PERSOONIA
Published by the Rijksherbarium, Leiden
Volume 9, Part 3, pp. 393–400 (1977)

NOTES ON GYMNOASCACEAE

J. A. VON ARX
Centraalbureau voor Schimmelcultures, Baarn

Based on type studies, the following genera are reclassified: *Petalosporus*, *Disarticulatus*, and *Plunkettomyces* as synonyms of *Arachniotus*; *Gymnascella*, *Gymnoascoides*, *Macronodus*, *Tripedotrichum*, and *Uncinocarpus* as synonyms of *Gymnoascus*, and *Kuehniella* as a synonym of *Arachnotheca*. The question of the type species of *Arachniotus* is discussed. *Rollandina* is considered to be a nomen confusum; sensu Apinis (*1970*) it belongs to *Nannizzia*. The accepted genera of the Gymnoascaceae are briefly reviewed.

Recent research on Gymnoascaceae has been based on pure cultures. The older genera described in the 19th century, however, were based on material collected on plant debris, dung, spoiled food and similar substrates. In general no type-material was preserved and the taxa have to be judged from descriptions which are usually short and insufficient for recognition of the fungus. In some cases type specimens are available, but these have mostly proved to be too poor for reidentification. Some older taxa have been provided with 'neotypes' which are usually living (and dried) cultures.

The results of a comparative study of some type specimens, some neotype cultures and type cultures will be discussed under the following.

1. ARACHNIOTUS Schroeter (*1893*)

Schroeter (*1893*) erected the genus for 3 species earlier described as *Gymnoascus*, viz. *G. candidus* Eidam (*1886*), *G. aureus* Eidam (*1886*), and *G. ruber* van Tieghem (*1887*). No generic type was indicated and no type specimens of the three species have been maintained. In general the first mentioned species was regarded as type, its description, however, is insufficient to recognize the fungus; a *Talaromyces* or *Neosartorya* species was probably meant. *Arachniotus aureus* (Eidam) Schroeter belongs to *Amauroascus* as *A. aureus* (Eidam) v. Arx; it has been redescribed by Kuehn & *al.* (*1964*) based on a neotype culture (CBS 593.71) isolated in Japan by K. Tubaki.

The description of *Arachniotus ruber* (v. Tiegh.) Schroet. allowed recognition of the fungus. The recent isolate IMI 92796 (=CBS 194.64) has been designated as neotype by Kuehn & Orr (*1964*). Several additional strains have become available (Apinis, *1964*). This species has been designated as lectotype of the genus by von Arx (*1970*, *1971*) among others. Without mentioning this decision, Orr & *al.* (*1977*) again regard *Arachniotus candidus* (Eidam) Schroet. as type. They do not, however,

give an adequate description of the species and no type specimen is designated. The remaining species of *Arachniotus* they partly classify in *Pseudoarachniotus*, partly in *Gymnascella*, but no characters are given for the separation of the two genera. In fact all species are congeneric and should preferably be retained in *Arachniotus*, with *A. ruber* as type of the genus.

2. GYMNASCELLA Peck (*1885*)

The genus was described for the single species, *Gymnascella aurantiaca* Peck. The diagnosis is very short and inadequate for recognition of the fungus. The specimen, maintained in the New York State Museum, Albany (NYS), was studied some years ago. It contained two small pieces of plant stem, on which only traces of fungi, mainly belonging to *Cladosporium*, *Chrysosporium*, and *Rhodotorula*, could be found. In one small patch, clusters of roughened, yellow hyphae and roundish or oblate, thin-walled, yellow spores, 3–4.5 × 2–3 μm in size, were observed. These hyphae and spores agree in size and shape with the peridial hyphae and ascospores of *Gymnoascus reessii* Baranetzky, the type species of the genus *Gymnoascus*. The classification of *Gymnascella aurantiaca* Peck in *Gymnoascus* by Saccardo (*1889*) could therefore be confirmed.

Recently, Orr & *al.* (*1977*) reintroduced the genus *Gymnascella* and identified its type species with a fungus described by Orr & Kuehn (*1971*) as *Arachniotus verruculosus*. A study of specimens received from G. F. Orr (CBS 636.72, 637.72) showed, however, that this fungus can be easily distinguished from *Gymnascella aurantiaca* (=*Gymnoascus reessii*) by its larger, rather thick-walled, pigmented, 4.5–6.2 × 3.5–4 μm ascospores. Compare in this respect Figs. 3, 4 with Fig. 6 in Orr & *al.* (*1977*). *Arachniotus verruculosus* proved to represent a species very close to or identical with *Arachniotus aurantiacus* (Kamyschko) v. Arx. The latter species in turn is very close to *Arachniotus dankaliensis* (Cast.) van Beyma=*Pseudoarachniotus roseus* Kuehn=*Arachniotus flavoluteus* Kuehn & Orr.

3. ROLLANDINA Patouillard (*1905*)

The genus was described with a single species, *R. capitata*, which is thus the type. The type specimen is maintained in the Farlow Herbarium, Cambridge (FH) and has been re-examined by Benjamin (*1956*) and Apinis (*1968*, *1970*). The material (in formalin) is now very poor, but the slides prepared by R. K. Benjamin and A. E. Apinis (also maintained in FH) proved to be useful. The fungus is described as having stalked ascomata, but these stalks belonged to another organism, as pointed out by Apinis (1970). The fungus forms densely and minutely asperulate peridial hyphae, oblate ascospores with an equatorial band, 3.5–4.5 × 2.5 μm in size, and large, fusiform, verrucose, 5-septate, 40–60 × 9–13 μm aleurioconidia. This fungus is without doubt a *Nannizzia* species, probably *N. fulva* Stockdale, and its *Microsporum-conidial* state is similar to *M. fulvum* Uriburu.

The genus *Rollandina* can be considered to be a nomen confusum as it was based on two different organisms. *Rollandina* sensu Apinis (*1970*), however, is a synonym of *Nannizzia* Stockdale (*1961*).

Roy, Orr, and Ghosh in Orr *& al.* (*1977*), identified *Pseudoarachniotus hyalinosporus* Kuehn *& al.* as *Rollandina capitata*. The former species has no conidial state and has a different ascigerous state with no peridial hyphae and hyaline, lenticular ascospores with an equatorial frill. It is similar to the type species of the genus *Narasimhella* (von Arx, *1972*).

Rollandina vriesii Apinis (*1970*) has spherical, pitted ascospores and *Chrysosporium*-like conidia. It may belong to *Apinisia*, but its type culture (CBS 407.72) is at present only conidial.

4. PETALOSPORUS Ghosh *& al.* (*1963*)

The examination of the type culture (CBS 577.63) of the type species *Petalosporus nodulosus* Ghosh *& al.* showed its resemblance to a fungus, usually treated as *Arachniotus citrinus* Mass. & Salm. (Apinis, *1964*; van Arx, *1971*). The type cultures of the later described species, *Petalosporus anodosus* Kuehn *& al.* (CBS 518.68) and *P. afilamentosus* Orr & Kuehn (CBS 658.71), also proved to represent forms of *Arachniotus citrinus*. This species is close to *A. dankaliensis* and intermediates exist. Both species do not usually include a conidial state. In some sulphur-yellow strains in the CBS-collection, swollen, rather large arthro- or aleurioconidia (*Chrysosporium*-like) were observed and these strains may represent undescribed taxa.

The genus *Petalosporus* has been considered to be a synonym of *Arachniotus* by von Arx (*1974*).

5. KUEHNIELLA Orr (*1976*)

The genus was based on *Myxotrichum racovitzae* Lagarde (*1913*), but no type specimen of this species has been maintained. Orr (*1976*) based the description on the culture ATCC 28557 (=NRRL 6154=CBS 156.77) which has been designated as neotype. This culture completely agrees with the type strain of *Arachniotus albicans* Apinis (IMI 100875=CBS 151.65). The fungus has been provided with an adequate diagnosis by Apinis (*1964*); that given by Orr (1976) is incomplete and misleading as the typical initials and asci and the sheath of the ascospores are not mentioned.

Arachniotus albicans is close to *Arachnotheca glomerata* (Müller & Pacha-Aue) v. Arx and has been classified as *Arachnotheca albicans* (Apinis) v. Arx (*1974*). Typical of both species are the white (or yellow) colonies and ascomata, the clavate ascogonia surrounded by an antheridial coil, the clavate asci borne from croziers and the spherical, hyaline ascospores which are surrounded by a persistent, ornamented sheath and are bluish or violet en masse.

The genus *Kuehniella* has to be considered to be a synonym of *Arachnotheca*.

6. UNCINOCARPUS Sigler & Orr (*1976*)

This genus has been described in a paper by Sigler & Carmichael (*1976*). Its type species, *Uncinocarpus reesii* Sigler & Orr, is very close to *Gymnoascus uncinatus* Eidam, as described by Orr & *al.* (*1936*) or Samson (*1972*). The neotype culture RSA 56 (=NRRL 3610 = CBS 408.72) of *Gymnoascus uncinatus* has been illustrated by Benjamin (*1956*) under the name *Myxotrichum uncinatum* (Eidam) Schroet.

Gymnoascus uncinatus is rather peculiar within the genus *Gymnoascus* by its uncinate appendages and the apically swollen initials. *Uncinocarpus reesii* is heterothallic and has 'bulbous' initials and similar uncinate appendages. Sigler & Orr in Sigler & Carmichael (*1976*) did not compare it with *G. uncinatus*.

Consequently the genus *Uncinocarpus* should be considered to be a synonym of *Gymnoascus*.

7. TRIPEDOTRICHUM Orr & KUEHN (*1964*)

The only species *Tripedotrichum herbariensis* Orr & Kuehn was based on some fructifications found on a herbarium specimen of *Myxotrichum chartarum* (Nees) Kunze, distributed on Rabenhorst's Fungi Europaei No. 179 (NY). No cultures of the fungus are known and the description is incomplete. The uncinate, dark, 80–260 µm long and 4–7 µm broad appendages and the pigmented, oblate, 3.5–5.5 × 2.2–3.5 µm ascospores indicate that the fungus is identical to *Gymnoascus uncinatus* Eidam or *Uncinocarpus reesii* Sigler & Orr.

The genus *Tripedotrichum* should therefore also be considered a synonym of *Gymnoascus*.

8. MACRONODUS Orr (*1977a*)

The genus *Macronodus* with *Macronodus bifurcatus* Orr as type is characterized by discrete ascomata surrounded by a peridium with uncinate or bifurcate appendages and by oblate, yellow-brown ascospores; the initials are not described. The genus is mainly compared with *Auxarthron*; an unrelated genus with a dark peridium and with spherical, ornamented ascospores. *Macronodus bifurcatus*, however, is again very close or identical to *Gymnoascus uncinatus*. A decision concerning the identity can only be taken after comparison of a larger number of strains. The genus *Macronodus* has to be considered a synonym of *Gymnoascus*.

9. GYMNOASCOIDES Orr, Roy & Ghosh (*1977*)

Several strains of *Gymnoascoides petalosporus* Orr & *al.*, the type species of the genus, were studied (a.o. CBS 630.72=O–2067 and CBS 629.72=O–2060). The fungus is rather variable in its cultural characters, in the formation of peridial hyphae (which may be absent) and in the size of the ascospores. The latter are oblate, yellowish or

brownish and 3–4.5 × 2–3 µm. The peridial hyphae are branched at right angles, brownish, thick-walled, 2–3 µm broad and terminate in lighter, appendage-like, blunt cells.

The species is intermediate between *Arachniotus* and *Gymnoascus*, is close to *Gymnoascus reessii* and has to be classified as **Gymnoascus petalosporus** (Orr & al.) v. Arx, *comb. nov.* (basionym: *Gymnoascoides petalosporus* Orr *& al. in* Mycotaxon **5**: 460. 1977).

10. PLUNKETTOMYCES Orr (*1977b*)

The type and some more strains of *Plunkettomyces littoralis* Orr, the type species of the genus, were maintained in the CBS collection as *Arachniotus* spec. (CBS 454.73, 455.73) and have been studied.

The slow growing colonies are rather flat and sulphur-yellow. The ascogonial initials are small, form irregular coils and are composed of hyaline, 2.5–3.5 µm broad hyphae. The clusters of asci have a diameter of 30–60 µm, but are often aggregated in masses, up to 200 µm. Characteristic peridial hyphae are absent, but some yellow, often verruculose, hyphae may develop around the ascal clusters and in the mycelial mat. The asci are spherical, botryose or in short chains, deliquescent, 9–11 µm in diameter and contain 8 oblate-lenticular, golden yellow, 4.5–6 × 3–4 µm ascospores which show a band-like equatorial thickening of the wall. The catenate conidia, separated from one another by empty parts of the conidiogenous hyphae, are slightly swollen, smooth, 1-celled, hyaline and 5–13 × 3.5–6.5 µm.

The genus *Plunkettomyces* has to be considered a synonym of *Arachniotus*. Its type species has to be renamed **Arachniotus littoralis** (Orr) v. Arx, *comb. nov.* (basionym: *Plunkettomyces littoralis* Orr *in* Mycotaxon **6**: 33. 1977). The fungus is close to *Arachniotus dankaliensis* and *Arachniotus citrinus*. It can be distinguished from the former by its sulphur-yellow colonies, from the latter by its equatorially thickened ascospore walls and from both by its *Chrysosporium*-like conidial state and by the adaption to marine environments.

11. DISARTICULATUS Orr (*1977b*)

A strain maintained in the CBS collection as *Arachniotus* spec. (CBS 546.72), isolated by C. Devroey from Somalian soil, has been studied. It is, without doubt, identical to the fungus described as *Disarticulatus devroeyi* Orr.

The description given by Orr (*1977b*) is incomplete. The colonies are initially whitish-yellow, but soon become cinnamon. The initials are composed of elongated, dense coils of hyaline gametangial hyphae. The clusters of asci are small, dispersed or aggregated and are not surrounded by a peridium. The asci are spherical, thin-walled, 12–17 µm; the ascospores are oblate, rather thick-walled, smooth, golden yellow, 5.5–6.5 × 4–5 µm, without an equatorial rim or thickening. Thick-walled, hyaline or brownish, swollen, 17–26 × 8–12 µm cells especially develop from swollen

parts of racquet-hyphae and may disarticulate with age. A *Malbranchea*-like conidial state was also observed: the conidia are cylindrical, not swollen, 1-celled, hyaline, 10–15 × 3–5 µm and separated from one another by empty cavities of the conidiogenous hyphae.

The genus *Disarticulatus* cannot be separated from *Arachniotus*. Its type species has to be classified as **Arachniotus devroeyi** (Orr) v. Arx, *comb. nov.* (basionym: *Disarticulatus devroeyi* Orr *in* Mycotaxon **6**: 35, 1977).

Discussion of the Gymnoascaceae

The Gymnoascaceae represent a small group of often keratinophilic Ascomycetes with or without arthric or aleuric conidial states (phialo- or blastoconidia absent). Von Arx (1974) keyed out 18 genera with about 60 species, but delimitation is partly based on conidial states. Formerly the genera were delimited mainly by the presence or absence and form of the peridial hyphae and their appendages. These characters, however, are often variable and only of limited taxonomic value. In one and the same strain of *Gymnoascus reessii* peridial hyphae and appendages may be absent or present, depending on medium, humidity, light, and age.

Von Arx (*1971*, *1974*) introduced the size and the shape of the ascospores and the type of the initials as useful characters for the delimitation of genera. Genera with ellipsoidal-fusiform, genera with oblate and genera with spherical ascospores are distinguished.

In the group with oblate ascospores, two genera can be distinguished without or with reduced peridial hyphae, viz. *Arachniotus* and *Narasimhella*. The latter genus is characterized by ring-like initials surrounding a central cell, clavate asci borne from croziers and inequally lenticular, hyaline or greenish ascospores with a small, equatorial frill. In *Arachniotus* the initials consists of two coiling gametingial hyphae, the asci are spherical and develop directly on the ascogenous hyphae. The oblate ascospores are pigmented and often have equatorial rims or thickenings. Both genera have no conidial states or form arthroconidia (*Malbranchea*- or *Chrysosporium*-like).

Arachniotus is close to *Gymnoascus* and intermediates exist, but in the latter genus smooth or verruculose peridial hyphae with long or short, blunt or uncinate appendages are usually present. The ascospores are generally smaller (3–4.5 µm in diameter) than those of *Arachniotus* (5–7 µm in diameter).

Most of the other genera with oblate ascospores have light ascomata with coiled appendages but have been mainly based on their conidial state. The genera *Arthroderma* and *Shanorella* comprise keratinophilic species with *Chrysosporium* or *Trichophyton* conidial states. *Nannizzia* is erected for the ascigerous states of *Microsporon*. In *Ctenomyces* the ascomata have a rather compact, dark wall and it is further characterized by dark, comb-like (ctenoid) hyphal structures (Eidam, *1883*).

The genera *Ajellomyces*, *Emmonsiella*, *Apinisia*, *Auxarthron*, *Amauroascus*, and *Arachnotheca* are characterized by spherical ascospores. *Ajellomyces* and *Emmonsiella* are

monotypic and heterothallic; *Ajellomyces dermatitidis* McDonough & Lewis being the ascigerous state of *Blastomyces dermatitidis* and *Emmonsiella capsulata* Kwon-Chung that of *Histoplasma capsulatum*. Both have small, smooth, hyaline ascospores and densely spirally coiled peridial appendages. In *Apinisia* the ascospores are pitted and the conidial state is *Chrysosporium*-like. In *Amauroascus* and *Auxarthron* the spherical ascospores are usually pigmented, thick-walled and ornamented, often spiny. Both genera are close, but in *Auxarthron* the ascomata have peridial hyphae with long, uncinate or branched appendages which are absent in *Amauroascus*.

In *Arachnotheca* the initials are composed of a clavate cell surrounded by a hyphal coil, the ascomata have a rather thick colourless peridium composed of hyphae, the asci develop from croziers and the ascopores are hyaline (bluish or violet en masse) and sheathed.

The genera *Myxotrichum*, *Pseudogymnoascus*, and *Byssoascus* have ellipsoidal fusiform ascopores. *Byssoascus* has no peridial hyphae and the ascopores are striated by flutes; *Pseudogymnoascus* has brownish peridial hyphae without spines and smooth (or indistinctly striate) ascopores; *Myxotrichum* has dark peridial hyphae with spines or long appendages and smooth or striate ascopores. The three genera are close to each other. Most of the species include *Oidiodendron*, *Malbranchea*, or *Chrysosporium* conidial states (Sigler & Carmichael, *1976*).

The Gymnoascaceae are close to the Onygenaceae (Malloch & Cain, *1971*). The genera *Xynophila* Malloch & Cain and *Neoxenophila* Apinis & Clark with a reduced ascocarp wall, oblate ascopores and arthroconidia may be intermediate.

REFERENCES

APINIS, A. E. (1964). Revision of British Gymnoascaceae. *In* Mycol. Pap. **96**.

—— (1968). Relationship of certain keratinophilic Plectascales. *In* Mycopath. Mycol. appl. **35**: 97–104.

—— (1970). Concerning *Rollandina*. *In* Trans. Br. mycol. Soc. **55**: 499–502.

ARX, J. A. VON (1970). The genera of fungi sporulating in pure culture. Lehre.

—— (1971). On *Arachniotus* and related genera of the Gymnoascaceae. *In* Persoonia **6**: 372–380.

—— (1974). The genera of fungi sporulating in pure culture, 2nd Ed. Vaduz.

BENJAMIN, R. K. (1956). A new genus of the Gymnoascaceae with a review of the other genera. *In* Aliso **3**: 301–328.

EIDAM, E. (1883). Beitrag zur Kenntnis der Gymnoasceen. *In* Beitr. Biol. Pfl. (ed. F. Cohn) **3**: 267–305 ('1880').

—— (1886). Untersuchungen über die Familie der Gymnoasceen. *In* Ber. Bot. Sect. Schles. Ges. 1886: 160–165.

GHOSH, G. R., ORR, G. F. & KUEHN, H. H. (1963). A new genus of the Gymnoascaceae with a rudimentary peridium. *In* Mycopath. Mycol. appl. **21**: 36–44.

KUEHN, H. H. & ORR, G. F. (1964). *Arachniotus ruber*. *In* Trans. Br. mycol. Soc. **47**: 553–558.

KUEHN, H. H., TUBAKI, K. & ORR, G. F. (1964). *Arachniotus aureus*. *In* Mycologia **56**: 863–873.

LAGARDE, J. (1913). Champignons (Prémière Série). *In* Arch. Zool. exp. gén. **53**: 277–307.

MALLOCH, D. & CAIN, R. F. (1971). New genera of Onygenaceae. *In* Can. J. Bot. **49**: 839–846.

ORR, G. F. (1976). *Kuehniella*, a new genus of the Gymnoascaceae. *In* Mycotaxon **4**: 171–178.
—— (1977a). Another genus of the Gymnoascaceae with swollen septa on peridial elements. *In* Mycotaxon **5**: 283–290.
—— (1977b). New Gymnoascaceae. *In* Mycotaxon **6**: 33–42.
ORR, G. F., GHOSH, G. R. & ROY, K. (1977). The genera *Gymnascella*, *Arachniotus* and *Pseudoarachniotus*. *In* Mycologia **79**: 126–163.
ORR, G. F. & KUEHN, H. H. (1964). A new genus of the Gymnoascaceae with dark ascocarps. *In* Mycologia **56**: 482–487.
—— & —— (1972). Notes on Gymnoascaceae. II. Some Gymnoascaceae and keratinophilic fungi from Utah. *In* Mycologia **64**: 55–72.
ORR, G. F., KUEHN, H. H. & PLUNKETT, O. A. (1963). The genus *Gymnoascus*. *In* Mycopath. Mycol. appl. **21**: 1–18.
ORR, G. F., ROY, K. & GHOSH, G. R. (1977). *Gymnoascoideus*, a new genus of the Gymnoascaceae. *In* Mycotaxon **5**: 459–469.
PATOUILLARD, M. N. (1905). *Rollandina*, nouveau genre de Gymnascées. *In* Bull. Soc. mycol. Fr. **21**: 81–83.
PECK, C. (1884). Report of the Botanist [for 1881]. *In* A. Rep. N. Y. St. Mus. **35**: 153.
SACCARDO, P. A. (1889). Syll. Fung. **8**.
SAMSON, R. A. (1972). Notes on *Pseudogymnoascus*, *Gymnoascus* and related genera. *In* Acta Bot. Neerl. **21**: 517–527.
SCHROETER, J. (1893). Die Pilze Schlesiens. *In* Kryptog. -Fl. Schles. (ed. F. Cohn). **3**.
SIGLER, L. & CARMICHAEL, J. W. (1976). Taxonomy of *Malbranchea* and some other hyphomycetes with arthroconidia. *In* Mycotaxon **5**: 349–488.
STOCKDALE, P. M. (1961). *Nannizzia incurvata*, a perfect state of *Microsporum gypseum*. *In* Sabouraudia **1**: 41–48.
TIEGHEM, P. VAN (1887). Sur le dévelopement de quelques Ascomycètes. *In* Bull. Soc. bot. Fr. **24**: 157–161.