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STUDIES ON THE AQUATIC CHYTRIDS OF JAPAN

I. Woroninaceae

BY

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(With one Plate)

The aquatic chytrids hitherto reported from Japan are three species of *Pseudolpidium* in Woroninaceae. They are *P. fusiforme* (CORNU) A. FISCHER, *P. stellatum* SAWADA and *P. Saprolegniae* (A. BRAUN) A. FISCHER all of which have been described by K. SAWADA¹⁾ from Formosa. He has also recorded an undetermined fungus parasitic in the hyphae of *Achlya prolifer* SAWADA (not NEES, identical with *A. flagellata* COKER), which was placed by him in Olpidiaceae as well as the three species above mentioned. After inspecting his description, however, the writer was led to the belief that this fungus in all probability belongs to Woroninaceae.

In the course of the studies on rot-disease of rice-seedlings, the writer observed many Chytridiaceous parasites in the hyphae of causal organisms of the disease. His interest in such groups of fungi urged him on an eager collection of higher water molds, algae, lower animals etc. which might have been affected by certain Chytridiaceous fungi. The materials obtained by him personally or sent from various districts were cultured in the laboratory and examined from time to time for the development of Chytridiaceous fungi. The present paper was prepared to record ten species belonging to four genera in Woroninaceae collected in Japan. The descriptions and illustrations of these fungi were made by the writer based upon his own observations with the one exception of *Pseudolpidium stellatum* SAWADA which was noted here as an addition.

The writer wishes to express here his sincere thanks to Prof. Emer. K. MIYABE for his valuable suggestions and to Profs. S. ITO and Y. TOCHINAI for their kind directions. He is also indebted to Mr. M. NAGAI for his kind help in the identifications of the host plants.

***Pseudolpidium* A. FISCHER**

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 33.

¹⁾ Studies on the rot-disease of rice-seedlings. (Spec. Bull. Agr. Exp. Sta. Formosa, III, 1912. *In Japanese*).

[Transact. Sapporo Nat. Hist. Soc., Vol. XIII, Pt. 1, 1933]

Syn. *Olpidiopsis* CORNU pro parte, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 114. *Olpidiopsis* (CORNU) SCHRÖTER, in ENGLER-PRANTL, Natürl. Pfl. Fam. I, 1, 1897, p. 69.

1. *Pseudolpidium fusiforme* (CORNU) A. FISCHER

(Pl. II, figs. 1 & 2)

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 35; SCHRÖTER, in ENGLER-PRANTL, Natürl. Pfl. Fam. I, 1, 1897, p. 69; SAWADA, in Spec. Bull. Agr. Exp. Sta. Formosa, III, 1912, p. 69, pl. VIII, figs. 15-16, pl. IX, figs. 1-9.

Syn. *Olpidiopsis fusiformis* CORNU, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 147 pro parte, pl. IV, figs. 1-3; A. FISCHER, in Jahrb. Wiss. Bot. XIII, 1882, p. 320 & 363, pl. XIII, fig. 1.

Zoosporangia solitary or gregarious in fusiformly swollen hyphae of the host, fusiform to cylindrical in shape, or rarely crooked, variable in size, 98-350 μ long, 30-78 μ wide, with colorless, smooth membrane and a short exit tube; zoospores egg-shaped, about $4 \times 2 \mu$, with two cilia; resting spores similar to zoosporangia in shape and size, but with densely echinulate membrane.

Hab. In hyphae of *Achlya flagellata* COKER.

Hokkaido: Prov. Ishikari; Kotoni (May 21, 1931; May 25, 1932. Y. TOKUNAGA); Shinoro (June 9, 1931. H. OTANI); Sapporo (June 7, 1932. Y. TOKUNAGA).

Honshu: Prov. Mutsu; Kuroishi (May, 1931. J. KIMURA). Prov. Rikuzen; Iwanuma (May, 1931). Prov. Iwashiro; Koriyama (May, 1931).

In hyphae of *Achlya flagellata* COKER var. *yezoensis* ITO et NAGAI.

Hokkaido: Prov. Ishikari; Shin-kotoni (May 28, 1931. Y. TOKUNAGA); Kotoni (May 25, 1932. Y. TOKUNAGA). Prov. Shiribeshi; Setana (May, 1931).

In hyphae of *Achlya racemosa* HILDEBR.

Hokkaido: Prov. Ishikari; Sapporo (May 27, 1931. Y. TOKUNAGA); Kotoni (May 25, 1932. Y. TOKUNAGA). Prov. Shiribeshi; Setana (May, 1931).

Distrib. Europe, Central Asia and Japan.

This was found very commonly in the hyphae of *Achlya* causing the rot-disease of rice-seedlings. In many cases, it was accompanied by *Olpidiopsis minor* A. FISCHER as many authors have reported already. This species is very remarkable among the fungi parasitic on water molds for its extremely large zoosporangium and resting spore. K. SAWADA has recorded this fungus from Formosa as parasitic in *Achlya prolifera* SAWADA (*A. flagellata* COKER). In his fungus, the zoosporangia are $45-305 \times 18-51 \mu$, having one to three exit tubes which are very long, up to 64 μ and 8 μ wide. The resting spores are $27-310 \times 19-78 \mu$ and germinate through one to nine exit tubes.

2. *Pseudolpidium Pythii* BUTLER

(Pl. II, figs. 3 & 4)

in Mem. Dept. Agr. India, I, 5, 1907, p. 127, pl. VII, figs. 9-16.

Zoosporangia solitary or gregarious in swollen diverticula of host hyphae, ovoidal or ellipsoidal, up to $32\ \mu$ in the longer diameter, with a single exit tube; zoospores elongated, having a cilium in front and another on the lateral side; resting spores solitary or gregarious, and also in company with zoosporangia, spherical or ellipsoidal, $19.2-30\ \mu$ in diameter, brownish, with fine, short spines.

Hab. In hyphae of *Pythium Oryzae* ITO et TOKUNAGA.

Hokkaido: Prov. Ishikari; Koton (May 20, 1932. Y. TOKUNAGA).

Distrib. Europe and Japan.

The fungus was found in the host hyphae growing on the rotted seedlings of rice-plant. This species is easily distinguished from the related species by its habitat, living in the vegetative hyphae of *Pythium*.

3. *Pseudolpidium Saprolegniae* (A. BRAUN) A. FISCHER

(Pl. II, fig. 5)

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 35; SAWADA, in Spec. Bull. Agr. Exp. Sta. Formosa, III, 1912, p. 72, pl. X, figs. 11-14.

Syn. *Chytridium Saprolegniae* A. BRAUN, in Abhandl. Berl. Akad. Wissensch. 1855, p. 61 pro parte, pl. V, fig. 23. *Olpidium Saprolegniae* A. BRAUN, ibidem p. 75. *Olpidiopsis Saprolegniae* CORNU, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 145 pro parte, pl. III, fig. 8; A. FISCHER, in Jahrb. Wiss. Bot. XIII, 1882, p. 363, pl. XIII, figs. 2-5; SCHRÖTER, in Krypt. Fl. Schlesien, III, 1, 1889, p. 183.

Zoosporangia gregarious in the host hyphae, ellipsoidal, with smooth membrane and long exit tubes, irregular in size, $34-120\ \mu$ in longer diameter; zoospores ovoidal, $4 \times 2\ \mu$, apically and laterally ciliated; resting spores spherical or ellipsoidal, with fine scattered spines, $64-87\ \mu$ in diameter.

Hab. In hyphae of *Saprolegnia Thureti* DE BARY.

Hokkaido: Prov. Ishikari; Sapporo (July 12, 1931. Y. TOKUNAGA); Maruyama near Sapporo (June 9, 1932. Y. TOKUNAGA).

Distrib. Europe, Central Asia and Japan.

K. SAWADA recorded this fungus parasitic in *Saprolegnia* sp. from Formosa. In his fungus, the zoosporangia are formed to the number of one to eight in a dilation of hypha and are elliptical to long elliptical, $40-103 \times 20-42\ \mu$ in size. The resting spores are not observed.

4. *Pseudolpidium steldlatum* SAWADA

in Spec. Bull. Agr. Exp. Sta. Formosa, III, 1912, p. 70, pl. VIII, figs. 11-16. (*In Japanese*).

Description condensed and translated from the original:

Zoosporangiis zoosporisque ignotis; sporis perdurantibus sphaericis, interdum ovoideo-globosis, hyalinis vel luteis, 24–100 μ diam., aculeis conicis, acribus, 9–24 μ longis ornatis.

Hab. In hyphae of *Achlya prolifer* SAWADA (*A. flagellata* COKER).

Distrib. Japan.

K. SAWADA found this fungus in the hyphae of *Achlya* causing the rot-disease of rice-seedlings in Formosa. According to his description, this fungus was found independently or in company with *Pseudolpidium fusiforme*. The resting spores resembled those of *Olpidiopsis minor* A. FISCHER, but the companion cells were never found in spite of careful and repeated observations. Accordingly he decided that this fungus was a new species of *Pseudolpidium*.

Olpidiopsis (CORNU) A. FISCHER

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 37; CORNU pro parte, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 114.

Syn. *Diplophysa* SCHRÖTER, in Krypt. Fl. Schlesien, III, 1, 1889, p. 195 & in ENGLER-PRANTL, Natürl. Pfl. Fam. I, 1, 1897, p. 85.

5. Olpidiopsis minor A. FISCHER

(Pl. II, figs. 6–8)

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 39; BUTLER, in Mem. Dept. Agr. India, I, 5, 1907, p. 134, pl. IX, figs. 8–11.

Syn. *Olpidiopsis fusiformis* CORNU, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 147 pro parte, pl. IV, figs. 3 a & 4.

Zoosporangia gregarious in large dilations of the host hyphae, spherical or ellipsoidal, sometimes elongated, 45–97 μ long, 25–50 μ wide, with one or two exit tubes which are 4.8–6.0 μ in width; zoospores ellipsoidal or elongated, with two cilia, one of them fixed laterally, the other in front; resting spores usually living with sporangia, spherical, yellowish-brown, with large, colorless, triangular spines, 32–52 μ in diameter without spines; companion cells usually single, sometimes double, spherical or ellipsoidal, 16–24 μ in diameter, with colorless, smooth, thin membrane.

Hab. In hyphae of *Achlya flagellata* COKER.

Hokkaido: Prov. Ishikari; Koton (May 21, 1931; May 25, 1932. Y. TOKUNAGA); Shinoro (June 9, 1931. H. OTANI); Bannosawa near Sapporo (June 5, 1932. Y. TOKUNAGA).

Honshu: Prov. Mutsu; Kuroishi (May, 1931. J. KIMURA). Prov. Rikuzen; Iwanuma (May, 1931).

In hyphae of *Achlya flagellata* COKER var. *jezoensis* ITO et NAGAI.

Hokkaido: Prov. Ishikari; Shin-kotoni (May 31, 1931. Y. TOKUNAGA).

In hyphae of *Achlya racemosa* HILDEBR.

Hokkaido: Prov. Ishikari; Sapporo (June 4, 1931. Y. TOKUNAGA). Prov. Shiribeshi; Setana (May, 1931).

Distrib. Europe, India and Japan.

The fungus was observed so commonly as *Pseudolpidium fusiforme* in the hyphae of *Achlya* causing the rot-disease of rice-seedlings. It is usually found in a swelling of host hyphae in company with *Pseudolpidium fusiforme*.

6. *Olpidiopsis Saprolegniae* CORNU

(Pl. II, fig. 9)

in Ann. Sci. Nat. 5 sér. XV, 1872, p. 145, pl. III, fig. 10 pro parte; BARRETT, in Ann. Bot. XXVI, 1912, p. 232, pl. XXIII, figs. 2-4, 8-9 & 21A.

Syn. *Chytridium Saprolegniae* A. BRAUN, in Abhandl. Berl. Akad. Wissensch. 1855, p. 61 pro parte.

Zoosporangia single or gregarious in the dilation usually near the end of hyphae, spherical or ellipsoidal, variable in size, with smooth membrane and one or two exit tubes; zoospores ellipsoidal, with two cilia; resting spores spherical, dark brown, with spiny membrane, 62-76 μ in diameter; companion cells usually one, sometimes two, spherical, hyaline, with smooth membrane, 25-28 μ in diameter.

Hab. In hyphae of *Saprolegnia monilifera* DE BARY.

Hokkaido: Prov. Ishikari; Sapporo (June 4, 1932. Y. TOKUNAGA).

Distrib. Europe, N. America and Japan.

This species was described by CORNU in 1872. According to his description the resting spores are provided with a large number of very fine spines and are accompanied by an adjacent cell with a smooth wall. In his illustration of this species the mature resting spores possess distinct spines rather than warts or tubercles. A. FISCHER in 1892 described *Olpidiopsis Saprolegniae* which he considered the same as CORNU's fungus. This fungus possesses resting spores provided with hemispherical or blunt colorless warts. The fungi above mentioned are species entirely distinct from each other. BARRETT has discussed this problem and described the latter as *Olpidiopsis vezans*. In our fungus, the resting spores are covered with membrane bearing numerous slender spines. The companion cells somewhat differ in size from those illustrated by CORNU, but the difference between the two fungi is not so remarkable to warrant as the different species.

7. *Olpidiopsis spinosa* TOKUNAGA, sp. nov.

(Pl. II, figs. 10 & 11)

Zoosporangii in hypha matricis solitariis vel gregariis, ellipsoideis vel cylindricis, majoribus, 92–198 μ longis, 34–61 μ latis, tubulis exitus 1–2, extra cellulam matricis prominentibus ornatis; zoosporis ellipsoideis vel elongatis, antice et lateraliter cilio praeditis; sporis perdurantibus sphaericis, membrana lutea vel argillacea tectis, spiculis numerosis, hyalinis, ca. 9.6 μ longis ornatis, sine spiculis 51–73 μ diam., cellula adhaerente singula, globosa, spinulosa, 25.2–32.4 μ diam. praeditis, germinatione nondum observata.

Hab. In hyphae of *Achlya flagellata* COKER.

Hokkaido: Prov. Ishikari; Kotoni (May 21, 1931. Y. TOKUNAGA).

Distrib. Japan.

This fungus was found in the hyphae of *Achlya flagellata* causing the rot-disease of rice-seedlings. The sporangia and resting spores are usually formed together in a dilation of hypha. The companion cells are thickly covered with hairy spines as well as the resting spores. *Olpidiopsis Index* CORNU is a unique species in the genus possessing the spiny companion cell. But its spines are very short and lie sparsely. This fungus was sometimes found together with *Pseudolpidium fusiforme* or *Olpidiopsis minor*.

Rozella CORNU

in Ann. Sci. Nat. 5 sér. XV, 1872, p. 114; A. FISCHER, in Jahrb. Wiss. Bot. XIII, 1882, p. 365.

8. *Rozella simulans* A. FISCHER

in Jahrb. Wiss. Bot. XIII, 1882, p. 365; von MINDEN, in Krypt. Fl. Mark Brandenburg, V, 1915, p. 273, fig. 11a.

Zoosporangia few to 15 or more in a single row, cylindrical, usually 60–250 μ long, 25–90 μ wide, with lateral membrane fused with the host cell-wall; zoospores liberating through the exit papillae at the apex or near the transverse wall, long ellipsoidal or cylindrical, about $6 \times 2.4 \mu$, with two cilia in front, one of them long, the other short; resting spores not observed.

Hab. In hyphae of *Achlya flagellata* COKER.

Honshu: Prov. Iwashiro; Koriyama (May, 1931).

Distrib. Europe and Japan.

This fungus was found in the materials of seedling-rot disease of rice-plant sent from the Iwate Agricultural Experiment Station. It was cultured for several months in a PETRI-dish to which the host fungus cultured on the sterilized rice-grains was occasionally added. Large globular bodies resembling the young

oogonia of the host were occasionally formed near the base of the sporangial range. They contained very dark and granular plasma and were easily burst by slight external pressure. It is highly probable that their contents may develop into the resting spore, but no mature resting spores were obtained in our culture. This species is closely related to *Rozella septigena* CORNU parasitic in *Saprolegnia*. There is no morphological difference between these species, but they are distinguishable from each other by their parasitism.

Woronina CORNU

in Ann. Sci. Nat. 5 sér. XV, 1872, p. 114.

9. *Woronina asterina* TOKUNAGA, sp. nov.

(Pl. II, figs. 15 & 16)

Zoosporangia in sori 4–20 aggregatis, sphaericis, 12–19 μ diam., membrana levi, hyalina cinctis, dein papilla brevi ornatis; zoosporis globosis vel ovoideis, 3–4 μ diam.; sporis perdurantibus in sori ut in zoosporangio formatis, sphaericis, 12–22 μ diam., flavis, aculeis conicis, crassis, hyalinis ornatis, germinatione nondum observata.

Hab. In hyphae of *Achlya americana* COKER.

Hokkaido: Prov. Oshima; Assabu, Hiyama (May, 1931).

Distrib. Japan.

This fungus was found in the hyphae of *Achlya americana* causing the rot-disease of rice-seedlings. The attacked hyphae lay down transverse septa dividing themselves into definite short cells. Such cells enclose the sorus of zoosporangia or resting spores. The sori are 96–216 μ long, 18–30 μ wide, and contain the zoosporangia or resting spores in single or double rows. The resting spores are provided with large conical spines as those of *Olpidiopsis minor* A. FISCHER. Their germination was not observed.

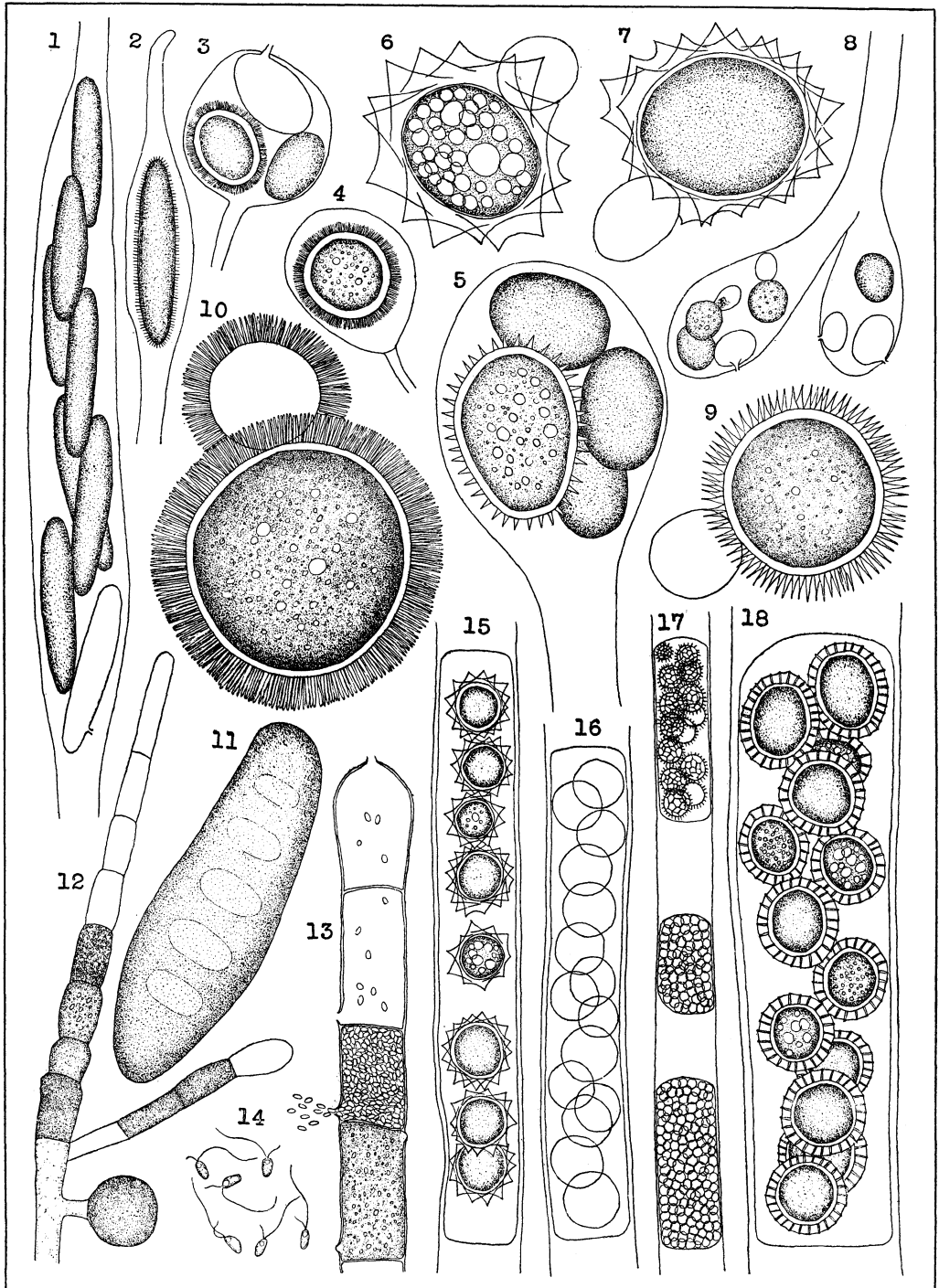
10. *Woronina glomerata* (CORNU) A. FISCHER

(Pl. II, figs. 17 & 18)

in RABENHORST's Krypt. Fl. I, 4, 1892, p. 67; ZOPF, in Beitr. z. Physiol. u. Morph. niederer Organismen, IV, 1894, p. 43, pl. II, figs. 1–13; pl. III, figs. 1–3.

Syn. *Chytridium glomeratum* CORNU, in Ann. Sci. Nat. 5 sér. XV, 1872, p. 187, pl. VII, figs. 20–22.

Sporangial sori scattered here and there in the filament of the host, cylindrical, irregular in size, 70–300 μ long, 50–96 μ wide; zoosporangia very irregular in number per sorus, spherical, 10–21 μ in diameter, with hyaline, smooth



membrane; zoospores ellipsoidal to cylindrical, about $3.6 \times 2.4 \mu$, with two cilia; resting spores formed in sori as in zoosporangia, spherical or ellipsoidal, 12–22 μ in diameter, with episore provided with fine spiny and net-like sculpture resembling spores of wheat-bunt (*Tilletia tritici*); spines 3.2–3.6 μ long.

Hab. In vegetative cells of *Vaucheria sessilis* DC.

Hokkaido: Prov. Ishikari; Sapporo (July 2, 1931. Y. TOKUNAGA).

Distrib. Europe and Japan.

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Explanation of Plate

Figs. 1 & 2. *Pseudolpidium fusiforme* in the host hyphae. ($\times 115$)

1. Zoosporangia. 2. Resting spore.

Figs. 3 & 4. Zoosporangia and resting spores of *Pseudolpidium Pythii* in the diverticula of host hyphae. ($\times 520$)

Fig. 5. A resting spore and three zoosporangia of *Pseudolpidium Saprolegniae* in the host hypha. ($\times 320$)

Figs. 6–8. *Olfidiopsis minor*.

6 & 7. Resting spore. ($\times 520$) 8. Zoosporangia and young resting spores in the host hypha. ($\times 150$)

Fig. 9. Resting spore of *Olfidiopsis Saprolegniae*. ($\times 320$)

Figs. 10 & 11. *Olfidiopsis spinosa*, n. sp. ($\times 520$)

10. Resting spore. 11. Zoosporangium.

Figs. 12–14. *Rozella simulans*.

12. A portion of host hypha attacked by the fungus. ($\times 90$) 13. Spor-
angial range. ($\times 160$) 14. Zoospores. ($\times 520$)

Figs. 15 & 16. *Woronina asterina*, n. sp. ($\times 520$)

15. Resting spores in a sorus. 16. Zoosporangia in a sorus.

Figs. 17 & 18. *Woronina glomerata*.

17. A portion of host filament attacked by the fungus. ($\times 170$) 18. Rest-
ing spores in a sorus. ($\times 520$)

摘 要

日本産水生壺状菌に就て

I. ボロニン菌科

徳 永 芳 雄

本編に報告せるボロニン菌科菌類は下記の如し。

1. *Pseudolpidium fusiforme* (CORNÜ) A. FISCHER
Achlya flagellata COKER, *A. flagellata* var. *yezoensis* ITO et NAGAI 及び *A. racemosa* HILDEBR. の菌絲に寄生す。
2. *Pseudolpidium Pythii* BUTLER
Pythium Oryzae ITO et TOKUNAGA の菌絲に寄生す。
3. *Pseudolpidium Saprolegniae* (A. BRAUN) A. FISCHER
Saprolegnia Thureti DE BARY の菌絲に寄生す。
4. *Pseudolpidium stellatum* SAWADA
Achlya prolifera SAWADA (*A. flagellata* COKER) の菌絲に寄生す。
5. *Olpidiopsis minor* A. FISCHER
Achlya flagellata COKER, *A. flagellata* var. *yezoensis* ITO et NAGAI 及び *A. racemosa* HILDEBR. の菌絲に寄生す。
6. *Olpidiopsis Saprolegniae* CORNU
Saprolegnia monilifera DE BARY の菌絲に寄生す。
7. *Olpidiopsis spinosa* TOKUNAGA (新種)
Achlya flagellata COKER の菌絲に寄生す。
8. *Rozella simulans* A. FISCHER
Achlya flagellata COKER の菌絲に寄生す。
9. *Woronina asterina* TOKUNAGA (新種)
Achlya americana COKER の菌絲に寄生す。
10. *Woronina glomerata* (CORNÜ) A. FISCHER
Vaucheria sessilis DC. の營養細胞に寄生す。