

On *Monilia sitophila* and some Families of Ascomycetes

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Abstract. — The genus *Monilia* is restricted to anamorphs of the ascomycete genus *Monilinia* (Sclerotiniaceae); all typical species are parasitic on Rosaceae and Ericaceae and cause blossom blight and fruit rot. A new genus, *Chrysonilia* is introduced to accommodate the red bread mould, *Monilia sitophila*. This genus contains anamorphs of *Neurospora* and all species are saprophytic. The similarity of the anamorphs of the genera *Neurospora*, *Diplogelasinospora*, *Faurelina*, *Pithoascus*, *Byssascus*, *Pseudogymnoascus* and *Myxotrichum* suggests that these taxa are related. The ascomycete families in which these genera have been classified are briefly discussed.

The anamorphs of the discomycete genus *Monilinia* HONEY (Sclerotiniaceae) and the pyrenomycete genus *Neurospora* SHEAR & B. DODGE (Sordariaceae) have been classified in the hyphomycete genus *Monilia* PERS. Because the two ascomycete genera are unrelated, their respective anamorphs are compared with each other and with genera with a similar conidiogenesis.

1. The anamorph of *Monilinia*

The genus *Monilia* PERS. (Syn. Meth. Fung. p. 693. 1801) ex FR. (Syst. mycol. 3: 409. 1832) is based on *Monilia fructigena* PERS. The teleomorph is known as *Sclerotinia fructigena* SCHROET. [= *Monilinia fructigena* (SCHROET.) HONEY (Mycologia 20: 153. 1928)]. The fungus is the causal agent of blossom blight and fruit rot in apple and pear. The disease is usually not serious, only damaged fruit being attacked. According to STAFLEU et al. (1978), the genus would have to be cited as *Monilia* BONORDEN (Handb. Mykol. p. 76. 1851) as a nomen conservandum with *M. cinerea* BONORDEN as type. This species is identical with *M. laxa* (EHRENB. ex PERS.) SACC. & VOGL., the anamorph of *Monilinia laxa* (see also BYRDE & WILLETTTS, 1977).

Several other species are known to cause similar diseases on Rosaceae and Ericaceae, e. g. *Monilinia fructicola* (WINT.) HONEY also on *Pyrus*, *M. laxa* (ADERHOLD & RUHLAND) HONEY on several *Prunus* species or *M. urnula* (WEINM.) HONEY on *Vaccinium vitis-idaea*. The rotting inflorescences and fruits become sclerotized and black and the *Monilia* anamorph forms erumpent, light, sporodochial pustules.

The conidiogenesis has been described in detail by WORONIN (1888), HASHMI et al. (1972) and others. The following details were observed on apples inoculated with a suspension of conidia of *Monilia fructigena*. Rotting cherries attacked by *Monilia laxa* (EHRENB. ex PERS.) SACC. & VOGL. were also studied.

The erect, often branched conidiogenous hyphae show regular constrictions and apical growth. No septa are formed during the growth phase. Later septa develop at each constriction, mostly beginning at the base. The apical conidia are usually smaller than the

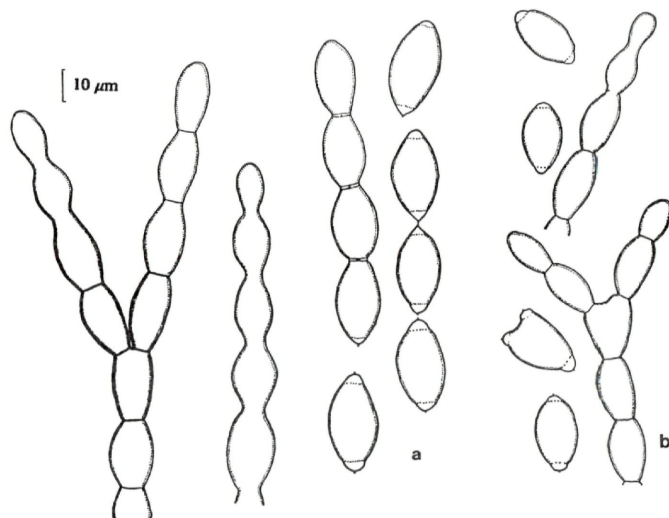


Fig. 1. a. *Monilia fructigena*. — b. *M. laxa*: conidiogenous structures and conidia

basal ones and a conidial chain may consist of 6—12 or more conidia. The septa become thicker and 2-layered (2 closely adherent layers with a central, disjunctive inclusion). When all the septa have been formed, the wall of the conidiogenous hypha disrupts around each septum and the conidia are separated by a convex bulging of the septa. This takes place under humid conditions. The conidia remain attached to each other by the central disjunctive body, which may become short cylindrical. They are dispersed under dry conditions as a powdery mass.

In culture on agar media, dark, sclerotial or stromatic, often crustose plectenchyma is formed, but conidiation is poor (exception:

Monilinia fructicola). The formation of apothecia in pure culture is also unknown. Spermatia are often formed on clustered, flask-shaped phialides, and are small, often spherical and form slimy masses.

Whether the conidia of *Monilia* have to be regarded as catenate blastoconidia or arthroconidia, remains debatable. The genus may be related to *Mauginiella* CAVARA (von ARX et al., 1981) which has usually many-celled conidia. Its type species, *M. scaettae*, is parasitic on date palm (RATTAN & AL-DHOON, 1980). *Monilia* is related to genera such as *Botrytis* and *Septotis* which have similar teleomorphs, classified in *Sclerotinia*, *Botryotinia* or *Septotinia*.

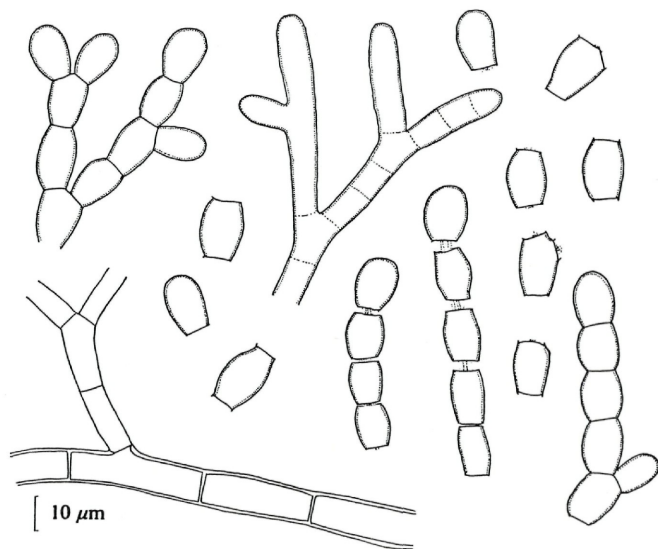


Fig. 2. *Chrysonilia sitophila*: conidiogenous structures and conidia

2. The anamorph of *Neurospora*

Monilia sitophila (MONT.) SACC., known as the red bread mould, the anamorph of *Neurospora sitophila* SHEAR & B. DODGE, is a saprophyte often isolated from cereals and cereal products, but is also soil-borne. The following description is based on CBS 260.47, in petri dishes on oatmeal agar.

The colonies expand quickly, the daily growth rate at 25° C being about 25 mm. They are colourless or nearly so, but soon develop

sporodochial pustules especially at the margin. Pustules are initially white but soon become orange. The erect or suberect conidiogenous hyphae form lateral branches, remain unseptate during the growth period and show no or only indistinct constrictions. The septa are formed in basipetal succession or at random. The cells then become swollen, especially in the apical part, the septa thickened and 2-layered. The arthroconidia are separated from each other by dehiscence of the wall around the septa and by excretion of a protoplasmic amorphous or fibrillar strand through the septal pores (Fig. 2). There is practically no bulging of the septa. The conidia separate very quickly from each other and are dispersed under dry conditions as a powdery mass.

The conidiation has been analyzed by HASHMI et al. (1972) using time-lapse photomicrography and by TURIAN et al. (1973) by TEM.

It is clear that *Monilia sitophila* is not related to the *Monilia* anamorphs of *Monilinia*. These show a different type of conidiogenesis (the one with acropetal chains of "blastoconidia", the other with arthroconidia, separated by a protoplasmatic strand), growth pattern and pigmentation of the colonies, while the teleomorphs are also unrelated. *Monilia sitophila* and similar species should be classified in a separate genus:

Chrysonilia v. ARX, gen. nov.

Coloniae celerrime expandentes, primum hyalinae; hyphae radiantes latae, septatae, crassitunicatae, hyalinae, ramosae; flocci sporodochiales aurantiaci, e ramis lateralibus hypharum radiantium oriundi, ex hyphis conidiogenis identidem ramosis constantes; hyphae conidiogenae primum neque septatae neque constrictae, sed cito in successione irregulari vel basipetali in cellulas limitatae; arthroconidia cylindrica, deinde inflata, faciliter secedentia, primum funiculo plasmatico e poro centrali oriundo connexa.

Species typica: *Chrysonilia sitophila* (MONT.) v. ARX.

Colonies quickly expanding, light; expanding hyphae broad, septate, thick-walled, hyaline, branched; sporodochial tufts orange, formed on lateral branches of the expanding hyphae, composed of repeatedly branched conidiogenous hyphae; conidiogenous hyphae at first non-septate and without constrictions, soon becoming septate at random or in basipetal succession; arthroconidia cylindrical or becoming swollen, easily separating from each other by dehiscence of the wall and excretion of protoplasmic strands through the central pore of the (double) septa.

Type species: *Chrysonilia sitophila* (MONT.) v. ARX, comb. nov.

Basionym: *Penicillium sitophilum* MONT. — Ann. Sci. Nat., Bot. 2, 20: 377. 1843.

Teleomorph: *Neurospora sitophila* SHEAR & B. DODGE — J. agr. Res. 34: 2016. 1927.

Further species:

Chrysonilia crassa (SHEAR & B. DODGE) v. ARX, comb. nov.

Basionym: *Monilia crassa* SHEAR & B. DODGE — J. agr. Res. **34**: 1026. 1927.

Teleomorph: *Neurospora crassa* SHEAR & B. DODGE — l. c.

Chrysonilia tetrasperma (SHEAR & B. DODGE) v. ARX, comb. nov.

Basionym: *Monilia tetrasperma* SHEAR & B. DODGE — l. c. p. 1027.

Teleomorph: *Neurospora tetrasperma* SHEAR & B. DODGE — l. c.

3. Discussion of similar anamorphs

The conidiogenesis in the genus *Botryomonilia* GOOS & PIROZYNSKI (1975) is similar to that of *Chrysonilia*. In *B. scheeleae* Goos & PIROZYNSKI (CBS 589.80) the conidiogenous hyphae develop apically on long, thick-walled, more or less erect conidiophores and are dichotomously branched. The colonies are rather restricted, and show a dark, stromatic or sclerotic, crustose plectenchyma of pigmented hyphae. The genus has been considered to be intermediate between *Monilia* and *Botrytis* and classified as an anamorphic Sclerotiniaceae. Its type species, however, seems to be a saprophyte and the conidiogenesis indicates a relationship to *Chrysonilia* and some other genera with arthroconidia, e. g. *Arthrographis* COCHET ex SIGLER & CARMICHAEL, *Oidiodendron* ROBAK, *Geomyces* TRAAEN and *Malbranchea* SACC. sensu SIGLER & CARMICHAEL (1976).

The species of the genus *Arthrographis* and the anamorph of the ascomycete *Faurelina indica* v. ARX & al. in particular, have conidiogenous structures similar to those of *Chrysonilia sitophila*. The colonies, however, are more restricted and may become pigmented with light, usually white tufts of fertile hyphae. In addition to arthroconidia, lateral aleurioconidia or blastoconidia may be present, similar to those of the form-genus *Trichosporiella* KAMYSCHKO ex W. GAMS & DOMSCH (van OORSCHOT, 1980). In *Faurelina indica* the arthroconidia are cylindrical or slightly swollen and often 2-celled (von ARX, 1978, as *F. elongata*).

The genera *Oidiodendron* and *Geomyces* are characterized by the formation of erect, mainly apically branched conidiophores, and much smaller conidia. Disjunctive structures, similar to those of *Chrysonilia* and *Botryomonilia* are often present in *Oidiodendron*, whereas the conidia in *Geomyces* become swollen and are separated from each other by empty parts of the conidiogenous hyphae. Intermediates between *Oidiodendron* and *Geomyces* exist. In *Malbranchea* conidiophores are absent; undifferentiated, often curved hyphae or curved branches forming cylindrical, non or hardly swollen conidia, separated from each other by empty parts of the hypha.

4. Discussion of the teleomorphs

The following ascomycete genera are connected with the above discussed, arthroconidial anamorphs:

anamorph	teleomorph
<i>Chrysonilia</i>	<i>Neurospora</i> SHEAR & B. DODGE
<i>Arthrographis</i>	<i>Pithoascus</i> v. ARX
	<i>Faurelina</i> LOCQUIN-LINARD
	<i>Petriellidium</i> MALLOCH
	<i>Diplogelasinospora</i> CAIN
<i>Oidiodendron</i>	<i>Byssosascus</i> v. ARX
	<i>Myxotrichum</i> KUNZE
<i>Geomyces</i>	<i>Pseudogymnoascus</i> RAILLO
<i>Malbranchea</i>	<i>Myxotrichum</i>

The ascomycete genus *Neurospora* is characterized by ostiolate (occasionally non-ostiolate), dark ascomata, cylindrical asci with an apical ring, absence of filiform paraphyses and by ellipsoidal or broadly fusiform, pigmented, longitudinally striate, 1-celled ascospores with 2 germ pores but no gelatinous sheath. It has usually been classified in the Sordariaceae (LUNDQVIST, 1972). The genus *Gelasinospora* is similar, but differs by the pitted or reticulate ascospores, which may have 1, 2 or more germ pores (CAILLEUX, 1972). The species of the genus *Diplogelasinospora* have non-ostiolate ascomata and the pitted ascospores become unequally 2-celled. The two species studied by UDAGAWA & HORIE (1972) form an *Arthrographis* anamorph.

A similar anamorph has been observed by von ARX (1973, 1978) in *Petriellidium desertorum* v. ARX & MOUSTAFA and in *Pithoascus langeronii* v. ARX; that of the latter has been identified as *Arthrographis kalrai* (TEWARI & MACPHERSIN) SIGLER & CARMICHAEL, the type species of the genus. The genera *Petriellidium* and *Pithoascus* are characterized by spherical, ostiolate or non-ostiolate, dark ascomata and often catenate, evanescent asci. *Petriellidium* has broadly ellipsoidal, copper-coloured or reddish-brown ascospores with 2 germ pores, those of *Pithoascus* are fusiform, ellipsoidal or navicular, brownish and have no visible germ pores. Von ARX (1973, 1978) classified both genera in the Microascaceae, but BENNY & KIMBROUGH (1980) created a new family Pithoascaceae for *Pithoascus* (and *Faurelina*), distinguished from the Microascaceae by the absence of germ pores on the ascospores.

The genera *Byssosascus*, *Pseudogymnoascus* and *Myxotrichum* have been classified in the Gymnoascaceae (Onygenaceae), because the ascomata are naked (in *Byssosascus*) or are surrounded by a loose

network of peridial hyphae with appendages (in the other two genera). The spherical or broadly ellipsoidal asci are small, usually with a short cylindrical stalk. The slightly pigmented, fusiform or ellipsoidal ascospores are furrowed in *Byssosascus*, smooth in *Pseudogymnoascus* and finely striate or smooth in *Myxotrichum*.

The similarity of the ascospores and the arthric anamorphs with similar conidiogenesis, suggest a relationship between the above discussed ascomycete genera. They represent a phylogenetic line, beginning with *Neurospora* and ending with *Pseudogymnoascus* and *Byssosascus* or vice versa. Their classification in a separate family can be considered, but this would contradict the accepted classification of the Ascomycetes. Suitable names would be Neurosporaceae CAIN and Pithoascaceae, but only the latter is validly published.

The Pithoascaceae are close to the Microascaceae and the Amorphythaceae. *Petriellidium desertorum* is intermediate between Microascaceae and Pithoascaceae having an *Arthrographis* anamorph and rather large, smooth ascospores with 2 germ pores.

5. Some remarks on related families

a. Microascaceae LUTTRELL

The Microascaceae (MALLOCH, 1970; von ARX, 1975, 1978) can be distinguished from the Pithoascaceae BENNY & KIMBROUGH by smooth, young dextrinoid, ripe straw- or copper-coloured ascospores with 1 or 2 germ pores and by anamorphs belonging to the genera *Scopulariopsis*, *Graphium*, *Scedosporium* and *Wardomyces*. As far as is known all species of the genera *Microascus*, *Kernia*, *Petriella* and *Petriellidium* do include such an anamorph, whereas many species of genera such as *Pithoascus*, *Neurospora* or *Myxotrichum* do not include anamorphs. In the genus *Petriellidium*, all species have *Scedosporium* and *Graphium* anamorphs with the exception of *P. desertorum* v. ARX & MOUSTAFA, which has an *Arthrographis* anamorph. This species also differs from the other species by having small ascospores and much larger ascospores, 11–14 × 7.5–10 μm in size. They are copper-coloured, thick-walled and have 2 indistinct germ pores (von ARX, 1973).

The Microascaceae now contain the genera *Microascus* ZUKAL, *Kernia* NIEUWLAND, *Petriella* CURZI, *Petriellidium* MALLOCH, *Lophotrichus* R. K. BENJAMIN and *Enterocarpus* LOCQUIN-LINARD. The latter genus has to be restricted to the type species *E. uniporus* LOCQUIN-LINARD. *E. grenotii* LOCQUIN-LINARD has ascospores with two germ pores and is identical to *Lophotrichus bartlettii* (MASSEE & SALMON) MALLOCH & CAIN. The type culture could be studied. The species of the genera *Lophotrichus* and *Enterocarpus* do not include anamorphs.

The genera *Pithoascus* v. ARX and *Faurelina* LOCQUIN-LINARD have been classified in a separate family Pithoascaceae by BENNY & KIMBROUGH (1980). The genus *Leuconeurospora* MALLOCH & CAIN is more closely related to the Melanosporaceae (von ARX, 1981). The Microascaceae are also related to the Ophiostomataceae and the Chaetomiaceae; intermediates exist (von ARX, 1975).

b. Amorphothecaceae PARBERY

Amorphotheca resiniae PARBERY, the only species of the Amorphothecaceae, is the teleomorph of *Hormoconis resiniae* (LINDAU) v. ARX & de VRIES. It is a lipolytic fungus, growing on oils and often isolated from kerosene and fuel containers. Especially in fresh isolates the fungus forms erect, long conidiophores, which become branched apically (tree-like) and form chains of blastoconidia often with protruding ends but without thickened scars. The ascomata develop at the margins of adjacent colonies, are spherical when immersed or obcampanulate when erumpent and have an amorphous, skin-like, brown wall. The asci are not catenulate, the ascospores ellipsoidal or navicular, slightly pigmented and smooth. The fungus shows some similarities to *Pithoascus langeronii* and may be related, though the family Amorphothecaceae should be retained. REDHEAD & MALLOCH (1977) classified it in the Endomycetaceae, but this family should be restricted to yeasts and yeast-like fungi with galeate (hat-shaped) ascospores.

c. Ophiostomataceae NANNF.

The Ophiostomataceae, circumscribed by BENNY & KIMBROUGH (1980) and others, comprising the genera *Ophiostoma* SYD., *Europhium* PARKER, *Ceratocystiopsis* UPADHYAY & KENDRICK, *Ceratocystis* ELLIS & HALST. and *Sphaeronaemella* KARST., is heterogeneous. The last two genera will have to be excluded. The genus *Ceratocystis* has to be restricted to species with *Chalara* anamorphs and is related to genera with similar anamorphs, e. g. *Chaetosphaeria* TUL. or probably *Pyxidiophora* BREF. & TAVEL. The latter genus has light ascomata with long beaks and apical "circhi" and elongate, usually 2-celled ascospores (LUNDQVIST, 1980). The species of the related genus *Sphaeronaemella* also have light ascomata and phialidic anamorphs but 1-celled ascospores. Both genera belong to the Nectriaceae (Hypocreaceae), from which the Pyxidiophoraceae ARNOLD should not be separated. The anamorphs of *Pyxidiophora* and *Sphaeronaemella* are similar. The genus *Chaetosphaeria* is usually classified in the Sphaeriaceae and can only be distinguished from *Nectria* by the dark pigmentation of the ascomata wall.

The family Ophiostomataceae can be maintained for the genera

Ophiostoma, *Europhium* and *Ceratocystiopsis* which include blastic anamorphs belonging to *Graphium*, *Sporothrix* and related genera. The Ophiostomataceae are rather close to the Microascaceae, but can be distinguished by hyaline, usually smaller ascospores without (visible) germ pores. REDHEAD & MALLOCH (1977) again treated them as a part of the Endomycetaceae; this was not accepted e. g. by BENNY & KIMBROUGH (1980) and von ARX (1981).

d. Onygenaceae FR. (including Gymnoascaceae BARANATZKY)

MALLOCH & CAIN (1971) considered the two families to be indistinguishable and this was accepted by von ARX (1981). A number of intermediates exist, for example species of the genera *Amauroascus* SCHROET. and *Otenomyces* EIDAM which have rather dark and compact ascomata walls. In the species of the genera *Xynophila* MALLOCH & CAIN and *Arachnotheca* v. ARX the wall of the ascomata is rather thick and composed of light, densely interwoven hyphae.

The family Onygenaceae would be more natural, if the genera *Myxotrichum*, *Pseudogymnoascus* and *Byssosascus* with ellipsoidal-navicular or fusiform, pigmented, often striate ascospores were excluded. Most of the remaining genera are characterized by oblate or spherical ascospores (exception: *Onygena* PERS. with ellipsoidal ascospores). Many species are keratinolytic and quite a large number have arthric or aleuric anamorphs, mostly unnamed. Some of them are classified in the genera *Malbranchea* (SIGLER & CARMICHAEL, 1977), *Chrysosporium* or *Myceliophthora* (van OORSCHOT, 1980). The arthroconidia may be cylindrical or swollen and are often separated from each other by empty parts of the conidiogenous hyphae. The aleurioconidia develop apically, sometimes laterally, are often ornamented and 1-celled, or manycelled in the genera *Microsporon* GRUBY and *Trichosporon* MALMSTEN.

Xylogone sphaerospora v. ARX & NILSSON has rather small ascomata with a wall of textura epidermoidea and an anamorph with erect conidiogenous hyphae, which separate into 2- to 4-celled, cylindrical arthroconidia.

The genus *Narasimjella* THIRUM. & MATHUR is peculiar in that the type species *N. hyalinospora* (KUEHN & al.) v. ARX forms erect, synnematosum ascomata with a brush of numerous ascogenous hyphae and asci from croziers with hyaline, lenticular, bivalvate ascospores. Similar ascospores have been observed in *Leucothecium emdenii* v. ARX & SAMSON, which also has ring-like initials, and includes an arthric anamorph (von ARX & SAMSON, 1973; von ARX, 1981).

Remarkable is the similarity of the anamorphs of *Onygena* and *Diplogelasinospora*, both also have ellipsoidal ascospores.

e. Sordariaceae WINTER and Lasiosphaeriaceae NANNF.

LUNDQVIST (1972) split the former Sordariaceae into the two families, Sordariaceae s. str. and Lasiosphaeriaceae, subdividing the latter into the subfamilies Lasiosphaerioideae and Podosporoideae. However, this classification was not considered in the accompanying key to the genera. LUNDQVIST placed the Neurosporaceae CAIN (not validly published) in synonymy with the Sordariaceae s. str., containing the genera *Sordaria* CES. & de NOT., *Neurospora*, *Gelasinospora*, *Diplogelasinospora*, *Thielavia* ZOFF (as *Boothiella* LODHI & MIRZA) and *Apodus* MALLOCH & CAIN.

All species of the genus *Sordaria* have ostiolate, smooth ascomata with a rather thick wall composed of thick-walled, dark, rather large cells. The asci are cylindrical, persistent, with an apical ring; filiform paraphyses are absent. The ascospores are 1-celled, dark, have a single germ pore and are surrounded by a gelatinous sheath (CAILLEUX, 1972).

In the genera *Neurospora* and *Gelasinospora* the ascomata and asci resemble those of *Sordaria*, but the ascospores are unsheathed, ornamented and usually have two germ pores. Some species of *Gelasinospora* have one or several germ pores (CAILLEUX, 1972). Anamorphs are absent in *Sordaria* and *Gelasinospora*.

If the Sordariaceae sensu LUNDQVIST (1972) are accepted, then the remaining genera would have to be excluded. *Thielavia* and *Apodus* (both sensu von ARX, 1975) cannot be considered the non-ostiolate counterparts of *Sordaria*, as they are closer to the genera classified by LUNDQVIST (1972) in the Podosporoideae. The two genera differ from *Sordaria* also by the structure of the ascomata wall, which is thin and of textura epidermoidea in *Thielavia*, and by the unsheathed, occasionally unequally 2-celled ascospores.

The Podosporoideae are characterized by thin-walled ascomata, by asci with paraphyses and by ascospores which are often unequally 2-celled or have cellular or gelatinous appendages. The ascospores always have one germ pore and the smaller cell of 2-celled ascospores remains hyaline and often aborts.

The genus *Diplogelasinospora* was considered a non-ostiolate counterpart of *Gelasinospora* with 2-celled ascospores, but UDAGAWA & HORIE (1972) showed that it is closer to *Zopfiella*. In both genera the usually non-ostiolate ascomata have a wall composed of relatively small cells, asci are not persistent, ascospores unequally 2-celled with only the pigmented larger cell having a germ pore. The only distinguishing character are the ascospores which are pitted in *Diplogelasinospora* and mostly smooth in *Zopfiella*. No arthric anamorphs are known in the latter genus. Other genera of the Podosporoideae include phialidic, spermatial anamorphs of the form genera *Phialophora*

MEDLAR and *Cladorrhinum* MARCHAL, e. g. *Apiosordaria* v. ARX & W. GAMS and *Echinopodospora* ROBISON.

The Lasiosphaerioideae are usually lignicolous, have ostiolate ascomata, often cylindrical or elongate, 1-celled or septate, unpigmented ascospores, which may become brown on liberation and often form phialides when germinating (CARROLL & MUNK, 1964; LUNDQVIST, 1972; HILBER & HILBER, 1978).

f. Coronophoraceae v. HÖHNEL

The Coronophoraceae are lignicolous or mycoparasitic and the ascomata develop in clusters or embedded in a dark, hyphal subiculum. The ascomata are non-ostiolate, often cupulate or turbinate, sometimes spherical, and have a thick, dark wall composed of thick-walled, distinct cells. The inner wall is thickened in the apical region and forms a periphysate canal or a so-called "Quellkörper" (a cell mass which may become swollen). The latter may be cushion-like or cylindrical and is composed of hyaline, thick-walled cells with a minute lumen.

As shown by CARROLL & MUNK (1964) and SIVANESAN (1974, 1975, 1978), the Coronophoraceae represent non-ostiolate relatives of the Lasiosphaeriaceae, some genera being intermediate. For this reason NANNFELDT (1975) no longer accepted his order, the Coronophorales, and united the two families Coronophoraceae and Nitschkiaceae (FITZPATRICK) NANNF.

A rather large number of genera were reduced to synonyms by von ARX & MÜLLER (1954). NANNFELDT (1975) accepted only the genera *Coronophora* FÜCKEL, *Bertia* de NOT., *Gaillardiiella* PAT., *Acanthonitschkea* SPEG. and *Nitschkia* OTH; the genus *Nitschkia* sensu NANNFELDT is rather heterogeneous, containing species with or without a subiculum, with or without a "Quellkörper", with 8- or many-spored asci, and appendaged or non-appendaged ascospores. The generic delimitation given by MÜLLER & von ARX (1973) is therefore preferred.

N. parasitans (SCHW.) NANNF. [= *N. fückelii* NIT. in FÜCKEL], the type species of the genus *Nitschkia*, is a mycoparasite of *Nectria cinnabarina* Fr. It has no subiculum, the densely aggregated ascomata are small and have no "Quellkörper", and the stalked asci each contain 8 allantoid ascospores.

NANNFELDT also classified *Fracchiæa broomeana* (BERK.) PETCH, the type species of the genus *Fracchiæa* SACC., in *Nitschkia*. However, this species has large, thick-walled ascomata with a spiny wall and long, stalked clavate asci with a large number of cylindrical ascospores. The genus *Fracchiæa* is closer to *Coronophora* than to *Nitschkia*, *Tympanopsis*, *Lasio-sphaeropsis* D. HAWKSW. & SIVANESAN and *Rhagadostoma* KOERBER.

The other species classified by NANNFELDT (1975) in *Nitschkia* are lignicolous, have ascomata larger than 0.3 mm, embedded in a subiculum and a "Quellkörper" is usually present. MÜLLER & VON ARX (1955, 1973) classified them in the genus *Tympanopsis* STARBÄCK (1894).

The genus *Biciliospora* PETRAK (1952) should be accepted for species with ellipsoidal or fusiform, rather broad ascospores and a recurved appendage at each end. The type species, *B. velutina* PETRAK, has 8-spored asci whereas in *Biciliospora similis* (BRES.) v. ARX, comb. nov. (= *Trichosphaerella similis* BRES. — Bull. Jard. Bot. Bruxelles 4: 7. 1914) the asci are 32-spored.

NANNFELDT (1975) found an older name, *Sphaeria tristis* PERS. ex FR. (Syst. mycol. 2: 444. 1823), for *Sydowinula moravica* PETRAK (1923), and classified it as *Acanthonitschkea tristis* (PERS. ex FR.) NANNF. This fungus is here named *Sydowinula tristis* (PERS. ex FR.) v. ARX, comb. nov. (basonym see above). It is the type species of *Sydowinula* PETRAK, which can be distinguished from the tropical genus *Acanthonitschkea* SPEG. by the smooth ascomata. Setae are present only on the hyphae of the subiculum and form a "cup" around the ascomata.

The following genera should thus be accepted in the Coronophoraceae: *Coronophora*, *Fracchiacea*, *Bertia*, *Gaillardielia*, *Acanthonitschkea*, *Tympanopsis*, *Biciliospora*, *Sydowinula*, *Nitschkia*, *Spinulosphaeria* SIVANESAN (1974) and probably *Lasiobertia* SIVANESAN (1978).

Despite the present different view on the classification of the Coronophoraceae, the well documented publication presented by NANNFELDT (1975) remains the most valuable contribution to our knowledge of the family.

g. Melanosporaceae BESSEY

The Melanosporaceae are characterized by ostiolate or non-ostiolate ascomata with a wall of thick-walled, rather large, usually light, sometimes pigmented, often ornamented cells, by clavate, evanescent asci and by one-celled, pigmented ascospores with two germ pores, one at each end. Occasionally the ascospores may have only one or 3—4 germ pores; those with one pore are mostly pyriform with the pore at the attenuated end. Anamorphs are usually absent, but phialidic spermatial states may be present and aleurionidia of the form genus *Myceliophthora* are characteristic for the genus *Corynascus*.

Neurospora differs from the Melanosporaceae by darker ascomata with a thicker wall composed of several layers of cells and by cylindrical, persistent asci. The taxa have rather similar ascospores, which are often fusiform and have 2 apical germ pores.

The genus *Melanospora* CORDA was revised by DOGUET (1955) and contains ostiolate and non-ostiolate species. The latter were classified in a separate genus *Microthecium* CORDA by UDAGAWA & CAIN (1969) and D. HAWKSWORTH & UDAGAWA (1977). This was not accepted by von ARX (1981), who reserved *Melanospora* for species with smooth ascospores and reintroduced the genus *Sphaerodes* CLEM. for species with reticulate ascospore ornamentation. The species of the latter genus may also be ostiolate or non-ostiolate. KRUG & JENG (1979) classified some of the non-ostiolate species placed by D. HAWKSWORTH & UDAGAWA (1977) in *Microthecium*, in separate genera *Rhytidospora* JENG & CAIN and *Pteridiosperma* KRUG & JENG on the basis of their deviating ascospore ornamentation. In *Rhytidospora* the ascomata wall is cephalothecoid as in *Leuco Neurospora pulcherrima* (WINTER) MALLOCH & CAIN. This species has reticulate, only slightly pigmented, small ascospores without visible germ pores. It may be related to *Rhytidospora* and *Sphaerodes*.

Other genera close to *Melanospora* include *Achaetomiella* von ARX (ascomata pyriform, ostiolate, setose with a light brown wall), *Corynascus* v. ARX (ascomata non-ostiolate, with a wall of distinct, finely ornamented cells) and probably *Crynascella* von ARX (ascomata non-ostiolate, with a hyphal wall, ascospore wall thickened around the germ pores). *Thielavia heterothallica* von KLOPOTEK (Arch. Microbiol. 107: 223. 1976) has ascospores with a single germ pore but should be classified as *Corynascus heterothallicus* (von KLOPOTEK) von ARX, comb. nov. (basionym see above). The anamorph is similar to that of other *Corynascus* species and is known as *Sporotrichum thermophilum* APINIS [= *Myceliophthora thermophila* (APINIS) van OORSCHOT].

h. Chaetomiaceae WINTER

The Chaetomiaceae are characterized by dark or bright ascomata with a wall, composed of rather small, often indistinct cells. The ascomata may be covered by characteristic hairs, may be setose or (nearly) glabrous. The asci are clavate or cylindrical, become evanescent at maturity and have no apical rings or thickenings. The ascospores are pigmented, unsheathed and have a single, basal germ pore. Some rare species with two germ pores have also been described (e. g. MILLNER et al., 1977); some should be transferred to *Achaetomiella*. Anamorphs are absent; phialidic spermatial states are known in a number of species and a few species of *Chaetomium* and *Farrowia* include *Botryotrichum* anamorphs with 1-celled, rather large, spherical aleurioconidia (chlamydospores). Many species are cellulolytic and/or prefer temperatures of 25–35° C.

Typical genera of the family are *Chaetomium* KUNZE ex FR., *Chaetomidium* (ZOPF) SACC., *Achaetomium* RAI et al. and *Farrowia* D. HAWKSW.

Chaetomidium is normally regarded as the non-ostiolate counterpart of *Chaetomium*. However, the structure of the ascomata wall and the covering hairs are further distinguishing characters (von ARX, 1975).

Chaetomium is characterized by the presence of hairs on the ascomata, especially around the ostiolum (AMES, 1963). *Achaetomium* has been described for taxa without such hairs, but with a thicker ascoma wall. Intermediates exist and *Achaetomium luteum* RAI et al., the type species of the genus, has also been placed in *Chaetomium*. Some other species of *Achaetomium* are close to the Sordariaceae and represent ostiolate counterparts of *Thielavia*.

Chaetomium is a large genus; more than 120 species have been distinguished by the structure of the ascomata hairs, the shape of the asci (clavate or cylindrical) and the size and shape of the ascospores. Many species are known by only one strain. Some species are easily recognized by their peculiar characters. The generic name *Bommerella* MARCHAL would suit this taxon. *Ch. cruentum* L. AMES has a bright, fleshy ascoma wall and delicate, simple, light ostiolar hairs. It has also been described as *Lophotrichus incarnatus* SETH. The ascospores are biapiculate, have a single germ pore and form pink masses. The two last-mentioned *Chaetomium* species, however, show some similarity to the Microascaceae.

Some Chaetomiaceae, e. g. *Chaetomium uniporum* AUE & MÜLLER, have initials, similar to that of the Onygenaceae *Arachnotheca glomerata* (MÜLLER & PACHA—AUE) v. ARX and *A. albicans* (APINIS) v. ARX (AUE & MÜLLER, 1967; MÜLLER & PACHA—AUE, 1968).

i. Coniochaetaceae MALLOCH & CAIN and Xylariaceae TUL.

The Coniochaetaceae were introduced for "Sordariaceae" with unsheathed 1-celled, pigmented ascospores with a germ slit. The asci may be cylindrical, clavate or spherical and may have non-amyloid apical thickenings. Phialidic anamorphs of the form-genera *Phialophora*, *Acremonium* and *Verticillium* are often present and carotinoid pigments are often formed in culture.

The family includes the genera *Coniochaeta* (SACC.) MASSEE (ascomata dark, ostiolate), *Coniochaetidium* MALLOCH & CAIN (ascomata nonostiolate, ascospores smooth), *Poroconiochaeta* UDAGAWA & FURUYA (ascomata nonostiolate, ascospores pitted) and *Wawelia* NAMYSLOWSKI (stromatic, ascomata ostiolate, with cirrhi). The genera *Ephemeroascus* van EMDEN and *Areolospora* JONG & DAVIS may also belong to the Coniochaetaceae. *Ephemeroascus* is characterized by stromatic, nonostiolate ascomata, dark, rather small ascospores without (visible) germ slits and a *Verticillium*-anamorph. *Areolospora* is also stromatic and nonostiolate and the areolate or punctulate ascospores show no germ slit (HAWKSWORTH, 1980; von ARX, 1981). The anamorph does not appear to be phialidic.

The genus *Ascotricha* BERK. does not belong to the Chaetomiaceae or Coniochaetaceae, but to the Xylariaceae. Its *Dicyna* anamorph is close to *Nodulisporium* and *Geniculisporium*, the anamorphs of *Hypoxyton* BULL. ex FR. The evanescent asci of *Ascotricha* include amyloid apical structures, which are characteristic of Xylariaceae (KHAN & CAIN, 1977).

Some genera of the classical Xylariaceae (e. g. MÜLLER & von ARX, 1973) have to be excluded. BOEDIJN (1959) proposed a new family, the Sarcostromellaceae, for two new genera *Sarcostromella* and *Pseudoxylaria*. According to NANNFELDT (1972) the Sarcostromellaceae cannot be separated from the Boliniaceae RICK. In this family the asci have no amyloid apical structures and the ascospores have an often indistinct, basal germ pore. NANNFELDT only accepted the genus *Camarops* KARST. with 14 species. He did not mention *Pseudoxylaria nigripes* (KLOTZSCH) BOEDIJN [= *Xylaria nigripes* (KLOTZSCH) SACC.] which is found on termite nests in tropical areas of the old world and has ascospores without (visible) germ pores. BOEDIJN classified this fungus in his Sarcostromellaceae but its position today is doubtful.

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