Indian Chytrids. IV. Nowakowskiella Multispora Sp. Nov. and other Polycentric Species.*)

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(8 text-figures).

Previous publications by the author (1964 a—e) on the aquatic zoosporic fungi of India related to members of the families *Plasmodiophoraceae, Olpidiaceae, Rhizidiaceae* and *Rhizidiomycetaceae*. The present contribution concerns the aquatic polycentric chytrids which were isolated from soil and water samples in various parts of India in 1963. Small soil samples were covered with boiled tap water and baited with bits of various substrata such as bleached corn leaves, onion skin, cellophane, chitin, skin, hair, and hemp seed in the manner which has become almost standarized for the trapping, isolation and study of aquatic zoosporic fungi. In addition to these substrata human fibrin film was used as a bait in most soil cultures, and several new chytrids were isolated on this substratum.

Among the numerous chytrids trapped on bleached corn leaves, cellophane and onion skin occurred a species of *Nowakowskiella* which the author has been unable to identify with the other eleven species of this genus. It is characterized principally by an unusually abundant production of resting spores and by small zoospores. Accordingly, it is diagnosed as a new species and named *multispora*.

Nowakowskiella multispora sp. nov.

Fungus saprophyticus. Rhizomycelio hyalino, profuso, copiose ramoso, partibus tenuibus, 2—5 μ diam., incrementis pluribus non septatis, ovalibus, fusiformibus, 10—15 × 17—30 μ, aut elongatis. Sporangiis terminalibus aut intercalaribus, 12—16 × 20—32 μ diam., elongatis aut cylindris, 10—14 × 32—40 μ diam., oblongatis, ovalibus aut sphericis, 8—26 μ diam. Zoosporis sphaericis, 3—3.9 μ diam., unico globulo refringenti; flagello 12—14 μ longo. Sporis perdurantibus numerosis, intercalaribus, laevibus, hyalinis, ovalibus, 12—15 ×

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15—30 μ, oblongatis aut elongatis, 8—10 × 17—22 μ; germinantibus ut prosporangio membrano tenui ad superficium sporae.

Rhizomycelium profose, tenuous portions 2—5 μ diam.; spindle-shaped enlargements numerous and frequently in tandem, non-septate, narrowly ovoid, fusiform, 10—15 × 17—30 μ diam., or elongate, 8—10 × 17—22 μ diam. Sporangia usually terminal, sometimes intercalary, non-apophysate, hyaline, smooth, predominantly fusiform 12—16 × 20—32 μ diam., with long exit tubes, frequently elongate and almost cylindrical, ovoid or spherical, 8—26 μ diam., endo- or exo-operculate. Zoospores small, spherical, 3—3.9 μ diam., with a minute refringent globule; flagellum 12—14 μ long. Resting spores unusually abundant, usually intercalarly; formed by transformation of intercalary enlargements into fairly thick-walled structures, hyaline, smooth, almost spherical, 15—30 μ, broodly to narrowly ovoid, 12—15 × 15—30 μ, oblong or elongate 8—10 × 17—22 μ diam., with truncate ends, containing numerous large refractive globules; functioning as prosporangia in germination.

Saprophytic in bleached corn leaves, and on cellophane from non-brackish soil in a dry catch basin along the Rhamnad Road near Valantaravai, Rhamnad District, Madras State.

Type slide no. 104, P. U. L.

The structure and distinguishing characteristics of this species are illustrated in figs. 1 to 8. Its development from zoospore to rhizomycelium, sporangium and resting spore is basically similar to that of other species; hence it is not described further. As noted earlier, attempts to identify this species with any of the 11 other known members of *Nowakowskiella* have been unsuccessful. In *N. elegans, N. ramosa, N. hemisphaerospora, N. elongata, N. profosa, N. atkinsii* and *N. macrospora* the zoospores are reported to be 5—7.5 μ, 6.6—8.8 μ, 4.4—6.3 μ, 5—6 μ, 4.5—5 μ 5.7—7.5 μ, 5—6.6 μ, 4.5—5.5 μ, 5 × 3 μ and 10—12 in diameter, respectively, while in *N. multispora* they are only 3—3.9 μ in diameter. In this respect *N. multispora* is more similar to *N. sculptura* in which the zoospores are 3—3.8 μ in diameter, but the two species differ markedly by the manner of development and structure of the resting spores.

Except for *N. ramosa* and *N. sculptura* in which the resting spores are formed at the end of buds on pseudoparenchymatous intercalary enlargements, resting spore development in *N. multispora* is similar to that of the other species in that the spores develop by direct transformation of the enlargements into thicker-walled sructures in which numerous refractive globules have accumulated. However, in these other species resting spore production is sparse, and in *N. elegans,* particularly, they are rarely formed, according to the author's observations. In *N. multispora,* on the other hand, their development may occur so soon and abundantly that zoosporangia may be com-

paratively few or almost completely lacking. Sometimes strips of cellophane may contain almost nothing more than the tenous rhizomycelium and mature and developing resting spores (fig. 1). Usually, the resting spores are more abundant than is shown in figure 1. The sporangia usually occur at the edge of the cellophane, and immediately beneath is a relatively clear area of tenuous filaments, rhizoids and almost empty enlargements. Then follow inwardly the dense areas of resting spores.

The structure and appearance of the tenous portions of the rhizomycelium, intercalary enlargements, and sporangia are not specifically characteristic for *N. multispora*. The sporangia vary markedly in size and shape as indicated in the diagnoses above and fig. 1, and the majority of them develop long necks on cellophane. These may be endo- or exo-operculate. In light of Haskins (1950) and Haskin's and Weston's (1950) contention that the presence of endo-opercula is not a decisive criterion of whether or not a species is operculate, particular attention was given to the development and dehiscence of the sporangia of *N. multispora*. Most of the sporangia along the edge of cellophane strips were exo-operculate but quite a few were endo-operculate. In the latter, the development of the endo-operculum occurred in much the same manner as the author (1944, 1945, 1961) described it for *N. granulata, N. macrospora,* and *N. sculptura,* and in no instance was inoperculate dehiscence observed.

So far only one other species of *Nowakowskiella, N. ramosa* Butler, has been reported in India, but during this study several other aquatic polycentric species were isolated from brackish and non-brackish soils at sea level and up to an altitude of 4000 feet. These include:

Nowakowskiella elegans (Nowak.) Schroeter, 1893. Engler and Prantl, Natürlich. Pflanzenf. 1, (1): 82.

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

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

Saprophytic in bleached corn leaves, cellophane and fibrin film from dry non-brackish soil at Satur; 10 km., 30 km., and 60 km. south of Madurai along the Rhamnad Road, Virudunagar, and brackish soil at Mandapam Camp, Madras State. Also, this species occurred abun-

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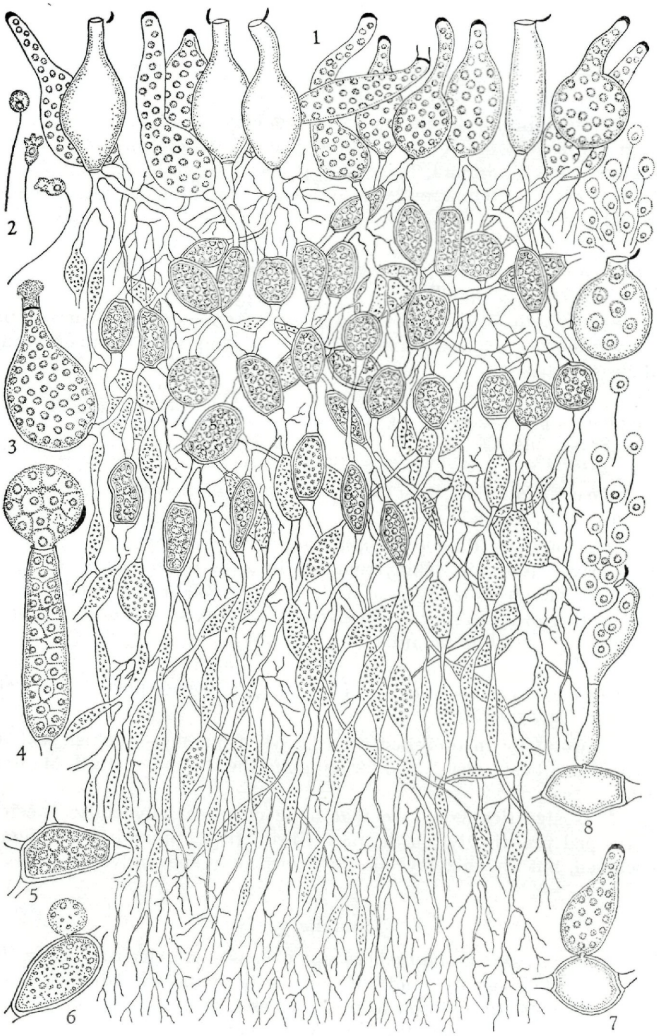
Figs. 1—8. *Nowakowskiella multispora*. Fig. 1. Portion of thallus on cellophane; sporangia at edge of substratum, resting spores within. Fig. 2. Zoospores. Fig. 3. Endo-operculate sporangium. Fig. 4. Dehiscence of almost cylindrical sporangium. Fig. 5. Mature polyhedral resting spore filled with globules. Figs. 6, 7, 8. Germination stages of resting spores.



dantly in soil collections in Ceylon, Thailand, Victoria Peak, Hong-Kong and Tokyo, Japan.

Nowakowskiella ramosa Butler, 1907. Mem. Dept. Agr. India, Bot. Ser. 1: 141, p. 10, figs. 3—10.

Saprophytic in bleached corn leaves, cellophane and fibrin film, from non-brackish soil and water at Satur, Uttarakosamangai, Virudunagar, and Rhamnad, Madras State, and Calcutta, Bengal State. Resting spore development was unusually abundant in all of these collections.

Nowakowskiella elongata Karling, 1944. Bull. Torrey Bot. Club 71: 375, figs. 30—44.

Saprophytic in bleached corn leaves, from non-brackish soil in a dry catch basin 5 km. north of Rhamnad along the Rhamnad Road, Madras State.

Cladochytrium replicatum Karling, 1931. Amer. J. Bot. 18: 538, pls. 42—44.

Cladochytrium hyalinum Berda, 1941. Amer. J. Bot. 28: 425, figs. 1—84.

Both of these *Cladochytrium* spezies were trapped on bleached corn leaves and onion skin from soil in a tea estate 39 km. west of Munnar, Kerala State, at an altitude of about 3500 ft. It is significant that neither of these species were found in brackish soil where *N. elegans* was usually abundant.

Septochytrium variabile Berdan, 1942. Amer. J. Bot. 29: 461, fig. 2.

Saprophytic in bleached corn leaves, from non-brackish soil in a dry catch basin near Valantarvai along the Rhamnad Road, Madras State.

It is significant to note that none of these polycentric species developed prolifically on human fibrin film. Sporadic infections occurred, but the rhizomycelia developed only sparingly.

Summary.

Nowakowskiella multispora sp. nov. is characterized primarily by a minute zoospores and an unusually abundant production of resting spores. In addition to this species *Cladochytrium replicatum* Karling, *C. hyalinum* Berdan, *Nowakowskiella elegans* (Nowa.) Schroeter, *N. ramosa* Butler, *N. elongata* Karling, and *Septochytrium variabile* Berdan were isolated from soil and water samples in India.

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