

Fig. 26. *Penicillium aethiopicum*. 7-day old colonies at (A) CYA, (B) MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. albocoremium (Frisvad) Frisvad, Int. Mod. Tax. Meth. Pen. Asp. Clas.: 275, 2000

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Corymbifera*

Type: Herb. IMI 285511, isotype Herb. C 60163

Culture ex type: IMI 285511 = CBS 472.84 = IBT 21502 = IBT 10682 = FRR 2931 = T12 (T,Y), ex salami, Hillerød, Denmark

Diagnostic features: Roquefortine C, meleagrins, orange brown reverse on CYA, smooth-walled conidia, warty conidiophore stipes, halotolerant, psychrotolerant.

Similar species: *P. albocoremium* differs from *P. tulipae* and *P. radicola* by its dark orange brown reverse on CYA and good sporulation on YES agar. *P. hirsutum* and *P. venetum* differ from *P. albocoremium* by their production of deep violet brown exudate.

Description:

Structure: Asymmetric terverticillate to quarterverticillate

Conidia: Smooth-walled, globose to subglobose, 3.1-4.5 µm

Phialides: 7.9-11.7 µm x 2.2-3.5 µm, with short collula

Metulae: Rough walled, cylindrical, 8.5-18.8 µm x 2.4-4.5 µm

Rami: 9.8-24.9 µm x 2.9-4.8 µm

Stipes: 150-2000 µm, very rough and warted

Synnemata or fasciculation: Fasciculate to coremiform, white stipes

Sclerotia: None

Colony texture: Floccose to fasciculate

Conidium colour on CYA: Greyish green to dull green

Exudate droplets on CYA: Copious, clear to pale yellow

Reverse colour on CYA: Brownish orange

Reverse colour on YES: Brownish yellow to orange

Diffusible colour on CYA: None

Ehrlich reaction: +, red violet

Odour and volatile metabolites: No data

Extrolites: 1) Roquefortine C & D, meleagrins; 2) Atrovenetin; 3) Cyclopeptin, dehydrocyclopeptin, cyclophenin, cyclophenol, viridicatin

Growth on creatine: Weak to moderate

Acid and base production on creatine: W/+ (no base)

Growth on UNO: Very good

Growth on nitrite: Weak

Abiotic factors:

Diam., 1 week, 25°C: CYA: 28-38 mm; MEA: 25-31 mm; YES: 48-60 mm; CREA: 18-28 mm; Cz: 14-20 mm, OAT: 23-27 mm; CYAS: 35-41 mm; CzBS: 12-17 mm; CzP: 0 mm; UNO: 8-14 mm; DG18: 33-43 mm

Diam., 1 week: 15°C: 32-35 mm; 30°C: 8-14 mm; 37°C: 0 mm

CYA/CYAS: 0.9 [0.8-1.0]: halotolerant

CYA15°C/CYA 25°C: 1.0 [0.9-1.1]

CYA30°C/CYA 25°C: 0.3 [0.3-0.4]

CZBS/CZ: 0.7 [0.5-0.9]

CZP/CZ: 0

Distribution: Denmark, Slovenia, Israel

Ecology and habitats: Roots of *Apium graveolens*, *Petroselinum crispum*, *Allium cepa*, and *Zingiber officinale*, on *Fragaria vespa*, cakes, salami and in a saltern.

Biotechnological applications: none

Biodeterioration & phytopathology: Possibly causing a rot of onions (*Allium cepa*)

Mycotoxins and mycotoxins: Roquefortine C has been listed as a neurotoxin (Cole and Cox, 1981)

Typical cultures: IBT 22806 = CBS 109583, ex saltern, Slovenia; IBT 22521 = CBS 109585, ex *Allium cepa*, Denmark; IBT 21071 = CBS 109584, ex *Zingiber officinale* imported to Denmark; IBT 12813 = CBS 109587 = NRRL 941 = Thom 4733.48 (identified by Biourge as *P. corymbiferum*, identified as *P. cyclopium* by Raper and Thom, 1949); IBT 16884 = CBS 320.97 = CBS 109586, ex *Allium cepa*, Denmark; IBT 20068 = CBS 109582, ex cake, Denmark; IBT 19154 = CBS 109614, cake, Denmark; IBT 3457 & IBT 10673, ex *Fragaria vesca*, Denmark; IBT 3891 & IBT 10672 ex *Apium graveolens*, Denmark; IBT 10679, ex food, Denmark; IBT 10683, IBT 10685 & IBT 10689, ex indoor air, Denmark; IBT 10689, ex salami, Denmark; IBT 13001 ex *Petroselinum crispum*, Denmark; IBT 19397 ex date imported to Denmark; IBT 21596, ex *Allium cepa*, Denmark.

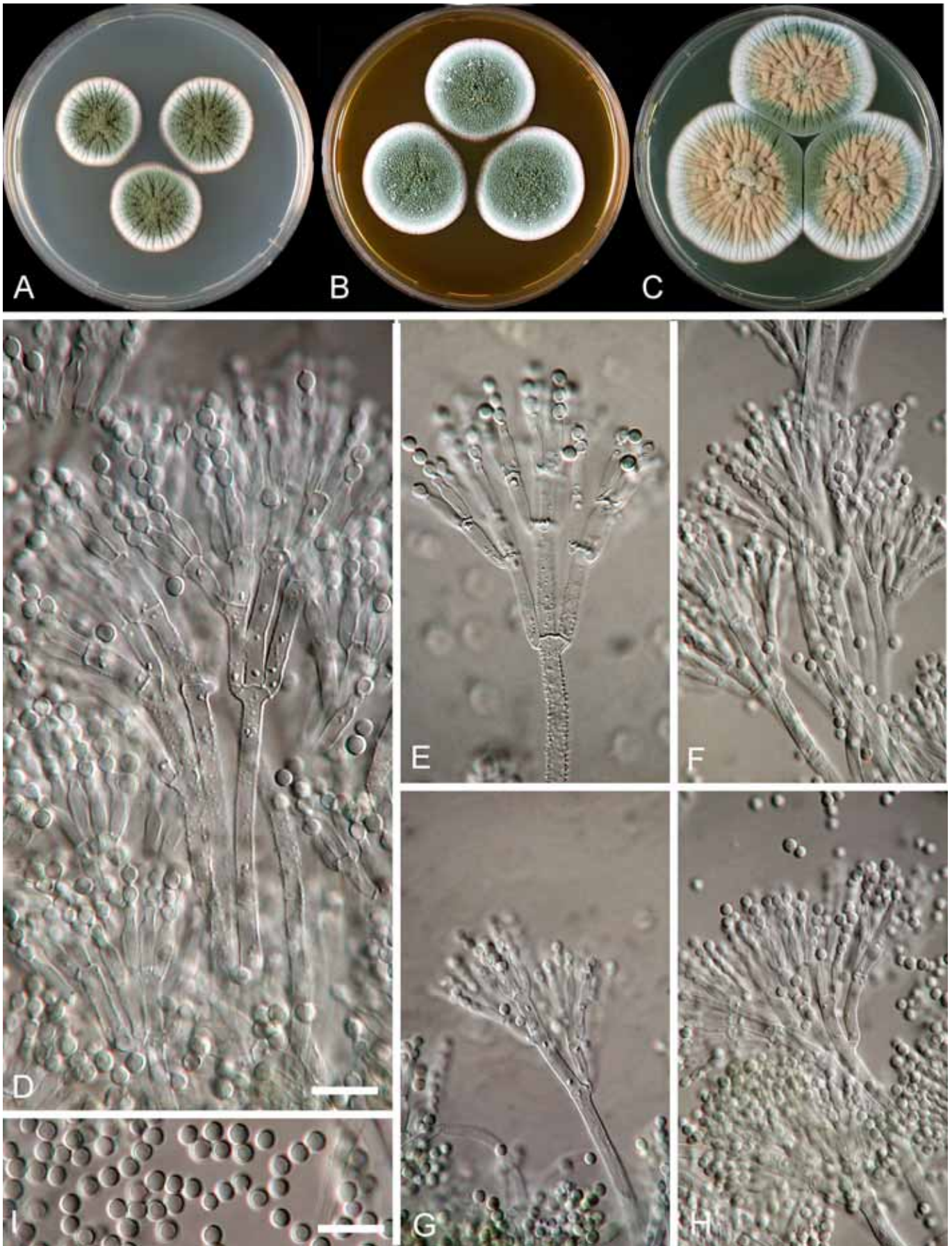


Fig. 27. *Penicillium albocoremium*. 7-day old colonies at (A) CYA, (B), MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. allii Vincent and Pitt, Mycologia 81: 300, 1989

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Corymbifera*

Type: Herb. MU Vincent 114

Culture ex type: CBS 131.89 = IBT 21503 = IBT 6610 = ATCC 64868 = FRR 3184 (T,Y), ex garlic, Egypt

Diagnostic features: Smooth-walled conidia, fulvic acid or analogues, a dark brown reverse, garlic rot

Similar species: *P. allii* differs from *P. hirsutum* by not being coremiform and by fewer and more lightly coloured exudates droplets. It differs from *P. albocoremium*, *P. radicola* and *P. tulipae* by its much darker brown reverse.

Description:

Structure: Terverticillate, some irregular structures

Conidia: Smooth-walled, globose 3.0-4.5 µm

Phialides: 6.5-11 µm x 2.8-3.2 µm

Metulae: 7.5-13 µm x 2.2-3.8 µm

Rami: 10-25 µm x 3.2-4.5 µm

Stipes: Short, rough-walled, 75-400 µm x 3.5-5 µm

Synnemata or fasciculation: Weakly fasciculate (especially on OAT)

Sclerotia: None

Colony texture on CYA: Granular to weakly fasciculate, only sulcate in center of colony

Conidium colour on CYA: Dull green

Exudate droplets: Small clear, yellow or brown on CYA

Reverse colour on CYA: Dark brown

Diffusible colour on CYA: Amber to brown, often produced

Reverse colour on YES: Yellow brown to dark yellow brown

Ehrlich reaction: Pink to red

Odour and volatile metabolites: Isobutanol, isopentanol, several terpenes (Larsen and Frisvad, 1995)

Extrolites: 1) Roquefortine C, meleagrins, oxalines; 2) Cyclopeptin, dehydrocyclopeptin, cycloopenin, cycloopenol, viridicatin, viridicatol; 3) Atrovenetins; 4) Dehydrofulvic acid, PI-3 and fulvic acid; 5) Chrysogine.

Growth on creatine: Weak

Acid and base production on creatine: No or weak acid, no base

Growth on UNO: Good

Growth on nitrite: Weak to moderate

Abiotic factors:

Diam., 1 week, 25°C: CYA: 26-40 mm (35-45 mm*); MEA: 20-37 mm (35-45 mm*); YES: 31-54 mm; CREA: 10-24 mm; Cz: 14-24 mm, OAT: 17-36 mm; CYAS: 27-39 mm; CzBS: 0-7 mm; CzP: 0 mm; UNO: 13-20 mm; DG18: 19-30 mm

Diam., 1 week: 5°C: 0 mm; 15°C: 24-30 mm; 30°C: 1-5 mm; 37°C: 0 mm

CYA/CYAS: 0.8 [0.8-0.9], halotolerant

CYA15°C/CYA 25°C: 1.0 [0.9-1.1], psychrotolerant

CYA30°C/CYA 25°C: 0.1 [0.04-0.2]

CZBS/CZ: 0 (one isolate 0.5)

CZP/CZ: 0

* According to Vincent and Pitt (1989)

Distribution: Egypt, Argentina, Korea, Spain, Czech Republic, Germany, United Kingdom, Denmark, Georgia, USA, Ontario, Canada.

Ecology and habitats: Garlic, occasionally in onions and rice.

Biotechnological applications: None

Biodeterioration & phytopathology: *P. allii* produces a severe rot in garlic (Vincent and Pitt, 1989; Frisvad and Filtenborg, 1989).

Mycotoxins and mycotoxins: Only roquefortine C is a known mycotoxin.

Typical cultures: IBT 20212 = CBS 875.95, ex garlic, Spain; IBT 4112 = CBS 109581 = CCF 1875 = IMI 297905, ex *Oryza sativa*, Czech Republic; IBT 14490 = CBS 109578, Georgia, USA; IBT 13030 = CBS 411.92, ex garlic, Korea; IBT 11735 = CBS 109579, ex walnut surface; IBT 3772 = IBT 3056 = CBS 188.88, ex food, United Kingdom; IBT 5553 = CBS 109580 = ATCC 64636 = IMI 321505 = NRRL 13630, ex garlic, Denmark; CBS 161.42 = ATCC 8507 = FRR 942 = IMI 039803 = MUCL 29086 = MUCL 29176 = NRRL 942 = IBT 4515 = IBT 5460 (as *P. cyclopium*); FRR 1668 = IMI 192216, ex soil, Egypt; IMI 321506, ex garlic, Denmark, IBT 24593, ex garlic Argentina, CBS 409.92 & 410.92, ex onion, Korea.

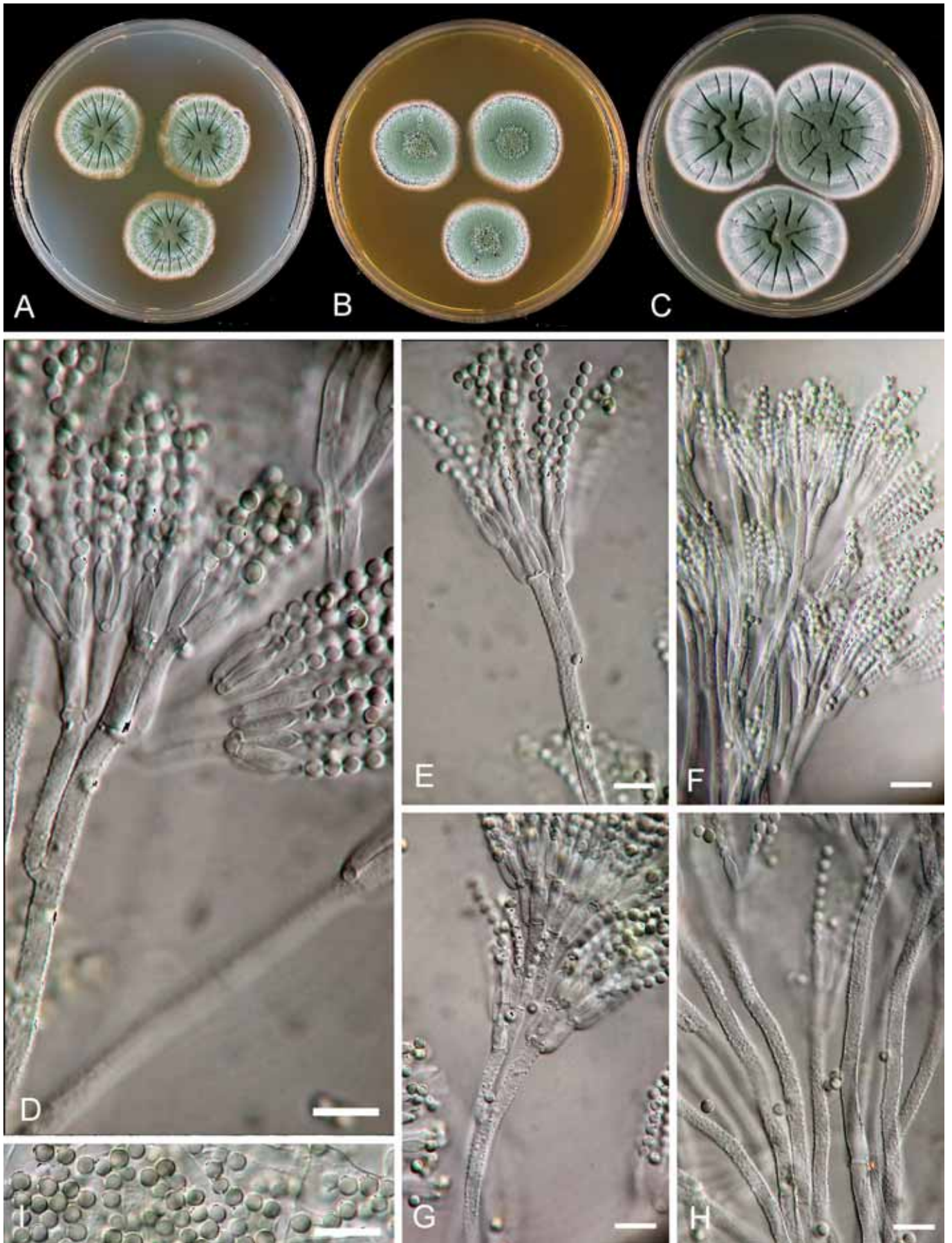


Fig. 28. *Penicillium allii*. 7-day old colonies at (A) CYA, (B), MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. atramentosum Thom, Bull. Bur. Anim. Ind. US Dept. Agric. 118: 65, 1910

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Camemberti*

Type: Herb. IMI 039752

Culture ex type: CBS 291.48 = IBT 6616 = ATCC 10104 = FRR 795 = IFO 8137 = IMI 039752ii = MUCL 29071 = MUCL 29126 = NRRL 795 = QM 7483 (T), ex French camembert cheese, USA.

Diagnostic features: globose smooth-walled conidia, good growth on CREA with no acid production, no growth at 30°C, production of oxaline, rugulovasins and ethyl-2-methyl-butanoate

Similar species: *P. atramentosum* differs from *P. chrysogenum* by its dark brown reverse and ability to grow on CREA. It differs from members of series *Roqueforti* by its smooth conidiophore stipes and from other species by its alkali tolerance and inability to produce acid on CREA.

Description:

Conidia: smooth-walled, globose to subglobose, 2.3-3.0 µm
Phialides: cylindrical with short collula, 7.5-10 µm x 2.3-2.5 µm

Metulae: Cylindrical, 10-15 µm x 2.5-3.0 µm

Rami: One or two, often somewhat divergent, 15-20 µm x 3.0-4.0 µm

Stipes: Long 300-500 µm, smooth-walled (finely roughened in CBS 109601), from subsurface hyphae

Synnemata or fasciculation: None

Sclerotia: None

Colony texture on CYA: Velutinous

Conidium colour on CYA: Dark green

Exudate droplets on CYA: Small droplets often produced, pale to dark red brown

Reverse colour on CYA: Dark brown to rosy brown

Diffusible colour: Brownish orange

Ehrlich reaction: None, a violet reaction may be observed in particular good rugulovasine producers

Odour and volatile metabolites: Ethyl-2-methyl-butanoate, ethyl isopentanoate, ethyl acetate, methyl isobutanoate, ethyl isobutanoate, isobutyl acetate (Larsen and Frisvad, 1995)

Extrolites: 1) Roquefortine C & D, meleagrins, oxaline, neoxaline, 2) Rugulovasine A and B

Growth on creatine: Very good

Acid and base production on creatine: No acid produced

Growth on UNO: Very good

Growth on nitrite: Good growth

Abiotic factors:

Diam., 1 week, 25°C: CYA: 23-39 mm (30-45 mm*); MEA: 13-34 mm (20-30 mm*); YES: 29-49 mm; CREA: 9-28 mm; Cz: 14-25 mm, OAT: 10-32 mm; CYAS: 29-32 mm; CzBS: 0-15 mm; CzP: 0 mm; UNO: 9-16 mm; DG18: 24-33 mm

Diam., 1 week: 15°C: 20-25 mm; 30°C: 0 mm; 37°C: 0 mm
CYA/CYAS: 1.0 [0.8-1.2]

CYA15°C/CYA 25°C: 0.7 [0.6-1.0]

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0 or 0.6 [0 or 0.4-0.8]

CZP/CZ: 0

Distribution: Denmark, Norway, Iceland, UK, the Netherlands, Switzerland, Slovenia, Spain, Costa Rica, Ontario, Canada, Tanzania, Australia, New Zealand, Japan; when found in the tropics usually found at higher elevations.

Ecology and habitats: Camembert, Danbo, Emmentaler and Gammelost cheeses, blood sausage, walnuts, soil, especially chalky soil, limestone quarries.

Biotechnological applications: None

Biodeterioration & phytopathology: Found on mouldy cheeses and sausages.

Mycotoxins and mycotoxins: Roquefortine C and rugulovasine A and B have been listed as mycotoxins (Cole and Cox, 1981).

Typical cultures: IBT 21504 = CBS 194.88 (Y), pig feed, Norway; IBT 21193 = CBS 109588, Mbizi rainforest soil, Ufipa Plateau, 2000 m elev., Tanzania; IBT 11800 = CBS 490.84 = IMI 285530 = FRR 2947, *Capsicum anuum*, Denmark; IBT 13139 = CBS 109601 = WT 37, ex soil, conifer forest, Switzerland; IBT 10565 = CBS 109611, soil, Urmston, UK; IBT 11801 = CBS 109613, hay, Iceland; IBT 14762 = CBS 109612, cheese, Hjørring, Denmark; IBT 23031 = CBS 243.73, ex man, Netherlands; IBT 22273, ex soil, Wilson Botanical Garden, Costa Rica, 1100 m elev.; IBT 15294, ex *Thymus vulgaris* imported to Denmark; IBT 4719 = FRR 1446 = IMI 192501, ex soil, Turrumurra, N.S.W., Australia; IBT 3417, rye bread, Denmark; IBT 3421, ex soil, the Netherlands; IBT 18891, ex air, Cake factory, Denmark, IBT 3420, ex agricultural soil, IBT 23511, New Zealand; IBT 24774, saltern, Slovenia

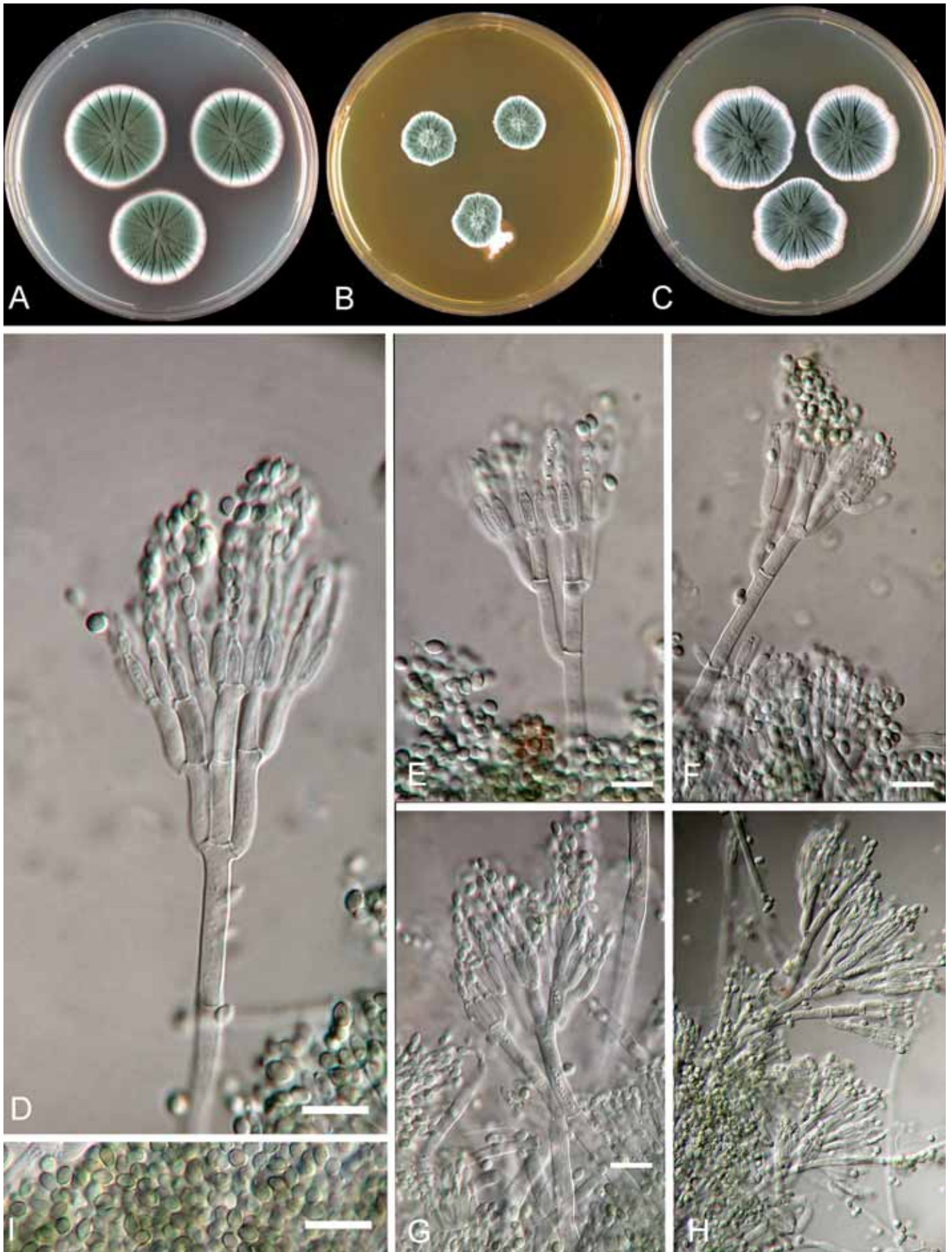


Fig. 29. *Penicillium atramentosum*. 7-day old colonies at (A) CYA, (B), MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. aurantiogriseum Dierckx, Ann. Soc. Scient. Brux. 25: 88, 1901

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Viridicata*

Type: Herb. IMI 195050

Culture ex type: CBS 324.89 = IBT 14016 = IMI 195050 = ATCC 48920 = NRRL 971 = IBT 13458 = IBT 3502 = FRR 971 (T)

Diagnostic features: Anacine, aurantiamin, auranthine, penicillic acid, verrucosidin, pseurotin, smooth-walled conidia, dark brown halo on Raulin-Thom agar.

Similar species: *P. aurantiogriseum* can be distinguished from *P. viridicatum*, *P. melanoconidium* and *P. tricolor* by its blue green conidia. It differs from *P. freii* by its warm orange reverse and poor production of exudates droplets and from *P. polonicum* by its much slower growth rate on CYA. It differs from *P. cyclopium* by its more blue conidia on CYA and its better sporulation and more white obverse mycelium on YES. It differs from *P. neoehinulatum* by its smooth walled conidia.

Description:

Conidiophores terverticillate, few biverticillate and quarterverticillate
Conidia: 3-4 x 2.5-3.5 µm, globose to subglobose (rarely ellipsoidal), smooth-walled,
Phialides: 7.5 -10 µm x 2.5-2.8 µm, cylindrical with collula
Metulae: 10-13 µm x 2.8-3.5 µm
Rami: 15-25 µm x 3-3.5 µm
Stipes: 180-400 µm x 3-4 µm, from subsurface hyphae, walls smooth to finely roughened
Sclerotia or fasciculation: Weak fasciculation
Sclerotia: None
Colony texture: Velutinous to weakly fasciculate
Conidium colour on CYA: Blue green to grey green to dark dull green
Exudate droplets on CYA: Occasionally present, pale or light brown
Reverse colour on CYA: Curry-yellow to warm orange to reddish brown
Reverse colour on YES: Yellow
Diffusible colour: Often present, orange to red brown
Ehrlich reaction: Pink
Odour and volatile metabolites: Isobutanol, isopentanol, 3-heptanone, 3-octanone (Larsen and Frisvad, 1995)
Extrolites: 1) Anacine, 2) Aurantiamin, 3) Auranthine, 4) Penicillic acid, 5) Verrucosidin and normethylverrucosidin, 6) Pseurotin, 7) Terrestrial acid and viridicatic acid, 8) Nephrotoxic glycopeptides
Growth on creatine: Weak to moderate
Acid and base production on creatine: Strong acid production, no base production
Growth on UNO: Weak
Growth on nitrite: Very weak

Abiotic factors:

Diam., 1 week, 25°C: CYA: 11-32 mm; MEA: 16-40 mm; YES: 24-46 mm; CREA: 12-29 mm; Cz: 19-27 mm, OAT: 15-35 mm; CYAS: 23-38 mm; CzBS: 19-28 mm; CzP: 0 mm; UNO: 6-11 mm; DG18: 19-28 mm
Diam., 1 week: 15°C: 16-23 mm; 30°C: 12-17 mm; 37°C: 0 mm
CYA/CYAS: 0.7 [0.6-1.0], halotolerant
CYA15°C/CYA 25°C: 0.9 [0.7-1.3]
CYA30°C/CYA 25°C: 0.7 [0.6-0.7]
CZBS/CZ: 0.9 [0.7-1.0]
CZP/CZ: 0
RT: Strong reaction, dark brown halo and reverse

Distribution: Denmark, Sweden, United Kingdom, Germany, Norway, Czech Republic, former Yugoslavia, Bulgaria, Russia, Iran, New South Wales, Australia, Argentina, USA, Canada

Ecology and habitats: Cereals and foods and feeds based on cereals, less common in onions, garlic, also found in soil.

Biotechnological applications: None

Biodeterioration & phytopathology: This species is a major agent deteriorating cereals at cool temperatures.

Mycotoxins and mycotoxins: This species produces a mixture of mycotoxins: penicillic acid, verrucosidin and nephrotoxic glycopeptides. The toxicity of the many alkaloids produced is unknown. This species and *P. polonicum* may be involved in Balkan Endemic Nephropathy (Barnes *et al.*, 1977, Macgeorge and Mantle, 1990, 1991; Mantle *et al.*, 1991; Mantle and McHugh, 1993, Mantle, 1993; Lund and Frisvad, 1994, Frisvad, 1995). The original isolate (IMI 180922A) investigated by Barnes *et al.* (1977) as *P. aurantiogriseum* was correctly identified, while most of the other strains subsequently identified as such or as *P. commune* (Macgeorge and Mantle, 1990) were in fact *P. polonicum* (Frisvad, 1995).

Typical cultures: IBT 11325 = IBT 21505 = CBS 792.95 (Y), ex apple juice production plant, Denmark; IBT 11252 = CBS 642.95, ex chicken feed, Denmark; IBT 5134 = CBS 112021 = NRRL 3672; IBT 14264 = CBS 110327 = NRRL 953; IBT 15986 = CBS 112023, ex mixed pig feed, Stara Zagova, Bulgaria; IBT 13169 = CBS 110329 = RMF 7862, ex soil, Wyoming, USA; IBT 12482 = CBS 110330, ex wheat, Canada; IBT 24592, garlic, Argentina; IBT 22509, waste, Germany; IBT 11624, IBT 11635; IBT 12954, IBT 12480, IBT 11660 & IBT 11672, ex wheat, Canada; IBT 21558, Czech Republic; IBT 5268 = CCF 1275; IBT 11293, ex barley, Denmark; IBT 11321 = NRRL 3564; IBT 11309 = NRRL 3612; IBT 12834 = NRRL 3747; IBT 12836 = NRRL 6317; IBT 12726 = NRRL 6318; IBT 11301 = IMI 092235; IBT 3992 = IMI 180922A; IBT 14454, ex Lechuquilla Cave, Carlsbad, New Mexico, USA; IBT 12716, ex kangaroo rat, New Mexico, USA; VKM F-232, Russia.

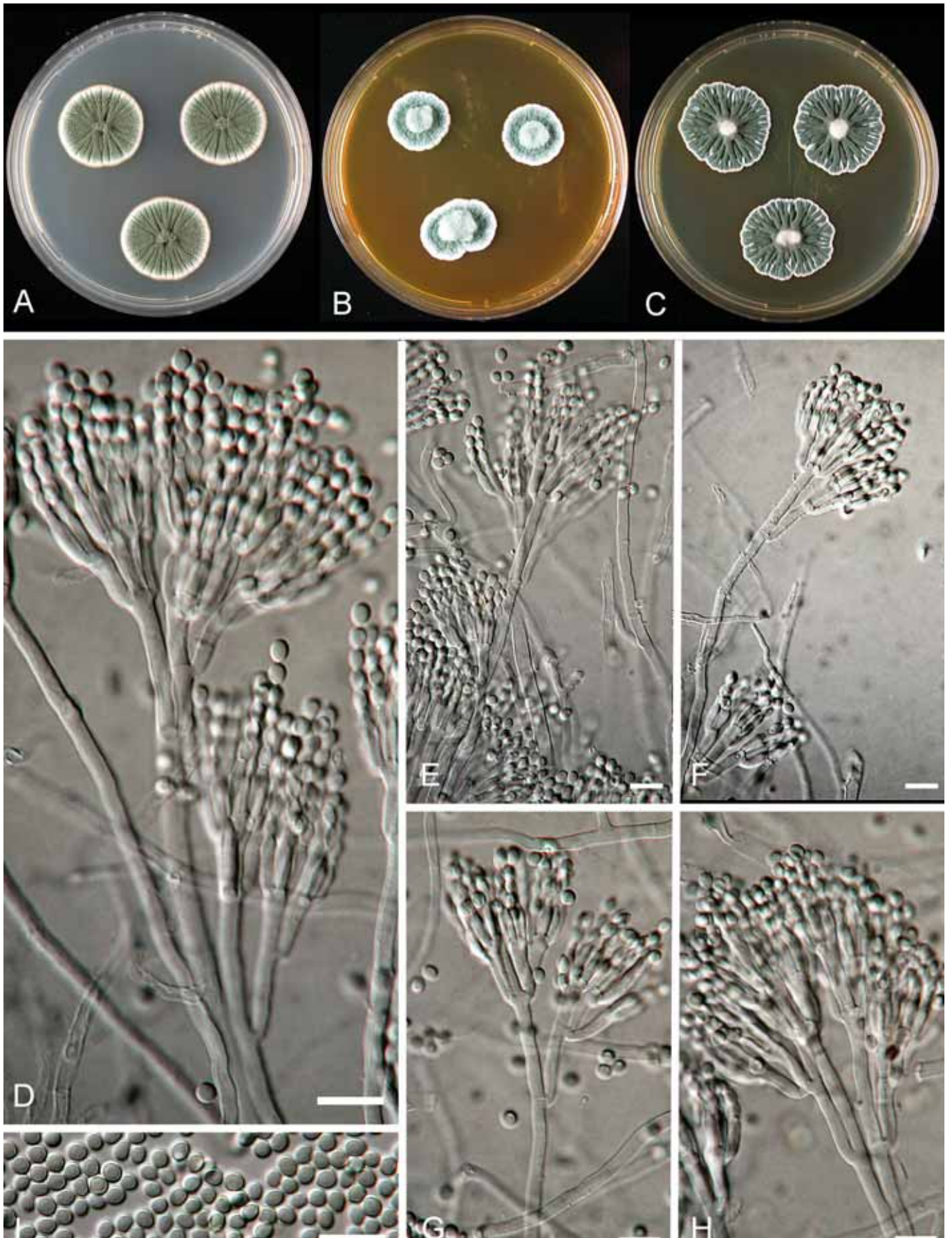


Fig. 30. *Penicillium aurantiigriseum*. 7-day old colonies at (A) CYA, (B) MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. bialowiezense K. Zaleski, Bull. Int. Acad. Pol. Sci. Lett., Sér. B 1927: 462, 1927

In *Penicillium* subgenus *Penicillium* section *Coronata* series *Olsonii*

Type: Herb. IMI 092237

Culture ex type: CBS 227.28 = IBT 23044 = IMI 092237 (T, Y), ex forest soil, Poland

Diagnostic features: ellipsoidal finely roughened conidia, long broad stipes with all elements short and appressed, quinolactacin, Raistrick phenols, mycophenolic acid, asperphenamate, poor growth on creatine, but good growth on nitrite-sucrose agar

Similar species: *P. bialowiezense* is closely related to *P. brevicompactum*. *P. bialowiezense* has shorter and less wide stipes than *P. brevicompactum*. *P. brevicompactum* consistently produces brevianamide A, while *P. bialowiezense* produces quinolactacin A consistently. Both species has shorter stipes and smaller colonies on CYA and YES than *P. olsonii*.

Description:

Conidiophores: Long, appressed, terverticillate

Conidia: Finely roughened subglobose to ellipsoidal, 2.5-3.5 µm x 2.0-3 µm

Phialides: Cylindrical with gradually tapering collula, 6.5-9 µm x 2.5-3 µm

Metulae: Cylindrical but apically inflated, 10-15 µm x 3-4.5 µm

Rami: 15-25 µm x 4-5 µm

Stipes: 250-400 µm x 4-6 µm, smooth-walled

Synnemata or fasciculation: None

Sclerotia: None

Colony texture on CYA: Velutinous

Conidium colour on CYA: Dull green to grey green

Exudate droplets on CYA: Often present, pale to reddish brown

Reverse colour on CYA: Beige to yellowish cream

Reverse colour on YES: Cream to cream beige

Diffusible colour on CYA: Pale or light brown

Ehrlich reaction: Red-violet

Odour and volatile metabolites: Not examined

Extrolites: 1) Raistrick phenols, 2) Mycophenolic acid, 3) Asperphenamate, 4) Breviones, 5) Quinolactacin A

Growth on creatine: Weak

Acid and base production on creatine: Weak acid production

Growth on UNO: Good

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 11-25 mm; MEA: 9-16 mm; YES: 18-30 mm; CREA: 8-12 mm; Cz: 9-18 mm, OAT: 11-25 mm; CYAS: 21-31 mm; CzBS: 6-16 mm; CzP: 0 mm; UNO: 6-13 mm; DG18: 16-22 mm

Diam., CYA, 1 week: 15°C: 17-22 mm; 30°C: 0 mm; 37°C: 0 mm

CYA/CYAS: 0.8 [0.5-1.3], halotolerant

CYA15°C/CYA 25°C: 1.1 [0.8-1.9], psychrotolerant

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0.8 [0.6-1.1]

CZP/CZ: 0

Distribution: Denmark, Faroe Islands, Poland, Italy, Slovenia, Chile, Wyoming, USA, Canada, Saudi-Arabia

Ecology and habitats: Forest soil, coffee cherries, mouldy mushrooms, seaweed, yoghurt, dried lamb meat, Brussels sprouts, sage, margarine, wheat bread, thyme, mouldy harness, air in factories.

Biotechnological applications: None

Biodeterioration & phytopathology: May degrade leather

Mycotoxins and mycotoxins: May grow in fruit yoghurts and cause intoxication, but the metabolites responsible are unknown (Frisvad, unpublished).

Typical cultures: IBT 13469, ex wheat, Denmark; IBT 20786 = CBS 110104, ex seaweed, Bellevue, Denmark; IBT 21225, ex soil under *Salix* sp. in dried root segment of Elisabeth Adams irrigation ditch, Centennial, Wyoming, USA; IBT 22460, ex soil under *Nothofagus* sp., Chile; IBT 22443 = CBS 110102, ex bread, Italy; IBT 13145, ex soil, conifer forest, Switzerland; IBT 21578 = CBS 112477, ex barley, Denmark; IBT 6510, ex *Thymus vulgaris*, Denmark; IBT 6500 = CBS 112478, ex margarine, Denmark.

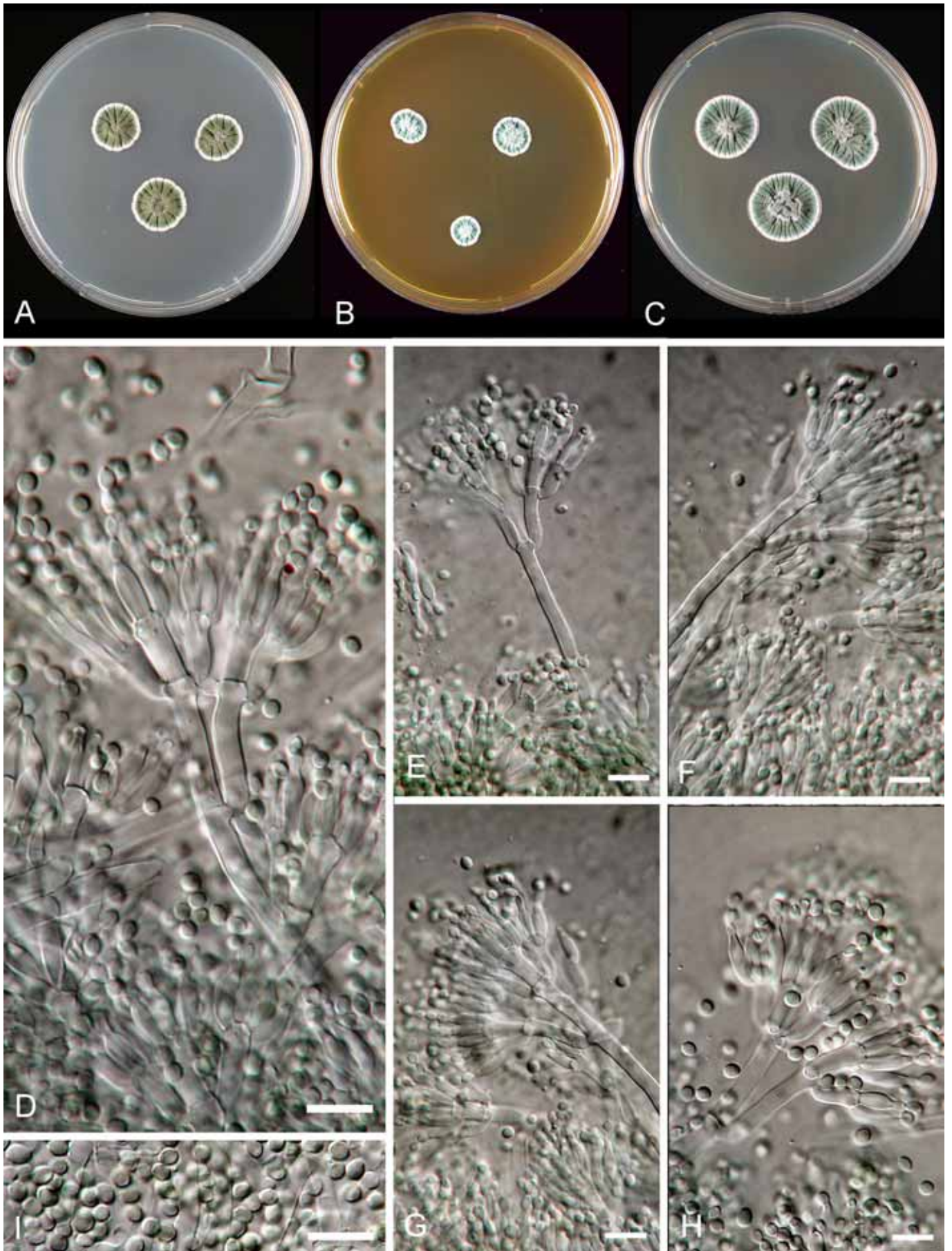


Fig. 31. *Penicillium bialowiezense*. 7-day old colonies at (A) CYA, (B), MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. brevicompactum Dierckx, Ann. Soc. Scient. Brux. 25: 88, 1901

In *Penicillium* subgenus *Penicillium* section *Coronata* series *Olsonii*

Type: Herb. IMI 040225

Culture ex type: CBS 257.29 = CBS 110071 = IBT 23045 = IMI 040225 = ATCC 9056 = ATCC 10814 = FRR 862 = NRRL 862 = NRRL 863 = NRRL 2011 (T), ex unrecorded source.

Diagnostic features: Brevianamide A, mycophenolic acid, pebrolides, Raistrick phenols, finely roughened ellipsoidal conidia, short broad penicilli, apically inflated metulae.

Similar species: See *P. bialowiezense*.

Description:

Conidiophores: Long, appressed, terverticillate
Conidia: Finely roughened ellipsoidal, 2.5-3.5 µm x 2.0-2.5 µm
Phialides: Cylindrical with gradually tapering collula, 6.5-9 µm x 2.5-3 µm
Metulae: Cylindrical apically inflated, 10-15 µm x 3.5-4.5 µm
Rami: 15-25 µm x 4-5 µm
Stipes: 400-800 µm x 4-6 µm, smooth-walled
Synnemata or fasciculation: None
Sclerotia: None
Colony texture: Velutinous
Conidium colour on CYA: Dull green to grey green
Exudate droplets on CYA: Pale to yellow or reddish brown
Reverse colour on CYA: beige to yellowish cream
Reverse colour on YES: Cream-coloured to beige, in few strains a conspicuous red reverse and diffusible pigment is produced
Diffusible colour on CYA: Pale or light brown
Ehrlich reaction: No reaction or yellow
Odour and volatile metabolites: Isobutanol, isopentanol (Larsen and Frisvad, 1995)
Extrolites: 1) Raistrick phenols; 2) Mycophenolic acids and mycochromenic acid, 3) Brevianamide A & B, 4) Asperphenamate, 5) Pebrolides, 6) Botryodiplodin, 7) 11-(5'-Epoxy-4'-hydroxy-3'-hydroxymethylcyclo-2'-hexenone)-Δ-8(12)-drimene, 8) Silvatins, 9) Brevigillide
Further extrolites reported: 10) Brevicompanins, 11) Brevioxims, 12) Adenophostins. The identity of the producing organisms has not been verified for the last three groups
Growth on creatine: Poor
Acid and base production on creatine: Most commonly no acid production, occasionally weak or good acid production
Growth on UNO: Good
Growth on nitrite: Moderate to good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 14-30 mm [atyp.: 8-11 mm]; MEA: 10-26 mm; YES: 20-36 mm; CREA: 4-18 mm; Cz: 9-18 mm, OAT: 16-26 mm; CYAS: (15-)21-26 mm; CzBS: 7-17 mm; CzP: 0 mm; UNO: 10-14 mm; DG18: 12-19 mm
Diam., CYA, 1 week: 15°C: 17-21 mm; 30°C: 0-3 mm; 37°C: 0 mm
CYA/CYAS: 0.9 [0.8-0.9], halotolerant

CYA15°C/CYA 25°C: 0.9 [0.7-1.0], psychrotolerant
CYA30°C/CYA 25°C: 0.1 [0-0.1]
CZBS/CZ: 0.9 [0.6-1.0]
CZP/CZ: 0

Distribution: Cosmopolitan. Denmark, Faroe Islands, Greenland, The Netherlands, Sweden, Svalbard, Norway, United Kingdom, Germany, Poland, France, Slovenia, Italy, Greece, Costa Rica, Venezuela, Columbia, Brazil, Chile, Connecticut, New Mexico, Wisconsin, South Carolina, USA, Canada, Ethiopia, India, Japan, Australia, Eastern Island (Chile). See also Domsch *et al.* (1980)

Ecology and habitats: Soil under conifers, agricultural soil, mouldy mushrooms, spruce cones, acorns, seaweed, sage, coffee cherries, apples, potatoes, barley, wheat, oats, sorghum, mouldy coffee beans, seaweed, air in factories, cod roe, mouldy bakers yeast, apricot puree, maple syrup, margarine, liver paté, salami and other processed foods, waste, dead insects, human bone, salt pans.

Biotechnological applications: Production of mycophenolic acid (mofetil) (brand name CellCept) (Bentley, 2000). This is used for treatment of many diseases, but is especially effective for prevention of rejection in heart and kidney transplantations (Bentley, 2000)

Biodeterioration & phytopathology: *P. brevicompactum* has been found growing actively on *Amanita citrina*, *Paxillus involutus*, *Flammulina velutipes*, *Boletus* spp., *Pleurotus ostreatus*, *Nectria rishbethii* and other macrofungi; it has also been found growing in cosmetics and on wood for building construction

Mycotoxins and mycotoxins: Mycophenolic acid is an antibiotic, with anti-tumor, anti-psoriasis and immunosuppressive features (Bentley, 2000) and may be of relevance for secondary mycotoxicosis (bacterial infections caused by intake of immunosuppressive mycotoxins). The other extrolites produced have not been reported to be mycotoxins in the strict sense of the word, except botryodiplodin. This mycotoxin is produced by some strains of *P. brevicompactum* (Fujimoto *et al.*, 1980 misidentified as *P. carneolutescens*; Frisvad, 1989)

Typical cultures: IBT 18329 = CBS 110067, ex soil under Juniper, Madrid, New Mexico, USA; IBT 21507 = IBT 6607 = CBS 480.84 = FRR 2938 (Y), ex *Raphanus* sp., Denmark; IBT 13151 = CBS 110068 = WSF 3531, ex soil, Wisconsin, USA; IBT 4342 = CBS 110072 = NRRL 867 = IMI 092219 = FRR 3719, ex unrecorded source (*P. griseobrunneum*); CBS 256.31 = IBT 23046 = IMI 089824 = NRRL 859 = FRR 859 = ATCC 10111 = IFO 5858, ex decomposing mushroom, Storrs, Connecticut, USA (*P. stoloniferum*); CBS 210.28 = IBT 23043 = IMI 092266, ex forest soil under conifers, Puszcza, Bialowiezka, Poland (*P. patris-maeae*); CBS 316.59 = IBT 23047 = IMI 092262 = NRRL 866 = FRR 866, ex soil under conifers, Tetry Mountains (*P. hagemii*); CBS 317.59 = IBT 23069 = IFO 5727 = FRR 1363 = IMI 068217 = ATCC 18311, ex soil, Japan (*P. brunneostoloniferum*); IBT 18098 = CBS 110069 = FRR 2455, ex artificial maple syrup, preserved with 650 ppm benzoic acid, Sydney, NSW, Australia.

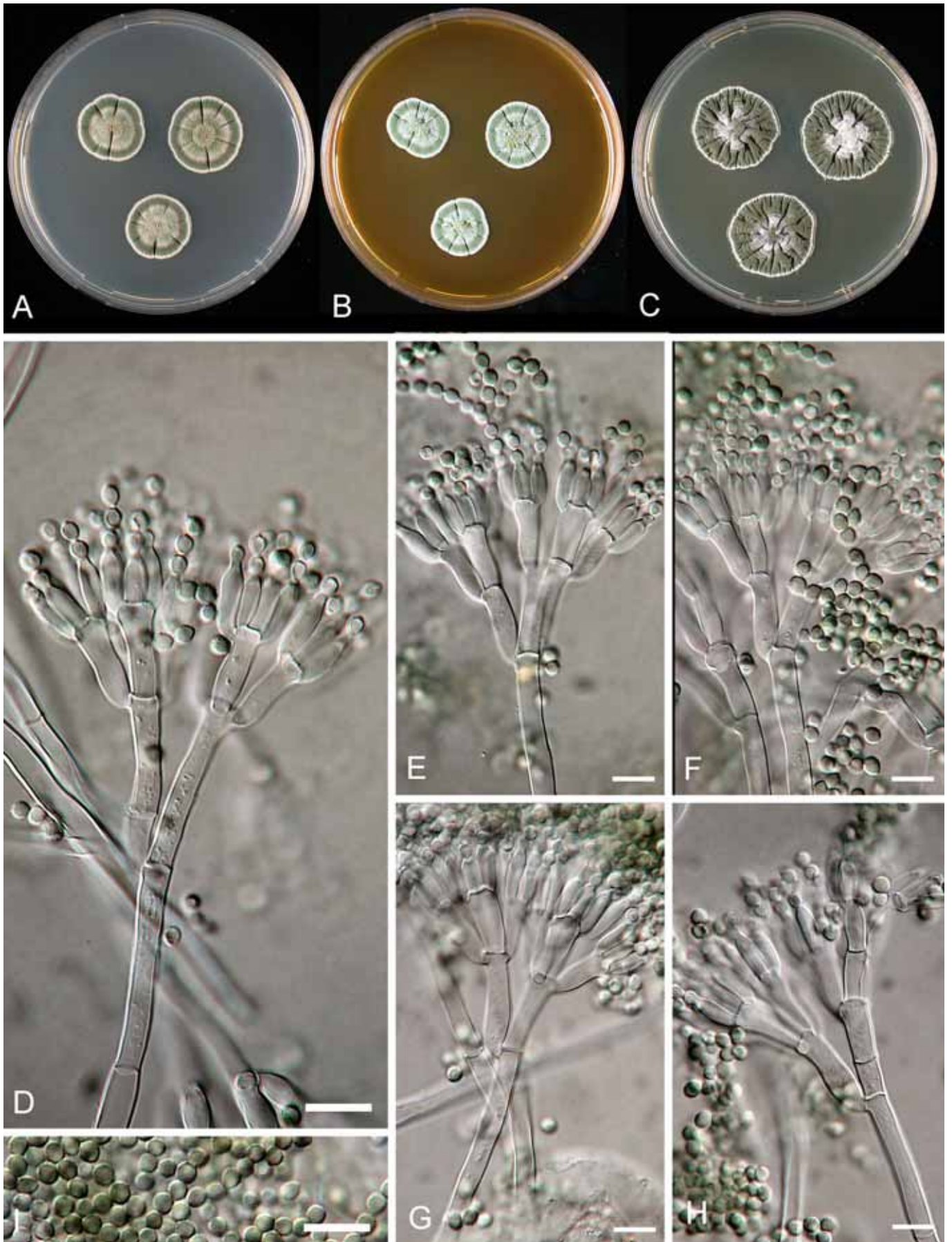


Fig. 32. *Penicillium brevicompactum*. 7-day old colonies at (A) CYA, (B), MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. camemberti Thom, Bull. Bur. Anim. Ind. US Dept. Agric. 82: 33, 1906

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Camemberti*

Type: Herb. IMI 027831

Culture ex type: CBS 299.48 = IBT 21508 = IBT 21604 = IMI 027831 = IMI 092200 = ATCC 1105 = ATCC 4845 = FRR 878 = LCP P11 = MUCL 29790 = NRRL 877 = NRRL 878 (T,Y)

Diagnostic features: Cyclopiazonic acid, white floccose colonies, poor sporulation

Similar species: Deteriorated strains of *P. commune* may look like *P. camemberti*. *P. camemberti* differs from *P. caseifulvum* by its poor sporulation and its inability to produce orange reverse colours on YES.

Description:

Conidiophores: Terverticillate to quaterverticillate, sometimes irregular structures
Conidia: Smooth-walled, globose to suglobose, 3.5-5 µm x 3.3-4.5 µm
Phialides: Cylindrical with long wide colulla, 10-13 µm x 2.5-3 µm
Metulae: Cylindrical 7.5-12 µm x 2.5-3.5 µm
Rami: Cylindrical, 15-25 µm x 3-4 µm
Stipes: 200-500 µm x 3-4 µm
Synnemata or fasciculation: None
Sclerotia: None
Colony texture: Floccose
Conidium colour on CYA: White or rarely grey green
Exudate droplets: None or few droplets (often large violet droplets on CREA)
Reverse colour on CYA: Pale, cream-coloured or yellowish
Reverse colour on YES: Cream yellow
Diffusible colour: none
Ehrlich reaction: Violet (no reaction in few old isolates)
Odour and volatile metabolites: 3-octanone, ethylacetat, isobutanol, ethyl isobutanoate, isobutyl acetate, styrene, 1-octen-3-ol, 3-octanol, ethyl hexanoate, 2-methyl-isoborneol (Larsen and Frisvad, 1995)
Extrolites: 1) Cyclopiazonic acids, 2) Cyclopaldic acid (rare), 3) Rugulovasine A & B (rare), 4) Aspereynone-like compounds, 5) Palitantin (rare)
Growth on creatine: Very good
Acid and base production on creatine: Moderate to good acid production followed by base production
Growth on UNO: Very good
Growth on nitrite: Weak or moderate

Abiotic factors:

Diam., 1 week, 25°C: CYA: 19-27 mm; MEA: 12-27 mm; YES: 23-38 mm; CREA: 9-17 mm; Cz: 13-20 mm, OAT: 10-21 mm; CYAS: 14-33 mm; CzBS: 6-17 mm; CzP: 0-1 mm; UNO: 13-18 mm; DG18: 14-27 mm
Diam., CYA, 1 week: 15°C: 14-26 mm; 30°C: 0-3 mm; 37°C: 0 mm
CYA/CYAS: 1 [0.8-1.2], halotolerant
CYA15°C/CYA 25°C: 1.0 [0.8-1.3], psychrotolerant
CYA30°C/CYA 25°C: 0 [0-0.2]
CZBS/CZ: 0.8 [0.5-1.3]
CZP/CZ: 0 [0-0.1]

Distribution: This domesticated species has been found in countries where white mould cheeses are produced and sold.

Ecology and habitats: On white mould cheeses (brie, camembert etc.). This species is a domesticated from of *P. commune* Thom. The species has never been found outside the white mould cheese environment. Occasionally cross-contaminating other cheeses in refrigerators.

Biotechnological applications: Production of white mould cheeses

Biodeterioration & phytopathology: -

Mycotoxins and mycotoxins: Cyclopiazonic acid is produced by some strains

Typical cultures: IBT 21601 = CBS 123.08 = NRRL 874 = ATCC 10387 = IMI 091932 (*P. camemberti* var. *rogeri*), ex French camembert cheese; IBT 11754 = CBS 303.48 = ATCC 10423 = FRR 875 = IMI 028810 = MUCL 29156 = NRRL 875 = UPSC 3178 (*P. caseicola*), ex French camembert cheese; IBT 21602 = CBS 112325 = NRRL 876 (*P. candidum* Roger), IBT 3505 = CBS 112479 (NB *P. commune* like back-mutation), ex French camembert cheese, "Prairie", IBT 15441 = CBS 112562, ex brie, Denmark; IBT 11568 = CBS 249.77A, ex German camembert cheese, T65 = IBT 11755 = CBS 190.67, ex Dutch camembert cheese; IBT 14856 = CBS 112078, ex Appenzeller cheese, Switzerland; CBS 160.42; IBT 11570 = CBS 131.67 = MUCL 8446, ex French brie cheese; CBS 133.67, ex French camembert cheese; CBS 248.77, Germany; IBT 13592 = CBS 273.97, ex dust, Denmark; IBT 23943 = Kulmbach Sp. 2491, Germany; IBT 23941 = ATCC 42009 = Kulmbach Sp. 912, ex camembert cheese.

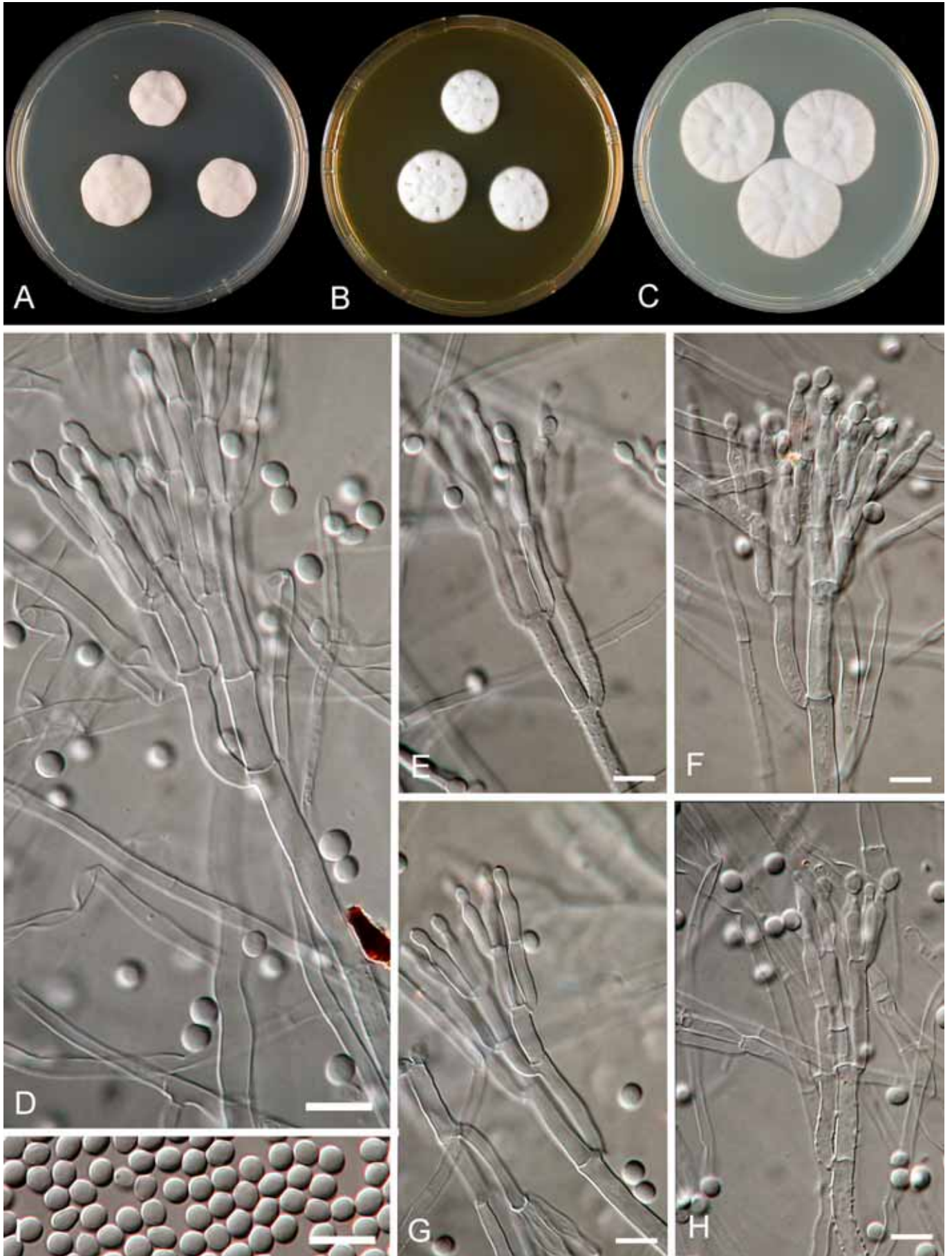


Fig. 32. *Penicillium camemberti*. 7-day old colonies at (A) CYA, (B) MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. carneum (Frisvad) Frisvad, Microbiology, UK, 142: 546, 1996

In *Penicillium* subgenus *Penicillium* section *Roqueforti* series *Roqueforti*

Type: Herb. IMI 293204

Culture ex type: CBS 112297 = IBT 6884 = IBT 18419 = IMI 293204 = ATCC 58624, ex rye bread, Denmark (T)

Diagnostic features: Mycophenolic acid, patulin, roquefortine C, isofumigaclavine A & B, penitrem A, globose large smooth-walled conidia, rough-walled stipes, high growth rate on all media, growth on propionic acid and acetic acid, growth at low oxygen and large carbon dioxide levels.

Similar species: *P. carneum* differs from *P. roqueforti* by its inability to produce the dark green reverse colour on CYA and from *P. paneum* by its strong smell of isobutanol and geosmin.

Description:

Conidiophores: Terverticillate, occasionally quarterverticillate, appressed elements, borne from subsurface hyphae

Conidia: smooth-walled, globose, 3.5-5 µm

Phialides: Cylindrical with short collula, 8-10 µm x 2.5-3.0 µm

Metulae: Cylindrical, 10-17 µm x 3-4 µm

Rami: Cylindrical, 17-35 µm x 3-4 µm

Stipes: Rough-walled often warty, 100-200 µm x 4-5 µm

Synnemata or fasciculation: None

Sclerotia: None

Colony texture: Velutinous

Conidium colour on CYA: Pistacio green to dark American green

Exudate droplets on CYA: None or clear droplets

Reverse colour on CYA: Beige to brown

Reverse colour on YES: Cream beige to curry

Diffusible colour on CYA: None

Ehrlich reaction: Violet

Odour and volatile metabolites: Isopentanol, geosmin, 2-methyl-3-butene-2-ol, isobutanol, 1-octene, isopentyl acetate, 1-methoxy-3-methyl-benzene (Larsen & Frisvad, 1995)

Extrolites: 1) Cyclopaldic acid and chromanols, 2) Mycophenolic acids, 3) Patulin, 4) Penicillic acid (only produced by CBS 449.78); 5) Roquefortine C, 6) Penitrem A; 7) Isofumigaclavine A

Growth on creatine: Very good

Acid and base production on creatine: Acid production in margin of colony

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 36-53 mm; MEA: 35-56 mm; YES: 51-74 mm; CREA: 27-35 mm; Cz: 23-34 mm, OAT: 34-72 mm; CYAS: 33-35 mm; CzBS: 17-38 mm; CzP: 23-34 mm; UNO: 28-36 mm; DG18: 39-44 mm

Diam., CYA, 1 week: 15°C: 32-36 mm; 30°C: 11-26 mm; 37°C: 0 mm

CYA/CYAS: 1.2 [1.1-1.2]

CYA15°C/CYA 25°C: 0.9 [0.8-0.9]

CYA30°C/CYA 25°C: 0.3 [0.3-0.6]

CZBS/CZ: 1.0 [0.7-1.1]

CZP/CZ: 0.9 [0.7-1.1]

High resistance to acid and good growth at high CO₂ levels.

Distribution: Denmark, Norway, Sweden, Germany, Great Britain, USA, Canada

Ecology and habitats: Dried meat, silage, rye bread, water, beer, (barley), cheddar cheese, mouldy bakers yeast, cork

Biotechnological applications: None

Biodeterioration & phytopathology: This fungus may deteriorate silage, other lactic acid fermentation products, and beer.

Mycotoxins and mycotoxins: Patulin, penitrem A, mycophenolic acid, (penicillic acid), isofumigaclavine A are all mycotoxins that can be produced potentially in silage and other acid containing products. *P. carneum* was involved in mycotoxicosis of a man drinking beer contaminated with *P. carneum* (IBT 11188) (reidentified by us, originally identified as *P. crustosum*). The beer contained both penitrem A and isofumigaclavine A (Cole *et al.*, 1983)

Typical cultures: IBT 21509 = IBT 3473 = IBT 6753 = CBS 449.78, ex cheddar cheese, USA (Y); IBT 6892 = CBS 468.95, ex salami, Germany; IBT 6885 = IBT 3472 = CBS 466.95, ex salami, Germany; IBT 3466 = CBS 467.95, ex water tank, Denmark; IBT 19478 = CBS 390.78, ex raw sausage, Germany; IBT 15600 = CBS 112489, ex chilled food, France; IBT 6888 = CBS 112487, ex *Hordeum vulgare*, Denmark; NRRL 1168 = IBT 16402, Ottawa, Canada; NRRL 855 = IBT 16434; IBT 11188, ex beer intoxicating man, Georgia, USA.

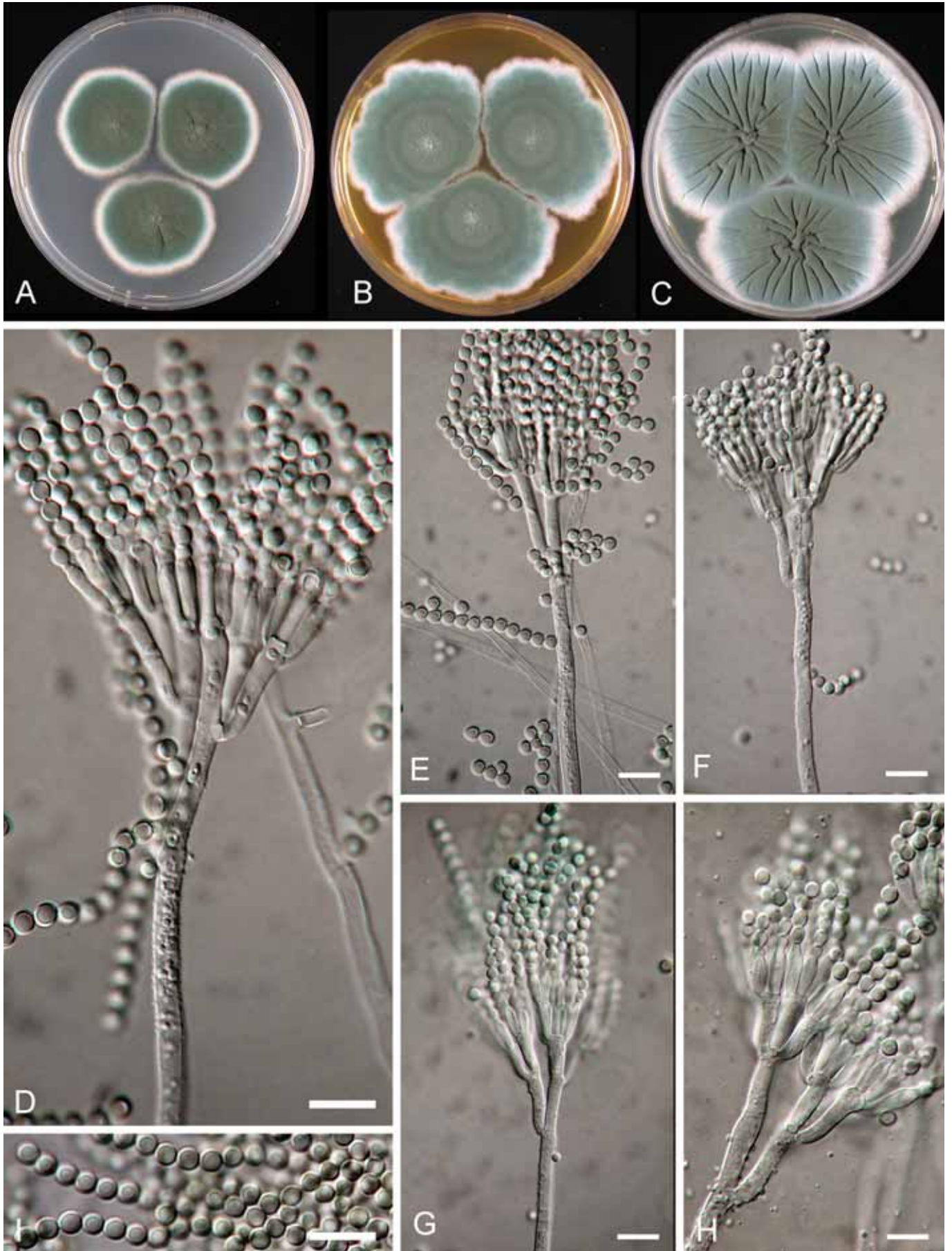


Fig. 33. *Penicillium carneum*. 7-day old colonies at (A) CYA, (B) MEA, (C) YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. caseifulvum Lund, Filt. & Frisvad, J. Food Mycol. 1: 97, 1998

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Camemberti*

Type: Herb. C 24999

Culture ex type: CBS 101134 = IBT 21510 = IBT 18282 (T,Y), ex Danish blue cheese

Diagnostic features: Cyclopeptin, rugulovasine A, smooth-walled conidia, floccose colonies, good growth on CREA, weak but consistent growth on CzP (1000 ppm propionic acid, pH 3.5)

Similar species: *P. caseifulvum* differs from *P. camemberti* by an orange reverse on YES agar.

Description:

Conidiophores: Born from aerial hyphae, terverticillate

Conidia: Smooth-walled, subglobose to broadly ellipsoidal, 3-5 µm x 2.5-3.5 µm

Phialides: Cylindrical with short narrow collula, 7-13 µm x 2.8-3.5 µm

Metulae: Cylindrical, 10-13 µm x 3.5-4.5 µm

Rami: Cylindrical, 12-25 µm x 4-5 µm

Stipes: 300-800 µm x

Synnemata or fasciculation: None

Sclerotia: None

Colony texture: Floccose

Conidium colour on CYA: Greyish green to greyish blue green (turquoise)

Exudate droplets on CYA: Small clear droplets at colony margin

Reverse colour on CYA: Creamish yellow to brown yellow

Reverse colour on YES: Vividly orange, rarely only cream yellow

Diffusible colour on CYA: None

Ehrlich reaction: Violet (weak reaction)

Odour and volatile metabolites: Not examined

Extrolites: 1) Cyclopeptin, 2) Rugulovasine A and B

Growth on creatine: Very good growth

Acid and base production on creatine: Good acid production followed by base production

Growth on UNO: Very good

Growth on nitrite: Very good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 15-24 mm; MEA: 16-28 mm; YES: 32-42 mm; CREA: 13-24 mm; Cz: 21-24 mm, OAT: 22-25 mm; CYAS: 23-33 mm; CzBS: 15-22 mm; CzP: 3-5 mm; UNO: 17-23 mm; DG18: 21-24 mm

Diam., CYA, 1 week: 5°C: 3-8 mm; 15°C: 18-23 mm; 30°C: 0 mm; 37°C: 0 mm

CYA/CYAS: 0.8 [0.7-1.0]

CYA15°C/CYA 25°C: 0.9 [0.8-1.1]

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0.9 [0.7-1.0]

CZP/CZ: 0.2 [0.1-0.2]

Distribution: Denmark, France, Germany

Ecology and habitats: Blue mould cheeses and some other German and French cheeses

Biotechnological applications: *P. caseifulvum* has been found to colonize some of the most highly regarded blue mould cheeses (unpublished results). White mould type cheeses have been made on an experimental basis with *P. caseifulvum*. These cheeses were turquoise on the surface and appeared to be of a very fine quality (unpublished results). Not producing cyclopiazonic acid, *P. caseifulvum* could be a potential new candidate for fermenting cheeses or salami.

Biodeterioration & phytopathology: The growth of *P. caseifulvum* on the surface of blue mould cheeses can be seen as biodeterioration, but also regarded as an indicator of very good quality.

Mycotoxicoses and mycotoxins: Rugulovasine A is a potential mycotoxin, but no relevant toxicity data (oral, skin or pulmonary toxicity) are available.

Typical cultures: IBT 19782 = CBS 108956, ex Danish blue cheese; IBT 18725 = CBS 108957, ex Danish blue cheesewe, Bornholm; IBT 19801 = CBS 111838, ex French cheese (Saint Lactaire); IBT 19802 = CBS 111837, ex French goat cheese; IBT 23156 = CBS 112324, ex German Montagnolo cheese; IBT 23155 = CBS 112323, ex Danish blue cheese; IBT 20915 = CBS 111836, ex Danish blue cheese.

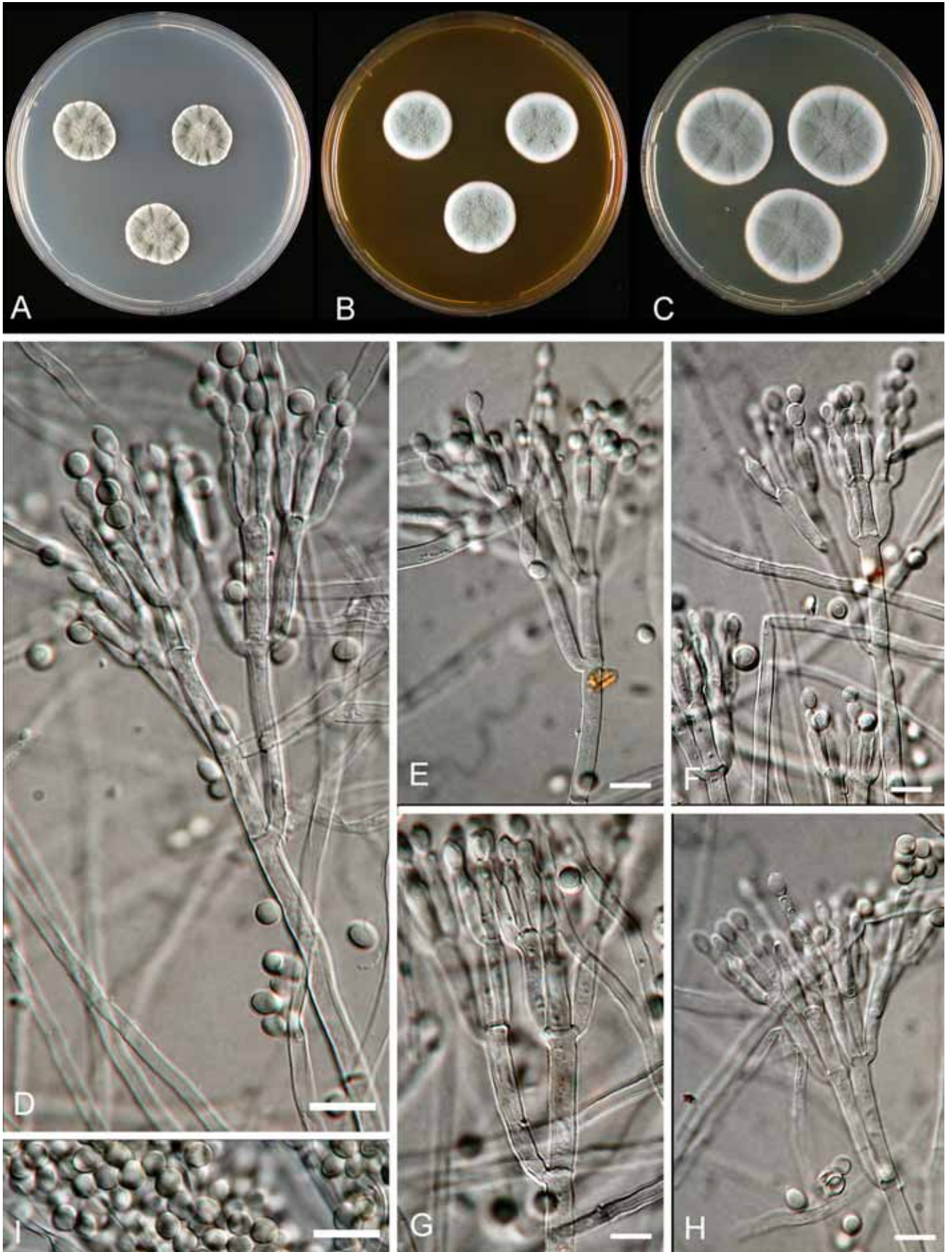


Fig. 35. *Penicillium caseifulvum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

***P. cavernicola* Frisvad & Samson, sp. nov.**

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Solita*

Type: Herb. CBS 100540

Culture ex type: IBT 14499 = CBS 100540, ex wall of the Lechuiguilla Cave, Carlsbad, New Mexico, USA (T)

Diagnostic features: Territrems, aurantiamine, asteltoxin, dark green rough-walled conidia, yellow brown reverse on CYA, good growth on CREA, no growth at 30°C

Similar species: Differs from *P. solitum*, *P. echinulatum* and *P. discolor* by its yellow brown reverse on CYA.

Description:

Conidiophores: Terverticillate, appressed elements, born from subsurface hyphae

Conidia: Rough-walled, globose to subglobose, 3.5-4.5 µm.

Phialides: Cylindrical tapering to a distinct collulum, 8-11 µm x 2.2-3.0 µm

Metulae: Cylindrical, 10-15 µm x 2.5-3.5 µm

Rami: Cylindrical, 12-20 µm x 3.2-4.2 µm

Stipes: Rough-walled, 300-550 µm x 3.5-4.2 µm

Synnemata or fasciculation: Weakly fasciculate

Sclerotia: None

Colony texture: Velutinous

Conidium colour on CYA: Dark green,

Exudate droplets on CYA: Present, clear

Reverse colour on CYA: Yellow brown

Reverse colour on YES: Strongly yellow

Diffusible colour on CYA: None

Ehrlich reaction: None (yellow in two isolates)

Odour and volatile metabolites: No data

Extrolites: 1) Territrems and arisugacins, 2) Asteltoxin, 3)

Aurantiamine, 4) Gyanthrypine, 5) Dipodazin, 6) Asperey-none-like compounds

Growth on creatine: Very good

Acid and base production on creatine: Weak to moderate acid, delayed base production

Growth on UNO: Moderate to good

Growth on nitrite: Weak

Abiotic factors:

Diam., 1 week, 25°C: CYA: 23-33 mm; MEA: 20-32 mm; YES: 28-44 mm; CREA: 18-23 mm; Cz: 20-23 mm, OAT: 17-28 mm; CYAS: 30-38 mm; CzBS: 12-18 mm; CzP: 0-1 mm; UNO: 13-19 mm; DG18: 22-27 mm

Diam., CYA, 1 week: 15°C: 16-27 mm; 30°C: 0 mm; 37°C: 0 mm

CYA/CYAS: 0.8 [0.8-0.9]

CYA15°C/CYA 25°C: 0.8 [0.6-0.9]

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0.7 [0.6-0.8]

CZP/CZ: 0.02 [0-0.04]

Distribution: Germany, New Mexico (USA), Venezuela, Japan

Ecology and habitats: Found twice on walls in caves, but also on butter and salami

Biotechnological applications: Can be potentially used to produce arisugacins.

Biodeterioration & phytopathology: May degrade lipid containing foods

Mycotoxinoses and mycotoxins: Produces territrems, tremorgenic mycotoxins, but appear to be too rare to cause significant mycotoxinoses

Typical cultures: IBT 5265 = CBS 109557 = FRR 1621 = IFO 5341, ex butter, Japan; IBT 3235 = CBS 109556 = Kulmbach Sp. 1894, ex salami, Germany; CBS 109558 = IBT 21194, ex bat cave, Venezuela (Y).

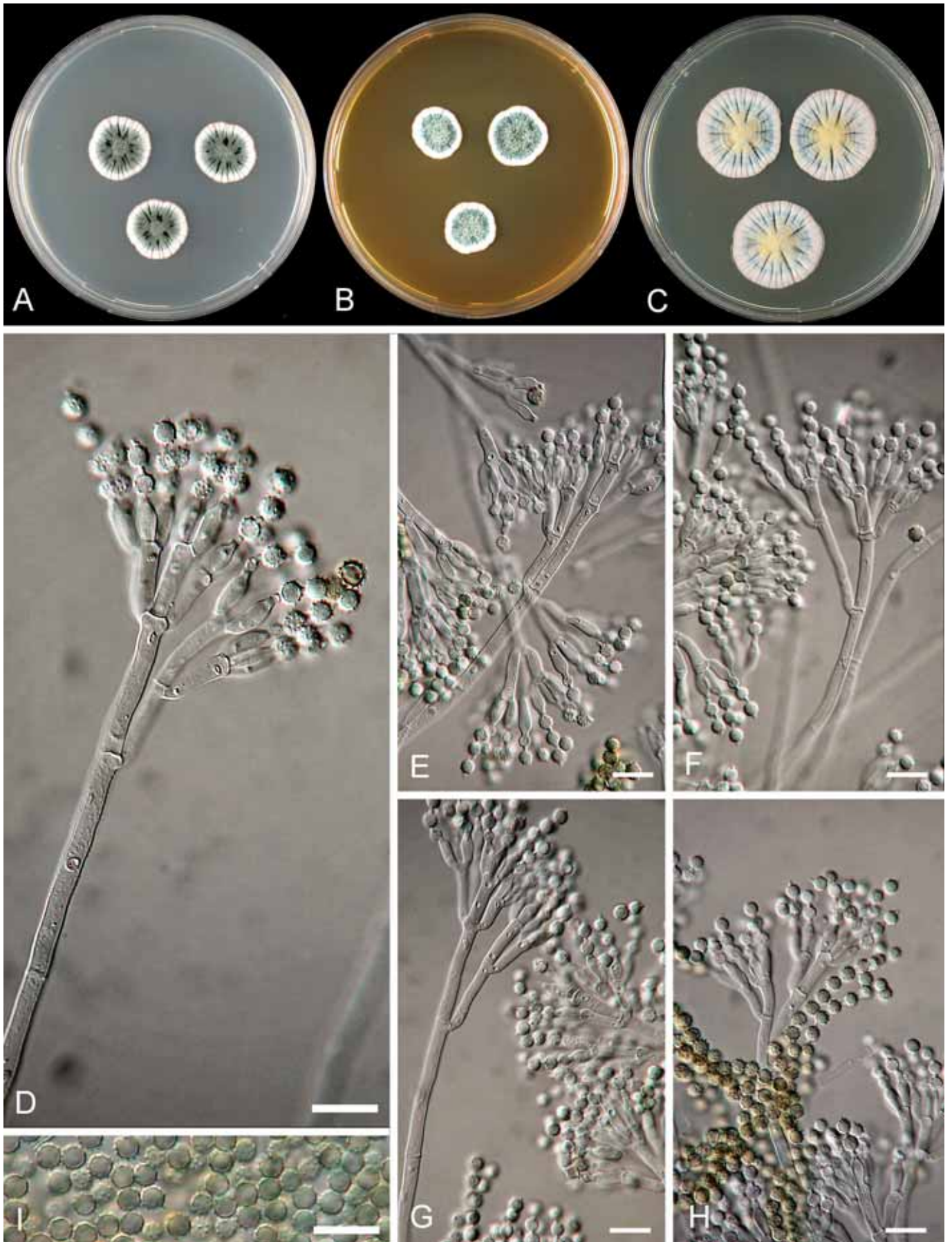


Fig. 36. *Penicillium cavernicola*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. chrysogenum Thom, Bull. Bur. Anim. Ind. US Dept. Agric. 118: 58, 1910

In *Penicillium* subgenus *Penicillium* section *Chrysogena* series *Chrysogena*

Type: Herb. IMI 024314

Culture ex type: CBS 306.48 = IBT 5233* = IMI 024314 = IMI 092208 = ATCC 10106 = CCRC 30564 = FRR 807 = MUCL 29079 = MUCL 29145 = NRRL 807 = NRRL 810 = QM 7500, ex cheese, Connecticut, USA (T)

Diagnostic features: Roquefortine C & D, chrysogine, penicillin F & G, globose to subglobose to broadly ellipsoidal smooth-walled conidia, relatively short phialides with short broad collula, high growth rate on YES with a yellow reverse and strong sporulation.

Similar species: *P. flavigenum* is most closely related to *P. chrysogenum*, but differs by the slower growth rate on CYAS and the deep yellow reverse on YES agar.

Description:

Conidiophores: Bi-, ter- and quarterverticillate, both appressed and divergent rami born from aerial and subsurface hyphae

Conidia: Smooth-walled, globose to subglobose to broadly ellipsoidal, 2.5-4 µm x 2.3-3.5 µm

Phialides: Cylindrical, with short broad collula, 7-9 µm x 2.3-2.5 µm

Metulae: Cylindrical, 8-12 µm x 2.5-4 µm

Rami: Cylindrical, 15-20 µm x 3-4 µm

Stipes: 200-300 µm x 3-4 µm

Synnemata or fasciculation: None

Sclerotia: None

Colony texture: Floccose to velutinous

Conidium colour on CYA: Blue green to green

Exudate droplets on CYA: Often present, copious, yellow

Reverse colour on CYA: Cream, yellow, rarely brown

Reverse colour on YES: Citrine Yellow

Diffusible colour: Yellow pigment often produced

Ehrlich reaction: No reaction or yellow reaction

Odour and volatile metabolites: 3-octanone, 1-heptene, 1,3-octadiene, 3-heptanone, 1-nonene, 1-octen-3-ol, 3-octanol, (pineapple odour at low water activities) (Larsen and Frisvad, 1995)

Extrolites: 1) Penicillins, 2) Roquefortine C and meleagrins, 3) Chrysogine, 4) Xanthocillins, 5) Secalonic acids, 6) Sorrentanone and sorbicillin 7) PR-toxin

Growth on creatine: Weak

Acid and base production on creatine: none or poor, no base production

Growth on UNO: Very good

Growth on nitrite: Occasionally good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 23-46 mm; MEA: 19-52 mm; YES: 40-64 mm; CREA: 16-26 mm; Cz: 18-33 mm, OAT: 18-42 mm; CYAS: 27-43 mm; CzBS: 7-24 mm; CzP: 0 mm; UNO: 15-29 mm; DG18: 29-41 mm

Diam., CYA, 1 week: 5°C: 1-4 mm; 15°C: 15-26 mm; 30°C: 14-27 mm; 37°C: 0-7 mm

CYA/CYAS: 0.9 [0.8-1.1]

CYA15°C/CYA 25°C: 0.6 [0.4-0.7]

CYA30°C/CYA 25°C: 0.6 [0.4-0.8]

CZBS/CZ: 0.6 [0.3-0.9]

CZP/CZ: 0

Distribution: Panglobal, very common

Ecology and habitats: Indoor environments, deserts, dried foods, salterns, cheese

Biotechnological applications: Production of penicillin and xanthocillin X, treatment of pulp mill waste, production of polyamine oxidase, polyamide oxidase, phospho-gluconate dehydrogenase, glucose oxidase, and also used for biotransformations.

Biodeterioration & phytopathology: Building materials are deteriorated

Mycotoxins and mycotoxins: PR-toxin, roquefortine C, secalonic acids have been regarded as mycotoxins

Typical cultures: IBT 14462 = CBS 776.95, ex Lechuiguilla Cave, Carlsbad, New Mexico, USA; IBT 5304* = CBS 775.95, ex air in kitchen, Denmark; T84 = IBT 21511 = CBS 478.84 (Y), ex air, Denmark; IBT 22809 = CBS 111216, ex saltern, Slovenia; IBT 21928* = CBS 111215, ex sage; IBT 23019 = CBS 205.57 = ATCC 8537 = ATCC 9478 = CECT 2306 = IMI 015378 = NRRL 1209 = NRRL 824 = QM 6749, ex culture contaminant, UK; IBT 22777 = CBS 111214, ex wheat bread, Italy; IBT 5848* = CBS 112208, ex soil, China; IBT 23022* = CBS 412.69, ex soil, Syria (*P. harmonense*); IBT 6048 = IBT 4344* = CBS 355.48 = NRRL 821 = IMI 039759ii = ATCC 10108 = IHEM 3181 = MUCL 31327 = QM 7601, ex decaying branch of *Hyssopus* sp., Norway (*P. notatum*); IBT 3363* = FRR 1142 = ATCC 48908, ex snack food, Sydney, NSW, Australia; IBT 19373* = CBS 289.53 = IMI 089373, ex gelatine, UK (the only strain found that does not produce meleagrins, but does produce emodic acid and ω-hydroxyemodin); CBS 307.48 = FRR 1951 = NRRL 1951 = IMI 040233 = CECT 2802 = QM 941 = VTT D-88381, ex *Citrullus lenotus*, Illinois, USA; IBT 4395 = IBT 6067 = NRRL 820 = IMI 092220 (*P. griseoroseum*); IBT 4350 = IBT 6062 = CBS 349.48 = NRRL 836 = ATCC 10468 = IFO 8143 = IMI 039762 = QM 7598 (AUT, *P. meleagrinum*); IBT 3361 = IMI 041606 (*P. camerunense*); IBT 3363 = IMI 092241 (*P. flavidomarginatum*); IMI 129964 (*P. aromaticum* var. *microsporium*)

*These isolates produce the unknown indole metabolite Ø

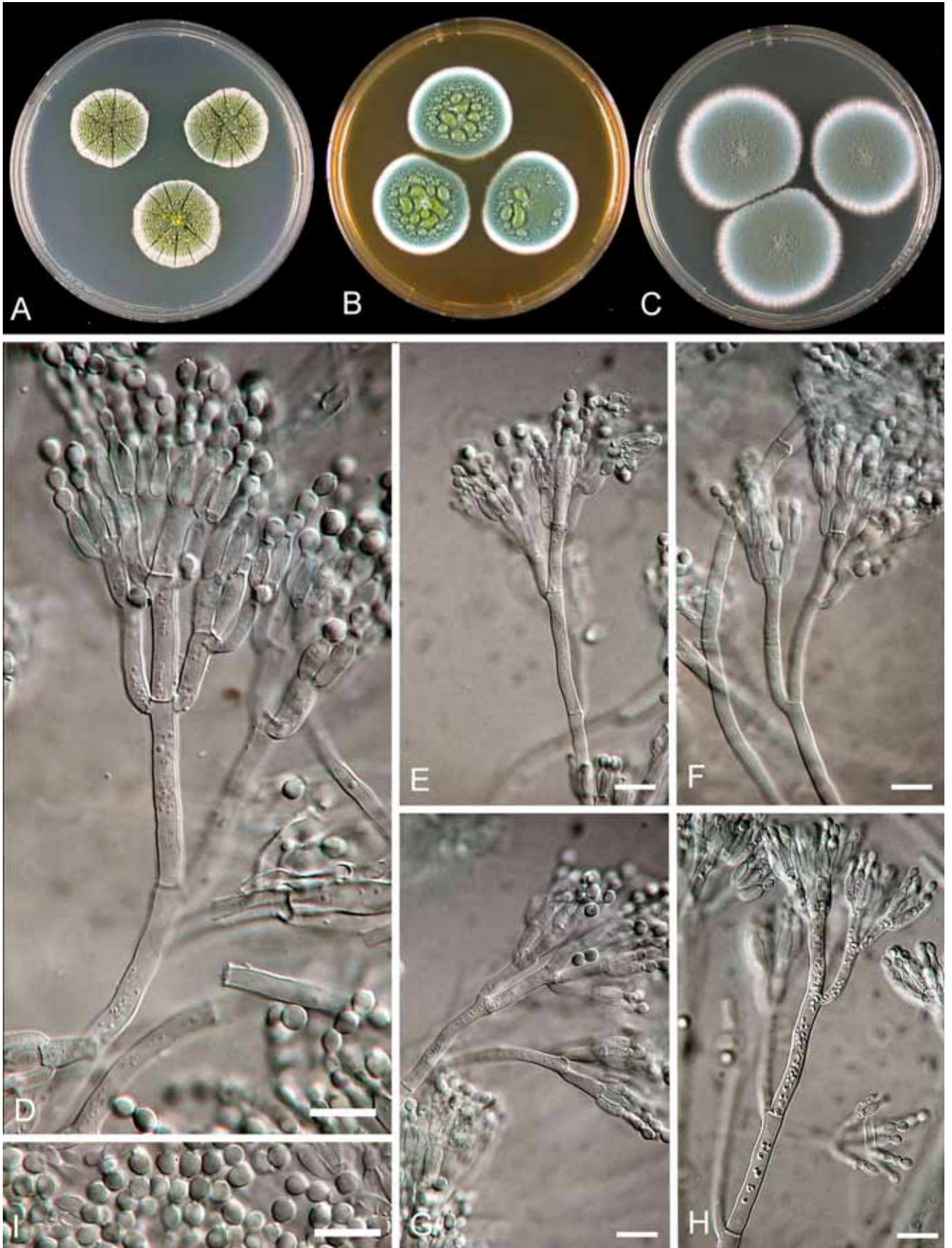


Fig. 37. *Penicillium chrysogenum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. clavigerum Demelius, Verh. Zool.-Bot. Ges. Wien 72: 74, 1922

In *Penicillium* subgenus *Penicillium* section *Penicillium* series *Claviformia*

Type: Herb. IMI 039807

Culture ex type: CBS 255.94 = CBS 310.48 = IBT 21512 = IBT 14993 = IMI 039807 = NRRL 1003 = ATCC 10427, ex man, Winnipeg, Manitoba, Canada (T, Y)

Diagnostic features: Long acicular synnemata especially on OAT and MEA, ellipsoidal smooth-walled conidia, patulin, penitrem A, asperfuran, very poor growth on CYAS, poor growth on CREA with no acid production.

Similar species: *P. clavigerum* differs from *P. vulpinum* by its thin acicular synnemata.

Description:

Conidiophores: Born on the synnemata rarely from aerial mycelium, sometimes sinuous, very long growing along the synnema, 3.5-4.5 µm wide

Conidia: Smooth-walled, ellipsoidal, 3-4 µm x 2.2-3 µm

Phialides: Cylindrical, slowly tapering to a short but distinct collulum, 7-9 µm x 2-3 µm

Metulae: Cylindrical, 10-12 µm x 3.5-4 µm

Rami: 12-15 µm x 3.5-4.5 µm

Stipes: Smooth walled, rough at the base,

Synnemata or fasciculation: Long acicular synnemata with conidiophores born along the entire length

Sclerotia: None

Colony texture: Coremiform, synnemata 10-40 mm

Conidium colour on CYA: Grey green near tea green and slate olive

Exudate droplets on CYA: Absent

Reverse colour on CYA: Dark brown

Reverse colour on YES: Yellow to yellow or orange brown

Diffusible colour on CYA: Often present, yellow to orange brown,

Ehrlich reaction: No or yellow reaction in one isolate a violet reaction

Odour and volatile metabolites: Geosmin, thujopsene, ethyl acetate, ethyl isobutanoate, isobutyl acetate, ethyl 2-methylbutanoate, ethyl isopentanoate, styrene (Larsen & Frisvad, 1995)

Extrolites: 1) Patulin, 2) Asperfuran, 3) Norlichexanthone, 4) TAN-1612, 5) Penitrem A, 6) Cyclopiazonic acid, 7) Viomellein

Growth on creatine: Poor

Acid and base production on creatine: No acid (nor base) production

Growth on UNO: Weak

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 13-31 mm; MEA: 17-37 mm; YES: 17-32 mm; CREA: 13-28 mm; Cz: 20-27 mm, OAT: 25-37 mm; CYAS: 0-8 mm; CzBS: 0-11 mm; CzP: 0 mm; UNO: 3-7 mm; DG18: 10-18 mm

Diam., CYA, 1 week: 15°C: 10-13 mm; 30°C: 7-13 mm; 37°C: 0 mm

CYA/CYAS: 6.3 [3-11.5]

CYA15°C/CYA 25°C: 0.6 [0.3-0.8]

CYA30°C/CYA 25°C: 0.5 [0.4-0.6]

CZBS/CZ: 0.6 [0-0.6] (5 isolates no growth on CzBS, 2 isolates 0.5 & 0.6)

CZP/CZ: 0

Distribution: UK, DC & Wyoming, USA, Alberta & Manitoba, Canada

Ecology and habitats: Found in soil, associated to rodents has been found twice in hospitals.

Biotechnological applications: None

Biodeterioration & phytopathology: None

Mycotoxins and mycotoxins: Penitrem A, patulin, cyclopiazonic acid, viomellein are produced, but *P. clavigerum* has not yet been found in foods.

Typical cultures: IBT 14991 = NRRL 1004, Inst. Of Health, Washington DC, USA; IBT 5523 = IBT 3507 = IBT 3830 = IMI 297557; USA; IBT 18977 = CBS 112482 = UAMH 2766, ex gopher hair, Cardston, Alta., Canada; IBT 18974 = CBS 112564 = UAMH 452, rodent survey, Alberta, Canada; IBT 18973 = CBS 112563 = UAMH 450, rodent survey, Alberta, Canada; IBT 19361 = CBS 112484 = IMI 299048, USA; IBT 20478 = CBS 112483, ex soil, rodent hole, Laramie Basin, Wyoming, USA; IBT 18976 = CBS 112436 = UAMH 2767, ex gopher hair, Cardston, Alta., Canada; IBT 19355 = IFO 5755 = FAT 1161, ex soil, Japan; IMI 224631 = CBS 189.89, ex soil, UK; IBT 3461 = IBT 3767 = IBT 3784 = IBT 5482 = IBT 5524, ex soil, UK.

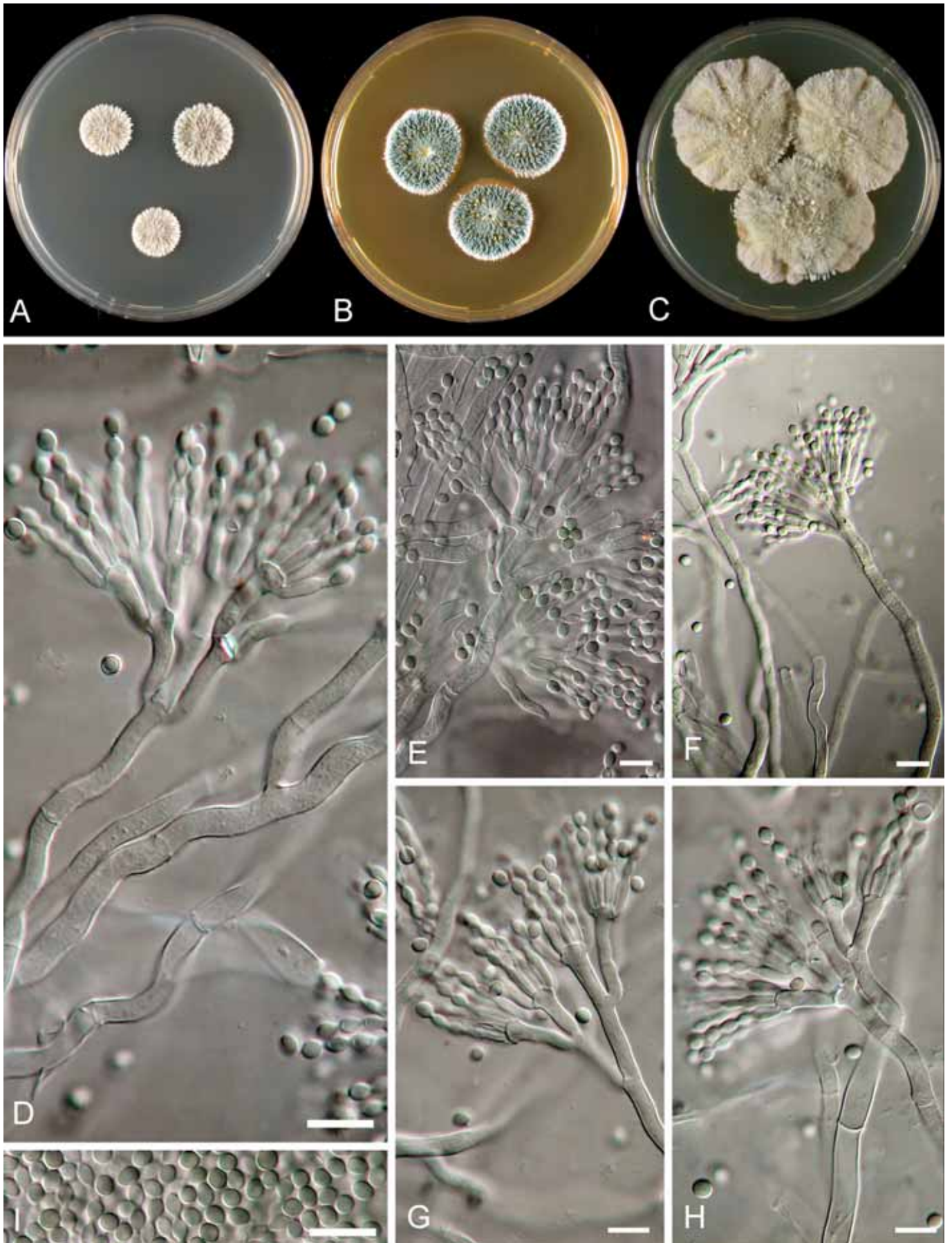


Fig. 38. *Penicillium clavigerum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. commune Thom, Bull. Bur. Anim. Ind. US Dept. Agric. 118: 56, 1910

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Camemberti*

Type: Herb. IMI 039812

Culture ex type: CBS 311.48 = IBT 6200 = IMI 039812 = FRR 890 = NRRL 890 = ATCC 10428 = IFO 5753 (T)

Diagnostic features: Cyclopiazonic acid, rugulovasine A & B, palitantin, subglobose to ellipsoidal smooth-walled conidia, good growth on CREA

Similar species: *P. palitans* can be distinguished from *P. commune* by its green conidia and good sporulation on YES agar. *P. camemberti* is much more floccose than *P. commune*.

Description:

Conidiophores: Terverticillate, appressed elements, born from subsurface hyphae

Conidia: Smooth-walled, globose to subglobose to (rarely) ellipsoidal, 3.5-4.5 µm.

Phialides: Cylindrical tapering to a distinct collulum, 9-12 µm x 2.5-3 µm

Metulae: Cylindrical, 10-15 µm x 3-4 µm

Rami: Cylindrical, 15-25 µm x 3-4 µm

Stipes: Rough-walled, 200-400 µm x 3-4 µm

Synnemata or fasciculation: Weakly fasciculate

Sclerotia: None

Colony texture: Velutinous to floccose or weakly fasciculate

Conidium colour on CYA: Blue green to green

Exudate droplets on CYA: Often present, clear

Reverse colour on CYA: Cream coloured to beige or cream-yellow

Reverse colour on YES: Cream coloured to yellow

Diffusible colour on CYA: None

Ehrlich reaction: Strong violet reaction

Odour and volatile metabolites: Isobutanol, isopentanol, styrene, 3-octanone, β-caryophyllene (?), ethyl acetate, 3-heptanone, 1-octen-3-ol, 3-octanol, 2-methyl-isoborneol (Larsen and Frisvad, 1995)

Extrolites: 1) Cyclopaldic acid and chromanols, 2) Palitantin, 3) Rugulovasine A & B, 4) Cyclopiazonic acids, 5) Viridicatin, 6) Aspergynone-like metabolites (Frisvad and Filtenborg, 1989)

Growth on creatine: Very good

Acid and base production on creatine: Mostly strong acid and base production, few isolates only show acid production under the colony

Growth on UNO: Very good

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: (15-)21-35 mm; MEA: (16-)20-37 mm; YES: 29-50 mm; CREA: 14-28 mm; Cz: 19-29 mm, OAT: 20-34 mm; CYAS: 19-34 mm; CzBS: 7-27 mm; CzP: 0-9 mm; UNO: 15-25 mm; DG18: 25-30 mm

Diam., CYA, 1 week: 15°C: 23-29 mm; 30°C: 0-4 mm; 37°C: 0 mm

CYA/CYAS: 1.0 [0.6-1.4]

CYA15°C/CYA 25°C: 1.0 [0.8-1.3]

CYA30°C/CYA 25°C: 0.0 [0-0.2]

CZBS/CZ: 0.8 [0.4-1.1]

CZP/CZ: 0.3 and three at 0 [0-0.3]

Distribution: Temperate regions, on cheese in refrigerators in warmer areas, Denmark, Greenland, Norway, UK, the Netherlands, Italy, Spain, Turkey, USA, Canada, Bahamas, Japan, Australia, New Zealand

Ecology and habitats: Cheese, nuts, wheat bread, dried fish, cherries, litchis, bromeliads, wood, *Sorbus* endophyte, bee larvae, and soil.

Biotechnological applications: None, however the domesticated form is *P. camemberti* (Pitt *et al.*, 1986; Polonelli *et al.*, 1987)

Biodeterioration & phytopathology: The major fungus deteriorating cheese (Lund *et al.*, 1995; Hocking and Faedo, 1992; Tzanetakis *et al.*, 1987; Kure and Skaar, 2000; Kure *et al.*, 2001). *P. palitans* is also quite common in Norwegian cheeses and may be separated from *P. commune* by differences in several features (Polonelli *et al.*, 1987; Lund, 1995b; Kure *et al.*, 2002). Fingerprinting has been used to separate isolates within these species (Lund and Skouboe, 1998; Hansen *et al.*, 2003; Lund *et al.*, 2003; Kure *et al.*, 2003).

Mycotoxins and mycotoxins: The production of cyclopiazonic acid was first reported from *P. griseofulvum*, at that time misidentified as *P. cyclopium* (Holzapfel, 1968; Hermansen *et al.*, 1984; Frisvad, 1989). Despite this it has later incorrectly been claimed that *P. cyclopium* produced it (Bennett and Klich, 2003). The production of cyclopiazonic acid was later reported from *P. camemberti* (Still *et al.*, 1978) and *P. commune* (Frisvad, 1985; Pitt *et al.*, 1986; Polonelli *et al.* 1987; El-Banna *et al.* (1987); Frisvad and Filtenborg, 1989). This mycotoxin may be produced directly on the cheese or may enter melted cheeses.

Typical cultures: IBT 21513 = CBS 468.84 = FRR 2926 = IMI 285507, ex liquorice root (Y); IBT 14135 = CBS 279.67, ex Roquefort cheese; IBT 3430 = CBS 112080 = IMI 291543, ex animal feed nuts, UK; IBT 10762 = CBS 112470, ex French cheese, Paris; IBT 10924 = CBS 269.97 = CBS 112079, ex feta cheese; IBT 14083 = CBS 111835, mummified bee larva, USA; IBT 21896 = CBS 112471, ex patient, the Netherlands; IBT 23305 = CBS 112472, ex ice, Svalbard, Norway; NRRL 845, contaminant in *P. puberulum* NRRL 1889; CBS 282.36 = NRRL 879 = IBT 16113, ex sweet water in glycerol still, UK (*P. lanosoviride*); CBS 247.32 = NRRL 873 = IBT 12807 (*P. ochraceum* var. *macrosporum*), ex mouldy tobacco, UK; NRRL 935 = IBT 21597 (*P. australicum*); CBS 327.48 = NRRL 948 = IBT 21599 (*P. flavoglaucum*); NRRL 930 = IBT 21605 (*P. lanosogriseum*); CBS 216.30 = NRRL 894 = IBT 21606 (*P. lanosogriseum*), ex leaf mould, Spouderwout, Bussum, the Netherlands; NRRL 932 = IBT 21598 = CBS 265.29 = CBS 254.31 = ATCC 10116 = FRR 932 = IMI 192904 (*P. psittacinum*), ex air; CBS 341.59 = ATCC 18381 = IMI 068234 = IFO 6237 = QM 7292 (*P. roqueforti* var. *punctatum*), ex cheese, Japan; IBT 3470 = IBT 3467 = IMI 295179 = ATCC 56608, ex turnips, Denmark; IBT 18102 = FRR 4192, ex cheddar cheese, Sydney, Australia; CBS 343.51 (*P. cyclopium* var. *album*); IBT 3469 = FRR 2160, ex cheddar cheese, Sydney, NSW, Australia.

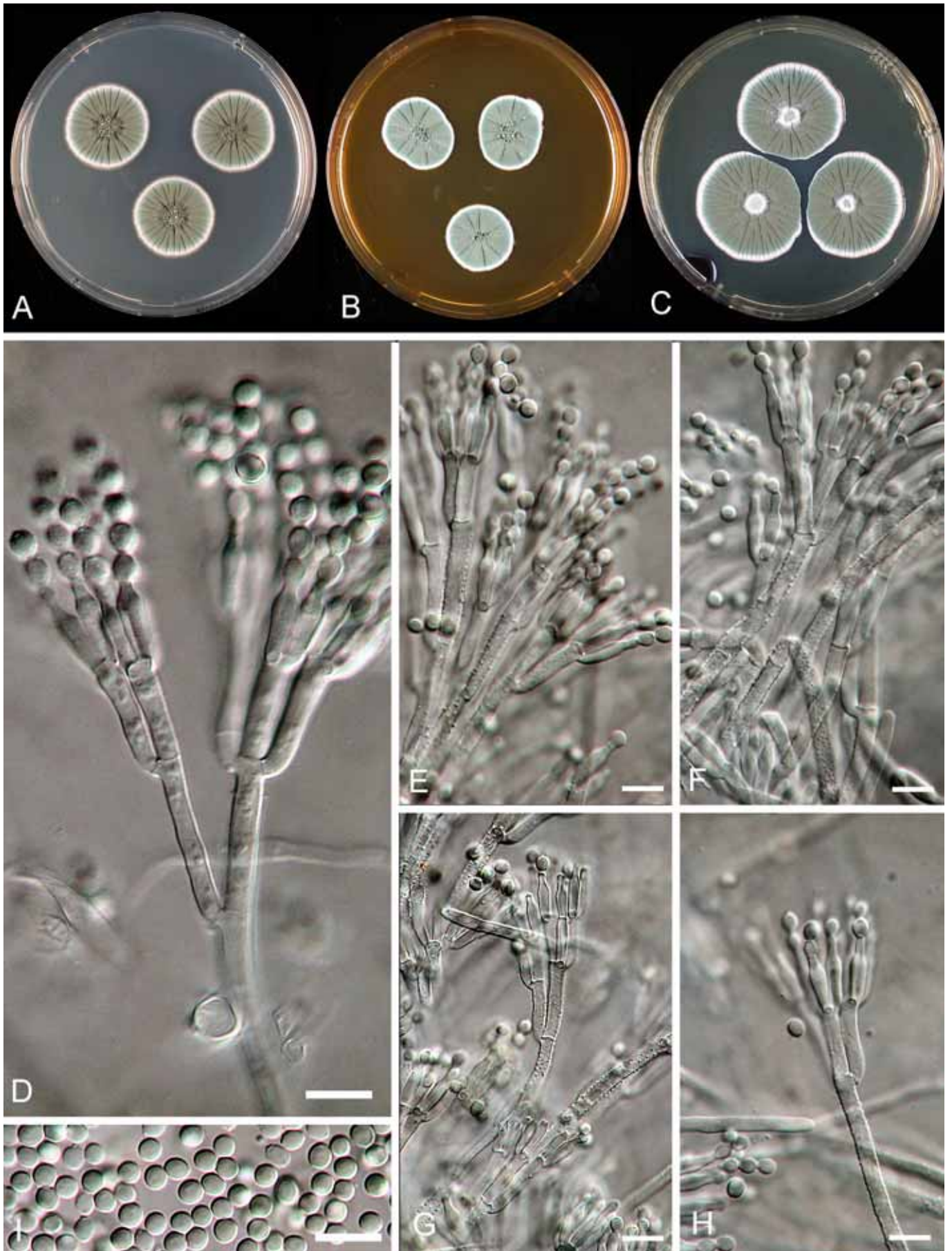


Fig. 39. *Penicillium commune*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. concentricum Samson, Stolk and Hadlok,
Stud. Mycol. (Baarn) 11: 17, 1976

In *Penicillium* subgenus *Penicillium* section *Penicillium*
series *Claviformia*

Type: Herb. CBS 477.75

Culture ex type: CBS 477.75 = IBT 14571 = IBT 6577 =
FRR 1715, ex colon of a deer, Germany (T)

Diagnostic features: Patulin, patulidin, roquefortine C,
meleagrins, oxaline, broadly ellipsoidal smooth-walled
conidia, fasciculate, orange reverse on all substrates,

Similar species: *P. concentricum* is most similar to *P.*
glandicola. The latter species produce very rough stipes in
contrast to *P. concentricum*.

Description:

Conidiophores: Terverticillate, appressed and somewhat
divergent elements, born from subsurface hyphae

Conidia: Smooth-walled, Broadly ellipsoidal, 3.2-3.7 µm x
2-2.5 µm

Phialides: Cylindrical tapering to a distinct collum, 5-10
µm x 2.2-2.5 µm

Metulae: Cylindrical, 9-13 µm x 3-3.5 µm

Rami: Cylindrical, 12-20 µm x 3-3.5 µm

Stipes: Smooth-walled (rarely finely rough-walled), 200-
400 µm x 3-4 µm

Synnemata or fasciculation: Fasciculate

Sclerotia: None

Colony texture: Fasciculate

Conidium colour on CYA: Artemisia to lily green

Exudate droplets on CYA: Copious, clear to pale yellow

Reverse colour on CYA: Orange to orange red

Reverse colour on YES: Yellow to strongly orange

Diffusible colour on CYA: Orange

Ehrlich reaction: No reaction or yellow

Odour and volatile metabolites: Not examined

Extrolites: 1) Patulin, 2) Patulodin & CT 2108A & B, 3)
Asteltoxin, 4) Barceloneic acid 5) Pyripyropens 6) Roque-
fortine C, meleagrins and oxaline, 7) Cyclopamine

Growth on creatine: Very good

Acid and base production on creatine: Good acid production
or just visible under colony followed by weak base produc-
tion

Growth on UNO: Very good

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 12-25 mm; MEA: 7-16 mm;
YES: 18-40 mm; CREA: 4-20 mm; Cz: 4-16 mm, OAT: 21-
30 mm; CYAS: 15-21 mm; CzBS: 3-15 mm; CzP: 0 mm;
UNO: 6-15 mm; DG18: 17-22 mm

Diam., CYA, 1 week: 15°C: 15-20 mm; 30°C: 0 mm; 37°C:
0 mm

CYA/CYAS: 1.1 [0.8-1.3]

CYA15°C/CYA 25°C: 1.0 [0.8-1.3]

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0.7 [0.5-1.0]

CZP/CZ: 0

Distribution: Denmark, Sweden, Norway, Germany,
United Kingdom, France, South Carolina, Wisconsin,
Kansas, USA

Ecology and habitats: Deer dung, soil (with deer dung),
salami, cheese, wheat flour; water tanks (*P. concentricum*
can be regarded as a faecal indicator)

Biotechnological applications: None

Biodeterioration & phytopathology: Unknown

Mycotoxins and mycotoxins: As in other coprophilic
species, many antibiotically active extrolites are found,
including patulin, patulidin, barceloneic acid and meleagrins,
but *P. concentricum* has rarely been found in foods.

Typical cultures: IBT 21514 = IBT 20230 = CBS 101024,
ex soil, University of South Carolina, USA (Y); IBT 5625,
ex pig feed, Norway; IBT 5623 = IBT 4372 = IBT 3848 =
CBS 185.89 = CBS 110762 = IMI 293197 = ATCC 58613
= FRR 3066, ex wheat flour, Denmark; IBT 5621 = IBT
3080 = CBS 285.36 = CBS 110765 = NRRL 2034 = ATCC
46510 = IMI 326061; IBT 22163 = CBS 110763, ex dung
from white-tailed deer, Turkey Swamp, New Jersey, USA;
IBT 13685 = CBS 110764, ex soil at Chateau Menthon, St.
Bernard, France; IBT 6778 = IBT 3078 = CBS 191.88 =
NRRL 13633 = IMI 321510 = ATCC 64635, ex soil,
Denmark; IBT 13168 = RMF 8051; ex soil, Konza Grass-
land, LTER, Kansas; IBT 5629 = IBT 3079 = IMI 285527 =
Kulmbach Sp. 831, ex salami, Germany; IBT 12736 = WSF
2352, soil in floodplain forest (Maple-Ash-Elm), Wiscon-
sin, USA; IBT 3847 = CBS 631.70; IBT 5618, ex cheese,
Denmark; UAMH 3893, ex oil-spilled soil, Norman Wells
NWT, Canada.

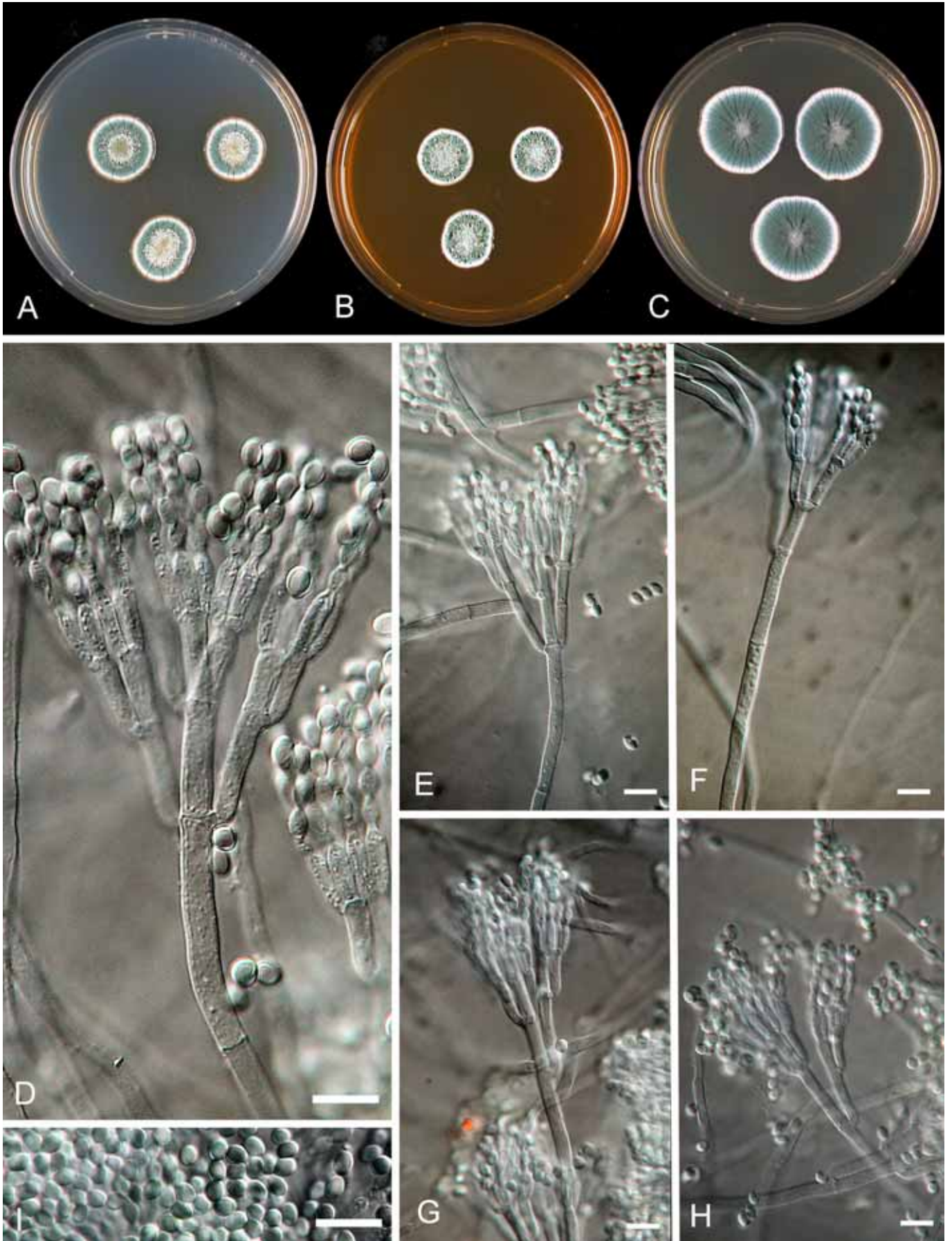


Fig. 40. *Penicillium concentricum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. confertum (Frisvad, Filt. & Wicklow) Frisvad,
Mycologia 81: 852, 1989

In *Penicillium* subgenus *Penicillium* section *Chrysogena*
series *Mononematosa*

Type: Herb. IMI 296930

Culture ex type: IBT 21515 = IBT 3098 = IBT 3093 = IBT
5672 = CBS 171.87 = IMI 296930 = NRRL 13488 = NRRL
A-26904, ex external fur-lined cheek pouch of *Dipodomys*
spectabilis, 6 km east of Portal, Arizona, USA (T,Y)

Diagnostic features: Asteltoxin, meleagrins, sinoid conidio-
phore stipes, good growth at 37°C.

Similar species: *P. confertum* is most closely related to
Penicillium mononemosum, but differs by its less compli-
cated penicilli and thin often sinoid stipes.

Description:

Conidiophores: Terverticillate, sinoid, appressed and
somewhat divergent elements, born from subsurface hyphae

Conidia: Smooth-walled, subglobose to broadly ellipsoidal,
3.2-3.7 µm x 2.2-3.0 µm

Phialides: Flask shaped with a distinct collulum, 7-9 µm x
2.5-3.0 µm

Metulae: Cylindrical, 10-15 µm x 3-4 µm

Rami: Cylindrical, 15-25 µm x 3-4 µm

Stipes: Thin, smooth-walled, sinoid, 150-300 µm x 2.5-3.5
µm

Synnemata or fasciculation: None

Sclerotia: None

Colony texture: Velutinous

Conidium colour on CYA: Greyish green to greyish tur-
quoise

Exudate droplets on CYA: Copious, clear to pale

Reverse colour on CYA: Cream to beige

Reverse colour on YES: Yellowish cream to curry

Diffusible colour: None

Ehrlich reaction: None to faint yellow

Odour and volatile metabolites: Not examined

Extrolites: 1) Asteltoxin, 2) Secalonic acid D, 3) Roque-
fortine C & meleagrins

Growth on creatine: Weak

Acid and base production on creatine: Acid under colony,
no base production

Growth on UNO: Weak

Growth on nitrite: Weak

Abiotic factors:

Diam., 1 week, 25°C: CYA: 20-24 mm; MEA: 17-29 mm;
YES: 26-36 mm; CREA: 18-24 mm; Cz: 14-24 mm, OAT:
23-29 mm; CYAS: 24-26 mm; CzBS: 1-2 mm; CzP: 0 mm;
UNO: 11-13 mm; DG18: 22-25 mm

Diam., CYA, 1 week: 5°C: 2-4 mm; 15°C: 13-15 mm;
30°C: 18-20 mm; 37°C: 7-10 mm

CYA/CYAS: 0.9

CYA15°C/CYA 25°C: 0.6

CYA30°C/CYA 25°C: 0.8

CZBS/CZ: 0.04

CZP/CZ: 0

Distribution: Arizona & New Mexico, USA

Ecology and habitats: Kangaroo rat mounds, deserts

Biotechnological applications: None

Biodeterioration & phytopathology: Unknown

Mycotoxins and mycotoxins: Asteltoxin, but the fungus
is apparently not food or feed-borne.

Typical cultures: IBT 16864, ex soil under *Atriplex gard-
neri*, Chetro Ketl, Chaco Canyon, New Mexico, USA.

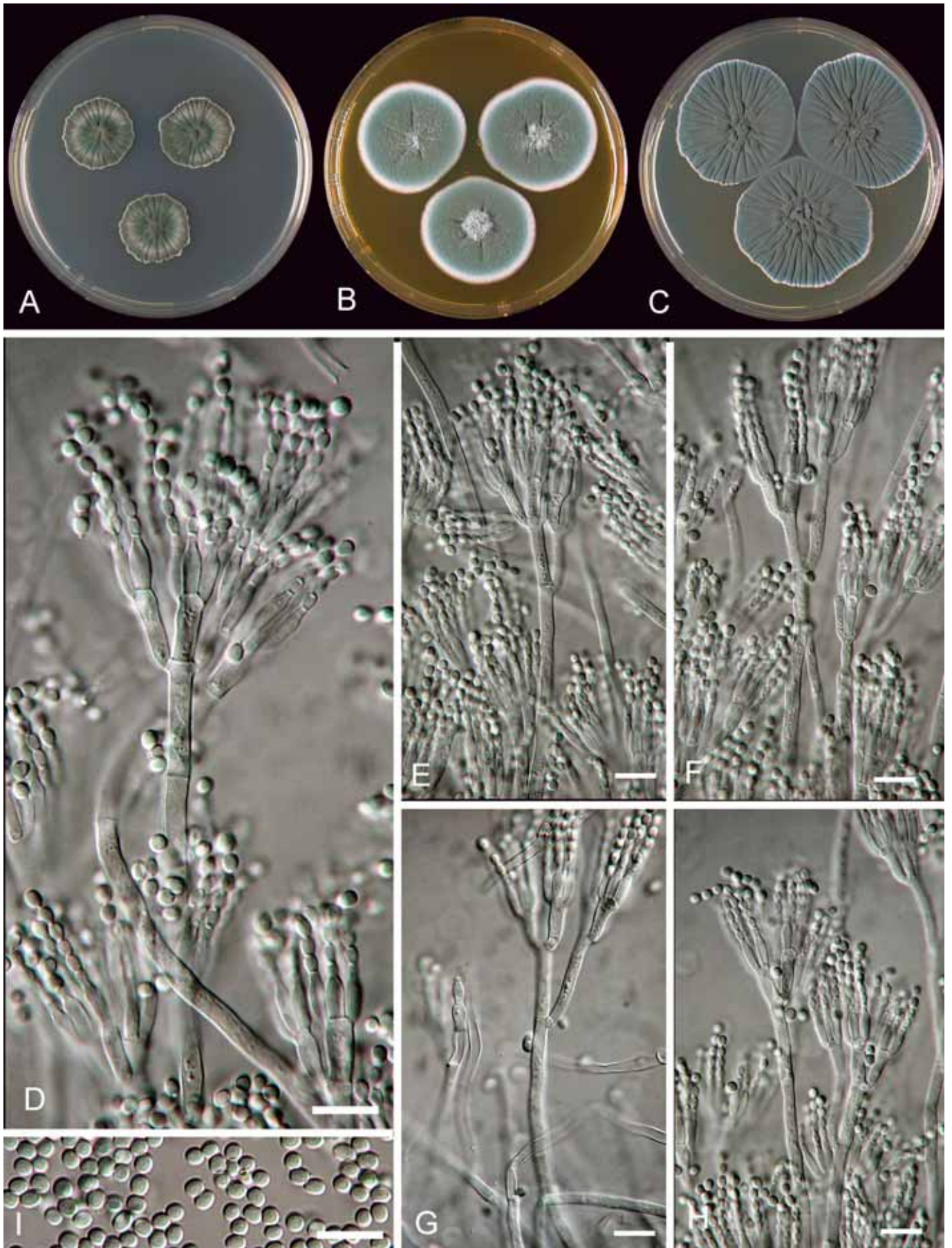


Fig. 41. *Penicillium confertum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 µm.

P. coprobium Frisvad, *Mycologia* 81: 853, 1989

In *Penicillium* subgenus *Penicillium* section *Penicillium* series *Claviformia*

Type: Herb. IMI 293209

Culture ex type: CBS 561.90 = IBT 3069 = IBT 4583 = IBT 6932 = IBT 21516 = IMI 293209 = ATCC 58615, ex pig feed, Norway (**T, Y**)

Diagnostic features: Patulin, roquefortine C, meleagrins, ellipsoidal smooth-walled conidia, fasciculate, small synnemata, pale reverse MEA, strong fruit-like smell.

Similar species: *P. coprophilum* differs from *P. coprobium* by uneven colony margins, and a dark brown reverse on CYA. *P. concentricum* has small colonies with a strong orange reverse on MEA, while the reverse of *P. coprobium* is cream coloured to light yellow.

Description (see also Kubatova (1993/1994) for colour photographs, as *P. coprophilum*):

Conidiophores: Terverticillate, appressed elements but divergent rami, born from subsurface hyphae

Conidia: Smooth-walled, broadly ellipsoidal, 3.2-4 µm x 2.5-3.0 µm

Phialides: Cylindrical tapering to a distinct collulum, 6.5-10 µm x 2.0-2.5 µm

Metulae: Cylindrical, 9-13 µm x 2.5-3 µm

Rami: Cylindrical, 12-20 µm x 3-3.5 µm

Stipes: Smooth-walled, 200-400 µm x 3-4 µm

Synnemata or fasciculation: Fasciculate, synnemata up to 1 mm with white stalks and green heads best developed on OAT

Sclerotia: White to pink and rare only seen on MEA after 3 weeks in a glass Petri dish (rare)

Colony texture: Fasciculate, not sulcate or only weakly sulcate

Conidium colour on CYA: Grey green to dark green

Exudate droplets on CYA: Copious, clear to pale brown

Reverse colour on CYA: Greyish brown to yellow brown

Reverse colour on YES: Cream coloured to curry to olive

Diffusible colour: Pale orange brown

Ehrlich reaction: None (one isolate faint yellow)

Odour and volatile metabolites: Isobutanol, isopentanol, 1,3,5-heptatriene and two isomers, 2-pentanone, isobutyl acetate, 1-nonene, styrene, 1-undecene, (blackberry smell) (Larsen & Frisvad, 1995)

Extrolites: 1) Patulin, 2) Pyripyropens, 3) Cyclopiamin, 4) Roquefortine C, meleagrins and neoxaline (Frisvad and Filtenborg, 1989)

Growth on creatine: Very good

Acid and base production on creatine: No acid production or acid just under colony

Growth on UNO: Very good

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 21-29 mm; MEA: 9-26 mm; YES: 25-34 mm; CREA: 3-15 mm; Cz: 12-17 mm, OAT: 18-31 mm; CYAS: 16-28 mm; CzBS: (0-) 4-17 mm; CzP: 0 mm; UNO: 5-16 mm; DG18: 23-29 mm

Diam., CYA, 1 week: 15°C: 14-19 mm; 30°C: 0-4 mm; 37°C: 0 mm

CYA/CYAS: 1.2 [0.9-1.3]

CYA15°C/CYA 25°C: 0.7 [0.5-0.9]

CYA30°C/CYA 25°C: 0.1 [0-0.2]

CZBS/CZ: 0.7 [one 0, 0.3-1.1]

CZP/CZ: 0

Distribution: Denmark, Norway, the Netherlands, Germany, United Kingdom, Czech Republic, Slovakia, Siberia, Russia, China, Kansas, USA

Ecology and habitats: Dung, soil and roots, cereal based animal feed, tea

Biotechnological applications: None

Biodeterioration & phytopathology: Unknown

Mycotoxins and mycotoxins: Patulin and roquefortine C are produced, but *P. coprobium* has only been found sporadically on foods and feeds. The species may indicate faecal contamination of feeds.

Typical cultures: IBT 6895 = IBT 3068 = IBT 4516 = CBS 184.88 = ATCC 64630 = IMI 321497 = NRRL 13626, ex soil, Houtribdijk, the Netherlands; IBT 3070 = IBT 3707 = IBT 3777 = IBT 6899 = CBS 185.88, ex pig feed, Norway; IBT 6897 = IBT 3071 = CBS 267.97, ex rabbit dung; IBT 15439 = CBS 280.97, ex *Hordeum vulgare*, Denmark; IBT 6900 = CBS 562.90 = CCF 2005, ex Českomoravská Vrchovina hills, Czech Republic; IBT 18861 = CBS 110762 = CCF 2800, ex soil Vrchy hills, Eastern Bohemia, Czech Republic; IBT 19342 = CBS 110761 = FRR 3645 = PREM 47700, ex grass roots, mangrove, Natal, South Africa; IBT 13168 = RMF 8051; ex soil, Konza Grassland, LTER, Kansas; IBT 22719, ex soil under snow 3 km west of Uthoss, Siberia, Russia; IBT 24820, tea, China; IBT 14656, ex potato, Denmark; IBT 3066, ex walnut; IBT 4369 = IBT 3067 = IBT 10555 = IMI 321499, ex soil, Loosdrecht, the Netherlands; IBT 18862 = CCF 2802, ex soil at Hlinsko, Czech Republic; IBT 18859 = FFC 2803, ex soil, Strážovské vrchy hills, Slovakia.

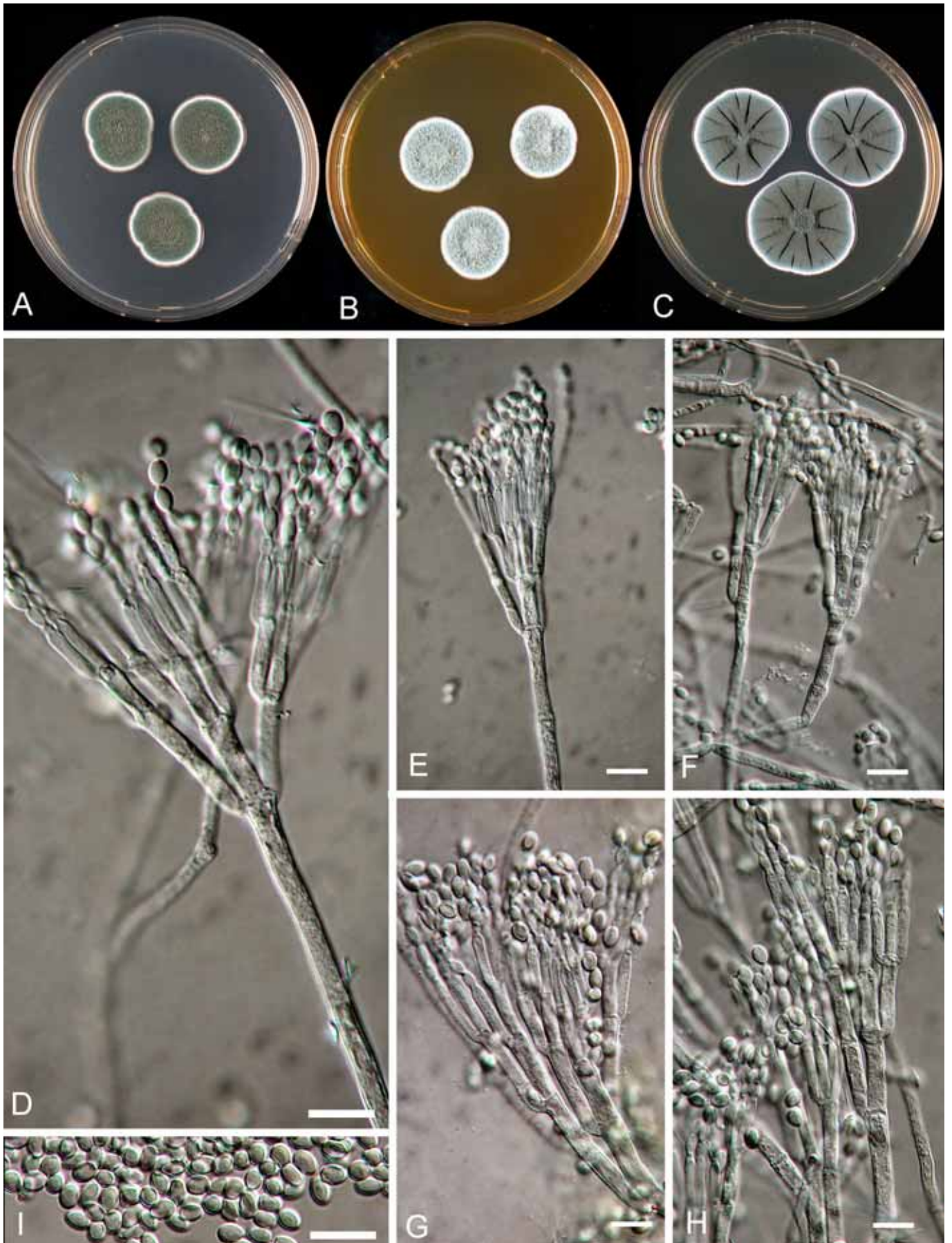


Fig. 42. *Penicillium coprobium*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μm.

P. coprophilum (Berk. & Curt.) Seifert & Samson, Adv. Pen. Asp. Syst.: 145, 1985

In *Penicillium* subgenus *Penicillium* section *Penicillium* series *Claviformia*

Type: herb. K, Cuba, Wright, 666

Ex epitype cultures: CBS 110760 = IBT 5551 = IBT 3064, ex rabbit dung, Groeneveld, Baarn, the Netherlands (**epiT**)

Diagnostic features: Griseofulvin, roquefortine C, meleagrins, oxalin, broadly ellipsoidal smooth-walled conidia, synnemata produced, uneven margin of colonies on MEA, dark brown reverse on CYA

Similar species: See *P. coprobium*.

Description:

Conidiophores: Terverticillate, appressed elements but divergent rami, born from subsurface hyphae

Conidia: Smooth-walled, broadly ellipsoidal, 3.2-3.7 µm x 2.0-2.5 µm

Phialides: Cylindrical tapering to a short distinct collum, 6.5-10 µm x 2.2-2.5 µm

Metulae: Cylindrical, 9-13 µm x 3-3.5 µm

Rami: Cylindrical, 12-20 µm x 3-3.5 µm

Stipes: Smooth- and rough-walled, 200-400 µm x 3-4 µm

Synnemata or fasciculation: Fasciculate, synnemata up to 1.3 mm with white stalks and green heads

Sclerotia: None

Colony texture: Fasciculate to coremiform

Conidium colour on CYA: Green to dark green

Exudate droplet on CYA: Copious, clear to pale brown

Reverse colour on CYA: Dark brown

Reverse colour on YES: Curry to brown yellow

Diffusible colour on CYA: Brown

Ehrlich reaction: None

Odour and volatile metabolites: Isobutanol, isopentanol, 1-octene, styrene, 2-pentanone, 3-methyl-2-pentanone, methyl isopentanoate, 1-nonene, 2-heptanol, 2-octanone, 3,4-dimethyl-hexanone, 1-methoxy-3-methyl-benzene, 1-undecene (Larsen and Frisvad, 1995)

Extrolites: 1) Griseofulvin, 2) Alternariol, 3) Pyripyropens, 4) Roquefortine C, meleagrins, oxalin, neoxalin 5) Cyclopiazamin

Growth on creatine: Very good

Acid and base production on creatine: Good acid production followed by base production, occasionally only acid under the colony

Growth on UNO: Very good

Growth on nitrite: Good

Abiotic factors:

Diam., 1 week, 25°C: CYA: 18-29 mm; MEA: 9-26 mm; YES: 25-34 mm; CREA: 3-15 mm; Cz: 12-17 mm, OAT: 18-31 mm; CYAS: 16-28 mm; CzBS: (0-) 4-17 mm; CzP: 0 mm; UNO: 5-16 mm; DG18: 23-29 mm

Diam., CYA, 1 week: 15°C: 14-19 mm; 30°C: 0-4 mm; 37°C: 0 mm

CYA/CYAS: 1.0 [0.9-1.2]

CYA15°C/CYA 25°C: 0.6 [0.6-0.8]

CYA30°C/CYA 25°C: 0.6 [0.3-0.7]

CZBS/CZ: 1.0 [0.9-1.3]

CZP/CZ: 7 isolates 0, two isolates 0.2 [0.2-0.3]

Distribution: Denmark, Norway, United Kingdom, Germany, South Carolina, New Jersey & Wisconsin (USA), Cameroon, Zambia, Ethiopia, South Africa, Australia, New Zealand

Ecology and habitats: Rabbit and deer dung, soil with herbivore dung, corn, rye bread, barley, compound feed, salami, hazelnuts

Biotechnological applications: None

Biodeterioration & phytopathology: Unknown

Mycotoxins and mycotoxins: Roquefortine C and alternariol are produced, but the species did not produce conspicuous growth on the food substrate from which they were isolated.

Typical cultures: CBS 186.89 = IBT 21517 = IBT 3768 = IBT 5539 = NRRL 13627, ex *Andropogon sorghum* imported to Denmark (Y); IBT 23268 = CBS 102444, ex woodchip paper behind skirting board, Germany; IBT 5546 = CBS 473.75, ex *Zea mays*, Pretoria, South Africa; IBT 3063 = IBT 3845 = IBT 4753 = IBT 5552 = CBS 110759 Kulmbach Sp. 1370, ex salami, Germany; IBT 18704 = CBS 110758, ex rye bread, Denmark; IBT 22162 = CBS 110757, ex *Styra cifolia* (liquid amber), Turkey Swamp, New Jersey, USA; IBT 12724 = CBS 110767, ex *Hordeum vulgare*, the Netherlands; IBT 12992 = CBS 272.97 = CBS 110768, ex wheat, Denmark; FRR 1403, ex chicken feed, Brisbane, Qld., Australia; IBT 12750 = WSF 5238.

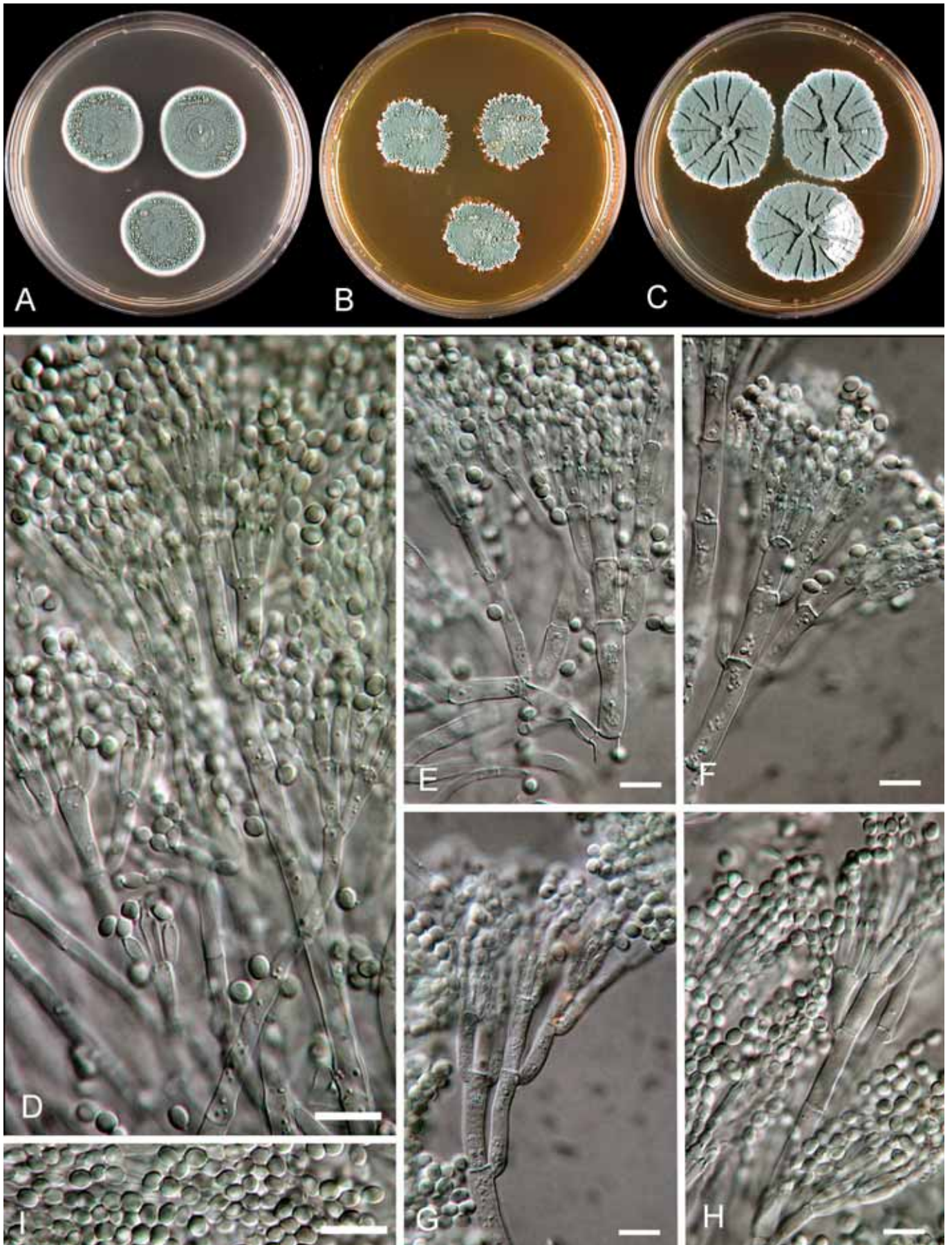


Fig. 43. *Penicillium coprophilum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 µm.

P. crustosum Thom, *Penicillia*: 399, 1930

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Camemberti*

Type: Herb. IMI 091917

Culture ex type: IBT 5528 = IBT 6175 = IMI 091917 = FRR 1669 = ATCC 52044 = NCTC 4002, ex lemon, Aberdeen, Scotland (T)

Diagnostic features: Penitrem A, roquefortine C, terrestrial acid, viridicatin, smooth-walled conidia, crustose on CYA and MEA after 7-10 days, high growth rate, good growth on CREA. Strong sporulation and high growth rate on YES agar.

Similar species: *P. expansum* has ellipsoidal conidia and usually smooth stipes and is not crustose. *P. commune* has smaller colony diameters, not a deep yellow reverse on YES and is not crustose. *P. palitans* has smaller colonies, darker and greener conidia and is not crustose.

Description:

Conidiophores: Terverticillate, appressed elements, born from subsurface hyphae

Conidia: Smooth-walled, globose to subglobose, 3-4 µm.

Phialides: Cylindrical tapering to a distinct collulum, 9-12 µm x 2.5-3 µm

Metulae: Cylindrical, 10-15 µm x 3-3.5 µm

Rami: Cylindrical, 15-25 µm x 3.5-4 µm

Stipes: Rough-walled, 200-400 µm x 3.5-4.5 µm

Synnemata or fasciculation: Weakly fasciculate

Sclerotia: None

Colony texture: Velutinous to weakly fasciculate, becoming crustose

Conidium colour on CYA: Dull green to grey green or blue green at the colony margin

Exudate droplets on CYA: Copious, clear or brown

Reverse colour on CYA: Cream-coloured to yellow brown

Reverse colour on YES: Strongly yellow

Diffusible colour: Pale brown or none

Ehrlich reaction: None

Odour and volatile metabolites: Ethyl acetate, isobutanol, ethyl propanoate, isopentanol, dimethyldisulphide, ethyl isobutanoate, isobutyl acetate, ethyl butanoate, ethyl-2-methyl butanoate, ethyl isopentanoate, isopentyl acetate, styrene, ethyl pentanoate, 3-octanone, ethyl hexanoate, ethyl octanoate, 2-methyl-isoborneol, geosmin.

Extrolites: 1) Penitrem A-G, 2) Roquefortine C-E, 3) Terrestrial acid and viridicatic acid, 4) Viridicatins (cyclopeptin, dehydrocyclopeptin, cycloopenin, cycloopenol, viridicatin, viridicatol), 5) Hadacidin, 6) Andrastin A

Growth on creatine: Very good

Acid and base production on creatine: Good acid production followed by base production

Growth on UNO: Very good

Growth on nitrite: Poor

Abiotic factors:

Diam., 1 week, 25°C: CYA: 32-46 mm; MEA: 25-46 mm; YES: 40-56 mm; CREA: 22-35 mm; Cz: 29-32 mm, OAT: 28-38 mm; CYAS: 29-39 mm; CzBS: 25-28 mm; CzP: 0-3 mm; UNO: 19-23 mm; DG18: 29-32 mm

Diam., CYA, 1 week: 15°C: 28-31 mm; 30°C: 15-26 mm; 37°C: 0 mm

CYA/CYAS: 1.3 [1.1-1.5]

CYA15°C/CYA 25°C: 0.7 [0.7-0.7]

CYA30°C/CYA 25°C: 0.5 [0.4-0.6]

CZBS/CZ: 0.9 [0.8-0.9]

CZP/CZ: 0.1 and four at 0 [0-0.1]

Distribution: Panglobal: Denmark, Norway, Germany, Slovenia, Greece, Bulgaria, Azoan Islands, Portugal, Georgia & New Mexico (USA), Kazakhstan, Victoria B.C., Indonesia; Canada, Australia, New Zealand.

Ecology and habitats: Pecans, walnuts, chestnuts, apples, cream cheese, blue cheese, salami, indoor air, coffee beans, maize, cotton seed, compound feeds, cardboard.

Biotechnological applications: None

Biodeterioration & phytopathology: *P. crustosum* can produce a weak rot in apples (Frisvad, 1981). It is a major degrader of compound feeds for animals and cheeses.

Mycotoxins and mycotoxins: Penitrem A and roquefortine C from *P. crustosum* growing on cheese or nuts have been implicated in toxicoses of dogs (Richard *et al.*, 1981; Richard and Arp, 1979; Puls and Ladyman, 1988; Hocking *et al.*, 1988; Naudé *et al.*, 2002). The case of mycotoxicosis of a man after drinking beer (Cole *et al.*, 1983; Cysewski *et al.*, 1975) was caused by *P. carneum*, not *P. crustosum*. Cattle has also been intoxicated with penitrem A from *P. crustosum* (Wilson *et al.*, 1968; Dorner *et al.*, 1984). Strains identified as *P. palitans* (Ciegler, 1969), *P. commune* (Mintzloff *et al.*, 1972; Wagener *et al.*, 1980), *P. lanosocoe-ruleum* (Wells and Cole, 1977), *P. cyclopium* (Wilson, 1968; Ciegler and Pitt, 1970; Vesonder *et al.*, 1980), *P. martensii*, *P. olivinoviride*, *P. puberulum* (Ciegler and Pitt, 1970) producing penitrem A and roquefortine C were all *P. crustosum* (Pitt, 1979b, Frisvad, 1989). The production of both toxins is very consistent in *P. crustosum* (El-Banna and Leistner, 1988; Frisvad and Filtenborg, 1989)

Typical cultures: IBT 21518 = IBT 14747 = CBS 101025, ex cheese, Azoan Islands (Y); IBT 23265 = CBS 181.89, ex soil with *Agaricus bisporus*; IBT 6579 = IBT 3425 = CBS 471.84 = IMI 285510 = FRR 2929, ex *Thymus vulgaris*, Greece; IBT 6580 = IBT 5529 = CBS 110076 = FRR 1387, ex Portuguese wine corks, Sydney, NSW, Australia; IBT 18099 = CBS 110077 = FRR 1513, ex deteriorating preserved wood-stakes; North Qld., Australia; IBT 15977 = CBS 110075, ex mixed pig feed, Bulgaria; IBT 14519 = CBS 110074, ex Lechuiguilla Cave, Carlsbad, New Mexico; IBT 16510 = CBS 110073, ex soil, ex soil under *Betula* sp., Victoria B.C., Canada; IBT 11095 = CBS 499.73 = IMI 174717 = FRR 1478 = VKM F-1746 = ATCC 24721, ex grapes in storage, Alma-Ata, Kazakhstan (*P. farinosum*); IBT 11150 = CBS 340.59 = QM 7293 = ATCC 18379 = FRR 3457 = IFO 6235 = IMI 068235, ex soil, Japan (*P. pseudocasei*); IBT 3426 = ATCC 32014, ex weevil-damaged pecans, Georgia, USA; IBT 6578 = FRR 2223, ex weevil-damaged pecans, Georgia, USA; IBT 16885, ex mouldy onion, Denmark; IBT 18359 = CCRC 32633, Taiwan; IBT 23710 = IMI 206159, ex soil, New Zealand.

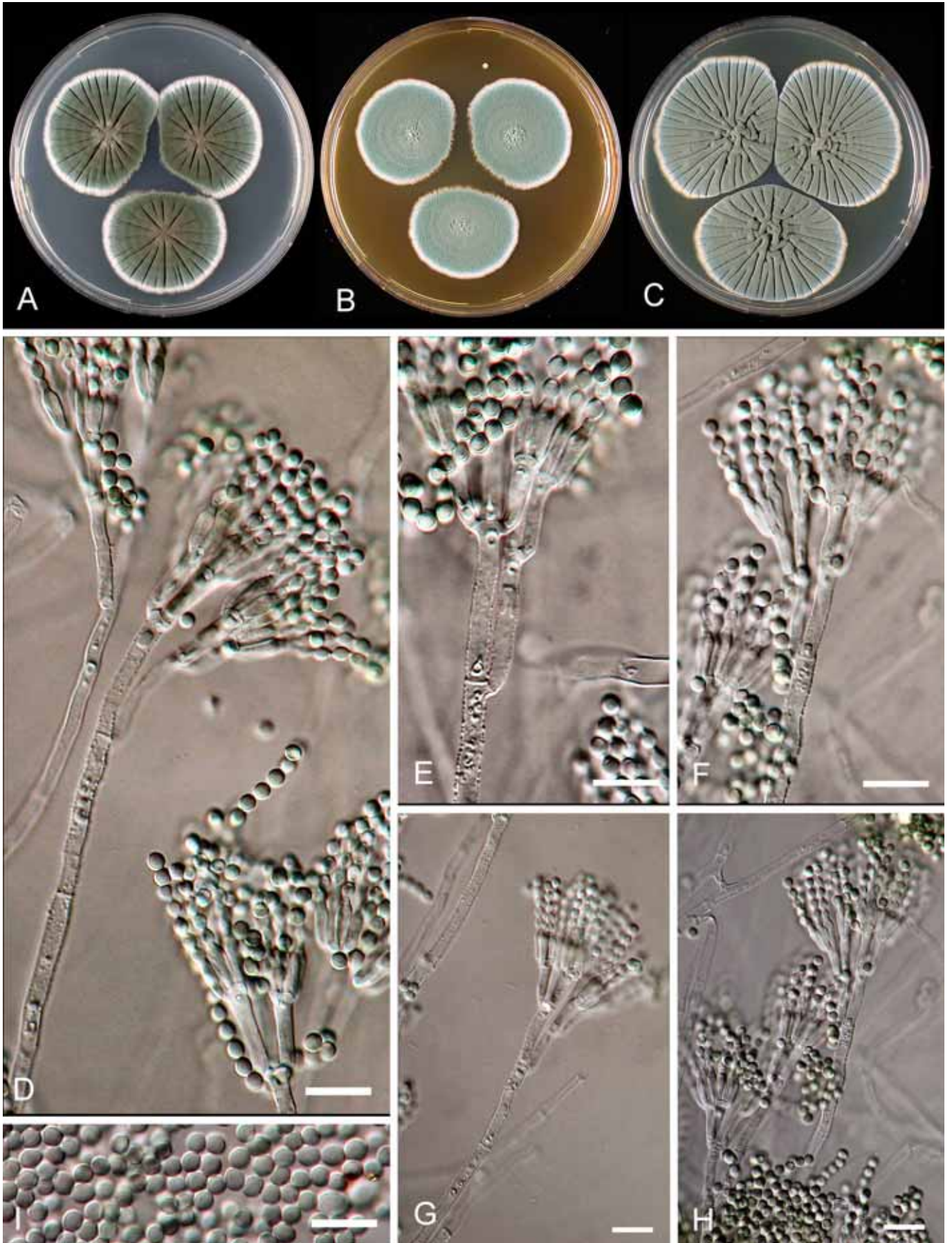


Fig. 44. *Penicillium crustosum*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 µm.

P. cyclopium Westling, Ark. Bot. 11: 90, 1911

In *Penicillium* subgenus *Penicillium* section *Viridicata* series *Viridicata*

Type: Herb. IMI 089372

Culture ex type: CBS 144.45 = CBS 114.74 = IBT 5130 = IMI 089372 = ATCC 8731 = ATHUM 2888 = CECT 2264 = DSM 1250 = LSHB 1923 = MUCL 15613 = QM 6839 = VKM F-265, ex fruit, Norway (T)

(*P. puberulum* Bain. 1907 is a *nomen dubium* as the culture ex neotype contains both material of *P. commune* (NRRL 845 = ATCC 8508) and *P. cyclopium* (NRRL 1889 = NRRL 2040))

Diagnostic features: Xanthomegnin, viomellein, vioxanthin, penicillic acid, blue green smooth-walled conidia, green on CYA and blue green on MEA

Similar species: See *P. aurantiogriseum*

Description:

Conidiophores: Terverticillate, appressed elements, born from subsurface hyphae

Conidia: Smooth-walled, globose to subglobose, 2.6-3.2 µm.

Phialides: Cylindrical tapering to a distinct collulum, 8-9 µm x 2.6-2.8 µm

Metulae: Cylindrical, 9.5-14 µm x 3.2-4.4 µm

Rami: Cylindrical, 15-25 µm x 3.2-4.4 µm

Stipes: Rough-walled, 200-750 µm x 3.5-5 µm

Synnemata or fasciculation: Weakly fasciculate

Sclerotia: None

Colony texture: Velutinous to weakly fasciculate

Conidium colour on CYA: Blue green to green, blue green on MEA

Exudate droplets on CYA: Copious, clear or light yellow

Reverse colour on CYA: Yellow to orange to red brown occasionally only cream yellow

Reverse colour on YES: Strongly yellow, also yellow obverse (poor sporulation on YES)

RT agar: Dark brown halo in most isolates

Diffusible colour: None or pink or red brown

Ehrlich reaction: pink to red or yellow brown

Odour and volatile metabolites: Close to the volatile profile of *P. aurantiogriseum*, but weaker

Extrolites: 1) Penicillic acid, 2) Xanthomegnin, viomellein and vioxanthin, 3) Puberulic acid and puberulonic acid 4) Puberuline and verrucofortine (rugulosuvine and leucyltryptophanyldiketopiperazine), 5) 3-Methoxyviridicatin (and cyclopeptin, dehydrocyclopeptin, cyclophenin, cyclophenol, viridicatinol)

Growth on creatine: Poor growth

Acid and base production on creatine: Good acid production, no base production

Growth on UNO: Weak

Growth on nitrite: Poor.

Abiotic factors:

Diam., 1 week, 25°C: CYA: 18-34 mm; MEA: 21-35 mm;

YES: 28-40 mm; CREA: 11-21 mm; Cz: 19-28 mm, OAT:

17-29 mm: CYAS: 25-34 mm; CzBS: 12-21 mm; CzP: 0 mm; UNO: 7-17 mm; DG18: 23-27 mm

Diam., CYA, 1 week: 15°C: 19-24 mm; 30°C: 2-6 mm; 37°C: 0 mm

CYA/CYAS: 0.9 [0.8-1.1]

CYA15°C/CYA 25°C: 0.8 [0.7-1.0]

CYA30°C/CYA 25°C: 0.2 [0.1-0.2]

CZBS/CZ: 0.8 [0.5-0.9]

CZP/CZ: 0

Distribution: Temperate regions with farming: Denmark, Sweden, United Kingdom, Norway, Canada, more rare in Saudi Arabia and California (USA)

Ecology and habitats: Cereals: wheat, barley, oats, maize, compound feeds, more rare on salami, seaweed and harness.

Biotechnological applications: None

Biodeterioration & phytopathology: Degrades cereals and animal feeds.

Mycotoxins and mycotoxins: This species is a very efficient producer of xanthomegnin, viomellein and vioxanthin, as are *P. freii*, *P. viridicatum* and *P. tricolor* (the latter is less common, however). These species are very commonly growing in low quality cereals and may cause liver and kidney diseases in domestic animals (Carlton *et al.*, 1968; Carlton and Tuite, 1970a & b; Budiarso *et al.*, 1968; 1971; Carlton *et al.*, 1972; Zwicker *et al.*, 1973). The latter reference reported on probable carcinogenicity of *P. viridicatum*, which always produces xanthomegnin, viomellein and vioxanthin, but also brevianamide A, viridic acid and viridamine distinguishing it from *P. cyclopium* (see also *P. viridicatum*). The mixture of penicillic acid and xanthomegnin, viomellein and vioxanthin is also present in most isolates of *Aspergillus ochraceus* (Frisvad and Samson, 2000). *A. ochraceus* give the same severe symptoms in mice and swine (Zimmerman *et al.*, 1976, 1977; 1979; Robbers *et al.*, 1978) as *P. viridicatum* indicating that xanthomegnin and viomellein are more important than previously thought. It appears that ochratoxin A from *P. verrucosum* (or some of the strains of *Aspergillus ochraceus*) mostly adds to the nephrotoxicity of mouldy cereals rather than to the hepatotoxicity. Xanthomegnin, viomellein and vioxanthin have been found to be naturally occurring in cereals (Hald *et al.*, 1983, Scudamore *et al.*, 1986) and the fungi responsible for this were *P. cyclopium* and *P. freii*.

Typical cultures: IBT 21519 = IBT 11415 = CBS 101136 (Y), ex harness, Saudi Arabia; IBT 5171 = CBS 477.84 = IMI 285516 = FRR 2935, ex *Hordeum vulgare*, Denmark; IBT 5167 = CBS 349.59 = QM 7314 = ATCC 18382 = FRR 1364 = IFO 6240 = IMI 068218 (*P. viridicyclopium*), ex soil, Japan; IBT 22027 = CBS 110335, ex wheat, UK; IBT 14369 = CBS 110336, ex wheat, UK; IBT 16769 = CBS 110337, ex malting barley, Denmark; IBT 3454 = CBS 110338; IBT 5141 = CBS 123.14 = NRRL 1889 = NRRL 2040 = ATCC 10483 = ATCC 8505 = ATCC 8732 = CCRC 31519 = FRR 2040 = IFO 7733 = IMI 034913 = LSHB Ad113 = QM 1556 = MUCL 29231 = MUCL 31198 = QM 1556 = VMK F-328 (*P. puberulum*), ex maize, Lincoln, Nebraska, USA; IBT 12480 = NRRL 970 = FRR 970 (*P. porraceum*); IBT 5362 = FRR 1347, from chicken feed implicated in fatty liver and kidney syndrome, Victoria, Australia.

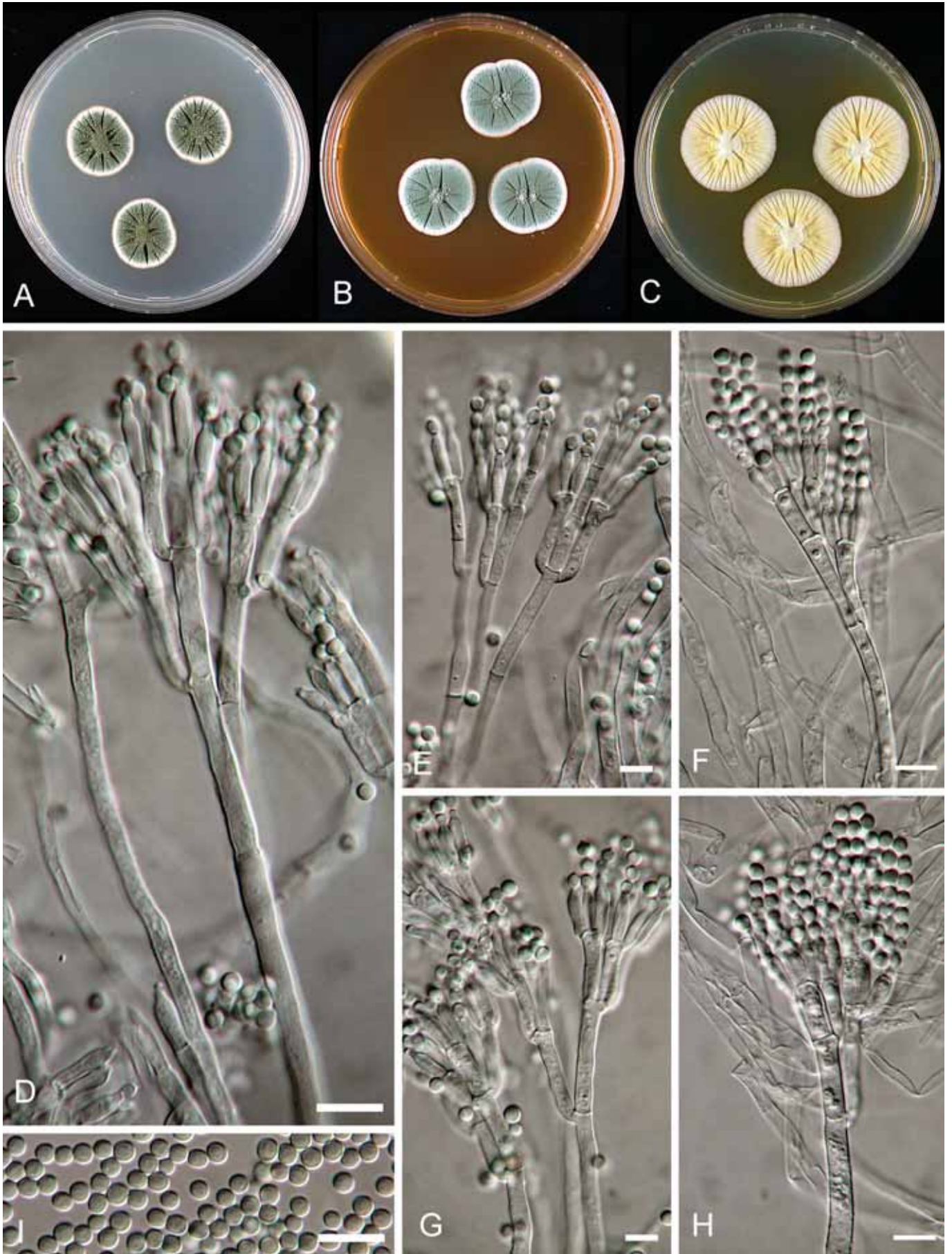


Fig. 45. *Penicillium cyclopium*. 7-day old colonies on A. CYA, B. MEA, C. YES, D-H. Conidiophores. I. Conidia. White bar = 10 μ m.

P. digitatum (Pers.:Fr.) Sacc., Fung. Ital.: 894, 1881

In *Penicillium* subgenus *Penicillium* section *Digitata* series *Digitata*

Type: Icon in Saccardo, Fung. Ital.: tab. 894 Jul. 1881

Epitype suggested: CBS 112082 = IBT 13068, ex *Citrus limon*, Italy (**epiT**)

Diagnostic features: Tryptoquialanines, large cylindrical to ellipsoidal smooth-walled olive green conidia, no growth on Czapek agar and CYAS

Similar species: None

Description:

Conidiophores: Terverticillate, appressed elements, born from subsurface or aerial hyphae

Conidia: Smooth-walled, ellipsoidal to cylindrical, 6-9 (-14) μm x 2.8-6 μm .

Phialides: Cylindrical tapering to a distinct collum, 10-17 μm x 4-5 μm

Metulae: Cylindrical, 15-25 μm x 5-6 μm

Rami: Cylindrical, 20-30 μm x 5-6 μm

Stipes: Rough-walled, 60-160 μm x 5-7 μm

Synnemata or fasciculation: None

Sclerotia: None

Colony texture: Velutinous

Conidium colour on CYA: Olive green

Exudate droplets on CYA: Only in few isolates

Reverse colour on CYA: greyish olive to beige

Reverse colour on YES: cream yellow with light brown center

Diffusible colour: None

Ehrlich reaction: None

Odour and volatile metabolites: Ethylene, ethyl alcohol, ethyl acetate, methyl acetate, isopropyl acetate, octyl acetate, limonene, valencene (Birkinshaw et al., 1931; Larsen and Frisvad, 1995)

Extrolites: 1) Tryptoquialanins, 2) Cholesterol, ergosta-7,22-dien-3 β -OH, ergosta-7,22-24(28)-trien-3 β -OH, episterol, eburicol, 3) Phenylalanine-proline dike-topiperazine (2 isomers), 4) 3,5-Dimethoxyphenol, methoxyphenol (5 isomers), 1,1'-biphenyl-3-ol, 2-methoxy-4-propyl phenol (ethyl vanillin)

Growth on creatine: Very poor

Acid and base production on creatine: No acid

Growth on UNO: Good

Growth on nitrite: Neither growth on Czapek nor nitrite agar

Abiotic factors:

Diam., 1 week, 25°C: CYA: (15-)24-37(-55) mm; MEA: 26-54 mm; YES: 44-76 mm; CREA: 0-6 mm; Cz: 13-27 mm, OAT: 19-38 mm: CYAS: 0 mm; CzBS: 2-4 mm; CzP: 0 mm; UNO: 3-8 mm; DG18: 44-56 mm

Diam., 1 week: 15°C: 8-22 mm; 30°C: 0 mm; 37°C: 0 mm

CYA/CYAS: No growth on CYAS

CYA15°C/CYA 25°C: 0.7 [0.3-1.1]

CYA30°C/CYA 25°C: 0

CZBS/CZ: 0.2 [0.1-0.3]

CZP/CZ: 0

Distribution: Italy, Spain, Cyprus, Turkey, Israel, Egypt, Saudi Arabia, Libya, Morocco, Nigeria, South Africa, Zimbabwe, Tanzania, Florida, California, USA, Cuba, Domenica, Argentina, Brazil, Australia, Indonesia, India, Bangla Desh, Pakistan, Japan, Korea, Taiwan, Viet Nam. On imported citrus fruits to Denmark, Sweden, United Kingdom, Netherlands, Belgium, France, Germany, the Netherlands, etc. (imported citrus fruits), Canada, Connecticut, North Carolina, Oklahoma, Wisconsin, USA.

Ecology and habitats: Citrus fruits are often degraded by *P. digitatum*. The species has been found on herbs, but citrus fruits may be the only real habitat. See also Domsch et al. (1980)

Biotechnological applications: None

Biodeterioration & phytopathology: *P. digitatum* is a major pathogen of citrus fruits (where it may co-occur with *P. italicum* and *P. ulaiense*) (Holmes et al., 1994)

Mycotoxins and mycotoxins: Some metabolites were shown to be toxic in the chick embryo test (Faid and Tantaoui-Elaraki, 1989).

Typical cultures: IBT 21520 = IBT 15179 = CBS 101026 (Y), ex chili mix, Indonesia; IBT 12919 = CBS 351.97 = CBS 529.97, ex chervil, Denmark; IBT 15037 = CBS 112083, ex *Citrus sinensis*; IBT 5533 = CBS 112322 = FRR 288 = ATCC 52304, ex soil, foreshore of Whiteswan Lake, Saskatchewan, Canada; IBT 3816 = CBS 112081, ex mandarin; IBT 23020 = CBS 136.65 = DSM 2731, ex fruit of *Citrus medica limonum*, Netherlands; IBT 23021 = CBS 319.48 = NRRL 786 = ATCC 10030 = IFO 7006 = IMI 039748 = QM 7552 = DSM 2748, ex fruit of *Citrus* sp., Connecticut, USA; CBS 492.84 = IMI 293202 = ATCC 58617, ex *Lipidium sativum*.