Some Zoosporic Fungi of New Zealand. VIII.

Cladochytriaceae and Physodermataceae

By John S. Karling
(Department of Biological Sciences, Purdue University, Lafayette, Indiana, U.S.A.)

With Plate XXV

Cladochytriaceae.

Species of this family are common and widely distributed in the soils of New Zealand, and up to the present time 13 species have been isolated and identified. The thallus of members of this family is polycentric in that many centers of growth and reproduction are developed and because it is mycelium-like and bears rhizoids along its length it has been described as a rhizomycelium (Karling, 1932), without any connotations of phylogeny. As presented here this family includes inoperculate and operculate species, and because the thalli in both are so similar in morphology, organization, growth, and reproduction there is little or no justification for segregating the operculate species in a separate family. The family name *Megachytriaceae* which has been created for the operculate species implies or suggests, at least, that they are longer and larger than the inoperculate species, but *Cladochytrium aurantiacum* Richards and *Physocladia obscura* Sparrow, inoperculate species for example, are considerably larger than *Nowakowskiella delica* Whiffen, an operculate species.

The species isolated and identified so far in New Zealand comprise the inoperculate genus *Cladochytrium* and the operculate genera *Nowakowskiella* and *Septochytrium*. Notably absent in the soil samples studied was the genus *Polychytrium* which has been found in soils in many parts of the world.

Cladochytrium

Cladochytrium tenue Nowakowski, 1876. Cohn, Beitr. Biol. Pflanz. 2: 92, pl. 6, fig. 6—13.

Saprophytic in bleached corn leaves in soil sample ASB.

Cladochytrium replicatum Karling, 1931. Amer. J. Bot. 18: 538, pls. 42—44; 1935, Amer. J. Bot. 22: 439—452, fig. 1—29.

Cladochytrium nowakowskii Sparrow, 1931. Amer. J. Bot. 18: 619, pl. 45, fig. H—N.

Entophlyctis aurantica Scherffel, 1936. In Domjan, Folia cryptogam. 2: 26, pl. 1, fig. 50—51, 57—59, 72, 73, 75.

Cladochytrium aureum Karling, 1949. Bull. Torrey Bot. Club 76: 298.

Saprophytic in bleached corn leaves, moribund *Nitella* internodes and other dead algae in soil samples AMA, AWRKF, ATH, WT3, WT4, WRFJ1, WK3 and CLO1.

From a more intensive study of specimens with the so-called spiny resting spores in this species the author has come to the conclusion that *C. aureum* is identical with *C. replicatum*, and he is, accordingly, listing it as a synonym.

Cladochytrium hyalinum Berdan, 1941. Amer. J. Bot. 28; 425, fig. 1—84.

Saprophytic on bleached corn leaves and cellophane in soil samples ASB and WGB.

Cladochytrium aurantiacum Richards, 1956. Trans. Brit. Mycol. Soc. 39: 264, fig. 1—3.

Saprophytic in bleached corn leaves in soil samples WRFJ1 and WK3.

This species was reported previously only from South Wales and for this reason its occurrence in New Zealand is of considerable interest. It occurred in abundance in the two soil samples noted above. Its rhizomycelium, spindle organs, and zoospores are similar to those of *C. replicatum* but much coarser and larger. When the two species occur together in the same substratum they can be distinguished readily by the relative sizes of the zoospores.

Nowakowskiella

Nowakowskiella elegans (Nowak.) Schroeter, 1897. Engler und Prantl, Die Natürl. Pflanzenf. 1 (1): 82.

Cladochytrium elegans Nowakowski, pro parte, 1876. Cohn, Beitr. Biol. Pflanz. 2: 95, pl. 6, fig. 14—17.

Nowakowskiella endogena Constantineanu, 1901. Rev. Gen. Bot. 13: 387, fig. 83.

Saprophytic in bleached corn leaves and cellophane in soil samples AAD, ADSIR, ATH, AW, ASJD, WT1, WT2, WT3, WK2, WK3, WW2, Mp OHR, OD1, CLO1, CLL, CGB and WFG.

As indicated by the above soil samples this was the most common and widely distributed species of *Nowakowskiella* observed in New Zealand.

Nowakowskiella hemisphaerospora Shanor, 1942. Amer. J. Bot. 29: 174, fig. 1—38.

Saprophytic in bleached corn leaves and cellophane in soil samples WRFJ1 and OHR.

This species was found in only two widely separated soil samples and does not appear to be as abundant in New Zealand as elsewhere in the world. Unlike most species of *Nowakowskiella,* except *N. multispora* Karling, it develops resting spores almost as abundantly as sporangia and is characterized primarily by the manner in which such spores are formed. According to Shanor, they develop in intercalary or terminal swellings of the rhizomycelium, but the content of such swellings undergoes cleavage as incomplete walls are laid down between the cleavage segments. The content of one segment or semi-cell then flows into the adjacent one and fuses with it to form the spore, after which wall formation is completed. As a result, the resting spore, which develops a wall of its own in the swelling, is accompanied by an empty cell. Shanor postulated that the latter might be a "male" cell. In the large swellings up to 4 resting spores may be formed in the same manner, and each of these is accompanied by an empty cell. According to Shanor, the wall of the spore is always fused with that of the swelling so that the spores never lie entirely free.

Some notable difference in spore formation from that described above occurred in the New Zealand isolations. In most of the intercalary and small terminal swellings a single resting spore occupied approximately half of these and was accompanied by an empty space (fig. 4) which could not be recognized conclusively as a distinct cell. In the formation of many of such resting spores the content of the swelling contracted to about a half its orignal size (fig. 3) and became invested with a wall without cleavage, the formation of a partial cross septum, and fusion (fig. 4). Sometimes the spore wall appeared to be fused with that of the swelling (fig. 11, 12), but in other cases the spores were free-lying in the vesicle or swelling (fig. 6, 7, 8, 10). Also, in some cases the content of the swelling divided into two unequal parts (fig. 5) which developed into 2 free-lying spores (fig. 6) within 28 hours. In this particular case there was no evidence of wall formation between the two unequal protoplasts. In other instances 3 (fig. 8), 4 (fig. 7) and even up to 7 spores occurred without the presence of an empty cell or space. Fig. 9 shows a large terminal swelling the content of which has divided into seven segments. In the course of 30 hours these segments developed into resting spores which were lying free in the swelling. Sometimes 2 spores occurred in a swelling with one (fig. 11) or two (fig. 12, 13) empty spaces. In such instances the empty spaces sometimes contained a few globules and cytoplasm.

The discovery of intercalary and terminal swellings with resting spores unaccompanied by empty spaces or cells casts doubt on the suggestion that the so-called "male" cell, if present, has sexual significance.

Nowakowskiella profusa Karling, 1941. Bull. Torrey Bot. Club 68: 386; 1944, Ibid. 71: 382, fig. 45—68.

Saprophytic in bleached corn leaves in soil samples ASB and WT5.

Nowakowskiella granulata Karling, 1944. Bull. Torrey Bot. Club 71: 374, fig. 1—29.

Cladochytrium granulatum (Karling) Sparrow, 1960. Aquatic Phycomycetes, p. 469.

Saprophytic in bleached corn leaves in soil samples WAN and WT4.

The sporangia in the New Zealand specimens were predominantly endooperculate, but exooperculate ones occurred occasionally, also.

Nowakowskiella macrospora Karling, 1945. Amer. J. Bot. 32: 29, fig. 1—30.

Saprophytic in bleached corn leaves in soil samples WK2 and WT5.

This species is characterized chiefly by unusually large zoospores and endo- as well as exooperculate sporangia, and the New Zealand specimens conformed closely to those described previously.

Nowakowskiella crassa Karling, 1949. Bull. Torrey Bot. Club 76: 295, fig. 1—15.

Saprophytic in bleached corn leaves in soil samples AEN and AWRKF.

This is the largest known species of *Nowakowskiella*, and in some of the New Zealand thalli the tenuous portions of the rhizomycelium were up to 22 μ diameter. Its large size relative to other species becomes particularly evident when it occurs in conjunction with *N. elegans*, *N. multispora* and other species in the same substratum, and there is no doubt in the author's mind about its identity as a distinct species.

Nowakowskiella multispora Karling, 1964. Sydowia 17: 314, fig. 1—8.

Saprophytic in bleached corn leaves and cellophane in soil samples AW, AWN, AWRKF, WT2, WT4, CLL, OHR, and ATFP.

This species is quite common and widely distributed in New Zealand, and like *N. hemisphaerospora* it forms resting spores almost as abundantly as sporangia.

Nowakowskiella atkinsii Sparrow, 1950. J. Wash. Acad. Sci. 40: 52, fig. 25—26.

Saprophytic in bleached corn leaves and cellophane in sandy silt (WFG) from the Franz Joseph Glacier, Westland Province.

This identification was made of a species which occurred in a watered sandy silt sample collected at an unusual location the edge of a glacier in Westland Province at an altitude of 4,600 ft. It this identification is correct, *N. atkinsii* is known so far only from subtropical Cuba and the Southern Alps of New Zealand. The rhizomycelium, sporangia and zoospores were similar to those described by Sparrow, but the sporangia and spindle organs often lacked setae (fig. 18). In other thalli only a few setae occurred on the sporangia and spindle organs (fig. 14). Some of the sporangia and spindle organs of other thalli bore up to 20 setae (fig. 15, 16), and on some sporangia the setae were reduced to short pegs (fig. 17). Obviously, this characteristic varies considerably. Particularly noteworthy is the great elongation of some setae which branched at the tips and became distinct rhizoids (fig. 15, 16). In one case the branched setae extended for a distance of 160 μ in the surrounding water. It is evident from such observations that the setae are aborted and potential rhizoids. Resting spores were not found in the New Zealand specimens.

Notably lacking in all of the New Zealand soil samples studied was *Nowakowskiella ramosa* Bulter (1907), a species which has been found commonly in soil throughout the world.

Septotrychium

Septochytrium variable Berdan, 1939. Amer. J. Bot. 26: 461, fig. 2; 1942, Amer. J. Bot. 29: 260—270, fig 1—72.

Saprophytic in bleached corn leaves in soil sample AMA.

Physodermataceae

Species of this family are characterized by a monocentric, eucarpic, rhizidiaceous ecto-endobiotic phase which usually alternates with a polycentric rhizomycelioid endobiotic phase that produces resting sporangia within the host tissues. As such they are quite distinct from species of the *Cladochytriaceae*. So far, only two species of *Physoderma* have been collected in New Zealand.

Physoderma alfalfae (Pat. and Lagerh.) Karling, 1950. Lloydia 13: 44.

Cladochytrium alfalfae Patouillard and Lagerheim, 1895. Bull. l'Herb. Boissier 3: (62).

Physoderma leproides Lagerheim, 1898. Bihang K. Svensk. Vet. Akad. Handl. 24, afd. 3, no. 4: 10, pls. 2, 3.

Urophlyctis alfalfae Magnus, 1902. Ber. Deut. Bot. Gesell. 20: 296, pl. 15, fig. 1—8.

Parasitic on *Medicago sativa*, Lincoln, Canterbury Province.

Physoderma potteri (Bartlett) Karling, 1950. Lloydia 13: 58.
Urophlyctis potteri Bartlett, 1926. Trans. Brit. Mycol. Soc. 11: 279, pls. 11—14.

Parasitis on *Lotus corniculatus,* Sharp's Bush, Te Hanga Valley and Kauaeranga Valley near Thames, Auckland Province, causing minute to pea-sized galls on the stems and roots.

Previously, this species was reported only from England, but it occurred fairly abundantly at the three localities noted above in New Zealand. The sizes and appearances of the galls induced, the endobiotic rhizomycelium, and resting sporangia were similar to those described by Bartlett, and the author has but little information to add about this species. Careful search and examination were made on submerged leaves of the host in a temporary pond for the ephemeral epibiotic stage, and on one leaf a few hyaline empty vesicle (fig. 19—22) with a basal tuft of rhizoids were found, which the author interpretes to be empty sporangia of *P. potteri.*

Several attemps were made to induce germination of the resting sporangia by alternate freezing, thawing, and drying, but these were unsuccessful.

Summary

Four species of *Cladochytrium,* eight of *Nowakowskiella,* one of *Septochytrium* and two of *Physoderma* were collected and identified in New Zealand. Among these *Cladochytrium aurantiacum* and *Physoderma potteri* had been reported previously only from Great Britain, and *Nowakowskiella atkinsii* only from Cuba.

Bibliography

Barlett, A. W. 1926. On a species of *Urophlyctis* producing galls on *Lotus corniculatus* Linn. Trans. Brit. Mycol. Soc. 11: 266—281, pls. 11—14.

Berdan, H. B. 1939. Two new genera of operculate chytrids. Amer. J. Bot. 26: 459—463, fig. 1, 2.

— 1941. A development study of three saprophytic chytrids. I. *Cladochytrium hyalinum* sp. nov. Amer. J. Bot. 28: 422—438, fig. 1—84.

— 1942. A developmental study of three saprophytic chytrids. III. *Septochytrium variabile* Berdan. Amer. J. Bot. 29: 260—270, fig. 1—72.

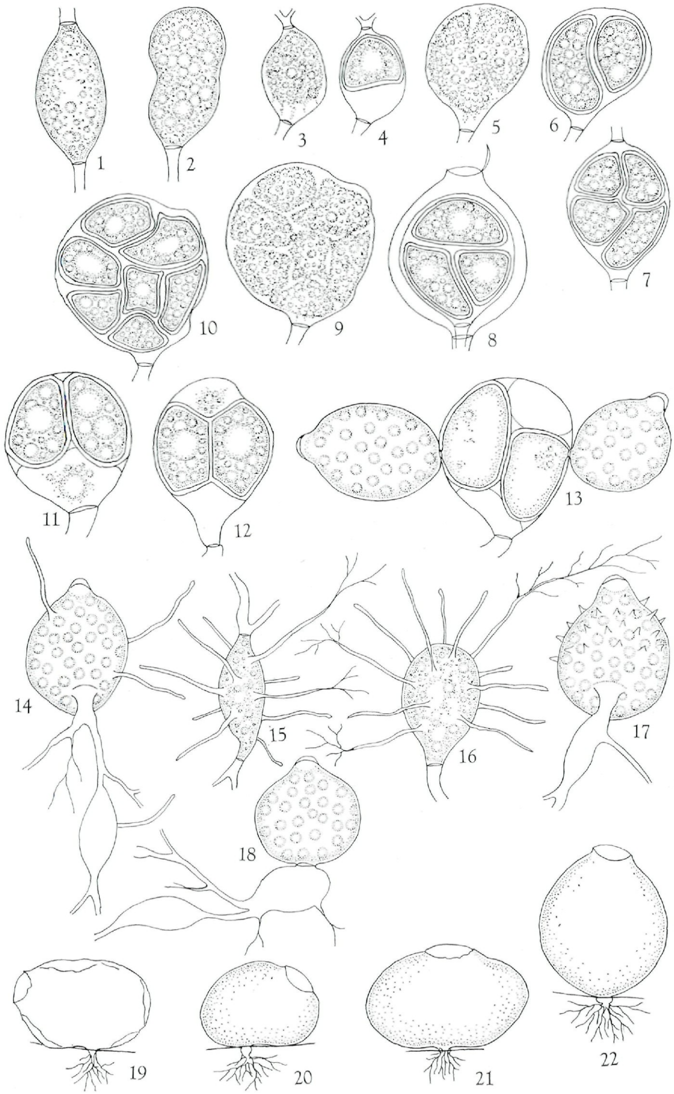
Butler, E. J. 1907. An account of the genus *Pythium* and some Chytridiaceae. Mem. Dept. Agric. India, Bot. ser. 1: 1—160, pls. 1—10.

Constantineanu, M. J. C. 1901. Contributions a la flore mycologique de la Romanie. Rev. Gen. Bot. 13: 369—389, fig. 75—84.

Karling, J. S. 1931. Studies in the Chytridiales. VI. The occurrence and life history of a new species of *Cladochytrium* in cells of *Eriocaulon septangulare.* Amer. J. Bot. 18: 526—557, pls. 42—44.

— 1932. Studies in the Chytridiales. VII. The organization of the chytrids thallus. Amer. J. Bot. 19: 41—47, 138 figs.

— 1935. A further study of *Cladochytrium replicatum* with special re-


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

ference to its distribution, host range, and culture on artificial media. Amer. J. Bot. 22: 439—452, fig. 1—29.

— 1941. *Cylindrochytridium johnstonii* gen. nov. et sp. nov., and *Nowakowskiella profusum* sp. nov. Bull. Torrey Bot. Club 68: 381—387, 16 figs.

— 1944. Brazilian chytrids. I. Species of *Nowakowskiella*. Bull. Torrey Bot. Club 71: 374—389, 69 figs.

— 1945. Brazilian chytrids. V. *Nowaskowskiella macrospora* n. sp., and other polycentric species. Amer. J. Bot. 32: 29—35, 51 figs.

— 1949. *Nowaskowskiella crassa* sp. nov., *Cladochytrium aureum* sp. nov. and other polycentric species from Maryland. Bull. Torrey Bot. Club 76: 294—301, 17 figs.

— 1950. The genus *Physoderma* (Chytridiales). Lloydia 13: 20—71.

— 1964. Indian chytrids. IV. *Nowakowskiella multispora* sp. nov., and other polycentric species. Sydowia 17: 314—319, fig. 1—8.

Lagerheim, G. 1898. Mykologische Studien I. Beiträge zur Kentnis der parasitischen Pilze, 1—3. Kong. Veten. Akad. Handl. 24 (111): 1—21.

Magnus, P. 1902. Ueber die in den Knolligen Wurzelwüchsen der Luzerne lebende *Urophlytis*. Ber. deut. Bot. Gesell. 20: 291—296.

Nowakowski, L., 1876. Beitrag zur Kenntnis der Chytridiaceen. Cohn, Beitr. Biol. Pflanz. 2: 73—100, pls. 4—6.

Patouillard, N., and G. Lagerheim, 1895. Champignons de l'equateur. Bull. l'Herb. Boiss. 3: 53—74.

Richards, M. 1956. Some inoperculate chytrids from South Wales. Trans. Brit. Mycol. Soc. 39: 261—266, 5 figs., pls. 6, 7.

Scherffel, A. 1936. In Domjan's „Vizigombas"-Adotok Szeged in Tihany Videkeröl („Wasserpilz"-Daten aus der Umgebung von Szeged und Tihany). Folio Cryptogam. 2 (1): 8—59, pl. 1.

Schroeter, J. 1897. Phycomycetes. Engler u. Prantl, Die Natürl. Pflanzenf. 1 (1): 63—141.

Shanor, L. 1942. A new fungus belonging to the Cladochytriaceae. Amer. J. Bot. 29: 174—179, 38 figs.

Sparrow, F. K., Jr. 1931. Two new chytridiaceous fungi from Cold Spring Harbor. Amer. J. Bot. 18: 615—623, pl. 45.

— Jr. 1950. Some Cuban Phycomycetes. J. Wash. Acad. Sci. 40: 50—55, 30 fig.

— Jr. 1960. Aquatic Phycomyetes ... pp. XXV—1187. Univ. Michigan Press, Ann Arbor.

Explanation of Figures

Figs. 1—13. *Nowakowskiella hemisphaerospora*. Fig. 1, 2. Incipient intercalary and terminal swellings or resting spore mother-cells; content dense with numerous coarse granules and globules. — Fig. 3. Contraction of contents in a small intercalary swelling. — Fig. 4. Same 18 hours later. — Fig. 5. Beginning of division of sporeplasm into two unequal parts. — Fig. 6. Same 28 hours later; empty cell or space lacking; spores lying free in the swelling. — Fig. 7. Intercalary swelling with 4 free-lying spores; empty cells lacking. — Fig. 8. Terminal swelling with 3 spores which has proliferated into an empty sporangium; empty cells lacking. — Fig. 9. Division of sporeplasm into 7 segments in an unusually large swelling. — Fig. 10. Same 30 hours later with 7 polyhedral spores. — Fig. 11. Terminal swelling with 2 spores and an empty area or cell (?) below. — Fig. 12. Terminal swelling with two spores and two empty areas or cells (?). — Fig. 13. Germination of 2 spores.

Figs. 14—18. *Nowakowskiella atkinsii.* Fig. 14. Sporangium with 3, and spindle organ with 1 flexuous setae. — Fig. 15, 16. Spindle organ and incipient sporangium, respectively, bearing numerous setae; some of setae branched at tips and rhizoid-like. — Fig. 17. Sporangium with pegs. — Fig. 18. Sporangium and spindle organ without setae.

Fig. 19—22. *Physoderm potteri* (?). Fig. 19—22. Probably empty sporangia of *P. potteri* on surface of young leaves of *Lotus corniculatus.*