

Enumeration of Water Moulds Found in Tsukuba

By

Kazuko KONNO*

今野和子*: 筑波地域で採集した水棲菌について

(Communicated by Sho KUROKAWA)

In the course of continuing investigation of the water moulds, 14 species have been identified and added to the water mould flora of Tsukuba reported by the author (1983). In current studies soils were collected not only in Tsukuba Botanical Garden, but also from Tsukuba Science City and Mt. Tsukuba. Of these 14 species, *Achlya cambrica*, *Achlya caroliniana*, *Aphanomyces phycophilus*, *Asterophlyctis sarcoptoides*, *Rhizophlyctis bonseyi*, *Karlingiomyces dubius* and *Nowakowskiella multispora* are reported for the first time in Japan.

The writer greatly appreciates generous assistance given by the staffs of the Tsukuba Botanical Garden and the Department of Botany of the National Science Museum in permitting her to proceed with this study.

OOMYCETES

1. *Olpidiopsis saprolegniae* var. *saprolegniae* (Braun) Cornu in Ann. Sci. Nat. Bot. V 15: 145, pl. 3, fig. 10 (1872); Tokunaga, Trans. Sapporo Nat. Hist. Soc. 13: 24, pl. 2, fig. 9 (1933); Konno, Sci. Rept., Tokyo Kyoiku Daigaku, Sec. B 14: 263, pl. 12, fig. J (1972).

Thalli gregarious in hypertrophied host hyphae. Zoosporangia ovoid, spherical, ellipsoidal, reniform or urceolate, 10-110 μm in diameter, 12-150 μm in length; wall smooth, thin, with one to several exit tubes; tubes 5-10 μm in diameter, 5-70 μm or more in length, straight, curved or swelling irregularly. Zoospores ellipsoid or reniform, 3-5 μm in diameter. Resting spores spherical, 25-70 μm in diameter; wall 3-6 μm in thickness, outer surface uneven; companion cells spherical, 12-30 μm in diameter.

Specimens examined: Parasitic in hyphae of *Saprolegnia ferax*(?). Akatsuka Park, Nov. 19, 1983, coll. by H. Oosuna.

Distribution: Australia, China, Czechoslovakia, Denmark, England, Germany, Japan, the Netherlands, New Zealand, Russia and the United States.

2. *Achlya cambrica* (Trow) Johnson in The genus *Achlya* 85, pl. 17, figs. E-I (1956).

Zoosporangia fusiform, 16-45 μm in diameter, 140-480 μm in length, renewed sympodially; zoospore discharged by achlyoid; zoospore cysts 9-11 μm in diameter. Oogonia

* Meikei Gakuen, 1-1, Inarimae, Yatabe-machi, Tsukuba-gun, Ibaraki Prefecture 305. 茗溪学園,
〒305 茨城県筑波郡谷田部町稲荷前 1-1

lateral, spherical, or angular, 26–42 μm in diameter; oogonial wall smooth, rarely with one to several papillate ornamentations, pitted or unpitted. Oogonial stalks straight, 12–60 μm or more in length. Antheridial branches lacking or sparse, monoclinal or androgynous, rarely declinal. Antheridial cells tubular, laterally appressed. Oospores eccentric, spherical or subspherical, 15–28 μm in diameter, one to four in a oogonium.

Specimens examined: Isolated on hemp seed from soil. Mt. Tsukuba, Oct. 18, 1984.

Distribution: Canada, England, and the Netherlands. New to Japan.

3. ***Achlya caroliniana*** Coker in Bot. Gaz. **50**: 381, figs. 1–8 (1910); Johnson, The genus *Achlya* 87, pl. 10, figs. D, E; pl. 21, figs. E–K (1956).

Hyphae stout, up to 70 μm in diameter. Zoosporangia fusiform, filiform or irregularly shaped, 34–60 μm in diameter, 160–340 μm in length, renewed sympodially. Oogonia abundant, lateral or intercalary, rarely terminal; spherical or oval when lateral or terminal, dolioform when intercalary, 23–42 μm in diameter; wall smooth, unpitted, occasionally with several papillate projections. Antheridial branches abundant, branched profusely, but most of them non-functional; when functional, androgynous or monoclinal. Oospores eccentric, spherical or subspherical, 15–25 μm in diameter, 1–6 in number in an oogonium.

Specimens examined: Isolated on hemp seed from soil. Pond of Botanical Garden, Dec. 2, 1984.

Distribution: Australia, Denmark, England, Germany and Jamaica. New to Japan.

4. ***Achlya klebsiana*** Pieters in Bot. Gaz. **60**: 486, pl. 21, figs. 1–4 (1915); Johnson, The genus *Achlya* 74, pl. 15, figs. A–E, pl. 16 (1956); Ookubo, Nagaoa **4**: 49, fig. 39 (1954); Ookubo & Kobayasi, Nagaoa **5**: 10 (1955).

Syn. *Achlya oryzae* Ito & Nagai in J. Fac. Agr., Hokkaido Imp. Univ. **32**: 17, pl. IV, figs. 3–11 (1931); T. Ito, Journ. Jap. Bot. **18**: 127, (1942); Kobayasi & Ookubo, Journ. Jap. Bot. **27**: 106, fig. 6 (1952); Ookubo, Nagaoa **4**: 53 (1954).

Specimens examined: Isolated on hemp seed from soil. Pond of Botanical Garden, Aug. 6, 1984.

Distribution: China, Denmark, England, India, Japan and Puerto Rico.

5. ***Aphanomyces phycophilus*** de Bary in Jahrb. wiss. Bot. **2**: 179, pl. 20, figs. 19–24 (1860); Scott, A monograph of the genus *Aphanomyces* 62, pl. IX, figs. A–C (1961).

Hyphae 6–10 μm in diameter, isodiametric, profusely developing in host cell to cell. Oogonia formed outside of the host cell, spherical, with numerous conical projections, 35–45 μm in diameter excluding projections; projections 4–5 μm in height. Antheridial cells ellipsoidal, 8–10 μm in diameter, 10–14 μm in length. Oospores spherical, 25–40 μm in diameter.

Specimens examined: Parasitic in *Spirogyra* sp. Pond of Botanical Garden, Apr. 23, 1983.

Distribution: Belgium, Germany, and the United States. New to Japan.

Since the zoospores have not been observed in the present study, it is difficult to decide whether the present species belongs to the genus *Aphanomyces* or genus *Pythium*. However, it has distinct large extramatrical oogonia which have numerous conical pro-

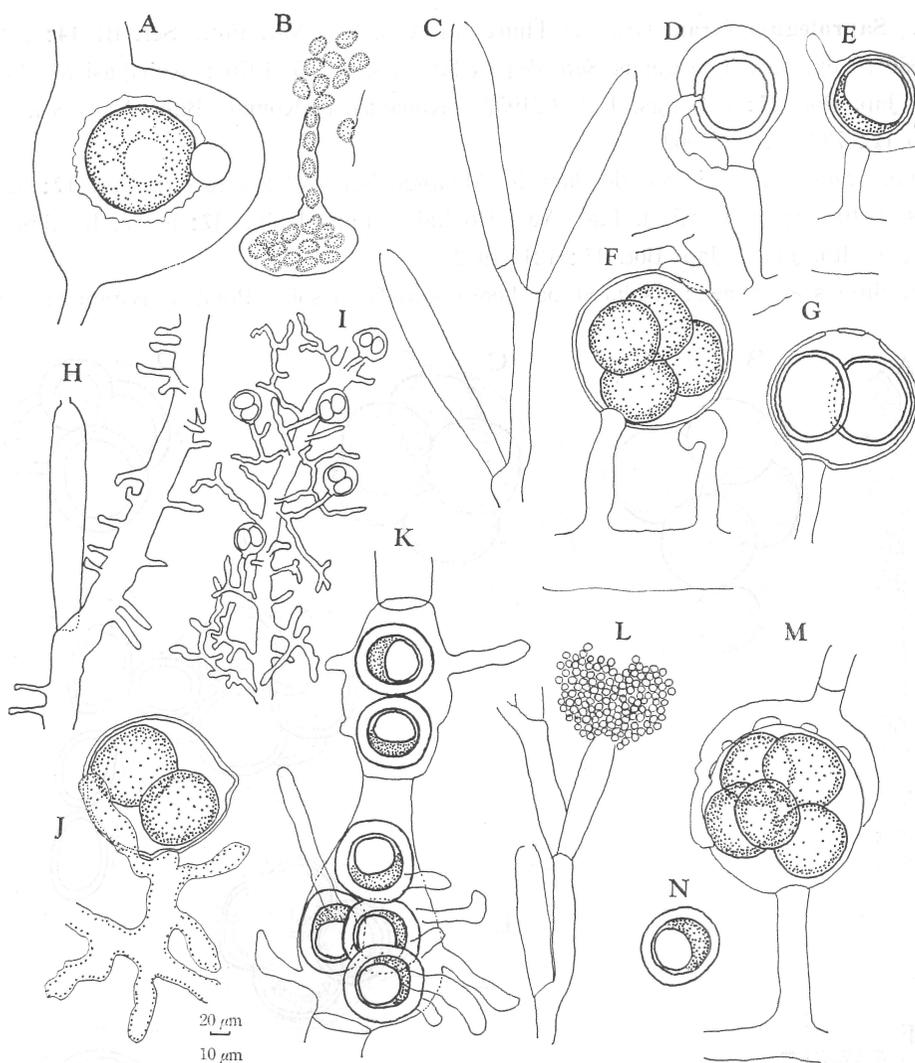


Fig. 1. A-B: *Olpidiopsis saprolegniae* var. *saprolegniae* (Braun) Cornu.

A: A resting spore with a companion cell in hypertrophied host hyphae.

B: A discharging zoosporangium.

C-G: *Achlya cambrica* (Trow) Johnson.

C: Empty zoosporangia. D-G: Oogonia in various types.

H-K: *Achlya caroliniana* Coker.

H: A part of hyphae with an empty zoosporangium and irregular projections. I: A part of hyphae with oogonia and nonfunctional antheridial branches. J: A young oogonium with nonfunctional antheridial branches. K: Intercalary oogonia with projections.

L-N: *Achlya klebsiana* Pieters.

L: Zoosporangia. M: An oogonium. N: A mature eccentric oospore. (Upper scale for C, H, L.)

jections and closely resembles the oogonia of *Aphanomyces phycophilus*.

There are thick filamentous zoosporangia (6-8 μm in thickness) in the other filaments of the *Spirogyra* which grow in the same petri dish. But, it is uncertain whether the zoosporangia belong to the present fungus or not.

6. *Saprolegnia ferax* (Gruith.) Thuret in Ann. Sci. Nat. Bot., Ser. III **14**: 214, pl. 22 (1850); Seymour, The genus *Saprolegnia* 29, figs. 48-55 (1970); Kobayasi & Ookubo, Journ. Jap. Bot. **27**: 184, figs. 1 & 2 (1952); Kobayasi & Konno, Bull. Nat. Sci. Mus., Tokyo **12**: 732, fig. 5 (1969).

Syn. *Saprolegnia thureti* de Bary in Abhandl. Senck. Naturforsch. Ges. **12**: 326, pl. 5, figs. 1-10 (1881); Nagai, J. Fac. Agr. Hokkaido Imp. Univ. **32**: 6, pl. II, figs. 2-15 (1931); T. Ito, Journ. Jap. Bot. **18**: 121 (1942).

Specimens examined: Isolated on hemp seed from soil. Pond of Botanical Garden,

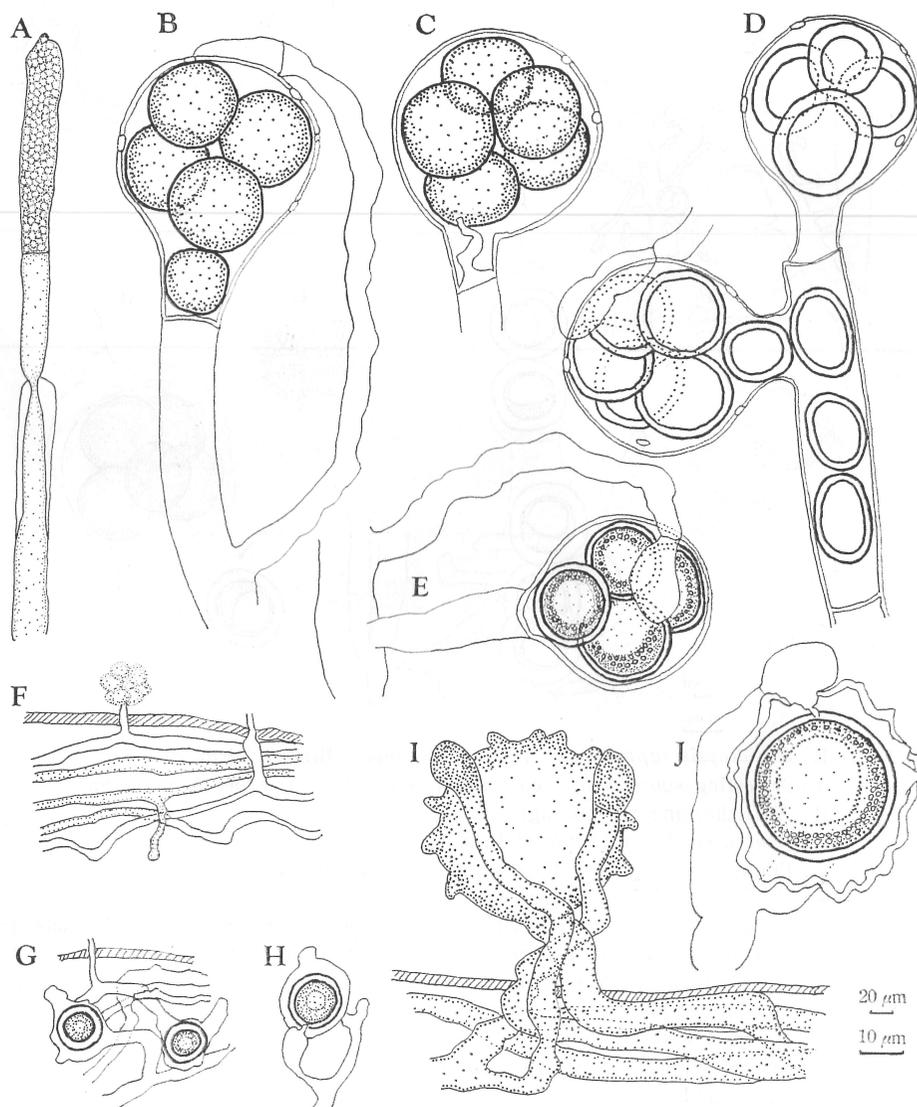


Fig. 2. A-E: *Saprolegnia ferax* (Gruith.) Thuret.

A: A tip of hyphae with a mature, proliferate zoosporangium. B-E: Oogonia.

F-H: *Pythium tenue* Gobi. Zoosporangia and oogonia.

I-J: *Aphanomyces phycophilus* de Bary. A young and a mature oogonium. (Upper scale for A.)

Nov. 12, 1984.

Distribution: Asia, Europe and the United States.

According to Seymour (loc. cit.), the antheridial branches of the species are monoclinalous or androgynous, rarely diclinous. On the other hand, the hypogynous type were observed in a few cases of the present strain.

7. *Pythium tenue* Gobi in Scrip. Bot. Hort., Univ. Imp. Petropol. **15**: 221-226, pls. 4-5 (1899-1900); Matthews, Studies on the genus *Pythium* 25, pl. 2 (1931); Tokunaga in S. Ito, Mycological Flora of Japan 102, pl. 42, fig. 5 (1936); Middleton, *Pythium* 38 (1943).

Hyphae slender, isodiametric, 1-3.5 μm in diameter, developing by penetrating cell wall of the host and branching profusely. Zoosporangia filamentous, not distinct from hyphae. Zoospores differentiated in a vesicle, 7-20 in number, 4-5 μm in diameter, 5-6 μm in length. Oogonia spherical, with or without apiculus, 10-15 μm in diameter; wall smooth. Antheridial branches 1-2 to an oogonium, monoclinalous or rarely diclinous; antheridial cells clavate, not delimited by septa. Oospores aplerotic, spherical, 9-13 μm in diameter; wall thin and smooth.

Specimens examined: Parasitic in *Spirogyra* sp. Pond of Botanical Garden, Apr. 23, 1983.

Distribution: Europe, Japan and the United States.

CHYTRIDIOMYCETES

8. *Asterophlyctis sarcoptoides* Petersen in Journ. de Botanique **17**: 218, figs. 3-10 (1903); Ann. Mycologici **8**: 549, fig. 21e (1910); Konno in Otani (ed.), Repts. Cryptogamic study in Nepal 126, fig. 1, J-V (1982).

Zoosporangia hyaline, colorless, asteroid, 18-44 μm in diameter, 14-32 μm in height; protrusions thin-walled, conical, bluntly conical or truncate up to 8 μm in diameter at the base, up to 7 μm in height; zoosporangial wall thin, hyaline; discharge papillae or tubes singular, lateral or sublateral, 4-6 μm in diameter; apophyses subspherical or spherical, 6-13 μm in diameter, 5-10 μm in height; rhizoids arising from the several portions of the apophyses, consisting of generally two (one in small thalli) thick main axes and several thin rhizoids; main axes branching and extending profusely. Zoospores hyaline, colorless, spherical, 3-4 μm in diameter, within a single small refractive globule.

Resting spores stellate, 12-38 μm in diameter including protrusions; protrusions spiny, acutely or bluntly conical, occasionally bifurcate; wall thick, up to 5 μm in thickness excluding protrusions.

Specimens examined: Isolated on decalcified exoskeleton of shrimp from soil. Pond of Botanical Garden, Aug. 6, 1984.

Distribution: Brazil, Denmark, England, Nepal and the United States. New to Japan.

The shape of the zoosporangia of the *Asterophlyctis sarcoptoides* is extremely variable as previously described by Antikajian (1949), Dogma (1974b) and Konno (1982). For example, typical zoosporangia are stellate-shaped by having many protrusions, however, they are occasionally inconspicuous or absent; although discharge tubes are formed fre-

quently in place of discharge papillae. In the present strain, such smooth-shaped zoosporangia and long discharge tubes were not observed, because zoosporangia of the present strain are few, as zoosporangial formation soon ceased and most thalli changed to resting spores.

9. *Rhizophlyctis bonseyi* Sparrow in Mycopath. et Mycol. Appl. **25**: 130, figs. 29-54 (1965); Konno, Bull. Natn. Sci. Mus., Tokyo, Ser. B **10**: 92 fig. 3, A-H (1984).

Zoosporangia pale yellow, spherical, subspherical or ovoid, 22-70 μm in diameter, 30-80 μm in height, with a single broad exit papillae or tubes; papillae or tubes 10-18 μm in diameter at the base, up to 25 μm in length; when matured, the tip of the papillae or tubes deliquessed and filled with hyaline, gelatinous substance; zoosporangial wall smooth with a hemispherical, thick zoospore cyst. Rhizoidal system arising from several portions of the zoosporangia, occasionally stout, branching and extending profusely. Zoospores spherical, 4-6 μm in diameter, with a single small, pale yellow refractive globule; flagella 30-35 μm in length.

Specimens examined: Isolated on decalcified exoskeleton of shrimp from soil. Mt. Tsukuba, Oct. 18, 1984, pond of Botanical Garden, June 25, 1985.

Distribution: Hawaii, New Zealand and Taiwan. New to Japan.

This is the first record of the species from Japan. However, this species seems to be a widely distributed in temperate or warm-temperate region in the world, because it was also isolated from many soil samples collected in Taiwan (Konno, loc. cit.).

10. *Catenochytridium laterale* Hanson in Torreyia **44**: 32 (1944); Amer. J. Bot. **33**: 389-393, figs. 1-31 (1946); Konno, Bull. Natn. Sci. Mus., Tokyo, Ser. B **10**: 93, fig. 3, I-N (1984).

Specimens examined: Isolated on Welsh onion skin from soil. Mt. Tsukuba, Oct. 18, 1984.

Distribution: Japan, Nepal, New Zealand, Taiwan and the United States.

Very small thalli (14 μm in diam.) were also observed along with the thalli of ordinary size. The rhizoidal system of these small thalli are simple and their apophyses are arranged in only one line (fig. 3J), and their rhizoids single and less branched. In extreme cases, such small thalli have only one apophysis and a rather simple rhizoid, and have a *Chytriomycetes*-like appearance (fig. 3I).

11. *Karlingia rosea* (de Bary & Woronin) Johanson in Amer. J. Bot. **31**: 399, figs. 1-37 (1944); Dogma, Nova Hedwigia **24**: 401 (1973); Konno in Otani (ed.), Repts. Cryptogamic study in Nepal 129, figs. 2A-C (1982).

Syn. *Rhizophlyctis rosea* (de Bary & Woronin) Fischer in Rabenhorst, Krypt. Fl. 1(4): 122 (1892); Sparrow, Aquatic Phycomycetes (2nd ed.) 441 (1960); Konno, Sci. Rept. Tokyo Kyoiku Daigaku, Sec. B **14**: 246, pl. 6, figs. A-I (1972).

Specimens examined: Isolated on Welsh onion skin from soil. Pond of Botanical Garden, June 25, 1985.

Distribution: Africa, Australia, Brazil, China, Cuba, England, France, the Galapagos Is., Germany, Greenland, Hawaii, Iceland, India, Japan, Lapland, the Marshal Is., Mexico, Nepal, New Guinea, New Zealand, Taiwan, the United States and West Indies.

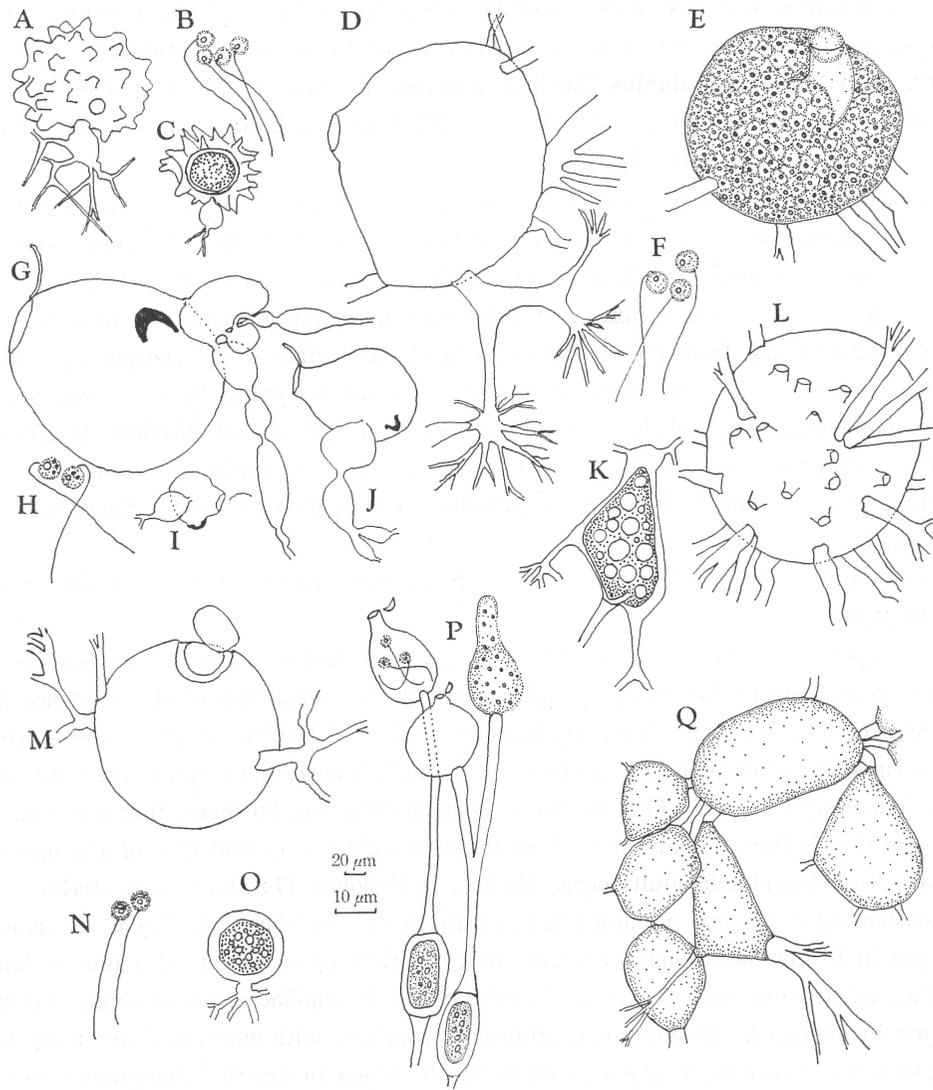


Fig. 3. A-C: *Asterophlyctis sarcoptoides* Petersen.

A: An empty zoosporangium. B: Zoospores. C: A resting spore.

D-F: *Rhizophlyctis bonseyi* Sparrow.

D: An empty zoosporangium. E: A mature zoosporangium with gelatinous plug in the tip of an exit tube. F: Zoospores.

G-J: *Catenochytridium laterale* Hanson.

G, I, J: Zoosporangia in various types. H: Zoospores.

K-L: *Karlingia rosea* (de Bary and Woronin) Johanson.

K: A resting spore. L: An empty, large zoosporangium.

M-O: *Karlingiomyces dubius* (Karling) Sparrow

M: An empty zoosporangium. N: Zoospores. O: A resting spore.

P: *Nowakowskiella multispora* Karling. A part of thallus with zoosporangia and resting spores.

Q: *Catenophlyctis variabilis* (Karling) Karling. Polycentric thallus. (Upper scale for L)

This is one of the most widely distributed species of the chytrids, growing on cellulose substances. The present strain forms asexual resting spores profusely.

12. *Karlingiomyces dubius* (Karling) Sparrow in *Aquatic Phycomycetes* (2nd ed.) 561 (1960); Dogma, *Nova Hedwigia* **24**: 400 (1973); Konno, *Bull. Natn. Sci. Mus., Tokyo, Ser. B* **10**: 96, figs. 3, Q-R (1984).

Zoosporangia spherical, subspherical, ovoid or pyriform, 35-90 μm in diameter; wall smooth or verrucose, with a broad, low, discharge papilla; papillae 10-22 μm in diameter at the base, exooperculate, slit appearing under the operculum prior to dehiscence, and as a result double rims recognizable at the orifice after the operculum dehiscence. Rhizoidal system arising from the several portions of the surface of the zoosporangia, stout, branched and extending profusely. Zoospores spherical, 5-6 μm in diameter, with a single conspicuous refractive globule. Resting spores spherical or subspherical, 11-25 μm in diameter; wall verrucose, thick, 2.5-4 μm in thickness; germination not observed.

Specimens examined: Isolated on decalcified exoskeleton of shrimp from soil. Mt. Tsukuba, Oct. 18, 1984.

Distribution: England, New Zealand, Singapore, Taiwan and the United States. New to Japan.

This species is a very unique chytrid by its operculation. After the dehiscence, two rims are recognized at the orifice. Explanations of the mechanism of this evidence have been presented by Karling (1949), Willoughby (1957) and Dogma (1974a). The existence of two rims means cleavage occurs two times, but it is uncertain whether the sporangium has a double wall or not. This is unquestionable evidence, however, that the wall between two rims is thinner than the wall of the sporangia proper and that of the opercula.

13. *Nowakowskiella multispora* Karling in *Sydowia* **17**: 314, 8 figs. (1963).

Zoosporangia terminal or intercalary, pyriform or subglobose, 10-22 μm in diameter, 18-30 μm in height, occasionally elongate or cylindrical up to 50 μm or more in length including exit tubes; wall thin, smooth, colorless; exit papillae or tubes singly, apically, 3.5-5 μm in diameter. Rhizomycelia profusely branched, with numerous intercalary swellings; swellings fusiform, 8-12 μm in diameter, 10-16 μm in length. Zoospores spherical, 3-3.5 μm in diameter, within a small refractive globule.

Resting spores abundant, intercalary, ellipsoid, fusiform or cylindrical, 8-12 μm in diameter, 15-20 μm in length; wall colorless, 1.5-3 μm in thickness; contents granulate, with numerous refractive globules. Germinations not observed.

Specimens examined: Isolated on Welsh onion skin from soil. Pond of Botanical Garden, Aug. 6, 1984.

Distribution: India, New Zealand and Oceania (Cook Is., Pitcairn, and American Samoa). New to Japan.

Present species closely resembles *N. profusa*, but differs in smaller zoospores and colorless resting spores. It grows profusely on Welsh onion skin and forms zoosporangia congregated at or near the edge of the substrata and resting spores at inner part of the substrata.

14. *Catenophlyctis variabilis* (Karling) Karling in *Amer. J. Bot.* **52**: 134, figs. 1-12

(1965); Konno, Sci. Rept., Tokyo Kyoiku Daigaku, Sec. B 14: 259 (1972).

Specimens examined: Isolated on snake skin from soil. Paddy field near the Botanical Garden, Aug. 9, 1984.

Distribution: Africa, Alaska, Australia, Brazil, England, India, Israel, Japan, New Zealand, Oceania and the United States.

摘 要

筑波地域で採集した水棲菌15種を列記した。1983年発表の筑波実験植物園の水棲菌につけ加えるものである。ただし採集範囲を植物園外にもひろげた。14種のうち次の7種は日本新産である。*Achlya cambrica*, *A. caroliniana*, *Aphanomyces phycophilus*, *Asterophlyctis sarcoptoides*, *Rhizophlyctis bonseyi*, *Karlingiomyces dubius*, *Nowakowskiella multispora*.

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- , 1983. Watermoulds collected from Tsukuba Botanical Garden. Ann. Tsukuba Bot. Gard. 2: 71-79, 1 fig.
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