

## SOME NEW OR NOTEWORTHY SPECIES OF MORTIERELLA

W. GAMS

*Centraalbureau voor Schimmelcultures, Baarn*

(With 22 Text-figures)

Twenty-two species of *Mortierella* are described and distributed over the sections defined by Gams (1970) which include the following new species: Section *Pusilla*: *M. roseo-nana*; Section *Alpina*: *M. globalpina* and *M. polygonia*; Section *Simplex*: *M. amoeboides*; Section *Hygrophila*: *M. elongatula*, *M. kuhlmanii*, *M. parazychnae*, *M. armillariicola*, *M. selenospora*, *M. basiparvispora*, and *M. clonocystis*; Section *Spinosa*: *M. epicladia*, *M. acrotona*, *M. cystojenkinii*, and *M. fimbriocystis*.

Complete accounts on species described in *Mortierella* are given by Linnemann (*in* Zycha & Siepmann, 1970) and Mil'ko (1974). Linnemann's arrangement of sections caused many difficulties in determination and consequently Gams (1970) proposed a different arrangement of sections but had not yet given a detailed account of or a key to the species. New findings sometimes allow the recognition of long forgotten species (e.g. Gams & Hooghiemstra, 1976), but several apparently new species from different origins have accumulated during the last years in the CBS collection and are described in this communication. In addition some hitherto imperfectly delimited species and, in particular, some species recently published in Russia are redescribed from type strains and more sharply delimited.

The species are arranged in the sections defined by Gams (1970). Cultures were generally grown on 2% malt extract agar (MEA) for the assessment of the macroscopic characters and growth rate, on soil extract agar (SEA) or potato-carrot agar (PCA) for the study of the sporangiophores, and incubated at room temperature (18-22 °C) for approximately one week or longer. The sexual states were not obtained in most species; usually too few strains were available to give a chance for compatible mating, but in some cases proved compatibility led to the synonymy of some already described species. On the other hand, the absence of a mating reaction justified the separation of strains which deviate from known species in minor characters, e.g. *M. elongatula* and *M. sarnyensis* from *M. elongata*, and *M. kuhlmanii* from *M. beljakovae*. From previous work on zygosporangium formation (Kuhlman, 1972) it is known, that in some species zygosporangium production is erratic and difficult to obtain; *M. humilis* and *M. marburgensis*, however, gave interspecific zygosporangia (Chien & al., 1974). A positive or negative result of mating with new isolates therefore only has limited value in delimiting species and the novelty of a species is judged rather on morphological characters of the asexual state than on mating behaviour. In so doing,

however, a considerable variability in length, width and branching intensity of the sporangiophores as well as in the size of the spores has been taken into account, whilst the type of ramification (acrotonous or basitonous), development of a columella and usually also the shape of the spores are found to be reliable criteria.

## DESCRIPTIONS

### Section ISABELLINA Turner

Growth restricted, compact, velvety. Sporangia often pigmented, many-spored or one-spored. Garlic-like odour never produced.

#### 1. *Mortierella roseo-nana* W. Gams & Gleeson *spec. nov.*—Fig. 1

Coloniae lente crescunt, velutinae, dilute roseae, non olent. Sporangiohora numerosa in agaro malti ex hyphis aeriis vel submersis oriuntur, prope superficiem 2–4 ramulos verticillatos proferunt, omnino 60–130  $\mu\text{m}$  longa, e 6–8  $\mu\text{m}$  ad 3–4  $\mu\text{m}$  angustata. Sporangia unisporea, 10–16  $\mu\text{m}$  diam., rubida, levia, dilapsa collare minutum relinquunt; sporae multis guttulis oleaginosi repletae. Chlamydosporae absunt.

Holotypus: CBS 473.74, isolatus e solo paupero, Parkville, ad Universitatem Melbourniensem in Australia, leg. P. Gleeson, Aug. 1974.

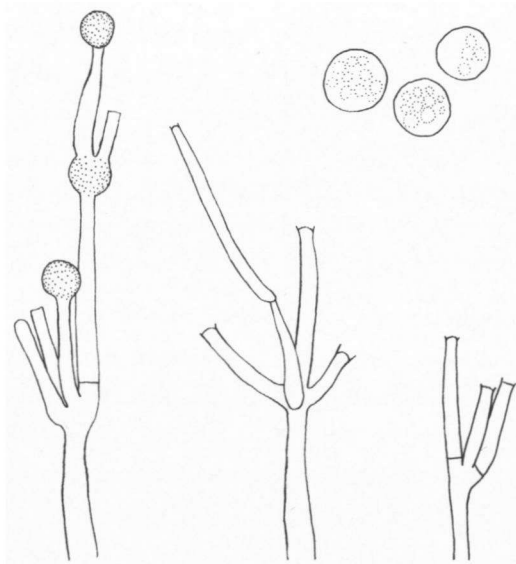


Fig. 1. *Mortierella roseo-nana*, sporangiophores (some proliferating) and one-spored sporangia  $\times 500$ .

Colonies reaching 2.2–3.0 cm in diameter in six days, velvety, very pale pink due to sporangia (like *M. vinacea*); odour absent. Good sporulation up to the margin on MEA; sporangiophores arising from aerial hyphae or from the substratum, in the latter case branching near the agar surface; bearing 2–4 short, verticillate branches, total length 60 up to more than 130  $\mu\text{m}$ , tapering from 6–8  $\mu\text{m}$  to 3–4  $\mu\text{m}$ . Sporangia one-spored, 10–16  $\mu\text{m}$  in diameter, reddish, smooth-walled, on dehiscence leaving a minute collarette. Spores containing numerous oil droplets. Chlamydospores absent. Know only from the type culture.

*Mortierella roseo-nana* is intermediate between *M. vinacea* Dixon-Stewart and *M. nana* Linnem. The occurrence of pigmented, one-spored sporangia is an indication that the latter species is properly classified in the section *Isabellina*.

### Section ALPINA Linnem.

Sporangiophores usually less than 200  $\mu\text{m}$  tall, always unbranched, often with an irregular swelling at the foot. Sporangia usually many-spored.

#### 2. *Mortierella globalpina* W. Gams & Veenbaas-Rijks *spec. nov.*—Fig. 2

Coloniae fere lente crescunt, dense lobulatae, mycelio aereo sparso obtectae, modice olent. Sporangiophora ex hyphis aeriis oriuntur, aculeata, 45–70  $\mu\text{m}$  longa, e 4–6  $\mu\text{m}$  ad 1.7–3.0  $\mu\text{m}$

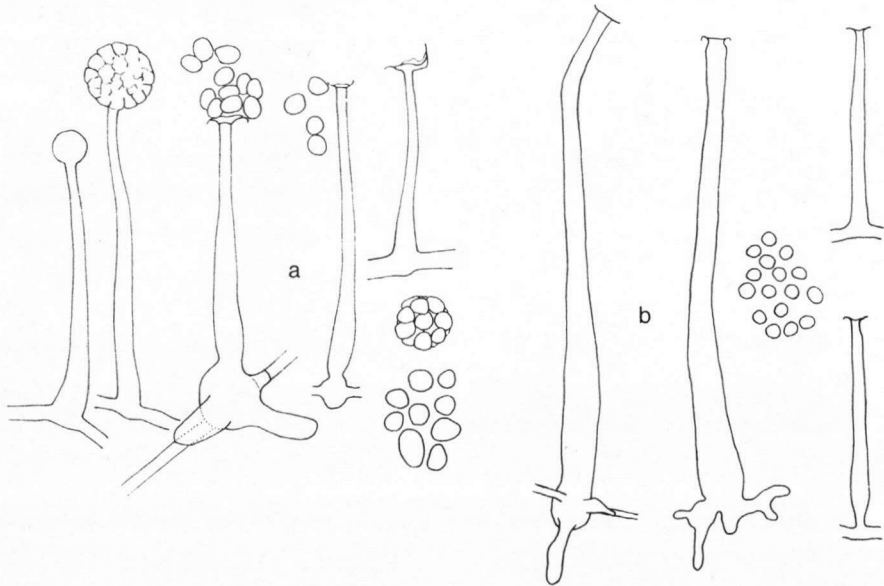


Fig. 2. *Mortierella globalpina*, sporangiophores, sporangia, and spores  $\times 500$ . — a. Strain from Kiel. — b. CBS 360.70.

angustata, numquam ramosa, prope basin inflata et saepe appendiculos velut rhizoidea proferentia. Sporangia semper multisporea, 8–15  $\mu\text{m}$  diam., globosa et levia, dilapsa collare conspicuum relinquunt. Sporae  $\pm$  globosae, leves, 2.5–4.0  $\mu\text{m}$  diam. Chlamydosporae plerumque absunt.

Holotypus: CBS 360.70, isolatus e solo agresti, East-Flevoland Polder in Neerlandia, *J. W. Veenbaas-Rijks*, 7 Oct. 1969.

Colonies rather slow-growing with a daily radial increment of 7–10 mm, forming a rosette of dense narrow lobes, with a moderate amount of aerial mycelium; odour weak but typical of the genus. Sporulation poor on MEA, abundant on SEA; sporangiophores arising from the aerial hyphae, awl-shaped, 45–70  $\mu\text{m}$  tall, always unbranched, tapering from 4–6  $\mu\text{m}$  at the base to 1.7–3.0  $\mu\text{m}$  at the tip, with a typical basal swelling ('basal foot' of Linnemann) and often some rhizoid-like outgrowths. Sporangia always many-spored, 8–15  $\mu\text{m}$  in diameter, globose and smooth-walled, leaving a distinct collarete on dehiscence. Spores  $\pm$  globose, smooth-walled, 2.5–4.0  $\mu\text{m}$  in diameter. Chlamydospores generally absent, rarely present as little differentiated intercalary structures not much wider than the original hypha.

CULTURES EXAMINED.—CBS 266.70 and 360.70 (type strain), ex agricultural soil in the East-Flevoland Polder, *J. W. Veenbaas-Rijks*, 7 Oct. 1969. Two more strains were isolated in 1964 by the author from a wheat field soil at Kiel, F. R. G., but are now lost.

*Mortierella globalpina* differs from *M. alpina* Peyronel not only by the globose shape of the spores but also by the absence of deciduous sporangioles which are not divided into small spores. It differs from the description of *M. antarctica* Linnem. (in Zycha & Siepmann, 1970) by the possession of smaller spores (*M. antarctica* is reported to have spores of 3–10  $\mu\text{m}$ ) and the absence of catenulate chlamydospores. Unfortunately the type strain of this species, CBS 609.70, has never shown any sporulation since it is preserved at Baarn, but still produces abundant chlamydospores. *Mortierella globalpina* may have been identified as *M. pusilla* Oudem. (e.g. Mil'ko, 1974), *M. humicola* Oudem. or *M. subtilissima* Oudem., three similar species, all inadequately described by Oudemans & Koning (1902), which are best abandoned as doubtful, since they may equally well have been quite different, and no type or other material is in existence.

### 3. *Mortierella polygonia* W. Gams & Veenbaas-Rijks *spec. nov.*—Fig. 3

Coloniae fere lente crescunt, vix lobulatae, mycelio aereo copioso obiectae, modice olent. Sporangiofiora plerumque ex hyphis submersis oriuntur, aculeata, numquam ramosa, 40–60(–115)  $\mu\text{m}$  longa, e 3.5–5.0  $\mu\text{m}$  ad 1.5–2.0  $\mu\text{m}$  angustata, prope basin vix inflata. Sporangia 10–14  $\mu\text{m}$  diam., semper multisporea, dilapsa collare conspicuum relinquunt. Sporae irregulariter lobatae, 6–9  $\mu\text{m}$  diam. Chlamydosporae vulgo absunt.

Holotypus CBS 685.71, isolatus e solo agresti prope Wageningen, *J. W. Veenbaas-Rijks*, 16 Apr. 1971.

Colonies rather slow-growing with a daily radial increment of approx. 5 mm, hardly lobed with much aerial mycelium; odour moderate, typical of the genus. Sporulation poor on MEA, good on SEA; sporangiophores arising mainly from the

substratum, awl-shaped, always unbranched, 40–60  $\mu\text{m}$  tall in fresh isolates, 85–115  $\mu\text{m}$  after several transfers, tapering from 3.5–5.0  $\mu\text{m}$  to 1.5–2.0  $\mu\text{m}$  at the tip, with the base hardly swollen, but in older cultures the lower part of the sporangiophores often undulate. Sporangia 10–14  $\mu\text{m}$  in diameter, sometimes appearing reddish, always many-spored, leaving no columella but a distinct collarete on dehiscence. Spores irregularly lobed, with 4–5 projections in optical section and 6–9  $\mu\text{m}$  in maximal diameter. Chlamydospores normally absent, but short hyphal fragments may act as such.

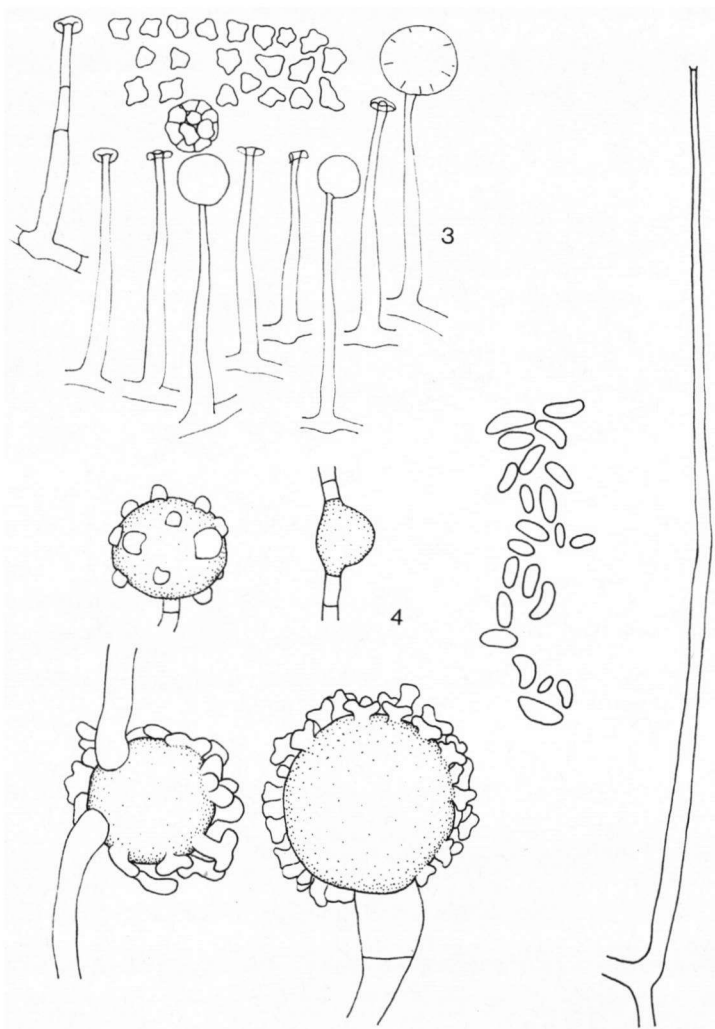


Fig. 3. *Mortierella polygonia*, sporangiophores and spores  $\times 500$ .

Fig. 4. *Mortierella amoeboides*, sporangiophore, spores, and chlamydospores  $\times 500$ .

CULTURES EXAMINED.—CBS 685.71, ex agricultural soil, Wageningen, J. W. Veenbaas-Rijks, 16 Apr. 1971 (strain 606). Another identical strain was isolated in 1965 by the author from a wheat field soil at Kiel, F. R. G., but is now lost.

*Mortierella polygonia* is unique in the genus by its lobed spores, but the sporangiophores are typical of section *Alpina*.

#### Section SIMPLEX W. Gams

Species with constantly unbranched, but sometimes aggregated, large and wide sporangiophores. One-spored sporangioles may occur jointly with many-spored sporangia.

#### 4. *Mortierella amoeboidea* W. Gams spec. nov.—Fig. 4

Coloniae fere lente crescunt, dense lobulatae, mycelio aereo parco in medio obtectae, modice olent. Sporangiophora pauca ex hyphis submersis oriuntur, 150–260  $\mu\text{m}$  longa, e 5  $\mu\text{m}$  ad 1.5  $\mu\text{m}$  angustata, numquam ramosa. Sporangia 10–15  $\mu\text{m}$  diam., multisporea, dilapsa collare inconspicuum relinquunt. Sporae elongato-ellipsoideae, nonnumquam curvatae, leves, 6–11(–13)  $\times$  3.5–5.0  $\mu\text{m}$ . Chlamydosporae abundantes, nonnumquam aggregatae, terminales vel laterales, dilute brunneae, 30–45  $\mu\text{m}$  diam., appendicibus retusis, saepe dichotomis, 6–10  $\mu\text{m}$  longis obtectae; chlamydosporae minores, leves etiam copiosae.

Holotypus: CBS 889.72, isolatus e *Chromelosporio* spec., Beller Holz, in Silva Teutoburgensi in Germania, W. Gams, Sept. 1972.

Colonies rather slow-growing with 5–7 mm daily radial increment, delicately and densely lobed, with some aerial mycelium in the centre; odour faint but typical. Sporulation rather poor on all media; sporangiophores arising from the substratum, 150–260  $\mu\text{m}$  tall, unbranched, tapering from 5  $\mu\text{m}$  to approx. 1.5  $\mu\text{m}$  at the tip. Sporangia 10–15  $\mu\text{m}$  in diameter many-spored, leaving an indistinct collarette after dehiscence. Spores elongate ellipsoidal, sometimes curved, smooth-walled, 6–11 (–13)  $\times$  3.5–5.0  $\mu\text{m}$ . Chlamydo-spores abundantly produced on SEA in the agar, in terminal or lateral positions, sometimes aggregated in clusters, light brown, 30–45  $\mu\text{m}$  in diameter, covered with blunt, often dichotomous appendages, 6–10  $\mu\text{m}$  long; smaller, smooth-walled chlamydo-spores also abundant.

Known only from the type culture.

*Mortierella amoeboidea* differs from *M. echinosphaera* Plaats-Niterink (in van der Plaats-Niterink & al., 1976) by larger chlamydo-spores and the possession of unbranched sporangiophores, whilst *M. fimbriocystis* W. Gams (cf. p. 138) has smaller spores and acrotonously branched sporangiophores. In both these species the chlamydo-spore appendages are narrower than in *M. amoeboidea* and fringe-like. The sporangiophores of *M. amoeboidea* are unusually small in the section *Simplex*.

#### Section HYGROPHILA Linnem. emend W. Gams (1970)

Sporangiophores tall or short, with basitonous, cymose ramification, bearing many- or few-spored sporangia.

5. *MORTIERELLA ECHINULA* Linnem.

in Zentbl. Bakt. ParasitKde, Abt. 2, 107: 229. 1953.—Fig. 5

Colonies growing rather fast with a daily radial increment of 6–10 mm, hardly lobed, without aerial mycelium; odour weak, typical of the genus. Sporulation poor; sporangiophores arising from the substratum, 320– over 500  $\mu\text{m}$  tall, with abundant basitonus ramification, tapering from 9–15  $\mu\text{m}$  to 3–4(–5)  $\mu\text{m}$  at the tip. Sporangia 30–50  $\mu\text{m}$  in diameter, many-spored, leaving a minute collarette on dehiscence. Spores  $\pm$  globose, distinctly echinulate, 8–10(–14)  $\mu\text{m}$  in diameter. Chlamydo spores scarcely produced on SEA, abundantly on MEA after 12 days, globose, thin-walled, 9–13  $\mu\text{m}$  in diameter, filled with oil drops.

CULTURE EXAMINED.—CBS 282.71, ex soil in Iceland, comm. *E. G. Kuhlman*, 1971.

Linnemann's original isolate is lost. The present strain matches the original description fairly well in which the spores are given as 7–8  $\mu\text{m}$ . *Mortierella echinula* may be confused with *M. globulifera* Rostrup (cf. Turner, 1956) which has similar spores but always unbranched sporangiophores. *Mortierella hyalina* (Harz) W. Gams (syn. *M. hygrophila* Linnem.) may also be mistaken for *M. echinula* since the spores are finely roughened (although always described as smooth!), but much less than in *M. echinula*; spores of *M. hyalina* are larger and the chlamydo spores more abundant and lemon-shaped.

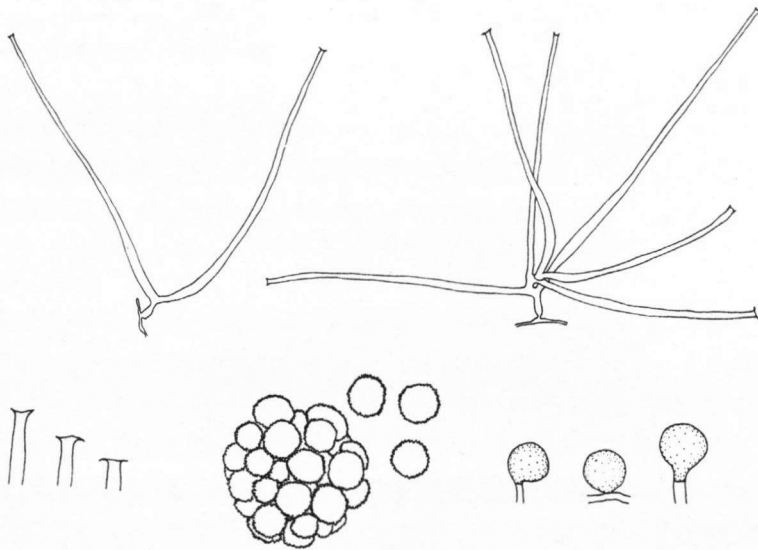


Fig. 5. *Mortierella echinula*: sporangiophores  $\times 100$ ; sporangiophore tips, sporangium and spores, and chlamydo spores  $\times 500$ .

6. *MORTIERELLA* cf. *VERRUCOSA* Linnem.

in Zentbl. Bakt. ParasitKde, Abt. 2, 107: 229. 1953.—Fig. 6

Colonies growing moderately fast with a daily radial increment of approx. 8 mm, broadly lobed and zonate, with some aerial mycelium mainly in the centre; odour very strong and typical. Sporulation abundant on MEA and SEA; sporangiophores arising from aerial hyphae, 60–160  $\mu\text{m}$  tall, with abundant basitonous ramification (habit of *M. humilis* Linnem.), tapering from 7–9  $\mu\text{m}$  to 2.0–2.5  $\mu\text{m}$  near the tip. Sporangia 20–30  $\mu\text{m}$  in diameter, usually not containing more than 10 spores, leaving a minute columella and a collarette on dehiscence. Spores  $\pm$  globose, finely echinulate, 6–12 (–16)  $\mu\text{m}$  in diameter. Chlamydo-spores abundantly produced on SEA, elongate,  $\pm$  lemon-shaped, 10–14  $\mu\text{m}$  in diameter.

CULTURE EXAMINED.—CBS 181.73, ex *Tricholoma flavovirens* (Pers. ex Fr.) Lund., Kootwijker Zand, Netherlands, *W. Gams*, 4 Nov. 1972.

Linnemann's original strains of *M. verrucosa* from Germany and Mexico are lost. The species is described as having sporangiophores up to 260  $\mu\text{m}$  tall, 3–4  $\mu\text{m}$  wide

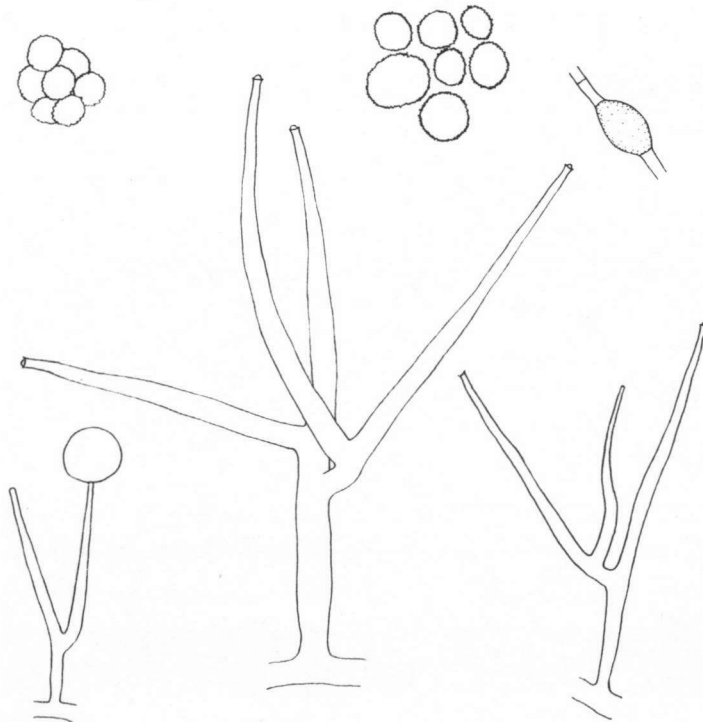


Fig. 6. *Mortierella* cf. *verrucosa*, sporangiophores, sporangium and spores, and chlamydo-spore  $\times 500$ .



near the tip and spores of 15–20  $\mu\text{m}$  diameter. The present strain is the closest to this description so far seen by the author. It is clearly distinct from *M. echinula* by shorter sporangiophores and somewhat larger spores.

7. *MORTIERELLA SARNYENSIS* Mil'ko  
in Nov. Sist. niz. Rast. 1973: 87.—Fig. 7

*Mortierella fatshederae* Linnem. in Zycha & Siepmann, Mucorales, 205. 1970 ('1969') (nom. inval. Art. 37).

Colonies growing moderately fast with a daily increment of approx. 5 mm, densely lobed, with much aerial mycelium in the centre; odour strong and typical of the genus. Good sporulation on SEA, less on MEA; sporangiophores arising from aerial hyphae, 100–275  $\mu\text{m}$  tall, many times basitonously branched, tapering from 5–7  $\mu\text{m}$  to 1.5–2.5  $\mu\text{m}$  near the tip. Sporangia 12–22  $\mu\text{m}$  in diameter, many-spored, leaving an indistinct collarete on dehiscence. Spores ellipsoidal to cylindrical, smooth-walled, 5.5–7.0  $\times$  3.5–4.5  $\mu\text{m}$ . Chlamydospores absent.

CULTURE EXAMINED.—CBS 122.72 = BKM-F 1638, type strain, ex soil near Sarny, Ukr. S. S. R., A. A. Mil'ko, 1971.

*Mortierella fatshederae* Linnem. was not validly published nor has a strain of it been preserved; neither can the designation of an iconotypus by Linnemann (1971) be accepted as a validation. It is described as having strongly bent sporangiophores but in all other aspects it agrees with the present species. *Mortierella sarnyensis* is very close to *M. elongata* Linnem. from which it is supposed to differ by shorter spores (Mil'ko, 1974) and the absence of chlamydospores. The sporangiophores are considerably shorter. The first criterion cannot be regarded as significant because many compatible strains of *M. elongata* with equally small spores have become available. In a mating experiment with a tester pair of *M. elongata* no zygospores were obtained.

8. *Mortierella elongatula* W. Gams & Domsch *spec. nov.*—Fig. 8

Coloniae fere lente crescunt, dense et inconspicue lobulatae, in medio parco mycelio aereo obtectae, typice olent. Sporangiphora ex hyphis aeriis oriuntur, 100–>300  $\mu\text{m}$  alta, raro basitone ramosa, e 4–13  $\mu\text{m}$  ad 1.0–2.5  $\mu\text{m}$  angustata. Sporangia 10–30  $\mu\text{m}$  diam., multisporea, dilapsa collare inconspicuum relinquunt. Sporae ellipsoideo-fusifformes, leves, 5.5–8.5  $\times$  2.0–3.0  $\mu\text{m}$ . Chlamydosporae copiosae, tenuitunicatae, globosae, nonnumquam paucis appendicibus papillatis praeditae, ad 40  $\mu\text{m}$  diam., guttulis oleaginosi repletae.

Holotypus: CBS 488.70, isolatus e dejectis domesticis, Braunschweig in Germania, K. H. Domsch, 1970.

Colonies growing rather slowly, with a daily radial increment of 4–5 mm, with a delicate rosette pattern of dense lobes, in the centre with some aerial mycelium; odour typical of the genus, moderately strong. Sporulation poor on MEA, better on SEA; sporangiophores arising from aerial hyphae, 100 to more than 300  $\mu\text{m}$  tall, rarely basitonously branched, tapering from 4–13  $\mu\text{m}$  to 1.0–2.5  $\mu\text{m}$  at the tip.

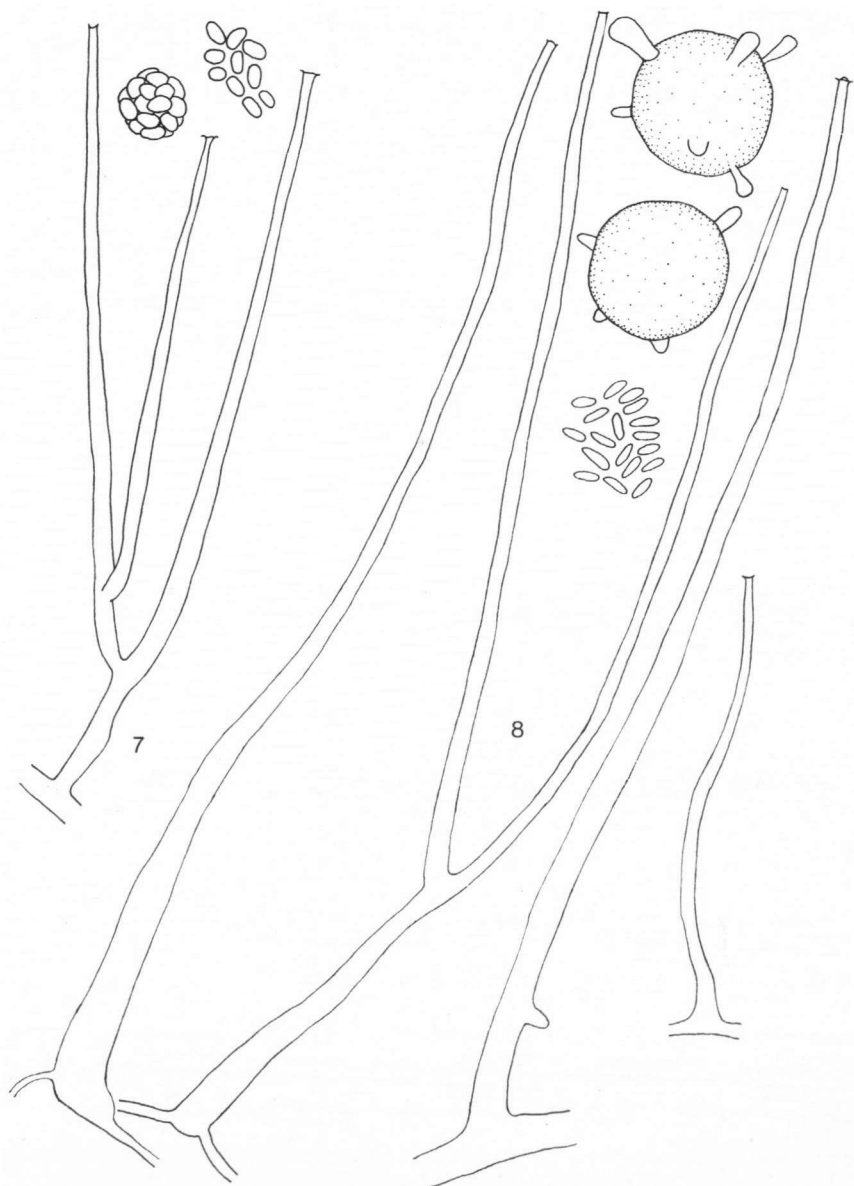


Fig. 7. *Mortierella sarmyensis*, sporangiophore, sporangium, and spores  $\times 500$ .

Fig. 8. *Mortierella elongatula*, CBS 468.70, sporangiophores, spores, and chlamydospores  $\times 500$ .

Sporangia 10–30  $\mu\text{m}$  in diameter, many-spored, leaving an indistinct collarette on dehiscence. Spores ellipsoidal to fusiform, smooth-walled, 5.5–8.5  $\times$  2.0–3.0  $\mu\text{m}$ . Chlamydospores abundantly produced on MEA and some other media, scarcely on SEA, thin-walled, globose, up to 40  $\mu\text{m}$  in diameter, sometimes with a few teat-like appendages, filled with small oil droplets.

CULTURES EXAMINED.—CBS 488.70 (D 79) and 661.70 (D 224), ex municipal wastes, Braunschweig, F. R. G., *K. H. Domsch*, 1970.

*Mortierella elongatula* is close to *M. elongata* Linnem. and *M. epigama* W. Gams & Domsch (Gams & al., 1972). It differs from the former by more fusiform spores and the presence of larger and globose chlamydospores. The latter species has similar spores but is homothallic and produces abundant zygospores but no chlamydospores. In mating experiments with *M. elongata* no reaction was observed; therefore *M. elongatula* is regarded as a distinct species.

#### 9. MORTIERELLA GEMMIFERA Ellis

in *Trans. Br. mycol. Soc.* **24**: 95. 1940.—Fig. 9

Colonies growing rather fast with a daily radial increment of 5–8 mm, broadly lobed and zonate, evenly covered with a thin cottony aerial mycelium with numerous hyphal knots. Sporulation good on SEA, somewhat less on MEA; sporangiophores arising from the substratum and from aerial hyphae, 600–700  $\mu\text{m}$  tall, with frequent basitonus ramification, tapering from 10–13  $\mu\text{m}$  to 2–4  $\mu\text{m}$  near the tip. Sporangia 12–35  $\mu\text{m}$  in diameter, leaving a minute trace of a columella and a distinct collarette on dehiscence. Spores short ellipsoidal to cylindrical, often irregularly bent, smooth-

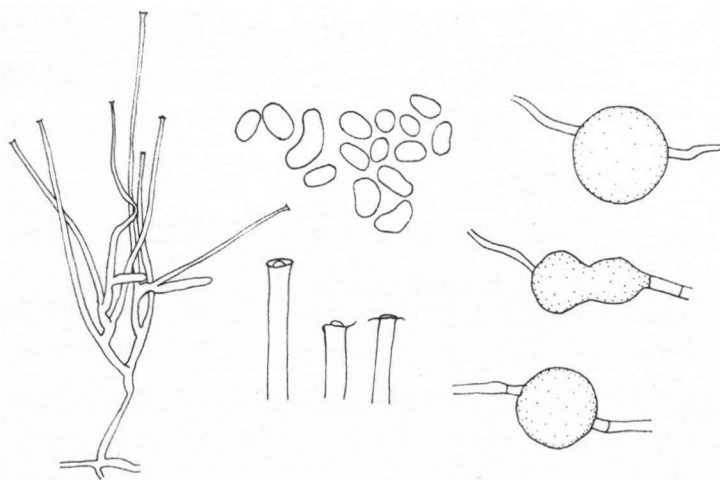


Fig. 9. *Mortierella gemmifera*, strain Kuhlman 4 II A: sporangiophore  $\times$  100; sporangiophore tips, and chlamydospores  $\times$  500.

walled,  $8-12(-17) \times 5-7(-9) \mu\text{m}$ . Chlamydo-spores abundant, globose or irregularly lemon-shaped, ochraceous,  $20-25 \mu\text{m}$  in diameter (orig. description  $30-50 \mu\text{m}$ ). Invested zygo-spores,  $100-150 \mu\text{m}$  in diameter, were described by Ellis (l.c.) but not observed since.

CULTURES EXAMINED.—CBS 134.45=NCTC 6082, type strain, ex pine forest soil near Nottingham, G. B.; CBS 842.70 (strain 7353), ex forest soil, sent by Mrs. M. Turner to E. G. Kuhlman in 1970, possibly identical with CBS 134.45 but with better sporulation.

CBS 124.72, ex humus layer of an oak forest soil, Meerdink-Bos near Winterswijk, Netherlands, B. E. Söderström, 1971.

NRRL A-16538, ex pine roots, North Carolina, E. G. Kuhlman (4IIA).

After publishing *M. gemmifera*, Turner (pers. comm.) doubted the justification of the specific separation of this species. Mating experiments with a tester pair of *M. elongata* Linnem. had no results. Therefore this uncommon species is regarded as sufficiently distinct.

#### 10. *Mortierella kuhlmanii* W. Gams *spec. nov.*—Fig. 10

*Mortierella elongata* Linnem. sensu Kuhlman in *Mycologia* 64: 335. 1972.

Coloniae celeriter crescunt, modice zonatae, mycelio aereo tenui obtectae, fortiter olent. Sporangio-phora numerosa ex hyphis submersis vel aeriis oriuntur,  $250-500 \mu\text{m}$  alta, crebro basitone ramosa, e  $12-20 \mu\text{m}$  ad  $4-8(-10) \mu\text{m}$  angustata, sed in summo ad  $8-14 \mu\text{m}$  inflata. Sporangia  $25-30 \mu\text{m}$  diam., multispora, dilapsa columellam applanatam conspicuam relinquunt. Sporae elongato-ellipsoideae, nonnumquam curvatae, leves,  $8-12(-17) \times 4-5(-7) \mu\text{m}$ . Chlamydo-spores abundantes, globosae, singulae, ochraceae,  $9-22 \mu\text{m}$  diam. Species homothallica: zygo-spores crassitunicatae, leves,  $50-55 \mu\text{m}$  diam.

Holotypus: CBS 157.71, isolatus e trunco *Pinii palustris*, Miley in Carolina meridionali, U.S.A., E. G. Kuhlman, 1971.

Colonies fast-growing with a daily radial increment of 8–9 mm, faintly zonate, covered with thin aerial mycelium; odour strong and typical of the genus. Sporulation good on MEA and SEA; sporangiophores arising from the substratum and aerial hyphae,  $250-500 \mu\text{m}$  tall, with abundant basitonous ramification, tapering from  $12-20 \mu\text{m}$  to  $4-8(-10) \mu\text{m}$  below the tip, with a pronounced apical inflation (apophysis) of  $8-14 \mu\text{m}$  in diameter and a slightly lower columella. Sporangia  $25-35 \mu\text{m}$  in diameter, many-spored. Spores elongate ellipsoidal, sometimes curved, smooth-walled,  $8-12(-17) \times 4-5(-7) \mu\text{m}$ . Chlamydo-spores abundant, globose, solitary, ochraceous,  $9-22 \mu\text{m}$  in diameter. Zygo-spore formation in the homothallic species was described by Kuhlman (1972) but could not be reproduced by the present author; zygo-spores smooth and thick-walled,  $50-55 \mu\text{m}$  in diameter.

CULTURES EXAMINED.—CBS 157.71, type strain, ex stump of *Pinus palustris*, Miley, South Carolina; CBS 269.71 (=NRRL A-11646); CBS 270.71, ex stump of *Pinus taeda*, Patrick, South Carolina; CBS 271.71, ex seedling of *Pinus palustris*, South Carolina; all comm. E. G. Kuhlman.

*Mortierella kuhlmanii* differs from the similar *M. elongata* by the wide sporangiophores with an apical apophysis and the larger and globose chlamydo-spores. The distinction

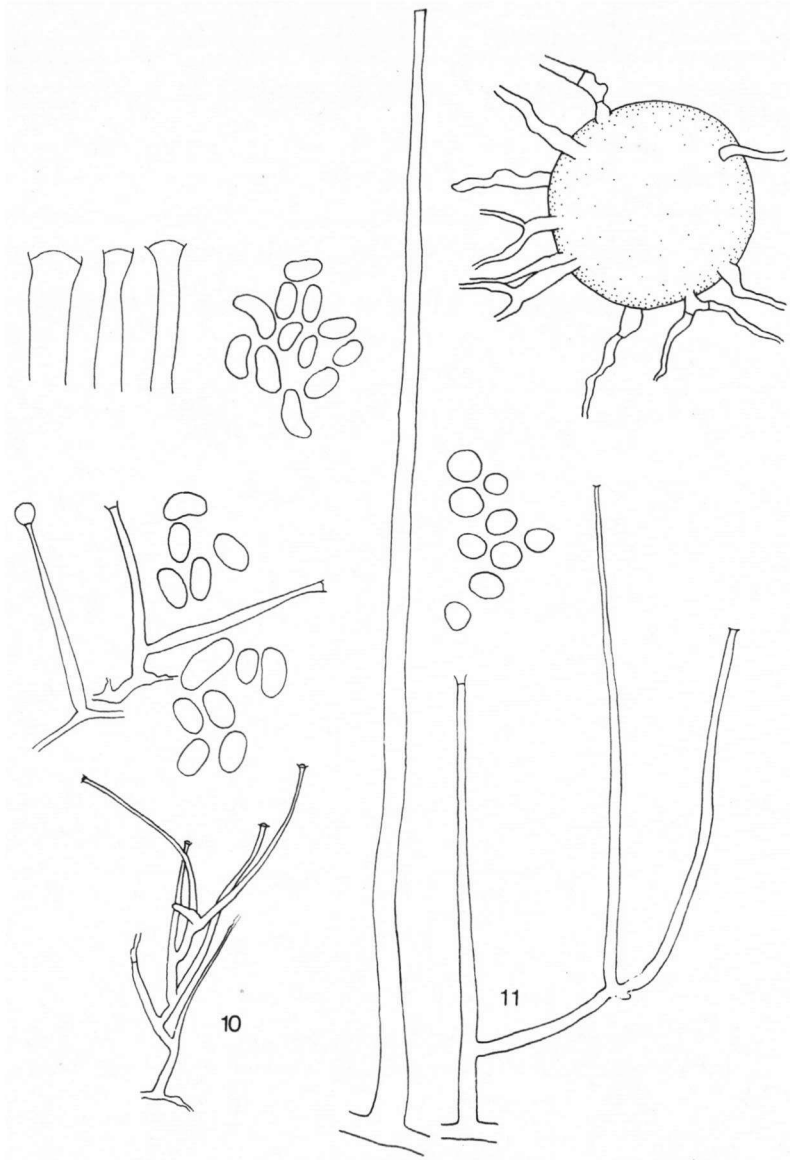


Fig. 10. *Mortierella kuhlmanii*, CBS 157.71 and 271.71: sporangiophores  $\times 100$ ; sporangiophore tips and spores  $\times 500$ .

Fig. 11. *Mortierella sclerotiella*, sporangiophores, spores, and a chlamydospore  $\times 500$ .

between these two species is also proved by the absence of any mating reaction between a tester pair of *M. elongata* and *M. kuhlmanii*. *Mortierella elongata* has smaller zygospores with a honey-comb like surface (Gams & al., 1972). *Mortierella kuhlmanii* has more affinity with *M. beljakovae* Mil'ko (cf. below) because of the apophysate sporangiophores; it differs from this species by the more elongate spores, always solitary chlamydospores and the homothallic behaviour, whilst *M. beljakovae* is heterothallic (Kuhlman, 1972).

#### 11. MORTIERELLA BELJAKOVAE Mil'ko

in Nov. Sist. niz. Rast. 1973: 85.—Fig. 12

*Mortierella candelabrum* Tiegh. & Le Monn. sensu Kuhlman in Can. J. Bot. 47: 1721. 1969; in Mycologia 64: 334. 1972.

*Mortierella zychnae* Linnem. sensu Kuhlman in Mycologia 64: 339. 1972.

Colonies fast-growing with a daily radial increment of 6–9 mm, surface even or sometimes broadly zonate and usually without aerial mycelium; odour typical of the genus but not strong (on SEA). Sporulation abundant on SEA, less on MEA; sporangiophores arising from the substratum, 150 to more than 800  $\mu\text{m}$  tall, with abundant basitonous ramification, tapering from 10–15(–18)  $\mu\text{m}$  to 4–8  $\mu\text{m}$  below the tip, with an inflation (apophysis) 7–13  $\mu\text{m}$  in diameter, and a somewhat shorter columella. Sporangia 20–35  $\mu\text{m}$  in diameter, many-spored. Spores short ellipsoidal to subglobose, smooth-walled, 6–9(–11)  $\times$  5–8  $\mu\text{m}$ . Chlamydospores abundantly produced, solitary or often in chains or irregular clusters (reminiscent of *M. zychnae* Linnem.), globose, thick-walled, ochraceous, 20–45(–60)  $\mu\text{m}$  in diameter. Zygospores were obtained by Kuhlman (1972) after mating between compatible strains; zygospores smooth and thick-walled, 43–56  $\mu\text{m}$  in diameter.

CULTURES EXAMINED.—CBS 805.68 (2 B) and 806.68 (127), ex pine root bark, North Carolina, E. G. Kuhlman, 1968 (previously preserved as *M. gemmifera* Ellis).

CBS 601.68 (13 B), ex pine stump bark; CBS 267.71 (M 70), mating type A, and 268.71 (M 72), mating type B, ex *Pinus taeda* seedling, E. G. Kuhlman, 1971, sent as *M. zychnae* Linnem.

CBS 274.71 (M 92), mating type A, CBS 275.71 (M 29, NRRL A-16539), mating type B, CBS 276.71 (M 93, NRRL A-16540), mating type A, all three ex *Pinus taeda* root, South Carolina, E. G. Kuhlman, 1971, sent as *M. candelabrum* Tiegh. & Le Monn.

CBS 123.72 = BKM F-1608, type strain, ex soil near Sarny, Ukr. S. S. R., A. A. Mil'ko, 1971.

CBS 209.72 (M 122), ex Piedmont soil, North Carolina, C. S. Hodges, 1971 (comm. E. G. Kuhlman).

The arrangement of the chlamydospores in chains and clusters has been observed in all strains but is not equally pronounced in all of them. The single chlamydospores are usually completely rounded off in contrast with *M. zychnae* Linnem., where the chlamydospore outline merges gradually into the connecting hyphal parts. The sporangiophores of *M. zychnae* are more slender than in *M. beljakovae* and do not have an apophysis. No further difference was observed between the strains originally sent as *M. candelabrum* and *M. zychnae*. The species is very close to *M. kuhlmanii* W. Gams

(cf. p. 122). Gams & Domsch (1970) put forward arguments for synonymizing *M. spinosa* Linnem. with *M. candelabrum* but this suggestion was not taken over by other specialists in this genus. The original description of *M. candelabrum* (van Tieghem & Le Monnier, 1873) agrees less with *M. beljakovae* than with *M. spinosa* or *M. hyalina*

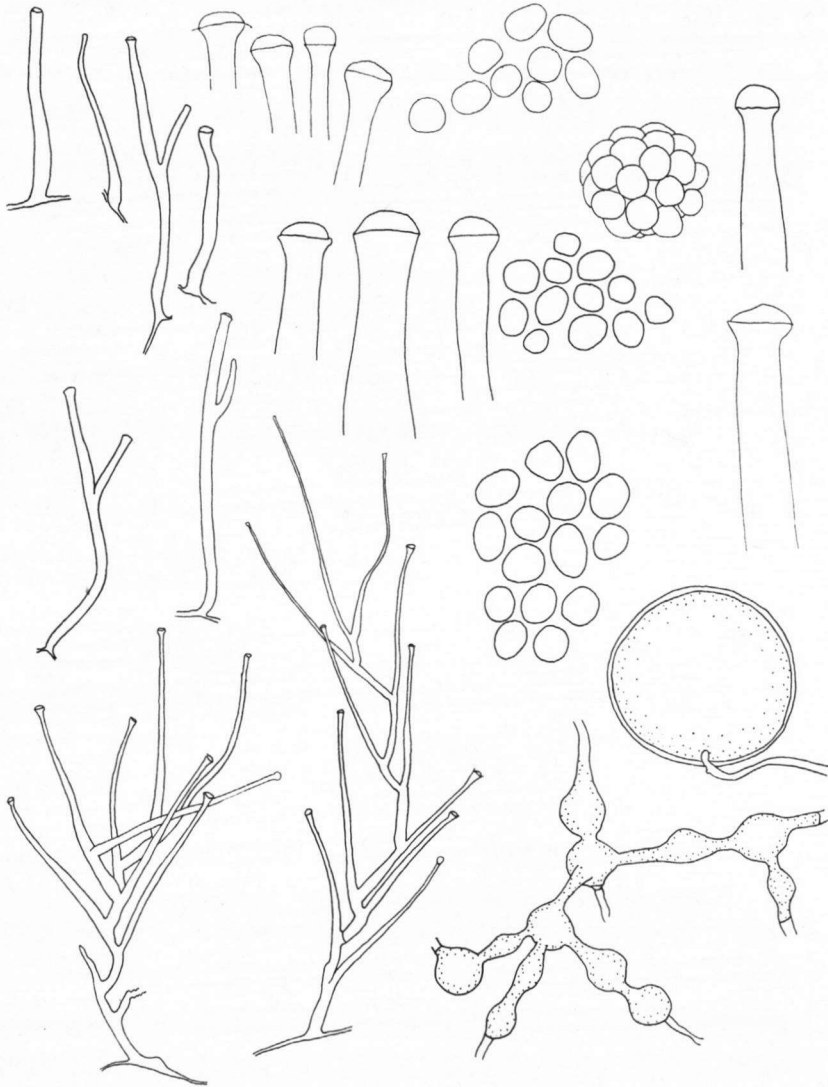


Fig. 12. *Mortierella beljakovae*: CBS 806.68, sporangiophores  $\times 100$ , sporangiophore tips and spores  $\times 500$ ; CBS 209.72, chlamydo spores  $\times 500$ .

(Harz) W. Gams; moreover, *M. beljakovae* is apparently very rare or absent in central and western Europe and has probably not been available to van Tieghem & Le Monnier (1873). *Mortierella candelabrum* is best left in the status of a doubtful species, so that misunderstandings about its identity can be avoided.

### 12. *Mortierella parazychae* W. Gams *spec. nov.*—Fig. 13a

Coloniae fere celeriter crescunt, dense lobulatae et zonatae, mycelio acrio in medio obtectae, fortiter olent. Sporangiphora pauca ex hyphis aeriis vel submersis oriuntur, 80–250  $\mu\text{m}$  alta, raro basitone ramosa, e 4–6  $\mu\text{m}$  ad 2.5–3.0  $\mu\text{m}$  angustata. Sporangia 12–20  $\mu\text{m}$  diam., multispora, dilapsa collare inconspicuum et columellam minutissimam relinquunt. Sporae ellipsoideae ad cylindricae, leves, duplicitunicatae, 3.5–8.0  $\times$  2.0–3.3  $\mu\text{m}$ . Chlamydosporae copiosae, praecipue in mycelio acrio, dense catenulatae et acervatae, ex articulis fere globosis, 10–18  $\mu\text{m}$  diam. compositae.

Holotypus: CBS 868.71, isolatus e ligno putrido *Pini sylvestris* una cum *Botryobasidio subcoronato* (Höhn. & Litsch.) Donk, Treck prope Amersfoort in Neerlandia, *J. A. Stalpers*, 1971.

Colonies growing moderately fast with a daily radial increment of 5–7 mm, densely lobed and zonate, with some aerial mycelium in the centre; odour rather strong and typical of the genus. Sporulation moderate on SEA, poor on MEA; sporangiophores arising from aerial hyphae or from the substratum, 80–250  $\mu\text{m}$  tall, with infrequent basitonous ramification, tapering from 4–6  $\mu\text{m}$  to 2.5–3.0  $\mu\text{m}$  at the tip. Sporangia 12–20  $\mu\text{m}$  in diameter, many-spored, leaving an inconspicuous collarette and a trace of a columella on dehiscence. Spores ellipsoidal to cylindrical, smooth-walled, surrounded by a thin outer wall, 3.5–8.0  $\times$  2.0–3.3  $\mu\text{m}$ . Chlamydospores abundantly produced, particularly in the aerial mycelium, in dense clusters, almost globose, gradually merging into the narrow portions, thin-walled, 10–18  $\mu\text{m}$  in diameter.

Known only from the type culture.

*Mortierella parazychae* differs from the similar *M. zychae* Linnem. (see Fig. 13b for comparison) by smaller (*M. zychae* 8–12  $\times$  4.5–6.0  $\mu\text{m}$ ), double-walled spores and also shorter, less conspicuously branched sporangiophores.

### 13. MORTIERELLA SCLEROTIELLA Mil'ko

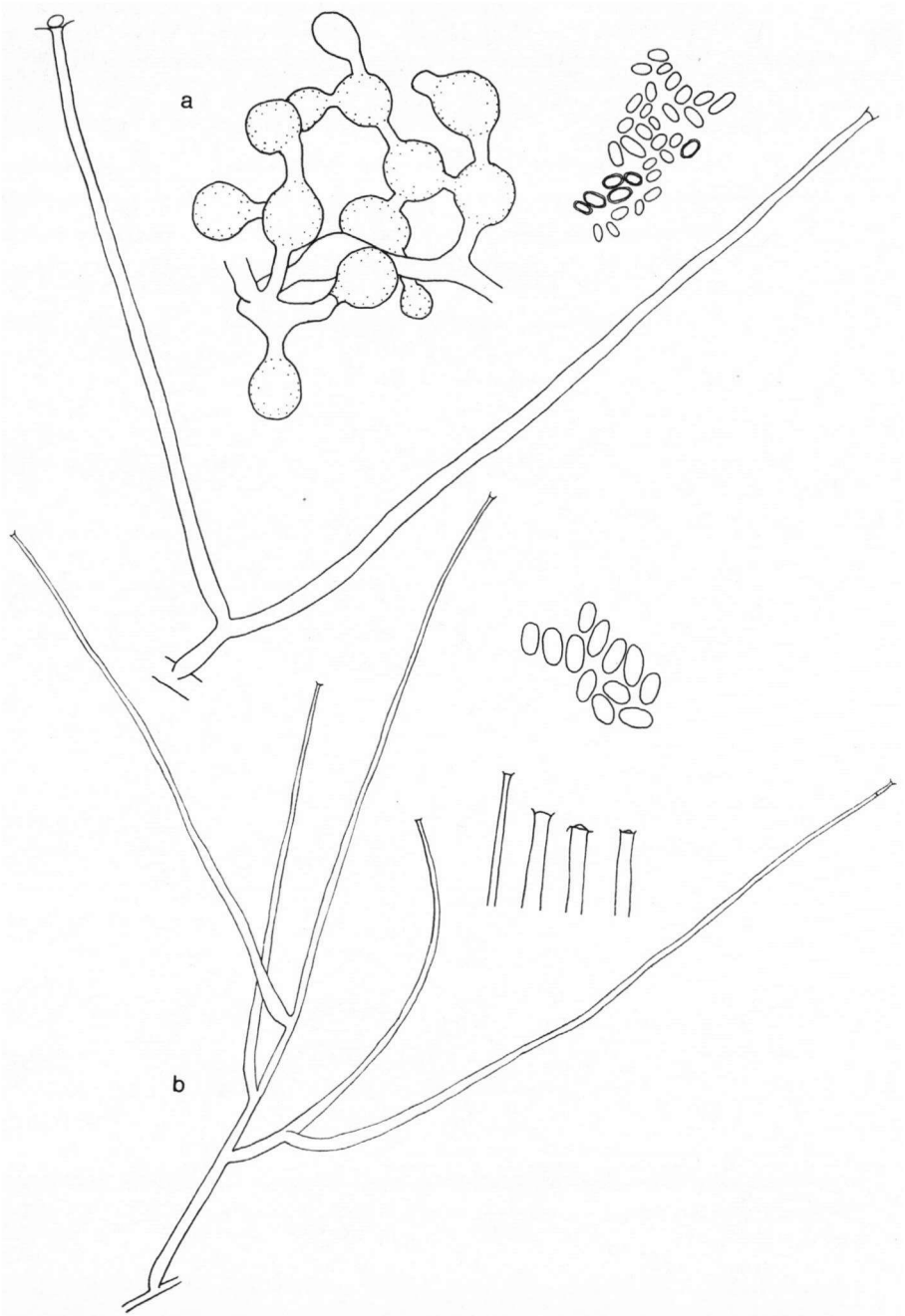
in Nov. Sist. niz. Rast. 1967: 160.—Fig. 11

Colonies growing moderately fast, with a daily radial increment of 5–6 mm, densely lobed and zonate with little aerial mycelium in the centre; odour weak but typical of the genus on SEA. Sporulation moderate on SEA; sporangiophores arising from the substratum or from aerial hyphae, 50–300  $\mu\text{m}$  tall, with basitonous ramification, tapering from 5–8  $\mu\text{m}$  to 2–4  $\mu\text{m}$  at the tip. Sporangia 15–20  $\mu\text{m}$  in diameter, few-spored, on dehiscence leaving an imperceptible collarette. Spores

Fig. 13a. *Mortierella parazychae*, sporangiophore, spores, and cluster of chlamydospores  $\times$  500.

Fig. 13b. *Mortierella zychae*, CBS 316.52: sporangiophore  $\times$  100; sporangiophore tips and spores  $\times$  500.





short ellipsoidal to subglobose, sometimes curved, with a minute striate ornamentation (visible particularly in lactic acid mounts where the outer wall is separated from the spore content),  $6-10 \times 6-8 \mu\text{m}$ . Chlamydospores abundantly produced, globose, sometimes elongate, ochraceous,  $40-90 \mu\text{m}$  in diameter, often giving rise to numerous shorter or longer radiating hyphae.

CULTURE EXAMINED.—CBS 529.68 = BKM-F 1909, type strain, ex mouse excrements, near Kiev, Ukr.S.S.R., A.A. Mil'ko, 1964.

*M. sclerotiella* is close to *M. gemmifera* Ellis, but differs by shorter, finely ornamented spores and the fimbriate appearance of the chlamydospores.

#### 14. *Mortierella armillariicola* W. Gams *spec. nov.*—Fig. 14

Coloniae celeriter crescunt, in margine lobulatae, in medio mycelio acrio obtectae, vix olent. Sporangiphora ex hyphis aeriis vel submersis oriuntur, ad  $1500-1700 \mu\text{m}$  alta, irregulariter basitone vel mesotone vel raro acrotone ramosa, e  $18-20 \mu\text{m}$  ad  $5-7 \mu\text{m}$  angustata. Sporangia  $60->90 \mu\text{m}$  diam., multisporea, dilapsa collare fere conspicuum relinquunt. Sporae irregulariter elongatae, saepe reniformes, leves,  $18-26(-32) \times 8-12(-17) \mu\text{m}$ . Chlamydosporae globosae, singulae, crassitunicatae,  $40-60 \mu\text{m}$  diam.

Holotypus: CBS 914.73, isolatus e lamellis *Armillariae melleae* una cum *Endomycete decipiente* (Tul.) Reess, Groeneveld prope Baarn in Neerlandia, W. Gams, Nov. 1973.

Colonies in fresh isolates fast-growing, after some transfers slow, with a daily radial increment of 2 mm, minutely lobed at the margin, covered with some aerial mycelium in the centre; odour weak. Sporulation abundant on SEA and PCA, moderate on MEA; sporangiophores arising from aerial and submerged hyphae, with a little distinct base, up to  $1500-1700 \mu\text{m}$  tall, with irregularly basitonous to mesotonous or rarely acrotonus ramification, tapering from  $18-20 \mu\text{m}$  to  $5-7 \mu\text{m}$  near the tip. Sporangia  $60-$  over  $90 \mu\text{m}$  in diameter, many-spored, leaving a rather conspicuous collarette but no columella on dehiscence. Spores irregularly elongate, often kidney-shaped, smooth-walled,  $18-26(-32) \times 8-12(-17) \mu\text{m}$ . Chlamydospores commonly produced, globose, solitary, thick-walled,  $40-60 \mu\text{m}$  in diameter.

Known only from the type strain and some other isolates from the same origin and locality.

*M. armillariicola* is similar to *M. gemmifera* Ellis, but has much larger dimensions.

#### 15. *Mortierella selenospora* W. Gams *spec. nov.*—Fig. 15

Coloniae celeriter crescunt, late zonatae, mycelio acrio pauco obtectae, modice olent. Sporangiphora ex hyphis submersis oriuntur, paucis rhizoideis praedita,  $350-900 \mu\text{m}$  alta, basitone vel mesotone ramosa, e  $7-12 \mu\text{m}$  ad  $3 \mu\text{m}$  angustata. Sporangia  $35-50 \mu\text{m}$  diam., multisporea, dilapsa collare inconspicuum relinquunt. Sporae lunatae, pariete utrinque inspisato, leves,  $15-20 \times 5-9 \mu\text{m}$ . Chlamydosporae rarae, terminales, pyriformes,  $15-18 \mu\text{m}$  diam.

Holotypus: CBS 811.68, isolatus e fimo culturae agaricorum, Horst/L. in Neerlandia, Sept. 1968.

Colonies fast-growing, with a daily radial increment of 7–8 mm, broadly zonate with little aerial mycelium; odour moderate but typical of the genus. Sporulation abundant on SEA, less on MEA; sporangiophores arising from the substratum with a few rhizoids, 350–900  $\mu\text{m}$  tall, with basitonous to mesotonous diffuse ramification, tapering from 7–12  $\mu\text{m}$  to 3  $\mu\text{m}$  at the tip. Sporangia 35–50  $\mu\text{m}$  in diameter, many-spored, on dehiscence leaving an inconspicuous collarette. Spores lunate (shape of



Fig. 14. *Mortierella armillariicola*: sporangiophore  $\times 100$ ; sporangiophore tips, spores, and chlamydospore  $\times 500$ .



Fig. 15. *Mortierella selenospora*: sporangiophores  $\times 100$ ; spores  $\times 500$ .

an orange slice) with a thickened wall at either end, smooth-walled,  $15-20 \times 5-9 \mu\text{m}$ . Chlamydospores scarcely produced, terminal, pyriform,  $15-18 \mu\text{m}$  in diameter.

Known only from the type strain.

The only other species with lunate spores is *M. umbellata* Chien (1972) which has unusual acrotonously verticillate sporangiophores and smaller spores of  $7-10 \times 3-5 \mu\text{m}$ .

16. *Mortierella basiparvispora* W. Gams & Grinbergs *spec. nov.*—Fig. 16

Coloniae fere celeriter crescunt, dense radiatim striatae, paucio mycelio aereo in medio obtectae, modice olent. Sporangiophora numerosa ex hyphis submersis oriuntur,  $250-300 \mu\text{m}$  alta, crebro basitone ramosa, e  $8-13(-18) \mu\text{m}$  ad  $3-7 \mu\text{m}$  angustata. Sporangia  $25-50 \mu\text{m}$  diam., multisporea, dilapsa collare conspicuum relinquunt. Sporae subglobosae ad globosae, leves,  $3-4 \mu\text{m}$  diam. vel  $5-6 \times 4-5 \mu\text{m}$ . Chlamydosporae absunt.

Holotypus: CBS 518.72, isolatus e solo sub *Fitzroya cupressoides*, Cordillera Pelada prope Valdiviam Chilensem, J. Grinbergs, 1972.

Colonies growing moderately fast, with a daily radial increment of 4–5 mm, narrowly radially striate, with little aerial mycelium in the centre; odour faint, but typical of the genus. Sporulation moderate on MEA, very rich on SEA; sporangiophores arising from the substratum, 250–300  $\mu\text{m}$  tall, with repeated basitonous ramification, tapering from 8–13(–18)  $\mu\text{m}$  to 3–7  $\mu\text{m}$  near the tip. Sporangia 25–50  $\mu\text{m}$  in diameter, many-spored, leaving a conspicuous collarette on dehiscence. Spores subglobose to globose, smooth-walled, 3–4  $\mu\text{m}$  in diameter or 5–6  $\times$  4–5  $\mu\text{m}$ . Chlamydospores absent.

CULTURES EXAMINED.—CBS 517.72 (No. 21) and 518.72 (No. 108), type strain, ex soil under *Fitzroya cupressoides*, Cordillera Pelada, Valdivia, Chile, *J. Grinbergs*, 1972.

The two strains differ somewhat in spore size and shape: 518.72 has smaller and globose spores and the sporangiophores are more slender at the tip (3  $\mu\text{m}$ ), whilst in CBS 517.72 the spores are bigger, subglobose and the sporangiophore tips 5–7  $\mu\text{m}$  wide. *Mortierella basiparvispora* can be regarded as a counterpart of *M. parvispora* Linnem. with consistently basitonous ramification and no trace of a columella; therefore it is placed in sect. *Hygrophila*.

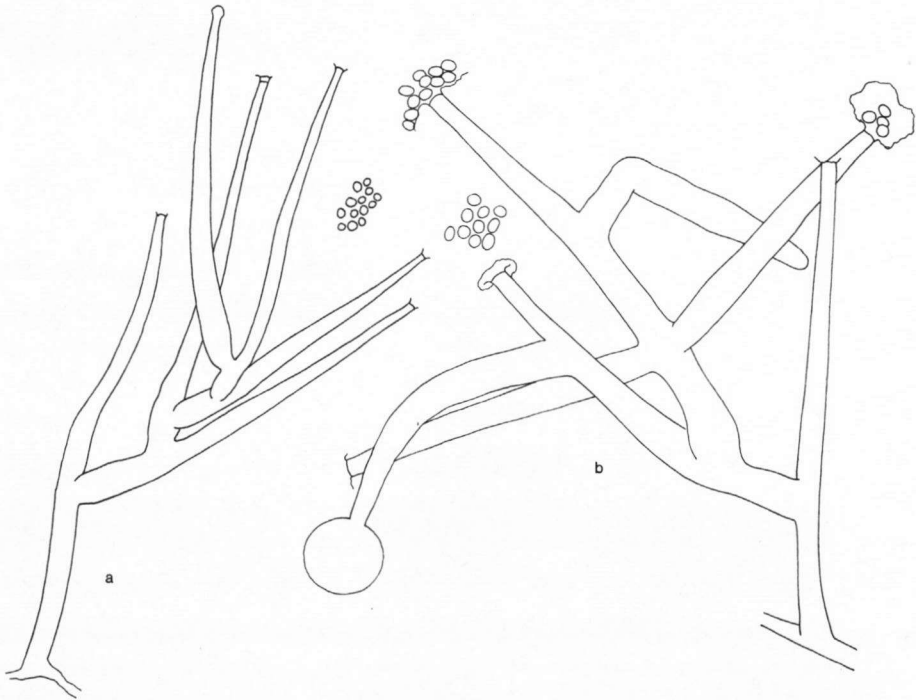


Fig. 16. *Mortierella basiparvispora*, sporangiophores and spores  $\times 330$ . — a. CBS 518.72. — b. CBS 517.72.

17. *Mortierella clonocystis* W. Gams *spec. nov.*—Fig. 17

Coloniae modice celeriter crescunt, late lobatae, quoque lobo mycelio aërio obtecto, modice olent. Sporangiophora pauca plerumque ex hyphis submersis oriuntur, 85–160  $\mu\text{m}$  alta, raro unum ramum mesotonum proferunt, e 2.5–3.0  $\mu\text{m}$  ad 1.0  $\mu\text{m}$  angustata. Sporangia 10–12  $\mu\text{m}$  diam., multispora, dilapsa collare inconspicuum relinquunt. Sporae subglobosae, leves, 2.5–4.0  $\mu\text{m}$  diam. Chlamydosporae aut parvae globosae, 6–10  $\mu\text{m}$  diam., aut rangiformes ex hyphis ramosis inflatus submersis vel aëriis, 7–12  $\mu\text{m}$  latis transformatae.

Holotypus: CBS 357.76, isolatus e solo sub *Apollonia canariensi* (Willd.) Nees in insula Gran Canaria prope Tafiram, leg. J. A. von Arx, Apr. 1976.;

Colonies growing moderately fast with a daily radial increment of 6–8 mm, broadly lobed, with patchy floccose aerial mycelium on the lobes; odour not strong but typical of the genus. Sporulation moderate on SEA, absent on MEA. Sporangiophores mostly arising from the substratum, 85–160  $\mu\text{m}$  tall, rarely bearing a mesotonously inserted lateral branch, tapering from 2.5–3.0  $\mu\text{m}$  to 1.0  $\mu\text{m}$ . Sporangia 10–12  $\mu\text{m}$  in diameter, many-spored, on dehiscence leaving an inconspicuous collar. Spores subglobose, smooth-walled, 2.5–4.0  $\mu\text{m}$  in diameter. Chlamydospores of two types: (a) small,  $\pm$  globose, 6–10  $\mu\text{m}$  in diameter, and (b) consisting of submerged or aerial broadened hyphal branches, repeatedly dichotomous, 7–12  $\mu\text{m}$  wide.

Known only from the type strain.

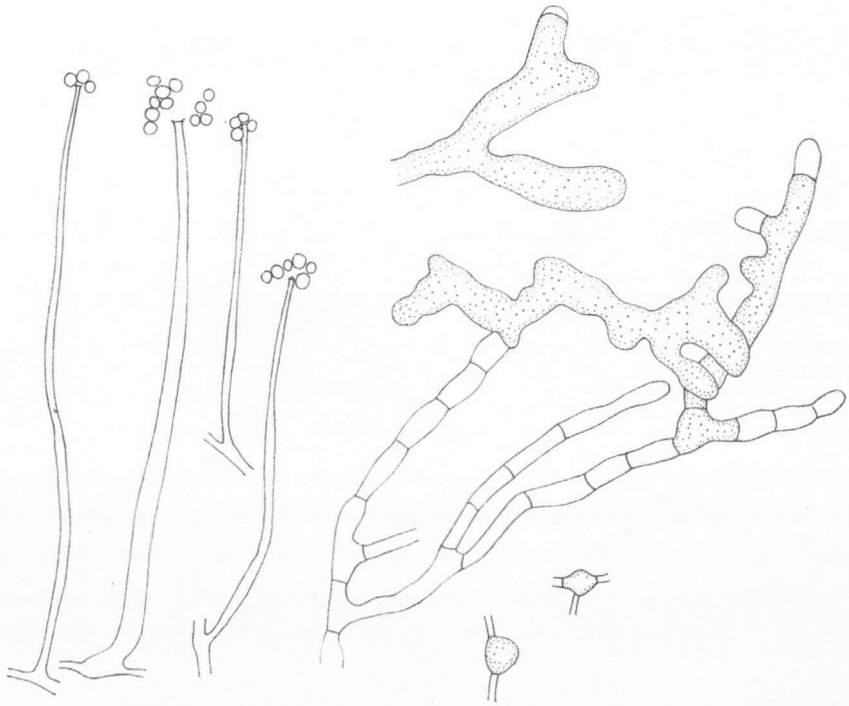


Fig. 17. *Mortierella clonocystis*, sporangiophores, spores, and two kinds of chlamydospores  $\times 500$ .

*Mortierella clonocystis* recalls *M. globalpina*, but has longer and more slender sporangiophores with an occasional side branch. It is therefore placed in section *Hygrophila*.

#### SECTION SPINOSA Linnem. emend. W. Gams

Sporangiophores with a wide, often curved base, bearing mesotonous to acrotonous cymose branches. Sporangia usually with a minute columella.

#### 18. *Mortierella epicladia* W. Gams & Emden *spec. nov.*—Fig. 18

Coloniae fere celeriter crescunt, dense lobulatae, mycelio aërio parco obtectae, modice olent. Sporangiphora ex hyphis submersis vel aëriis oriuntur, 60–160  $\mu\text{m}$  alta, 1–3 ramos acrotonos proferunt, e 6–8(–9)  $\mu\text{m}$  ad 1.5–2.0(–3.5)  $\mu\text{m}$  angustata. Sporangia 12–20  $\mu\text{m}$  diam., multi-spora, dilapsa columellam minutam et collare inconspicuum relinquunt. Sporae  $\pm$  globosae, leves, 4–7(–10)  $\mu\text{m}$  diam. Chlamydosporae raras,  $\pm$  limoniformes, vulgo 6  $\mu\text{m}$  diam.

Holotypus: CBS 355.76, isolatus e solo sub *Apollonia canaricensis* (Willd.) Nees in insula Gran Canaria prope Tafiram, leg. J. A. von Arx, Apr. 1976.

Colonies growing moderately fast with a daily radial increment of 6–8 mm, forming a rosette of dense lobes, with very little aerial mycelium; odour moderate but typical of the genus. Sporulation rich on SEA, less on MEA, sporangiophores arising from the substratum or aerial hyphae, 60–160  $\mu\text{m}$  tall, bearing 1–3 acrotonous branches, tapering from 6–8(–9) to 1.5–2.0 (–3.5)  $\mu\text{m}$  at the tip. Sporangia 12–20  $\mu\text{m}$  in diameter, many-spored, on dehiscence leaving a minute columella and inconspicuous collarette. Spores  $\pm$  globose, smooth-walled, 4–7(–10)  $\mu\text{m}$  in diameter. Chlamydospores scarcely produced,  $\pm$  lemon-shaped, about 6  $\mu\text{m}$  in diameter.

CULTURES EXAMINED.—CBS 246.75, ex soil under *Elaeis guineensis*, Surinam, J. H. van Emden, 1975.

CBS 355.76 (type strain) and 356.76, ex soil, Gran Canaria, nr. Tefira, under *Apollonias canariensis*, leg. J. A. von Arx, Apr. 1976.

This is the only *Mortierella* species isolated during an extended study of soil fungi in a soil sample from Surinam by J. H. van Emden. *M. epicladia* is closest to *M. pulchella* Linnem., but differs by faster growth (*M. pulchella* has 4–5 mm daily radial increment), slightly bigger spores and the presence of chlamydospores. The relative length of the lateral branches is variable (cf. Fig. 18a and b) as in *M. pulchella* and cannot be regarded as being of taxonomic importance.

#### 19. *Mortierella acrotona* W. Gams *sp. nov.*—Fig. 19

Coloniae celeriter crescunt, late zonatae, mycelio aërio tenui lanuginoso usque ad marginem obtectae, modice olent. Sporangiphora ex hyphis aëriis tarde oriuntur, 110–350  $\mu\text{m}$  alta, plerumque unum (raro duos) ramulum acrotonum proferunt, e 7–12  $\mu\text{m}$  ad 2–5  $\mu\text{m}$  angustata. Sporangia 15–40  $\mu\text{m}$  diam., 1–4-spora, dilapsa collare conspicuum infundibuliforme relinquunt. Sporae globosae, leves, duplicitunicatae, 11–24  $\mu\text{m}$ , plerumque 17–20  $\mu\text{m}$  diam. Chlamydosporae vulgo adsunt, fere globosae, 15–22  $\mu\text{m}$  diam.

Holotypus: CBS 386.71, isolatus e solo prope Rambagh Palace Hotel, Jaipur in India, leg. D. H. Wieringa-Brants, Jan. 1971.

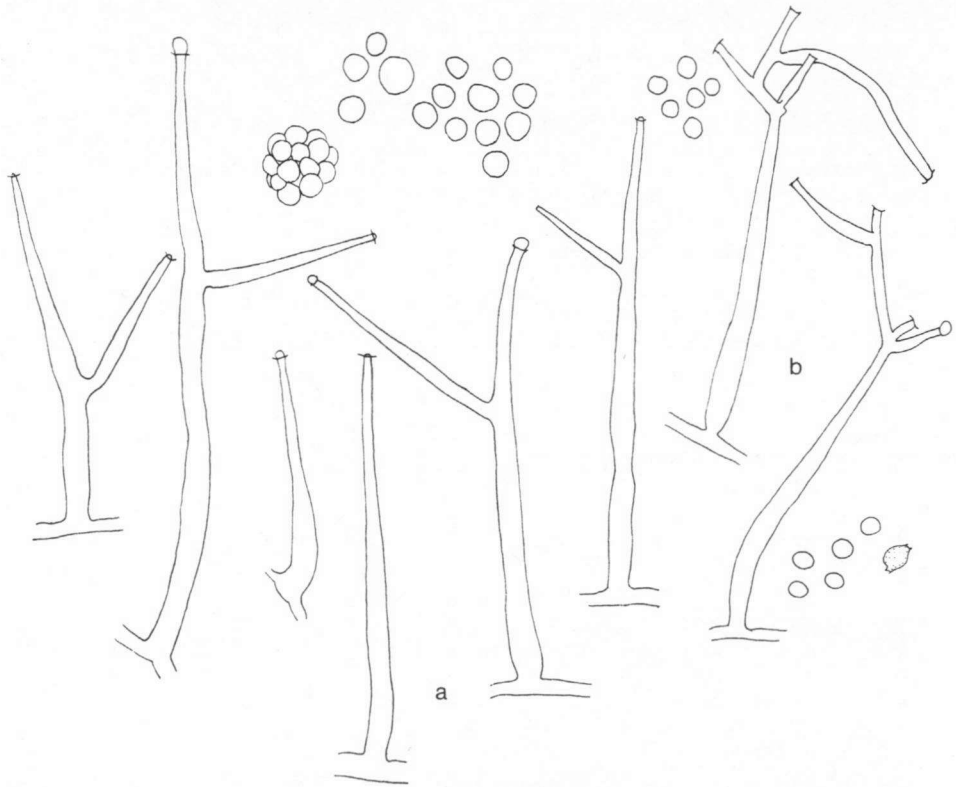


Fig. 18. *Mortierella epicladia*, sporangiophores, sporangium, spores, and chlamydospore  $\times 500$ . — a. CBS 355.76. — b. CBS 246.75.

Colonies fast-growing with a daily radial increment of 9–12 mm, broadly zonate, evenly covered with a thin cottony aerial mycelium which extends to the margin; odour moderate but typical of the genus. Sporulation appearing only after 2–3 weeks on MEA and SEA; sporangiophores arising from aerial hyphae, 110–350  $\mu\text{m}$  tall, bearing usually one (rarely two) acrotonous branches, tapering from 7–12  $\mu\text{m}$  to 2–5  $\mu\text{m}$  at the tip. Sporangia 15–40  $\mu\text{m}$  in diameter, containing each 1–4 spores, on dehiscence leaving a pronounced, funnel-shaped collarette. Spores globose, smooth-walled, surrounded by a thin outer wall, 11–24  $\mu\text{m}$ , mostly 17–20  $\mu\text{m}$  in diameter. Chlamydospores commonly produced, globose, gradually merging into the subtending hypha, 15–22  $\mu\text{m}$  in diameter.

CULTURES EXAMINED.—CBS 383.71, 385.71, 386.71 (type strain), ex soil near Rambagh Palace Hotel, Jaipur (loose light-brown soil), India, leg. D. H. Wieringa-Brants, Jan. 1971.

*Mortierella acrotona* is very distinct by its large, double-walled spores. Similar wall structures occur rarely in species of various sections, viz. in *M. angusta* (Linnem.) W. Gams, *M. parazychnae* W. Gams (cf. p. 126), and *M. wolfii* Mehrotra & Bajjal.



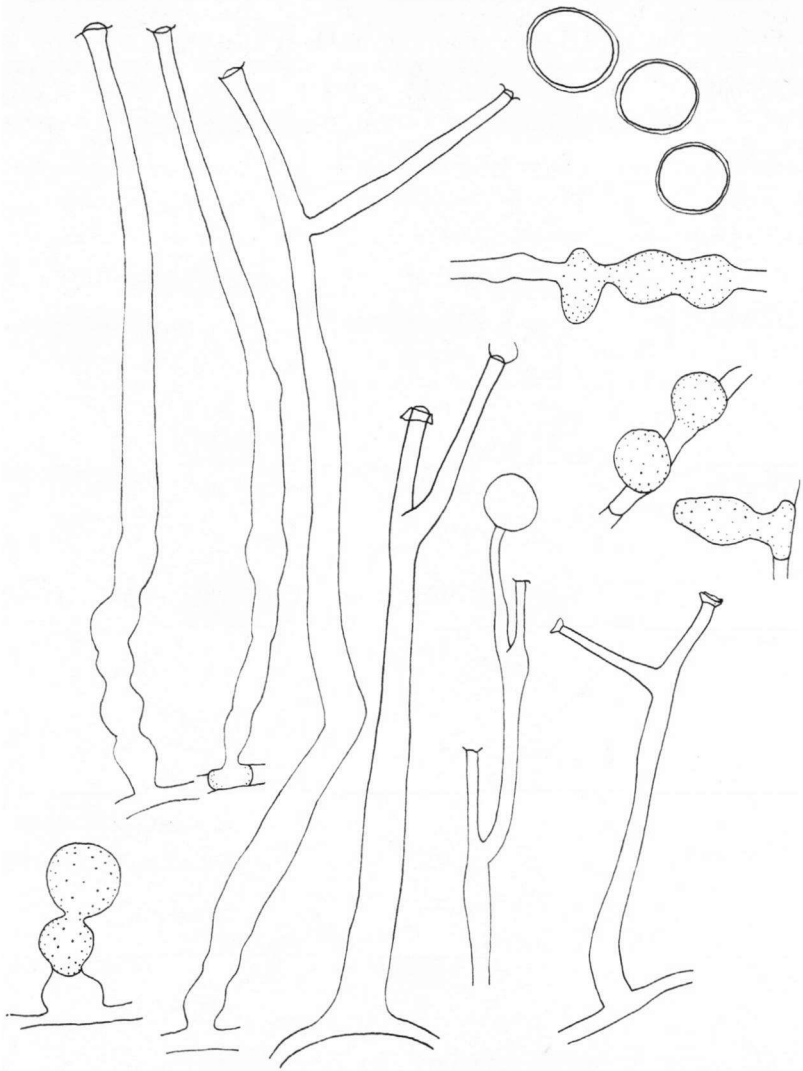


Fig. 19. *Mortierella acrotona*, CBS 386.71 and 385.17, sporangiophores, spores, and chlamydospores  $\times 500$ .

20. *MORTIERELLA JENKINII* (A. L. Sm.) Naumov—Fig. 20

*Mortierella bainieri* Cost. var. *jenkinii* A. L. Sm. in J. Bot., Lond. **36**: 180. 1898. — *Mortierella jenkinii* (A. L. Sm.) Naumov, *Opredelitel' Mukorovykh* (Mucorales), Ed. 2: 97. 1935. Moskva-Leningrad.

Colonies moderately fast-growing with a daily radial increment of about 5 mm, finely radially striate, with little aerial mycelium in the centre; odour typical of the genus but not strong. Sporulation abundant on SEA and oatmeal agar, weak on MEA; sporangiophores arising mostly from aerial hyphae, sometimes from the substratum with rhizoids, 400– over 1500  $\mu\text{m}$  tall, the basal part often curved and up



Fig. 20. *Mortierella jenkinii*, CBS 667.70: sporangiophores  $\times 100$  and  $\times 350$ ; spores  $\times 500$ .

to 600  $\mu\text{m}$  long before the numerous basitonous, mesotonous or acrotonous branches are inserted, tapering from 10–12 (to over 20)  $\mu\text{m}$  to 2.0–3.5  $\mu\text{m}$  at the tip. Sporangia 10–60  $\mu\text{m}$  in diameter, many-spored, on dehiscence leaving a minute trace of a columella and a small collarete. Spores short-ellipsoidal to cylindrical, smooth-walled, 3.5–4.0(–0.5)  $\times$  2.0–2.5  $\mu\text{m}$ . Chlamydospores absent or tardily produced, lemon-shaped, 7–10  $\mu\text{m}$  in diameter. Zygospores were not obtained in spite of repeated mating.

CULTURES EXAMINED.—CBS 109.68, ex *Daedalea quercina* (L. ex Fr.) Pilát, Iloo Forest, Kr. Rendsburg, F. R. G., *W. Gams*, 1965.

CBS 667.70 and 850.70, ex agricultural soil, Wageningen, *J. W. Veenbaas-Rijks*, 1970.

CBS 516.72, ex soil under *Fitzroya cupressoides*, Cordillera Pelada, Valdivia, Chile, *J. Grinbergs* (No. 107), 1972.

CBS 188.73, ex turf layer of a golf green which has received fungicidal treatment for a long period, Nottingham, G. B., comm. *J. I. Williams*, 1973.

CBS 965.73 A–D and 666.75 A–D, ex forest soil under *Picea abies*, Sweden, *B. E. Söderström*.

The strains listed here are of rather constant morphology with the very variable branching pattern ranging from basitonous to acrotonous. The classification in section *Spinosa* is preferred over section *Hygrophila* because of the thick, often curved basal part of the sporangiophores and the sometimes occurring minute columella. This interpretation of *M. jenkinsii* agrees perfectly with the original description and illustration, but expands the range of variability.

## 21. *Mortierella cystojenkinsii* W. Gams & Veenbaas-Rijks *spec. nov.*—Fig. 21

Coloniae fere lente crescunt, leves, parco mycelio aereo obtectae, modice olent. Sporangio-phora numerosa ex hyphis submersis vel aeriis oriuntur, 120–>200  $\mu\text{m}$  alta, raro mesotone vel acrotone ramosa, e 3–8  $\mu\text{m}$  ad 1.2–3.0  $\mu\text{m}$  angustata. Sporangia 10–20  $\mu\text{m}$  diam., multispora, dilapsa collare inconspicuum et columellam minutissimam relinquunt. Sporae ellipsoideo-cylindricae, leves, 3–4  $\times$  1.2–2.0  $\mu\text{m}$ . Chlamydosporae abundantes, globosae, crassitunicatae, dilute brunneae, 20–60  $\mu\text{m}$  diam.

Holotypus: CBS 456.71, isolatus e solo agresti prope Wageningen, *J. W. Veenbaas-Rijks*, 20 Feb. 1971.

Colonies rather slow-growing, with a daily radial increment of about 5 mm, smooth, with little aerial mycelium; odour weak but typical of the genus. Sporulation abundant on MEA and SEA; sporangiophores arising from the substratum and aerial hyphae, 120 to over 200  $\mu\text{m}$  tall, with infrequent mesotonous to acrotonous ramification, tapering from 3–8  $\mu\text{m}$  to 1.2–3.0  $\mu\text{m}$  at the tip. Sporangia 10–20  $\mu\text{m}$  in diameter, many-spored, leaving an inconspicuous collarete on dehiscence and a small trace of a columella. Spores ellipsoidal-cylindrical, smooth-walled, 3–4  $\times$  1.2–2.0  $\mu\text{m}$ . Chlamydospores abundantly produced, globose, thick-walled, light brown, 20–60  $\mu\text{m}$  in diameter.

CULTURES EXAMINED.—CBS 456.71, type strain, ex agricultural soil, Wageningen, *J. W. Veenbaas-Rijks*, 20 Feb. 1971. Another strain was isolated from *Betula* leaf litter, Osterau, Kr. Plön, F. R. G. in 1965, but is now lost.

*Mortierella cystojenkinsii* differs from *M. jenkinsii* not only by the presence of large, globose chlamydospores but also by smaller spores.



Fig. 21. *Mortierella cystojenkinii*: sporangiophore  $\times 100$ ; sporangiophore, spores, and chlamydospore  $\times 500$ . — a. strain from *Betula* litter. — CBS 456.71.

## 22. *Mortierella fimbricystis* W. Gams *spec. nov.*—Fig. 22

Coloniae fere lente crescunt, inconspicue radiatim striatae, mycelio aereo absente, modice olent. Sporangiophora ex hyphis submersis, nonnumquam ad basin rhizoideis praedita, vel ex hyphis aeriis oriuntur, 140–320  $\mu\text{m}$  alta, raro acrotone ramosa, e 7–13  $\mu\text{m}$  ad 2–4  $\mu\text{m}$  angustata. Sporangia 15–30  $\mu\text{m}$  diam., multispora, dilapsa collare inconspicuum et columellam minutissimam relinquunt. Sporae ellipsoideo-cylindricae, leves, 4.0–5.5  $\times$  2.0–3.0  $\mu\text{m}$ . Chlamydosporae copiosae, praecipue in mycelio aereo, intercalares vel laterales, globosae vel elongatae, ochraceae ad aurantiacae, 28–45  $\mu\text{m}$  diam., appendicibus 2–4  $\mu\text{m}$  longis dense fimbriatae.

Holotypus: CBS 973.70, isolatus e pulvino musci cuiusdam, Puerto Edwards in Patagonia meridionali prope canalem navis Beagle, *F. W. Went*, 1970.

Colonies rather slow-growing with a daily radial increment of 3–5 mm, with a fine radiating structure and no aerial mycelium; odour weak but typical of the

genus. Sporulation good on MEA and SEA; sporangiophores arising from the substratum, sometimes with rhizoids, or from aerial hyphae, 140–320  $\mu\text{m}$  tall, with scarce acrotonous ramification, tapering from 7–13  $\mu\text{m}$  to 2–4  $\mu\text{m}$  at the tip. Sporangia 15–30  $\mu\text{m}$  in diameter, many-spored, leaving an inconspicuous collarette and a trace of a columella on dehiscence. Spores ellipsoidal-cylindrical, smooth-walled,

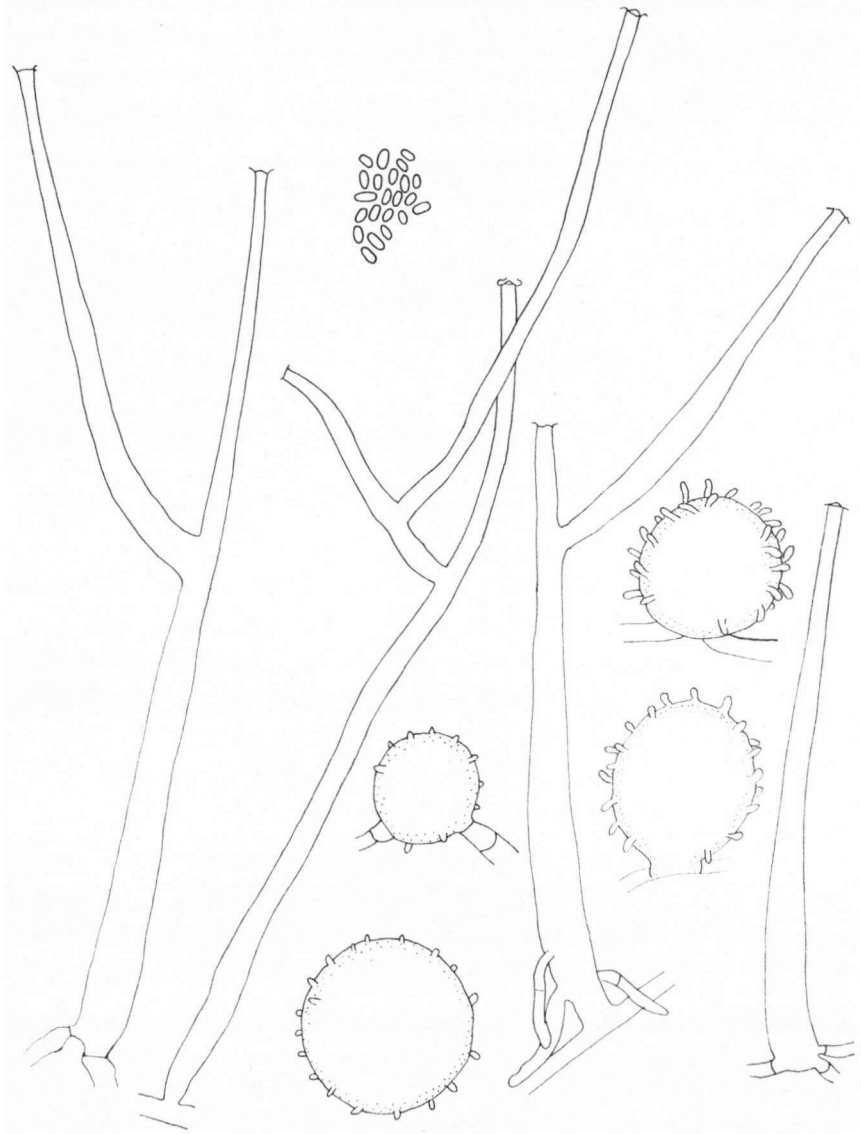


Fig. 22. *Mortierella fimbriocystis*, sporangiophore, spores, and chlamydospores  $\times 500$ .

4.0–5.5 × 2.0–3.0 μm. Chlamydospores abundantly produced, often in the aerial mycelium in intercalary or lateral position, globose or elongate, ochraceous to orange, 28–45 μm in diameter, densely covered with fimbriate appendages, 2–4 μm long.

Known only from the type strain.

*Mortierella fimbriocystis* is close to *M. echinosphaera* Plaats-Niterink (van der Plaats-Niterink & al., 1976) but differs by larger, somewhat pigmented chlamydospores and the presence of sporangiophores. The strain was preserved as *M. alliacea* Linnem. until recently, but differs from this species by taller and branched sporangiophores and also taller chlamydospores.

#### ACKNOWLEDGEMENTS

The writer thanks all the mycologists mentioned in the text who contributed isolates of *Mortierella* to this study. Miss C. A. N. van Oorschot corrected the English and Miss M. Nieuwstad inked the drawings.

#### REFERENCES

- CHIEN, C.-Y. (1971). A new species of *Mortierella* from North Carolina. *In Mycologia* **63**: 826–830.
- (1972). *Mortierella umbellata*, a new species from Georgia. *In Mycologia* **64**: 99–102.
- CHIEN, C.-Y., KUHLMAN, E. G., & GAMS, W. (1974). Zygosporangia in two *Mortierella* species with 'stylospores'. *In Mycologia* **66**: 114–121.
- GAMS, W. (1970). Gliederungsprinzipien in der Gattung *Mortierella*. *In Nova Hedw.* **18**: 30–43 ('1969').
- GAMS, W., CHIEN, C.-Y., & DOMSCH, K. H. (1972). Zygosporangium formation by the heterothallic *Mortierella elongata* and a related homothallic species, *M. epigama* sp. nov. *In Trans. Br. mycol. Soc.* **58**: 5–13.
- GAMS, W. & DOMSCH, K. H. (1970). Bemerkungen zu einigen schwer bestimmbareren Bodenpilzen. *In Nova Hedw.* **18**: 1–29 ('1969').
- GAMS, W. & HOOGHIEMSTRA, H. (1976). *Mortierella turficola* Ling Yong, *In Persoonia* **9**: 141–144.
- KUHLMAN, E. G. (1969). Mucorales isolated from pine root bark and wood. *In Can. J. Bot.* **47**: 1719–1723.
- (1972). Variation in zygosporangium formation among species of *Mortierella*. *In Mycologia* **64**: 325–341.
- LINDEMANN, G. (1971). Ergänzungen zu Zycha & Siepmann, Mucorales. *In Nova Hedw.* **19**: 565–566.
- MIL'KO, A. A. (1977). Opredelitel' mukoral'nykh Gribov. Izd. Naukova Dumka, Kiev.
- PLAATS-NITERINK, A. J. VAN DER, SAMSON, R. A., STALPERS, J. A., & WEIJMAN, A. C. M. (1976). Some Oomycetes and Zygomycetes with echinulate asexual reproductive structures. *In Persoonia* **9**: 85–93.
- SMITH, A. L. (1898). New or rare British fungi. *In J. Bot., Lond.* **36**: 180–182.
- TIEGHEM, P. VAN & LE MONNIER, G. (1873). Recherches sur les Mucorinées. *In Annls Sci. nat. (Bot.)*, Sér. V, **17**: 261–399.
- TURNER, M. (1956). *Mortierella globulifera* Rostrup. *In Trans. Br. mycol. Soc.* **39**: 291–296.
- ZYCHA, H. & SIEPMANN, R. (1970). Mucorales, eine Beschreibung aller Gattungen und Arten dieser Pilzgruppe. J. Cramer, Lehre ('1969').