The Eremomycetaceae (Ascomycotina)

DAVID MALLOCH

Department of Botany, University of Toronto, Toronto, Ont., Canada M5S 1A1

AND

LYNNE SIGLER

University of Alberta Microfungus Collection and Herbarium, Devonian Botanical Garden, Edmonton, Alta.,
Canada T6G 2E1

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The Eremomycetaceae is shown to contain three species: *Eremomyces bilateralis* Malloch & Cain, *Rhexothecium globosum* Samson & Mouchacca, and *Pithoascus langeronii* von Arx, which is treated as a new combination in *Eremomyces*. The family is characterized by members having pseudoparenchymatous ascomatal initials, cleistothecia, clavate to ovoid evanescent asci, and one-celled hyaline to pale brown ascospores. Two of the three species have *Arthrographis*-like or *Trichosporiella*-like anamorphs. The pseudoparenchymatous ascomatal initials characteristic of this family strongly suggest that it should be included in the class Loculoascomycetes.

MALLOCH, D., et SIGLER, L. 1988. The Eremomycetaceae (Ascomycotina). Can. J. Bot. **66** : 1929–1932.

Les auteurs démontrent que les Eremomycetaceae contiennent trois espèces : *Eremomyces bilateralis* Malloch & Cain, *Rhexothecium globosum* Samson & Mouchacca et *Pithoascus langeronii* von Arx, ce dernier étant traité comme une combinaison nouvelle chez les *Eremomyces*. La famille se caractérise par des membres possédant des cellules initiales des ascomata pseudoparenchymatiques, des cleistothèces, des asques évanescents clavés à ovoïdes, et des ascospores unicellulaires hyalines à brun pâle. Deux des trois espèces possèdent des anamorphes ressemblant à des *Arthrographis* ou *Trichosporiella*. La présence de cellulels initiales des ascomata de type pseudoparenchymatique qui caractérise cette famille, suggère fortement qu'elle devrait être incluse dans la classe des Loculoascomycètes.

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Introduction

Of all the families of cleistothecial Loculoascomycetes the Eremomycetaceae is the smallest, up to now represented only by *Eremomyces bilateralis* Malloch & Cain and *Rhexothecium globosum* Samson & Mouchacca. We have recently found that a third species, *Pithoascus langeronii* von Arx, also belongs here. A sound family concept does not presently exist for the Eremomycetaceae. The family was established by Malloch and Cain (1971) to accommodate *E. bilateralis*. Samson and Mouchacca (1975) suggested that their new species *R. globosum* might also belong here and this was accepted without discussion by Malloch (1981*b*) and Eriksson and Hawksworth (1986). With the discovery of a third member it seems appropriate to reexamine the family circumscription as well as the relationship between its three members.

The family concept

The three species of Eremomycetaceae can be treated as a family on the basis of (*i*) their pseudoparenchymatous ascomatal initials, (*ii*) cleistothecial ascomata, (*iii*) clavate to ovoid, evanescent asci that are borne uniformly throughout the centrum, (*iv*) hyaline to pale yellow brown, one-celled ascospores, and (*v*) anamorphs (when present) characterized by solitary to catenulate, schizolytically dehiscent, hyaline conidia. On a purely structural basis the Pseudeurotiaceae is the family most similar to the Eremomycetaceae; the two families are presently separable mainly by differences in morphology of the ascomatal initials (coiled in Pseudeurotiaceae, pseudoparenchymatous in Eremomycetaceae). In addition, the Pseudeurotiaceae frequently have phialidic anamorphs, a type of conidiogenesis not known in the Eremomycetaceae. We wish to stress that this relationship with the Pseudeurotiaceae is one that is solely structural and does not in any way reflect a taxo-

nomic affinity. We believe that the one feature indicating evolutionary origins in this structurally simplified family is the type of ascomatal initials and that this feature is one of very profound taxonomic significance.

Infrafamilial relationships

All three species have been described adequately by their original authors and we present here only abbreviated descriptions that may aid the reader in following our discussion.

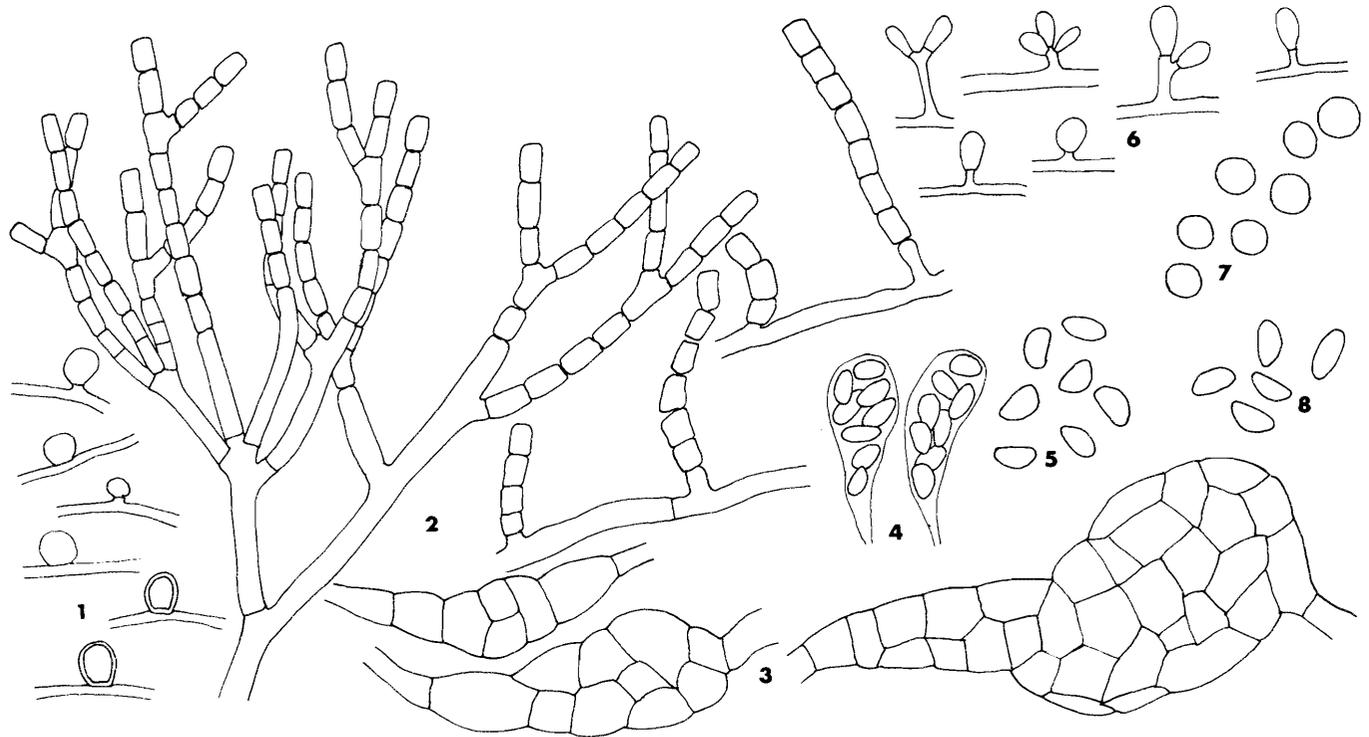*Eremomyces bilateralis*   Fig. 8

Colonies relatively slow growing on most laboratory media (e.g., modified Leonian's medium (Malloch 1981*a*)), attaining a diameter of about 20 mm in 2 weeks at 20°C, dark grey to brown or producing white sectors. Ascomata spherical or nearly so, black, with a cephalothecoid peridium on the natural substrate but with this feature less pronounced in pure culture, setose to strigose with dark hyphal elements, 100–300 μm in diameter, splitting open at maturity to release the spore mass or sometimes prematurely. Outer cells of ascomatal peridium having thickened anticlinal walls and thin periclinal walls. Asci clavate, thin walled, and evanescent, 8-spored. Ascospores (Fig. 8) 3.5–5.5 × 1.6–3.5 μm (D/d = 1.6–2.5), phaseoliform or shaped like sections of an orange, hyaline in mass, smooth, without germ pores. Anamorph lacking. Unable to perforate hair.

Occurring on dung of (usually) sedentary animals, especially rodents. Canada (Ontario), Kenya, Tanzania, U.S.A. (California).

Pithoascus langeronii   Figs. 1–5

Homothallic. Colonies growing rather slowly on most laboratory media (e.g., modified Leonian's medium (Malloch 1981*a*)), attaining a diameter of about 20 mm in 2 weeks at

FIGS. 1–5. *Eremomyces langeronii*. Fig. 1. *Trichosporiella* anamorph. Fig. 2. *Arthrographis* anamorph. Fig. 3. Ascomatal initials. Fig. 4. Asci. Fig. 5. Ascospores. FIGS. 6 and 7. *Rhexothecium globosum*. Fig. 6. *Trichosporiella*-like anamorph. Fig. 7. Ascospores. FIG. 8. Ascospores of *Eremomyces bilateralis*. All figures ×1500.

20°C, creamy white to buff coloured. Ascomata often submerged in the agar, spherical or nearly so, 75–160 μm in diameter, brown to black, with a pseudoparenchymatous peridium, glabrous to tomentose with dark hyphae, splitting open at maturity to release the spore mass. Outer cells of ascomatal peridium having thickened anticlinal walls and thin periclinal walls. Asci (Fig. 4) clavate, thin walled, evanescent, 8-spored. Ascospores (Fig. 5) 2.7–5.0 × 1.8–2.6 μm (D/d = 1.34–1.99), phaseoliform or shaped like sections of an orange, hyaline to yellow brown in mass, smooth, without germ pores. Anamorph *Arthrographis*, characterized by chains of schizolytic arthroconidia (Fig. 2) 2.0–4.5 × 2.0–2.5 μm produced from short but distinct conidiophores. Conidiophores sometimes reduced and difficult to distinguish from vegetative mycelium and then with arthroconidia longer and narrower than those produced from well-developed conidiophores. Producing a *Trichosporiella* synanamorph (Fig. 1) characterized by the production of nearly sessile, subglobose to globose conidia 2.7–4.8 × 2.7–3.3 μm. Able to perforate hair and thus probably weakly keratinolytic.

Occurring on dung, Canada (Ontario), India (Delhi Zoo), and U.S.A. (Arizona). The type strain was a culture contaminant with another fungus isolated from dung, so it is assumed to have been coprophilous.

Rhexothecium globosum   Figs. 6 and 7

Colonies growing slowly on most laboratory media (e.g., modified Leonian's medium (Malloch 1981*a*)), attaining a diameter of about 22 mm in 14 days at 35°C, growing more slowly at 20°C, white, tomentose. Ascomata spherical, 150–125 μm in diameter, brown to black, with a pseudoparenchymatous peridium, with a sparse covering of thick-walled brown hyphae. Outer cells of ascomatal peridium

having thickened anticlinal walls and thin periclinal walls. Asci clavate, thin walled, and evanescent, 8-spored. Ascospores (Fig. 7) 2.5–5.0 × 2.5–3.4 μm (D/d = 1.03–1.28), very broadly oblate and thus appearing nearly sperhical, yellow to yellow brown in mass, very finely roughened. Anamorph (Fig. 6) *Trichosporiella*-like, represented by solitary, lateral or terminal, hyaline, ovoid conidia. Unable to perforate hair.

Isolated from soil, Egypt and Kenya.

Although we have acknowledged the similarity of the three species, we have had difficulty with the generic concepts. *Eremomyces bilateralis* and *P. langeronii* are quite similar in having phaseoliform ascospores and in their coprophilous habit of growth. On the other hand, *R. globosum*, which has fewer features in common with *E. bilateralis* than does *P. langeronii*, appears to resemble *P. langeronii* in having a *Trichosporiella*-like anamorph. Although *E. bilateralis* and *P. langeronii* might be combined into a common genus without much difficulty, the case for inclusion of *R. globosum* in this group requires careful review of the evidence.

Rhexothecium globosum, unlike the other two species, does not have phaseoliform ascospores. Although originally described as globose to subglobose these are in fact broadly oblate, i.e., the axis of rotation is slightly shorter than the diameter. We are not aware of other genera of ascomycetes where both phaseoliform and oblate ascospores occur and find this fact alone to be an impediment to uniting *R. globosum* with the other two species. Our main argument for doing this might be based on the similarities in anamorphs between *R. globosum* and *P. langeronii*. Because of this we believe it necessary to discuss in greater detail the precise nature of the anamorphs of both species.

The anamorph of *Pithoascus langeronii* has been referred to

Arthrographis Cochet ex Sigler & Carmichael and is readily recognized by its narrow, cylindrical arthroconidia borne from dendritic conidiophores (Fig. 2). The arthroconidial anamorph has been described previously in detail (von Arx 1978; Sigler and Carmichael 1976, 1983). Associated with the *Arthrographis* anamorph, but occurring predominantly on the submerged mycelium, are lateral, sessile, globose to subglobose conidia (Fig. 1). Sigler and Carmichael (1983) referred this synanamorph to *Trichosporiella* Kamyschko ex Gams & Domsch, a genus characterized by solitary, lateral, sessile conidia borne scattered on more or less undifferentiated hyphae. In both the type species, *T. cerebriformis*, and the *Trichosporiella* anamorph of *Pithoascus langeronii*, the conidia are not readily detached; indeed, in the description of *P. langeronii*, von Arx referred to them as chlamydospores.

The anamorph of *Rhexothecium globosum* might also be assignable to *Trichosporiella* on the basis of the original description and illustration of solitary, lateral, sessile conidia borne on the aerial hyphae. However, the conidia occur more commonly on short pedicels rather than sessile on the hyphae, or are borne terminally or laterally on short side branches, with the terminal conidium developing first and 1−3 lateral conidia developing retrogressively (Fig. 6). Occasionally a lateral sessile conidium arises from a terminal conidium. This type of development suggests that the anamorph of *R. globosum* may not be well placed in *Trichosporiella*.

The lack of any convincing relationships between the anamorphs of *R. globosum* and *P. langeronii* effectively removes the only argument we might be able to make for the two species being congeneric. The remaining question is then whether *E. bilateralis* and *P. langeronii* should be combined. Arguments against this are (*i*) presence of a cephalothecoid peridium in *E. bilateralis* and a lack of it in *P. langeronii*, (*ii*) lack of an anamorph in *E. bilateralis*, (*iii*) dark coloured colonies in *E. bilateralis* versus cream to buff coloured colonies in *P. langeronii*, and (*iv*) inability of *E. bilateralis* to perforate hair and thus its apparent lack of keratinolytic enzymes. Arguments in favour of congenericity are (*i*) phaseoliform ascospores in both species, (*ii*) dark coloured ascomata with thick-walled dark hyphal attachments in both, and (*iii*) coprophilous growth habit. We find it difficult to formulate a separate generic concept for each of the two species but find it equally difficult to unite them in the face of the arguments outlined above. Valmaseda et al. (1987) placed *P. langeronii* in a new genus, *Pithoascina* Valmaseda, Martínez & Barrasa, incorrectly assigned to the Microascaceae, which should be maintained if separate genera are recognized. With some reservations, however, we have decided that a practical solution is to transfer *P. langeronii* into *Eremomyces*; the two species are very similar and, when encountered on the natural substrate, seem even more so. Thus we propose the following new combination.

Eremomyces langeronii (von Arx) Malloch & Sigler, comb.nov.
= *Pithoascus langeronii* von Arx, Persoonia, 10: 24. 1978
= *Pithoascina langeronii* (von Arx) Valmaseda, Martínez & Barrasa, Can. J. Bot. 65: 1805. 1987

The correct name for the anamòrph of *E. langeronii* is also problematic. In 1976, Sigler and Carmichael validated Cochet's genus *Arthrographis* and selected as type *Oidiodendron kalrai* Tewari & Macpherson (as *Arthrographis kalrae* (Tewari & Macpherson) Sigler & Carmichael). *Arthrographis langeroni*

Cochet (nom. nud.) was placed in synonymy. In his description of *Pithoascus langeronii*, von Arx (1978) referred the arthroconidial anamorph to *Arthrographis langeroni* Cochet, rather than *A. kalrae*. The question then arises whether von Arx's use of *A. langeroni* constitutes valid publication of Cochet's name. Two arguments can be made against this. First, von Arx made no mention of the arthroconidial anamorph in the Latin diagnosis. Second, the arthroconidial anamorph was described but not named in the English description. The only reference to the name for the anamorph occurred in the discussion section.

In 1983, Sigler and Carmichael questioned the validity of the connection between *P. langeronii* and *A. kalrae* since ascomata could not be obtained in any of 12 strictly anamorphic isolates and the morphs had been found together in only one strain. Now that we have seen three teleomorphic isolates, we have found no reasonable basis to separate the strictly anamorphic isolates. Therefore we conclude that the correct name for the anamorph of *Eremomyces langeronii* is *Arthrographis kalrae*.

A further complication arises from two publications in 1984. In the first, Stalpers and van Oorschot (Stalpers 1984) transferred *Sporotrichum sulphureum* Grev. to *Arthrographis* as *Arthrographis sulphurea* (Grev.) Stalpers and van Oorschot and placed *A. kalrae* in synonymy. No illustration of *S. sulphureum* was provided. In the second (van Oorschot and de Hoog 1984), *Sporotrichum sulphureum* (as "*sufureum*") was wrongly identified with *Oospora cuboidea* Sacc. & Ell. (= *Arthrographis cuboidea* (Sacc. & Ell.) Sigler). The junior author (L. Sigler), who examined a slide prepared from the type of *S. sulphureum* kindly sent by the Centraalbureau voor Schimmelcultures, concurs with the view of von Arx (1985), who considered *S. sulphureum* to be very different from either *A. kalrae* or *A. cuboidea*. Indeed, the identity of *Sporotrichum sulphureum* appears doubtful and should be considered a *nomen dubium*.

Extrafamilal relationships

Because of the pseudoparenchymatous ascomatal initials we maintain the Eremomycetaceae in the class Loculoascomycetes. Their ascospores, however, are rather unusual for that group. Eriksson (1981) listed very few species of loculoascomycetes having unicellular ascospores and these were mainly confined to lichenized species or powdery mildews. The three members of the Eremomycetaceae seem to be nearly unique for this character among the saprophytic loculoascomycetes.

It might be argued, of course, that the Eremomycetaceae are not loculoascomycetes at all. von Arx and Müller (1975), for example, stated that "the classification [of *Eremomyces bilateralis*] in 'Loculoascomycetes' is based only on the pseudoparenchymatous ascoma initials and is questionable." If the ascomatal initials are discounted as taxonomic indicators, then there is indeed little evidence for including them there. The asci are very thin walled and delicate and give no indication at all of being bitunicate, which might otherwise have been the basis on which to argue for placement of the Eremomycetaceae in the Loculoascomycetes.

In stressing the significance of asci to taxonomy many authors have lost sight of the equal importance of ascomatal development. This neglect is not because ascomatal development has fallen into taxonomic disfavour but rather because it is less easily evaluated. The taxonomic value of ascomatal

development, clearly articulated by Nannfeldt (1932) and Luttrell (1951, 1955), has never been successfully challenged and as Luttrell (1981) pointed out, "The concept of ascostroma or pseudothecium is not being questioned...."

In hymenoascomycetes (or euascomycetes) the ascomata develop from hyphae that surround the ascogonium after it has been formed. In loculoascomycetes, on the contrary, the ascoma is an ascostroma; that is, it develops stromatically and precedes the ascogonium, which later develops within it. In many cases the ascostroma is massive and may contain hundreds of fertile locules but may also be much smaller than that and contain but a single locule. In most cleistothecial and many perithecial loculoascomycetes that can be studied in pure culture, the first indication that ascomata are beginning to form is a swollen intercalary cell. This cell then begins to divide in several planes so that a distinct and generally spherical pseudoparenchymatous body begins to take form (Fig. 3). The ascogonium later develops within the pseudoparenchyma and the whole structure differentiates in a characteristic way into a mature ascoma. As far as we are aware, the type of development whereby a single cell divides to form a pseudoparenchymatous mass that ultimately forms an ascoma is characteristic only of loculoascomycetes. We know of no cases where this developmental type occurs in hymenoascomycetes. Thus we lay considerable stress on the kind of ascomatal initials found in the Eremomycetaceae and take these to indicate that the family does indeed belong in the class Loculoascomycetes.

Acknowledgements

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