Systema Ascomycetum

VOLUME 14 PART 2 APRIL 1996

Delimitation, typification, and taxonomic placement of the genus *Arachnomyces*

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Abstract

Abbott S.P., Sigler L. & Currah R.S. 1996. Delimitation, typification, and taxonomic placement of the genus *Arachnomyces*. - *Systema Ascomycetum* 14: 79-85.

The genus *Arachnomyces* is emended based on four accepted species and a reevaluation of morphological characteristics. One species has an arthroconidial anamorph described in *Onychocola*. A reexamination of the original material indicates that typification of the genus by *A. sulphureus* could have been intended, but in order to avoid nomenclatural instability, *A. nitidus* should remain the type as designated by Malloch & Cain in 1970. *Arachnomyces*, listed as *incertae sedis* in the latest *Outline* of ascomycetes, is disposed in the *Gymnoascaceae* (*Onygenales*).

Introduction

The genus *Arachnomyces* Massee & E.S. Salmon was described in 1902 for two species of appendaged cleistothecial ascomycetes (*A. nitidus* Massee & E.S. Salmon and *A. sulphureus* Massee & E.S. Salmon). Two additional species have been described: *A. minimus* Malloch & Cain (1970) and *A. nodosetosus* Sigler & S.P. Abbott (in Sigler *et al.* 1994). *Anixiopsis peruviana* Cain was placed in *Arachnomyces* by Malloch & Cain (1970), but has been transferred to the monotypic genus *Xanthothecium* Arx & Samson (1973).

The genus *Arachnomyces* has been placed in a number of families and orders of the *Ascomycota*. Massee and Salmon included it in the *Perisporiaceae*, and mentioned *Pleuroascus* Massee & E.S. Salmon (*Onygenaceae*, Malloch & Benny 1973) and *Magnusia* Sacc. (= *Kernia* Nieuwl., *Microascaceae*, Malloch & Cain

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1971) as similar taxa. Later authors have placed *Arachnomyces* in the *Onygenales, Gymnoascales*, and *Eurotiales* (Scott *et al.* 1993, Arx 1981, Arx & Samson 1973). Malloch & Cain (1970) and Arx (1981) referred it to the *Onygenaceae sensu lato* (=*Gymnoascaceae sensu lato*). Currah (1985) revised the taxonomic disposition of families and genera of *Onygenales*, but did not include *Arachnomyces* in the order. *Xanthothecium* was excluded from the *Onygenales* by Currah (1988). Although the most recent 'Outline of the ascomycetes' (Eriksson & Hawksworth 1993) lists *Arachnomyces* as a genus *incertae sedis*, Greuter *et al.* (1993) followed Malloch & Cain's treatment in the *Onygenaceae*.

Generic delimitation

Massee & Salmon's description, although rather brief, still adequately circumscribes the genus: "*Perithecia globosa simplicia astoma membranacea parenchymatica appendicibus fuscis eumorphis instructa, ascis minutis numerosis globosis, sporis primum conglobatis continuis fuscis.*"

Malloch & Cain (1970) provide a more detailed description, but their circumscription must be slightly altered because they included *A. peruvianus* in the genus and since no species was then known to produce a conidial stage. An emended generic circumscription and a key to the four species currently recognized in the genus are provided below.

Arachnomyces Massee & E.S. Salmon, *Annals of Botany* 16: 68 (1902). ***emend. nov.*,** **Figs. 1-6.**

Ascomata globose, 100-700 µm diam., non-ostiolate, non-stromatic, with a membranous cleistoperidium of *textura angularis*, dark brown to reddish brown, bearing several (2-10) long (up to 3 mm), flexuous, straight or rarely branched, thick-walled, smooth to nodose, reddish brown appendages. Appendages are frequently coiled or contorted at the apex which is often hyaline initially. Asci numerous and irregularly disposed in ascoma, globose to subglobose, evanescent, hyaline, bearing eight ascospores. Ascospores one-celled, oblate, 2.5-5 µm diam., reddish brown, smooth, lacking germ pores or slits, producing 1-3 germ tubes. Mycelium hyaline, septate; thick-walled brown hyphae resembling appendages of ascomata sometimes produced among vegetative hyphae.

Anamorph absent or present, conidial state: *Onychocola* Sigler (in Sigler & Congly, *Journal of Medical and Veterinary Mycology* 28: 409, 1990). Conidia thallic-arthric, barrel-shaped to subcylindrical, hyaline, 0-1 septate, separating by rhexolysis of thin-walled cells or by schizolysis, often persisting in chains.

Key to species of *Arachnomyces*

1.	Ascospores 3.5-5 µm diam.	2
1'.	Ascospores 2.5-3.5 µm diam.	*A. minimus*
2.	Ascomatal appendages (setae) smooth	3
2'.	Ascomatal appendages (setae) distinctly nodose	*A. nodosetosus*
3.	Ascomata 500-700 µm diam.; appendages 6-7 µm diam.	*A. sulphureus*
3'.	Ascomata 100-300 µm diam.; appendages 3.5-6 µm diam.	*A. nitidus*

Typification

Massee & Salmon (1902) did not specifically designate either *A. nitidus* or *A. sulphureus* as the type of their new genus. Malloch & Cain (1970) selected *A. nitidus* as lectotype, but typification is problematic. There are two extant collections of *A. nitidus* from the herbarium of George Massee in the New York Botanical Garden (NY), both labeled "type" in Massee's handwriting. These are dated 6/01 and 8/01 collected at Queens Cottage, Kew, with collection data hand written by Massee. Presumably, these are the collections referred to in the original description: "We have met the fungus in two localities at Kew on fragments of rotting plants," but the paper lists "Kew, Sept. 1901" as the collection data. Two other specimens were cited; of these, the Yorkshire specimen is apparently lost and the Cheshire specimen on rat dung is represented only by an illustration (NY). These original collections must be considered syntypes (International Code of Botanical Nomenclature (ICBN) Greuter *et al.* 1994, art. 9.4) and a lectotype chosen (ICBN art. 9.2, 9.9). Because Malloch & Cain (1970) designated the August 1901 collection as type, we accept it as lectotype (first author to designate lectotype must be followed under ICBN art. 9.13), even though it could be challenged based on the disparity between the collection data and the protologue (ICBN art. 10.5). Furthermore, the June collection still contains many ascocarps, and is the best authentic collection. Additional problems arise when the prepared slides are examined since they are simply labeled "slide made from the type material," and which of the two collections is not indicated.

Although Massee & Salmon (1902) did not select a type species, several pieces of evidence suggest that their intention was for *A. sulphureus* to be the type species. 1) The herbarium packet of *A. sulphureus* is labeled in Massee's writing "Type of gen." (Fig. 7), while the two packets of *A. nitidus* are simply labeled "Type". 2) The figure legend in Massee & Salmon (1902) reads "*Arachnomyces sulphureus*, gen. nov. sp. nov." and "*Arachnomyces nitidus*, sp. nov." 3) Given that the collection date of *A. sulphureus* was April 1901, it is likely that a concept for a new genus was developed before *A. nitidus* was discovered.

The two species are clearly congeneric. Even though Malloch & Cain did not follow ICBN recommendation 9A.3 ("In choosing a lectotype, any indication of intent by the author of a name should be given preference unless such indication is contrary to the protologue. Such indications are manuscript notes, annotations on herbarium sheets, ..."), it is our opinion that *A. nitidus* should remain the lectotype species of the genus. This species is represented by excellent extant authentic material (lectotype and syntypes) and has been collected on several occasions from England (Massee & Salmon 1902, Apinis & Chesters 1964) and North America (Malloch & Cain 1970) while *A. sulphureus* is known only from the original collection. The holotype specimen in NY now consists primarily of a prepared slide. Isotype material of *A. nitidus* and *A. sulphureus* is available at Kew (B. Spooner, pers. comm.), but was not examined in this study. Recent amendments to the International Code of Botanical Nomenclature (Greuter *et al.*, 1994), as summarized by Hawksworth (1993) support nomenclatural stability and accept that names of taxa should not be changed for purely nomenclatural reasons. If this principle is extended to typification of genera, then *A. nitidus* should be retained as type, as it is listed in the generic names in current use (Greuter *et al.* 1993), and in agreement with ICBN art. 9.13.

Taxonomic placement of *Arachnomyces*

Recently, Sigler *et al.* (1994) placed *Arachnomyces* in the *Gymnoascaceae* (*sensu stricto*, Currah 1985) of the *Onygenales*. This genus fits well within the *Gymnoascaceae* based on its smooth-walled (as observed with SEM), oblate, reddish brown ascospores (Figs. 3,4,6). The inability of species of *Arachnomyces* to degrade keratin as shown by *in vitro* hair digestion assays also supports the inclusion of the genus in the *Gymnoascaceae* rather than the *Onygenaceae*. Ascospore morphology is similar to some species of *Gymnascella* Peck such as *G. aurantiaca* Peck and *G. devroeyi* (G.F. Orr) Currah, or species of *Gymnoascus* Baranetzky and *Acitheca* Currah, but none of these species has a membranous peridium. A membranous peridium also occurs in *Aphanoascus* Zukal in the *Onygenaceae*, but species of *Aphanoascus* differ in their punctate to reticulate ascospores, strong keratinolytic activity, and *Chrysosporium* Corda or *Malbranchea* Saccardo anamorphs. Additionally, *Aphanoascus* species lack appendages on the ascocarp. *Arachnomyces* is the first member of the *Gymnoascaceae* known to have a membranous peridium (Figs. 1,2), although a variety of peridial types is also seen among genera in the *Onygenaceae*. The *Onychocola* anamorph (Sigler & Congly 1990, Sigler *et al.* 1994), is known only in one of the two *Arachnomyces* species which have been studied in culture. The persistent chains of swollen arthroconidia (Fig. 6) are unusual in the order. Conidia secede by rhexolysis of a thin-walled region of the adjacent cell or by schizolysis of adjacent conidia (Sigler & Congly 1990). *Malbranchea* anamorphs with cylindrical, alternate, rhexolytic arthroconidia are common in the *Onygenaceae*, *Gymnoascaceae*, and *Myxotrichaceae* (Currah 1985, Currah 1988, Sigler & Carmichael 1976).

Arachnomyces is reported to differ from other members of the *Onygenales* in its elaborately coiled ascocarp initials, as described for *A. minimus* by Malloch & Cain (1970), but we have observed less elaborate initials (Fig. 5). The majority of *Onygenales* and *Eurotiales* have simple gametangia with slight coiling which are of little value for inferring relationships (Currah 1994).

Among the families of *Onygenales*, data from molecular and biochemical techniques have supported the dichotomy between the *Onygenaceae* and *Arthrodermataceae* (LeClerc *et al.* 1994, Takizawa *et al.* 1994), but the relationships among the taxa of the *Gymnoascaceae* and between this family and other prototunicate taxa have been difficult to interpret. The morphological convergences and relatively simple structure of these ascomycetes presents several unresolved dilemmas. For example, Currah (1985) suggested that some species in the *Gymnoascaceae* may have closer affinities to the *Eurotiales* and subsequently he transferred *Arachniotus* J. Schröt. from the *Gymnoascaceae* to the *Eurotiales* (Currah 1988). However, analysis of large subunit ribosomal RNA sequences places *A. ruber* (Tieghem) J. Schröt. and *Gymnoascus reessii* (J. Schröt.) Baranetzky with some species of the *Onygenaceae sensu stricto* (LeClerc *et al.* 1994). Some caution is necessary in the interpretation of molecular results because their significance depends on the number and taxonomic diversity of taxa used in the analysis.

Considering that taxa chosen for study using molecular techniques are predicated on hypotheses presented by classifications based on morphological data, Currah (1994) proposed a realignment of the taxa of the *Gymnoascaceae*. *Gymnoascus* was placed in the *Trichocomaceae* (*Eurotiales*) and the large genus *Gymnascella* was split between two subfamilies, the *Trichocomoideae* and the

Dichlaenoideae (*Trichocomaceae*). *Gymnoascoideus* G.F. Orr, K. Roy & G.R. Ghosh was placed in the *Arthrodermataceae*. While such a realignment should encourage a broader analysis of the relationships among these taxa and other prototunicates, formal acceptance should be delayed until molecular data is correlated with morphological characters.

Until further systematic studies provide new insights into the phylogeny of this difficult group of ascomycetes, the family *Gymnoascaceae* is retained as circumscribed by Currah (1985, 1988) and *Arachnomyces* is accepted as a fifth genus in the family.

Acknowledgements

We thank the curators of the New York Botanical Garden (NY) for the loan of type specimens and the American Type Culture Collection (ATCC) for cultures. The efforts of B. Spooner to locate type material at Kew and comments of the reviewers are also appreciated. Photographic assistance provided by L. Abbott is gratefully acknowledged. This work was supported by operating grants to LS and RC from the Natural Sciences and Engineering Research Council of Canada.

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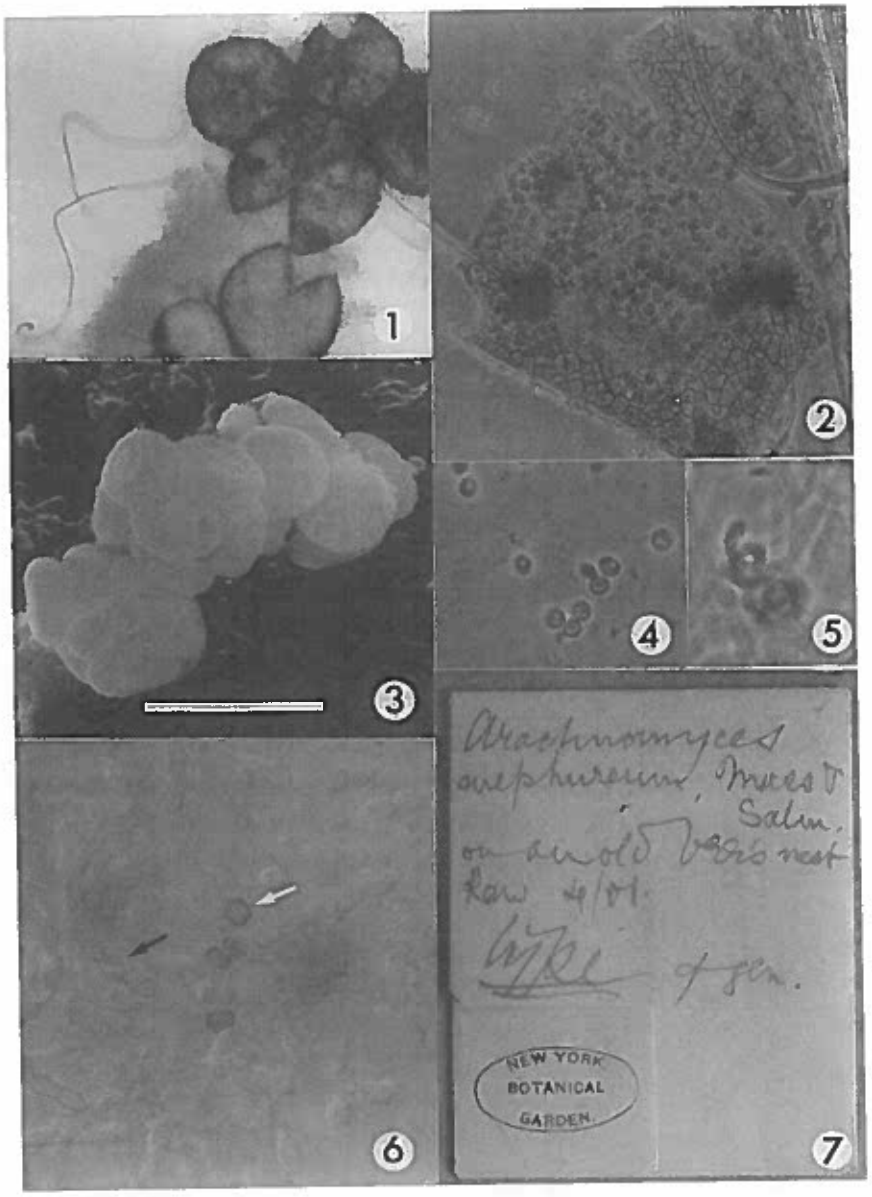
Figs. 1-7. *Arachnomyces* species.
1. *Arachnomyces minimus* (ex-type culture UAMH 7113). Cleistothecia with membranous peridia and flexuous appendages. X70.
2. *Arachnomyces sulphureus* (holotype NY). Peridium of textura angularis and asci. X280.
3. *Arachnomyces nodosetosus* (holotype UAMH 7480). SEM of asci and ascospores. bar= 5 mm.
4. *Arachnomyces nitidus* (syntype NY). Ascospores. X680.
5. *Arachnomyces minimus* (UAMH 7097). Ascomatal initial. X750.
6. *Arachnomyces nodosetosus* (holotype UAMH 7480). Ascospores (white arrow) and conidia (black arrow). X925.
7. *Arachnomyces sulphureus* (holotype NY). Herbarium packet with annotation.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Arachnomyces
onephureum, Peck &
Salm.
on an old Vireo's nest
Raw 4/01.
NEW YORK
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GARDEN
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