

THE GENUS *TAENIOSPORA* AND ITS TELEOMORPHS

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Two new taxa are described in *Taeniospora*: *T. descalsii* sp. nov. and *T. gracilis* var. *enecta* var. nov., both with teleomorphs in *Fibulomyces* (Corticaceae), in which *F. crucelliger* is described as a new species.

Leptosporomyces galzinii (Bourd.) Jülich was reported as the teleomorph of a staurosporous fresh-water hyphomycete (Nawawi, Descals & Webster, 1977), later named as *Taeniospora gracilis* (Marvanová, 1977). Several new isolates of *T. gracilis* and of a new anamorph forming an athelioid teleomorph prompted a revision of the present concept of both the anamorphous and teleomorphous taxa.

METHODS

All strains were grown on 2% malt agar (MEA) and LCA agar (Miura & Kudo, 1970) at 10-12 °C.

To obtain the anamorph, pieces of mycelium with agar were submerged in Petri dishes with distilled water and stored in daylight at 12-15°. Basidiomata were obtained by placing small agar blocks with the fungus in Petri dishes with 2-3 mm water, so that they were not submerged. Tests on laccase (with α -naphthol) and tyrosinase (with *p*-cresol) were performed according to Stalpers (1978), and SEM preparations were made according to Samson *et al.* (1979).

KEY TO *TAENIOSPORA* SPECIES

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|---|---|---|
| 1 | Conidia cruciate, one lateral originating from the central clamp of the conidial axis. | <i>T. descalsii</i> |
| 1 | Conidia not cruciate, conidial branches alternate, both typically originating from the conidial axis. | 2 |
| 2 | Conidial elements nearly cylindrical, axis usually mildly curved, mostly with an excentric basal extension, branch insertion broad. | <i>T. gracilis</i> var. <i>enecta</i> |
| 2 | Conidial elements long fusoid, axis usually strongly bent or sigmoid, basal extension lacking, branch insertion narrowed. | <i>T. gracilis</i> var. <i>gracilis</i> |

TAENIOSPORA GRACILIS

Nawawi *et al.* (1977) reported a staurosporous hyphomycete as the anamorph of *Leptosporomyces galzinii* (Bourd.) Jülich. They included 2 isolates, IMI 203146 (Exeter no. 3212) from the U.K. and IMI 203145 (Exeter no. 3213) from the Basque region of Spain. Minor morphological differences between them were mentioned and both isolates were provided with a separate description. Only the isolate of IMI 203146 produced the teleomorph. Marvanová (1977), in accordance with Art. 59 of ICBN, established the genus *Taeniospora* for these anamorphs the conidia of which occur frequently in streams. The only species, *T. gracilis* Marvanová, was typified from her isolate CCM F-564 from the ČSSR. She mentioned its close

similarity to IMI 203145 and the failure to produce a teleomorph, but having observed some variation in conidial morphology with the changing temperature in her isolate, she considered the differences between various isolates as probably environmentally conditioned. Later, more cultures of *T. gracilis* were isolated in the U.K. and it became evident that each of the two morphological types of conidia mentioned above is linked with a certain type of colony; (1) with monilioid cells, producing smaller conidia with fusoid elements and lacking a teleomorph; (2) without monilioid cells, having larger conidia with nearly cylindrical elements and being able to produce a teleomorph. These differences in our opinion justify recognizing two varieties in *T. gracilis*.

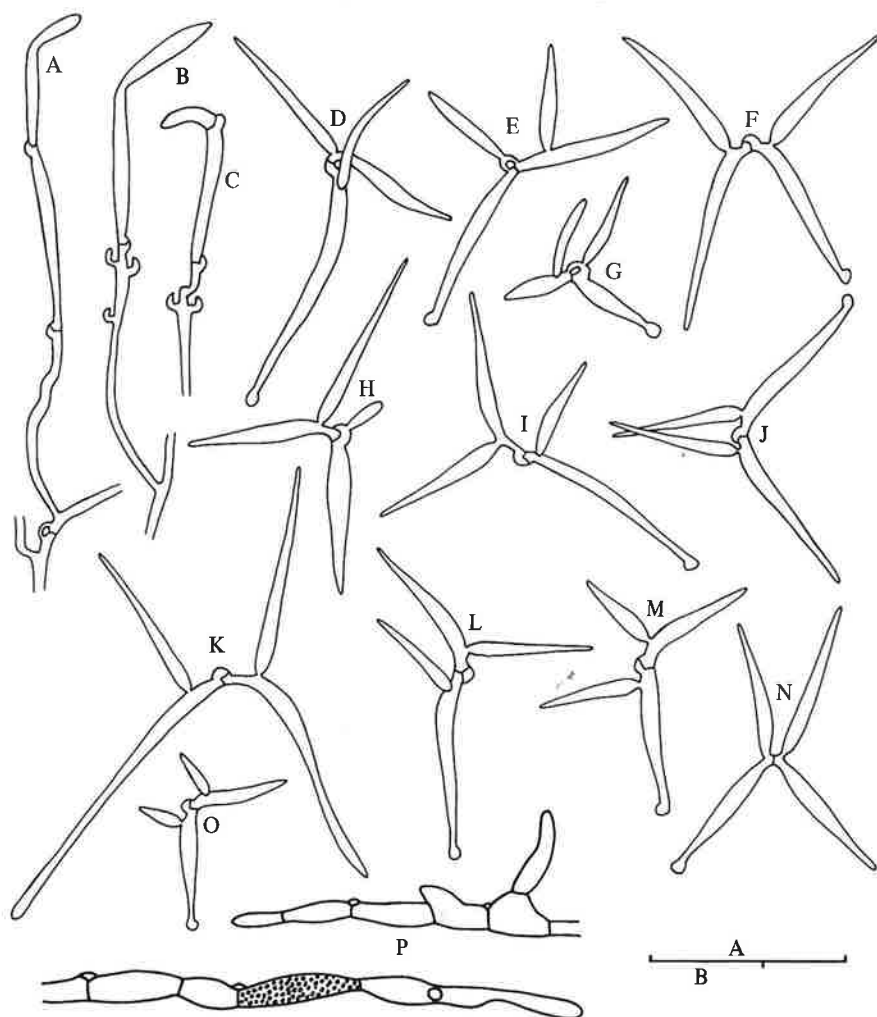


Fig. 1. *Taeniospora gracilis* var. *gracilis*. (A-C) Developing conidia; (D-O) free conidia; note the origin of one conidial branch from the clamp in E, G, H, and the clampless septum in N. (P) chains of inflated cells. (A-J and L, M, O, = CCM F-18683; K and N from foam.) Scale A, B = 20 μm ; P according to scale B, the rest to scale A.

Taeniospora gracilis Marvanová var. *gracilis*,
Trans. Br. mycol. Soc. **69**: 146 (1977).

(Figs 1-2)

Growth on MEA (2%) slow at 10-12°, restricted, becoming inconspicuous after ca 20 days; colony pale beige, glabrous, compact, silky, with suberect funiculose hyphae in the centre; reverse pale brown, darker below inoculum. Advancing zone appressed, even. Odour pungent, mushroom-like, especially after tearing the colony. Reaction on laccase negative to weak, on tyrosinase negative.

Marginal hyphae hyaline, thin-walled, straight or

slightly undulating, 1-1.5 μm wide, with clamps at all primary septa. In older parts of the mycelium the hyphae are up to 3 μm wide. Chains of broadly fusiform or irregularly swollen cells 8-25 \times 4-9 μm , somewhat thick-walled, with granular contents, separated with clamped septa present. Sporulation upon submergence or on the water level. *Conidiophores* up to 20 μm long when lateral, with a clamp at the base of the conidium, simple, rarely with one branch. *Conidiogenous cells* integrated, proliferation sympodial, from the subapical part or, rarely, from the loop of the clamp at the conidium base; rachis

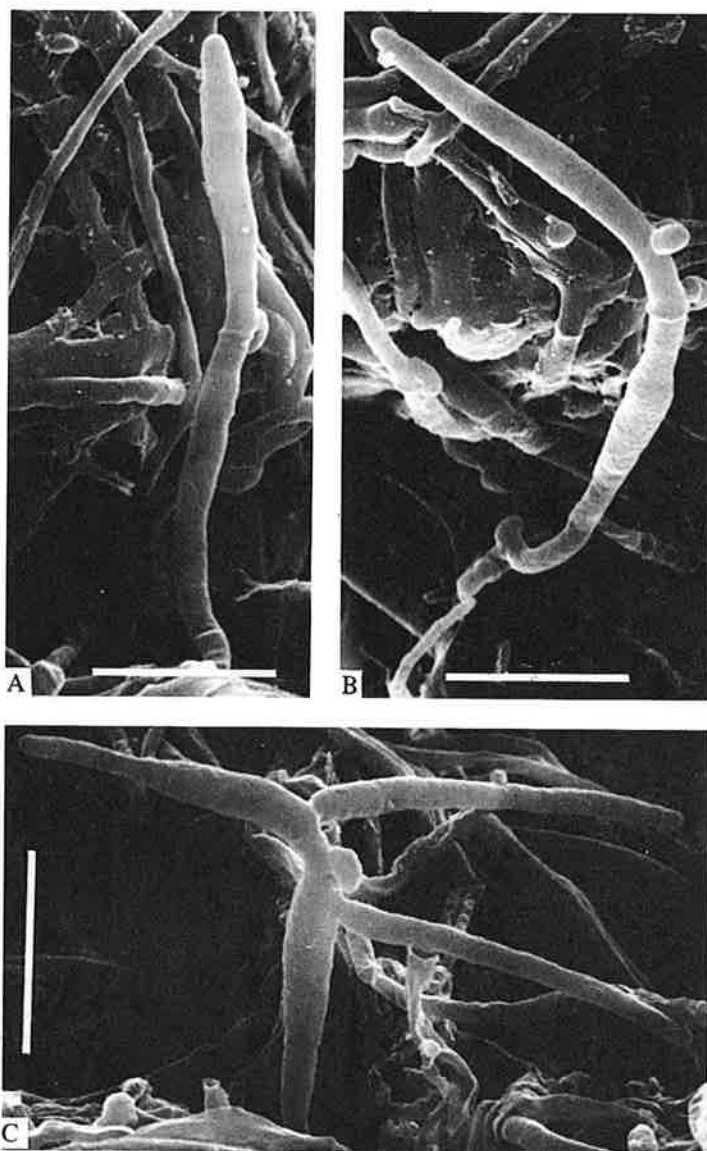


Fig. 2. *Taeniospora gracilis* var. *gracilis* CCM F-18683. (A, B) Developing conidia; (C) mature conidium. Bar = 5 μm .

geniculate with hooks or meander-like distortions. *Conidia* single to grouped, acro-pleurogenous, consisting of an axis and two alternate laterals. Axis arcuate to bent, sometimes sigmoid or twisted, with a clamped septum near the middle, long fusoid, attenuated distinctly in the area between laterals, (18-)27-47 (-57) \times 1.5-3 μm , each half binucleate; apex subulate, base foot-shaped due to the remnant of the basal clamp. Laterals dorsal, more or less

perpendicular to the axis, not in one plane, appearing in basipetal succession, situated (1-)2-5(-12) μm apart from each other, each on one half of the axis, the upper one often retrorse, the lower antrorse, sometimes crossing each other, straight to slightly curved, narrowly fusoid to obclavate, 8-24 \times 1-2.5 μm , the lower one usually somewhat shorter. *Conidial secession* schizolytic. Free conidia when suspended longer in water may

break along the median clamp. During development the rod-like conidium initial becomes attenuate and bent below the apex, resembling a hockey-stick. No teleomorph observed.

Conidia in water often exhibit microcycle conidiation, with new conidia formed on short conidiophores appearing on the ends of the parent conidium. On solid substrate, germination occurs, with germ-tubes growing from the ends. In a small percentage of conidia in culture, one branch may originate from the loop of the central clamp or may be lacking. Conidia without the median clamp, but with a septum, or rarely with several clamps on axis and laterals were observed both in foam and in culture. The clampless conidia ceased growth soon after producing a short germ-tube.

Isolates examined: CCM F-564 (the original isolate of *T. gracilis*), from water, among plant debris, Jeseníky Mountains, ČSSR, L. Marvanová; CCM F-18683 (= CBS 713.83), CCM F-18683, CCM F-20083; from foam in the river Afon Artro, Snowdonia Park, N. Wales, U.K., March 1983, L. Marvanová.

Beside these localities, conidia of this variety are known from foam in several mountain and submountain streams in ČSSR and from the Basque region of Spain (Nawawi *et al.*, 1977).

After 9 years of periodical transfer the type strain (CCM F-564) shows some kind of degeneration: the growth rate increases, monilioid cells are no longer formed and the sporulating ability is lost.

The presence of thick-walled cells coinciding with the absence of a teleomorph may suggest that these structures function as a resting stage and play some role in surviving unfavourable conditions.

Similar structures are found in the corticiaceous genus *Sistotrema* Fr., which is related to *Fibulomyces*, and also contains at least one species with a staurosporous anamorph (Nawawi & Webster, 1982). *S. brinkmannii* (Bres.) J. Erikss. forms monilioid cells in culture, which generally remain thin-walled, but occasionally become thick-walled and agglomerate to form bulbils or sclerotia which are classified in *Burgoa* Goid.

Taeniospora gracilis Marvanová var. **enecta** anam. var. nov. (Fig. 3)

Teleomorph: as *Leptosporomyces galzinii* Nawawi *et al.*, *Trans. Br. Mycol. Soc.* **68**: 33 (1977).

Etym. enectus (L.) = starved: refers to the slim appearance of the conidia in contrast to those of var. *gracilis*.

A varietate *gracilis* conioniis albidis non restrictis, cellulis monilioideis absentibus, conidiophoris longioribus, conidiis cum axe cylindraceo vel paulo attenuato in media parte, (40-) 50-75 × 1.2-2.2 (-3.5) μm, extensione excen-

trica 2-4 μm longa in parte proxima basis, ramis cylindraceis vel paulo attenuatis (4-) 7.5-10 (-17.5) μm distantibus, (10-) 20-35 × 0.7-1.2 (-2) μm, differt.

Conidia libera in spuma in flumine loco Aber Falls dicto, Snowdonia Park, N. Wales, mense Martio 1983, L. Marvanová, IMI 309246 holotypus, ex cultura CCM F-17583.

Colonies not restricted, whitish, woolly, forming hyphal strands. Advancing zone appressed or a few hyphae raised, even. *Marginal hyphae* hyaline, thin-walled, 1-1.5 μm wide, with clamps at all primary septa. Monilioid cells absent. *Conidiophores* up to 50 μm long. *Conidial axis* (40-) 50-75 × 1.2-2.2 (-3.5) μm, usually arcuate to almost straight in culture, less often sigmoid, cylindrical, tapering slightly towards the apex, or to both ends, sometimes slightly attenuate near the middle, basal extension usually present, excentric, 2-4 μm long. *Laterals* (4-) 7.5-10 (-17.5) μm apart, cylindrical, often slightly tapering distally, more or less perpendicular to the axis, (10-) 20-35 × 0.7-1.2 (-2) μm, insertion broad. Microcycle conidiation not observed. Germination by germ-tubes from the ends. Aberrant conidia with one arm lacking or originating from the central clamp of the axis may appear in culture; clampless conidia seen in foam resemble conidia of a small *Tricladium* species. Contrary to var. *gracilis*, the clampless conidia give rise to colonies with clamped mycelium. Teleomorph present in some isolates (see Nawawi *et al.*, 1977, as *L. galzinii*).

Isolates examined: CCM F-11083, CCM F-11883, foam, river Teign, Glassy Steps, Devon, England, U.K., Feb. 1983, L. Marvanová; CCM F-16283, CCM F-16583, CCM F-16683, foam, Bryn Gefeilia; CCM F-17583, foam, Aber Falls, Snowdonia Park, North Wales, U.K., March 1983, L. Marvanová.

In the U.K. conidia of this kind are illustrated by Ingold (1968, Fig. 1, Pl. 8A; 1974, Fig. 6) in foam and unnamed, Willoughby & Archer (1973, Fig. 4c) on twig baits and unnamed. The species is also known from Sweden (Müller-Haeckel & Marvanová, 1979, 1982) in fresh water and in an estuary, from several localities in lowland, highland and mountains in foam in ČSSR (Marvanová, unpub.) and Japan (Miura, 1974, fig. 78) in foam.

As mentioned above, the teleomorph produced in strain IMI 203146 (Exeter 3212) has been identified by Nawawi *et al.* (1977) as *Leptosporomyces galzinii*. However, the CBS strains of *L. galzinii* originating from tissue of a basidioma (CBS 205.54 and 131.75) when compared with our isolates of *T. gracilis* var. *enecta*, show considerable differences in the colony characters: the CBS strains grow faster, possess slightly thick-walled and in some parts incrustated hyphae,

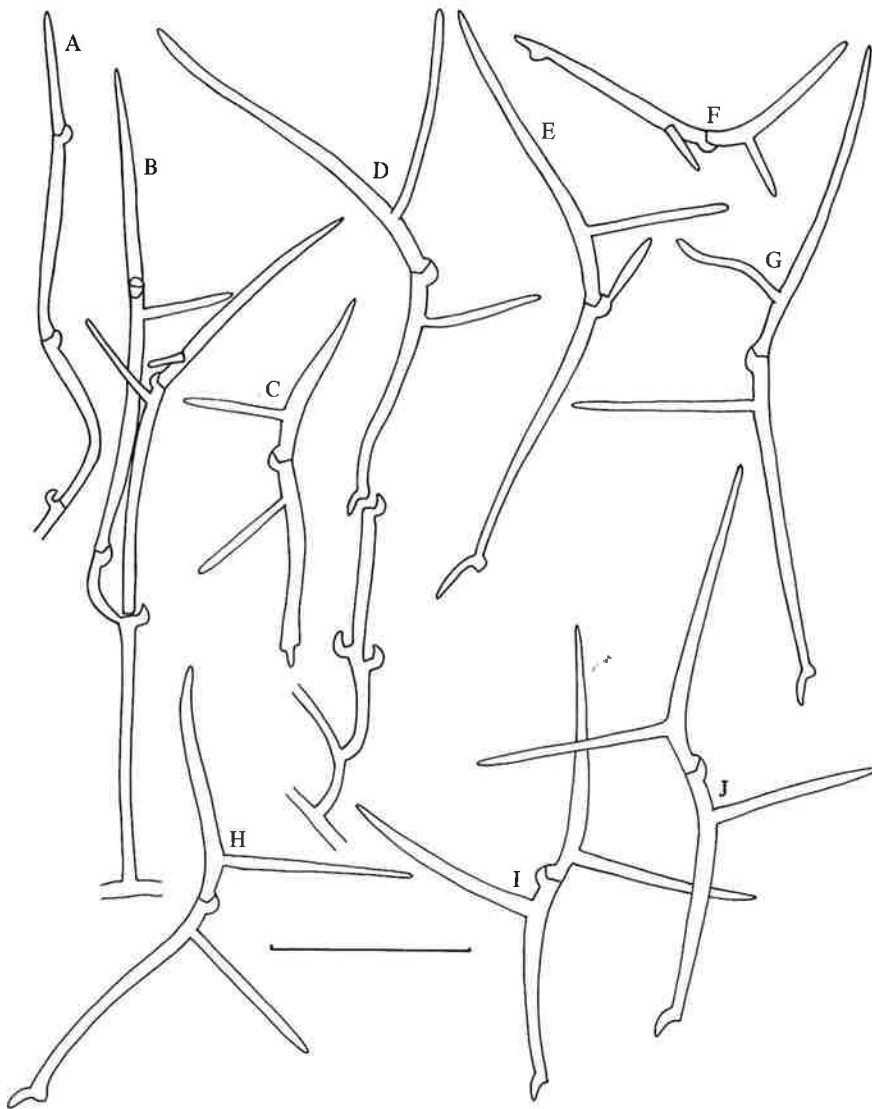


Fig. 3. *Taeniospora gracilis* var. *enecta* CCM F-17583. (A, B) Developing conidia; (D) just-liberated conidium; (C, E-J) free conidia; (E) conidium with a sprouting clamp. Scale = 20 μ m.

have tyrosinase and do not produce the characteristic mushroom odour.

When considering the few characters of athelioid fungi which can be observed in culture, there are only two genera which can be considered to accommodate the teleomorph of *Taeniospora gracilis* var. *enecta* - *Leptosporomyces* Jülich and *Fibulomyces* Jülich, published at the same time (Jülich, 1972). The type species, *L. galzinii* (Bourd.) Jülich and *F. mutabilis* (Bres.) Jülich are closely related. Both are pellicular, may form hyphal strands, have

a loose subiculum with some thick-walled basal hyphae, have clavate to subcylindrical basidia and ellipsoid to subcylindrical spores which are sometimes slightly widened towards the base.

The differences lie only in the dimensions of the basidia and spores. In *L. galzinii* the basidia are 8-12 (-13) μ m long and in *F. mutabilis* (10-) 12-15 (-20) μ m. This is also the only difference between the genera. It is doubtful if this will be sufficient in future classifications. Because of the size of the basidia, we prefer to classify the

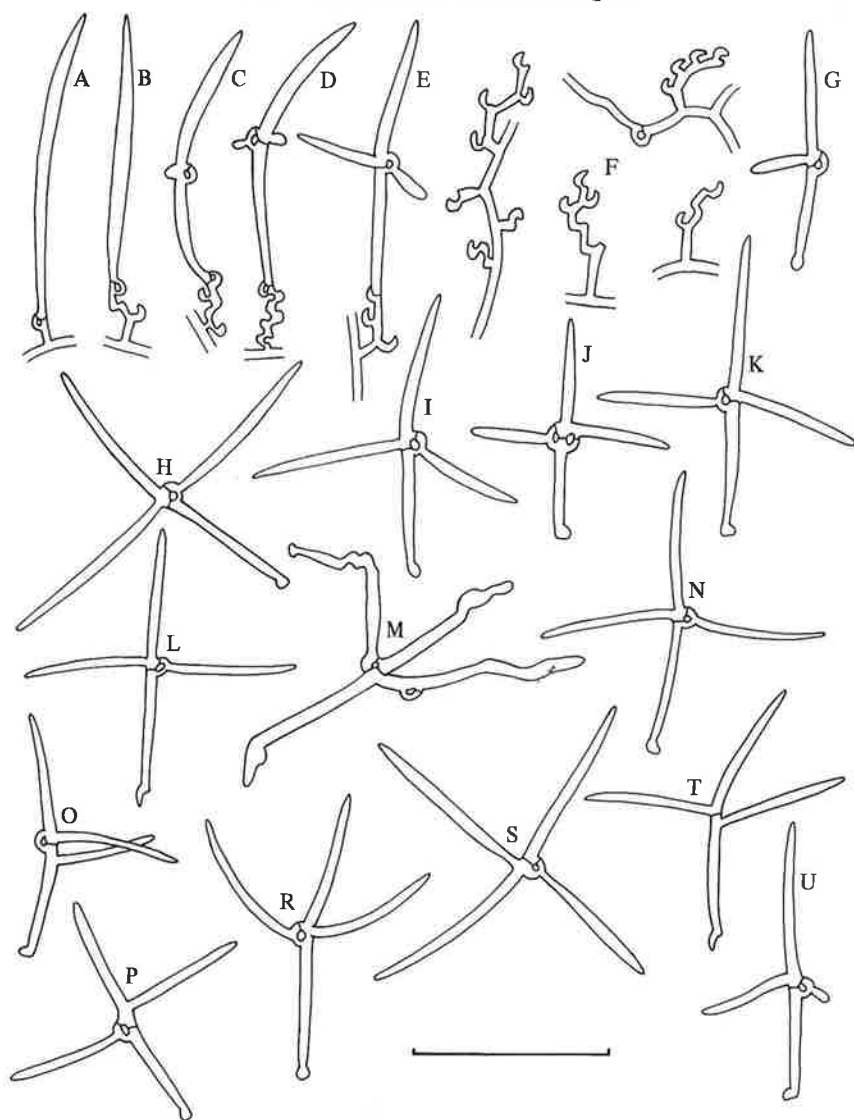


Fig. 4. *Taeniospora descalsii*. (A-E) Developing conidia; (F) spent conidiophores; (G-U) free conidia; (M) germinating conidium; (G, J, O) aberrant conidia; (T) clampless conidium. (A-S, U, from CCM F-11483; T, from foam). Scale = 20 μ m.

teleomorph of *T. gracilis* var. *enecta* in the genus *Fibulomyces*. Although we are aware that it very likely represents an as yet unnamed species, we refrain from naming it because of the scarcity of the material (for description see Nawawi *et al.*, 1977, as *L. galzinii*).

TAENIOSPORA DESCALSII

Small cruciform conidia with a clamp near the middle were isolated in England and Wales. An

athelioid teleomorph similar to that of *T. gracilis* var. *enecta* developed in culture. This and the type of conidial configuration prompted us to classify the anamorph in *Taeniospora*.

Taeniospora descalsii anam. sp.nov. (Figs 4, 5)

Etym. Named in honour of Dr E. Descals, who drew the attention of the first author to the conidia in foam

Conidiophora ex hyphis crescentia, praecipue lateralia, brevia, simplicia vel paulo ramosa, cylindrica, sympto-

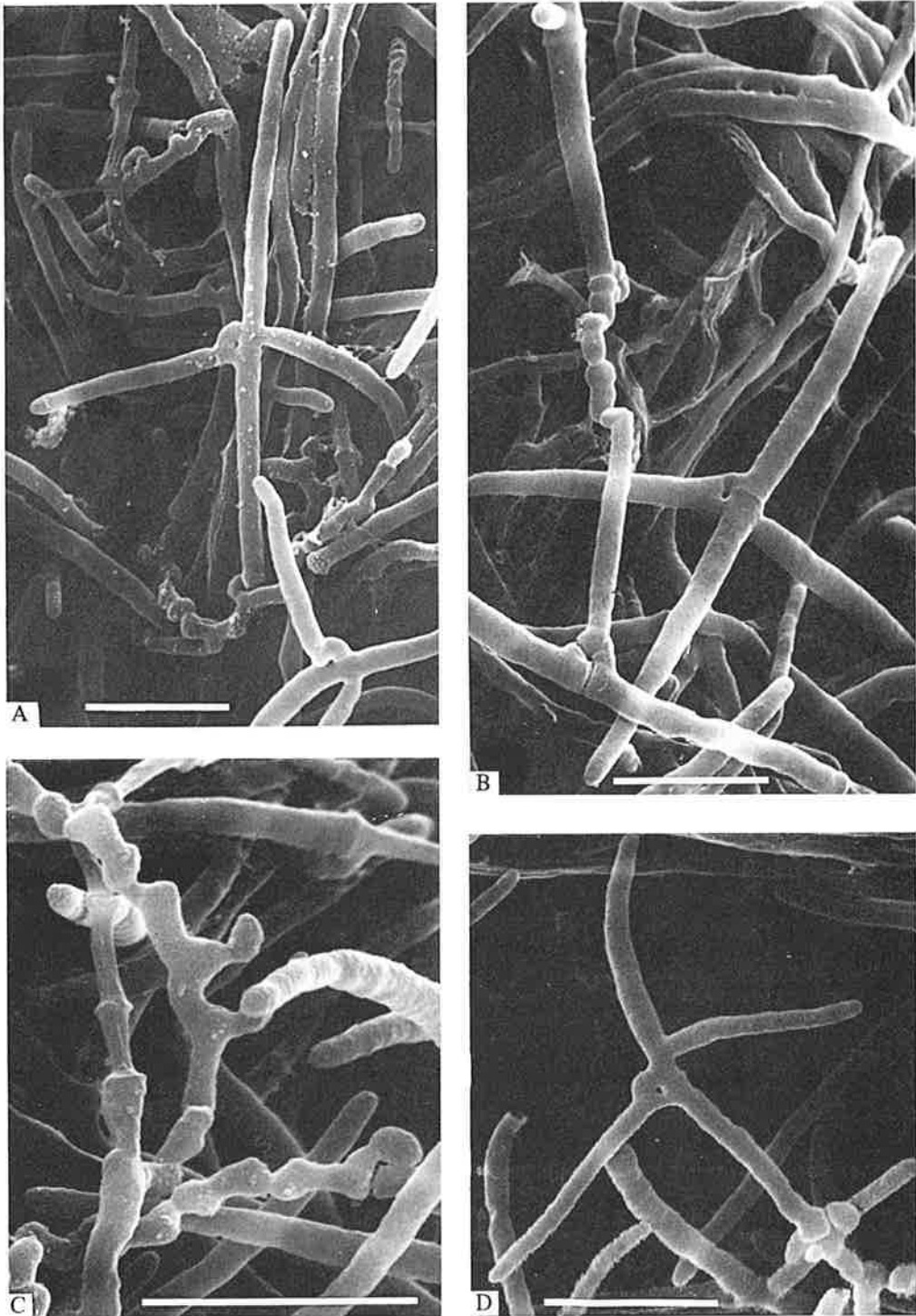


Fig. 5. *Taeniospora descalsii* CCM F-11483. (A, D) Mature conidia; (B) conidiophore originating from a clamp and a liberated conidium; (C) conidiogenous rachis with the loop of a clamp remaining attached. Bar = 5 μ m.

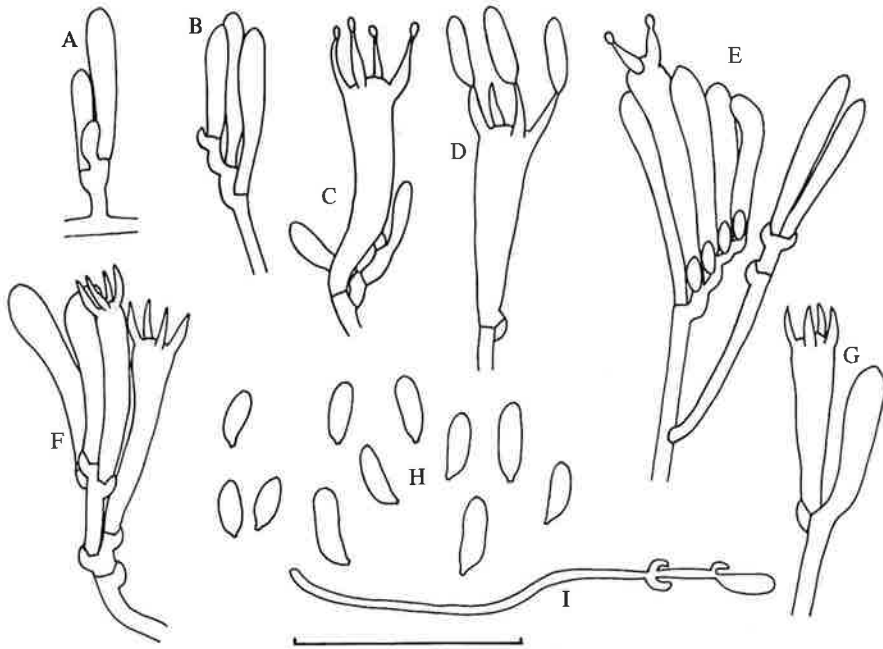


Fig. 6. *Fibulomyces crucelliger* CCM F-11483. (A-G) Basidia in various stages of development; (H) basidiospores; (I) germinating basidiospore with clamps still open. Scale = 20 μm .

dialiter prolificantia; pars conidiifera recta vel fractiflexa, reliquiis fibularum ornata; conidia cruciformia, singularia vel aggregata, acro-pleurogena; axis rectus vel subcurvatus, cylindricus, 17-38 (-55) \times 1-2 (-3) μm (mediocriter ca 25 \times 1.5 μm), in media parte septum unum cum fibula gerens, apex subulatus, basis pediformis vel truncata, rami duo, suboppositi, recti vel subcurvati, cylindrici, ramus primus ex axe, ramus secundus e fibula oriens et ramum primum sequens, 7-15 (-22) \times 1-2 μm , apice subulati vel obtusi, basi cylindrici vel subattenuati. Dehiscentia schizolytica, fibula basali fissa.

Ut conidia libera in spuma in flumine Teign, loco Glassy Steps dicto, Devon, Britannia australis, mense Februario, 1983, L. Marvanová. Holotypus: IMI 309245, ex CCM F-11483 (anamorphosis).

***Fibulomyces crucelliger* Stalpers & Marvanová, sp. nov.** (Fig. 6)

Etym. *crucelliger* (Latin) = bearing small crosses (the shape of conidia).

Basidioma resupinatum, effusum vel pustulatum, albidum vel cremeum vel pallide brunneum, laxe adhaerens. Hyphae hyalinae, tenui-(vel minime crassi-) tunicatae, 1.5-2.5 μm diam, septa fibulata. Cystidia absentia. Basidiophora recta, ramosa. Basidia clavata, basi vulgo fibulata, seriatim vel inordinate aggregata, saepe in planis variis inserta, 12-20 (-25) \times (3-) 4-5 μm , sterigmata (1-)4. Basidiosporae hyalinae, laeves, tenuitunicatae, ellipsoideae, (3.5-) 4-5.5 (-7) \times (1.7-) 2-2.5 (-2.8) μm , non amyloideae.

Holotypus: IMI 309244, ex cultura CCM F-11483 (teleomorphosis).

Growth on MEA slow, radius in 20 days 15-17 mm at 10-12°. Odour insignificant. Advancing zone raised, even, hyphae dense. *Colonies* white, woolly, with abundant aerial mycelium. Reverse pale brown, darker in the centre. Laccase test positive, tyrosinase negative.

Marginal hyphae hyaline, thin-walled, 1-1.5 μm wide, straight to slightly undulate, septate, with clamps (sometimes medallion clamps). Cells binucleate, 40-75 μm long. Substrate hyphae 1-3 μm wide, sometimes with secondary septa. Cubical colourless crystals present in the agar.

Basidioma pustulate or very small and effused, developing on floating pieces of agar, always above the water level. Pustules small, ca 1 mm diam, hemispherical, separable, whitish to pale brownish. *Basidia* in small clusters (up to five), inserting on various levels, sometimes in ascending rows (Fig. 6), narrowly clavate, 12-20 (-25) \times (3-) 4-5 μm , 2 μm wide at the base, with (1-)4 sterigmata up to 2 μm long. *Basidiospores* hyaline, smooth, ellipsoid, (3.5-) 4-5.5 (-7) \times (1.7-) 2-2.5 (-2.8) μm , not amyloid. Germination scarce, germ-tube with or without clamps.

Conidiophores arising as lateral branches on

hyphae, usually without a basal septum, exceptionally growing from a clamp of the parent hypha. With progressing conidiogenesis the conidiophores elongate considerably and may sometimes become branched. The proliferation is sympodial, either from the basal clamp of the conidial axis or from the conidiophore stalk opposite that clamp, with both conditions usually present in the same conidiophore. Rachis meander-like, or variously bent, bearing upward-directed hooks (remnants of clamps; Fig. 4, E-H). *Conidium development* initiates with the production of a rod-like straight primordium separated from the conidiophore by a clamped septum. When about 30 µm long, a clamped septum divides the initial in two more or less equal parts. Then the first lateral grows immediately above the septum opposite the clamp and a second arm develops somewhat later from the loop of the clamp. Conidial secession is schizolytic by disarticulation of the basal clamp. *Mature conidia* are cruciform, consisting of a straight to slightly bent axis, 17-38 (-55) × 1-2 (-3) µm (av. 25 × 1.5 µm), with a foot-shaped base and a subulate or blunt apex, bearing a clamp on the single septum in the middle, and two laterals in a perpendicular position, one originating from the loop of the clamp. The arms are 7-15 (-22) × 1-2 µm, straight or slightly curved downwards or upwards. They do not always lie in the same plane. Germination occurs from the ends, with a germ-tube.

Misshapen conidia occur in a low percentage: one arm can be lacking or very short, a third arm may appear on the upper or lower cell of the axis or both arms develop beside the clamp, thus resembling *Taeniospora gracilis*. Clampless conidia were also encountered in foam (Fig. 4, T).

Sporulation occurs on the agar as well as when partially submerged in distilled water; in the latter case the conidia appear more freely near or on the water surface. Conidia from pure culture tend to have slightly broader elements than those from foam.

Isolates examined: CCM F-11483 (= CBS 715.83), from foam, river Teign, Glassy Steps, Devon, U.K., February 1983, L. Marvanová; CCM F-16083 (= CBS 716.83), from foam in a stream, Bryn Gefeilia, Snowdonia, Wales, U.K., March 1983, L. Marvanová; CCM F-15186, from foam in a mountain stream, Western Tatra, Czechoslovakia, May 1986, L. Marvanová.

The anamorph was illustrated by Ingold (1979, p. 219, fig. 47) as a 'conidium of unknown basidiomycete' from a foam sample in Scotland. E. Descals (pers. comm.) collected conidia of this species in foam in various streams in England and Wales from April to May and in November, once also on wood.

Free conidia of *Taeniospora descalsii* in water are fairly easily recognizable. Only the small conidia of *Alatospora acuminata* Ingold as neotypified by Dyko (1978), which may have an inflation at the point of insertion of the branches, can be confused with this species when examined at low magnification. However, clamps are never present in *Alatospora* conidia. *Taeniospora descalsii* is close to *T. gracilis* var. *enecta* with respect to the teleomorph, the sympodial proliferation of the conidiophores, the sprouting clamps, the sequence of conidial arms, the presence of a single clamp in the middle of the axis and the schizolytic secession of conidia. It approaches *T. gracilis* var. *gracilis* in the small size of conidia, whose branches may be very close to each other, and one of them may originate from the clamp.

Taeniospora is not the only genus where *T. descalsii* could be placed. There is the genus *Titaella* Arnaud (1951), a name recently validated by Ando & Tubaki (1985), whose only species *T. capnophila* was rediscovered in the rainwater on *Pinus densiflora* needles by the above authors. Its conidia are of similar size to those of *Taeniospora descalsii*, but possess only one horizontal lateral growing from a clamp in the middle of a straight axis, and one secondary branch, originating near the base of the primary lateral and directed downwards. No teleomorph is known of *Titaella capnophila*, but that species was reported growing together with *Hypochnus capnophilus* Arnaud on leaves covered with sooty moulds: considering our present knowledge of stauroid conidia in the Aphyllophorales, it may well be its anamorph.

At least three staurosporous anamorph taxa are linked to members of the Athelieae so far: *Taeniospora gracilis* var. *enecta* with *Fibulomyces* sp., *Taeniospora descalsii* with *F. crucelliger*, and *Ingoldiella hamata* Shaw with *Sistotrema hamatum* (Nawawi & Webster, 1982). It would be worthwhile to isolate those members of this subfamily that grow near streams and to search for staurosporous anamorphs in their cultures. Submerging would probably enhance the chance of finding anamorphs.

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