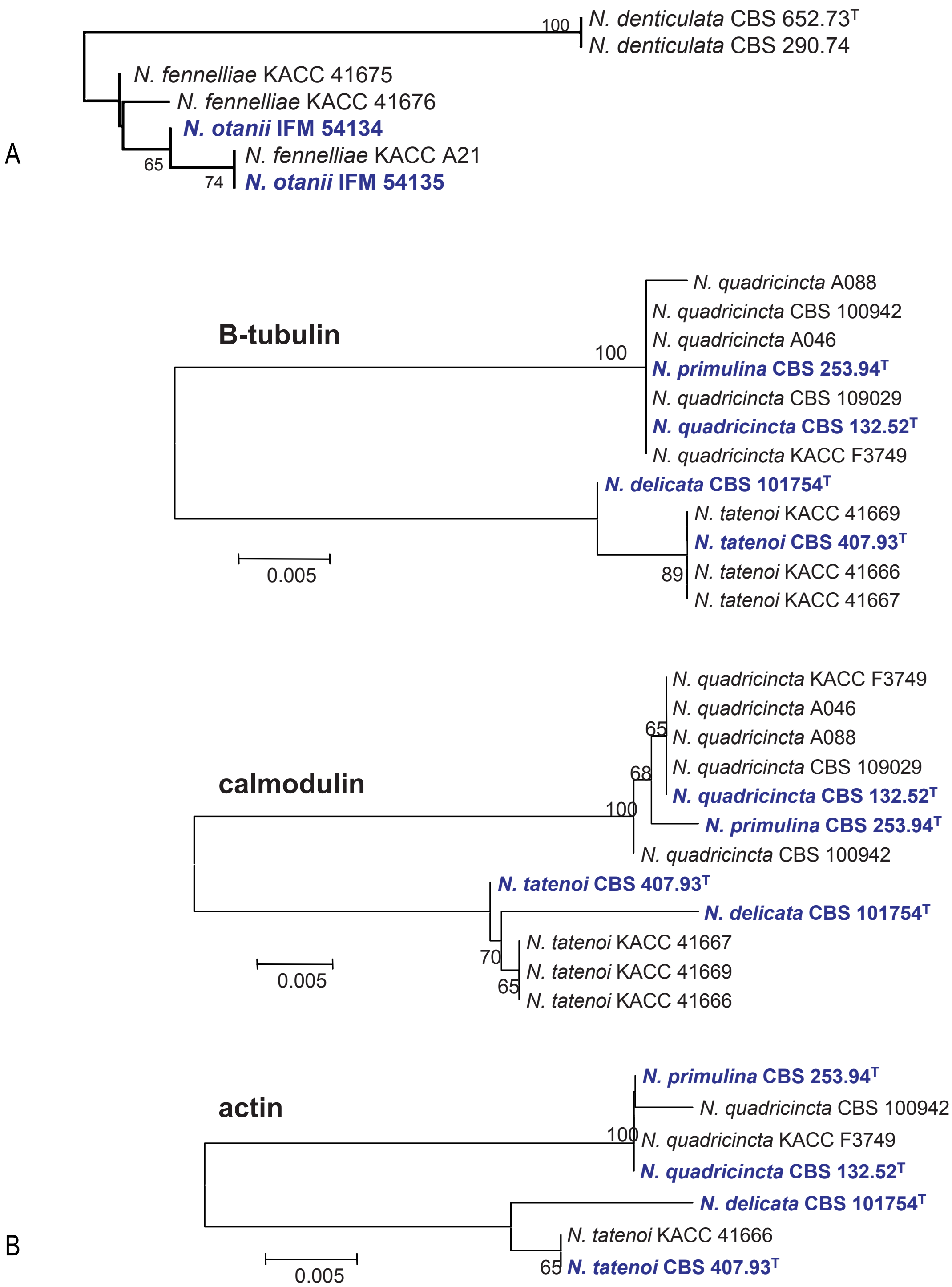

Fig. 5 A. Neighbour-joining tree based on β–tubulin sequences showing the relationship of *N. otanii* and *N. fennelliae*. **B.** Neighbour-joining trees based on β-tubulin, calmodulin and actin sequence data of *Neosartorya* spp. showing the relationship of *N. primulina, N. quadricincta, N. tatenoi* and *N. delicata*.

These experiments could not be carried out because the ex type cultures of *N. otanii* were not available.

Neosartorya primulina Udagawa, Toyaz. & Tsub. (1993) was characterised by its restricted growth on Czapek agar, chalky-buff ascomata, and lenticular ascospores with a very irregular ornamentation composed of several narrow crests and verrucose hemispheres. The ascospore ornamentation and anamorph morphology resembles those of *N. quadricincta.* Furthermore, the ex type culture (CBS 253.94) of *N. primulina* showed nearly identical sequences with strains of *N. quadricincta* for β-tubulin, calmodulin and actin genes (Fig. 5B). *N. primulina* is reduced to synonymy with *N. quadricincta*.

Neosartorya delicata H.Z. Kong (1997) was described based on its ellipsoid or nearly clavate vesicles, and ascospores with conspicuous spines, joining one spine to another by fairly prominent ridges and reticulate ornamentation, the ridges spreading to the equatorial crests. This species has identical ascospore morphology with *N. tatenoi* (Fig. 36), and both taxa were clustered into a clade in three gene trees (99.6 % in β-tubulin, 98.5 % in calmodulin and 97.3 % in actin gene sequences) (Fig. 5B). Therefore, we consider *N. delicata* as a synonym of *N. tatenoi*.

Neosartorya nishimurae (Takada *et al.* 2001), *N. indohii, N. tsurutae* (Horie *et al.* 2003), *N. takakii* (Horie *et al.* 2001) and *N. sublevispora* (Someya *et al.* 1999) ex-type cultures were not available for this monograph of *Aspergillus* section *Fumigati*, and because we could not study them, they are listed as doubtful species.

Table 2. Extrolites produced by species assigned to *Aspergillus* section *Fumigati*.

Species	Extrolites produced
Aspergillus brevipes	roquefortine C, meleagrin-like
Aspergillus duricaulis	pseurotin A, fumagillin, asperpentyn, duricaulic acid and asperdurin, phthalides, chromanols, cyclopaldic acid, 3-O-methylcyclopolic acid
Aspergillus fumigatiaffinis	auranthine, cycloechinuline, fumigaclavines, helvolic acid, neosartorin, palitantin, pyripyropenes A, E, O & S, tryptoquivaline, tryptoquivalone
Aspergillus fumigatus	fumagillin, fumitoxins, fumigaclavines A &C, fumitremorgins, gliotoxin, trypacidin, pseurotins, helvolic acid, pyripyropens, methyl-sulochrin, verruculogen, fumiquinazolines
Aspergillus fumisynnematus	neosartorin, pyripyropens, fumimycin
Aspergillus lentulus	cyclopiazonic acid, pyripyropenes A, E & O, terrein, auranthine, neosartorin
Aspergillus novofumigatus	aszonalenin, cycloechinuline, fiscalins, helvolic acid, neosartorin, palitantin, terrein, territrem B
Aspergillus turcosus	kotanins and several unique but not yet elucidated secondary metabolites
Aspergillus unilateralis	mycophenolic acid, other unique secondary metabolites
Aspergillus viridinutans	viriditoxin, 13-O-methylviriditin, phomaligin A, variotin, viriditin, wasabidienone B0, B1, viriditin, 4-acetyl-6,8-dihydroxy-5-methyl-2-benzopyran-1-1 A
Neosartorya assulata	indole alkaloids and apolar metabolites
Neosartorya aurata	helvolic acid, yellow unidentified compounds
Neosartorya aureola	fumagillin, tryptoquivaline, tryptoquivalone, pseurotin A and viriditoxin (FRR 2269 also produces helvolic acid)
Neosartorya australensis	wortmannin-like, aszonalenin-like
Neosartorya coreana	aszonalenins
Neosartorya denticulata	gliotoxin, viriditoxin
Neosartorya fennelliae	asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin
Neosartorya ferenczii	asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, gliotoxin-like, fumigatins, aszonalenin-like
Neosartorya fischeri	terrein, fumitremorgins A & C, tryptoquivaline A, trypacidin, TR-2, verruculogen, sarcin, aszonalenins, fischerin, neosartorin, fiscalins, helvolic acid
Neosartorya galapagensis	gregatins
Neosartorya glabra	asperpentyn, avenaciolide, wortmannin-like compound
Neosartorya hiratsukae	avenaciolide
Neosartorya laciniosa	aszonalenins, tryptoquivaline, tryptoquivalone
Neosartorya multiplicata	helvolic acid
Neosartorya papuensis	wortmannin-like
Neosartorya pseudofischeri	asperfuran, cytochalasin-like compound, fiscalin-like compound, pyripyropens, gliotoxin
Neosartorya quadricincta	quinolactacin, aszonalenins
Neosartorya spinosa	aszonalenins, 2-pyrovoylaminobenzamide, pseurotin
Neosartorya spathulata	xanthocillins, aszonalenins
Neosartorya stramenia	quinolactacin, avenaciolide
Neosartorya tatenoi	aszonalenins
Neosartorya udagawae	fumigatin, fumagillin, tryptoquivaline, tryptoquivalone
Neosartorya warcupii	wortmannin-like, aszonalenin-like, chromanols-like, tryptoquivaline-like and tryptoquivalone-like

Morphology and extrolite production

The atypical *N. glabra* isolate NRRL 4179 (Raper & Fennell 1965) produced asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, and fumigatins, extrolites common in *N. fennelliae*, but none of the extrolites produced by *N. glabra*. However, in contrast with the heterothallic *N. fennelliae*, this isolate is homothallic. It is closely related to *N. denticulata* based on phylogenetic analysis of sequence data, although their ascospore ornamentations are strikingly different (Figs. 21, 23). Ascospore ornamentation of NRRL 4179 is similar to that of the heterothallic *N. fennelliae* (Fig. 22) with equatorial crests much narrower, while *N. denticulata* has denticulate ascospores without equatorial crests. Isolate NRRL 4179 exhibited 72 % nuclear DNA relatedness to *N. fennelliae* and only 60 % relatedness to *N. glabra* isolates (Peterson 1992). This isolate also yielded different mtDNA and *Sma*I-digested repetitive DNA patterns from those of all the other *Neosartorya* strains examined (Rinyu *et al.* 2000). Hybridisation experiments were also carried out with *Neurospora crassa* mating type genes (the A idiomorph with about 6 kb flanking sequences, or the a idiomorph flanked by about 2 kb genomic DNA on either side) to the *Eco*RI digested DNA of several teleomorphic and asexual *Aspergillus* strains. Hybridisation to a 1.9 kb band was observed for both mating-type strains of *N. fennelliae* and isolate NRRL 4179 (Rinyu *et al.* 2000). Based on these observations, isolate NRRL 4179 seems to be closely related to *N. fennelliae* strains. These results are in agreement with those found using carbon source utilisation tests and isoenzyme analysis of these strains (Varga *et al.* 1997).

Strain NRRL 35723 was isolated from soil in Australia, and produced compounds structurally related to wortmannin, aszonalenin, chromanols, tryptoquivalins and tryptoquivalons. This isolate was markedly different from all other known *Neosartorya* species in secreting a bluish pigment after 7 d incubation on MEA and CYA plates. The microtuberculate ascospore ornamentation of this isolate is similar to those of *N. laciniosa, N. glabra* and *N. galapagensis* (Hong *et al.* 2007). However, it grew more slowly on CYA than these species, and phylogenetic data also indicate that this isolate represents a new species.

CBS 112.55 was isolated from garden soil in Adelaide, Australia, and produced compounds similar to wortmannin and aszonalenin and some unique metabolites, while CBS 841.96 was isolated from *Podocarpus* bark in Papua New Guinea, and produced a compound related to wortmannins and some unique compounds the structures of which have not yet been elucidated (Table 2). The ascospore ornamentations of these isolates were microtuberculate, similarly to those of *N. glabra* and *N. galapagensis*. However, both isolates produced cream-coloured colonies on CYA in contrast with *N. glabra* which produces greyish green colonies. In phylogenetic analysis they were unrelated to any other *Neosartorya* species, justifying their treatment as new species. We propose four new homothallic and monotypic *Neosartorya* species; *N. ferenczii* (NRRL 4179), *N. warcupii* (NRRL 35723), *N. australensis* (CBS 112.55) and *N. papuensis* (CBS 841.96).

Identification

Traditionally the identification of members of section *Fumigati* were done using the colony patterns and the morphology of the conidiogenous structures, conidia, ascomata and ascsopores. Ascospore ornamentation has been studied by Scanning electron microscopy, but our studies have shown that different species have similar ascospore shape and surface structure. Several species such *A. fumigatus*, *A. novofumigatus, fumigatiaffinis, A. fumisynnematus* and *A. lentulus* show strong morphological resemblance and in the lightmicroscope these species can be difficult to be separated. The anamorphs of *Neosartorya udagawae* and *N. fennelliae* also show a similar morphology. Therefore we recommend that for a correct species identification, sequence analysis should be carried out. Our experience with sequencing the calmodin and β-tubulin gen revealed good species delimitation and recognition. All sequences of the ex type cultures of section *Fumigati* are available from specialised databases and also from GenBank.

List of accepted species belonging to *Aspergillus* section *Fumigati*

The list of known species of *Neosartorya* and anamorphic species from the section *Fumigati* (Horie *et al*. 2003; Hong *et al*. 2005, 2006, 2007) is still expanding. With the species proposed here, there are now 23 *Neosartorya* species (including four new taxa) and 10 *Aspergillus* species in this group, 33 species in total and they are illustrated below.

Strict anamorphic species:

Aspergillus brevipes Smith
Aspergillus duricaulis Raper & Fennell
Aspergillus fumigatiaffinis Hong, Frisvad & Samson
Aspergillus fumigatus Fresenius
= *A. anomalus* Pidoplichko & Kirilenko
= *A. fumigatus* var. *acolumnaris* Rai *et al*.
= *A. fumigatus* var. *ellipticus* Raper & Fennell
= *A. fumigatus* mut. *helvola* Rai *et al*.
= *A. phialiseptus* Kwon-Chung
= *A. neoellipticus* Kozakiewicz
= *Aspergillus arvii* Aho, Horie, Nishimura & Miyaji
Aspergillus fumisynnematus Horie, Miyaji, Nishimura, Taguchi & Udagawa
Aspergillus lentulus Balajee & Marr

Aspergillus novofumigatus Hong, Frisvad & Samson
Aspergillus turcosus Hong, Frisvad & Samson
Aspergillus unilateralis Thrower
≡ *A. brevipes* var. *unilateralis* (Thrower) Kozakiewicz
Aspergillus viridinutans Ducker & Thrower
= *A. fumigatus* var. *sclerotiorum* Rai, Agarwal & Tewari

Teleomorph species:

Neosartorya assulata Hong, Frisvad & Samson [anamorph: *A. assulatus* Hong, Frisvad & Samson]
Neosartorya aurata (Warcup) Malloch & Cain [anamorph: *A. igneus* Kozakiewicz]
Neosartorya aureola (Fennell & Raper) Malloch & Cain [anamorph: *A. aureoluteus* Samson & Gams]
Neosartorya australensis Samson, Hong & Varga, **sp. nov.**
Neosartorya coreana Hong, Frisvad & Samson [anamorph: *A. coreanus* Hong, Frisvad & Samson]
Neosartorya denticulata Samson, Hong & Frisvad [anamorph: *A. denticulatus* Samson, Hong & Frisvad]
Neosartorya fennelliae Kwon-Chung & Kim [anamorph: *A. fennelliae* Kwon-Chung & Kim]
= *Neosartorya otanii* Takada, Horie & Abliz [anamorph: *A. otanii* Takada, Horie & Abliz]
Neosartorya ferenczii Varga & Samson, spec. nov.
Neosartorya fischeri (Wehmer) Malloch & Cain [anamorph: *A. fischeranus* Kozakiewicz]
Neosartorya galapagensis Frisvad, Hong & Samson [anamorph: *A. galapagensis* Frisvad, Hong & Samson]
Neosartorya glabra (Fennell & Raper) Kozakiewicz [anamorph: *A. neoglaber* Kozakiewicz]
Neosartorya hiratsukae Udagawa, Tsubouchi & Horie [anamorph: *A. hiratsukae* Udagawa, Tsubouchi & Horie]
Neosartorya laciniosa Hong, Frisvad & Samson [anamorph: *A. laciniosus* Hong, Frisvad & Samson]
Neosartorya multiplicata Yaguchi, Someya & Udagawa [anamorph: *A. muliplicatus* Yaguchi, Someya & Udagawa]
Neosartorya papuensis Samson, Hong & Varga, **sp. nov.**
Neosartorya pseudofischeri Peterson [anamorph: *A. thermomutatus* (Paden) Peterson]
Neosartorya quadricincta (Yuill) Malloch & Cain [anamorph: *A. quadricingens* Kozakiewicz]
= *Neosartorya primulina* Udagawa, Toyazaki & Tsubouchi [anamorph: *A. primulinus* Udagawa, Toyazaki & Tsubouchi]
Neosartorya spinosa (Raper & Fennell) Kozakiewicz [anamorph: *A. spinosus* Kozakiewicz]
≡ *Aspergillus fischeri* var. *spinosus* Raper & Fennell 1965 (basionym)
= *Sartorya fumigata* var. *verrucosa* Udagawa & Kawasaki
= *Neosartorya botucatensis* Horie, Miyaji & Nishimura [anamorph: *A. botucatensis* Horie, Miyaji & Nishimura]
= *Neosartorya paulistensis* Horie, Miyaji & Nishimura [anamorph: *A. paulistensis* Horie, Miyaji & Nishimura]
? = *Neosartorya takakii* Horie, Abliz & Fukushima [anamorph: *A. takakii* Horie, Abliz & Fukushima]
Neosartorya spathulata Takada & Udagawa [anamorph: *A. spathulatus* Takada & Udagawa]
Neosartorya stramenia (Novak & Raper) Malloch & Cain [anamorph: *A. paleaceus* Samson & Gams]
Neosartorya tatenoi Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi [anamorph: *A. tatenoi* Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi]
= *Neosartorya delicata* Kong [anamorph: *A. delicatus* Kong]
Neosartorya udagawae Horie, Miyaji & Nishimura [anamorph: *A. udagawae* Horie, Miyaji & Nishimura]
Neosartorya warcupii Peterson, Varga & Samson, **sp. nov.**

Doubtful species:

Neosartorya sublevispora Someya, Yaguchi & Udagawa [anamorph: *A. sublevisporus* Someya, Yaguchi & Udagawa]
Neosartorya indohii Horie [anamorph: *A. indohii* Horie]
Neosartorya tsurutae Horie [anamorph: *A. tsurutae* Horie]
Neosartorya nishimurae Takada, Horie & Abliz [anamorph: *A. nishimurae* Takada, Horie & Abliz]

Aspergillus brevipes Smith, Trans. Br. mycol. Soc. 35: 241. 1952. Fig. 6.

Type: CBS 467.91, from soil, New South Wales, Australia

Other no. of the type: ATCC 16899; CBS 118.53; IFO 5821; IMI 16034; IMI 51494; NRRL 2439; WB 4772 = IBT 22571; WB 4078 = IBT 22572

Description
Colony diam (7 d): CYA25: 12–15 mm; MEA25: 30–34 mm; YES25: 23–25 mm; OA25: 28–33 mm; CYA37: 16–19 mm; CREA: weak growth, no acid production
Colony colour: purple red
Conidiation: abundant
Reverse colour (CZA): dull yellow turning to reddish brown
Colony texture: velutinous
Conidial head: short columnar
Stipe: 15–50 (–100) µm, occasionally septate, heavy walled
Vesicle diam, shape: 10–18 µm, pear shaped
Conidium size, shape, surface texture: 2.8–3.5 µm, globose, spinulose

Cultures examined: CBS 467.91; WB 4772; WB 4078; CBS 118.523 = IBT 3051, all from the same original source

Diagnostic features: short heavy walled stipes, finely spinulose conidia, purple red colony colour, coloured vesicles and phialides and dark blue conidia; characterised by its vesicles borne at an angle to the stipe, as in *A. viridinutans* and *A. duricaulis*

Similar species: *A. duricaulis*

Distribution: Australia

Ecology and habitats: soil

Extrolites: Roquefortine C, cf. meleagrin, red metabolite (not structure elucidated)

Pathogenicity: not reported

Note: previous reports on viriditoxin production of *A. brevipes* (Weisleder & Lillehoj 1971; Cole & Cox 1981) were based on studies of a mixed culture of *A. brev*ipes and *A. viridinutans* (Peterson SW, pers. comm.)

Aspergillus duricaulis Raper & Fennell, The genus *Aspergillus*, 249. 1965. Fig. 7.

Type: CBS 481.65, from soil, Buenos Aires, Argentina

Other no. of the type: ATCC 16900; IMI 172282; JCM 01735; IBT 23177; NRRL 4021; VKM F-3572; WB 4021

Description
Colony diam (7 d): CYA25: 21–25 mm; MEA25: 20–22 m; YES25: 40–44 mm; OA25: 40–44 mm, CYA37: 21–25 mm, CREA: poor growth, no acid production
Colony colour: lily green to slate olive
Conidiation: heavy in central areas
Reverse colour (CZA): colourless to pinkish drab
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 5–50 × 3.5–5.5 µm, smooth thick walled
Vesicle diam, shape: 7–14 µm, flask shaped
Conidium size, shape, surface texture: (2.8–)3–3.3(–3.3) µm, globose, echinulate

Cultures examined: IMI 172282 = IBT 23177; CBS 481.65

Diagnostic features: echinulate conidia and weakly coloured reverse on CYA distinguish it from other anamorphic species

Similar species: *A. brevipes*

Distribution: Argentina

Ecology and habitats: soil

Extrolites: pseurotin A, fumagillin (found here), asperpentyn (Muhlenfeld & Achenbach 1988), duricaulic acid and asperdurin (Achenbach *et al.* 1985a), phthalides and chromanols (Achenbach *et al.* 1982a, 1985b), cyclopaldic acid and 3-O-methylcyclopolic acid (Brillinger *et al.* 1978; Achenbach *et al.* 1982b)

Pathogenicity: not reported

Aspergillus fumigatiaffinis Hong, Frisvad & Samson, Mycologia 97: 1326. 2005**.** Fig. 8.

Type: CBS 117186, from soil, Socorro County, Sevilleta National Wildlife Refuge, New Mexico, U.S.A..

Other no. of the type: KACC 41148; IBT 12703

Description
Colony diam (7 d): CYA25: 46–49 mm; MEA25: 53–60 mm; YES25: 67–74; CYA37: 65–70; CREA: weak griowth, good acid production
Colony colour: white, with center dull green
Conidiation: limited
Reverse colour (CZA): yellowish to greyish orange
Colony texture: floccose
Conidial head: short columnar
Stipe: 6–8 µm in diam.
Vesicle diam, shape: 18–24 µm, globose-subglobose
Conidium size, shape, surface texture: 2–3 µm, globose-subglobose, smooth

Diagnostic features: has comparatively small (sub)globose vesicles (16–24 µm); able to grow at 10 °C, and unable to grow at 50 °C

Similar species: *A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis*

Distribution: U.S.A., Spain

Ecology and habitats: kangaroo rat, soil, human

Extrolites: auranthine, cycloechinuline, fumigaclavines, helvolic acid, neosartorin, palitantin, pyripyropenes A, E, O & S, tryptoquivaline, tryptoquivalone

Pathogenicity: pathogenic to humans (Alcazar-Fuoli *et al.* 2007)

Note: exhibits high MICs to amphotericin B and several triazoles (Alcazar-Fuoli *et al.* 2007)

Fig. 6. *Aspergillus brevipes*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–I. Conidiophores. J. Conidia. Scale bars = 10 µm.

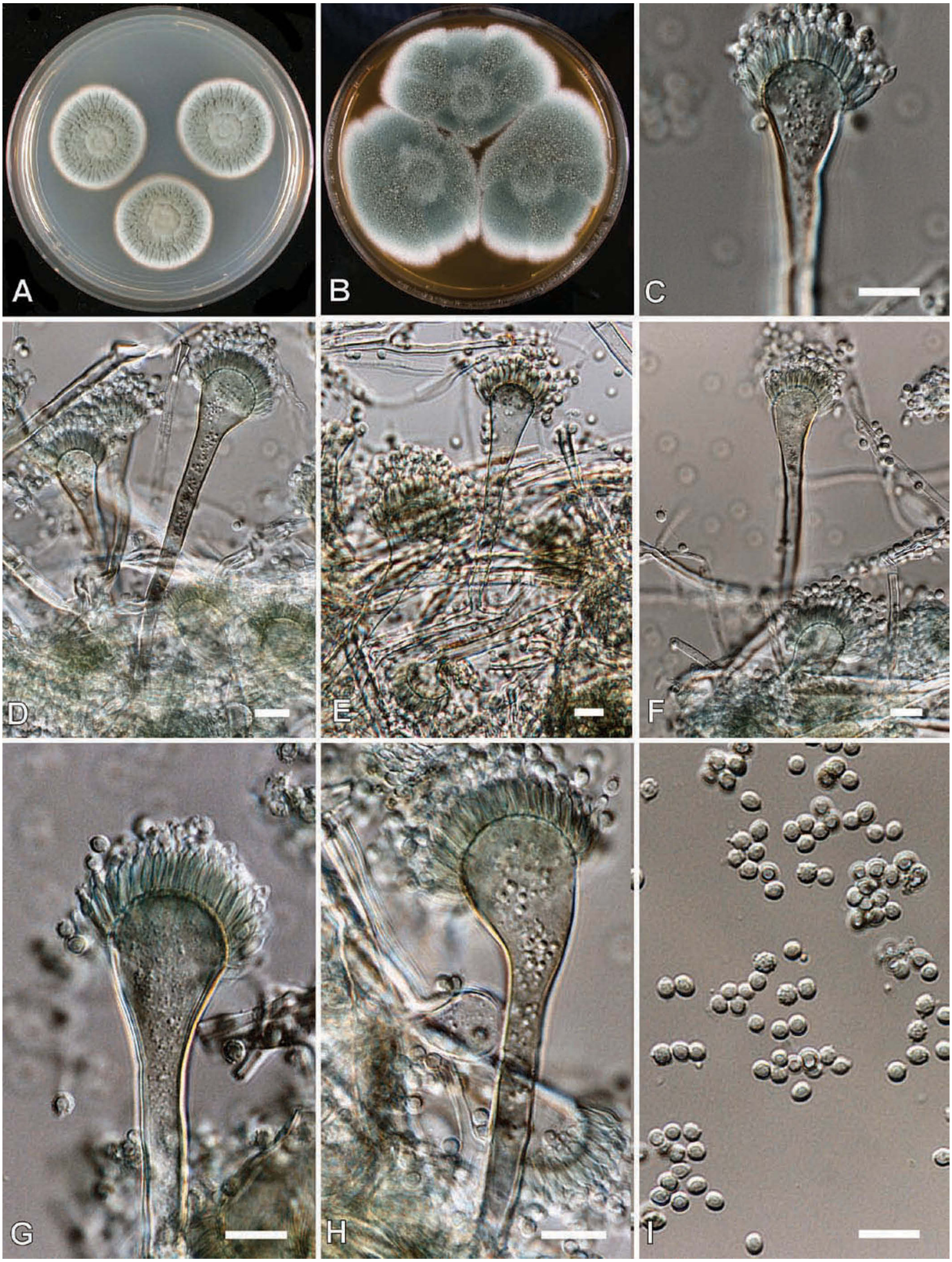

Fig. 7. *Aspergillus duricaulis*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 µm.

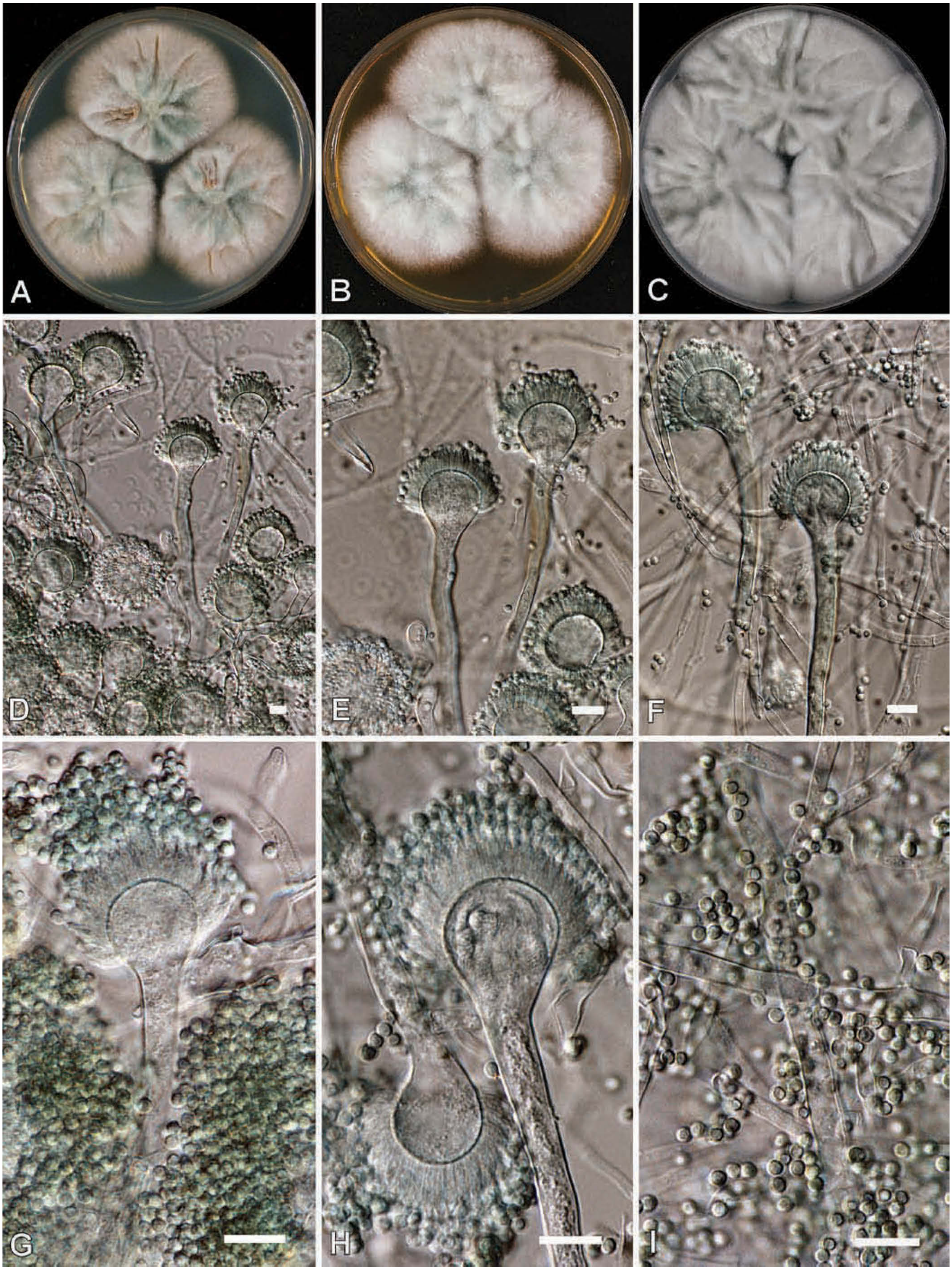

Fig. 8. *Aspergillus fumigatiaffinis*. A–C. Colonies 7 d 25 °C. A. CYA. B. MEA 25 °C. C. MEA 37 °C. D–H. Conidiophores. I. Conidia. Scale bars = 10 µm.

Aspergillus fumigatus Fresenius, Beitr. Mykol. 81: 18. 1863. Fig. 9.

= *Aspergillus fumigatus* var. *acolumnaris* Rai, Agarwal & Tewari (1971)
= *Aspergillus fumigatus* var. *albus* Rai, Tewari & Agarwal (1974)
= *Aspergillus fumigatus* var. *cellulosae* Sartory, Sartory & Mey. (1935)
= *Aspergillus fumigatus* var. *coeruleus* Malchevsk. (1939)
= *Aspergillus fumigatus* var. *ellipticus* Raper & Fennell (1965)
= *Aspergillus fumigatus* var. *fulviruber* Rai, Tewari & Agarwal (1974)
= *Aspergillus fumigatus* var. *fumigatus* Fresen. (1863)
= *Aspergillus fumigatus griseibrunneus* var. Rai & Singh (1974)
= *Aspergillus fumigatus* var. *helvolus* Yuill (1937)
= *Aspergillus fumigatus* var. *lunzinense* Svilv. (1941)
= *Aspergillus fumigatus* var. *minimus* Sartory (1919)
= *Aspergillus neoellipticus* Kozak. (1989)
= *Aspergillus phialoseptus* Kwon-Chung (1975)
= *Aspergillus bronchialis* Blumentritt (1901)
= *Aspergillus septatus* Sartory & Sartory (1943)
= *Aspergillus arvii* Aho, Horie, Nishimura & Miyaji (1994)

Type: IMI 016152, from chicken lung, Connecticut, U.S.A.

Other no. of the type: Thom 118; QM 1981; WB 163; CBS 133.61; NRRL 163; ATCC 1022; LSHB Ac71; NCTC 982; KACC 41143

Description
Colony diam (7 d): CYA25: 21–67 mm; MEA25: 25–69 mm; YES25: 48–74 mm; OA25: 34–62 mm, CYA37: 60–75 mm, CREA: poor growth, no or very weak acid production
Colour: greyish turquoise or dark turquoise to dark green to dull green
Conidiation: abundant, rarely less abundant
Reverse colour (CYA): creamy, yellow to orange
Colony texture: velutinous, st. floccose (define the abreviation st.)
Conidial head: columnar
Stipe: 50–350 × 3.5–10 µm
Vesicle diam, shape: 10–26 µm, pyriform to subclavate, sometimes subglobose, but rarely globose
Conidia length, shape, surface texture: 2–3.5(–6) µm, globose to ellipsoidal, smooth to finely rough

Cultures examined: ATCC 32722, AF71, AF 293, AF294, CBS 112389, CBS 487.65, CBS 133.61, CBS 545.65, CBS 457.75, CBS 542.75, CBS 113.26, CBS 110.46, CBS 120.53, CBS 132,54, CBS 123.59, CBS 158.71, CBS 180.76, CBS 143.89, CBS 148.89, CBS 488.90, CBS 287.95, CBS 100076, CBS 109032, CBS 386.75, CBS 286.95, CEA10, IMI 376380, NRRL 1979

Diagnostic features: Rapid growing velutinous colonies, abundant and fast conidiation, thick stipe (*ca.* 6–10 um), large pyriform to semi-clavate vesicle is representative morphological features of the species. However, the characteristics are various according to strains, and some stains have exceptional characteristics. The species grows at 50 °C, no growth at 10 °C.

Similar species: *A. fumigatiaffinis, A. fumisynnematus, A. lentulus, A. novofumigatus, A. viridinutans.*

Distribution: Worldwide distribution, cosmopolitan fungus (Pringle *et al.* 2005)

Ecology and habitats: soil, human

Extrolites: fumagillin, fumitoxins, fumigaclavines A & C, fumitremorgins, fumiquinazolines, gliotoxin, helvolic acid, pseurotins, pyripyropens, methyl-sulochrin, trypacidin, verruculogen

Pathogenicity: pathogenic to humans (Raper & Fennell 1965; Marr *et al.* 2002)

Note: no growth at 10 °C, growth at 50 °C; some isolates carry dsRNA mycoviruses (Anderson *et al.* 1996)

Aspergillus fumisynnematus Horie, Miyaji, Nishimura, Taguchi et Udagawa, Trans. Mycol. Soc. Japan: 34: 3–7. 1993. Fig. 10.

Type: IFM 42277, from soil, Sabaneta, Coro City, Falcon State, Venezuela

Description
Colony diam (7 d): CYA25: 44–48 mm; MEA25: 56–60 mm; YES25: 35–39 mm; OA25: 42–46; CYA37: 57–61 mm, CREA: poor growth and no acid production
Colony colour: greenish grey
Conidiation: limited
Reverse colour (CZA): orange white to orange grey
Colony texture: floccose
Conidial head: short columnar
Stipe: 210 × 6–8.5(–10) µm
Vesicle diam, shape: 16–20(–25) µm, hemispherical
Conidium size, shape, surface texture: 2.8–3.2 × 2.4–2.8 µm, broadly ellipsoidal, verruculose

Cultures examined: IFM 42277

Diagnostic features: production of synnemata on MEA with age (1-4-2.3 mm in height, 30–40 µm in diam.)

Similar species: *A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis*

Distribution: Brazil, Venezuela, Spain

Ecology and habitats: soil, human

Extrolites: neosartorin, pyripyropens (found here), fumimycin (Kwon *et al.* 2007)

Pathogenicity: pathogenic to humans (Alcazar-Fuoli *et al.* 2007; Yaguchi *et al.* 2007)

Note: growth at 10 °C, no growth at 50 °C

Aspergillus lentulus Balajee & Marr, Eukaryot. Cell 4: 631.2005. Fig. 11.

Type: FH5, from clinical specimens of patients hospitalised at the Fred Hutchinson Cancer Research Center, U.S.A.

Other no. of the type: KACC 41940, NRRL 35552; IBT 27201

Description
Colony diam: CYA25: (19–)25–56 mm, MEA25: (30)40–70 mm; YES25: 42–80 mm; OA25: 44–59 mm; CYA37: 54–70 mm, CREA: weak growth, no acid production
Colour: white with interspersed grey green conidia
Conidiation: usually poor, but abundant in some isolates
Reverse colour (CYA): pale yellow to grey orange, greyish brown
Colony texture: floccose
Conidial head: short columnar
Stipe: 20–500 × 4–7 µm, smooth, sometimes sinuous and constricted neck
Vesicle diam, shape: (6–)10–25 µm, globose to pyriform, usually subglobose

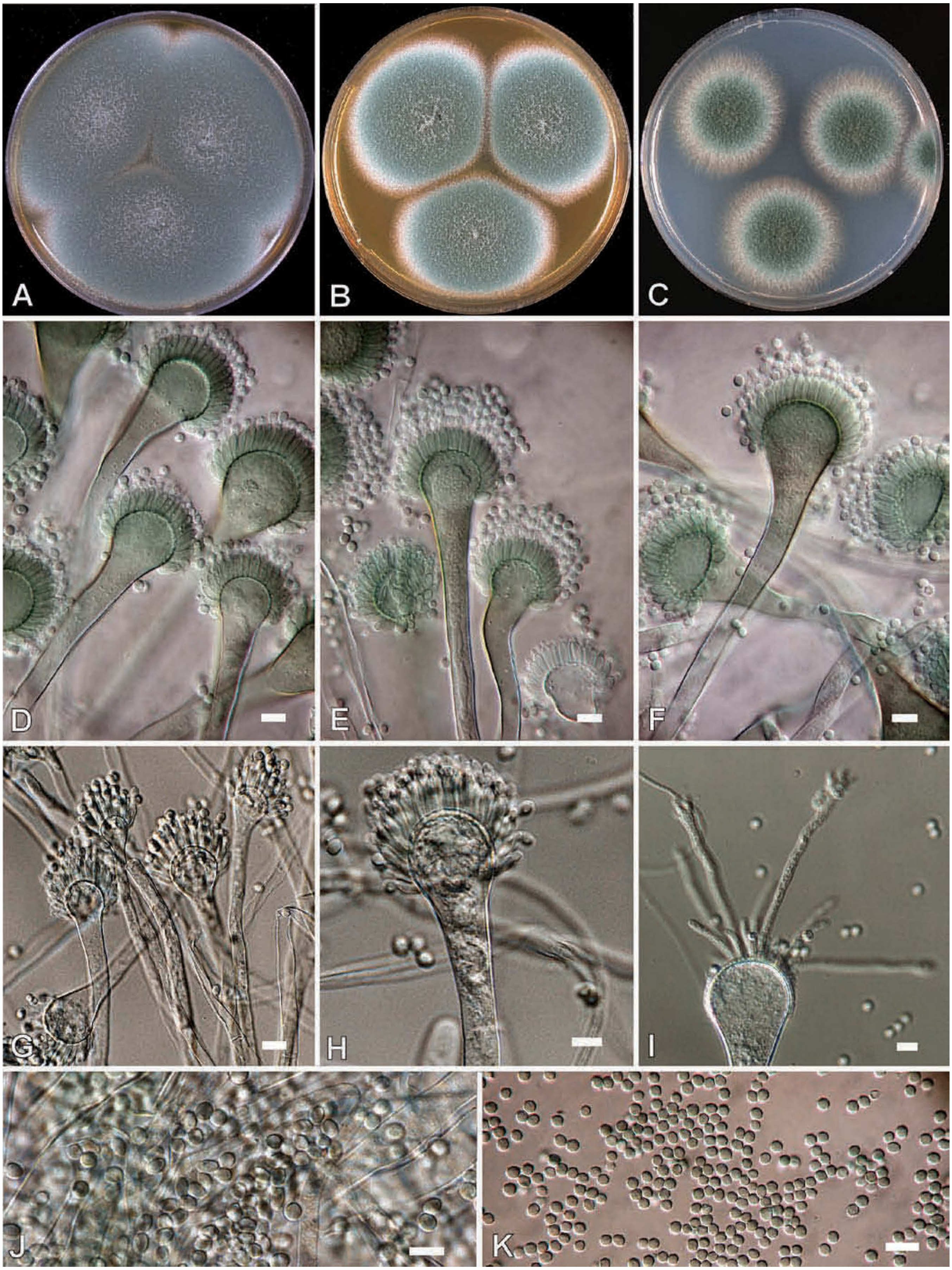

Fig. 9. *Aspergillus fumigatus*. A–C. Colonies 7 d 25 °C. A. CYA. B. MEA. C. CYA 37 °C. after 3 d. D–I. Conidiophores. D–F. A. fumigatus. G–H. *A. fumigatus* var. *ellipticus*. I. Atypical conidiophore of CBS 133.61. J. Conidia of *A. fumigatus* var. *ellipticus*. K. Conidia of *A. fumigatus*. Scale bars = 10 µm.

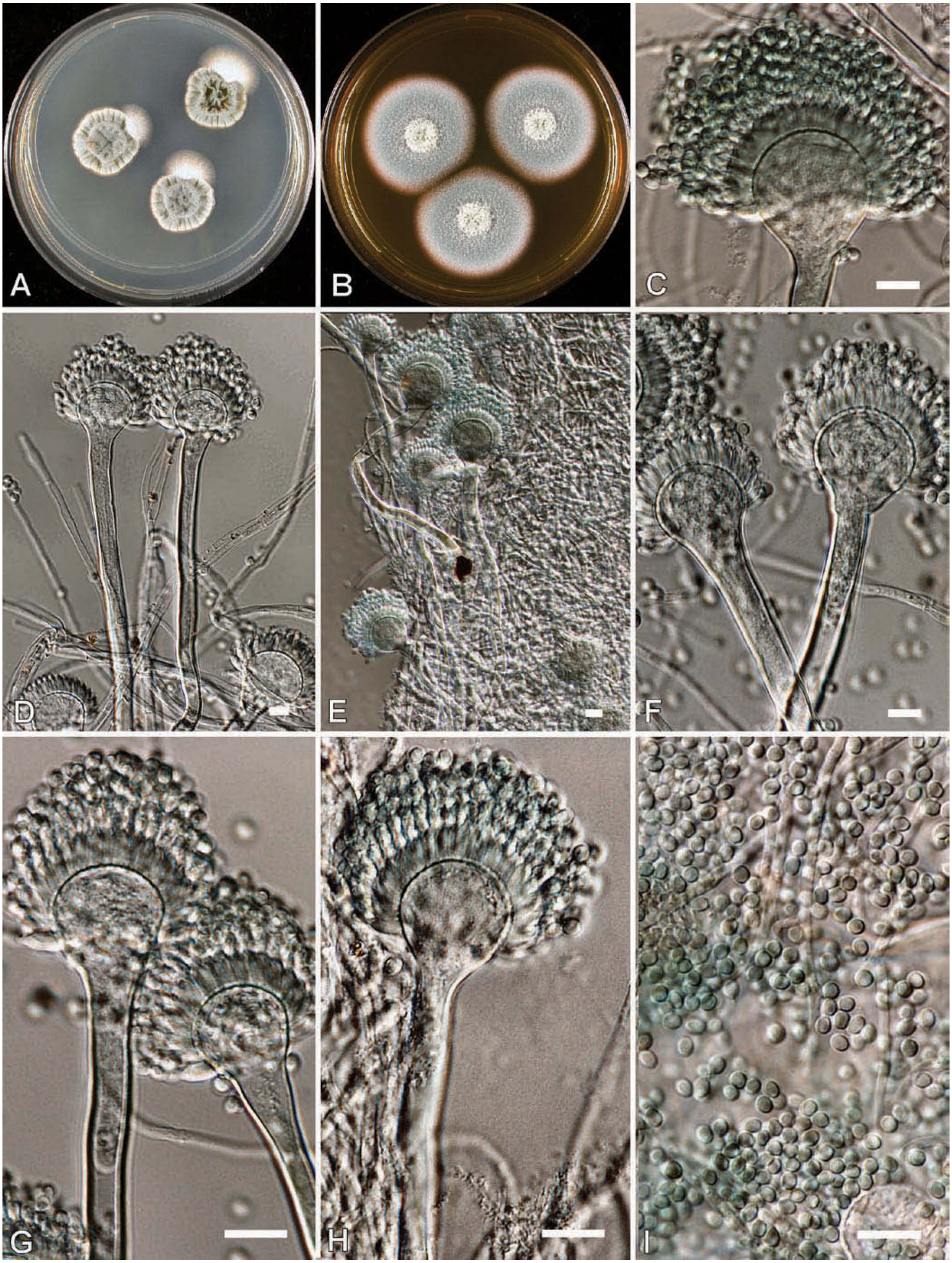

Fig. 10. *Aspergillus fumisynnematus*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 µm.

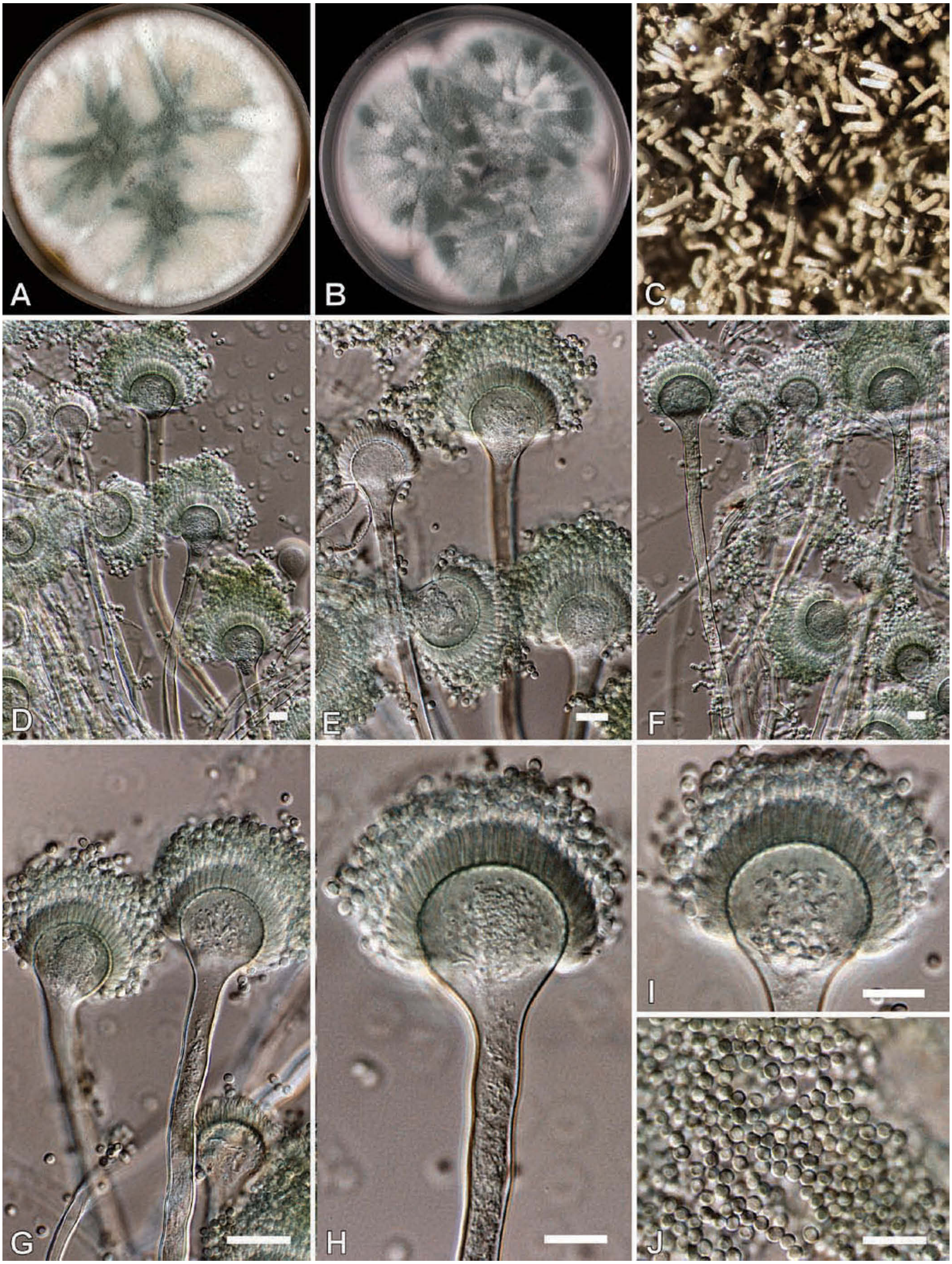

Fig. 11. *Aspergillus lentulus*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C. Macroscopic vieuw of the columnar conidial heads. D–I. Conidiophores. J. Conidia. Scale bars = 10 µm.

Conidia length, shape, surface texture: 2–3.2 µm, globose to broadly ellipsoidal, smooth to finely roughened

Cultures examined: KACC 41391 = CBS 116886, KACC 41392, KACC 41393, KACC 41681, KACC 41682, KACC 41642, KACC 41394, KACC 41395, KACC 41939 =FH7 = IBT 27209, KACC 41941 = FH4 = IBT 27210, KACC 41942 = FH220 = IBT 27202, KACC 41940 = FH5 = IBT 27201 = NRRL 35552

Diagnostic features: slow and poor conidiation, floccose colony texture, short columnar conidial heads, thin stipe (<7um), globose vesicle; growth at 10 °C and no growth at 50 °C

Similar species: *A. fumigatiaffinis, A. fumigatus, A. fumisynnematus, A. novofumigatus, A. viridinutans*

Distribution: Korea, U.S.A., Japan, Australia, Netherlands, Spain etc. It is assumed that the species is distributed worldwide.

Ecology and habitats: soil, human, dolphin

Extrolites: cyclopiazonic acid, pyripyropenes A, E & O, terrein, auranthine, neosartorin

Pathogenicity: pathogenic to humans (Balajee *et al.* 2005b; Alhambra *et al.* 2006; Alcazar-Fuoli *et al.* 2007; Yaguchi *et al.* 2007; Lau *et al.* 2007)

Note: exhibits high MICs to amphotericin B and several triazoles (Balajee *et al.* 2004, 2005b)

Aspergillus novofumigatus Hong, Frisvad & Samson, Mycologia 97: 1326. 2005. Fig. 12.

Type: CBS 117520, from soil, Galapagos Islands, Ecuador

Other no. of the type: IBT 16806

Description
Colony diam (7 d): CYA25: 33–48 mm; MEA25: 48–60 mm; YES25: 44–55 mm; OA25: 54–67 mm; CYA37: 49–52 mm; CREA: weak growth, no acid production
Colony colour: deep green to grey green
Conidiation: in central areas
Reverse colour (CZA): greyish orange to yellowish orange
Colony texture: velutinous
Conidial head: short columnar
Stipe: 50–500 × 4–7 µm in diam
Vesicle diam, shape: (13–)15–30 µm subglobose to flask shaped
Conidium size, shape, surface texture: 2.5–3 µm, ellipsoidal, smooth

Cultures examined: CBS 117520 = IBT 16806, CBS 117519 = IBT 16755

Diagnostic features: has nearly flask-shaped and comparatively large vesicles (15–30 mm); growth at 10 °C, no growth at 50 °C

Similar species: *A. fumigatus, A. lentulus, A. fumisynnematus, A. fumigatiaffinis*

Distribution: Galapagos Islands, Ecuador

Ecology and habitats: soil

Extrolites: aszonalenin, cycloechinuline, fiscalins, helvolic acid, neosartorin, palitantin, terrein, territrem B

Pathogenicity: not reported

Aspergillus turcosus Hong, Frisvad & Samson, Antonie van Leeuwenhoek (in press). Fig. 13.

Type: KACC 42091, from air conditioner, Seoul, South Korea

Other no. of the type: IBT 27921

Description
Colony diam: CYA25: 32–41 mm; MEA25: 42–53 mm; YES25: 48–52 mm; OA25: 46–52 mm; CYA37: 48–56; CREA poor growth, no acid production
Colony colour: grey-turquoise to grey-green
Conidiation: abundant
Reverse colour (CZA): yellowish orange to greyish orange
Colony texture: velutinous
Conidial head: short columnar
Stipe: 80–100 × 4–7 µm
Vesicle diam, shape: 15–25 µm, flask shaped to globose
Conidium size, shape, surface texture: 2.5–3.5 µm, subglobose, smooth

Cultures examined: KACC 42091 = IBT 27921, KACC 42090 = IBT 27920, KACC 41955 = IBT 3016

Diagnostic features: Velutinous colony, grey-turquoise (green) colony colour and yellowish orange reverse on MEA and CYA, phialides cover distal two-thirds of the vesicle and growth at both 10 and 50 °C

Similar species: -

Ecology and habitats: air conditioner

Distribution: South Korea

Extrolites: Kotanins and several unique compounds but not yet elucidated secondary metabolites

Pathogenicity: not reported

Aspergillus unilateralis Thrower, Austral. J. Bot. 2: 355. 1954. Fig. 14.

≡ *A. brevipes* var. *unilateralis* (Thrower) Kozakiewicz

Type: CBS 126.56, from rhizosphere of *Hibbertia fasciculata* and *Epacris impressa*, Australia

Other no. of the type: ATCC 16902; IFO 8136; IMI 062876; NRRL 577, QM 8163; WB 4366; WB 4779; IBT 3210

Description
Colony diam: CZA25: 30 mm; MEA25: 60–70 mm in 14 d, CRWEA: poor growth, no acid production
Colony colour: slate olive
Conidiation: limited
Reverse colour (CZA): nearly black
Colony texture: thin, brittle, folded in central area
Conidial head: diminutive, with few divergent spore chains
Stipe: 5–30 × 1.2–2.2 µm
Vesicle diam, shape: 4–8.5 µm, irregularly globose
Conidium size, shape, surface texture: 2.5–3.5 µm, globose, coarsely echinulate

Cultures examined: CBS 126.56; CBS 283.66 = IBT 3211

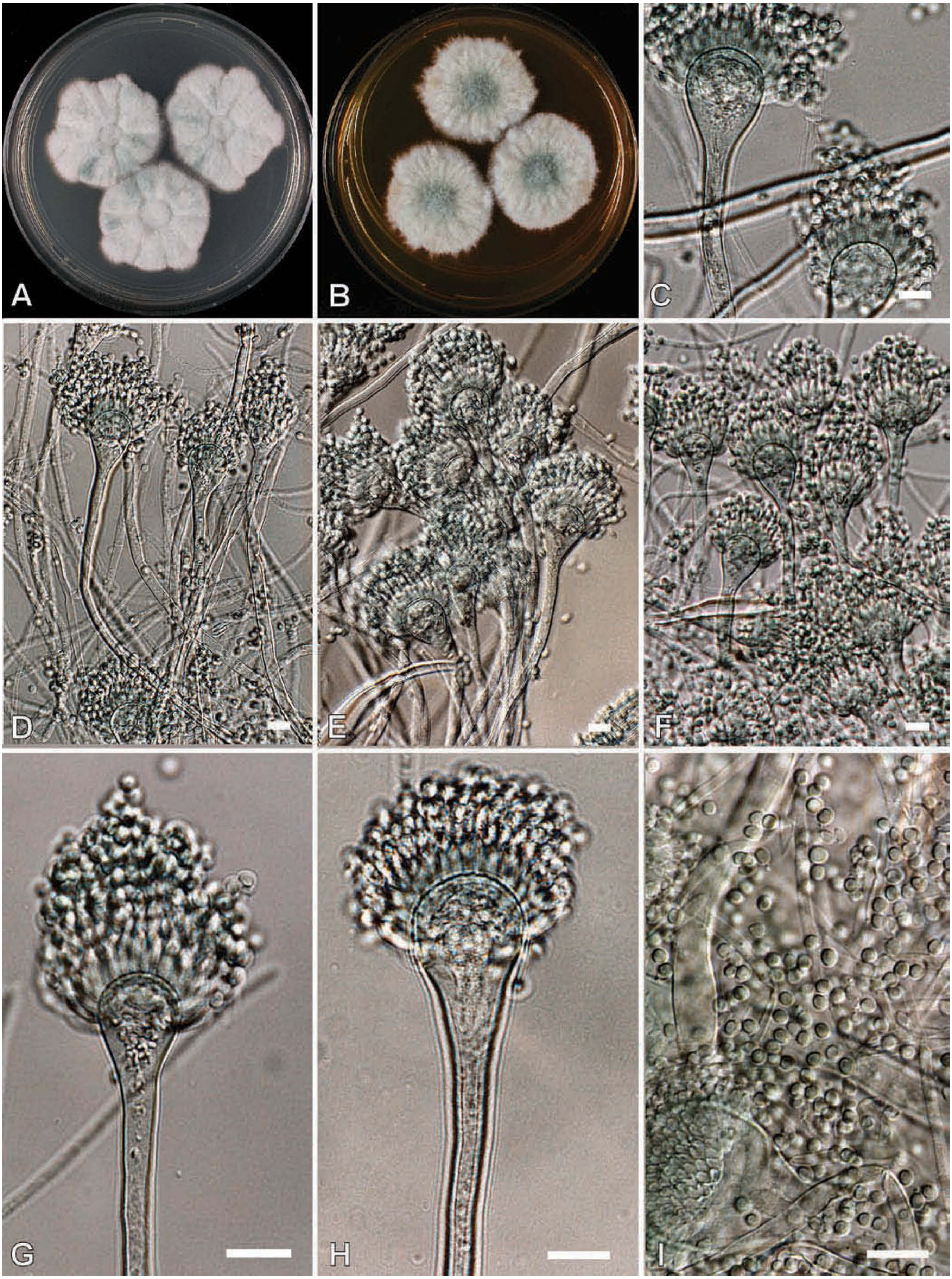

Fig. 12. *Aspergillus novofumigatus*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 µm.

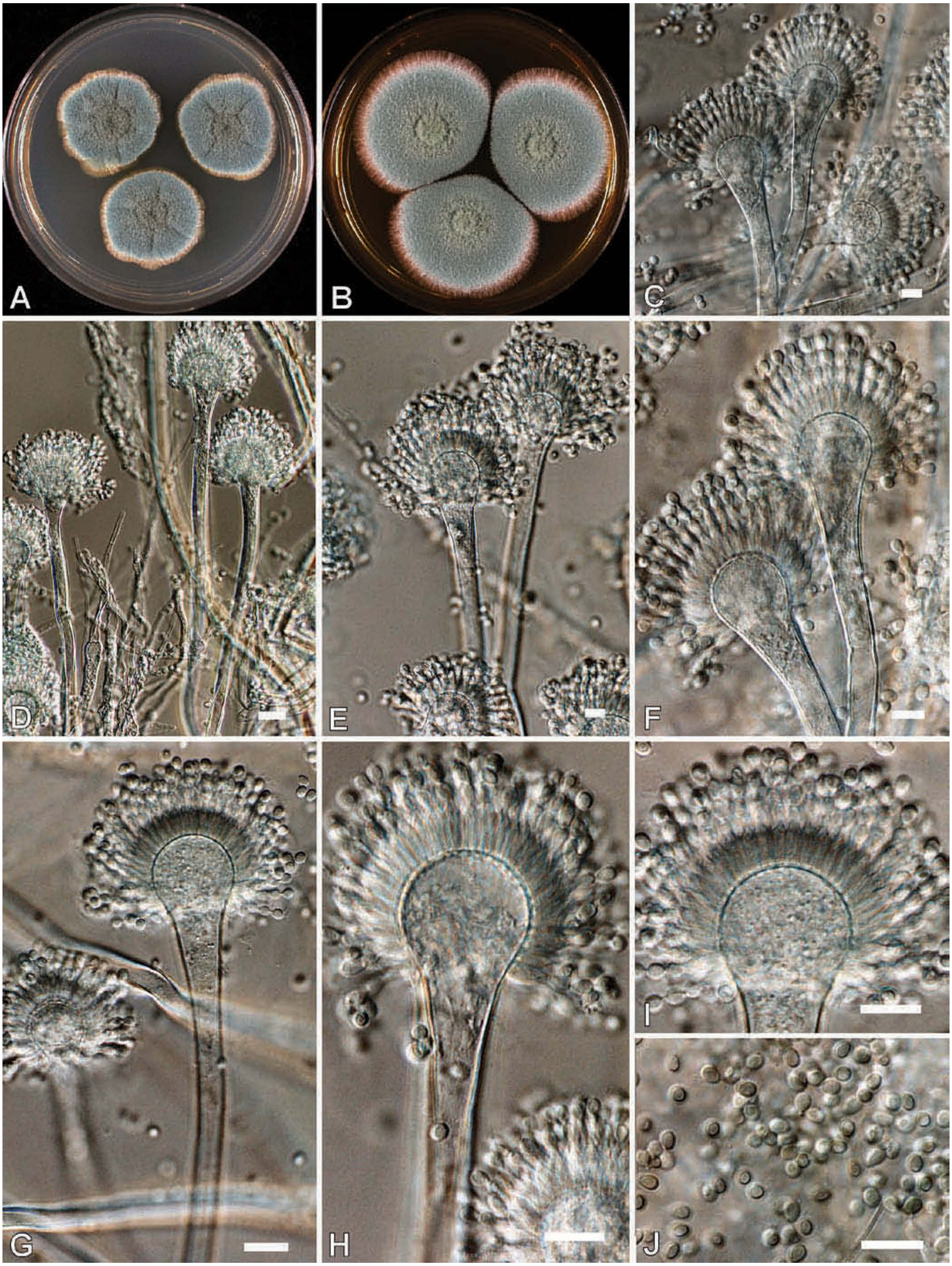

Fig. 13. *Aspergillus turcosus*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–I. Conidiophores. J. Conidia. Scale bars = 10 µm.

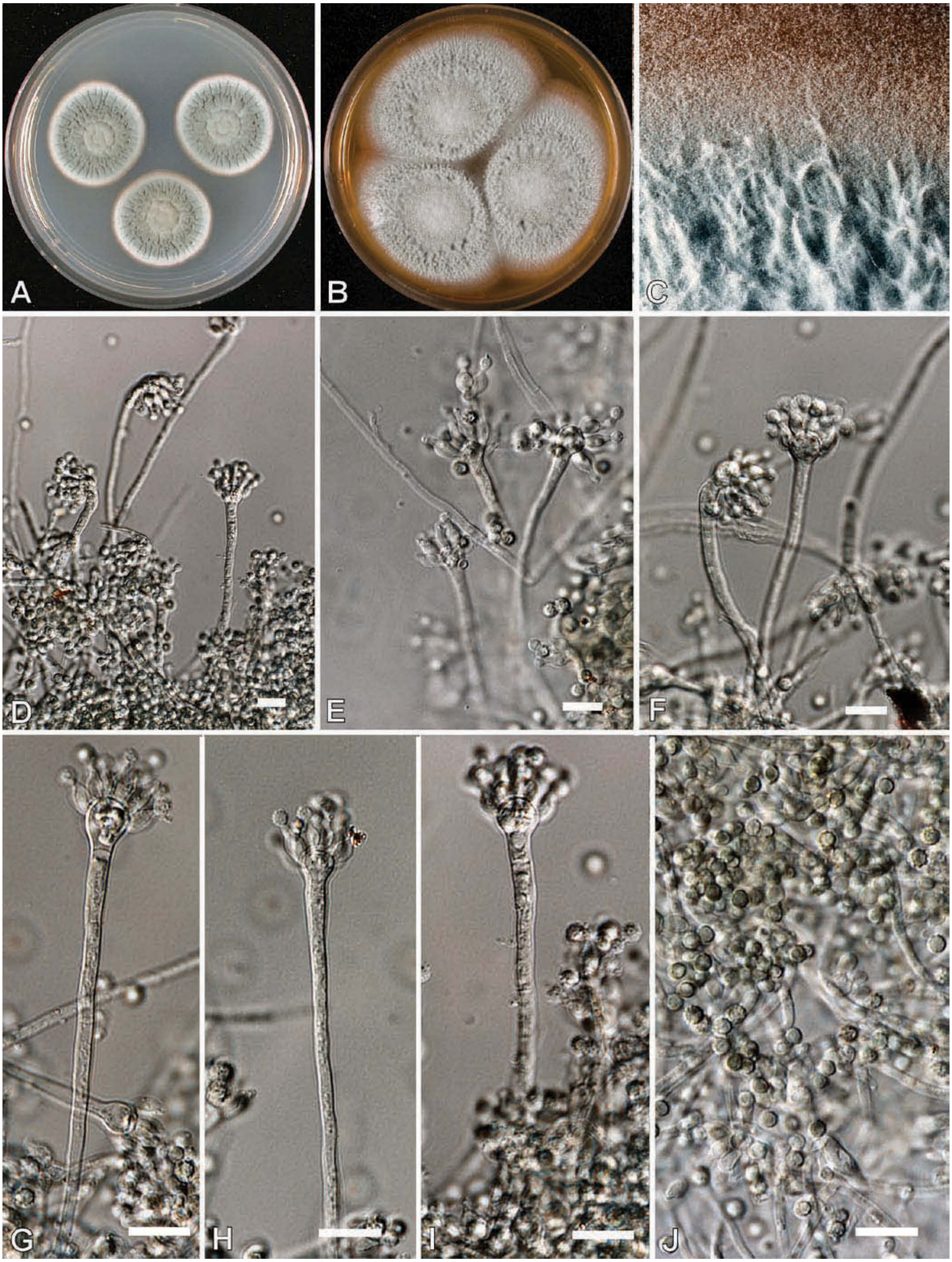

Fig. 14. *Aspergillus unilateralis*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C. Macroscopic view of the conidial heads. D–I. Conidiophores. J. Conidia. Scale bars = 10 µm.

Diagnostic features: phialides clustered on one side of the vesicle, echinulate conidia, slow growth rate and dark reverse on CYA

Similar species: -

Distribution: Australia

Ecology and habitats: soil

Extrolites: mycophenolic acid, other unique secondary metabolites

Pathogenicity: not reported

Aspergillus viridinutans Ducker & Thrower, Austral. J. Bot. 2: 355. 1954. Fig. 15.

= *A. fumigatus* var. *sclerotiorum* J.N. Rai, S.C. Agarwal & J.P. Tewari

Type: CBS 127.56, from dung of rabbit, Frankston, Victoria, Australia

Other no. of the type: ATCC 16901; IMI 062875; IMI 062875ii; NRRL 4365; WB 4081; WB 4782; WB 4365

Description

Colony diam (7 d): CYA25: 20–40 mm; MEA25: 11–15 mm; YES25: 24–28 mm; OA25: 29–31 mm; CYA 37: 25–28 mm; CREA: poor griowth, no acid production
Colony colour: Niagara green
Conidiation: limited on CZA, abundant on MEA
Reverse colour: colourless (CZA), yellowish green to light brownish olive (MEA)
Colony texture: centre raised, velutinous on MEA
Conidial head: columnar
Stipe: 20–35 × 3.3–4.4 µm
Vesicle diam, shape: 7.5–12 µm, flask shaped to subglobose
Conidium size, shape, surface texture: 2–2.8 µm, globose, delicately roughened

Cultures examined: CBS 127.56

Diagnostic features: "nodding" conidial heads, Niagara green colony colour

Similar species: none

Ecology and habitats: soil, dung, human

Distribution: Australia, Sri Lanka, Zambia, Russia (Varga *et al.* 2000b)

Extrolites: viriditoxin, 13-O-methylviriditin, phomaligin A, variotin, viriditin, wasabidienone B0, B1, viriditin A (Omolo *et al.* 2000), 4-acetyl-6,8-dihydroxy-5-methyl-2-benzopyran-1-1 A (Aldridge *et al.* 1966)

Pathogenicity: pathogenic to humans (Katz *et al.* 2005, Yaguchi *et al.* 2007, Alcazar-Fuoli *et al.* 2007)

Notes: this is a highly variable species; further taxonomic studies needed to clarify the taxonomic position of the isolates assigned to it (Varga *et al.* 2000a, b); exhibits high MICs to some azoles (Alcazar-Fuoli *et al.* 2007)

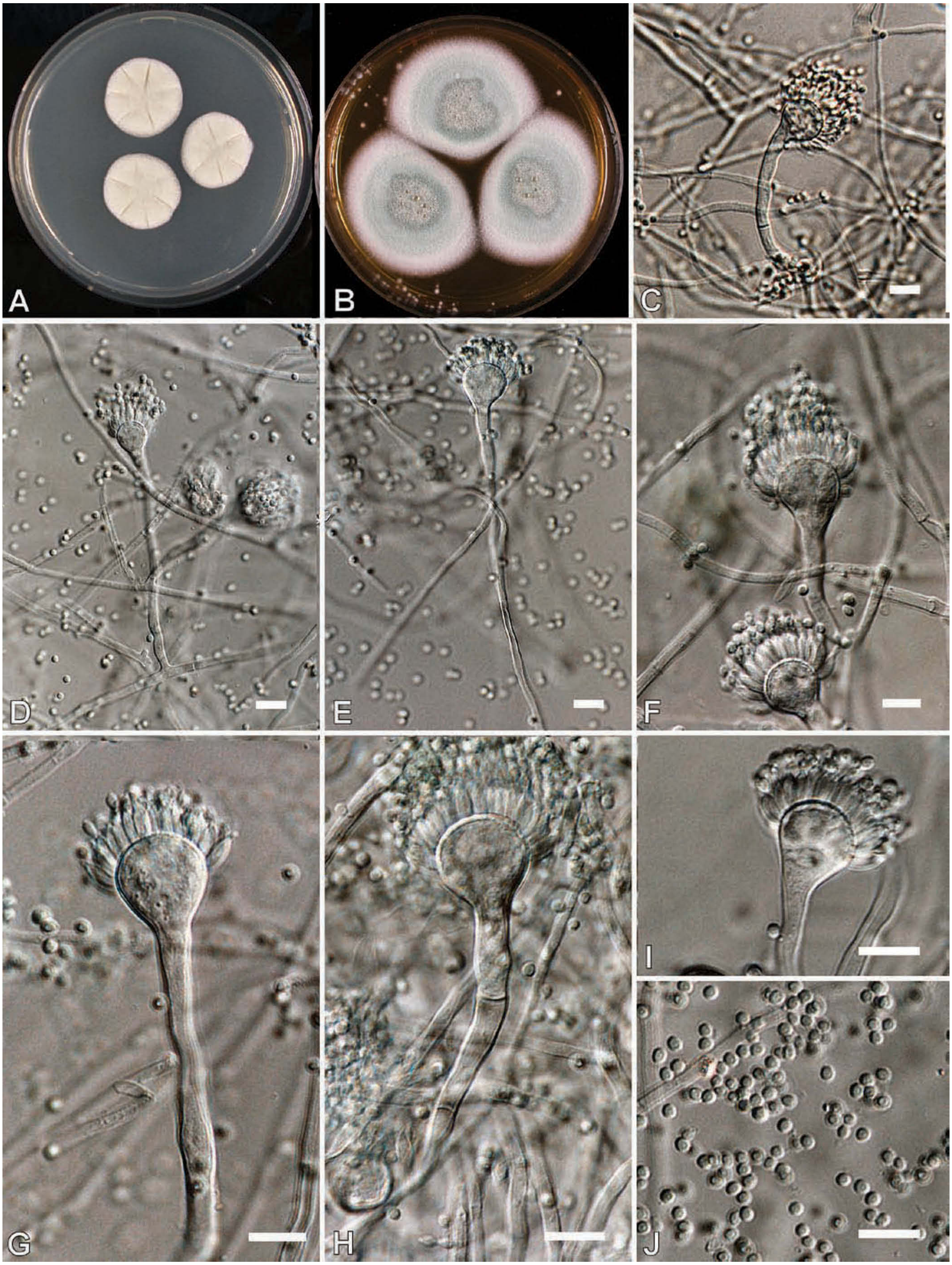

Fig. 15. *Aspergillus viridinutans*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–I. Conidiophores. J. Conidia. Scale bars = 10 µm.

Neosartorya assulata Hong, Frisvad & Samson [anamorph: *A. assulatus* Hong, Frisvad & Samson], Antonie van Leeuwenhoek (in press). Fig. 16.

Type: KACC 41691, from Tomato field soil, Buyeo, Korea

Other no. of the type: IBT 27911

Morphological characteristics
Colony diam (7 d): CYA25: (19–)37–41 mm;, MEA25: 47–58 mm; YES25: 28–31 mm; OA25: 36–40; CYA37: 32–68 mm
Colony colour: white
Conidiation: abundant
Reverse colour (CYA): yellowish white to pale yellow
Colony texture: radially sulcate
Conidial head: short columnar
Stipe: 3–7.5 µm wide
Vesicle diam, shape: 10–18 µm, subclavate
Conidium size, shape, surface texture: 2–3 µm, subglobose to ovoid, smooth
Homothallic
Cleistothecia: 120–250 µm, white to yellowish
Ascospores: 5–6 µm, lenticular, with two well-separated equatorial crests and convex surface decorated with several large, round flaps

Cultures examined: KACC 41691 = IBT 27911, IBT 27910

Diagnostic features: well developed long and round flaps on convex surface of ascospore with two distinct equatorial crests; grow on MEA and CZA much slower than *N. pseudofischeri*

Similar species: *N. pseudofischeri*

Distribution: Korea

Ecology and habitats: soil

Extrolites: some indole alkaloids and some apolar metabolites

Pathogenicity: not reported

Neosartorya aurata (Warcup) Malloch & Cain [anamorph: *A. igneus* Kozakiewicz], Raper & Fennell 1965. Fig. 17.

Type: CBS 466.65, from jungle soil, Berakas, Muama, Brunei

Other no. of the type: ATCC 16894; IFO 8783; IMI 075886; IMI 075886ii; NRRL 4378; QM 7860; WB 4378; IBT 3028

Morphological characteristics
Colony diam (7 d): CYA25: 13–15 mm; MEA25: 30–42 mm; YES25: 17–29 mm; OA25: 31–35 mm; CYA37: 13–16 mm, CREA: weak growth and no acid production
Colony colour (MEA): orange to ochraceus orange
Conidiation: sparse
Reverse colour (CZA): orange to dull brown
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 60–120 × 2–4 µm
Vesicle diam, shape: 10–16 µm, flask shaped
Conidium size, shape, surface texture: 2.5–3 µm, globose, punctate
Homothallic
Cleistothecia: 50–150 µm, orange, surrounded by a loose tangle of encrusted orange hyphae
Ascospores: 6–6.5 × 4.5–5 µm, lenticular, with two narrow equatorial crests and convex walls finely reticulate

Cultures examined: CBS 466.65; WB 4379; IFO 9817

Diagnostic features: bright orange colour of the colony on MEA, restricted growth on CZA

Similar species: *N. stramenia*

Distribution: Brunei

Ecology and habitats: soil

Extrolites: helvolic acid, yellow unindentified compounds

Pathogenicity: not reported

Neosartorya aureola (Fennell & Raper) Malloch & Cain [anamorph: *A. aureoluteus* Samson & Gams], Mycologia 47: 71–75. 1955. Fig. 18.

Type: CBS 105.55, from soil, Tafo, Ghana

Other no. of the type: ATCC 16896; IFO 8105; IMI 061451; IMI 061451ii; MUCL 13579; NRRL 2244; QM 1906; WB 2244; IBT 3027

Morphological characteristics
Colony diam (7 d): CYA25: 64–80 mm; MEA25: 77–90 mm; YES25: 70–75 mm; OA25>: 55–59 mm; CYA37: 75–80 mm, CREA: poor growth, no acid prodution
Colony colour (CZA): apricot to light cadmium yellow
Conidiation: sparse
Reverse colour (CZA): yellow ocher to ochraceus
Colony texture: radially furrowed at center, slightly zonate
Conidial head: loosely columnar
Stipe: 50 × 2.5–4.5 µm
Vesicle diam, shape: 6–9 µm, clavate to flask shaped
Conidium size, shape, surface texture: 3–3.3 µm, globose to subglobose, delicately echinulate
Homothallic
Cleistothecia: 175–500 µm, pale lemon yellow, surrounded by loose wefts of dark golden yellow hyphae
Ascospores: 6–7 × 4.4–5 µm, lenticular, with two prominent equatorial crests and with convex surfaces conspicuously echinulate

Cultures examined: CBS 105.55; WB 2391

Diagnostic features: yellow to golden pigmentation of hyphae surrounding the cleistothecia

Similar species: *N. udagawae, A. viridinutans*

Distribution: Suriname, Ghana, Liberia, Fiji

Ecology and habitats: soil, canned passionfruit

Extrolites: fumagillin, tryptoquivaline, tryptoquivalone, pseurotin A and viriditoxin (FRR 2269 also produces helvolic acid)

Pathogenicity: not reported

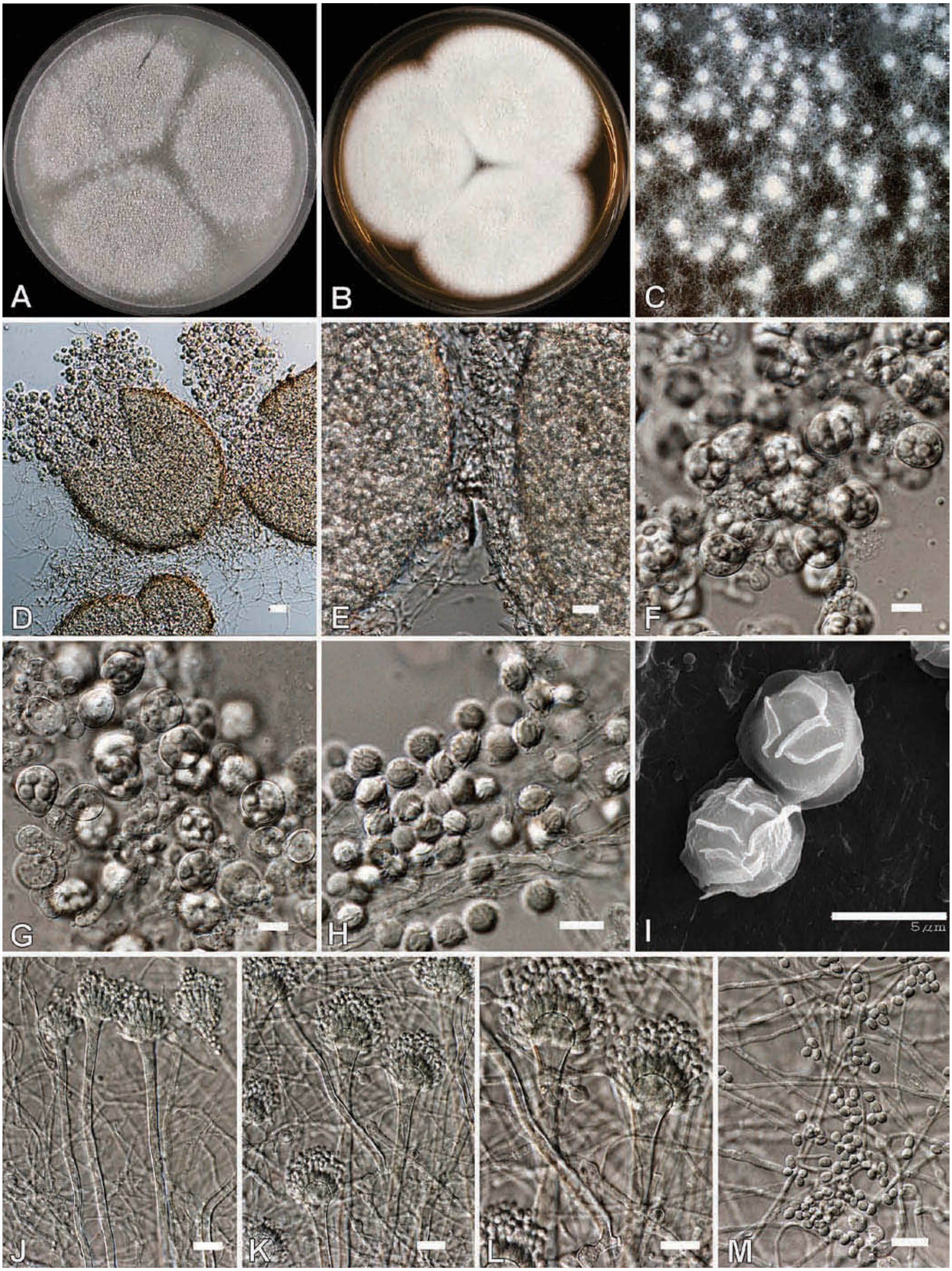

Fig. 16. *Neosartorya assulata*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.

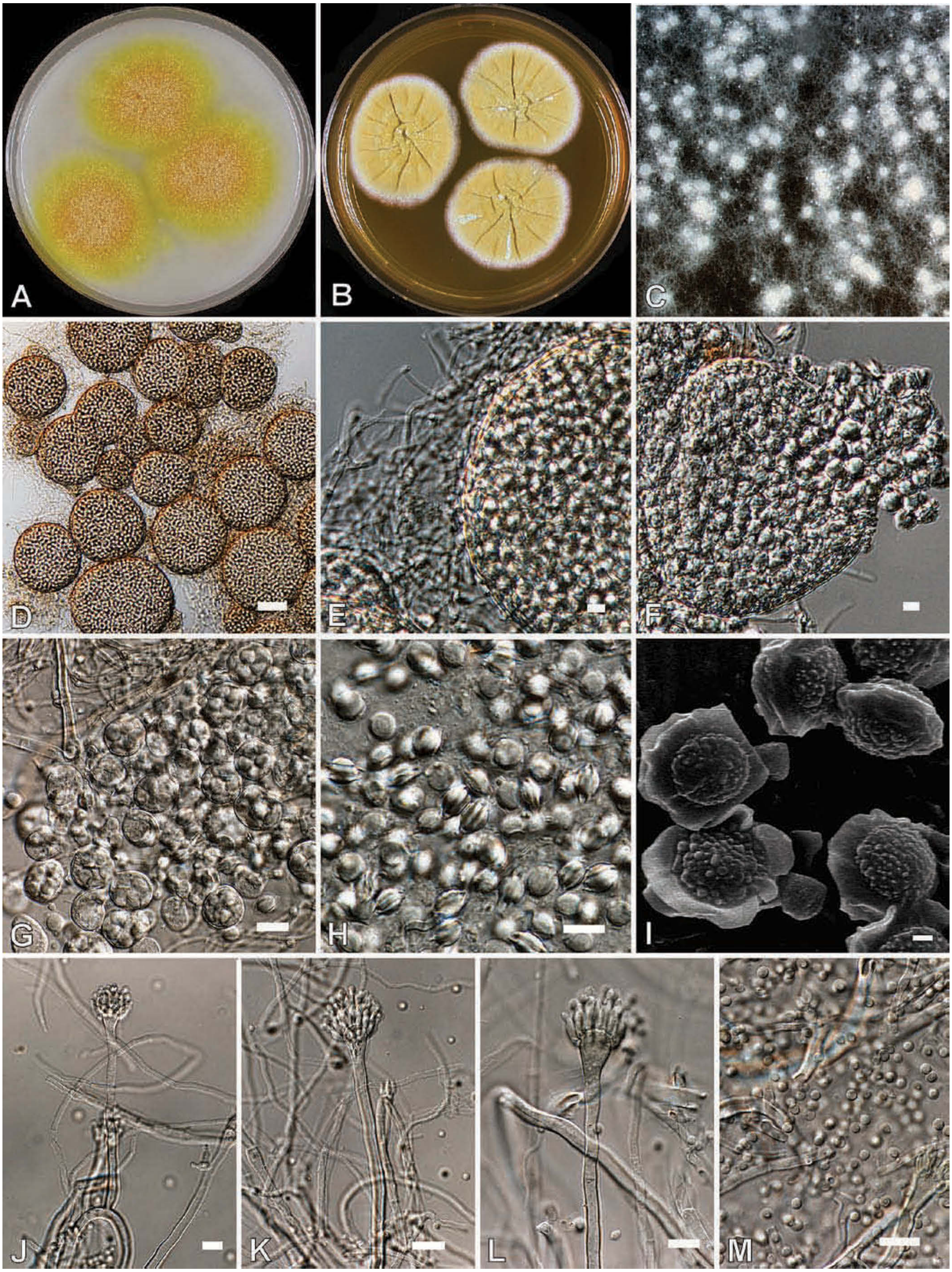

Fig. 17. *Neosartorya aurata*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

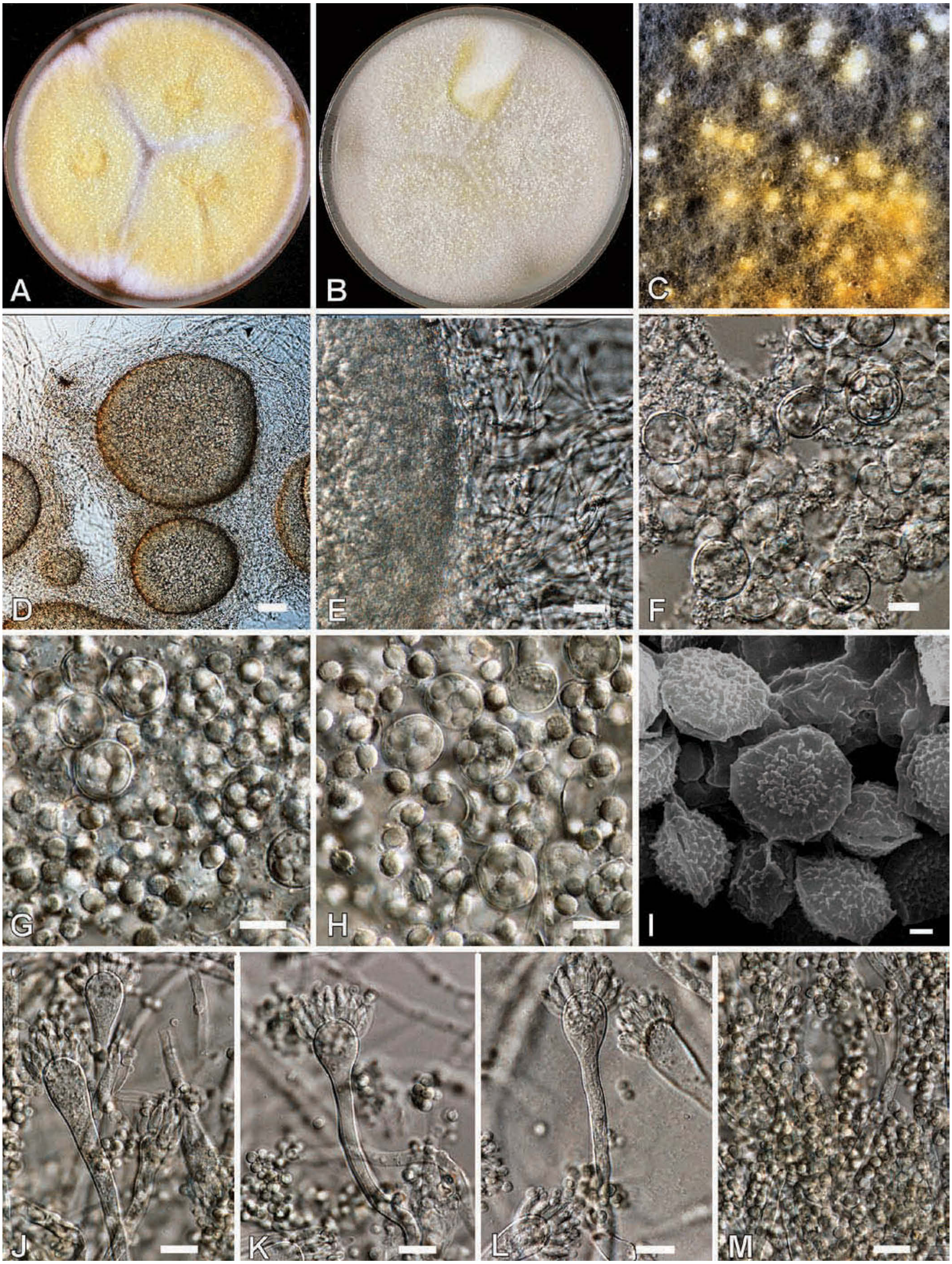

Fig. 18. *Neosartorya aureola*. A–B. Colonies 14 d 25 °C. A. MEA. B. OA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Neosartorya australensis Samson, Hong & Varga, **sp. nov.** (Fig. 19) – MycoBank MB492203.

Homothallica; cleistothecia superficialia, luteoalba vel dilute lutea, globosa vel subglobosa, 150–380 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci octospori, globosi vel subglobosi, 12–14 µm diam, evanescentes. Ascosporae 4.5–7.5 µm diam, cristis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnaria. Conidiophora ex hyphis aeriis exorientia, uniseriata, stipitibus 8–14 µm; vesiculae ampulliformes, 12–30 µm diam; phialides 7.5–9 × 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobosa vel ellipsoidea, laevia, 3.5–5 µm diam. Coloniae in agaro MEA in 7 dieibus et 25 °C celeriter crescentes, 40–45 mm diam, albae, capitulis conidialibus paucis. Coloniae in agaro CYA in 7 dieibus et 25 °C 30–35 mm diam, cremeoalbae, centro ab hyphis aerialibus laxe obtecto; capitula conidialia pauca; colonia reversa luteoalba vel luteobrunnea.

Holotype of *Neosartorya australensis,* here designated as CBS 112.55[T] (dried culture), isolated from garden soil, Adelaide, Australia.

Homothallic, cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 150–380 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 12–14 µm, evanescent at maturity. Ascospores lensshaped, 4.5–7.5 µm, with two equatorial crests, convex surfaces smooth to microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae often curling, uniseriate, stipes 12–30 µm; vesicles flask-shaped, 8–14 µm in diam.; phialides 7.5–9 × 2–3µm,, covering the upper half of vesicle. Conidia subglobose to ellipsoidal, smooth, 2.0–3.2 µm. Colonies on MEA growing rapidly, 40–45 mm in 7 d at 25 °C, white. Conidial heads produced few in number. Colonies on CYA, 30–35 mm in 7 d at 25 °C, creamy white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow.

Etymology: isolated from soil in Australia

Extrolites: wortmannin-like, aszonalenin-like

Distinguishing features: conidiophores often curled

Other no. of the type: IMI 061450; NRRL 2392; IBT 3021; WB 2392; Warcup SA14

Diagnostic features: smooth or microtuberculate 4.5–7.5 µm ascospores

Similar species: *N. glabra*

Distribution: Australia

Ecology and habitats: soil

Pathogenicity: not reported

Neosartorya coreana Hong, Frisvad & Samson [anamorph: *A. coreanus* Hong, Frisvad & Samson], Int. J. Syst. Evol. Microbiol. 56: 477. 2006. Fig 20.

Type: CBS 117059, from tomato field soil, Buyeo, Korea

Other no. of the type: KACC 41659 = NRRL 35590 = IBT 24945

Morphological characteristics
Colony diam (7 d): CYA25: 41–62 mm; MEA25: 57–66 mm; YES25: 50–74 mm; OA25: 54–58 mm; CYA37: 70–74 mm, CREA: poor growth, no acid production
Colony colour: white to yellowish white
Conidiation: sparse
Reverse colour (CYA): pale to light orange
Colony texture: radially sulcate
Conidial head: columnar
Stipe: 3–4 µm wide
Vesicle diam, shape: 8–13(–15) µm, subclavate
Conidium size, shape, surface texture: 2.5–3.5 µm, subglobose to broadly elliptical, smooth
Homothallic
Cleistothecia: 200–300 µm, white to light yellow
Ascospores: 4–5 µm, with two well-separated but often bent equatorial crests up to 2 µm, convex surface reticulate

Cultures examined: CBS 117059

Diagnostic features: rugose to weak reticulate ascospores with two often bent crests, but without the equatorial rings of small projections

Similar species: *N. spinosa, N. laciniosa*

Distribution: South Korea, Australia

Ecology and habitats: soil, strawberry

Extrolites: aszonalenins

Pathogenicity: not reported in humans (although isolated from the air sacks of an ostrich: Katz *et al.* 2005)

Neosartorya denticulata Samson, Hong & Frisvad [anamorph: *A. denticulatus* Samson, Hong & Frisvad], Antonie van Leeuwenhoek (in press). Fig. 21.

Type: CBS 652.73, from Soil under *Elaeis guineensis*, Suriname

Other no. of the type: KACC 41183

Morphological characteristics
Colony diam (7 d): CYA25: 22–24 mm; MEA25: 35–40 mm; CYA37: 35–38 mm; CREA: poor growth, no acid production
Colony colour: white
Conidiation: only on the marginal area
Reverse colour (CYA): yellowish white to pale yellow
Colony texture: loosely overgrown by aerial hyphae in the centre, sulcate in marginal areas
Conidial head: short columnar
Stipe: 3–4.5 µm wide
Vesicle diam, shape: 7–12 µm, spathulate
Conidium size, shape, surface texture: 2–3 µm, subglobose to broadly elliptical, smooth
Homothallic
Cleistothecia: 140–230 µm, yellowish white to pale yellow
Ascospores: 4–5 µm, denticulate with a prominent equatorial furrow

Cultures examined: CBS 652.73

Diagnostic features: denticulate ascospore surface and lacking equatorial crests make this a distinctive species

Similar species: *N. fennelliae, N. ferenczii*

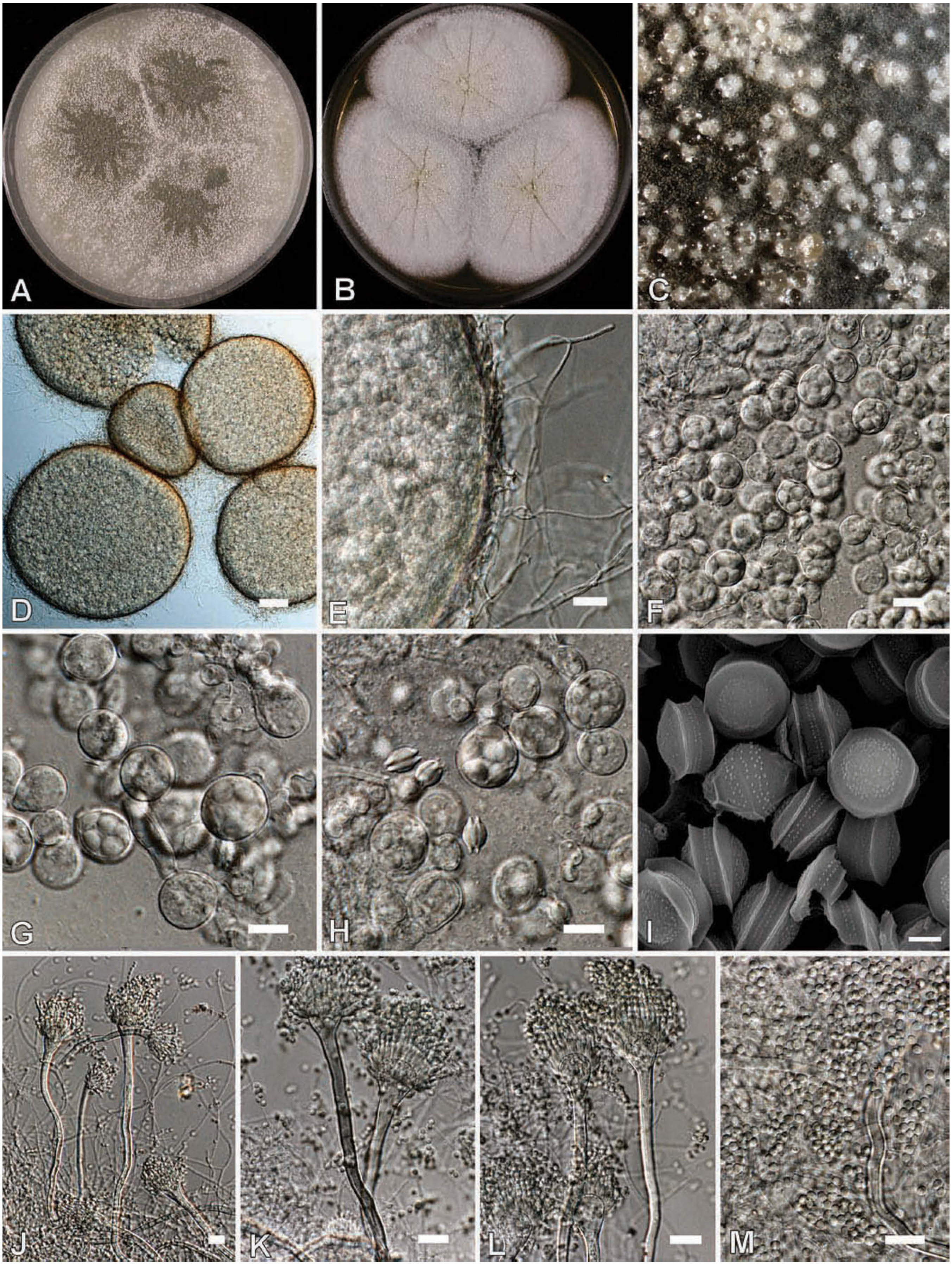

Fig. 19. *Neosartorya australiensis*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

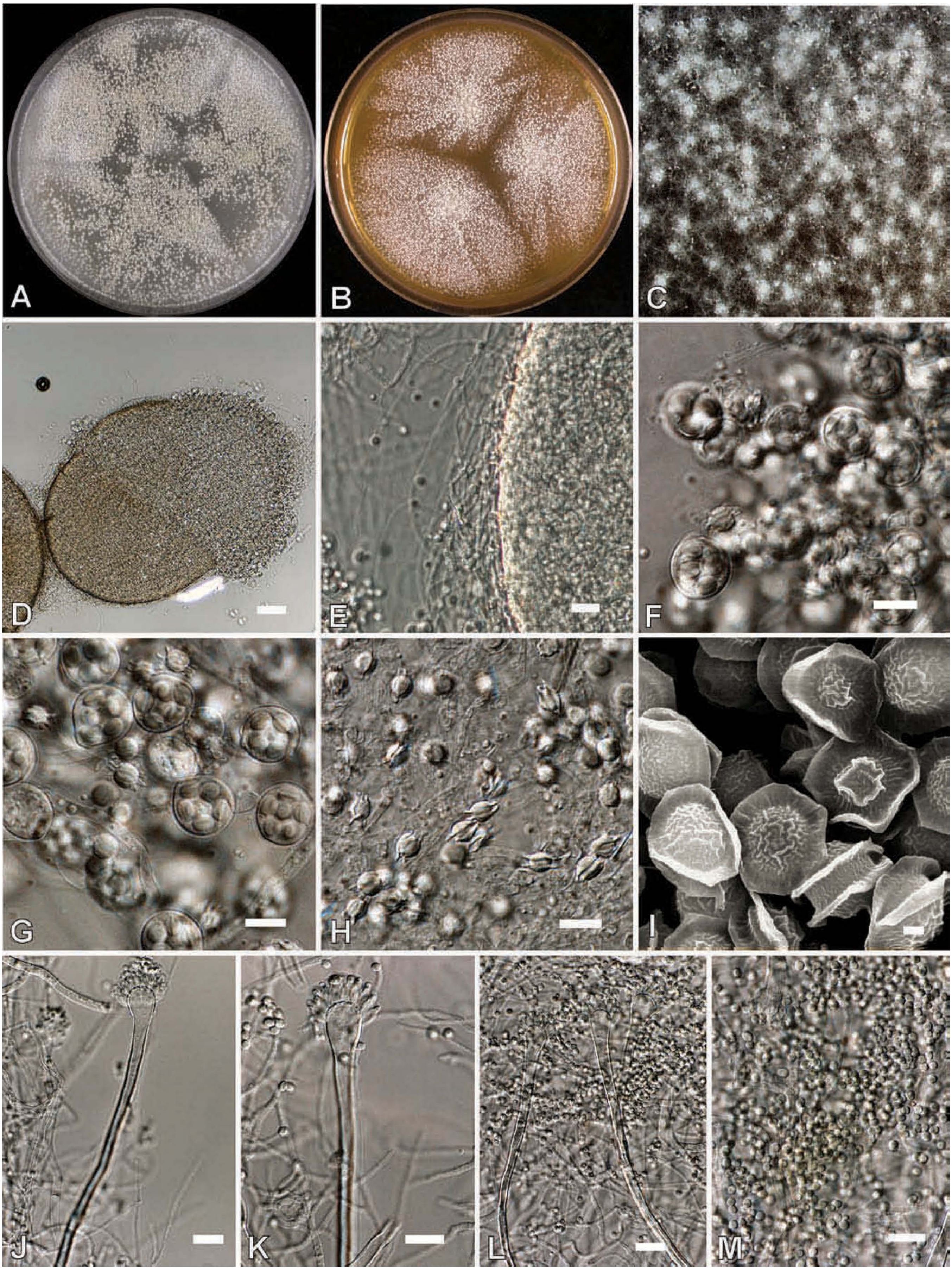

Fig. 20. *Neosartorya coreana*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

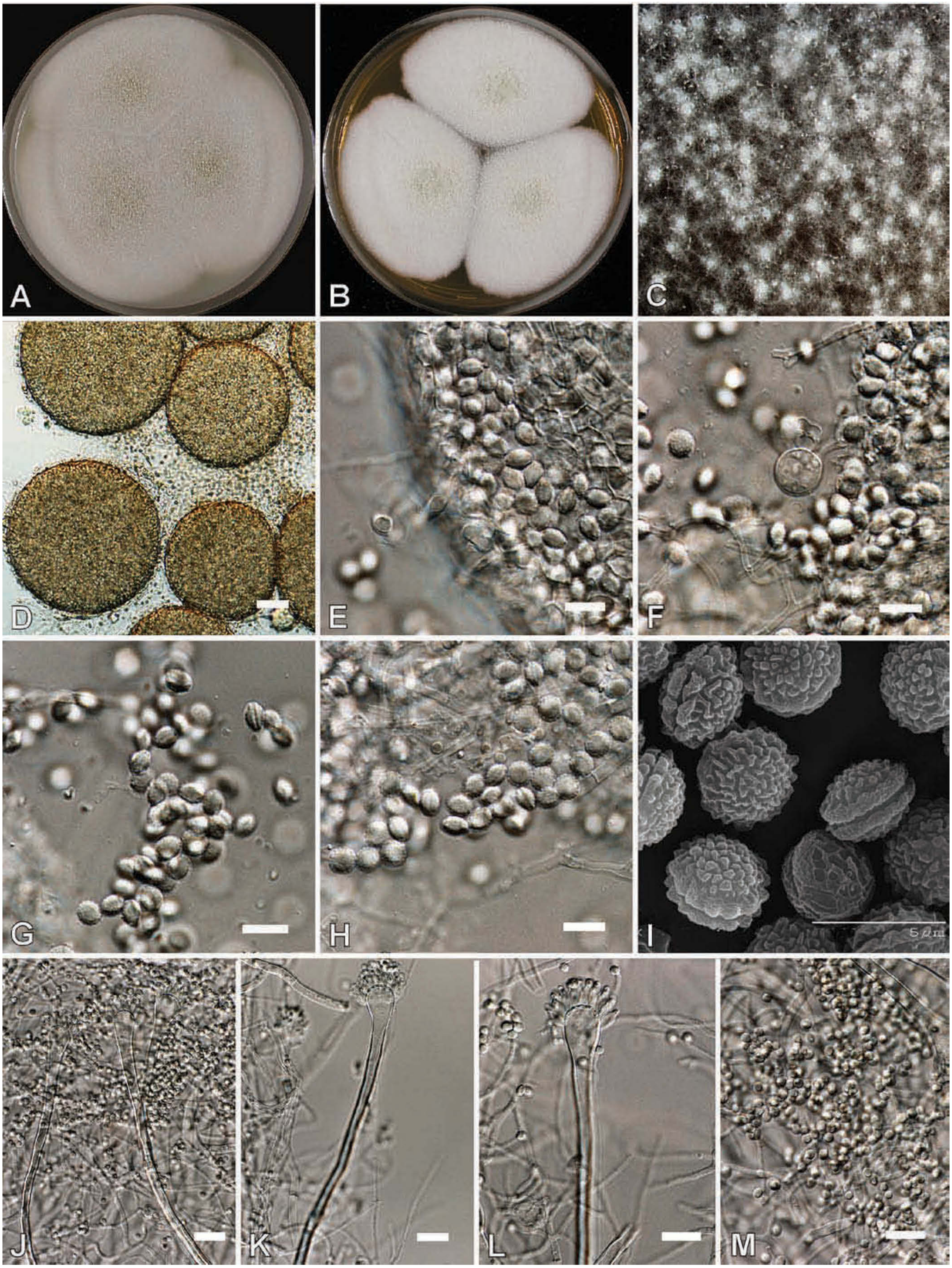

Fig. 21. *Neosartorya denticulata*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.

Distribution: Netherlands, Suriname

Ecology and habitats: soil, sycamore

Extrolites: gliotoxin, viriditoxin

Pathogenicity: not reported

Neosartorya fennelliae Kwon-Chung & Kim [anamorph: *A. fennelliae* Kwon-Chung & Kim], Mycologia 66: 628. 1974. Fig. 22.

Type: CBS 598.74 & CBS 599.74, from eye ball of Oryctolagus cuniculus, U.S.A.

Other no. of the type: ATCC 24325 & ATCC 24326, NRRL 5534 & NRRL 5535

Morphological characteristics
Colony diam (7 d): CYA25: 25–30 mm; MEA25: 44–48 mm; YES25: 30–34 mm; OA25: 34–38 mm; CYA37: 50–58 mm; CREA: poor growth and no acid production
Colony colour: grey
Conidiation: abundant
Reverse colour (CZA): white
Colony texture: velutinous
Conidial head: short columnar
Stipe: 150–250 × 4–6 µm
Vesicle diam, shape: 10–17 µm, flask-shaped
Conidium size, shape, surface texture: 2.2–2.5(–2.8) µm, globose to subglobose to ellipsoid, smooth or finely roughened
Heterothallic
Cleistothecia: 150–450 µm, white
Ascospores: 5.5–7.7 × 3.2–5 µm, with two equatorial crests, convex surfaces delicately roughened

Cultures examined: CBS 598.74, CBS 599.74

Diagnostic features: heterothallic

Similar species: *N. denticulata, N. ferenczii*

Distribution: U.S.A., Japan, South Korea

Ecology and habitats: soil, mirne sludge, rabbit

Extrolites asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin

Pathogenicity: not reported in humans

Note: no growth at 47 °C

Neosartorya ferenczii Varga & Samson, **sp. nov.** (Fig. 23) – MycoBank MB504847.

Homothallica; cleistothecia superficialia, luteoalba vel dilute lutea, globosa vel subglobosa, 180–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci octospori, globosi vel subglobosi, 12–16 µm diam, evanescentes. Ascosporae 3.5–5.5 µm diam, cristis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnaria. Conidiophora ex hyphis aeriis exorientia, uniseriata, stipitibus 100–150 × 4–5 µm; vesiculae ampulliformes, 10–14 µm diam; phialides 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia globosa vel subglobosa, laevia, 2–2,5 µm diam. Coloniae in agaro MEA in 7 dieibus et 25 °C celeriter crescentes, 35–40 mm diam, albae, capitulis conidialibus paucis. Coloniae in agaro CYA in 7 dieibus et 25 °C 20–30 mm diam, cremeoalbae, centro ab hyphis aerialibus laxe obtecto; capitulis conidialibus paucis; colonia reversa luteoalba vel pallide lutea.

Holotype of *Neosartorya ferenczii,* here designated as CBS 121594^T (dried culture), isolated from soil in Australia.

Homothallic, cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 180–350 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 12–16 µm, evanescent at maturity. Ascospores lens shaped, 3.5 × 5.5 µm, with two narrow equatorial crests, convex surface nearly smooth, microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae, uniseriate, stipes 100–150 × 4–5 µm; vesicles subclavate, 8–14 µm in diam; phialides 7.5–9 x 2–3 µm, covering the upper half of vesicle. Conidia globose to subglobose, smooth, 2–2,5 µm. Colonies on MEA growing rapidly, 35–40 mm in 7 d at 25 °C, white. Conidial heads produced few in number. Colonies on CYA, 20–30 mm in 7 d at 25 °C, creamish white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow (12A23) (Kornerup & Wanscher 1978).

Etymology: named after Prof. Lajos Ferenczy, eminent mycologist.

Extrolites: asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, gliotoxin-like, fumigatins and aszonalenin-like

Type: CBS 121594, from soil, Australia

Other no. of the type: IBT 27813, NRRL 4179; Warcup SA57

Diagnostic features: ascospore ornamentation similar to that of *N. fennelliae*, but with equatorial crests much narrower, and markedly different from those of *N. denticulata*

Similar species: *N. fennelliae, N. denticulata*

Distribution: Australia

Ecology and habitats: soil

Extrolites: asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, gliotoxin-like, fumigatins, and aszonalenin-like

Pathogenicity: not reported

Neosartorya fischeri (Wehmer) Malloch & Cain [anamorph: *A. fischeranus* Kozakiewicz], Can. J. Bot. 50: 2621. 1973. Fig. 24.

= *Aspergillus fischeri* Wehmer, Centr. Bakteriol. Parasitenk. Abt. II 18: 390. 1907.
= *Sartorya fumigata* Vuill., Compt. rendu Acad. Sci. Paris 184: 136. 1927.

Type: CBS 544.65, from canned apples, Wehmer

Other no. of the type: ATCC 1020; DSM 3700; IMI 211391; NRRL 181; QM 1983; Thom 4651.2, WB 181; IBT 3018

Morphological characteristics
Colony diam (7 d): CYA25: 45–68 mm; MEA25: 66–80 mm; YES25: 70–80 mm; OA25: 58–80 mm; CYA37: 65–84 mm; CREA: poor growth and no acid production
Colony colour (CZA): white to pale yellow to buff
Conidiation: sparse
Reverse colour (CZA): colourless to flesh coloured

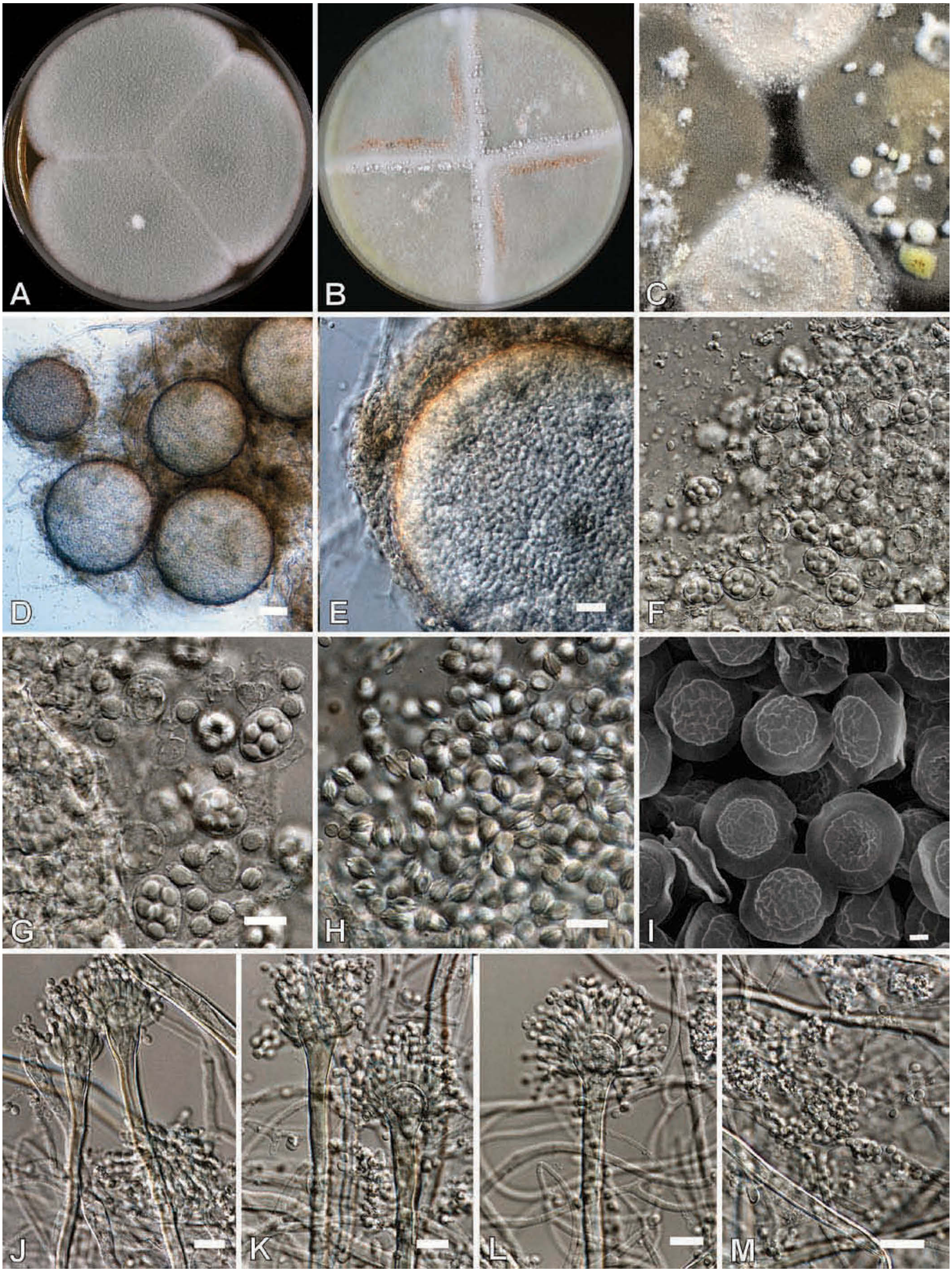

Fig. 22. *Neosartorya fennelliae*. A–B. Colonies 14 d 25 °C. A. MEA. B–C. Crossing of mating types on MEA. D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

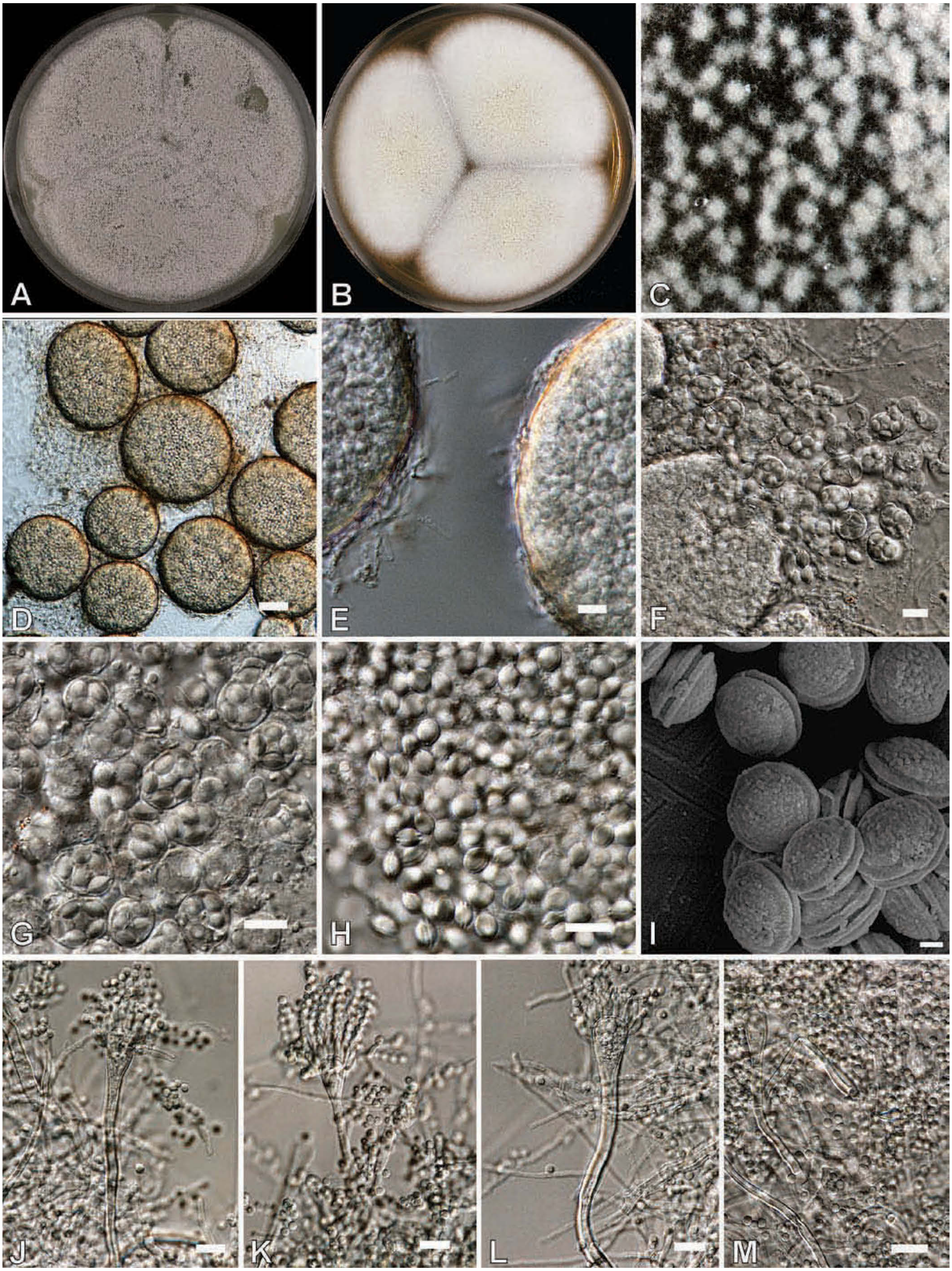

Fig. 23. *Neosartorya ferencii*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

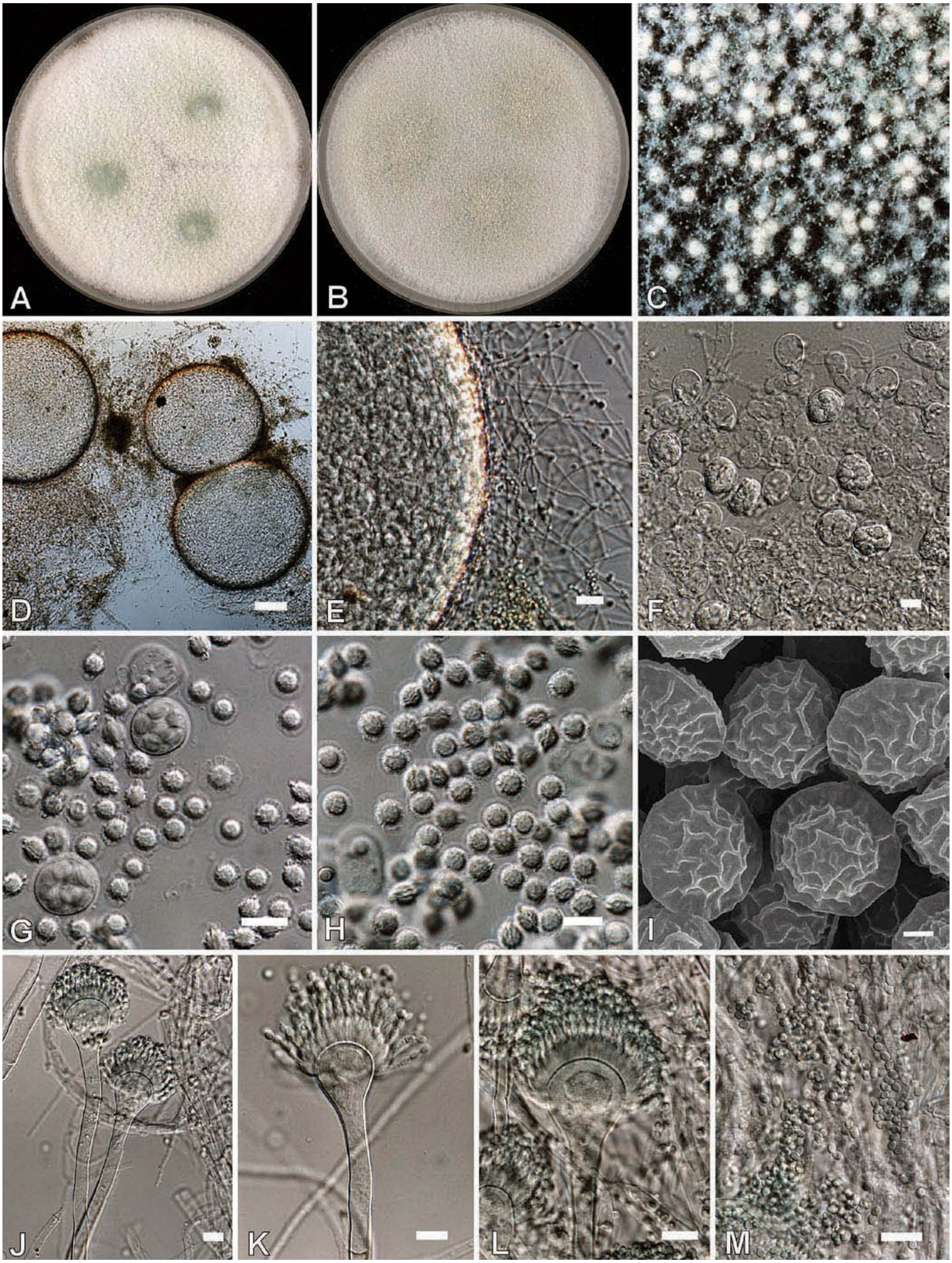

Fig. 24. *Neosartorya fischeri*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C. Macroscopic view of the columnar conidial heads. D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 12–18 µm, flask shaped
Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: up to 400 µm, light cream, borne singly or in small clusters within a loose hyphal envelope
Ascospores: 7–8 × 3–4 µm, convex surfaces bearing anastomosing ridges (reticulate)

Cultures examined: CBS 544.65; WB 4075; CBS 317.89; CBS 584.90; CBS 118441; NRRL 181; NRRL 4075; NRRL 4161; NRRL 4585

Diagnostic features: reticulate ascospore ornamentation

Similar species: *N. tatenoi*

Distribution: worldwide

Ecology and habitats: Soil, (milled) rice, cotton, potatoes, groundnuts, leather, paper products, canned products, human

Extrolites: terrein, fumitremorgins A & C, tryptoquivaline A, trypacidin, TR-2, verruculogen, sarcin, aszonalenins, fischerin, neosartorin, fiscalins, helvolic acid

Pathogenicity: pathogenic to animals and humans (Coriglione *et al.* 1990; Lonial *et al.* 1997; Mellado *et al.* 2006; Chim *et al.* 1998; Gori *et al.* 1998)

Neosartorya galapagensis Frisvad, Hong & Samson [anamorph: *A. galapagensis* Frisvad, Hong & Samson], Antonie van Leeuwenhoek (in press). Fig. 25.

Type: CBS 117522, from soil, Galapagos Islands, Ecuador

Other no. of the type: KACC 41935 = IBT 16756

Morphological characteristics
Colony diam (7 d): CYA25: 25–40 mm; MEA25: 26–35 mm; YES25: 39–44 mm; OA25: 34–41 mm; CYA37: 44–65 mm; CREA poor growth and no acid production
Colony colour: white
Conidiation: sparse
Reverse colour (CYA): golden yellow
Colony texture: strongly funiculose
Conidial head: columnar
Stipe: 2–4 µm wide
Vesicle diam, shape: 4–11 µm, (sub)clavate
Conidium size, shape, surface texture: 2.3–3 µm, globose to subglobose, smooth
Homothallic
Cleistothecia: 90–220 µm, yellowish white, surrounded by a loose covering of aerial hyphae
Ascospores: 5 µm, with two distinct equatorial crests 1–2 µm wide, convex surface of ascospores microtuberculate

Cultures examined: CBS 117522 = IBT 16756; CBS 117521 = IBT 16763

Diagnostic features: colonies funiculose, the *Aspergillus* anamorph arises from bundles of aerial hyphae, ascospores with two wide conspicuous equatorial crests and with microtuberculate convex surface

Similar species: *N. glabra, N. australensis*

Distribution: Galapagos Islands (Ecuador)

Ecology and habitats: soil

Extrolites: gregatins

Pathogenicity: not reported

Neosartorya glabra (Fennell & Raper) Kozakiewicz [anamorph: *A. neoglaber* Kozakiewicz], Mycol. Pap. 161: 56. 1989. Fig. 26.

Type: CBS 111.55, from rubber scrab of an old tire, Iowa, U.S.A.

Other no. of the type: ATCC 16909; IFO 8789; IMI 061447; IMI 061447ii; NRRL 2163; QM 1903; WB 2163

Morphological characteristics
Colony diam (7 d): CYA25: 24–43 mm; MEA25: 49–66 mm; YES25: 45–54 mm; OA25: 55–76 mm; CYA37: 30–80 mm; CREA: poor growth and no acid production
Colony colour (CZA): white to pale yellow to buff
Conidiation: sparse
Reverse colour (CZA): colourless to light pink
Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 10–18 µm, flask shaped
Conidium size, shape, surface texture: 2.5–3.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: 100–500 µm, yellowish white
Ascospores: 6.5–7.5 × 4.5–5 µm, lenticular, with two equatorial crests of 1–1.5 µm, convex surfaces finely roughened

Cultures examined: CBS 111.55; IMI 144207; IMI 102073; CBS 165.63

Diagnostic features: has smaller and whiter cleistothecia and relatively straight equatorial crests and smoother walled convex surfaces compared to *N. laciniosa, N. coreana* and *N. spinosa; N. glabra* grows somewhat slower than the other species and grows well at comparatively low temperatures; can be distinguished from *N. papuensis* and *N. australensis* using sequence data or extrolite profiles

Similar species: *N. papuensis, N. australensis*

Distribution: U.S.A., Morocco, Denmark, Australia, Netherlands, South Korea

Ecology and habitats: soil, foods, indoor

Extrolites: asperpentyn, avenaciolide, wortmannin-like compound

Pathogenicity: not reported

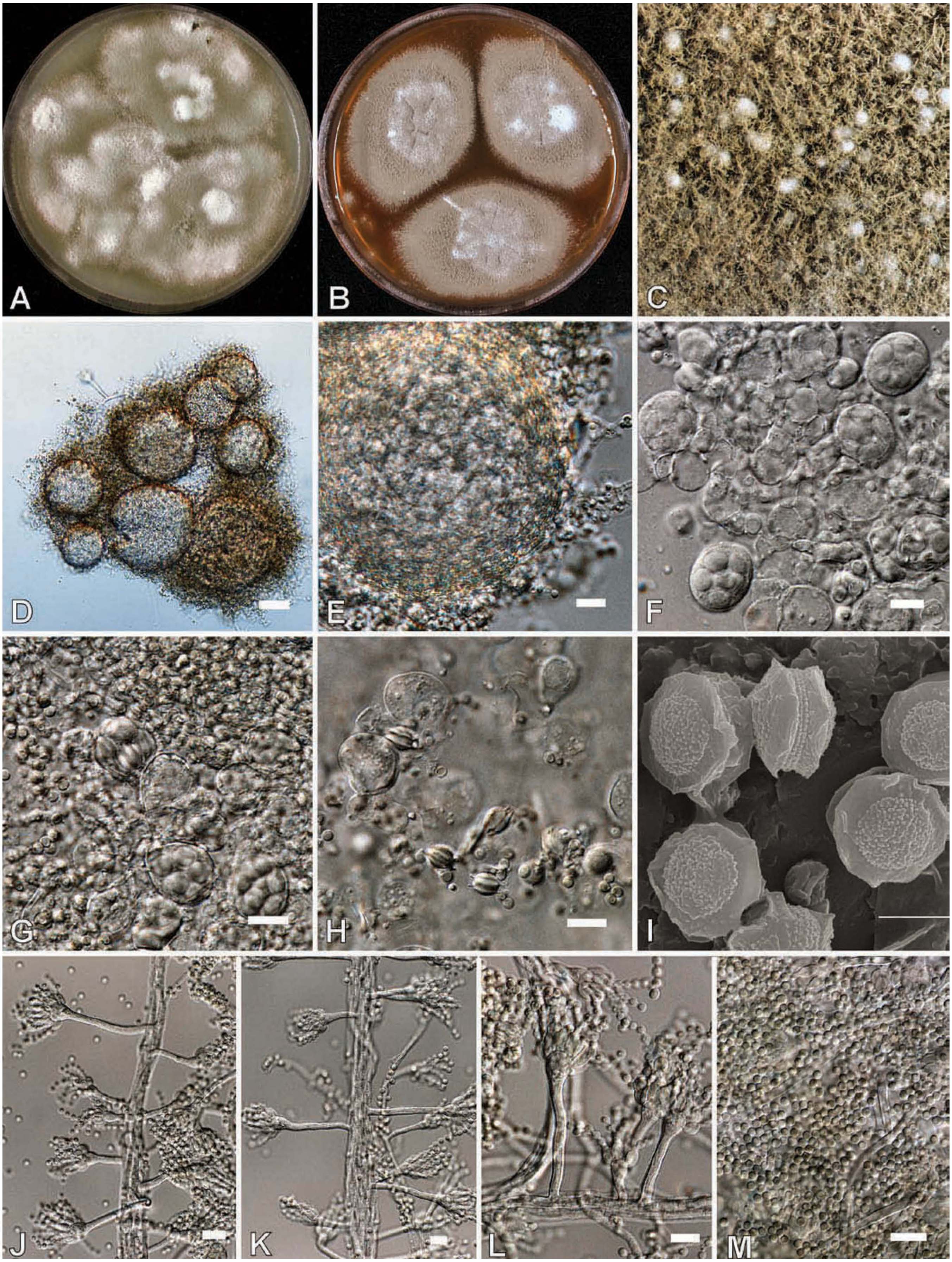

Fig. 25. *Neosartorya galapagensis*. A–B. Colonies 14 d 25 °C. A. CYA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.

Fig. 26. *Neosartorya glabra*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA, C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Fig. 27. *Neosartorya hiratsukae*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Neosartorya hiratsukae Udagawa, Tsubouchi & Horie [anamorph: *A. hiratsukae* Udagawa, Tsubouchi & Horie], Trans. Mycol. Soc. Japan 32: 23. 1991. Fig. 27.

Type: NHL 3008, from pasteurised aloe juice, Tokyo, Japan

Other no. of the type: CBS 294.93; NRRL 20819

Morphological characteristics
Colony diam (7 d): CZA25: 14–15 mm; CYA25: 12–14 mm; MEA25: 26–39 mm; YES25: 42–45 mm; OA25: 42–45 mm; CYA37: 27–30 mm; CREA: rather poor growth and no acid production
Colony colour: greyish green
Conidiation: moderate
Reverse colour (CZA): light brown
Colony texture: velutinous
Conidial head: short columnar
Stipe: 120–380 × 5–7 µm
Vesicle diam, shape: 15–24 µm, flask-shaped
Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, smooth or delicately roughened
Homothallic
Cleistothecia: 130–220 µm, light cream coloured
Ascospores: 4.5–5 µm, lenticular, with two closely appressed equatorial crests, convex surfaces finely reticulate

Cultures examined: CBS 294.93; IFM 50770 = IBT 27913

Diagnostic features: restricted growth on CZA, small cleistothecia, finely reticulate ascospores

Similar species: *N. fischeri, N. tatenoi*

Distribution: Japan, Brazil, South Korea

Ecology and habitats: soil, fruit juice, indoor air, human

Extrolites: avenaciolide

Pathogenicity: pathogenic to humans (Guarro *et al.* 2002; Mellado *et al.* 2006; Alcazar-Fuoli *et al.* 2007)

Note: no growth above 48 °C; some isolates carry dsRNA mycoviruses which are efficiently transmitted both through ascospores and conidia to the progeny (Varga *et al.* 1998)

Neosartorya laciniosa Hong, Frisvad & Samson [anamorph: *A. laciniosus* Hong, Frisvad & Samson], Int. J. Syst. Evol. Microbiol. 56: 477. 2006. Fig. 28.

Type: CBS 117721, from tomato field soil, Buyeo, Korea

Other no. of the type: NRRL 35589 = KACC 41657

Morphological characteristics
Colony diam (7 d): CYA25: 38–58 mm; MEA25: 53–67 mm; YES25: 60–78 mm; OA25: 52–59 mm; CYA37: 70–80 mm; CREA: poor growth and no acid production
Colony colour: white to pale yellow
Conidiation: sparse
Reverse colour (CYA): greyish orange to yellowish orange
Colony texture: sulcate, granular
Conidial head: columnar
Stipe: 3–4 µm wide
Vesicle diam, shape: 10–14 µm, subclavate
Conidium size, shape, surface texture: 2.5–3.5 µm, globose to subglobose, smooth
Homothallic
Cleistothecia: 300–400 µm, white to light yellow
Ascospores: 4–5 µm, broadly lenticular, with two distinct straight equatorial crests which are up to 2 µm

Cultures examined: CBS 117721; IBT 6660; KACC 41648; CBS 117719 = KACC 41652; KACC 41644

Diagnostic features: cleistothecia surrounded by a loose covering of hyaline to yellowish white, 2–4 µm wide hyphae; microtuberculate ascospores with two bent crests and two distinct equatorial rings of small projections

Similar species: *N. spinosa, N. coreana*

Distribution: South Korea, U.S.A., Pakistan, Netherlands, Suriname, Dominican Republic, Kenya

Ecology and habitats: soil

Extrolites: aszonalenins, tryptoquivaline, tryptoquivalone

Pathogenicity: not reported

Neosartorya multiplicata Yaguchi, Someya & Udagawa [anamorph: *A. muliplicatus* Yaguchi, Someya & Udagawa], Mycoscience 35: 309. 1994. Fig. 29.

Type: PF 1154, from soil, Taiwan

Other no. of the type: CBS 646.95, IBT 17517

Morphological characteristics
Colony diam (7 d): CYA25: 24–36 mm; MEA25: 35–50 mm; YES25: 38–42 mm; OA28–43 mm; CYA37: 41–80 mm, CREA: poor growth and no acid production
Colony colour: white
Conidiation: sparse
Reverse colour (CYA): greyish yellow to olivaceous buff
Colony texture: floccose
Conidial head: loosely columnar
Stipe: 20–160 × 2.5–4 µm
Vesicle diam, shape: 4–8 µm, flask-shaped to irregular
Conidium size, shape, surface texture: 2.5–4 µm, globose to subglobose, smooth
Homothallic
Cleistothecia: 100–300 µm, cream coloured
Ascospores: 4–5 µm, with a shallow furrow but without distinct equatorial crests, ornamented on surfaces by several linear ridges presenting ribbed or somewhat reticulate pattern

Cultures examined: CBS 646.95

Diagnostic features: can be distinguished from other species of *Neosartorya* by its almost globose ascospores, which have ribbed ornamentation with several linear ridges, and by the reduced production of its conidial heads on common media

Similar species: none

Distribution: Taiwan

Ecology and habitats: soil

Extrolites: helvolic acid

Pathogenicity: not reported

Fig. 28. *Neosartorya laciniosa*. A–B. Colonies 14 d 25 °C. A. MAA. B. CYA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

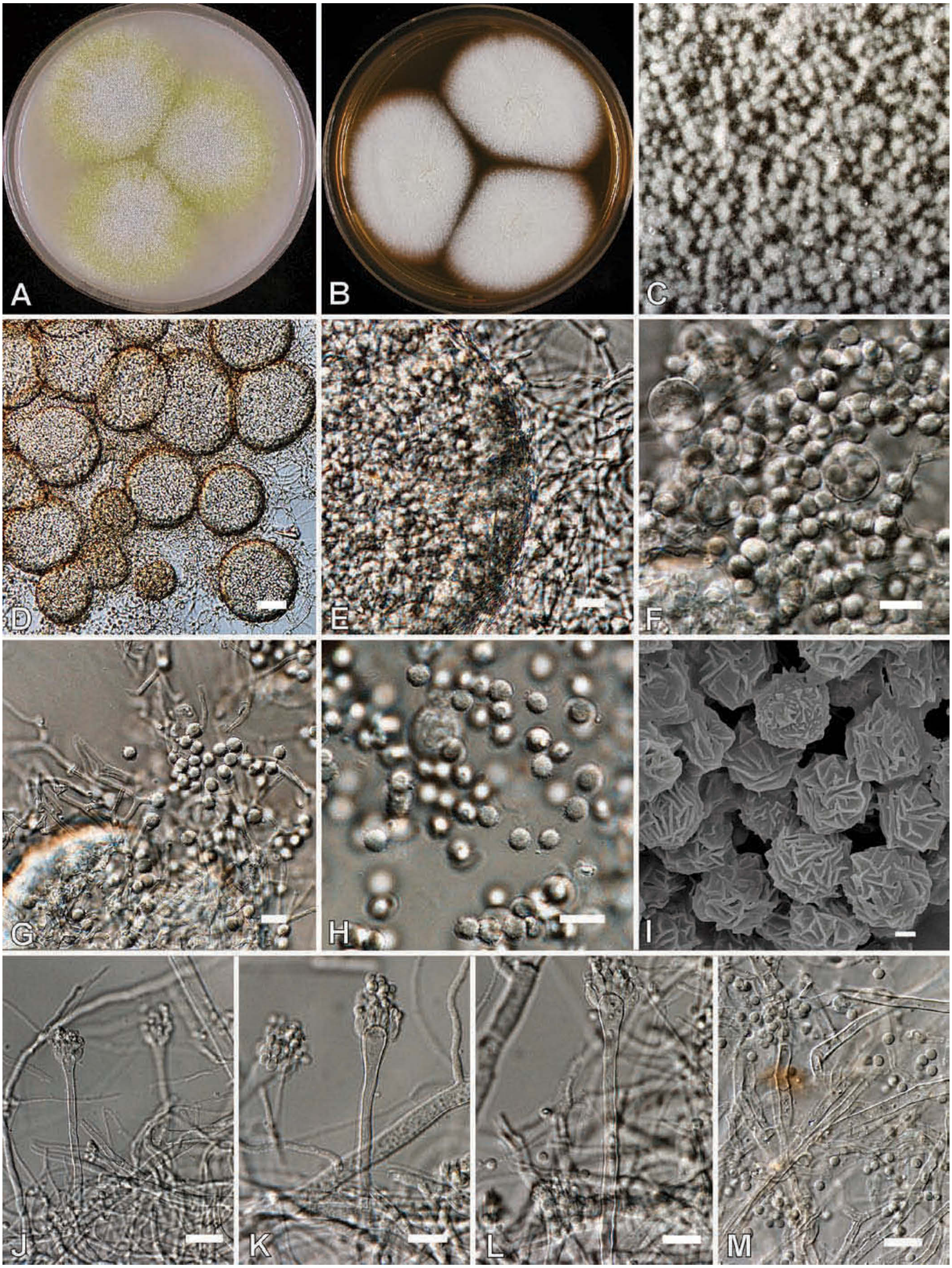

Fig. 29. *Neosartorya multiplicata*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C. Macroscopic view of the columnar conidial heads D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Fig. 30. *Neosartorya papuensis*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Neosartorya papuensis Samson, Hong & Varga, **sp. nov.** (Fig. 30) – MycoBank MB505571.

Homothallica; cleistothecia superficialia, luteoalba vel dilute lutea, globosa vel subglobosa, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci octospori, globosi vel subglobosi, 14–20 µm diam, evanescentes. Ascosporae 5.5–7.5 µm diam, cristis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnaria. Conidiophora ex hyphis aeriis exorientia, uniseriata, stipitibus 80–120 x 4–5 µm; vesiculae ampulliformes, 10–14 µm diam; phialides 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia globosa vel subglobosa, laevia, 2–3 µm diam. Coloniae in agaro MEA in 7 dieibus et 25 °C celeriter crescentes, 35–40 mm diam, albae, capitulis conidialibus paucis. Coloniae in agaro CYA in 7 dieibus et 25 °C 20–30 mm diam, cremeoalbae, centro ab hyphis aerialibus laxe obtecto; capitula conidialia pauca; colonia reversa luteoalba vel pallide lutea.

Holotype of *Neosartorya papuensis,* here designated as CBS 841.96[T] (dried culture), isolated from *Podocarpus* (Podocarpaceae), bark, Myola, Owen Stanley Range, Northern Province, Papua New Guinea.

Homothallic, cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 200–350 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 14–20 µm, evanescent at maturity. Ascospores 5.5–7.5 µm, with two equatorial crests, convex surface smooth microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae, uniseriate, stipes 100–150 × 4–5 µm; vesicles flask-shaped, 10–14 µm in diam.; phialides 7.5–9 x 2–3 µm, covering the upper half of vesicle. Conidia globose to subglobose, smooth, 2–3 µm. Colonies on MEA growing rapidly, 35–40 mm in 7 d at 25 °C, white. Conidial heads few in number. Colonies on CYA, 30–35 mm in 7 d at 25 °C, producing sectors, creamy white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow (12A23) (Kornerup and Wanscher 1978).

Etymology: isolated in Papua New Guinea

Extrolites: wortmannin-like

Distinguishing features: smooth microtuberculate 5.5–7.5 µm, ascospores

Other no. of the type: IBT 27801

Cultures examined: CBS 841.96

Similar species: *N. galapagensis, N. glabra, N. australensis*

Distribution: Papua New Guinea

Pathogenicity: not reported

Neosartorya pseudofischeri Peterson [anamorph: *A. thermomutatus* (Paden) Peterson], Mycol. Res. 86: 547. 1992. Fig. 31.

Type: NRRL 20748, from human vertebrae, Atlanta, Georgia, U.S.A.

Other no. of the type: CBS 208.92

Holotype: 404.67, moldy cardboard, Victoria, British Columbia, Canada

Morphological characteristics
Colony diam (7 d): CYA25: 60–70 mm; MEA25: 90 mm in 7 d
Colony colour: white to pale creamish
Conidiation: sparse
Reverse colour (CZA): clear or faintly yellowish
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 200–300 × 4–7 µm
Vesicle diam, shape: 10–17 µm, subglobose
Conidium size, shape, surface texture: 3–4 µm, globose to subglobose, smooth
Homothallic
Cleistothecia: 150–300 µm, white
Ascospores: 4.5–6 µm, subglobose, with two equatorial crests of 1 µm wide, convex surfaces with raiased flaps resembling triangular projections

Cultures examined: CBS 208.92, CBS 404.67

Diagnostic features: distinctly ornamented ascospores

Similar species: -

Distribution: U.S.A., Canada, Netherlands, South Korea, Spain, Denmark, Estonia

Ecology and habitats: soil, indoor, human

Extrolites: asperfuran, cytochalasin-like compound, fiscalin-like compound, pyripyropens, gliotoxin

Pathogenicity: pathogenic to humans (Padhye *et al.* 1994; Matsumoto *et al.* 2002; Jarv *et al.* 2004; Balajee *et al.* 2005a; Alcazar-Fuoli *et al.* 2007; Lau *et al.* 2007) and animals (Barrs *et al.* 2007)

Neosartorya quadricincta (J.L. Yuill) Malloch & Cain [anamorph: *A. quadricingens* Kozakiewicz], Can. J. Bot. 50: 2621. 1973. Fig. 32.

= *Neosartorya primulina* Udagawa, Toyaz. & Tsub. [anamorph: *A. primulinus* Udagawa, Toyaz. & Tsub.]

Type: CBS 135.52, from cardboard, York, U.K.

Other no. of the type: ATCC 16897; IMI 048583; IMI 048583ii; NRRL 2154; QM 6874; WB 2154

Morphological characteristics
Colony diam (7 d): CYA25: 26–42 mm; MEA25: 52–59 mm; YES25: 36–59 mm; OA25: 47–55 mm; CYA37: 50–58 mm; CREA: poor growth and no acid production
Colony colour (CZA): white to light tan
Conidiation: sparse
Reverse colour (CZA): colourless to flesh coloured
Colony texture: floccose
Conidial head: loosely columnar
Stipe: 400–500 × 2–7 µm
Vesicle diam, shape: 10–20 µm, flask shaped
Conidium size, shape, surface texture: 2–3 µm, elliptical to globose, microtuberculate
Homothallic
Cleistothecia: up to 300 µm, buff to light tan

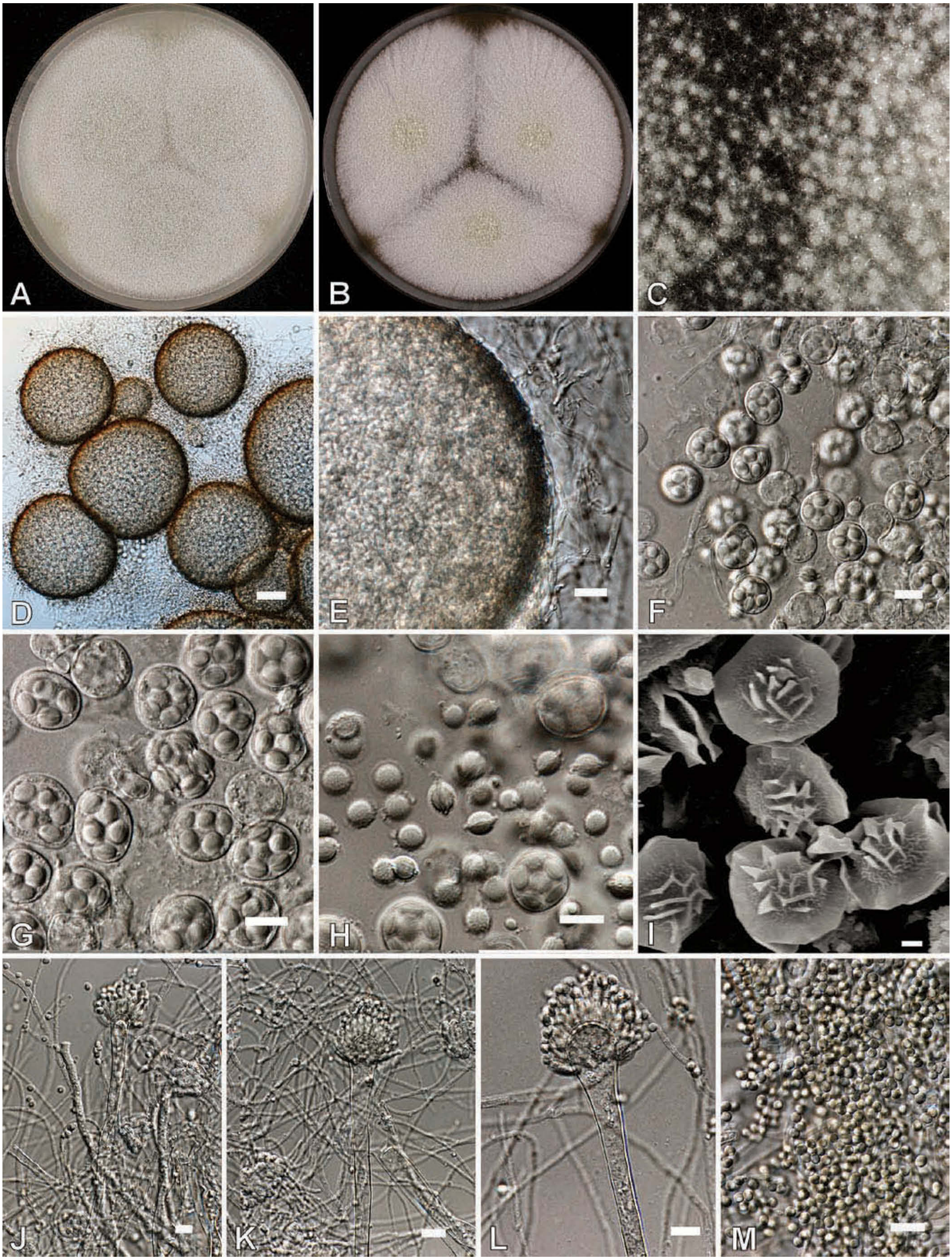

Fig. 31. *Neosartorya pseudofischeri*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Fig. 32. *Neosartorya quadricincta*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm , I = 1 µm.

Ascospores: 4–5 µm, with two prominent equatorial crests, each duplicated by a some-what less prominent band, reticulate

Cultures examined: CBS 135.52; WB 2221; WB 4175; CBS 100942

Diagnostic features: presence of 4 equatorial crests on ascospores, reticulate ascospore ornamentation

Similar species: -

Distribution: Suriname, South Korea, U.K., Netherlands, Australia

Ecology and habitats: Soil, pectin, cardboard, fruit juice, mango pulp

Extrolites: quinolactacin, aszonalenins

Pathogenicity: not reported

Note: some isolates carry dsRNA mycoviruses (Varga *et al.* 1998)

Neosartorya spathulata Takada & Udagawa [anamorph: *A. spathulatus* Takada & Udagawa], Mycotaxon 24: 395. 1985. Fig. 33.

Type: CBS 408.89 & CBS 409.89, from cultivated soil under *Alocasia macrorrhiza*, Taiwan

Other no. of the type: IMI 308593& IMI 308593; NHL 2948, NHL 2949; NRRL 20549 & NRRL 20550

Morphological characteristics
Colony diam (7 d): CZA25: 33–38 mm, MEA25: 80 mm; OA25: 40–46 mm
Colony colour: greyish green
Conidiation: abundant
Reverse colour (CZA): uncoloured
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 500–1500 × 11–18(–25) µm and 60–250 × 4–10 µm
Vesicle diam, shape: 25–52 µm and 8–15 µm, flask-shaped
Conidium size, shape, surface texture: 3–5.5 × 2–4.5 µm, ellipsoidal, smooth
Heterothallic
Cleistothecia: 100–260 µm, pale yellow to light yellow
Ascospores: 3.5–4 µm, lenticular, with two equatorial crests, convex surfaces nearly smooth

Cultures examined: CBS 408.89 & CBS 409.89

Diagnostic features: yellowish cleistothecia, ascospores with large equatorial crests and smooth surface, two types of conidial heads (diminutive??)

Similar species: -

Distribution: Taiwan

Ecology and habitats: soil

Extrolites: xanthocillins, aszonalenins

Pathogenicity: not reported

Neosartorya spinosa (Raper & Fennell) Kozakiewicz [anamorph: *A. spinosus* Kozakiewicz], Mycol. Pap. 161: 58. 1989. Fig. 34.

≡ *Aspergillus fischeri* var. *spinosus* Raper & Fennell 1965 (basionym)
= *Sartorya fumigata* var. *verrucosa* Udagawa & Kawasaki
= *Neosartorya botucatensis* Y. Horie, Miyaji & Nishim. [anamorph: *A. botucatensis* Y. Horie, Miyaji & Nishim.]
= *Neosartorya paulistensis* Y. Horie, Miyaji & Nishim. [anamorph: *A. paulistensis* Y. Horie, Miyaji & Nishim.]
? = *Neosartorya takakii* Horie, Abliz & K. Fukush. [anamorph: *A. takakii* Horie, Abliz & K. Fukush.]

Type: CBS 483.65, from soil, Nicaragua

Other no. of the type: ATCC 16898; IFO 8782; IMI 211390; NRRL 5034; WB 5034; IBT 3022

Morphological characteristics
Colony diam (7 d): CYA25: 41–70 mm; MEA25: 55–75 mm; YES25: 55–80 mm; OA25: 56–64 mm; CYA37: 67–85 mm; CREA: poor growth and no acid production
Colony colour (CZA): white to pale yellow to buff
Conidiation: sparse
Reverse colour (CZA): colourless to light pink
Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 12–18 µm, flask shaped
Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: 200–300 µm, cartridge buff
Ascospores: 4.5 µm, with two widely separated equatorial crests, with convex surfaces bearing spinelike projections

Cultures examined: CBS 483.65

Diagnostic features: have echinulate ascospores with spines ranging from <0.5 µm up to 7 µm long, or with verruculose and small triangular, sometimes circularly arranged, projections

Similar species: *N. coreana, N. laciniosa*

Distribution: Nicaragua, Kenya, Denmark, Dominican Rebublic, U.S.A., Belgium, Sudasn, Japan, India, pakistan, South Korea

Ecology and habitats: Soil, fruit juice, human

Extrolites: aszonalenins, 2-pyrovoylaminobenzamide, pseurotin

Pathogenicity: pathogenic to humans (Summerbell *et al.* 1992; Mellado *et al.* 2006; Gerber *et al.* 1973)

Neosartorya stramenia (R.O. Novak & Raper) Malloch & Cain [anamorph: *A. paleaceus* Samson & Gams], Can. J. Bot. 50: 2622. 1972. Fig. 35.

Type: CBS 498.65, soil from maple-ash-elm forest, Wisconsin, U.S.A.

Other no. of the type: ATCC 16895; IFO 9611; IMI 172293; WB 4652

Morphological characteristics
Colony diam (7 d): CYA25: 10–40; MEA25: 40–59 mm; YES25: 58–62 mm; OA: 56–60 mm; CYA37: 45–49 mm; CREA: poor growth and no acid production

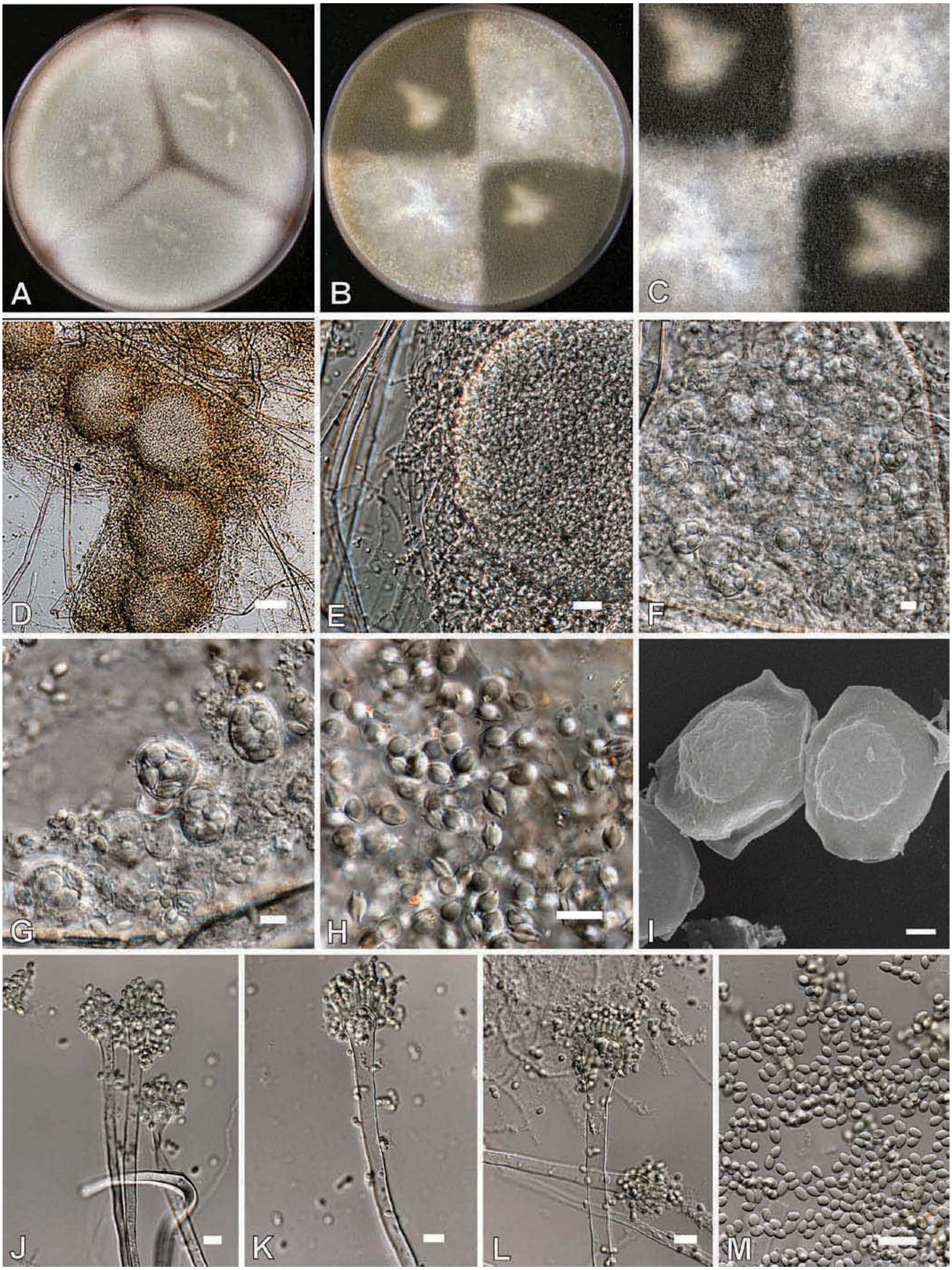

Fig. 33. *Neosartorya spathulata*. A–B. Colonies 14 d 25 °C. A. MEA. B–C. Crossing of mating types on MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

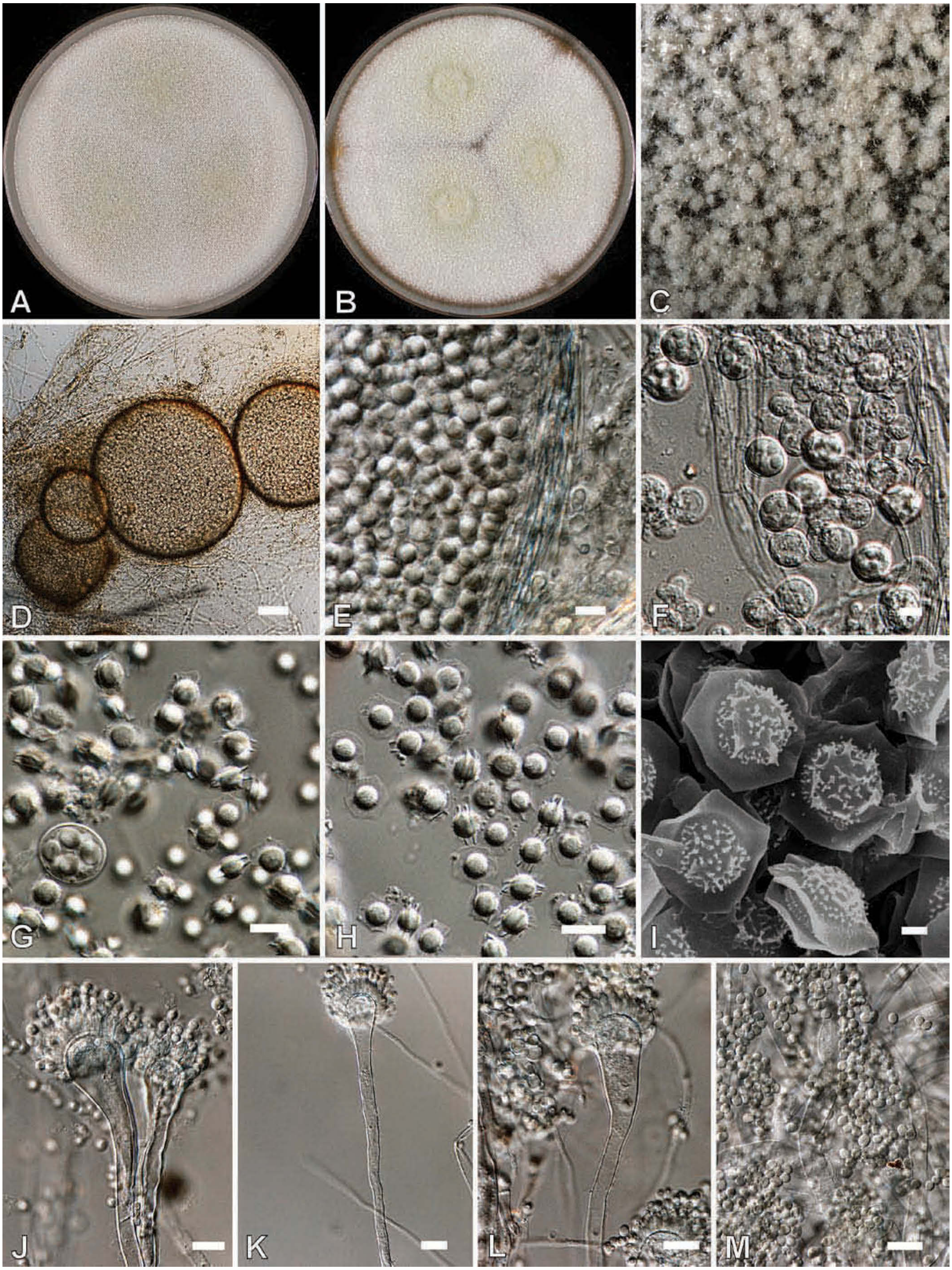

Fig. 34. *Neosartorya spinosa*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Colony colour (CZA): mustard-yellow
Conidiation: sparse
Reverse colour (CZA): yellow-orange
Colony texture: granulose
Conidial head: loosely columnar
Stipe: 80–140 × 3.5–5.5 µm, heavy walled, septate, coloured in terminal areas
Vesicle diam, shape: 10–12 µm, flask shaped to globose
Conidium size, shape, surface texture: 2.5–3 µm, globose, microverrucose
Homothallic
Cleistothecia: 50–175 µm, cartridge buff
Ascospores: 4.5–5.5 µm, with two widely separated flexuous equatorial crests, convex surfaces finely echinulate

Cultures examined: CBS 498.65; IFO 31358

Diagnostic features: faster growth rate and pronounced echinulate ascospore ornamentation distinguishes this species from *N. aurata*

Similar species: *N. aurata*

Distribution: U.S.A., Argentina

Ecology and habitats: Soil, salt grass (*Distichlis scoparia*)

Extrolites: quinolactacin, avenaciolide

Pathogenicity: not reported

Neosartorya tatenoi Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi [anamorph: *A. tatenoi* Y. Horie, M. Miyaji, K. Yokoy., Udagawa & Campos-Takagi], Trans. Mycol. Soc. Japan 33: 395. 1992. Fig. 36.
= *Neosartorya delicata* H.Z. Kong [anamorph: *A. delicatus* H.Z. Kong]

Type: CBM FA 0022, from soil, Brazil

Other no. of the type: CBS 407.93; IBT 21589

Morphological characteristics
Colony diam (7 d): CYA25: 35–39 mm mm; MEA25: 31–39 mm; YES25: 57–74 mm; OA25: 50–55 mm; CYA37: 72–78 mm; CREA: poor gowth and no acid production
Colony colour: pale yellow to yellowish white
Conidiation: sparse
Reverse colour (CZA): orange white to pale orange
Colony texture: velutinous to floccose
Conidial head: short columnar
Stipe: 270 × 4–7.5 µm
Vesicle diam, shape: 10–20 µm, hemispherical to flask-shaped
Conidium size, shape, surface texture: 2–3(–3.5) µm, globose to ovoid, smooth
Homothallic
Cleistothecia: 140–360 × 140–310 µm, hyaline to pale yellowish brown
Ascospores: 5–5.5 µm, lenticular, with two equatorial crests, convex surfaces with distinctly and nerrowly reticulate ridges

Cultures examined: CBS 407.93; NRRL 4584

Diagnostic features: distinct narrowly reticulate ascospore ornamentation

Similar species: *N. fischeri, N. multiplicata*

Distribution: Brazil, Dominican Republic

Ecology and habitats: soil

Extrolites: aszonalenins

Pathogenicity: not reported

Neosartorya udagawae Horie, Miyaji & Nishim. [anamorph: *A. udagawae* Horie, Miyaji & Nishim.], Mycoscience 36: 199. 1995. Fig. 37.

Type: CBM FA-0703 & CBM FA-0702, from soil, Brazil

Other no. of the type: CBS 114217 & CBS 114218

Morphological characteristics
Colony diam (7 d): CYA25: 33–36 mm; MEA25: 63–68 mm; YES25: 64–68 mm; OA25: 51–55 mm; CYA37: 61–65mm; CREA: poor growth and no acid production
Colony colour (CZA): dull green
Conidiation: abundant
Reverse colour (CZA): light orange to greyish orange
Colony texture: velutinous
Conidial head: columnar
Stipe: up to 530 × 4–6 µm
Vesicle diam, shape: 12–15 µm, hemispherical to flask shaped
Conidium size, shape, surface texture: 2.6–3.2 × 2.4–2.6 µm, subglobose to broadly ellipsoidal, smooth
Heterothallic
Cleistothecia: 310–620 x 280–530 µm, yellowish white to light yellow, surrounded by a loose covering of hyaline to pale yellowish brown hyphae
Ascospores: 5–5.5 × 4–5 µm, broadly lenticular, with two equatorial or often irregular crests, convex surfaces tuberculate

Cultures examined: CBS 114217, CBS 114218

Diagnostic features: heterothallic species, with characteristic tuberculate ascospore ornamentation

Similar species: *N. aureola, A. viridinutans*

Distribution: Brazil, U.S.A., Spain, Japan

Ecology and habitats: Soil, human

Extrolites: fumigatin, fumagillin, tryptoquivaline, tryptoquivalone

Pathogenicity: pathogenic to humans (Balajee *et al.* 2006; Moragues *et al.* 2006)

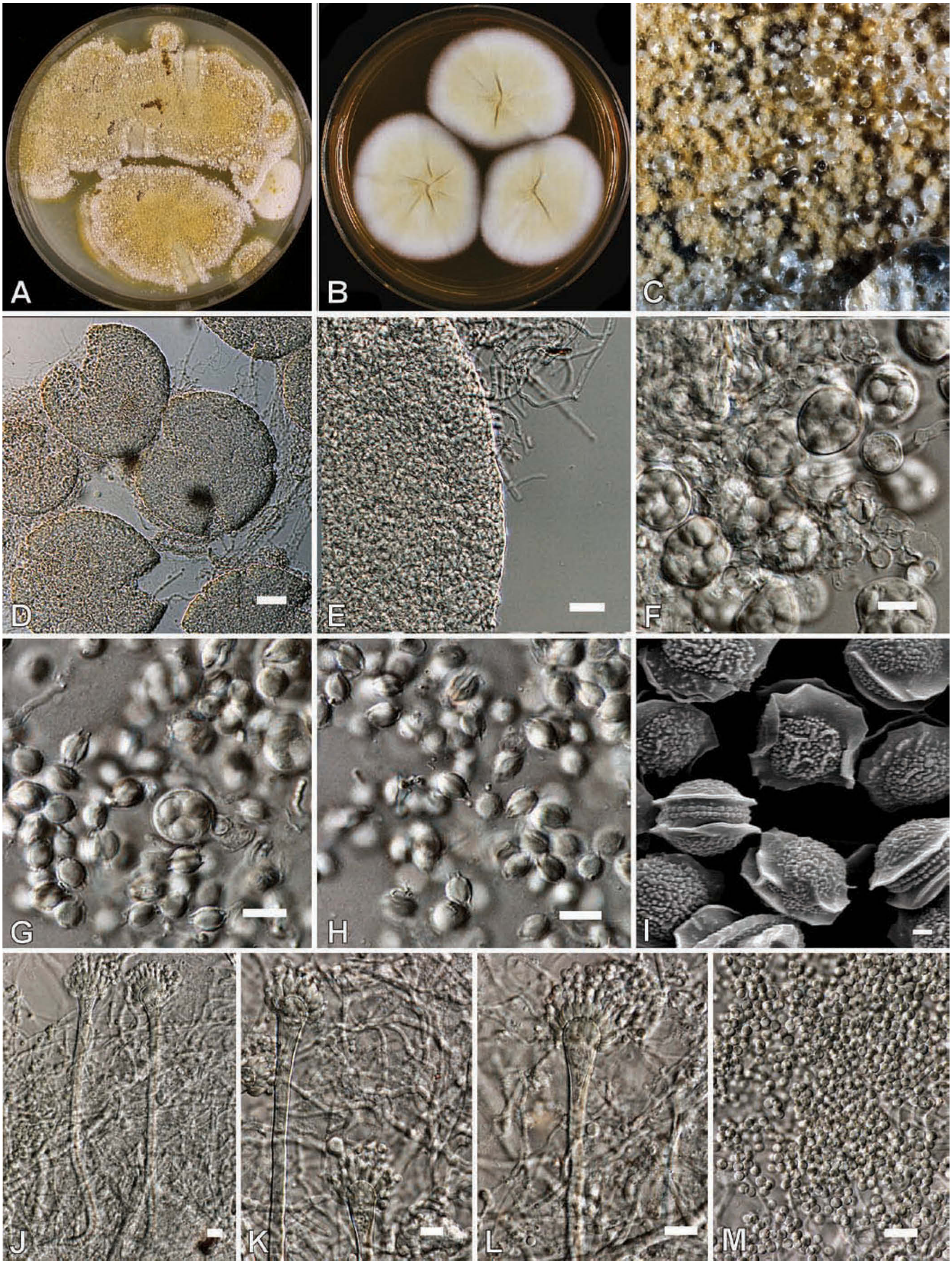

Fig. 35. *Neosartorya stramenia*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

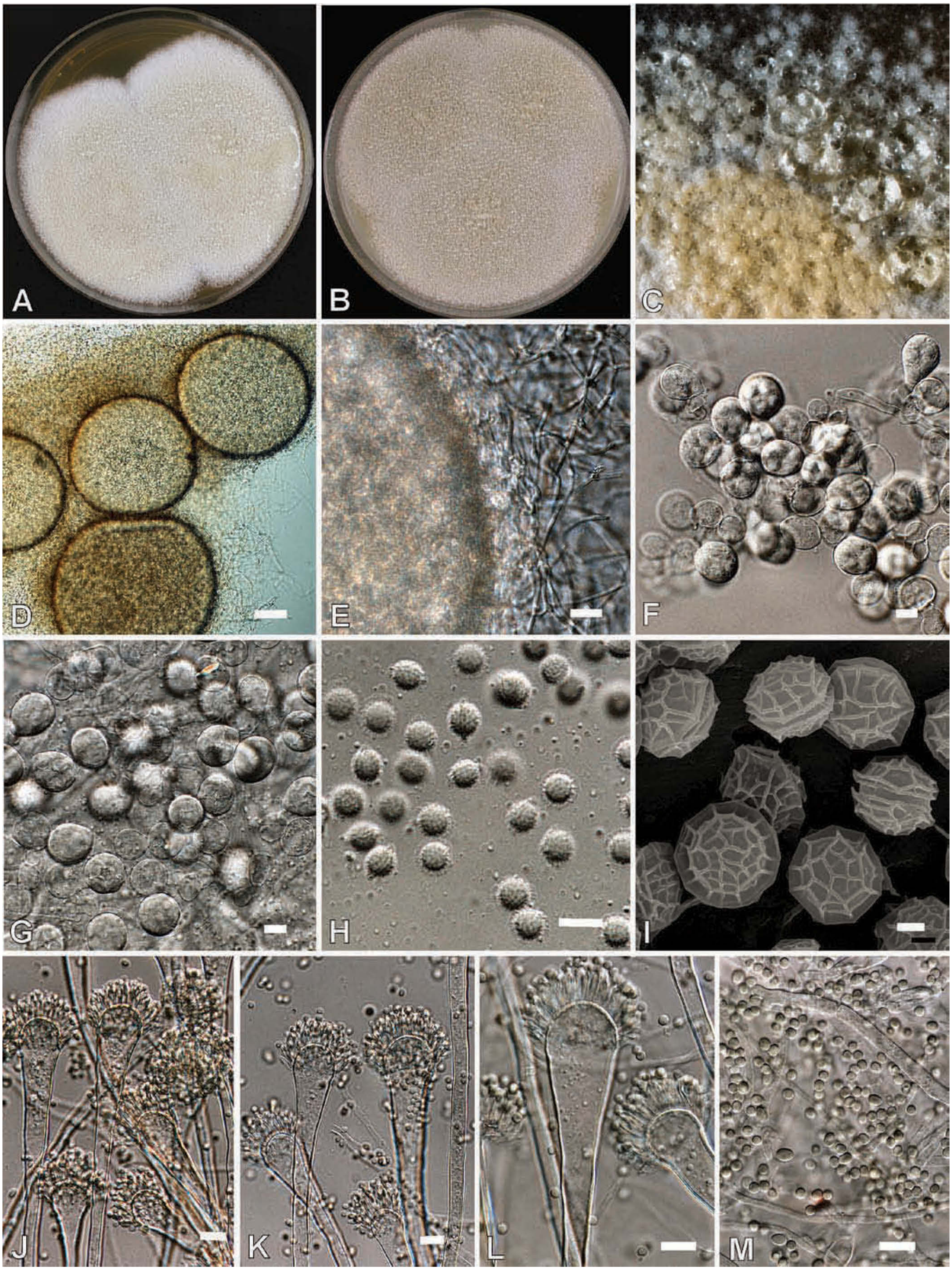

Fig. 36. *Neosartorya tatenoi*. A–B. Colonies 14 d 25 °C. A. MEA. B. OA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm¸ I = 1 µm.

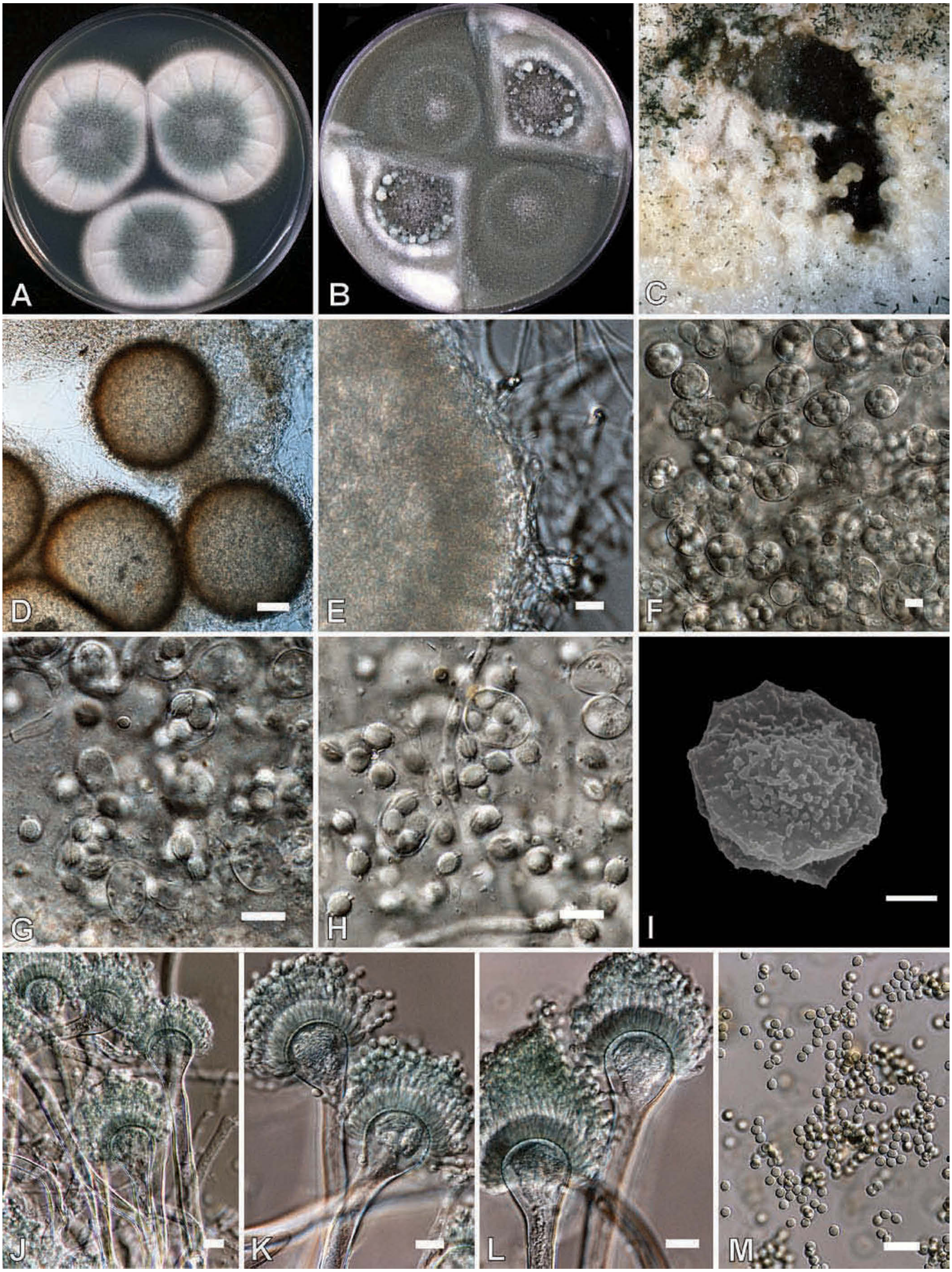

Fig. 37. *Neosartorya udagawae*. A–B. Colonies 14 d 25 °C. A. MEA. B. Crossing of mating types on MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

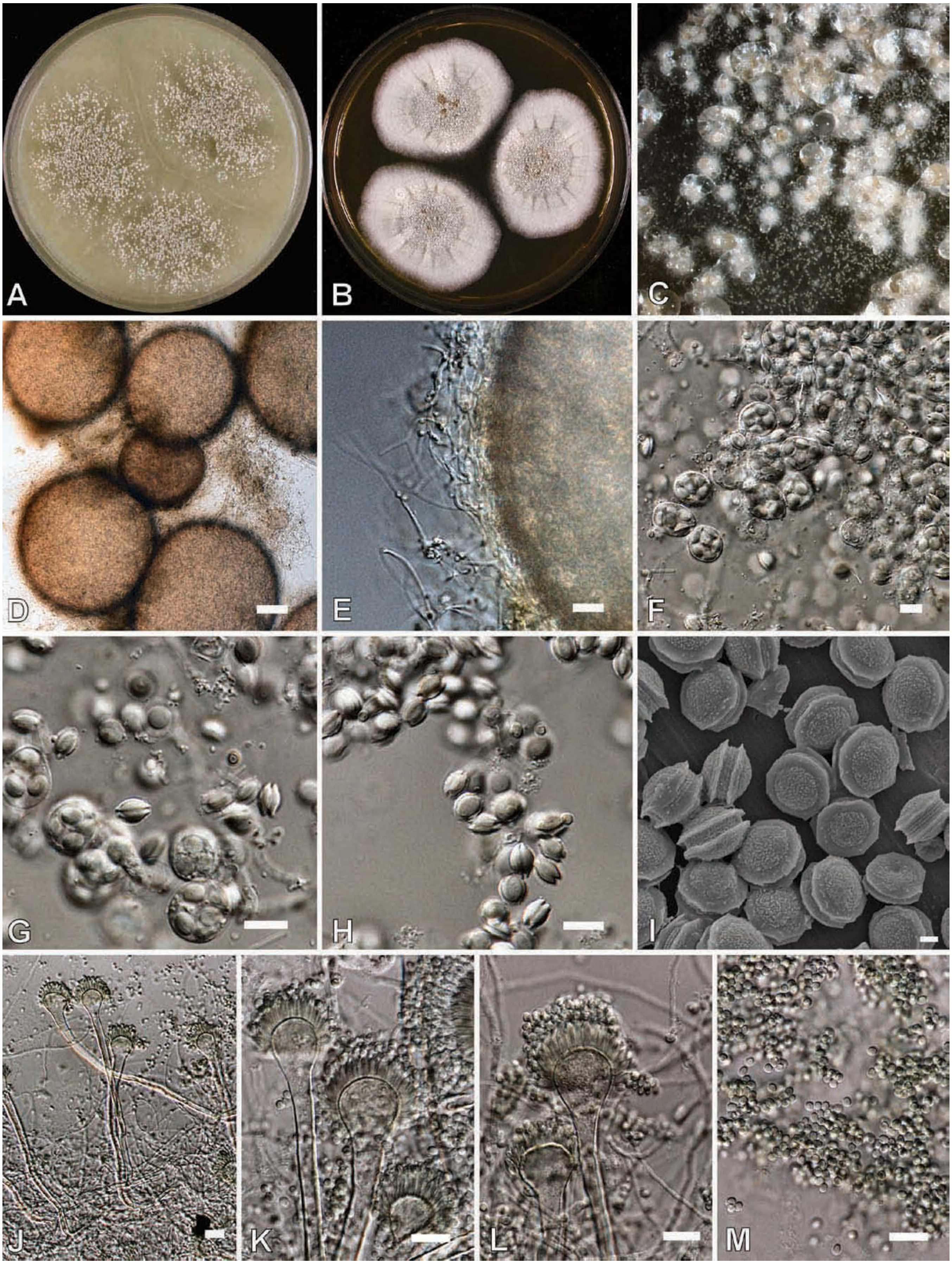

Fig. 38. *Neosartorya warcupii*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.

Neosartorya warcupii Peterson, Varga & Samson, **sp. nov.** (Fig. 38) – MycoBank MB505572.

Homothallica; cleistothecia superficialia, alba vel dilute lutea, globosa vel subglobosa, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, cristis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnaria. Conidiophora ex hyphis aeriis exorientia, uniseriata, stipitibus 100–150 x 4–5 µm; vesiculae ampulliformes, 10–25 µm diam; phialides 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobosa vel ellipsoidea, laevia, 1.8–1.5 µm diam. Coloniae in agaro MEA in 7 dieibus et 25 °C celeriter crescentes, 35–40 mm diam, albae, capitulis conidialibus paucis. Coloniae in agaro CYA in 7 dieibus et 25 °C 20–30 mm diam, cremeoalbae, centro ab hyphis aerialibus laxe obtecto; capitula conidialia pauca; colonia reversa luteobrunnea vel atrobrunnea.

Holotype of *Neosartorya warcupii,* here designated as NRRL 35723^{T} (dried culture), isolated from soil, Finder"s Range, Australia.

Homothallic, cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 180–350 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 10–16 µm, evanescent at maturity. Ascospores lens shapedm 4.5–7 µm, with two prominent equatorial crests, convex surface smooth to microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae, uniseriate, stipes 100–150 × 4–6 µm; vesicles subclavate to subglobose, 12–18 µm in diam; phialides 7.5–9 x 2–3 µm, covering the upper half of vesicle. Conidia globose to subglobose, smooth, 1.8–2.5 µm. Colonies on MEA growing rapidly, 35–40 mm in 7 d at 25 °C. Colonies on CYA, 18–22 mm in 7 d at 25 °C, creamish white, sectors frequently produced. Conidial heads few in number. Reverse bluish in colour.

Etymology: named after Prof. J. H. Warcup, eminent mycologist, who isolated this culture.

Extrolites: wortmannin-like, aszonalenin-like, chromanol-like, tryptoquivaline-like and tryptoquivalone-like

Distinguishing features: secretes a blue pigment to the medium in 7–10 d; relatively slow growth on CYA at 25 °C

Distribution: Australia

Ecology and habitats: soil

Pathogenicity: not reported

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