

STUDIES ON THE MUCORALES ISOLATED FROM YANG-MING-SHAN HUMUS

NANCY SHIAU-MANN HO⁽¹⁾, BAO-YU YANG⁽²⁾ and
CHARLES E. DEVOL⁽³⁾

Abstract: This study is an investigation of the Mucorales in the acidic humus of Yang-ming-shan. The 34 samples were collected from eight different areas on Yang-ming-shan. By repeated cultivation and observation, 19 species were identified. They belong to seven different genera: 11 species of *Mucor*, 2 species of *Rhizopus*, 2 species of *Cunninghamella*, 1 species of *Coemansia*, 1 species of *Syncephalastrum*, 1 species of *Mortierella* (2 varieties), and 1 species of *Zygorhynchus*.

Among those collected, *Mucor*, *Cunninghamella* and *Rhizopus* were the genera most frequently encountered. Newly reported species of Mucorales to Taiwan are: *Mucor luteus*, *M. varians*, *M. heterosporus*, *M. genevensis*, *Rhizopus arrhizus*, *Zygorhynchus moelleri*, *Mortierella ramanniana* var. *ramanniana*, *Mortierella ramanniana* var. and an unidentified species of *Coemansia*.

INTRODUCTION

The Mucorales is an order of the Phycomyces, its sporangiospores lack flagella (aplanospores), most are saprophytes, and grow abundantly in the soil especially in acidic humus.

It is the purpose of this study to present a survey of the fungal flora of the Mucorales of Yang-ming-shan. Thirty-four soil samples were collected from eight sites on Yang-ming-shan.

The mucoraceous fungi from Yang-ming-shan soil which have previously been reported are *Mucor javanicus* Wehmer (Adachi & Hiranayashi, 1932), *M. globosus* Fischer, *M. lamprosporus* Lendner (Chien, 1972), and *M. adventitius* Oudemans (Liu & Yang, 1973). No taxonomic study on the Mucorales of this area has been done. Nineteen species of Mucorales were isolated and identified, these belong to 7 genera. Living cultures of these species are maintained in the Mycology Laboratory, Department of Botany, National Taiwan University.

MATERIAL AND METHODS

- (1) Soil samples: Soil was collected from eight sites on Yang-ming-shan, they were all humus samples gathered from under litter, or road-side shrubs. The litter and the upper 5 cm of soil was discarded and a short plug of the underlying soil was collected and placed in a plastic bag and transported to the laboratory.
- (2) Media used in present study: (Booth, 1971)
 - A. Media used for isolation: Carrot Agar (CA), Corn Meal Agar (CMA), Martin's Medium.
 - B. Medium used for cultivation: Mucor Synthetic Agar (SMA).
 - C. Medium used for stock culture: Malt Yeast Extract Agar (MYE).

(1) 何小曼, Research Assistant in the Department of Botany, National Taiwan Univ.

(2) 楊寶瑜, Late Professor of Botany, National Taiwan Univ.

(3) 傑克·德伏爾, Professor of Botany, National Taiwan Univ.

Table 1. Showing date of collection, culture no. and total number of times isolated.

Name of fungus	Cul. no.	Date of collection	Total no. of times isolated
<i>Mucor adoventitius</i>	10(1)	Oct. 1972	2
	9(3)	Oct. 1972	
<i>M. corticolus</i>	18(2)	Dec. 1972	1
<i>M. genevensis</i>	30(1)	Feb. 1973	1
<i>M. heterosporus</i>	7(3)	Oct. 1972	1
<i>M. jansseni</i>	1(1)	Sep. 1972	5
	7(4)	Oct. 1972	
	20(4)	Dec. 1972	
	13(2)	Nov. 1972	
<i>M. lamprosporus</i>	31(3)	Mar. 1973	2
	7(9)	Oct. 1972	
	23(1)	Jan. 1973	
<i>M. luteus</i>	4(9)	Sep. 1972	1
<i>M. mucedo</i>	18(9)	Sep. 1972	1
<i>M. piriformis</i>	21(1)	Dec. 1972	1
<i>M. sp.</i>	33(1)	Apr. 1973	1
<i>M. varians</i>	13(C)	Nov. 1972	1
<i>Coemansia sp.</i>	34(1)	Apr. 1973	1
<i>Cunninghamella echinulata</i>	5(1)	Sep. 1972	1
<i>C. elegans</i>	6(1)	Oct. 1972	3
	34(2)	Apr. 1973	
	20(6)	Dec. 1972	
<i>Mortierella ramanniana</i> var. <i>ramanniana</i>	20(1)	Dec. 1972	2
	20(3)	Dec. 1972	
<i>Mortierella ramanniana</i> var.	20(2)	Dec. 1972	1
<i>Rhizopus arrhizus</i>	5(5)	Sep. 1972	1
<i>R. nigricans</i>	7(5)	Oct. 1972	3
	20(5)	Dec. 1972	
	33(4)	Apr. 1973	
<i>Syncephalastrum racemosum</i>	4(5)	Sep. 1972	1
<i>Zygorhynchus moelleri</i>	4(2)	Sep. 1972	2
	13(8)	Nov. 1972	

(3) Methods of Isolation:

A. Dilution plate method (Barron, 1971): (1). 25g. dry weight of soil was placed in a sterile measuring cylinder and the volume was made up to 250 ml with sterile 0.15% water agar. (2). The soil/agar mixture was poured into a flask and blended for 30-60 sec. (3). 5 ml of this blended primary suspension was transferred with a wide-mouth pipette, into 45 ml of 0.15% sterile water

agar blank in a flask. (4). 5 ml sample was transferred through a succession of agar blanks until the desired final dilution was reached. (5). 1 ml aliquotes of 1/100, 1/1000, 1/10000 dilutions were pipetted into each of three Petri dishes for each dilution, and 10–15 ml of cooled (45°C) agar medium was added. (6). The soil suspension was mixed with the medium by gentle swirling.

B. Soil plate method (Warcup, 1950): 1–1.5g. dry weight of soil was transferred into a sterilized Petri dish and 10 ml of cool (45°C) agar medium was added. Sometimes, the soil particles were mixed with a few drops of distilled water before the medium was added.

C. Modified method: 1–1.5g. dry weight of soil was added to 10 ml of cooled agar medium.

For isolation, these plates were incubated at $22 \pm 2^\circ\text{C}$ for 24 hours, then examined under a dissecting microscope. Single spore or single sporangium isolation was used to secure a pure culture. Identifications were based on pure cultures grown on SMA at $22 \pm 2^\circ\text{C}$.

OBSERVATION AND RESULTS

Nineteen species (including 2 varieties), representing 7 genera were isolated (Table I) and identified. Among them 11 species belong to *Mucor*; 2 species to *Rhizopus*; 2 species to *Cunninghamella*; 1 species to *Mortierella* (2 varieties); 1 species to *Syncephalastrum*; 1 species to *Zygorhynchus*; and 1 species to *Coemansia*.

Details of which are presented as follows:

1. *Mucor adventitius* Oudemans, Oudemans & Koning, Extr. Arch. Néerl. Sc. Nat. II. 7: 278, 1902 (Gilman 1957; Zycha & Siepmann 1969). **Pl. I, Fig. 1.**

Turf white, about 2.2 cm in height; sporangiophores simple or branched, 5–9 μ in width; sporangia at first white, later becoming gray, globose, 40–57 μ in diameter, sporangial wall diffuent; columella oval, with a flattened, wide base, 16.3–30 \times 20–40 μ , collar present; sporangiospores elongate, 2–4 \times 4–7 μ ; chlamydospores present in substrate, zygospore not observed. (#9(3), #10(1)).

2. *Mucor corticolus* Hagem, Ann. Mycol. 8: 277, f. 8, 1970 (Gilman 1957; Zycha & Siepmann 1969). **Pl. I, Fig. 2.**

Turf at first light gray, later becoming grayish–brown, about 2.5 cm in height; sporangiophores at first simple, later with few sympodial branches; sporangia dark brown when mature, globose, 40–105 μ in diameter, sporangial wall diffuent; columella oval or subglobose, 25–70 \times 25–60 μ , collars present; sporangiospores oval, 4–7 \times 3–5 μ (1:1.2–1.7); zygospore and chlamydospore not observed. (#18(2)).

3. *Mucor genevensis* Lender, Mucor. Suisse. p. 80, f. 27, 1908 (Hesseltine 1954; Gilman 1957; Zycha & Siepmann 1969). **Pl. I, Fig. 3.**

Turf dense, light gray, 1.5 cm high; sporangiophores simple or with sympodial branches, 5–7 μ in diameter; sporangia globose, 100 μ in diameter, sporangial wall soon diffuent, collars present; columella pyriform to oval, 20–35 \times 10.5–30 μ ; sporangiospores elongate, 2–3 \times 4–7 μ (about 1:2); zygospores numerous, produced on adjacent branches, but not on forks of the same branch, near the substrate, giving the culture a blackish zone, 25–55 \times 29–52.5 μ ; exines very thick, with warts 3–4 μ in length, at first brown then brownish–black; suspensors equal or somewhat unequal; zygophore 6.3–10 μ in diameter; homothallic. (#30(1)).

4. *Mucor heterosporus* Fischer, Rabenhorst. Krypt. Fl. 1: 199, 1892 (Gilman 1957; Zycha & Siepmann 1969). **Pl. I, Fig. 4.**

Turf high, up to 3 cm, at first cream colored, later yellowish brown, hyphae with sympodial branches, about 7-11 μ in diameter, with many yellow oil droplets; sporangia globose, 40-110 μ in diameter, at first colorless, then grayish brown; sporangial wall easily diffluent, leaving a collar at the base; columella smooth, oval or globose; sporangiospores globose, reniform or irregular, about 3-11 μ in diameter; gemmae and zygospores not observed. (#7(3)).

5. *Mucor jansseni* Lendner, *Mucor. Suisse*, 88, f. 30, 1908 (Gilman 1957; Zycha & Siepmann 1969; Chien 1972). **Pl. I, Fig. 6.**

Turf low, velvety (on SMA at 22+2°C), becoming gray to dark at maturity with pale gray margins; turf up to 6 mm high; sporangiophores branched; sporangia 35-50 μ in diameter, globose, sporangial walls persistent or fragile; columella rounded with a wide flattened base, collars present, 27-35 μ in diameter, tinted deep blue or gray, sporangiospores globose, 4-6 μ in diameter; chlamydospores and zygospores not observed. (#1(1), #7(4), #20(4), #13(2), #31(3)).

6. *Mucor lamprosporus* Lendner, *Mucor. Suisse*, 92, 1908. (Gilman 1957; Zycha & Siepmann 1969; Chien 1972). **Pl. I, Fig. 5, 7, 8.**

Turf at first white, later becoming pale gray, height up to 3 cm, at 22+2°C forming a dense, thick felt; hyphae branches sympodial, 6-10 μ in diameter; sporangia of 2 types: larger sporangia produced on the main sporangiophores are globose, most are 28-40 μ (max. 70 μ) in diameter, sporangial walls diffluent; smaller sporangia are produced on slender, curved or circinate side branches, 12-17 μ in diameter, monosporous; columella dome-shaped or globose, 19-30 \times 19-32 μ in diameter; sporangiospores rounded or angular, smooth, hyaline, mostly 7.5 \times 10 μ (7.5-8.7 \times 7.5-10 μ); zygotes and gemmae not observed. (#7(9), #23(1)).

7. *Mucor luteus* Linnemann, *Flora* 130: 195, f. 11, 1936. (Gilman 1957; Zycha & Siepmann 1969). **Pl. I, Fig. 9.**

Turf deep cream colored, about 2.2 cm, with many small colonies around the main colony, mycelium growing in the substrate containing many yellow particles, appearing orange-yellow on the underside; sporangia globose, gray when mature, 45-85 μ in diameter, sporangial wall slowly diffluent, collars present; sporangiophores simple or sympodially branched, 5-11 μ in diameter; spores mostly elongate, some ellipsoidal, 2.3 \times 4-6 μ (1: 1.3-2), size not uniform; columella egg-shaped, slightly pyriform or subglobose, 17.5-36.5 \times 20-42.5 μ ; zygospores not observed. (#4(9)).

8. *Mucor mucedo* (L.) Fresenius, *Beitr. Mykol.* 7, f. 1-12, 1850. (Gilman 1957; Zycha & Siepmann 1969; Yang & Liu 1972). **Pl. I, Fig. 10.**

Turf white, hyphae prostrate on surface of agar in dark, but erect when grown in light, up to 1.5 cm high; sporangiophores at first simple, later sympodially branched, 40-87 μ in diameter; sporangia globose, hyaline, 160-650 μ in diameter; visible with naked eye; sporangial wall persistent, with needle-shaped crystals on the surface; columella egg-shaped, 120-125 \times 150-170 μ ; sporangiospores large, oval or elongate, 6.3-7.5 \times 11-14 μ ; zygospores & gemmae not observed. (#18(9)).

The gross morphology of #18(9) resembles *Mucor mucedo*, to which it may be related. But it has 2 distinct characters: (a) the sporangial wall of *M. mucedo* is easily dissolved, while the wall of #18(9) is not diffluent. (b) the turf of *M. mucedo* is normally very high, but that of #18(9) is less than 1.5 cm. Naganishi (1969) has reported a species, *Mucor oblongisporus*, which has some characters in common with #18(9), a comparison between #18(9) and Naganishi's *M. oblongisporus* is shown in Table III. The most important difference between them is that the sporangia of

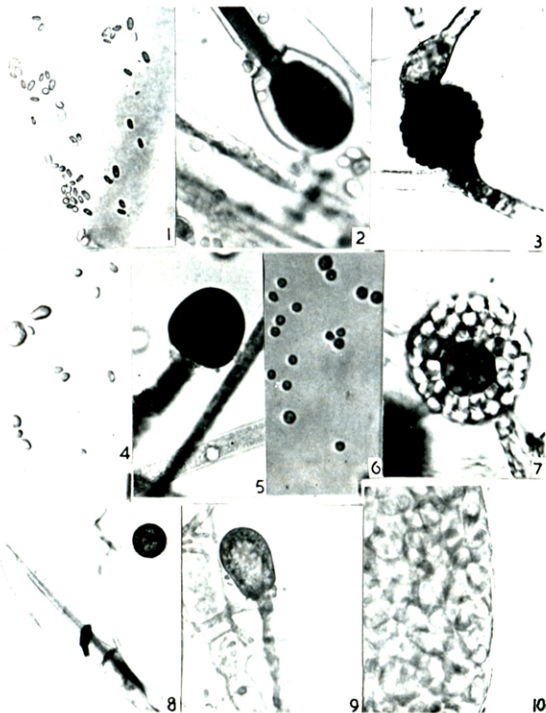


Plate 1. *Mucor advertitius*: spores, 500X; 2. *Mucor corticolus*: columella, 500X; 3. *Mucor genispensis*: zygospore with suspensors, 500X; 4. *Mucor heterosporus*: spores, 500X; 6. *Mucor jansseni*: spores, 500X; 5. 7. 8. *Mucor lamprosporus*: 5. dome-shaped columella, 500X; 7. sporangium, 500X; 8. sporangiola with only one spore inside, 500X; 9. *Mucor luteus*: columella, 500X; 10. *Mucor mucedo*: sporangial wall with needle-shaped crystals on the surface, 500X.

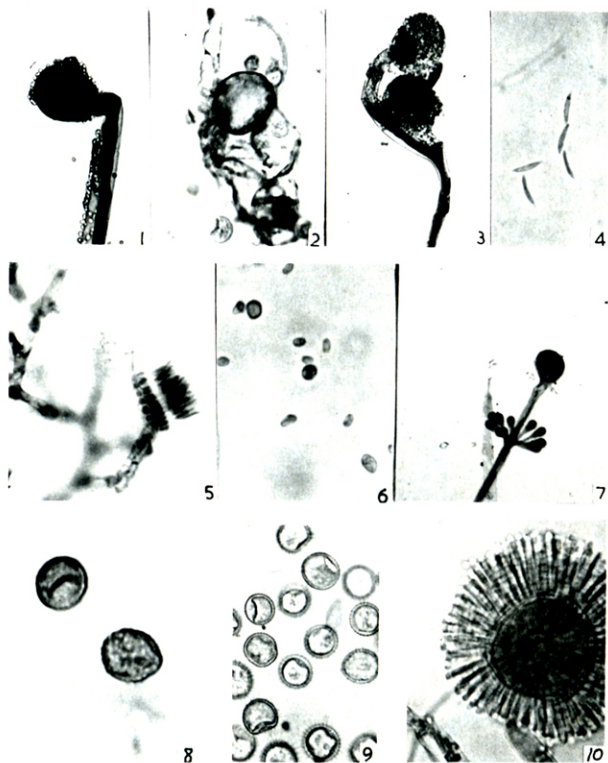


Plate II. 1. *Mucor piriformis*: columella with spores, 125X; 2-3. *Mucor* sp.: 2. columella with ruptured sporangial wall, 500X; 3. branching sporangiophore with sporangia, 125X; 4-5. *Coemansia* sp.: 4. sporangia (conidia), 500X; 5. sporocladia, 500X; 6. *Mucor varians*: spores, 500X; 7-8. *Cunninghamella elegans*: 7. branching conidiophore with side branches, 125X; 8. conidia with very short spines or without spines, 500X; 9. *Cunninghamella echinulata*: conidia with long spines on the surface, 500X; 10. *Syncephalstrum racemosum*: globose sporangial head with merosporangia on it, 500X.

#18(9) are usually up to 3 times larger than *M. oblongisporus*. Reasons for recognizing #18(9) being related to *M. mucedo* is that they have many characters in common: (a). sporangia very large, (b). with many needle-shaped crystals on the surface of sporangium, (c). columella oval-shaped, (d). sporangiospores large, elongate or oval.

9. *Mucor piriformis* Fischer, Rabenhorst, Krypt. Fl. 1: 191, 1892. (Gilman 1957; Zycha & Siepmann 1969; Liu & Yang 1973). **Pl. II, Fig. 1.**

Turf woolly, at first white, later yellowish, about 4 cm high; sporangiophores simple, 35–38 μ in diameter, with a few side branches when old; sporangia 75–150 μ in diameter, globose, hyaline when young and becoming olive with age; sporangial wall finely echinulate, quickly dissolved; columella pear-shaped, 50–100 \times 60–115 μ ; sporangiospores elongate or oval, 6–7 \times 8–14 μ (1:1.3–2); zygospore and gemmae not observed. (#21(1)).

10. *Mucor* sp., **Pl. II, Fig. 2-3.**

Turf gray, very low, not dense, about 2 mm high; sporangiophores with slightly curved side branches, sporangia on terminals, with septa at the site where branches fork, sporangiophores 18–35 μ in diameter; sporangia globose, black when mature, 40–100 μ in diameter; sporangial wall irregularly fragile; columella dome-shaped, size varies with the size of the sporangia; sporangiospores rounded, 6–7 μ (max. 10 μ) in diameter; zygospores and gemmae not observed. (#33(1)).

#33(1) is an unknown species, there is no known species of *Mucor* having these characters, therefore #33(1) may be new to Taiwan.

11. *Mucor varians* Povah, Bull. Torrey Bot. Cl. 44: 297, fig. 1–6, 1917. (Zycha & Siepmann 1969). **Pl. II, Fig. 6.**

Turf at first white, later light gray, about 2.7 cm high, sporangiophores branches, 6–15 μ in diameter; sporangia globose, hyaline when young and becoming dark brown at maturity, about 40–100 μ in diameter; sporangial wall easily dissolved, leaving a collar; columella subglobose, 21–40 μ in diameter; sporangiospores of irregular shape, oval, elongate, or subglobose, size variable, 2.5 \times 3–7 μ ; zygospore and gemmae not observed. (#13(C)).

12. *Coemansia* sp., **Pl. II, Fig. 4-5.**

Turf pale yellow; vegetative hyphae septate, with branches; sterile branches usually anchored to the substratum and forming rhizoids; sporogenous branches up to 2 mm high, with septa, 13–17 μ wide; sporocladia arranged in a compact cluster on the sporangiophore; sporocladial stipe 1 celled, 6–7 \times 14–20 μ ; sporocladia composed of 7–8 cells (excluding the stipe), 4–5 \times 32–50 μ , slightly sigmoid; pseudophialides 3–4 \times 1.5 μ ; sporangiola fusiform, arcuate, 1–1.4 \times 1.8–2 μ ; zygospore and gemmae not observed. (#34(1)).

#34(1) is a curious species of *Coemansia* isolated in our present study, its most distinguishing character is its arched, fusiform sporangiola. It is considered as new to Taiwan.

13. *Cunninghamella echinulata* (Thaxter) Thaxter, Rhodora, 5: 98, 1903 (Gilman 1957; Zycha & Siepmann 1969; Yang & Liu 1972). **Pl. II, Fig. 9.**

Turf at first white, later light gray, up to 1.1 cm high; rhizoids present; vegetative hyphae with side branches; conidial head oval or globose, about 35 \times 40 μ (max. 45 \times 50 μ); conidia light colored, oval or globose, average 12.5 μ in diameter (max. 17 μ), with long spines on the surface, spines up to 3 μ long, immature conidia sometimes smooth; zygospores and gemmae not observed. (#5(1)).

14. *Cunninghamella elegans* Lendner, Mucor. Suisse., 159. f. 58, 59, 1908. (Gilman 1957; Zycha & Siepmann 1969). **Pl. II, Fig. 7-8.**

Turf at first white, later gray, about 3 cm high, vegetative hyphae containing many oil droplets; rhizoids present; conidiophores erect, without side branches or if with side branches arranged in a whorl; conidial head 80-120×100-150 μ in diameter, oval, with short spines on the surface to which conidia are attached; conidia lemon-shaped or spherical, 8.75-13.75×11-18 μ , with short spines or smooth; heterothallic; zygospores and gemmae not observed. (#6(1), #34(2), #20(6)).

15. *Mortierella ramanniana* (Möller) Linnemann var. ***ramanniana*** (Evans 1971; 1972)

Pl. III, Fig. 1-2.

Turf very short, less than 2 mm, velvety, at first white, later becoming carmine-reddish-brown; the margin of colony at first white, later gray; sporangiophores simple, 3-7 μ wide; sporangia small, globose, 15-25 μ in diameter, copper-red, wall smooth, unequally diffluent; sporangiospores ellipsoidal or oval, 2×3 μ ; columella spherical, 6-10 μ in diameter, collar present; chlamydospores numerous, globose or ovoid; mycelium and sporangiophores frequently septate; giant cells present (#20(1)).

Mortierella ramanniana (Möller) Linnemann var. ***ramanniana*** (Evans 1971; 1972).

Pl. III, Fig. 3.

Turf very low, less than 2 mm high, velvety, at first gray, later reddish-brown, the margin of colony grayish-white; sporangiophores simple, side branches rarely present, 3-7 μ wide; sporangia small, 12-22.5 μ in diameter, globose; sporangial wall smooth, easily dissolved, leaving a collar; columella present, with a septum, about 17-21 μ beneath the sporangium; sporangiospores oval, 3×4-5 μ in diameter, spore mass grayish-brown; zygospores and giant cells not observed; gemmae rarely present. (#20(3)).

16. *Mortierella ramanniana* (Möller) Linnemann var. ***ramanniana*** (Evans 1971; 1972).

Pl. III, Fig. 4-5.

Turf at first grayish-white, later light grayish-brown, with grayish white margins, less than 1 mm high; sporangiophores usually branched, 2-4 μ wide; sporangia globose, 11-17 μ in diameter; sporangial wall easily dissolved, leaving a short collar; columella not easily observed, even under the oil immersion; cross wall present, about 55-80 μ (max. 102 μ) beneath the sporangium; sporangiospores globose, 2-2.5 μ in diameter, spore mass grayish-brown; giant cells and zygospores not observed; gemmae rarely present, (#20(2)).

Three isolates of *Mortierella ramanniana* were identified. They have some characters in common, such as: turf very low, less than 2 mm, velvety; sporangia and sporangiospores very small; collar not distinct. There are three varieties of *Mortierella ramanniana*: *Mort. ramanniana* var. *ramanniana*, *Mort. ramanniana* var. *autotrophica*, and *Mort. ramanniana* var. *angulispora*. The turfs of #20(1), #20(3), *Mort. ramanniana* var. *ramanniana*, *Mort. ramanniana* var. *autotrophica* were all red colored, a comparison of them is given in Table II. Evans (1972), reported that *Mort. ramanniana* var. *ramanniana* stops growth at 35°C, but *Mort. ramanniana* var. *autotrophica* does not. Because #20(1), #20(3) both stopped growth at 35°C, they were both named *Mort. ramanniana* var. *ramanniana*, but there are several differences between them, such as spore size, turf color, etc; so they are listed separately. As to #20(2), the turf color, branching form of sporangiophores are like *Mort. ramanniana* var. *angulispora*, but the spores of #20(2) are rounded and so are different from the angular spores of *Mort. ramanniana* var. *angulispora*. Therefore #20(2) is recognized as an unknown variety of *Mort. ramanniana*.

Table II. Comparison of characters between #20(1), #20(3), *Mort. ramanniana* var. *ramanniana* and *Mort. ramanniana* var. *autotrophica*.

	Turf color	Spore size	Spore shape
20(1)	red-carmine brown	2 × 3 μ	oval
20(3)	reddish brown	3 × 4–5 μ	oval
<i>Mort. ramanniana</i> var. <i>ramanniana</i>	vinaceous brown	2 × 4 μ (1.5–3 × 2.5–5.5 μ)	oval or ellipsoid
<i>Mort. ramanniana</i> var. <i>autotrophica</i>	pale congo pink	2–3 μ	spherical to irregular

Table III. Differences between #18(9) and *Mucor oblongisporus* of Naganishi.

	18(9)	<i>M. oblongisporus</i>
Sporangial size	160–650 μ	200 μ or less
Sporangial wall	difficult to rupture	easy to rupture
Turf height	1.5cm	2.5cm
Sporangial color	hyaline	pale yellow becoming yellowish-brown

17. *Rhizopus arrhizus* Fischer, Rabenhorst Kryptog. Fl., 1: 253, 1892. (Gilman 1957; Zycha & Siepmann 1969). **Pl. III, Fig. 6.**

Turf at first white, later becoming gray or grayish-brown; sporangiophores brown, usually simple, sometimes 2–3 in a cluster on the stolons; stolons do not form nodes at constant distances, bearing sporangiophores at the nodes; rhizoids arising from the nodes opposite to sporangiophores, are not very well developed; sporangiophores 0.28–0.9 mm long, 7.5–12.5 μ wide; sporangia at first white, later black, 48–80 μ in diameter; sporangiospores oval, angular, more or less striated, 4–6 μ in diameter; gemmae and zygospores not observed; grows well over 37°C (#5(5)).

18. *Rhizopus nigricans* Ehrenberg, Nova Acta Acad. Leop. 10. 1: 198, 1820. (Gilman 1957; Zycha & Siepmann 1969; Yang & Liu 1972) **Pl. III, Fig. 7–8.**

Turf at first white, later brownish-black, with creeping stolons; rhizoids well developed, occurring at the nodes; sporangiophores arising opposite the rhizoids, internodes 1–2 cm long, sporangiophores rarely single, usually united in groups of 2–5, 2–4 mm high, 25 μ wide; sporangia globose, at first white, black at maturity; columella broad, hemispherical, depressed, about 90 × 135 μ ; sporangiospores oval, rounded, angular, with striae on surface, sizes unequal, 7–9 × 10–13 μ ; no growth above 37°C; zygospores and gemmae not observed. (#7(5), #20(5), #33(4)).

19. *Synecephalastrum racemosum* Cohn ex Schroter. Kryptogamenfl. Schlwa. 2, 1: 217. 1886 (Gilman 1957; Benjamin 1959; Zycha & Siepmann 1969). **Pl. II, Fig. 10.**

Turf at first white, later grayish, about 6 mm high, sporangiophores with many side branches, arranged in sympodia, lacking cross walls above the divisions of the lateral branches; sporangial head oval, 25–75 μ wide, with numerous short warts on the surface, to which the merosporangia are attached; merosporangia about 18–30 μ in length; within which 5–10 spores are arranged in a linear row, when merosporangia become detached from the warts, the sporangial walls are invisible; sporangiospores 2.5–3 μ , mostly angular; zygospores and gemmae not observed. (#4(5)).

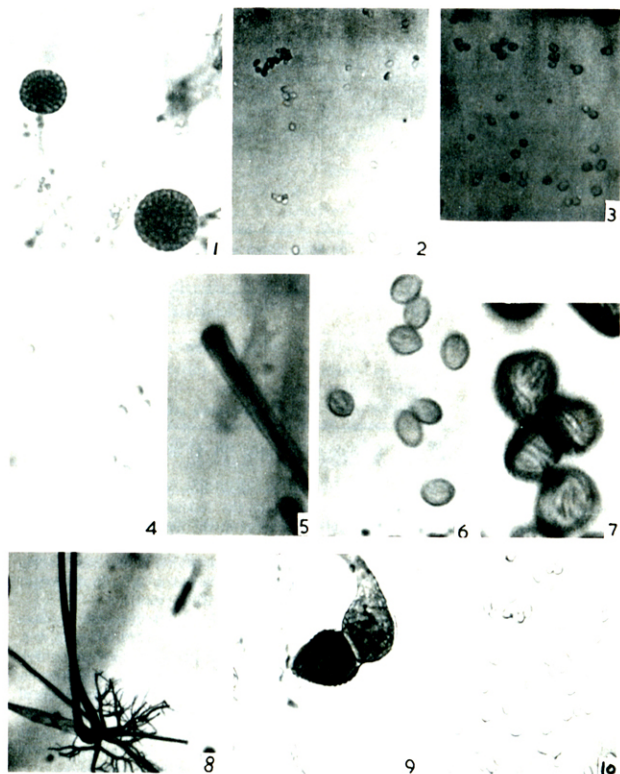


Plate III. 1-2. *Mortierella ramanniana* var. *ramanniana* (#20(1)): 1. sporangia, 500X; 2. spores, 500X; 3. *Mortierella ramanniana* var. *ramanniana* (#20(3)): spores, 500X; 4-5. *Mortierella ramanniana* var.: 4. spores, 1250X; 5. columella, 1250X; 6. *Rhizopus arrhizus*: spores with striated surface, 1250X; 7-8. *Rhizopus nigricans*: 7. spores with striated surface, 1250X; 8. well developed rhizoids, 125X; 9-10. *Zygorhynchus moelleri*: 9. zygospore with unequal suspensors, 500X; 10. spores, 500X.

20. *Zygorhynchus moelleri* Vuillemin, Bull. Soc. Mycol. France, 19: 117, 1903. (Gilman 1957; Hesseltine 1959; Zycha & Siepmann 1969). **Pl. III, Fig. 9-10.**

Turf at first white, later gray, about 1.5 cm high, sporangiophores branched, 10–12.5 μ wide; homothallic, zygospores and sporangia arising on the same hyphae; sporangia globose, black at maturity, 20–35 μ in diameter (max. 58 μ); sporangial walls smooth, not easily dissolved; columella globose, smooth, 17.5 \times 18–32.5 μ , collapsing when sporangial walls rupture; sporangiospores smooth, oval, 3 μ \times 5 μ ; zygospores globose, 30–35 μ in diameter, arising from the surface of substrate, or on aerial hyphae, dark brown, with numerous warts on the surfaces, warts 3–4 μ in length; suspensors unequal, the larger one recurved, smooth, 17–30 μ wide; gemmae not observed. (#4(2), #13(8)).

Key to the species of Mucorales isolated from Yang-ming-shan humus:

1. Multi-spored sporangia present.....(2)
1. Only mono-spored sporangia (conidia) present.....(3)
2. Sporangia globose or pyriform.....(4)
2. Sporangia cylindrical, spores arranged in a linear form; rhizoids poorly developed.....*Syncephalastrum racemosum*
3. Conidia growing on the surface of a globose conidial head.....(5)
3. Conidia growing on a sporocladium.....*Coemansia sp.*
4. Columella distinct; zygospores naked or with a few appendages.....(6)
4. Sporangia small; columella not very distinct, sometime invisible; turf very low, less than 2 mm.....*Mortierella romaniiana*
5. Conidia with dense long spines.....*Cunninghamella echinulata*
5. Conidia with short spines.....*Cunninghamella elegans*
6. Rhizoids and stolons present.....(7)
6. Rhizoids and stolons absent.....(8)
7. Spores 4–6 μ*Rhizopus arrhizus*
7. Spores 10–13 μ*Rhizopus nigricans*
8. Zygospore with equal suspensors.....(9)
8. Zygospore dark brown, with unequal suspensors.....*Zygorhynchus moelleri*
9. Homothallic.....*Mucor genevensis*
9. Heterothallic or not homothallic.....(10)
10. Spores globose.....(11)
10. Spores not always globose.....(12)
11. Turf low, about 7 mm.....*Mucor jansseni*
11. Turf about 3 mm in high.....*Mucor lamprosporius*
11. Turf about 2 mm in high.....*Mucor sp.*
12. Spores with variable shapes.....(13)
12. Spores with somewhat distinct shape.....(14)
13. Turf up to 3 cm high.....*Mucor heterosporus*
13. Turf less than 3 cm high.....*Mucor varians*
14. Sporangia usually less than 100 μ in diameter.....(15)
14. Sporangia larger.....(16)
15. Spores elongate (1:2–2: 7).....*Mucor advertitias*

15. Spores oval (1: 1.2-1.7) *Mucor corticolus*
 15. Spores ellipsoid or elongate (1: 1.3-2) *Mucor luteus*
 16. Sporangia less than 150 μ in diameter *Mucor piriformis*
 16. Sporangia larger than 150 μ in diameter *Mucor mucedo*

DISCUSSION AND CONCLUSION

1. In the early stages of our work, CA, CMA, and Martin's medium were used to determine which was the best medium for growing mucoraceous fungi. The results showed that these three media were all good for *Mucor* growth and isolation. The reason is that their turfs become luxurious and dominant over other microorganisms thus making isolation easy. Since CMA and CA are easier to prepare than Martin's medium, they were more frequently used for isolation in this study.
2. There are many species of Mucoraceous fungi inhabiting the acidic humus in Yang-ming-shan and most of them belong to the genus *Mucor*. The frequency of isolation for each species is given in Table I. Almost all of them are heterothallic, only *Mucor genevensis* and *Zygorhynchus moelleri* are homothallic.
3. From the results, we conclude that further studies will likely reveal many other undiscovered species.
4. *Mortierella ramanniana* has been described as a fungus characteristic of acid sandy podzols. The pH range for the best growth of this species is between pH 3.3 and 4.1 (Evans, 1971). Because the soil samples being studied were acidic humus, the frequency of isolation of this species was very high.
5. The frequency of *Mucor jansseni* was also high. It is concluded that the optimum pH range for this species was within the acidic range. But its exact pH range has not been tested.
6. The growth rate of *Coemansia* sp. was rather slow. On the original isolation plate, 2-3 weeks after the other mucoraceous fungi turf were beginning to wilt, the turf of *Coemansia* began to appear as a delicate, yellow, tufted colony which could be seen with the naked eye and was isolated under the dissecting microscopes.
7. Work is now in progress on studies of mating in related species, and the zygospore formation of isolated species.

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