

The genus *Aphanoascus*

J. CANO AND J. GUARRO

Unitat de Microbiologia, Facultat de Medicina, Universitat de Barcelona, 43201-Reus, Tarragona, España

The genus *Aphanoascus*. *Mycological Research* 94 (3): 355–377 (1990).

The genus *Aphanoascus* is re-described, discussed, and a key to the 12 species is presented. Six are proposed as new (*A. keratinophilus*, *A. clathratus*, *A. hispanicus*, *A. multiporus*, *A. saturnoideus* and *A. verrucosus*) and two others as new combinations (*A. durus* and *A. mephitilis*) from *Keratinophyton durum* and *Xynophila mephitilis* respectively. *A. canadensis*, *A. fulvescens*, *A. reticulisporus* and *A. terreus* are accepted as good species.

Key words: *Aphanoascus*, *Anixiopsis*, Keratinophilic fungi, *Chryso sporium*, *Malbranchea*, *Keratinophyton*, *Xynophila*.

Since its foundation by Zúkal (1890), the genus *Aphanoascus* has suffered continuous taxonomic confusion. Its nomenclature has been exhaustively reviewed by Apinis (1968), who considered *A. fulvescens* (Cooke) Apinis the type species. Most other authors follow this proposal (Domsch *et al.*, 1980; v. Arx, 1981; Currah, 1985), but some medical mycologists consider *Aphanoascus* to be a synonym of *Anixiopsis* Hansen (De Vries, 1969; Gueho & De Vroey, 1986). Further confusion has been caused by the description by Udagawa & Takada (1973) of a neotype for what they believe is the type species, *Aphanoascus cinnabarinus*, based on a soil isolate characterized by ascospore ornamentation in the form of irregular crests as well as by a *Faecilomyces* anamorph. According to Stolk & Samson (1983), *Aphanoascus cinnabarinus sensu* Udagawa & Takada probably should be placed in a new genus, somewhere between *Thermoascus* Miehe and *Talaromyces* Benjamin. Benny & Kimbrough (1980), on the basis of Udagawa & Takada's neotypification recognize both *Aphanoascus* and *Anixiopsis* as distinct. They are distinguished by having reticulate and ridged ascospores respectively.

Aphanoascus was placed by Apinis (1968) in the Cephalothecaceae, by Malloch & Cain (1971) and Currah (1985) in the Onygenaceae, by Benny & Kimbrough (1980) in Trichocomaceae and by v. Arx (1987) in Amauroascaceae.

The following species are currently accepted in the genus: the type species *A. fulvescens*, *A. terreus* (Randhawa & Sandhu) Apinis with ascospores featuring a prominent equatorial crest, *A. canadensis* Currah with ascospores appearing smooth-walled by optical microscopy and with a *Malbranchea* anamorph, *A. reticulisporus* (Routien) Hubalek, with ascospores regularly alveolate-reticulate and lastly a species described almost at the same time by Currah (1985) as *Keratinophyton durum* and by Gueho & De Vroey (1986) as *Anixiopsis biplanata*.

Another species which it is believed should be included in *Aphanoascus* is *Xynophila mephitilis* Malloch & Cain (1971) probably described as *Neoxenophila foetida* by Apinis & Clark (1974).

In the course of studies on keratinophilic fungi from Spain we have had the opportunity of studying a large number of recent isolates of *Aphanoascus* and are thus able to establish a better delimitation of the genus and its constituent species.

Aphanoascus Zúkal, *Ber. dt. bot. Ges.* 8: 295 (1890).

Anixiopsis Hansen, *Bot. Ztg* 7: 131 (1897).

Keratinophyton Randhawa & Sandhu, *Sabouraudia* 3: 252 (1964).

Xynophila Malloch & Cain, *Can. J. Bot.* 49: 845 (1971).

Neoxenophila Apinis & B. Clark, *Trans. Br. mycol. Soc.* 63: 263 (1974).

Type species: *Aphanoascus fulvescens* (Cooke) Apinis

Colonies expanding, white or pale brown, occasionally reddish-brown, powdery to felty, normally flat. *Hyphae* hyaline, branched, septate, thin-walled; reproductive initials seen as intertwining paired hyphae, sometimes forming a globose mass. *Ascomata* superficial, solitary or in clusters under a common tomentum, spherical, non-ostiolate, glabrous, pale to dark-brown; ascoma wall composed of a variable number of layers of flattened, angular or intricate, rather thick-walled cells. *Asci* numerous, subglobose to ellipsoidal, 8-spored, evanescent. *Ascospores* lenticular, discoid or oblate with or without equatorial rim, pale to dark-brown, one-celled, with reticulate, pitted or verrucose wall. *Anamorph*: *Chryso sporium* or *Malbranchea*.

Species are found on soil and dung and occasionally are cited as pathogenic to man.

When only the four above-mentioned species were known and few specimens had been examined with the scanning

electron microscope it seemed appropriate to accept two genera, *Aphanoascus* with dorsiventrally flattened ascospores with reticulate walls and *Keratinophyton* where ascospores bore a prominent equatorial crest and smooth walls. However, as a result of the description of several new species (all of them studied with the SEM) with ornamented ascospores and with characters intermediate between these two genera, it is preferred to treat them all under one genus, with *Keratinophyton* as a synonym of *Aphanoascus*.

v. Arx (1987) regarded the ascospores of *Aphanoascus* as bilaterally flattened, and those of the Gymnoascaceae as dorsiventrally flattened. However, it is believed that in this group of fungi it is very difficult to differentiate these categories. *Aphanoascus* and the Gymnoascaceae have ascospores with the same symmetry, i.e. oblate, discoid or lenticular (round in face view, ellipsoidal or quadrangular in lateral view). *Aphanoascus* on these grounds is not a typical member of the Amauroscaceae, where ascospores are usually

globose or subglobose. The Gymnoascaceae are distinctive for their generally smooth spores which are never reticulate, alveolate or pitted.

Other genera with pigmented ascospores which are similar to *Aphanoascus* are *Amauroascus* Schroeter, *Byssomygena* Guarro, Punsola & Cano and *Brunneospora* Guarro, Punsola & Figueras. The first has a peridium formed exclusively of more or less differentiated hyphae, the ascospores being wholly or almost spherical. *Byssomygena* has ascomata with a membranous peridium, which is hyaline and very delicate, and unevenly brown ascospores. The distinguishing features of *Brunneospora* are the presence of ellipsoid ascospores, ascomata with coiled appendages and a poorly defined peridium. Other related genera are *Leucothecium* v. Arx & Samson and *Xanthothecium* v. Arx & Samson. The first is known for its yellow ascomata and hyaline ascospores, while *Xanthothecium* is mainly characterized by not being keratinophilic and by having echinulate and hyaline to yellowish ascospores.

Key to *Aphanoascus* species

- | | |
|---|--------------------------|
| 1. Ascospores with an equatorial rim | 2 |
| 1. Ascospores without an equatorial rim | 7 |
| 2. Ascospores 7.5–8.5 × 4.5–5 µm, with a prominent narrow rim, with acute edges | <i>A. saturnoideus</i> |
| 2. Ascospores smaller and with a broad rim with flattened edges | 3 |
| 3. <i>Malbranchea</i> anamorph | <i>A. multiporus</i> |
| 3. <i>Chrysosporium</i> anamorph | 4 |
| 4. Ascomata with a peridium of <i>textura intricata</i> ; ascospores with a reticulate walled rim | <i>A. clathratus</i> |
| 4. Ascomata with a peridium of <i>textura angularis</i> ; ascospores with a pitted rim | 5 |
| 5. Ascospores subrectangular (cruciform) in lateral view | <i>A. durus</i> |
| 5. Not as above | 6 |
| 6. Ascospores with a narrow equatorial rim; conidia cymbiform | <i>A. terreus</i> |
| 6. Ascospores with a broad equatorial rim; conidia obovate to clavate | <i>A. hispanicus</i> |
| 7. Ascospores smooth by optical microscopy; <i>Malbranchea</i> anamorph | 8 |
| 7. Ascospores reticulate or verrucose by optical microscopy; <i>Chrysosporium</i> anamorph | 9 |
| 8. Ascomata in clusters under a common tomentum; cultures with a strong odour of skunk | <i>A. mephitalis</i> |
| 8. Ascomata solitary, cultures without pronounced odour | <i>A. canadensis</i> |
| 9. Ascospores with irregularly ridged or verrucose wall; conidia 5–8 × 2.7–4 µm | <i>A. verrucosus</i> |
| 9. Ascospores reticulate; conidia larger | 10 |
| 10. Ascospores 6.5–8.5 × 4.5–6 µm; conidia 8.5–13 × 5.5–9 µm | <i>A. keratinophilus</i> |
| 10. Ascospores not as above; conidia smaller | 11 |
| 11. Ascospores 3.5–4.7 × 2.5–3.5 µm, with irregularly reticulate walls | <i>A. fulvescens</i> |
| 11. Ascospores 4.2–5.5 × 3–3.7 µm, with regularly reticulate walls | <i>A. reticulisporus</i> |

Aphanoascus durus (Zukal) Cano & Guarro. comb. nov.
(Figs 1A, 2A, 4)

Gymnoascus durus Zukal, *Ber. dt. bot. Ges.* **8**: 295 (1890).

Keratinophyton durum (Zukal) Currah, *Mycotaxon* **24**: 156 (1985).

Ascocalvatia dura (Zukal) v. Arx, *Persoonia* **13**: 178 (1986).

Anixiopsis biplanata Gueho & De Vroey, *Can. J. Bot.* **64**: 2207 (1986).

Anamorph: *Chrysosporium* sp.

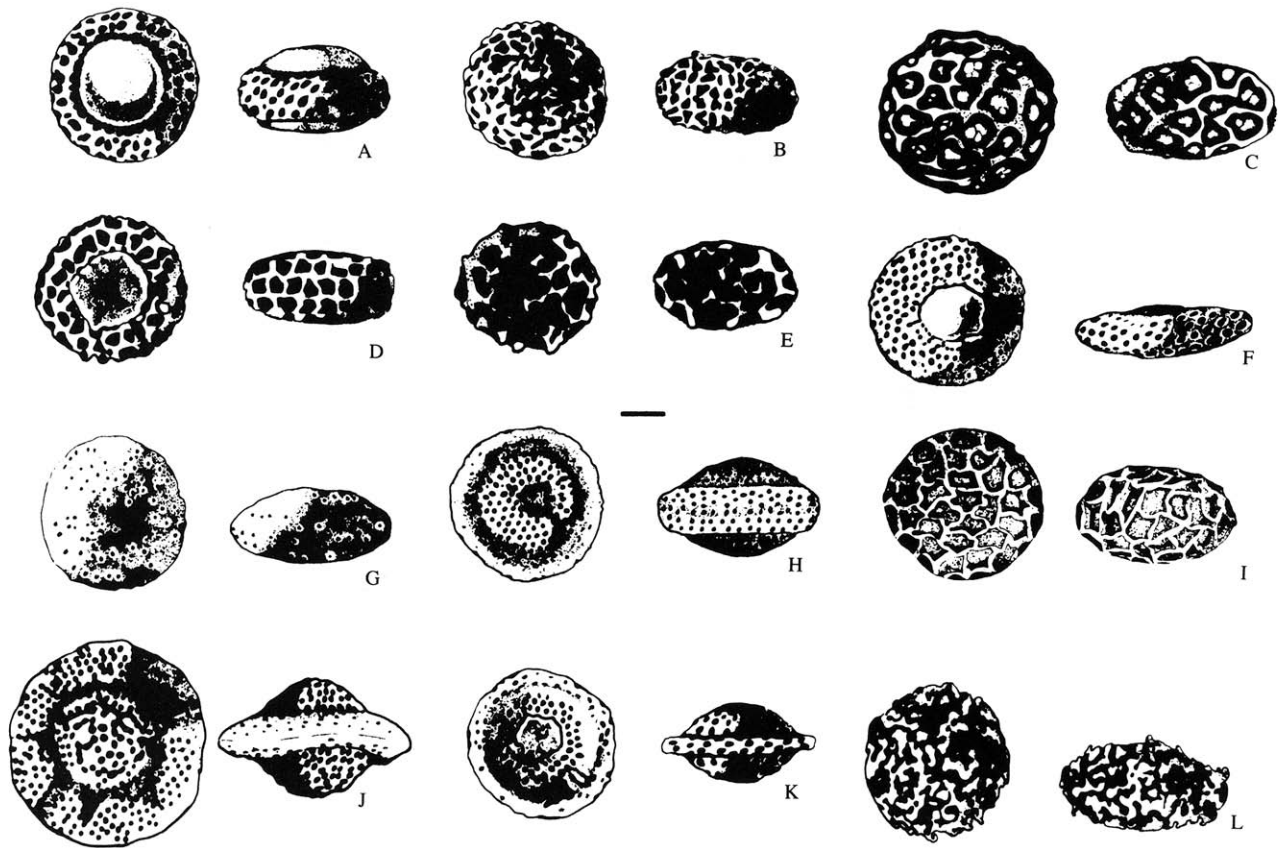
Colonies on YpSs with a daily growth rate of 2–3 mm in the dark at 28 °C; cream-coloured, felty, plane, margin regular and not well-defined; reverse uncoloured. Hyphae hyaline, branched, smooth, septate, 1.7–2.5 µm broad, thin-walled. Ascomata maturing within 20–23 d at 28 ° on YpSs, superficial and surrounded by the aerial mycelium, spherical, non-ostiolate, dark brown, 500–1050 µm diam, glabrous; ascoma wall 6–8 µm thick, composed of 3–4 layers of flattened, angular, rather thick-walled (0.5–1.5 µm), 8–15 ×

6–11 µm cells. *Asci* numerous, subglobose to ovoid, 7–8 × 6–7 µm, 8-spored, evanescent. *Ascospores* discoid with flattened poles, with a broad equatorial rim, cruciform in side view, broad-ridged, foveate-reticulate, smooth in the poles, one-celled, light greyish brown, 4–4.5 × 2.7–3 µm. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, pyriform to clavate with a truncate base, thin-walled, 4.5–7.7 × 2–3 µm.

Colonies on PYE with a daily growth rate of 2–3 mm in the dark at 28 °, white to light buff, felty with scattered groups of aerial hyphae at the centre, margin regular, definite; reverse cream-coloured. On PYE media only the strains UAMH 856 and UAMH 3671 also grew at 37 °, reaching 15–17 mm diam in 7 d. Keratinophilic.

Material examined: A slide of the type (CBS 118-85). Living strains with teleomorph and anamorph: UAMH 856, chicken yard soil, Edmonton, Alberta, June 1960; UAMH 3671 from hedgehog, Ivory Coast; FMR 2119 (IMI 330347), from garden soil, Alhaurin de la

Fig. 1. Ascospores of the different species of *Aphanoascus*. A, *A. durus*; B, *A. canadensis*; C, *A. keratinophilus*; D, *A. clathratus*; E, *A. fulvescens*; F, *A. hispanicus*; G, *A. mephitalis*; H, *A. multiporus*; I, *A. reticulisporus*; J, *A. saturnoideus*; K, *A. terreus*, L, *A. verrucosus* (bar = 1 µm).



Torre, Málaga, Spain, Apr. 1987; FMR 2121, from arable soil, El Burgo, Málaga, Spain, Apr. 1987; FMR 2237, from arable soil, Albuñol, Granada, Spain, 1987. Living strains with only anamorph: RV 37551 (CBS 119.85); RV 37552 (CBS 120.85).

This species, with *A. clathratus*, *A. hispanicus* and *A. terreus*, belongs to the group characterized by ascospores with a prominent equatorial rim and smooth poles. *A. durus* is distinct because of the morphology of its ascospores, which in lateral view show a rhomboidal shape due to the strong flattening of the poles and broad-ridged reticle of the rim, while in the other three species the poles are more convex.

Aphanoascus durus was first described by Zukal (1890) as a species of *Gymnoascus*. The type material was lost but based on an isolate from soil (UAMH 856). Currah (1985) proposed a neotype for the species epithet and transferred *Gymnoascus durus* to *Keratinophyton*. This transfer was based on a close similarity in the shape and size of the ascospores of Currah's neotype with those depicted in Zukal's original drawings and descriptions. v. Arx (1986) transferred the name of the species to *Ascocalvatia* but this genus is inappropriate because the type of *Ascocalvatia* has cylindrical ascospores and *Aphanoascus durus* has oblate spores with broad polar thickenings at each end.

Gueho & De Vroey (1986) reported *Anixiopsis biplanata* as heterothallic and they found that the strain CBS 120.85 produce sterile ascomata on diluted Sabouraud agar. We did

Fig. 2. Anamorphs of different species of *Aphanoascus*. A, *A. durus*; B, *A. canadensis*; C, *A. keratinophilus*; D, *A. clathratus*; E, *A. fulvescens*; F, *A. hispanicus* (bar = 10 µm).

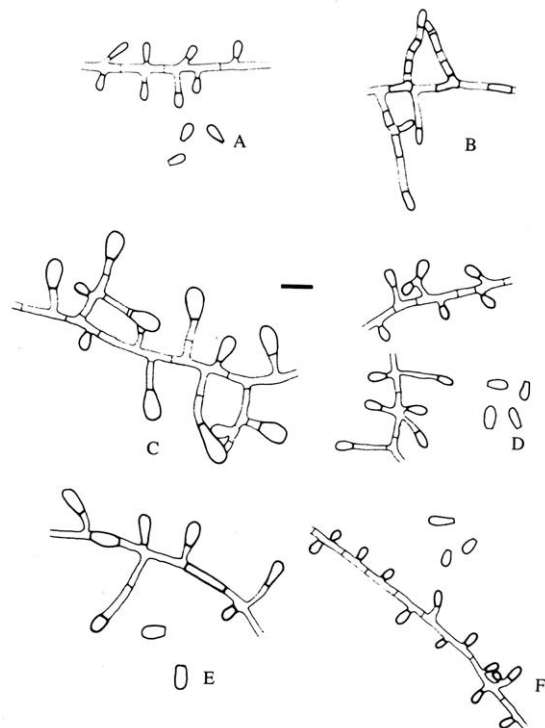
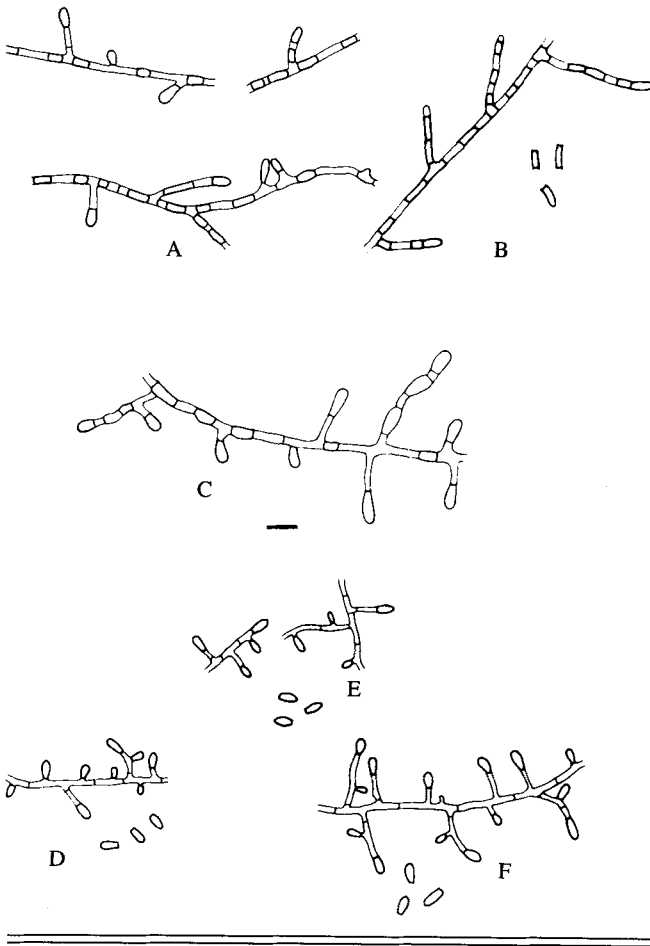


Fig. 3. Anamorphs of different species of *Aphanoascus*. A, *A. mephitalis*; B, *A. multiporus*; C, *A. reticulisporus*; D, *A. saturnoides*; E, *A. terreus*; F, *A. verrucosus* (bar = 10 µm).



not succeed in obtaining fertile crosses with mating types provided by those authors, either on diluted Sabouraud's agar (Takashio, 1972), on YpSs, or directly on soil mixed with hair, however we also obtained infertile cleistothecia with strain CBS 120.85. All our strains and those received from UAMH were self-fertile.

The *Chrysosporium* anamorph of this species does not differ significantly from those of other *Aphanoascus* species, the main feature being that conidia are disposed on very short branching systems, often sessile and sometimes 1-septate, especially in UAMH 856 and UAMH 3671.

Aphanoascus canadensis Currah, *Mycotaxon* **24**: 139 (1985). (Figs 1B, 2B, 5)

Anamorph: *Malbranchea* sp.

Colonies on YpSs with a daily growth rate of 3–3.5 mm in the dark at 28°, white to light cream-coloured, powdery, sometimes felty, plane, with regular and defined margin; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 2–3.2 µm broad, thin-walled. *Ascomata* maturing within 25–30 d at 28° on YpSs, superficial and slightly covered by aerial mycelium, spherical, non-ostiolate, reddish-brown, 400–700 µm diam, glabrous; ascoma wall 4–7 µm thick, composed of 3–4 layers of flattened, angular, rather thick-walled (0.5–1 µm), 6–12 × 4–9 µm cells. *Asci* numerous, globose to some-

what ellipsoidal, 8–11 µm, 8-spored, evanescent. *Ascospores* oblate-elliptical, broad-ridged slightly and irregularly reticulate, smooth under light microscopy, one-celled, yellowish-brown, 3.8–4.2 × 2.5–3.1 µm. *Conidia* cylindrical, alternate, hyaline, smooth, 5–15 × 2.2–3.5 µm, thin-walled.

Colonies on PYE with a daily growth rate of 2–2.2 mm in the dark at 28°, white, felty, raised at the centre, margin defined and regular; reverse uncoloured. At 37° there is no growth. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: UAMH 4574 type of *A. canadensis*, carnivore dung, Lesser Slave, Alta, May 1982; FMR 2292, forest soil, Madriu, Andorra, Mar. 1985.

This species was first considered as synonymous with *A. mephitalis* on the basis of the similarity of size and shape of the ascospores as well as of the anamorph. More detailed studies with SEM allowed us to differentiate them mainly by the ornamentation of the ascospores and by cultural characters (strong odour of skunk and ascomata in clusters under a common tomentum in *A. mephitalis*).

Aphanoascus keratinophilus Punsola & Cano, sp. nov.

Etym.: *keratinophilus* (L) – keratinophilic (Figs 1C, 2C, 6)

Anamorph: *Chrysosporium keratinophilum* (Frey) Carmichael

Hyphae vegetativae hyalinae, ramosae, 2.7–3.2 µm crassae. *Ascomata* superficialia, sphaerica, non-ostiolata, levia, 500–600 µm diam, pallide brunnea; peridio 4–6 µm crassi, et 2–3 stratis cellularum complanatarum angularum composito, 7–10 × 4.5–8 µm constans. *Asci* octospori, subglobosi vel ellipsoidei, evanescentes, 14–16 × 12–13 µm. *Ascosporae* subglobosae vel oblatae, obscure brunneae, reticulatae, 6–8.5 × 4.5–6 µm. *Conidia* piriformia, terminalia et alternalia, sessilia vel in protrusionibus brevibus oriunda, solitaria, hyalina, crassitunicata, levia, 8.5–13 × 5.5–9 µm. Keratinophila.

Holotypus: IMI 319010 (UAMH 6141, FMR 2149), isolatus ex solo, apud San Mateo, Castellón (Hispania), Jul. 1985.

Colonies on YpSs with a daily growth rate of 5.5 mm in the dark at 28°; not producing ascomata; yellowish-cream coloured, powdery, flat, margin defined and regular; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 2.7–3.2 µm broad, thin-walled. *Ascomata* on natural substrate superficial, spherical, non-ostiolate, light brown, 500–600 µm diam, glabrous; ascoma wall 4–6 µm thick, composed of 2–3 layers of flattened, angular, rather thick-walled (0.5–1 µm), 7–10 × 4.5–8 µm cells. *Asci* numerous, subglobose to oblate, 14–16 × 12–13 µm, 8-spored, evanescent. *Ascospores* subglobose to oblate, reticulate-alveolate, with small verrucae in the pits, one-celled, brown to dark brown, 6–8.5 × 4.5–6 µm. *Conidia* terminal and lateral, sessile or on short or long protrusions, hyaline, smooth, pyriform, thick-walled, 8.5–13 × 5.5–9 µm, without intercalary conidia.

Colonies on PYE with a daily growth rate of 3–3.5 mm in the dark at 28°, cream-coloured, powdery, flat, margin regular and defined; reverse cream-yellow. At 37° on PYE it has restricted growth at a daily rate of 0.7–1 mm. Keratinophilic.

Material examined: Living strain with anamorph and teleomorph: FMR 2149, from garden soil, San Mateo, Castellón, Spain, Aug. 1985. Living strains only with anamorph: FMR 2150, from arable soil, Villareal, Castellón, Spain, Apr. 1985; FMR 2151, from arable soil, Onda, Castellón, Spain, Apr. 1985; FMR 2152, from arable soil,

Fig. 4. *Aphanoascus durus* (FMR 2119). A, Peridium (N) (bar = 10 μ m); B, E, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); D, Ascospores (N) (bar = 5 μ m). (N) = Nomarski Microscopy, (SEM) = Scanning Electron Microscopy, (PC) = Phase Contrast Microscopy.

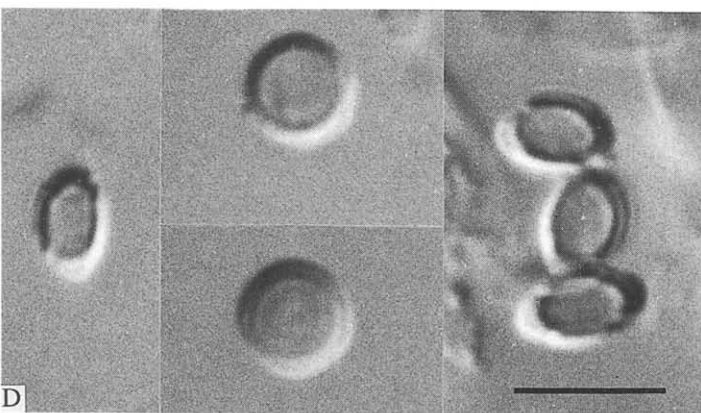
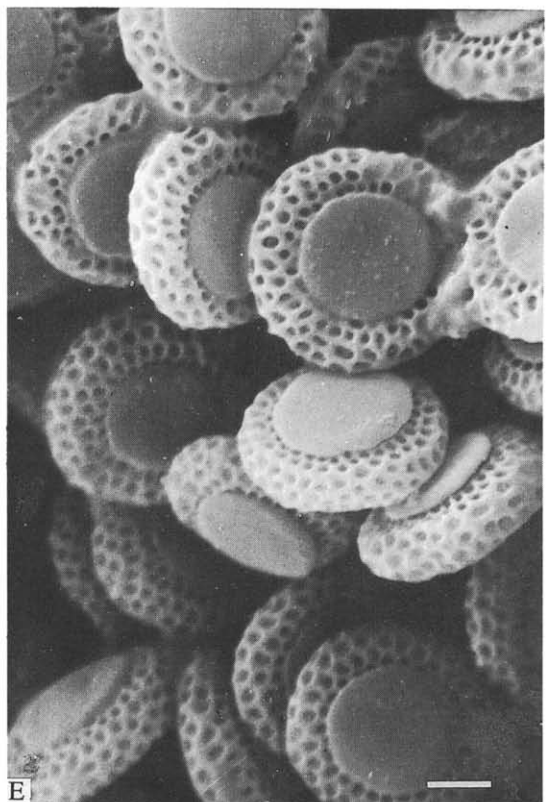
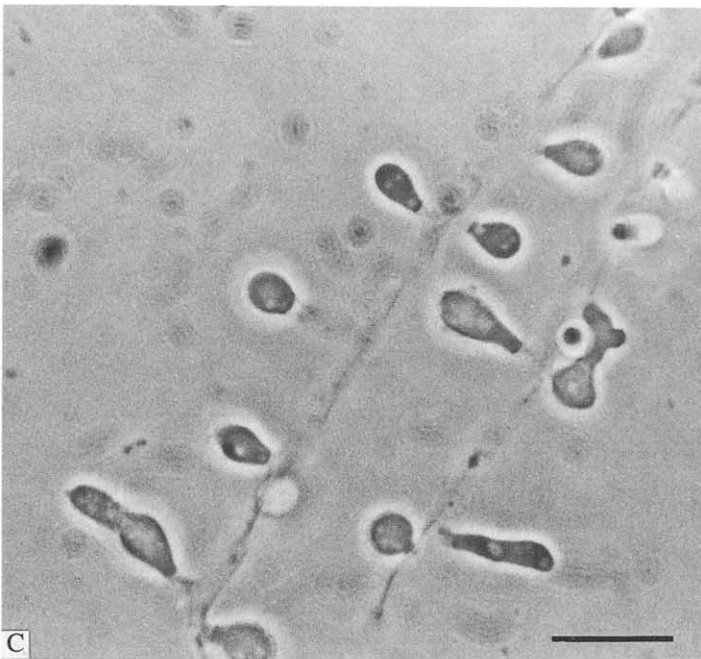
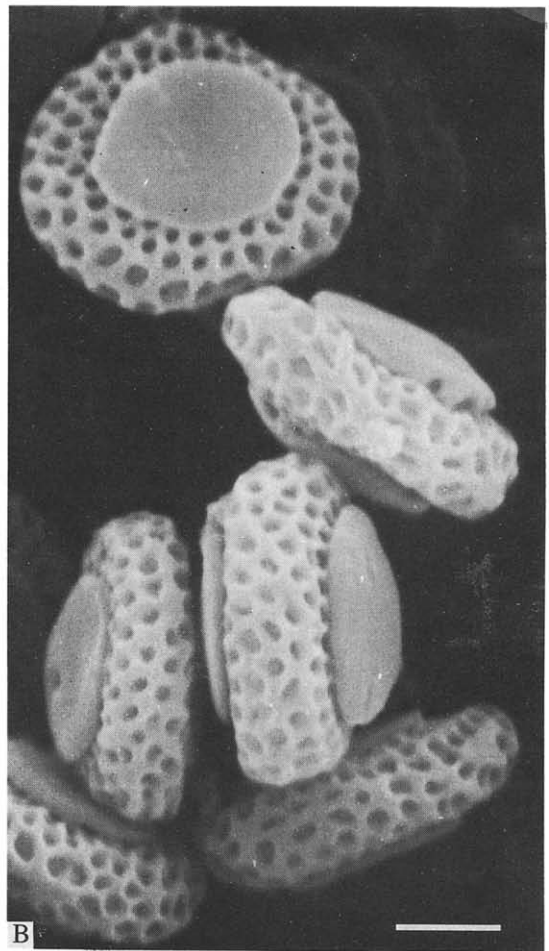
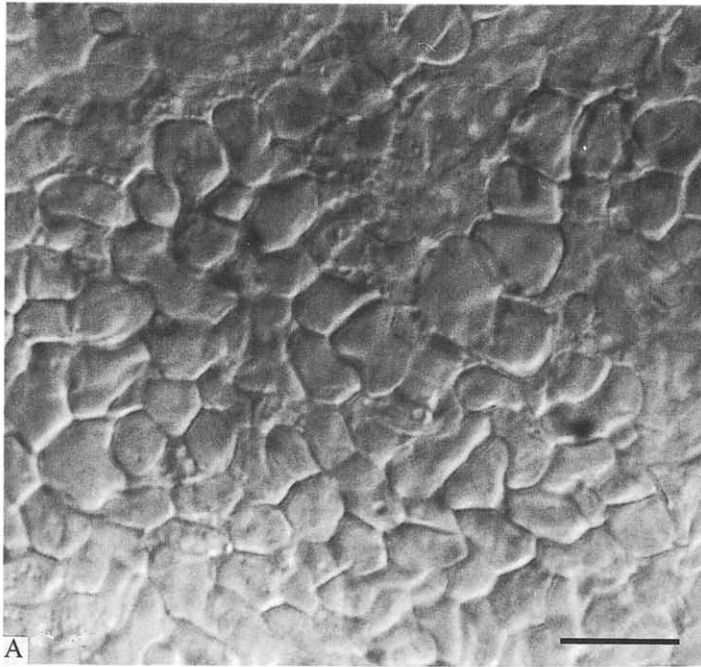
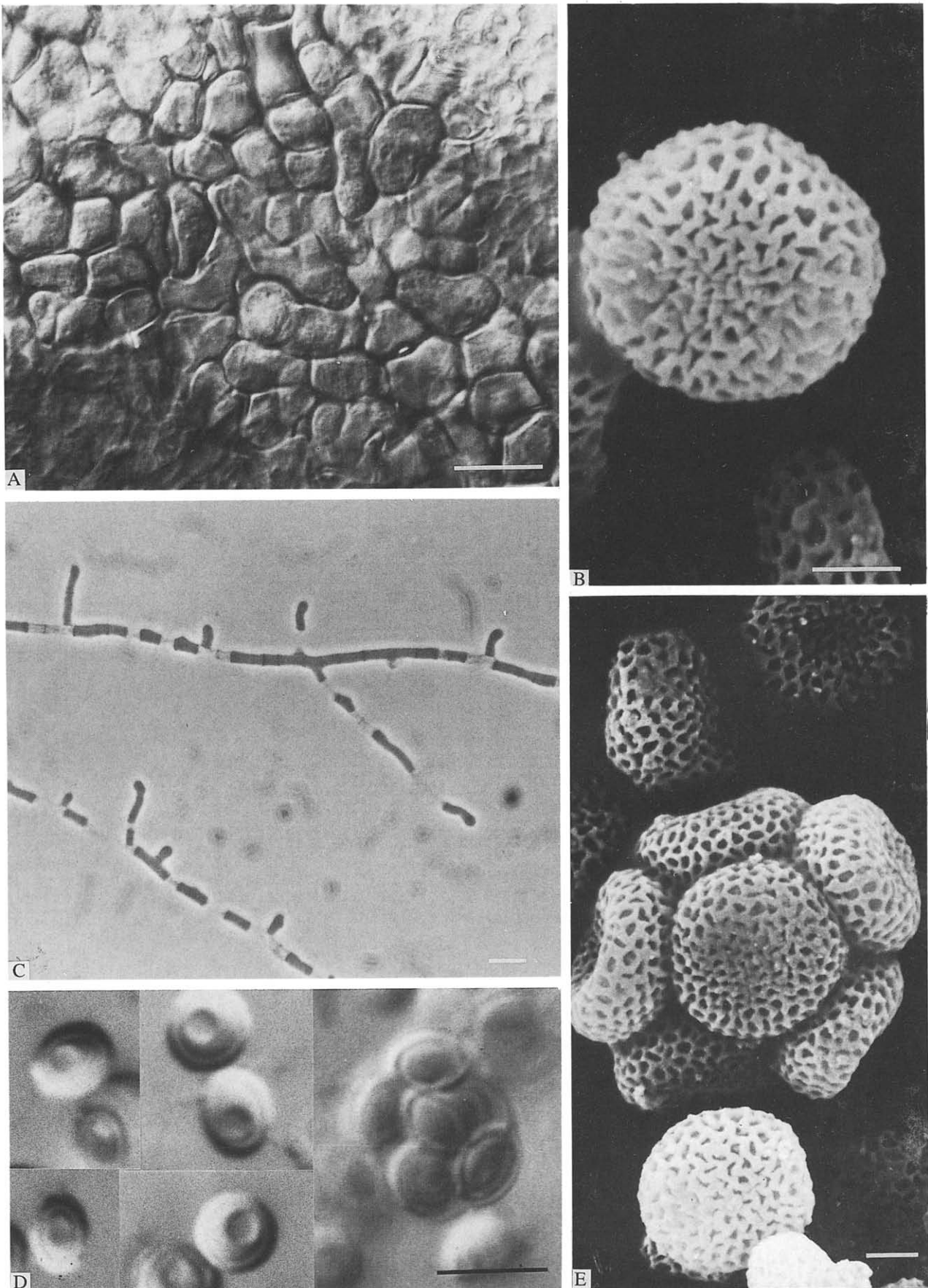


Fig. 5. *Aphanoascus canadensis* (UAMH 4574). A, Peridium (N) (bar = 10 μ m); B, E, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m), D, Ascospores and ascus (N) (bar = 5 μ m).



Ahín, Castellón, Spain, Apr. 1985; FMR 2153, from arable soil, Bétera, Valencia, Spain, Apr. 1985; FMR 2154, from garden soil, Dolores, Alicante, Spain, Apr. 1985; FMR 2155, from arable soil, Albujón, Murcia, Spain, Apr. 1985; FMR 2156, from garden soil, Fuente Alamo de Murcia, Murcia, Spain, Apr. 1985; FMR 2157, from garden soil, Adra, Almería, Spain, Apr. 1985; FMR 2158, from arable soil, Los Gallardos, Almería, Spain, Apr. 1985; FMR 2159, from garden soil, Aguadulce, Almería, Spain, Apr. 1985; FMR 2160, from garden soil, Albondón, Granada, Spain, Apr. 1985; FMR 2161, from garden soil, Orjiva, Granada, Spain, Apr. 1985; FMR 2162, from garden soil, Lanjarón, Granada, Spain, Apr. 1985; FMR 2163, from garden soil, Orjiva, Granada, Spain, Apr. 1985; FMR 2164, from arable soil, Tolox, Málaga, Spain, Apr. 1985; FMR 2165, from arable soil, La Almoraina, Cadiz, Spain, Apr. 1985; FMR 2166, from arable soil, Cabanes, Castellón, Spain, Aug. 1986; FMR 2167, from arable soil, Nules, Castellón, Spain, Aug. 1986; FMR 2876, from arable soil, Finestrat, Alicante, Spain, Aug. 1986; FMR 2877, from arable soil, Sella, Alicante, Spain, Aug. 1986; FMR 2878, from garden soil, Ciudad del aire, Murcia, Spain, Aug. 1986; FMR 2879, from arable soil, Cuevas del Almanzora, Almería, Spain, Aug. 1986; FMR 2880, from garden soil, Vera, Almería, Spain, Aug. 1986; FMR 2881, from garden soil, Vera, Almería, Spain, Aug. 1986; FMR 2882, from arable soil, Alfarix, Almería, Spain, Aug. 1986; FMR 2883, from garden soil, Orgiva, Granada, Spain, Aug. 1986; FMR 2884, from garden soil, Orgiva, Granada, Spain, Aug. 1986; FMR 2885, from garden soil, Lanjarón, Granada, Spain, Aug. 1986; FMR 2886, from garden soil, Salobreña, Granada, Spain, Aug. 1986; FMR 2887, from garden soil, Almuñecar, Granada, Spain, Aug. 1986; FMR 2889, from arable soil, Nerja, Málaga, Spain, Aug. 1986; FMR 2890, from arable soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2891, from arable soil, Onda, Castellón, Spain, Nov. 1987; FMR 2892, from arable soil, Albocacer, Castellón, Spain, Nov. 1987; FMR 2893, from arable soil, Hondon de las Nieves, Alicante, Spain, Mar. 1988; FMR 2894, from arable soil, Uleila del Campo, Almería, Spain, Mar. 1988; FMR 2895, from garden soil, Cuevas del Almanzora, Almería, Spain, Mar. 1988; FMR 2896, from garden soil, Valencia, Spain, Mar. 1988.

Aphanoascus keratinophilus is very similar to *A. reticulisporus*, both species bearing regularly reticulate ascospores. *A. reticulisporus* has smaller ascospores. Their anamorphs are also different, that of *A. keratinophilus* being *Chrysosporium keratinophilum*, while that of *A. reticulisporus* has longer clavate conidia, and intercalary conidia are very abundant. Another difference between the species is that *A. keratinophilus* is capable of forming ascomata on culture only on Oatmeal media (L. Sigler, pers. comm.), while in *A. reticulisporus* these appear normally within 20–25 d on YpSs and other media.

***Aphanoascus clathratus* Cano & Guarro, sp. nov.**

Etym.: *clathratus* (L) – clathrate (Figs 1D, 2D, 7)

Anamorph: *Chrysosporium* sp.

Hyphae vegetativae hyalinae, ramosae, 2–3 µm crassae. *Ascomata* superficialia, sphaerica, non-ostiolata, levia, 400–570 µm diam, brunnea; peridio 8–10 µm crassi, et 3–5 stratis cellularum complanatarum intricatum composito, 3.5–4.5 µm constans. *Asci* octospori, subglobosi vel ellipsoidei, evanescentes, 6–8 × 5.5–6 µm. *Ascospores* discoideae, pallide brunneae, unicellulares, monstrantes cristam equatorialem, 3.2–4 × 2–2.5 µm, cum externalibus reticulis minutis. *Conidia* terminalia et alternalia, sessilia vel in protrusionibus brevibus, hyalina, tenuitunicata, levia, piriformia, 5–7 × 2.5–3.7 µm. Keratinophila.

Holotypus: IMI 329400 (FMR 2289), isolatus ex solo, apud LLaborsi in Lerida (Hispania), Mar. 1985.

Colonies on YpSs with a daily growth rate of 3–4 mm in the dark at 28°, white in the centre and pale cream-coloured in the marginal area, powdery in marginal and submarginal areas, dense and velvety in the centre, margin regular and defined, aerial hyphae present only in the centre; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 2–3 µm broad, thin-walled. *Ascomata* maturing within 30–40 d at 28° on YpSs, superficial and slightly covered by aerial mycelium, spherical, non-ostiolate, 400–570 µm diam, brown, glabrous; ascoma wall light brown, 7–10 µm thick, composed of 3–5 layers of flattened, intricate, rather thick-walled (0.5–1 µm) cells 6–9 × 3.5–4.5 µm. *Asci* numerous, globose-ellipsoidal, 8-spored, 6–8 × 5.5–6 µm, evanescent. *Ascospores* discoid with a broad equatorial rim, narrow-ridged, reticulate-alveolate, smooth at the poles, pale-brown, one-celled, 3.2–4 × 2–2.5 µm. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, subpyriform, 5–7 × 2.5–3.7 µm, thin-walled, with a truncate base.

Colonies on PYE with a daily growth rate of 2–2.2 mm in the dark at 28°, white to pale cream-coloured, felty, raised at the centre, margin defined and regular; reverse uncoloured. At 37° there is no growth. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: FMR 2289, arable soil, LLaborsi, Lérida, Spain, Mar. 1985; FMR 2897, from forest soil, Gilet, Valencia, Spain, Aug. 1986; FMR 2950, from forest soil, La Jana, Castellón, Dec. 1987; CBS 271.85 (FMR 2014); CBS 663.86 (UAMH 6284, FMR 2000); CBS 662.86 (UAMH 6177, FMR 2001, IMI 329401).

Aphanoascus clathratus is very similar to *A. durus*, distinguished by the reticulation of the equatorial rim, narrow-ridged in the former, and broad-ridged with small pits in the latter. In side view the ascospores of *A. durus* are also distinguishable because they are typically cruciform. *Aphanoascus clathratus* was previously cited by de Vries *et al.* (1979) as an undetermined *Anixiopsis* originating from soil in Zuid Flevoland (Holland).

***Aphanoascus fulvescens* (Cooke) Apinis, Mycopath. Mycol. Appl. 35: 101 (1968).** (Figs 1E, 2E, 8)

Badhamia fulvescens Cooke, *Grevillea* 4: 69 (1875).

Eurotium stercorarium Hansen, *Videnskab. Medd. naturh. foren. Kjöbenhavn*: 310 (1876).

Eurotium fulvescens (Cooke) Cooke, *Grevillea* 8: 11 (1879).

Aphanoascus cinnabarinus Zukal, *Ber. dt. Bot. Ges.* 8: 296 (1890), non *sensu* Udagawa & Takada (1973).

Anixiopsis stercoraria (Hansen) Hansen, *Bot. Zeit.* 55: 127 (1897).

Anixiopsis fulvescens (Cooke) de Vries var. *stercoraria* (Hansen) de Vries, *Mykosen* 12: 121 (1969).

Anamorph: *Chrysosporium* sp.

Colonies on YpSs with a daily growth rate of 3–4 mm in the dark at 28°; white to tan due to the presence of numerous ascomata on the surface, powdery, flat, margin defined and regular, aerial hyphae present in the centre; reverse brown. *Hyphae* hyaline, branched, smooth, septate, 1.7–3 µm broad, thin-walled. *Ascomata* maturing within 8–10 d at 28° on YpSs, superficial, spherical, non-ostiolate, buff to light brown, 290–500 µm diam, glabrous; ascoma wall 4–6 µm thick, composed of 2–4 layers of flattened, angular, rather thick-

Fig. 6. *Aphanoascus keratinophilus* (FMR 2149). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).

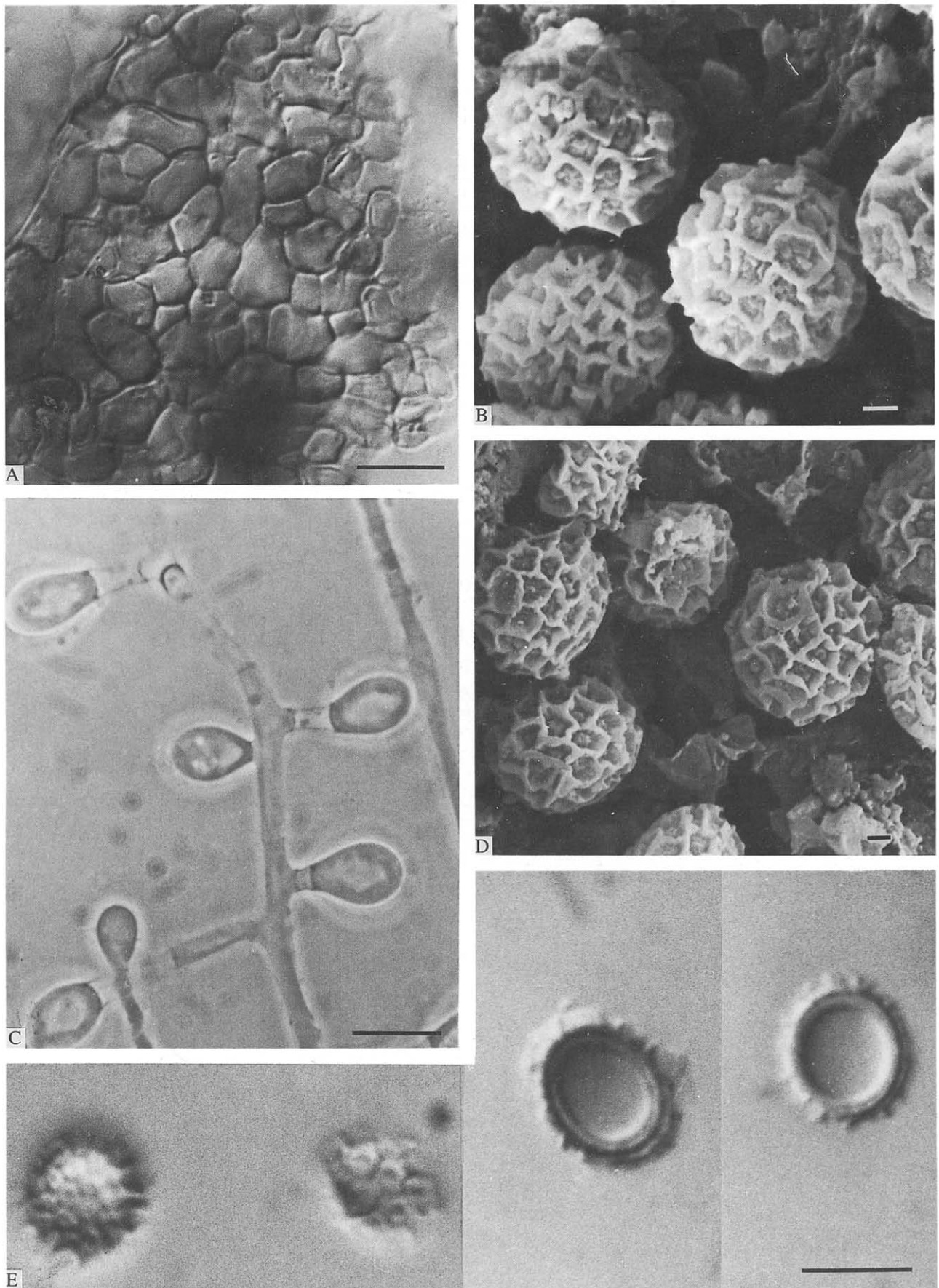
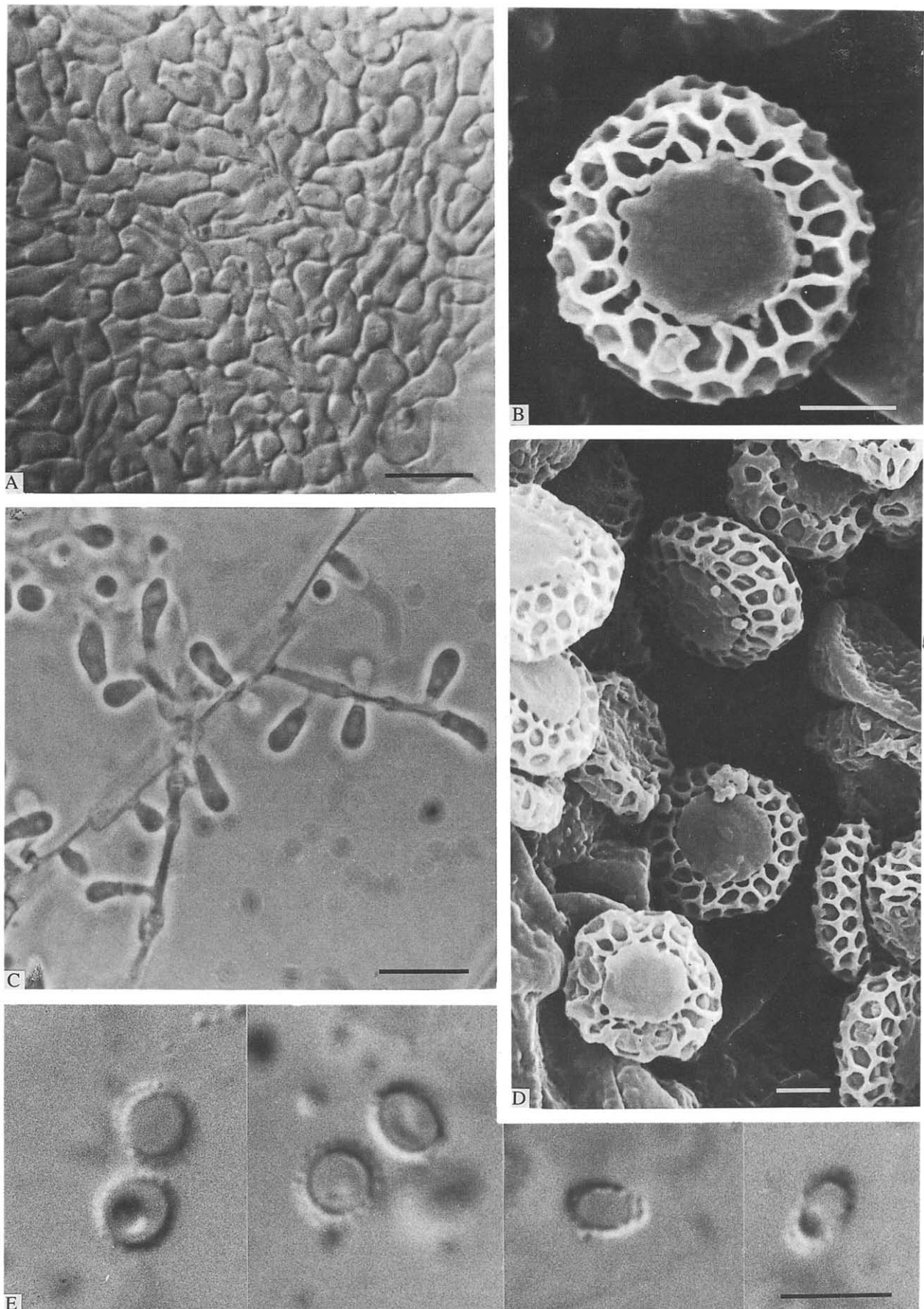


Fig. 7. *Aphanoascus clathratus* (CBS 271.85). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).



walled (0.5–2 µm), 5.5–6 × 10–12 µm cells. *Asci* subglobose to ellipsoidal, 8-spored, 9.5–11 × 7–9 µm, evanescent. *Ascospores* oblate, light brown, yellowish to pale brown in mass, one-celled, irregularly and discontinuously reticulate, 3.5–4.7 × 2.5–3.5 µm. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, clavate, 15–17.5 × 3.7–6 µm, thin-walled; intercalary conidia frequent, cylindrical, 11–15 × 4–5.5 µm.

Colonies on PYE with a daily growth rate of 2–2.7 mm in the dark at 28°, white, felty, raised in the centre with a small crateriform portion, margin defined and regular, droplets of exudate present; reverse uncoloured, brown in the central area. At 37° some strains show restricted growth on PYE, reaching a diameter of 5–6 mm in 7 d. Keratinophilic.

Material examined: UAMH 582, ringworm ex cat, Edmonton, Alta, 1957; UAMH 1895, hair, apparently healthy wild rodents, *Clethrionomys glareolus*, Czech; UAMH 1896, cow; UAMH 2596, birds nest; UAMH 3218, cow hair and dung; UAMH 3338, *Tinea corporis* (= ATCC 18996); UAMH 3518, soil, Sudan, 1972; UAMH 4114, soil, Bath, Somerset; UAMH 4228, horse, N: Japan; UAMH 4449, hair-filled dung, Devonian Botanic Garden, Devon, Alta, 1981; UAMH 4603, Great Horned Owl pellet, Devonian Botanic Garden, Devon, Alta, 1982; UAMH 4808, coyote dung, Devonian Botanic Garden, Devon, Alta; UAMH 5057, tinea pedum, human, Poland; UAMH 5191, collie dog's hair, Edmonton, Alta, 1985; UAMH 5244, with *Onygena* ex feather stuffing old sleeping bag, 1985; UAMH 5117, toe cleft, DE negative, Wellington, 1985; UAMH 4823, coyote dung, Devonian Botanic Garden, Devon, Alta, 1983; IP 1528–84; IP 1529–84; IP 1530–84; IP 1526–84; and 140 further strains isolated by us from Spanish soils and dung.

The main difference between the present species and the two closely related species *A. keratinophilus* and *A. reticulisporus* is the size of the ascospores (in both cases larger than in *A. fulvescens*) as well as the type of surface reticulation. The anamorph of *A. keratinophilus* is *C. keratinophilum*, with infrequent intercalary conidia, while conidia of both other species are longer and narrower, with intercalary conidia being abundant. We have not been able to observe significant differences in conidial size between *A. fulvescens* and *A. reticulisporus*, as reported by Gueho *et al.* (1985) and Gueho & De Vroey (1986).

De Vries (1969), after studying 40 strains, distinguished two varieties: *Anixiopsis fulvescens* (Cooke) de Vries var. *fulvescens* (Cooke) de Vries with regularly alveolate-reticulate ascospores measuring 4.5–6.5–7 × 4–6 µm, and *A. fulvescens* (Cooke) de Vries var. *stercoraria* (Hansen) de Vries with smaller ascospores measuring 3.6–5 × 3.2–5 µm, the reticulation being less regular. De Vroey & Recacochea (1977) and Gueho & De Vroey (1986) preferred to elevate both varieties to species rank, giving the following ascospore dimensions for both: 4–5 × 3–3.5 µm and 4–7 × 4–4.5 µm. Domsch *et al.* (1980) and Currah (1985) accept only one species for both taxa, with ascospores measuring 5–8.5 × 4–5.5 µm.

Van Oorshot (1980) cited *C. keratinophilum* as the anamorph of *A. fulvescens*. Furthermore she did not observe clear differences between the two varieties of *Anixiopsis fulvescens* described by de Vries. With regard to anamorph-teleomorph connexions Chabasse & Six (1987) contrasted conidial dimensions and various cultural characters of 55 strains of *C.*

keratinophilum with 86 strains of *Anixiopsis stercoraria*, and concluded that *C. keratinophilum* can be differentiated from *A. stercoraria*.

In view of the discrepancies stated above for ascospore dimensions, we have carried out a detailed study from both water and lactophenol mounts, measuring 100 ascospores for each of the approximately 100 strains featuring ascospores with reticulate walls and lacking an equatorial rim. We conclude that there are three well-defined species: *A. fulvescens*, *A. reticulisporus* and *A. keratinophilus* differentiated by ascospore size (6–8.5 × 4.5–6 µm *A. keratinophilus*, 5–6 × 3.5–4.5 µm *A. reticulisporus*, and 3.5–4.7 × 2.5–3.5 µm *A. fulvescens*), surface ornamentation (wide-meshed regular reticulation in *A. keratinophilus*, small-meshed regular reticulation in *A. reticulisporus* and irregular reticulation, sometimes indistinct, in *A. fulvescens*).

The anamorphs are also different, for *A. keratinophilus* it is *Chrysosporium keratinophilum* while those of each of the other species are a *Chrysosporium* with elongated conidia and abundant intercalary conidia.

Aphanoascus fulvescens has been reported as a human pathogen by different authors (Rippon *et al.*, 1970; Vanbreuseghem & De Vroey, 1980; Albala *et al.*, 1982; Todaro *et al.*, 1984; Marin & Campos, 1984; Gueho *et al.*, 1985), and potentially pathogenic to experimental animals (Hubálek, 1977; Hubálek & Hornich, 1977).

***Aphanoascus clathratus* Cano & Guarro, sp. nov.**

Etym: *hispanicus* (L, adj.) – Spain (Figs 1F, 2F, 9)

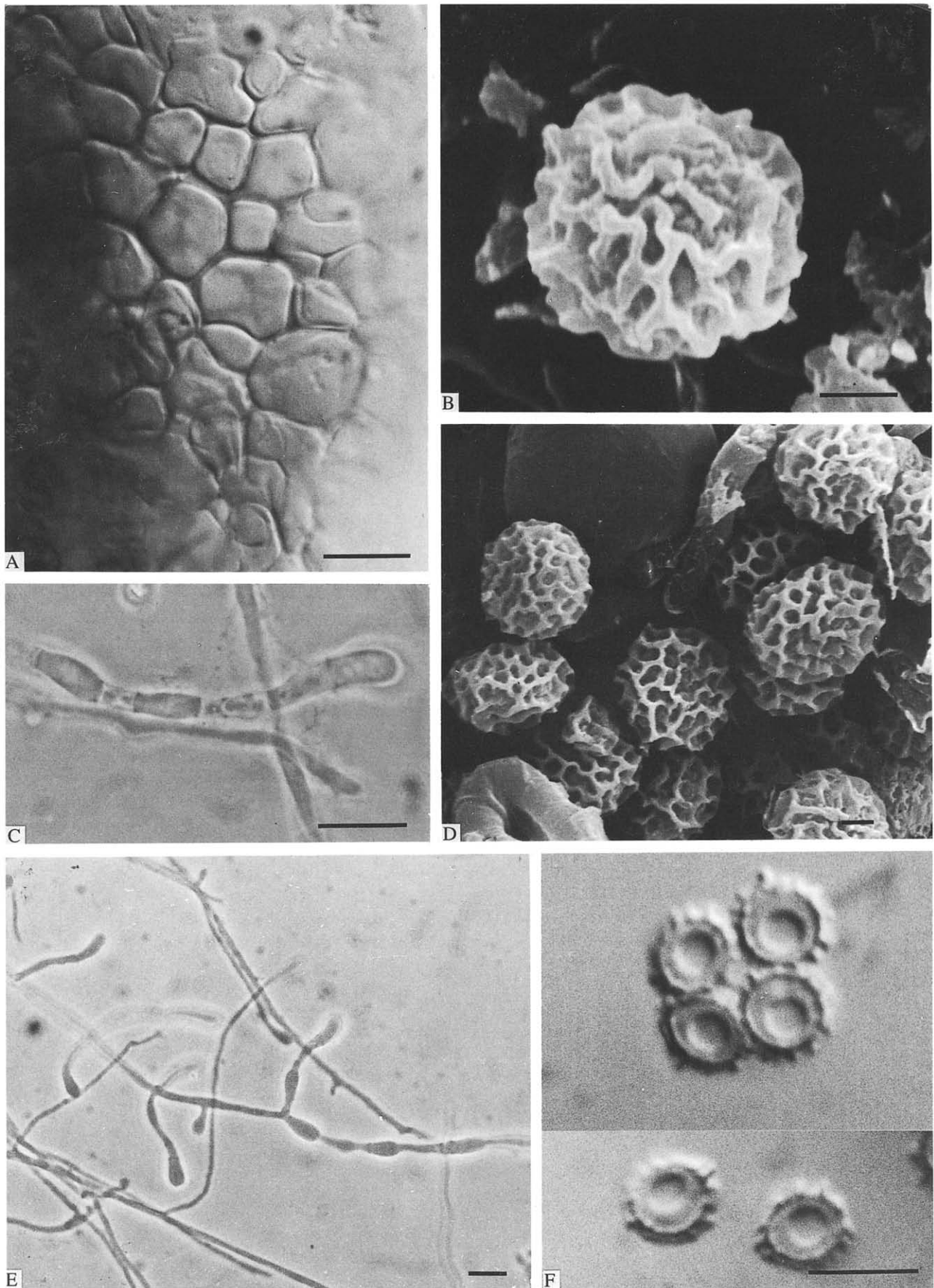
Anamorph: *Chrysosporium* sp.

Hyphae vegetativae hyalinae, ramosae, 2.2–2.7 µm crassae. *Ascوماتа* superficialia, sphaerica, non-ostiolata, levia, 450–560 µm diam, obscure brunnea vel rubido brunnea; peridio 8–9 µm crassi, et 3–5 stratis cellularum complanatarum angularum composito, 10–15 × 5–11 µm constans. *Asci* octospori, globosi vel subglobosi, evanescentes, 7.5–9 × 7.5–8 µm. *Ascosporae* discoideae, pallide brunneae, unicellulares, monstrantes cristam equatorialem, 4.2–5 × 2.2–3 µm, cum foraminibus minutis. *Conidia* terminalia et alternalia, sessilia vel in protrusionibus brevibus, hyalina, tenuitunicata, levia, fusiformia 3.5–8 × 2–3 µm. Keratinophilica.

Holotypus: IMI 328139 (UAMH 6179, FMR 2263), isolatus ex solo, apud Alhaurín de la Torre in Málaga, Hispania, Apr. 1987.

Colonies on YpSs with a daily growth rate of 1–2 mm in the dark at 28°; white to buff-coloured, powdery to felty, flat, margin regular and defined; reverse uncoloured with small brown patches. *Hyphae* hyaline, branched, smooth, septate, 2.2–2.7 µm broad, thin-walled. *Ascوماتа* maturing within 20–30 d on YpSs, superficial, spherical, non-ostiolate, 450–560 µm diam, glabrous, dark-brown to reddish-brown; ascoma wall 8–9 µm thick, composed of 3–5 layers of flattened, angular, rather thick-walled (0.5–1 µm), 10–15 × 5–11 µm cells. *Asci* globose to subglobose, 8-spored, 7.5–9 × 7.5–8 µm, evanescent. *Ascospores* discoid, broad-ridged, foveate-reticulate, smooth in the poles, smooth under optical microscopy, one-celled, light-brown, brown in mass, 4.2–5 × 2.2–3 µm. Terminal and lateral conidia sessile or on short protrusions, solitary, hyaline, smooth, clavate. 3.5–8 × 2–3 µm, thin-walled, with a truncate base, intercalary conidia rare and irregular in length.

Fig. 8. *Aphanoascus fulvescens* (FMR 2248). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, E, Anamorph (PC) (bar = 10 μ m); F, Ascospores (N) (bar = 5 μ m).



Colonies on PYE with a daily growth rate of 3–4 mm in the dark at 28°, white to cream-coloured, felty in the centre and powdery in the rest, flat, slightly raised at the centre, margin defined and regular; reverse uncoloured. At 37° on PYE the growth rate is the same as at 28°; on YpSs, ascospores not produced. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: FMR 2263, from arable soil, Alhaurín de la Torre, Málaga, Spain, Apr. 1985; FMR 2264, from sandy soil, Alcoceber, Castellón, Spain, Apr. 1987; FMR 2245, from sandy soil, Faro Torrox, Málaga, Spain, Apr. 1987; CBS 379.72 (FMR 999).

Aphanoascus hispanicus has ascospores similar to those of *A. terreus* although in the latter the rim is narrower. This difference, detectable by optical microscopy, is more evident with SEM. With this technique, ascospores of *A. hispanicus* resemble a wheel, while those of *A. terreus* are saturnoid. The anamorphs are also distinct: conidia of *A. hispanicus* are obovate to clavate, while those of *A. terreus* are obovoid to ellipsoidal and often cymbiform.

Aphanoascus mephtalis (Malloch & Cain) Cano & Guarro, comb. nov. (Figs 1G, 3A, 10)
Xynophila mephtalis Malloch & Cain, *Can. J. Bot.* **49**: 845 (1971).

Neoxenophila foetida Apinis & B. Clark, *Trans. Br. mycol. Soc.* **63**: 263 (1974).

Anamorph: *Malbranchea* sp.

Colonies on YpSs with a daily growth rate of 3–4 mm in the dark at 28°; white to olivaceous-white, densely velvety, flat, margin undefined, aerial hyphae only present in the centre; with a strong and characteristic odour of skunk; reverse uncoloured and olivaceous in the centre. *Hyphae* hyaline, branched, septate, 2–2.7 µm broad, smooth, thin-walled. *Ascospores* maturing within 25–30 d at 28° on YpSs, in clusters under a common tomentum, spherical, non-ostiolate, light brown, 150–300 µm diam, glabrous; ascoma wall light brown, 3–4 µm thick, composed of 2–3 layers of flattened, angular, rather thick-walled (0.5–1 µm), 5–13 × 4–9 µm cells, which develop tardily. *Asci* numerous, subglobose, 8-spored, 8–10 × 6–7 µm, evanescent. *Ascospores* oblate, finely pitted, smooth under light microscopy, one-celled, yellowish brown, 3.2–4 × 2–2.5 µm. *Conidia* infrequent, cylindrical, hyaline, 5–30 × 2–5 µm. At 37° there is no growth. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: CBS 783.70 (type), Ontario, on carnivore dung, Sept. 1964; FMR 2113 (IMI 329755), from arable soil, Cadiar, Granada, Spain, Aug. 1986. A slide of the type of *Neoxenophila foetida* (IMI 135731).

In pure culture, we have observed that the two strains only occasionally produce arthroconidia. Malloch & Cain (1971) describe the conidial anamorph produced by fragmentation of the vegetative mycelium into arthroconidia, pyriform to cylindrical or irregular in shape, nonseptate to multiseptate, simple or branched, hyaline and smooth.

Xynophila was founded by Malloch & Cain (1971) for a species characterized by a strong odour and ascospores tomentose at maturity, usually in clusters under a common tomentum. These features in their view placed this species

quite apart from those in *Aphanoascus*. v. Arx (1987) included it in the Gymnoascaceae because the ascospores by optical microscopy appear smooth and because of the absence of a true peridium. Furthermore, in *Xynophila* peridium development is delayed, and may be absent if ascospores are observed in immature stages. Ascospores and conidia of *A. canadensis* greatly resemble *A. mephtalis* by optical microscopy. However, under SEM the ascospore surface of the former is reticulate, while in the latter it is pitted. In *A. canadensis* the characteristic odour is not present, ascoma wall formation occurs early and ascospores are solitary, never clustered nor covered by a common tomentum.

Aphanoascus multiporus Cano & Guarro, sp. nov.

Etym.: *multi* (L) – many et *porus* (L) – pore

(Figs 1H, 3B, 11)

Anamorph: *Malbranchea* sp.

Hyphae vegetativae hyalinae, ramosae, 2–2.7 µm crassae. *Ascospores* superficialia, sphaerica, non-ostiolata, levia, 100–500 µm diam, obscure brunnea; peridio 4–5 µm crassi, et 2–3 stratis cellularum complanatarum angularum composito, 6–8 × 3–8 µm constans. *Asci* globosi vel subglobosi, octospori, evanescentes, 9–11 × 7–8 µm. *Ascospores* obscure brunneae, unicellulares, subglobosae vel oblatae, monstrantes cristam equatoriam, 5–6 × 3.5–4 µm, cum foraminibus minutis. *Arthroconidia* hyalina, tenuitunicata, levia, 4–7.7 × 2.2–2.7 µm. Keratinophila.

Holotypus: IMI 328660 (UAMH 6178, FMR 2146), isolatus ex solo, apud Cervera del Maestre in Castellón, Hispania, Aug. 1985.

Colonies on YpSs with a daily growth rate of 1–2 mm in the dark at 28°; red-brown, powdery, margin regular and defined, flat; reverse red-brown. *Hyphae* hyaline, branched, smooth, septate, 2–2.7 µm broad, thin-walled. *Ascospores* maturing within 25–30 d at 28° on YpSs, superficial and lightly covered by aerial mycelium, spherical, non-ostiolate, 100–500 µm diam, glabrous, dark-brown; ascoma wall dark-brown, 4–5 µm thick, composed of 2–3 layers of flattened, angular, rather thick-walled (0.5–1 µm), 6–8 µm cells. *Asci* globose to subglobose, 8-spored, 9–11 × 7–8 µm, evanescent. *Ascospores* subglobose to oblate with an equatorial rim, finely pitted over the entire surface, one-celled, dark-brown, 5–6 × 3.5–4 µm. *Conidia* cylindrical, hyaline, smooth, 4–7.7 × 2.2–2.7 µm, thin-walled.

Colonies on PYE with a daily growth rate of 0.6–0.8 mm in the dark at 28°, buff to cream-coloured, felty, slightly raised at the centre, margin defined and regular; reverse red-brown. At 37° there is no growth. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: FMR 2146, from arable soil, Cervera del Maestre, Castellón, Spain, Aug. 1985; FMR 2147, arable soil, Sorvilán, Granada, Spain, Aug. 1985; FMR 2148, arable soil, Herrería, Guadalajara, July 1985; FMR 2948, uncultivated soil, Campohermoso, Almería, Mar. 1988; FMR 2949, forest soil, Prades, Tarragona, Dec. 1987.

This species is clearly distinct from the others with ascospores with equatorial rims by having a *Malbranchea* anamorph and by its behaviour in culture, i.e. its colony growth rate is slow and the reverse is of a characteristic mahogany colour.

Fig. 9. *Aphanoascus hispanicus* (FMR 2263). A, Peridium (N) (bar = 10 μ m); B, C, Ascospores (SEM) (bar = 1 μ m); D, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).

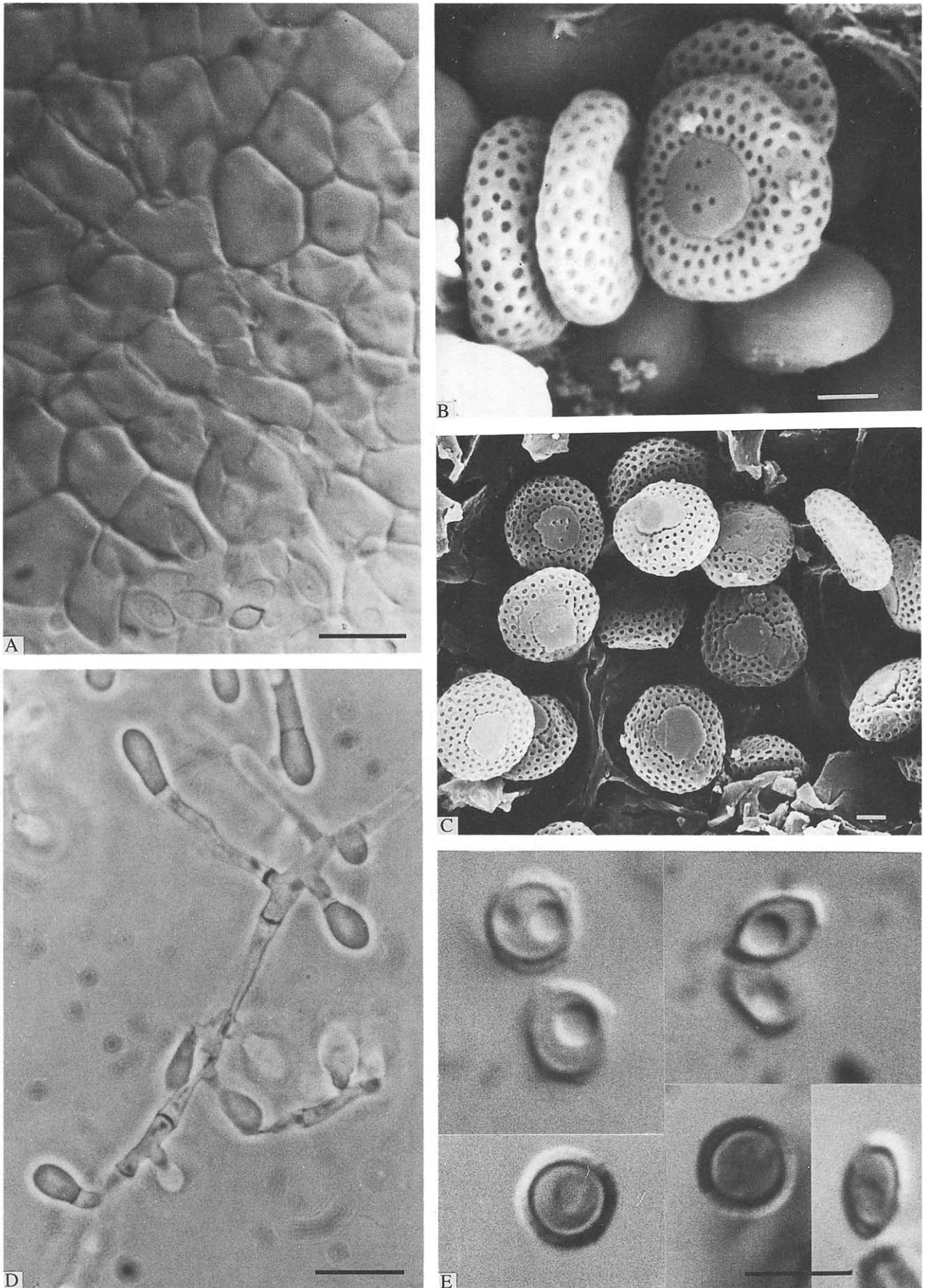


Fig. 10. *Aphanoascus mephitalis* (CBS 783.70). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).

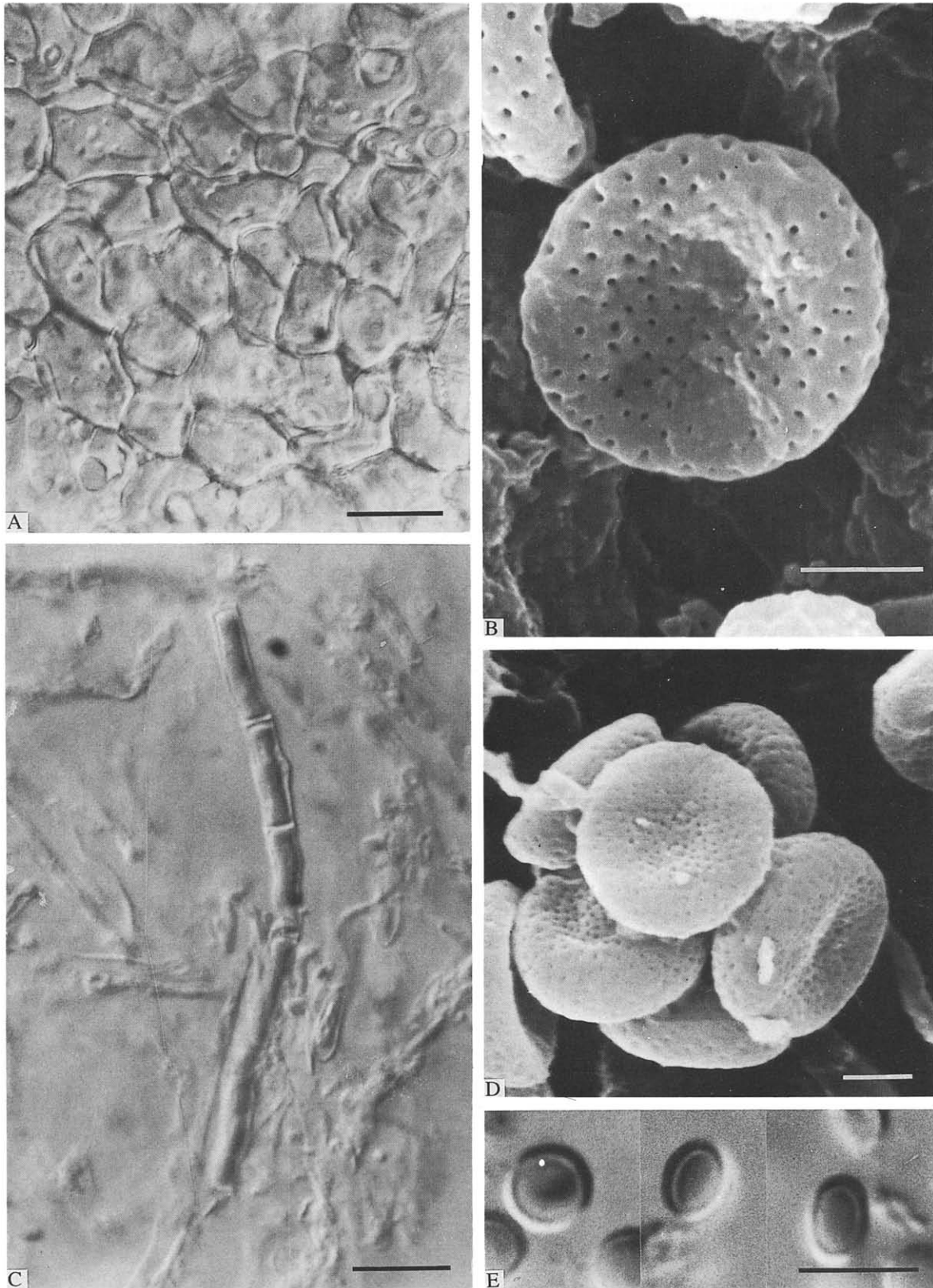
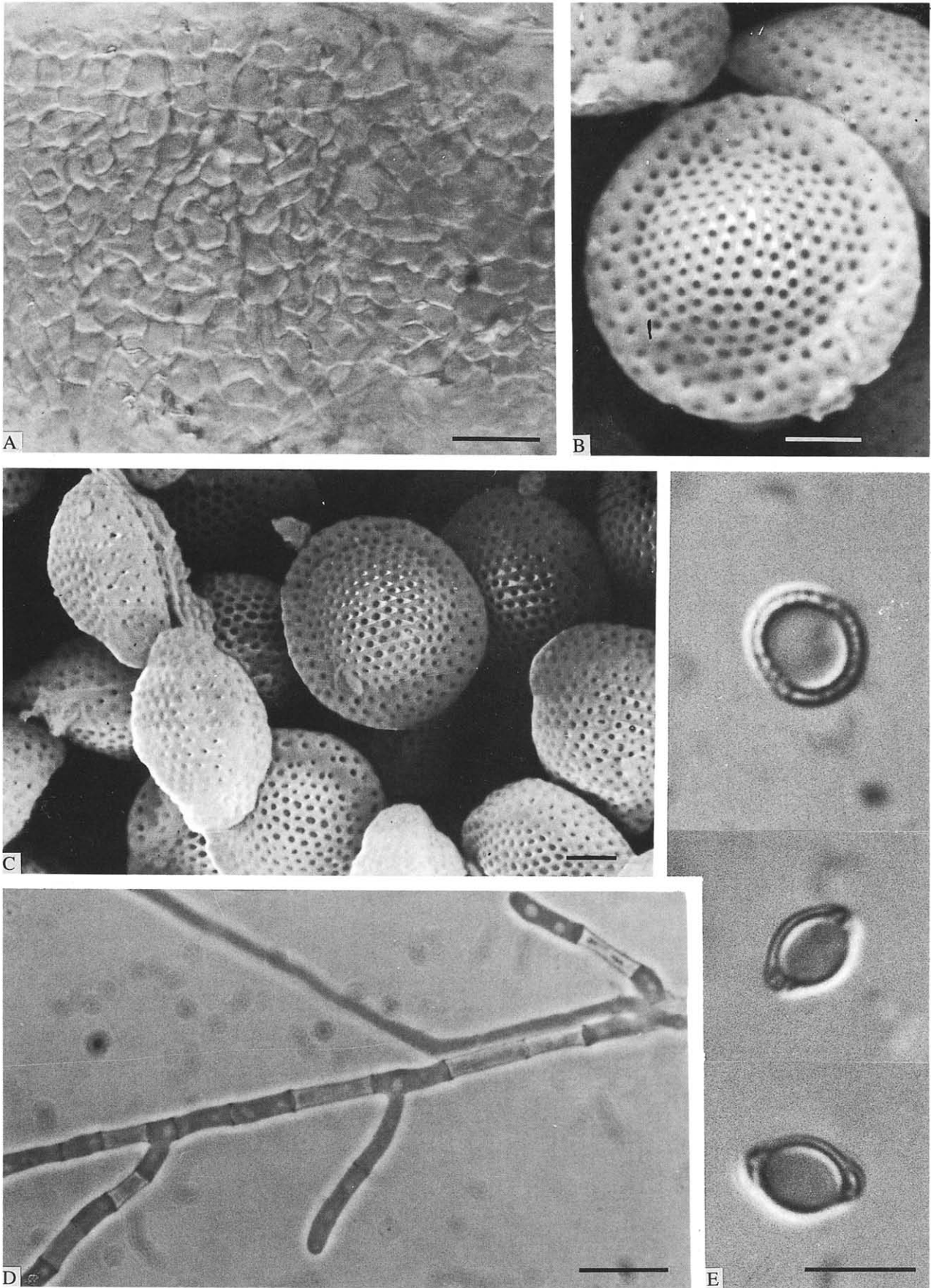


Fig. 11. *Aphanoascus multiporus* (FMR 2146). A, Peridium (N) (bar = 10 μm); B, C, Ascospores (SEM) (bar = 1 μm); D, Anamorph (PC) (bar = 10 μm); E, Ascospores (N) (bar = 5 μm).



Aphanoascus reticulisporus (Routien) Hubálek, *Acta Scient. nat. Brno*, Ser. 8: 28 (1974). (Figs 1I, 3C, 12)
Anixiopsis reticulisporea Routien, *Mycologia* 59: 476 (1967).
Anixiopsis fulvescens (Cooke) de Vries var. *fulvescens sensu*
 de Vries, *Mykosen* 12: 119 (1968).
Anamorph: *Chrysosporium* sp.

Colonies on YpSs with a daily growth rate of 4–4.5 mm in the dark at 28°; white, powdery to velvety, margin regular and defined, aerial hyphae present in the margin, small drops of exudate transparent (0.5–1 mm diam); reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 2–3 µm broad, thin-walled. *Ascomata* maturing within 20–25 d at 28° on YpSs, superficial, spherical, 400–770 µm diam, glabrous, dark-brown; ascoma wall light brown, 10–14 µm thick, composed of 4–6 layers of flattened, angular, 10–18 × 7–10 µm cells, rather thick-walled (1–2 µm). *Asci* subellipsoid, 8-spored, 10–13 × 8–10.5 µm, evanescent. *Ascospores* ellipsoid to oblate, narrow-ridged alveolate-reticulate, with small verrucae in the pits, one-celled, pale-brown, 5–6 × 3.5–4.5 µm. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, clavate, 7–16 × 4–4.5 µm, thin-walled, with a truncate base; arthroconidia very abundant, thin-walled, cylindrical, smooth, 4–14 × 3–5 µm.

Colonies on PYE with a daily growth rate of 4–4.2 mm in the dark at 28°, white, felty, margin defined and regular, flat, reverse uncoloured. At 37° some strains show restricted growth on YpSs, reaching a diameter of 6–7 mm in 12 d. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: CBS 392.67 (type), from soil, New Zealand; FMR 2244, arable soil, Estivella, Castellón, Spain, Aug. 1985; FMR 2290, garden soil, Lanjarón, Granada, Spain, Aug. 1985; FMR 2291, garden soil, Almuñecar, Granada, Spain, Aug. 1985; FMR 2898, from arable soil, Bétera, Valencia, Spain, Aug. 1986; FMR 2899, from arable soil, La Oliva, Valencia, Spain, Aug. 1986; FMR 2900, from garden soil, Faro Torrox, Málaga, Spain, Aug. 1986; FMR 2901, from garden soil, Faro Torrox, Málaga, Spain, Aug. 1986; FMR 2902, from garden soil, Faro Torrox, Málaga, Spain, Aug. 1986; FMR 2903, from arable soil, Torros, Málaga, Spain, Aug. 1986; FMR 2904, from arable soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2905, from garden soil, Vallengiza, Málaga, Spain, Aug. 1986; FMR 2906, from garden soil, Málaga, Málaga, Spain, Aug. 1986; FMR 2907, from garden soil, Estepona, Málaga, Spain, Aug. 1986; FMR 2908, from arable soil, Costar, Castellón, Spain, Nov. 1987; FMR 2909, from garden soil, La Barona, Castellón, Spain, Nov. 1987; FMR 2910, from arable soil, Albocacer, Castellón, Spain, Nov. 1987.

This species is characterized by its ascospore dimensions and regularly reticulate surface, as well as by its abundance of arthroconidia. According to Gueho *et al.* (1985) the conidia of *A. fulvescens* are smaller than those of *A. reticulisporus* but we have not observed any differences.

Aphanoascus reticulisporus has been considered as heterothallic by some authors, nevertheless we have often obtained monosporic fertile cultures.

Aphanoascus saturnoideus Cano & Guarro, sp. nov.
 Etym.: *saturnoideus* (L) – with an equatorial rim
 (Figs 1J, 3D, 13)
Anamorph: *Chrysosporium* sp.

Hyphae vegetativae hyalinae, ramosae, 1.5–3 µm crassae. *Ascomata* superficialia, sphaerica, non-ostiolata, levia, 450–600 µm diam, pallide

brunnea; peridio 5–8 µm crassi, et 3–4 stratis cellularum complanatarum angularum composito, 6–10 × 3–8 µm constans. *Asci* octospori, subglobosi vel ellipsoidei, evanescentes, 12–13 × 8–12 µm. *Ascosporae* subglobosae vel oblatae, pallide brunneae, unicellulares, monstrantes cristam angustum equatorialem, 7.5–8.5 × 4.5–5 µm, cum foraminibus minutis. *Conidia* terminalia et alternalia, sessilia vel in protrusionibus brevibus, hyalina, tenuitunicata, levia, clavata, 3.5–6.5 × 2–3 µm. Keratinophila.

Holotypus: IMI 318416 (UAMH 6165, CBS 628.88, FMR 2002), isolatus ex solo, apud Don Benito in Badajoz, Hispania, Dec. 1984.

Colonies on YpSs with a daily growth rate of 3–4 mm in the dark at 28°; white, loose velvety in marginal and submarginal areas, dense velvety in the centre, margin regular and not defined, aerial hyphae present in the centre and marginal areas; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 1.5–3 µm broad, thin-walled. *Ascomata* maturing within 25–30 d at 28° on YpSs, superficial and surrounded by the aerial mycelium, spherical, non-ostiolate, 450–600 µm diam, glabrous, light-brown; ascoma wall light brown, 5–8 µm thick, composed of 3–4 layers of flattened, angular, rather thick-walled (0.5–1 µm), 6–10 × 3–8 µm cells. *Asci* subglobose to ellipsoid, 8-spored, 12–13 × 3–8 µm, evanescent. *Ascospores* subglobose to oblate with a prominent narrow equatorial rim with acute edges in side view (1.7–2.2 µm wide), finely pitted, smooth by optical microscopy, one-celled, pale-brown, 7.5–8.5 × 4.5–5 µm. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, clavate, 3.5–6.5 × 2–3 µm, thin-walled, with a truncate base.

Colonies on PYE with a daily growth rate of 1–2 mm in the dark at 28°, white, felty, raised at the centre, margin regular and defined; reverse cream to reddish brown. At 37° there is no growth. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: FMR 2002, from arable soil, Don Benito, Badajoz, Spain, Dec. 1984; UAMH 5356 (FMR 3009); FMR 3016, from garden soil, Panquipulli, Valdivia, Chile, Nov. 1988.

This species bears some resemblance to *A. terreus* but has larger ascospores and the equatorial rim, in top view, is angular while in *A. saturnoideus* is of even width. Gueho & De Vroey (1986) recognize two strains of *A. terreus* based on ascospore size, i.e. 5.5–6.5 × 4–4.5 µm and 7.8 (9) × 5–6 µm respectively. It is probable that the strain with the larger ascospores belongs to *A. saturnoideus*.

The anamorph of the present species is quite similar to that of *A. terreus*, but conidia are not characteristically cymbiform.

Aphanoascus terreus (Randhawa & Sandhu) Apinis, *Mycopath. Mycol. Appl.* 35: 99 (1968). (Figs 1K, 3E, 14)
Keratinophyton terreum Randhawa & Sandhu, *Sabouraudia* 3: 253 (1964).

Anixiopsis terreus (Randhawa & Sandhu) De Vroey & Recacocha, *Bull. Soc. fr. Mycol. Med.* 6: 209 (1977).
Anamorph: *Chrysosporium indicum* (Randhawa & Sandhu) Garg

Colonies on YpSs with a daily growth rate of 2–3 mm in the dark at 28°; white to cream-coloured, powdery to velvety, margin irregular and undefined, flat; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 2–3 µm broad, thin-walled. *Ascomata* maturing within 45–50 d at 28° on

Fig. 12. *Aphanoascus reticulisporus* (FMR 2244). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Asci (N) (bar = 5 μ m); E, Anamorph (PC) (bar = 10 μ m); F, Ascospores (N) (bar = 5 μ m).

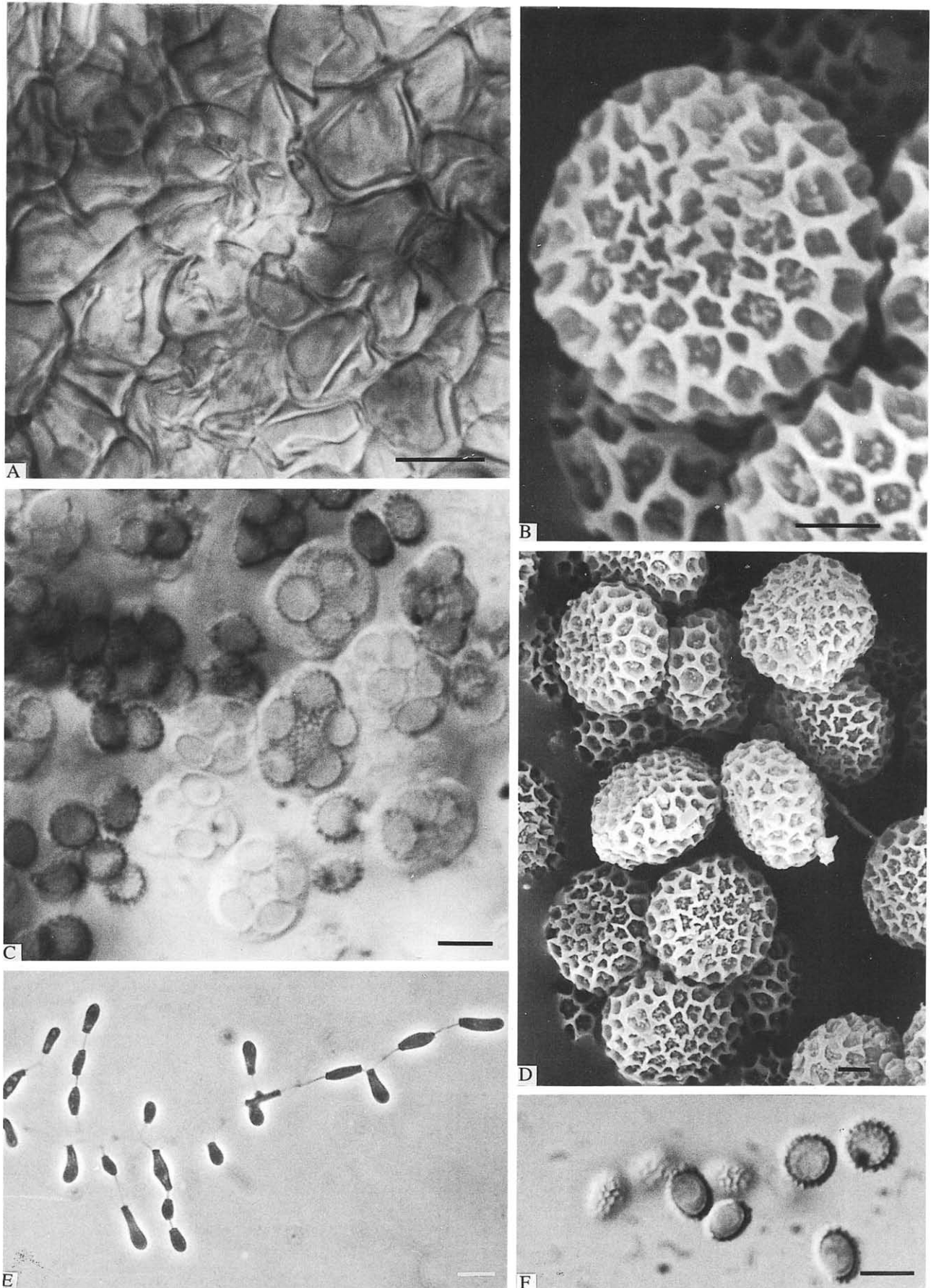
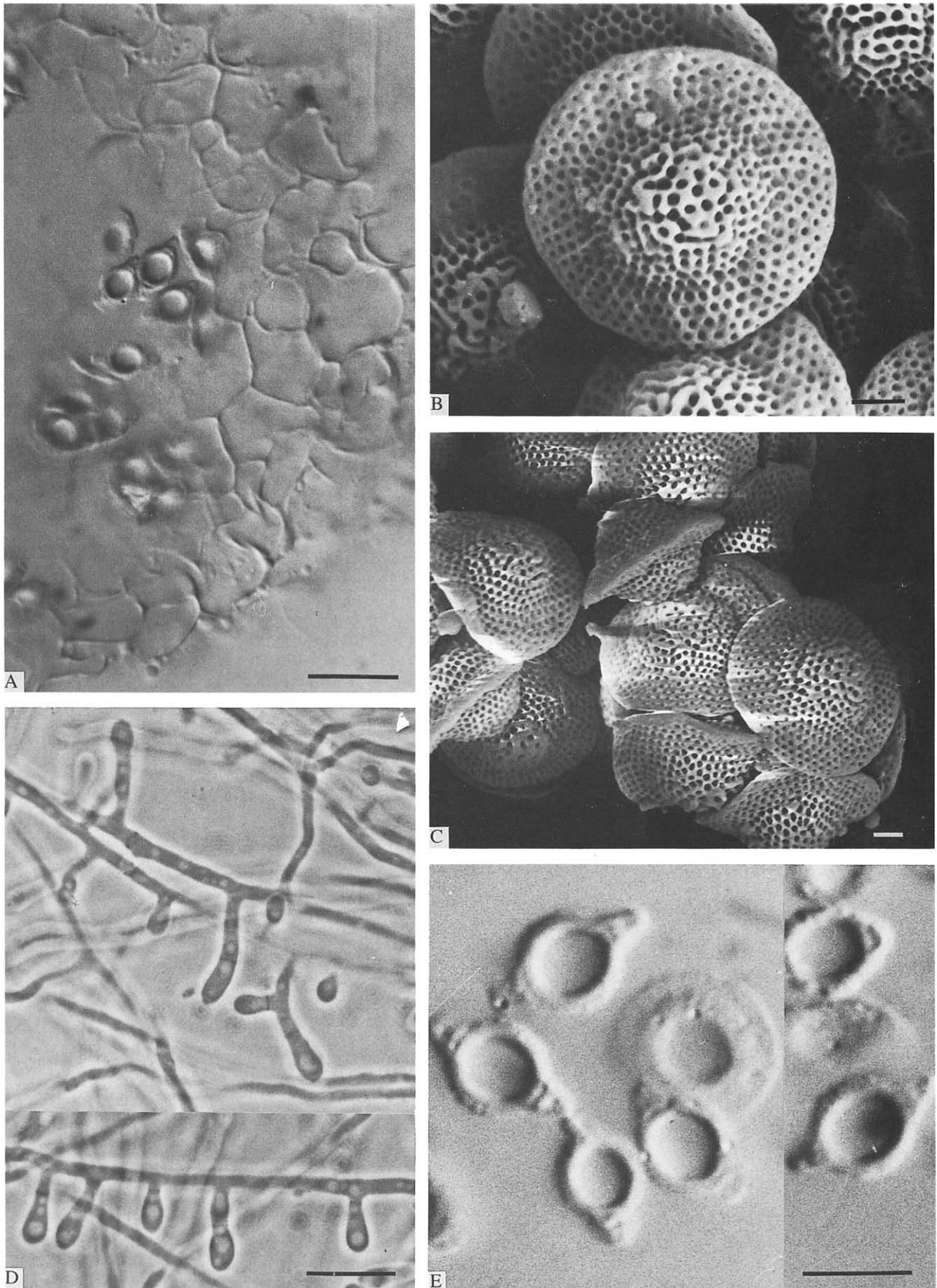


Fig. 13. *Aphanoascus saturnoideus* (FMR 2002). A, Peridium (N) (bar = 10 μ m); B, C, Ascospores (SEM) (bar = 1 μ m); D, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).



YpSs, superficial, spherical, non-ostiolate, 650–810 µm diam, glabrous, dark brown to reddish brown; ascoma wall 7–8 µm thick, composed of 2–3 layers of flattened, angular, 11–16 × 5–11 µm cells, with rather thick walls 1–1.2 µm. *Asci* subglobose to ellipsoid, 8-spored, 10–12 × 8–9 µm, evanescent. *Ascospores* lenticular with a prominent narrow equatorial rim and with flattened polar thickenings, finely pitted over the entire surface, at the poles 2–4 pits may be occasionally present, smooth by optical microscopy, one-celled, brown under transmitted light, dark brown in mass, 5–6 × 2.5–3.5 µm including rim. *Conidia* terminal and lateral, sessile or on short protrusions, solitary, hyaline, smooth, obovoid to ellipsoid, often cymbiform, 4.5–7.5 × 1.5–3 µm.

Colonies on PYE with a daily growth rate of 3–4 mm at 28°, white-buff, flat and slightly raised with radial ridges in the centre, margin regular and defined; felty in the central area and felty to woolly otherwise; reverse uncoloured. The colony growth rate is the same at 37° and 28°. The only differential cultural feature is the presence of pronounced radial ridges at 37°. Keratinophilic.

Material examined: Living strains with only anamorph: UAMH 4066 = CBS 342.64 = ATCC 16413, (ex-type culture of *K. terreum*) soil, India, 1964. Living strains with teleomorph and anamorph: FMR 2259, from arable soil, Serra, Valencia, Spain, Aug. 1985; FMR 2260, from garden soil, Náquera, Valencia, Spain, Aug. 1985; FMR 2261, from forest soil, Villamarchante, Valencia, Spain, Aug. 1985; FMR 2262, from sandy soil, El Manreny, Valencia, Spain, Aug. 1985; FMR 2263, from sandy soil, El Manreny, Valencia, Spain, Aug. 1985; FMR 2264, from garden soil, Balanegra, Almería, Spain, Aug. 1985; FMR 2265, from garden soil, Balanegra, Almería, Spain, Aug. 1985; FMR 2266, from arable soil, Albuñol, Granada, Spain, Aug. 1985; FMR 2267, from arable soil, Albondón, Granada, Spain, Aug. 1985; FMR 2268, from arable soil, Albondón, Granada, Spain, Aug. 1985; FMR 2269, from arable soil, Albondón, Granada, Spain, Aug. 1985; FMR 2270, from forest soil, Orjiva, Granada, Spain, Aug. 1985; FMR 2271, from garden soil, Lanjarón, Granada, Spain, Aug. 1985; FMR 2272, from garden soil, Orjiva, Granada, Spain, Aug. 1986; FMR 2273, from garden soil, Torrox, Málaga, Spain, Aug. 1986; FMR 2274, from garden soil, Torrox, Málaga, Spain, Aug. 1986; FMR 2275, from garden soil, Coin, Málaga, Spain, Aug. 1986; FMR 2276, from arable soil, Coin, Málaga, Spain, Aug. 1986; FMR 2277, from arable soil, Yunquera, Málaga, Spain, Aug. 1986; FMR 2937, from forest soil, El Burgo, Málaga, Spain, Aug. 1985; FMR 2938, from garden soil, Lanjarón, Granada, Spain, Aug. 1986; FMR 2939, from garden soil, Lanjarón, Granada, Spain, Aug. 1986; FMR 2940, from garden soil, Lanjarón, Granada, Spain, Aug. 1986; FMR 2941, from garden soil, Nerja, Málaga, Spain, Aug. 1986; FMR 2942, from garden soil, Nerja, Málaga, Spain, Aug. 1986; FMR 2943, from arable soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2944, from garden soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2945, from garden soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2946, from garden soil, Mezquitilla, Málaga, Spain, Aug. 1986; FMR 2947, from arable soil, La Barona, Castellón, Nov. 1987; UAMH 2409.

The ascospore size of our isolates is larger (5–6 × 2.5–3.5 µm) than in the type of *K. terreum*, reported by Randhawa & Sandhu to be 3.3–5 × 1.7–3.3 µm. Gueho & de Vroey (1986) also noticed this difference in their isolates. There may have been an error of measurement in the original description because the remaining characters are identical. The holotype was not available, and cultures derived from it only yielded

conidia. The species is widely distributed and frequently cited by students of keratinophilic fungi.

***Aphanoascus verrucosus* Cano & Punsola, sp. nov.**

Etym.: *verrucosus* (L) – verrucose (Figs 1L, 3F, 15)

Anamorph: *Chrysosporium* sp.

Hyphae vegetativae hyalinae, ramosae, 1.7–2.5 µm crassae. *Ascomata* superficialia, sphaerica, non-ostiolata, levia, 560–990 µm diam, obscure brunnea; peridio 4–6 µm crassi, e 2–3 stratis cellularum complanatarum angularum composito, 8–21 × 6–9 µm constans. *Asci* octospori, subglobosi vel ellipsoidei, evanescentes, 11–12 × 8.5–9 µm. *Ascospores* subglobosae vel oblatas, pallide brunneae, asperulae, 4.5–6 × 3.5–4.5 µm. *Conidia* terminalia et alternalia, sessilia vel in protrusionibus brevibus oriunda, solitaria, hyalina, crassitunicata, levia, clavata, 5–8 × 2.7–4 µm. Keratinophila.

Holotypus: IMI 319009 (UAMH 6140, CBS 468.88, FMR 2122), isolatus ex solo, apud Cadiar in Granada (Hispania), VIII–1985.

Colonies on YpSs with a daily growth rate of 2–3 mm in the dark at 28°; white, powdery to velvety, cottony in the central area, flat, margin regular and defined; reverse uncoloured. *Hyphae* hyaline, branched, smooth, septate, 1.7–2.5 µm broad, thin-walled. *Ascomata* maturing within 30–40 days at 28° on YpSs, superficial and loosely covered by the aerial mycelium, spherical, non-ostiolate, 560–990 µm diam, dark brown; ascoma wall brown, 4–6 µm thick, composed of 2–3 layers of flattened, angular, 8–21 × 6–9 µm cells, rather thick-walled (1–1.75 µm). *Asci* subglobose to ellipsoidal, 8-spored, 11–12 × 8.5–9 µm, evanescent. *Ascospores* subglobose to oblate, irregularly reticulate, with spine-like and tuberculate projections, one-celled, yellowish to pale-brown, dark brown in mass, 4.5–6 × 3.5–4.5 µm. *Conidia* terminal and lateral, sessile or on short protrusions, hyaline, smooth, pyriform to clavate, 5–8 × 2.7–4 µm, thick-walled; some intercalary conidia are present.

Colonies on PYE with a daily growth rate of 4–5 mm at 28°; white, slightly raised and crateriform in the centre; submarginal areas brownish, velvety; marginal areas velvety to lanose, white; margin defined, regular; reverse cream-coloured. At 37°, when grown on PYE and YpSs, colony characters are the same as at 28°, except that growth rate is slower. *Ascomata* have not been observed. Keratinophilic.

Material examined: Living strains with teleomorph and anamorph: FMR 2122, from arable soil, Cadiar, Granada, Spain, Aug. 1985; FMR 2123, from forest soil, Sueras, Castellón, Spain, Aug. 1985; FMR 2124, from arable soil, Liria, Valencia, Spain, Aug. 1985; FMR 2125, from arable soil, Pozo-Estrecho, Murcia, Spain, Aug. 1985; FMR 2126, from garden soil, Pozo-Estrecho, Murcia, Spain, Aug. 1985; FMR 2129, from arable soil, Huercal-Overa, Almería, Spain, Aug. 1986; FMR 2130, from garden soil, Huercal-Overa, Almería, Spain, Aug. 1986; FMR 2131, from garden soil, Tabernas, Almería, Spain, Aug. 1986; FMR 2132, from garden soil, Tabernas, Almería, Spain, Aug. 1986; FMR 2911, from garden soil, Huercal de Almería, Almería, Spain, Aug. 1985; FMR 2912, from sand soil, Aguadulce, Almería, Spain, Aug. 1985; FMR 2916, from arable soil, Cadiar, Granada, Spain, Aug. 1985; FMR 2917, from garden soil, Orjiva, Granada, Spain, Aug. 1985; FMR 2918, from forest soil, Isbor, Granada, Spain, Aug. 1985; FMR 2930, from garden soil, Cuevas del Almanzora, Almería, Spain, Aug. 1986; FMR 2931, from garden soil, Vera, Almería, Spain, Aug. 1986; FMR 2932, from garden soil, Almuñecar, Granada, Spain, Aug. 1986. Living strains only with

Fig. 14. *Aphanoascus terreus* (FMR 2259). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).

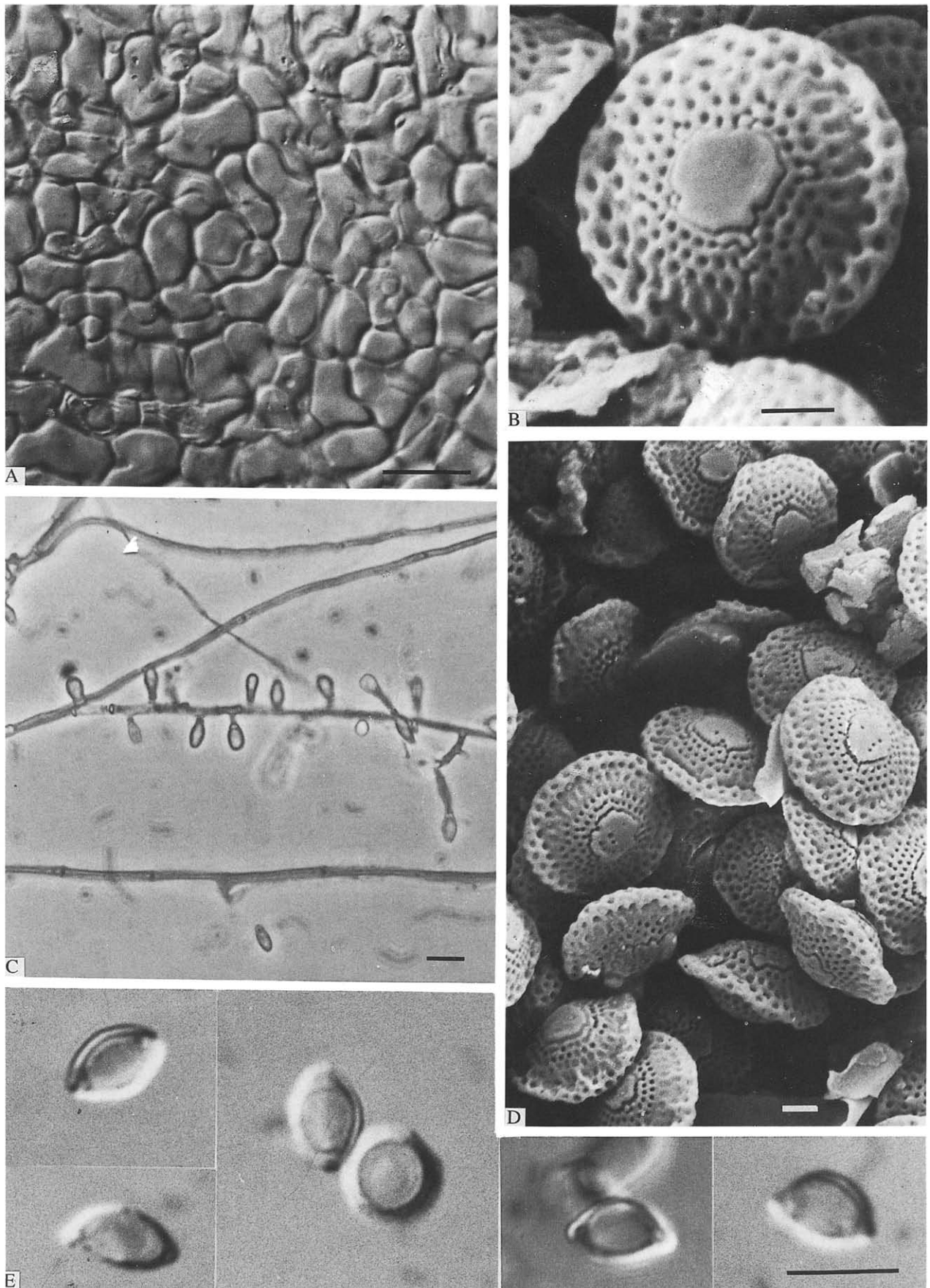
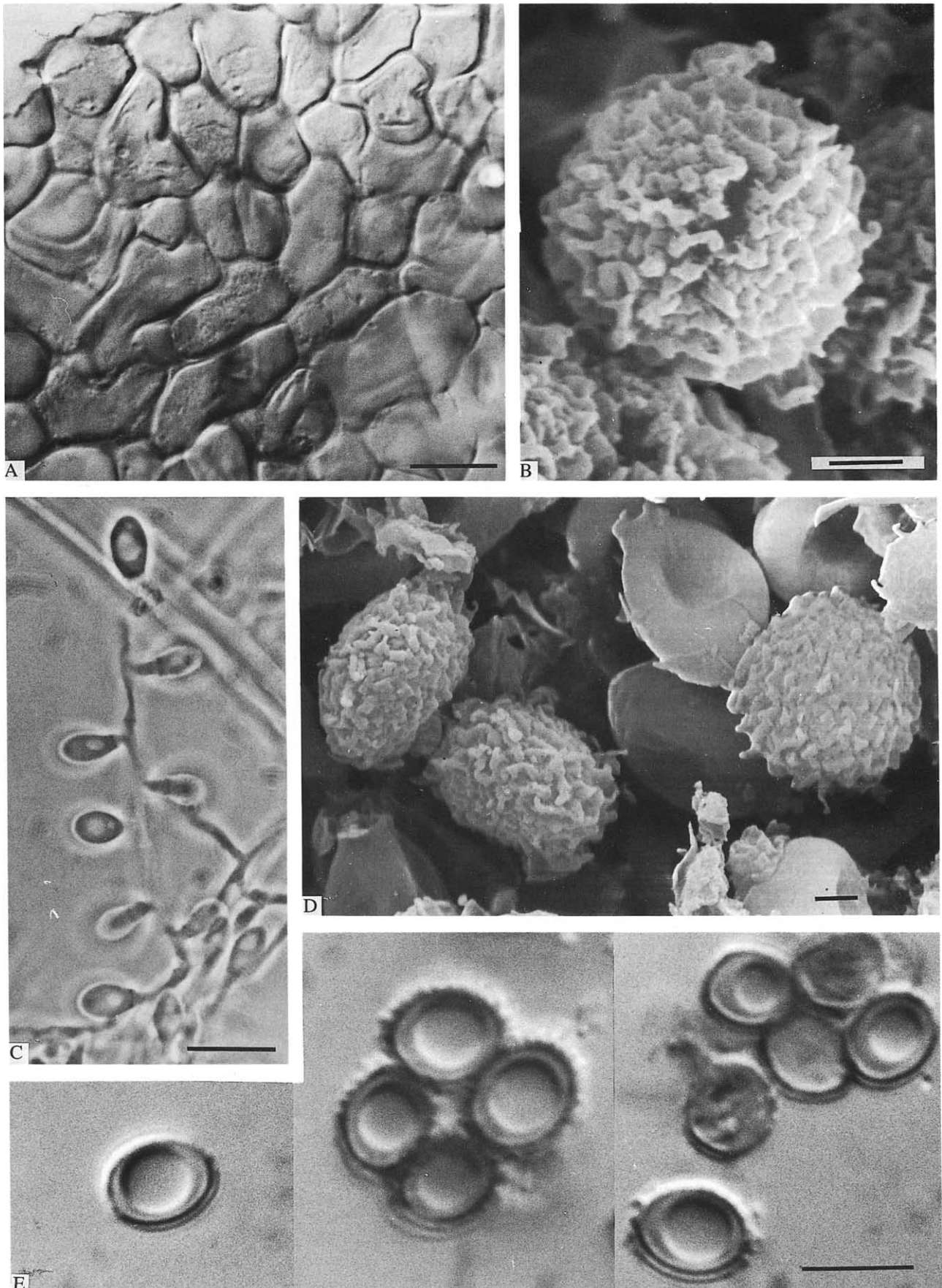


Fig. 15. *Aphanoascus verrucosus* (FMR 2122). A, Peridium (N) (bar = 10 μ m); B, D, Ascospores (SEM) (bar = 1 μ m); C, Anamorph (PC) (bar = 10 μ m); E, Ascospores (N) (bar = 5 μ m).



anamorph: FMR 2127, from garden soil, Albuñón, Murcia, Spain, Aug. 1985; FMR 2128, from garden soil, Totana, Murcia, Spain, Aug. 1985; FMR 2913, from sand soil, Aguadulce, Almería, Spain, Aug. 1985; FMR 2914, from garden soil, Aguadulce, Almería, Spain, Aug. 1985; FMR 2915, from sand soil, Roquetas, Almería, Spain, Aug. 1985; FMR 2919, from garden soil, Salobreña, Granada, Spain, Aug. 1985; FMR 2920, from garden soil, Salobreña, Granada, Spain, Aug. 1985; FMR 2921, from garden soil, Salobreña, Granada, Spain, Aug. 1985; FMR 2922, from garden soil, Almuñecar, Granada, Spain, Aug. 1985; FMR 2923, from sand soil, Almuñecar, Granada, Spain, Aug. 1985; FMR 2924, from arable soil, Alhaurin de la Torre, Málaga, Spain, Aug. 1985; FMR 2925, from arable soil, Tolox, Málaga, Spain, Aug. 1985; FMR 2926, from garden soil, Vinaroz, Castellón, Spain, Aug. 1986; FMR 2927, from garden soil, Gilet, Valencia, Spain, Aug. 1986; FMR 2928, from garden soil, La Ribera, Murcia, Spain, Aug. 1986; FMR 2929, from garden soil, Aguilas, Murcia, Spain, Aug. 1986; FMR 2933, from garden soil, Almuñecar, Granada, Spain, Aug. 1986; FMR 2934, from garden soil, La Herradura, Granada, Spain, Aug. 1986; FMR 2935, from sand soil, Faro Torrox, Málaga, Spain, Aug. 1986; FMR 2936, from arable soil, Al Alquian, Almería, Mar. 1988.

This species forms quite a compact cluster with *A. fulvescens*, *A. reticulisporus* and *A. keratinophilus*, characterized by the absence of an equatorial rim and very similar ascospore shapes. *A. verrucosus* is distinct from the other three species by the ascospore ornamentation, irregularly reticulate with spiny and tuberculate protrusions, while in the others the reticulation is always well marked, except in *A. fulvescens*. The anamorph in *A. verrucosus* is similar to *C. tropicum*, while in *A. keratinophilus* is *C. keratinophilum*, and in *A. fulvescens* and *A. reticulisporus* it is a *Chryso sporium* species, with quite elongate conidia and with abundant arthroconidia. Another diagnostic feature of *A. verrucosus* is the sparse production of slowly maturing ascomata, taking about a month to develop. On the other hand, in *A. fulvescens* and *A. reticulisporus* ascomata uniformly cover the whole plate in large numbers and mature in 14 d. *A. keratinophilus* does not produce ascomata on YpSs. The ascospore dimensions of *A. verrucosus* are very similar to those of *A. reticulisporus* and intermediate between those of *A. fulvescens* and *A. keratinophilus*.

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