Some Zoosporic Fungi of New Zealand. XI.

Plasmodiophorales

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In the previous publications in this series on the zoosporic fungi of New Zealand the author listed and described the species with posteriorly uniflagellate and anteriorly uniflagellate zoospores which comprise, respectively, the Chytridiomycetes and Hypochytriomycetes. The present publication begins a series of papers on species which produce biflagellate zoospores. Among these is the order Plasmodiophorales whose species have a fairly complex life cycle which in the fully known species includes in sequence cysts or resting spores, primary anteriorly biflagellate heterocont zoospores, sporangial plasmodia, sporangiosori, sporangia, secondary anteriorly biflagellate heterocont zoospores, cystogenous plasmodia and usually cystosori. At present this order include one family, the Plasmodiophoraceae, approximately nine genera and thirty-five species (Karling, 1942, 1967). Most of these species are almost worldwide in distribution and parasitize algae, fungi and higher plants.

Among these parasites four genera and four species had been reported previously in New Zealand, and a fifth genus and species had been identified among the herbarium specimens. In addition to these the author collected and identified two genera and three species so that up to the present time the following members are known to occur in New Zealand.

Plasmodiophora brassicae Woronin, 1877. Arb. St. Petersbourg Nat. Gesell. 8: 169.

Parasitic in the root hairs and roots of cultivated crucifers in numerous localities in New Zealand, principally the South Island.

So far as the author is aware, this parasite was reported first in New Zealand by Kirk in 1894, and since that time numerous other plant pathologists, including Cunningham (1922), Anony. (1937), Tennent (1925, 1930, 1933), Gibbs (1931—1939), Neill (1933), Lammerink (1964—1967), Watson (1965) and others, have reported and studied its occurrence. Gibs in particular devoted several years to a study of its occurrence and to the control of clubroot, but he (1931) questioned the presence and importance of physiological races of the

parasite in New Zealand. More recently, however, Lammerink demonstrated the presence of six and possibly seven races in fields on the North and South Islands.

Tetramyxa parasitica Goebel, 1884. Flora 67: 517, pl. 10.

Thecaphora ruppiae Setchell, 1924. Mycologia 16: 243, pl. 18, figs. 3, 4.

Parasitic in *Ruppia spiralis* in a saline pond, Washdyke, South Canterbury.

This identification was made from a single specimen (no. 10841, PDD) collected by Miss R. Mason, May 23, 1951, and identified by Miss Joan M. Dingley.

Sorosphaera veronicae Schroeter, 1885. Cohn, Kryptogamen-Fl. Schlesiens 3: 135.

Tubercinia veronicae Schroeter, 1877. Cohn, Beitr. Biol. Pflanz. 2: 383.

Sorosporium veronicae Winter, 1884. Die Pilze Deutschlands, Oesterreichs und der Schweitz, 1: 103.

Parasitic in the roots and stems of *Veronica tournefortii*, Mangere District, Auckland Province.

This species (spec. no. 14955, PDD) was collected first by P. Fry at Mangere in August, 1955 and described by Dingley and Brien (1956). The author confirmed this identification from Fry's specimens and later in 1965 found it on the same host in the Kauearanga Valley near Thames, Auckland Province.

Spongospora subterranea (Wallr.) Lagerh. var. *subterranea* Tomlinson, 1958. Trans. Brit. Mycol. Soc. 31: 498.

Erysibe subterranea Wallroth, 1842 a. Linnea 16: 332; 1942 b, Beitr. zu Bot. 1: 118.

Protomyces Tuber-Solani Martius, 1842 a. Die Kartoffelepidemie der letzten Jahre oder die Stockfäule und Räude der Kartoffeln, München; 1942 b. Comp. Rend. Acad. Sci. Paris 15: 314.

Rhizosporium solani Rabenhorst, 1843. Arch. Pharm. 83: 300.

Tubercinia scabies Berkeley, 1846. J. Hort. Soc. London 1: 33,pl.4, fig. 30, 31.

Sorosporium scabies Waldheim, 1877. Apercu System des Ustilag, Paris, p. 51.

Spongospora solani Brunchorst, 1887. Bergens Mus. Aarberet. 1886: 225.

S. subterranea (Wallr.) Lagerheim, 1891. J. Mycol. 7: 104.

S. scabies Massee, 1908. J. Bd. Agric. England 15: 592, fig. 1—12.

S. subterranea radicola Blattny, 1935, Rec. Inst. Rech. Agron. Rep. tchecosl. 137: 21.

S. subterranea tubericola Blatny, l. c., p. 21.

Parasitic on the tubers of *Solanum tuberosum*, Christchurch, Canterbury Province (spec. no. 3799, PDD) and Wellington, Wellington Province (spec. no. 172, PDD).

The author studied the above-mentioned specimens and found that the cystosori exhibited the same variations in sizes, shapes and structure as those reported for specimens in other parts of the world.

Ligniera pilorum Fron and Gaillat, 1925. Bull. Soc. Mycol. France 41: 390, pl. 10.

Parasitic in the root hairs of *Lolium percenne* (Latch, 1966) at Gisborne, Hawkes Bay Province, causing local swellings, stunting and killing of seedlings.

Latch succeed in transferring this fungus to *L. multiflorum*, and reported that trace infections of rye grass were found in several areas of New Zealand. He believes that the seedling disease which it causes is wide-spread in that country.

This species has been the subject of considerable controversy regarding its identity. Fron and Gaillat reported te zoospores to be uniflagellate and minute, 1 μ diam., but Latch found them to be biflagellate and 3—3.8 μ in diameter. Cook (1926, 1933) regarded *L. pilorum* as identical with *L. junci* because it occurs on *Poa annua* and is similar in cyst size and life cycle. According to Fron and Gaillat, however, the two species differ in zoospore size and the fact that *L. pilorum* causes local hypertrophy of the host cell. Cook (1926) implied that the hypertrophy is not always due to the stimulus of the parasite and that *L. pilorum* may accidentally infect root hairs that are already hypertrophied from other causes. This had been shown earlier by Schwartz (1910) for *L. junci* and confirmed subsequently. However, it seems unlikely, in the author's opinion, that all of the infected root hairs in Fron and Gaillat's figure 1 are locally enlarged from other causes than *L. pilorum*. This view is substantiated by Latch's observations and the author's examination of his preparation at North Palmerston. Latch reported that root hairs containing cystosori are generally hypertrophied locally, but only two out of 74 root hairs containing zoosporangia were locally swollen. Apparently, the cystogenous plasmodium and cystosori stimulate a greater response in the host than the sporangial plasmodium and sporangiosori as has been found in *Plasmodiophora brassicae* and *Spongospora subterranea* var. *subterranea*. According to Latch's and the author's observations of his preparations the present-day concept of *Ligniera* must be modified to include species which cause hypertrophy.

Woronina polycystis Cornu, 1872. Ann. Sci. Nat. Bot. ser. 15: 176, pl. 7.

Parasitic in the hyphal tips of *Saprolegnia* sp. in a pond at the Soil Bureau, Taita, Wellington Province.

The New Zealand specimens conformed closely to those described elsewhere, and exhibited the same variations in the sizes and shaped of the cystosori.

Woronina pythii Goldie-Smith, 1956. J. Elisha Mitchell Sci. Soc. 72: 384, figs. 1—8, 16—35.

Parasitic in *Pythium* sp. in soil sample ADSIR,

This is a common parasite of *Pythium* and the author has found it in Brazil, several states of the U.S.A., Jamaica and India (1964). Also, Persiel (1960) has reported it from the Alps in Europe.

Polymyxa graminis Ledingham, 1939. Canad. J. Res. 17: 50, figs. 1—3, pls. 1—4.

Parasitic in the roots of *Lolium* sp. and *Trifolium* sp., Glassbrook Farm, Hawkes Bay Province.

Summary.

The family Plasmodiophoraceae is well represented in the flora of New Zealand, and up to the present time eight species in seven genera have been identified.

Bibliography.

Anony. 1927. Estimated losses through plant diseases in New Zealand. N. Z. J. Sci. Tech. 9: 44—46.

Berkeley, M. J. 1846. Observations, botanical and physiological, on the potato Murrain. J. Roy. Hort. Soc. London 1: 9—34, pls. 1—4.

Blattny, C. 1935. Příspěvečk k póznaní hlenky Bromborove. Rec. Inst. Rech. Agron. Rep. tchecosl. 137: 21—25.

Brunchorst, J. 1887. Über eine sehr verbreitete Krankheit der Kartoffelknollen. Bergens Mus. Aarberet. 1886: 219—226, pl. 1.

Cornu, M. 1872. Monographie des Saprolegniées; étude physiologique et systematique. Ann. Sci. Nat. Bot. V, 15: 1—198, pls. 1—7.

Cunningham, G. H. 1922 a. Some recent changes in the names of plant diseases. Pt. III-Diseases of vegetables. N. Z. J. Agric. 24: 37—45.

— 1922 b. Some recent changes in the names of plant diseases. Pt. IV-Diseases of field crops. N. Z. J. Agric. 24: 96—102.

Dingley, J. M., and R. M. Brien, 1956. New records of fungus diseases in New Zealand 1955—1966. N. Z. J. Sci. Tech. Sect. A, 38: 434—439, 3 figs.

Fron, M., and Mlle Gaillat, 1925. Contribution a l'étude du genre *Ligniera*. Bul. Soc. Mycol. France 41: 388—390, pl. 10.

Gibbs, J. G. 1931 a. Club-root in cruciferous crops. N. Z. J. Agric. 42: 1—17.

— 1931 b. Dissemination of club-root in the dung of farm stock. N. Z. Agric. 42: 193—198.

— 1932 a. Club-root of Brassicas. Experiments on disinfection of seed beds. N. Z. J. Sci. Tech. 14: 145—151.
— 1932 b. Control of club-root. Experiments with lime and fertilizers. N. Z. J. Agric. 44: 28—32.
— 1932 c. Weed hosts of club-root in New Zealand. N. Z. J. Agric. 44: 273—276.
— 1934. Club-root control. Further experiments on the control of club-root in cabbage seed beds. N. Z. J. Sci. Tech. 16: 159—162.
— 1935. Control of club-root in cabbage seed beds. N. Z. J. Agric. 50: 294.
— 1939. Factors influencing the control of club-root. N. Z. J. Sci. Tech. 20 A: 409—412.

Goebel, K. 1884. *Tetramyxa parasitica*. Flora 67: 517—521, pl. 7.

Goldie-Smith, E. K. 1956. A new species of *Woronina*, and *Sorodiscus cokeri* emended. J. Elisha Mitchell Sci. Soc. 72: 348—356, figs. 1—8, 16—35.

Karling, J. S. 1942. The Plasmodiophorales. V—139 pp., 15 pls. Free Press Printing Co., New York.
— 1964. *Woronina pythii* Goldie-Smith in India. Bull. Torrey Club 91: 224—227, 39 figs.
— 1967. The Plasmodiophorales and diseases of economic crops caused by its species. 2nd ed. (In press), Hafner Pub. Co. New York.

Kirk, T. W. 1894. Report of acting biologist. N. Z. Dept. Agric. 2nd Ann. Rept. 2: 47—106.

Lagerheim, H. 1891. Remarks on the fungus of potato scab. J. Mycol. 7: 103—104.

Lammerink, J. 1964. Pathologic specialization of *Plasmodiophora brassicae* Wor. in New Zealand. N. Z. J. Agric. Res. 7: 37—41.
— 1965 a. Six pathogenic races of *Plasmodiophora brassicae* Wor. in New Zealand. N. Z. J. Agric. Res. 8: 156—164.
— 1965 b. A survey of pathogenic races of club-root in the South Island of New Zealand. N. Z. J. Agric. Res. 8: 667—671.
— 1967. The inheritance of club-root resistence in *Brassica napus* L. N. Z. J. Agric Res. 10 (In press).

Latch, G. C. M. 1966. Fungus disease of rye grass in New Zealand. II. Foliage, root and seed diseases. N. Z. J. Agric Res. 9: 808—819, figs. 1—2 b.

Ledingham, G. A. 1939. Studies on *Polymyxa graminis*, n. gen. n. sp., a plasmodiophoraceous root parasite of wheat. Canad. J. res. C, 17: 38—51, figs. 1—3, pls. 1—4.

Martius, C. F. P. 1842 a. Die Kartoffel-Epidemie der letzten Jahre . . . München.
— 1842 b. Sur la gangrène des pomme de terre, observe depuis quelques annees en Allemagne. Comp. Rend. Acad. Sci., Paris 15: 310—319.

Neill, J. C. 1933. Production of diseases-free swede seed. N. Z. J. Agric 46: 207—210.

Persiel, I. 1960. Über die Verbreitung niederer Phycomyceten in Böden aus verschiedenen Höhenstufen der Alpen und an einigen subtropischer und tropischer Gebirge. Arch. f. Mikrobiol. 36: 257—282.

Rabenhorst, L. 1843. Über die Knollenkrankheit der Kartoffel. Arch. Pharm. 83: 300.

Schroeter, J. 1877. Bemerkungen und Beobachtungen über einige Ustilagineen. Cohn, Beitr. Biol. Pflanz. 2: 249—383, pl. 12.
— 1885. Die Pilze Schlesiens. Cohn's Kryptogamen.-Fl. von Schlesiens. 3: 133—135.

Schwartz, E. J. 1910 a. A new parasitic disease of the Juncaceae-preliminary notice. Ann. Bot. 24: 236.
— 1910 b. Parasitic root diseases of the Juncaceae. Ann. Bot. 24: 511—522, pl. 40.
Setchell, W. A. 1924. Three new fungi. Mycologia 16: 240—244.
Tennent, R. B., 1925. Club-root in trunips. Trials with "disease resistent" varieties in Otago and Southland. N. Z. J. Agric. 20: 259—269.
— 1930. Club-root in turnips. Ten years investigation in Otago and Southland. N. Z. J. Agric. 41: 318—325.
— 1933. The Bruce club-root resistent turnip. N. Z. J. Agric. 47: 297—301.
Tomlinson, J. A. 1958. Crook root of watercress III. The causal organism *Spongspora subterranea* (Wallr.) Lager, f. sp. *Nasturtii* f. sp. nov. Trans. Brit. Mycol. Soc. 31: 491—498, figs. 1—4.
Waldheim, A. A. F., von, 1877. Apercu systématique des Ustilaginees, p. 51, Paris.
Wallroth, R. W. 1842 a. Die Naturgeschichte der *Erysibe subterranea* Wallr. Wallroth's Beitr. z. Bot. 1: 118—123, pl. 2, figs. 12—15.
— 1842 b. Der Knollenbrand der Kartoffel. Linnea 16: 332.
Watson, A. G. 1965 a. Toxicity and persistence of fungicides against *Plasmodiophora brassicae* Wor. N. Z. J. Agric. Res. 8: 977—987.
— 1965 b. Club-root control in Pukekoke. N. Z. J. Agric. Res. 8: 988—996.
Winter, G. 1884. Die Pilze Deutschlands, Oesterreichs und der Schweitz 1: 103.
Woronin M. 1877. *Plasmodiophora brassicae*, der Organismus, der die unter dem Namen Hernie bekannte Krankheit der Kohlpflanzen verursacht. Arb. St. Petersbourg Nat. Gesell. 8: 169—201, pls. 29—34.