Some Zoosporic Fungi of New Zealand. I.

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With Plate XLVI.

Except for the species which are parasitic principally on economic crop plants, ornamentals, and trees, the zoosporic fungi have received very little attention in New Zealand, and so far several of the larger groups are only partly known. This is particularly true of the Chytridiales, Blastocladiales, Monoblepharidiales, Leptomitales and Saprolegniales. In fact, New Zealand and the neighboring Pacific islands and almost virgin lands so far as our knowledge of the occurrence of most of these fungi is concerned. On the other hand, the parasitic species, such as members of the Plasmodiophorales, Albuginaceae, Pythiaceae and Peronosporaceae, are better known and have been studied intensively by a large number of workers.

Accordingly, the present studies were undertaken to enlarge our knowledge of the lesser known groups of zoosporic fungi of New Zealand. These investigations were made during the author's tenure as a Senior Fulbright Research Fellow in 1965 and 1966 and conducted principally at the various divisions of the Department of Science and Industrial Research and the University of Otago, including the Soil Bureau at Taita, Lower Hutt; the Plant Disease Division at Mt. Albert,

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Auckland; Grasslands Division at Palmerston North; the Crop Research, and Botany Divisions at Lincoln, Canterbury; and the Botany Department of the University of Otago at Dunedin. Special emphasis was given to the occurrence of the zoosporic fungi in the soil because this medium is the richest source of species throughout the world. However, aquatic species, parasites of algae and fungi, as well as terrestrial species of *Synchytrium* and *Physoderma,* also, were searched for, collected and studied. In addition to the New Zealand soils, samples from Auckland Islands, Cook Islands, Fiji, Niue, Pitcairn, Ross Dependency in Antartica, American Samoa, and Snares Island were studied. The sources and types of New Zealand soil according to provinces and islands under New Zealand's jurisdiction are described in the accompanying appendix and designated by appropriate symbols which are used to denote the place of occurrence of the fungus species. The first letter in each symbol indicates the province in which the samples were collected.

For study of the soil-inhabiting species, small soil samples were covered with approximately 1" of water in 3 inch-deep dishes, and after the floating debris had been removed and the turbulence had subsided strips of bleached seedling leaves of *Zea mays,* cellophane, snake skin, hair, insect wings, purified shrimp chitin, fibrin film, pollen grains, and bits of hemp seed were floated on the surface of the water as substrata or bait for trapping the zoosporic species. Inasmuch as all of the species which might be present in a soil sample do not develop at the same time and rate, all cultures were maintained for more than a month and rebaited once to several times.

The present series of papers on New Zealand zoosporic fungi will begin with the Chytridiales, or the species with posteriorly uniflagellate zoospores, and then procede with the members of the Blastocladiales, Anisochytridiales or Hypochytriales, Plasmodiophorales, Lagenidiales, and Saprolegniales which were collected and identified.

CHYTRIDIALES

Olpidiaceae

Species of this family are fairly common in New Zealand, and up to the present time 15 species in 3 genera have been identified and studied. A few additional species were found but it was impossible to identify from the limited material at hand.

Olpidium

Olpidium appendiculatum sp. nov.

Sporangia solitaria vel usque ad 20 in uno pollinis grano evoluta, ovoidea, 8—10 $\times$ 12—18 μ, subsphaerica vel sphaerica, 8—28 μ diam., in cumulo e mutua pressione polyedrica, pariete hyalino, tenui, levi praedita, in apice tubulum germinationis breviusculum formantia; tubulo 2,5—12,5 μ longo, 4—5 μ crasso, superficiem matricis cellulae parum tantum protrudente; zoosporae sphaericae, 2,8—3,4 μ diam., globulo refringente hyalino unico et nonnullis globulis minutissimis farctae; flagello 10—13 μ longo; sporae perdurantes singulatim vel copiose in quadam matricis cellula ortae, globosae, 5—20 μ diam., tunica hyalina levi, pro ratione tenui praeditae, globulis refringentibus numerosis farctae; germinatio ignota.

Sporangia single or up to 20 in a pollen grain, ovoid, 8—10 × 12—18 μ, subspherical to spherical, 8—28 μ diam., or polyhedral when crowded, with a thin, hyaline smooth wall; formed at the tip of a short germ tube; zoospore cyst persistent as an appressorium on outside of pollen grain and becoming thick-walled; discharge tube 7,5—12,5 μ long by 4—5 μ diam., and projecting slightly beyond surface of host cell. Zoospores spherical, 2,8—3,4 μ diam., with a small hyaline refractive globule and several small granules; flagellum 10—13 μ long. Resting spores single to numerous in a host cell, spherical, 5—20 μ diam., with a hyaline, smooth, relatively thin wall, and containing numerous large refractive globules; germination unknown.

Saprophytic in dead pollen of *Pinus sylvestris* and *Phyllocladus trichomanoides* added to a watered coarse sand and moss culture from the vicinity of the Alex Heiberg Glacier, Ross Dependancy (Antarctica), alt. 1000 ft., lat. 84°, 30 S, long, 175° W.

This species occurred in abundance when pine and *Phyllocladus* pollen was floated on the surface of the sand and moss culture, pH 6,6, as noted above. It is characterized principally by the persistence of the zoospore cyst as an appressorium on the surface of the host and the development of the sporangium from the tip of the persistent germ tube. Its occurrence in the Ross Dependancy (Antarctica), New Zealand makes it the most southern of all chytrids reported so far. However, it was isolated later at Auckland, New Zealand, on pollen from soil samples AKT, ADSIR, ASB, AR as well as beach sand (ABS) which had been flooded daily by tides. Apparently, it is rather widely distributed in the Southern Hemisphere and occurs in marine as well as fresh waters.

So far only one other species, *O. zootocum* (Braun) Sorokin with a persistent zoospore cyst and germ tube has been reported in the literature. Braun (1865) gave the name *Chytridium zootocum* to an organism which Claparede found in a dead *Anguillula* species. Later, Sorokin (1883) found what he believed to be the same species in the claw of a dead crustacean in Russia and renamed it *Olpidium zootocum*. In his organism, however, the sporangium was spherical with a narrow discharge tube instead of elongate, tubular and curved with a lateral funnel-like exit tube as in Braun's species. Schroeter (1885, p. 182) included in this species a parasite of *Anguillula* with a tubular sporangium which remained attached by its attenuated end to the zoospore cyst, but he questioned the identity of his fungus with Braun's. Neither zoospores nor resting spores were observed in any of these parasites, and the identity and validity of *O. zootocum* are, obviously, questionable. Except for the persistence of the zoospore cyst (5 μ diam.) in Schroeter's species, it has little in common with *O. appendiculatum*, so far as it is known.

In *Olpidium pendulum* Zopf (1890), which has been reported on pine pollen in various parts of the world (Voronichin, 1920; Graff, 1928; Sparrow, 1952; Gaertner, 1954) the infection tube is often persistent on the resting spore and appears as an appendage. However, its zoospores (4—5 μ diam.) are larger than those of *O. appendiculatum*, and its resting spore has a thick wall and a large globule in contrast to the relatively thin-walled spores with numerous globules as in *O. appendiculatum*. Sparrow (1960) was of the opinion that *O. maritimum* Höhnk and Aleem (1953) which occurs in pollen grains in brackish soil may be indistinguishable from *O. pendulum* and that the lack of a persistent infection tube in *O. maritimum* is not a specific character. This species is fairly similar to *O. appendiculatum* in the sizes of the sporangia and zoospores, but in the latter species the persistent zoospore cyst and germ tube are consistently present and appear to be specific characteristics.

The developmental cycle of *O. appendiculatum*, which is shown in figs. 1—13, was studied in pollen of *Phyllocladus trichomanoides* because its grains are relatively transparent and have only minute or vestigal wings. In this substratum it was easy to see infection and development of the sporangia and resting spores at the tip of the germ tube. The zoospore cyst and germ tube become so thick-walled that only a minute lumen and canal appear in them by the time the sporangia and resting spores are mature, and in this respect the cyst (fig. 10) is very similar in appearance to that of *Lagena radicicola* Vanterpool and Ledingham (1930). Particularly noteworthy is the development of the sporangia (fig. 4, 5) and resting spores at the end of the germ tube as in some of the rhizoidiaceous chytrids and species of *Lagenidium* and *Lagena*. The subsequent developmental phases and the discharge and behavior of the zoospores in swimming are fundamentally similar to those of other species of *Olpidium* and need not be described further.

In addition to this species several other members of *Olpidium* were found and studied. These include:

Olpidium gregarium (Nowak.) Schroeter, 1885. Kryptogamenfl. Schlesiens 3 (1) : 182.

Chytridium gregarium Nowakowski, 1876. In Cohn's Beitr. Biol. Pflanz. 2 : 77.

Parasitic in rotifer eggs in water from wayside ditch, Soil Bureau, Taita, Wellington Province.

Olpidium pendulum Zopf, 1890. In A. Schenk Handb. d. Bot. —, 4 : 555.

Saphrophytic in dead pollen of *Pinus sylvestris* and *Phyllocladus trichomanoides,* from soil sample AAB.

Chytridium entophytum Braun, 1856. Monatsber. Berlin Akad. 1856 : 589.

Olpidium entophytum (Braun) Rabenhorst, 1868. Flora Europ. algarum 3 : 283.

Parasitic in *Zygnema* sp. from a pond near Cascade Creek in the Eglinton Valley, southern Otago.

It is not certain that this species is *O. entophytum* because the resting spores were not found. The sporangia are elongately pyriform, 12—18 μ in greatest diameter, and develop a straight or curved, tapering exit tube, 5—6 μ diam. by 8—28 μ long, which projects far beyond the surface of the host cell. The zoospores and their behavior after discharge, however, are similar to those of *O. entophytum.*

Olpidium saccatum Sorokin, 1883. Arch. Bot. Nord. France 2 : 30.

Parasitic in *Cosmarium undulatum* in a pond by the Soil Bureau, Taita, Wellington Province.

Olpidium brassicae (Wor.) Dangeard, 1886. Ann. Sci. Nat. Bot., (ser. 7) 4 : 284.

Chytridium brassicae Woronin, 1878. Jahrb. wiss. Bot. 11 : 556.

Parasitic in roots of lettuce seedlings, DSIR laboratory, Mt. Albert, Auckland, and cabbage seedlings, Botany Division, Lincoln, Canterbury.

Olpidium luxurians (Tomaschek) Fischer, 1892. Rabenhorst Kryptogamenfl. 1(4) 29.

Chytridium luxurians Tomaschek, 1879. Sitzungber. Acad. Wiss. Wien. (Math-Nat. Cl.) 78 : 204.

Olpidium diplochytrium (Tomaschek) Schroeter, 1885. Kryptogamenfl. Schlesiens 3 (1) : 181.

Olpidiella diplochytrium Lagerheim, 1888. J. de Bot. 2 :439.

Saprophytic in dead *Pinus sylvestris* and *Phyllocladus trichomanoides* pollen from soil samples, ATI, AMA, AOTH, ADSIR, AR, AAD, AW. ATH, AMH, ASJD, HBTF, HBGF1, HBHW, HBW, WT6, WKi, WK2, WSPN, OKF, OLW, and OGB.

In relation to *O. luxurians* attention is called to another species of *Olpidium* which occurred in pine and *Phyllocladus* pollen added to water from a ground tank on the Jury Farm in the Hawkes Bay Province. Unlike those of *O. luxurians,* the sporangia (figs. 15—18) occurred singly and varied from ovoid to elongate, 12—14 × 28—32 μ, and deeply-lobed in shape and formed a fairly broad, 5—7,5 μ, exit tube which was strongly constricted in passing through the host wall and extended for a short distance beyond the surface of the host cell (figs. 17, 18). The zoospores (figs. 14) were ovoid to slightly elongate, 2 × 3 μ, with a dark area or body. The resting spores (figs. 19, 20) were spherical, 15—20 μ diam., hyaline and thick-walled and were formed by contraction of the thallus content and its investment by a thick wall. Consequently, they were lying in a hyaline vesicle as in *O. allomycetos* Karling (1948).

Rozella

Species of this genus are unusually common in the soil of New Zealand, particularly those species which parasitize *Pythium.* At least, fifty percentage of the cultures of *Pythium* trapped on hemp seed bits and strips of corn leaves became parasitized sooner or later, and in many instance the hosts were killed within a few days. Many of the *Rozella* species failed to form resting spores and it was impossible to identify them. However, the following species were studied and identified.

Rozella longicollis sp. nov.

Sporangia solitaria matricis sporangia omnino implentia, sphaerica 20—60 μ diam., subinde piriformia vel ovoidea, 15—18 × 2,2—3,5 μ, tubulis 1—5 rectis vel curvulis, 7—15 μ longis, 3—3,7 μ crassis superficiem cellulae matricis exeuntibus praeditae; zoosporae late piriformes vel ovoideae, 1,5—2 μ 2,5—3 μ, in extremo uno lenissime attenuatae, in cytoplasmate corpusculo minuto praeditae et flagello 12—14 μ longo auctae, ante ejectionem in sporangio palantes; sporae perdurantes partem cellulae matricalis tantum implentes, ovoideae vel sphaericae, 12—17 μ diam., guttula centrali maxima et protoplasmate grosse granuloso farctae, pariete fusco, punctato vel minutissime spinuloso, rarissime etiam levi praeditae; germinatio ignota.

Sporangia solitary, filling the host sporangia, spherical, 20—60 μ diam., pyriform, ovoid. 15—18 × 22—35 μ, with 1—5 straight or curved exit tubes, 7—15 μ long by 3—3,7 μ diam., which project beyond surface of host cell. Zoospores broadly pyriform while motile, 1,5—2 × 2,5—3 μ, with a slightly tapering anterior end and a minute dense body in the cytoplasm; flagellum 12—14 μ long; swirling in the sporangium before emerging. Resting spores filling only a portion of host cell, dark-brown, ovoid to spherical, 12—17 μ diam., wall punctate to spiny, rarely smooth; germination unknown.

Parasitic in *Pythium* sp., from soil samples HBTF, HBFG1, W1, and WT1, causing marked hypertrophy of the infected cell.

This species is characterized principally by long exit tubes and differs in this respect from all other known species of *Rozella.* It frequently resembles species of *Pleothrachelus* except for its small zoospores and the fact that its sporangium fills the host cell completely. No marked differences in the size, shape, and behavior of the zoospores from those of other monosporangiate species of *Rozella* has been observed so far. The resting spores, also, are basically similar to those of other species except for the darker brown color of the wall.

Infection of the host sporangia, development of the parasite's sporangia and exit tubes, discharge of the zoospores, and the development of the resting spores are shown in figs. 21 to 29. These precesses are essentially similar to those described by the author (1944) for *Rozella laevis,* and they will not be described further.

Rozella cuculus (Butler) Sparrow, 1938. Mycologia 30 : 377.

Pleolpidium cuculus Butler, 1907. Mem. Dept. Agric. India, Bot. Ser. 1 : 125.

Parasitic in sporangia of *Pythium intermedium* and *Pythium* sp. from soil samples AME, WRR1 and ODBL.

Rozella laevis Karling, 1942. Mycologia 34 : 105.

Parasitic in *Pythium* sp. from soil samples AMA, ADSIR, AOTH, WK1, WO, OLW, and OGD.

Rozella cladochytrii Karling, 1941. Torreya 41 : 105.

Parasitic in *Nowakowskiella elegans* in soil sample AAD.

Rozella rhizophlyctii Karling, 1942. Amer. J. Bot. 29: 32.

Parasitic in *Karlingia rosea* from soil sample WW1, and *Rhizophydium globosum* from soil sample AK1.

Rozella chytriomycetis Karling, 1946. Mycologia 38: 107.

Parasitic in *Chytriomyces hyalinus* from soil sample ATH.

The species of *Rozella* which the author (1947, figs. 44—48 reported in *Catenophlyctis (Phlyctorhiza) variabilis* occurred in six isolations of this host. It's identity is not known because it did not develop resting spores in any of the isolations. Also, it may be noted here that *Rhizophidium polystomum* sp. nov. was frequently infected by a *Rozella* species which may possibly prove to be *R. rhizophydii* Karling (1941).

Sphaerita

Only two species, which may be identified only tentatively, were found in New Zealand.

Sphaerita dangeardii Chatton and Brodsky, 1909. Arch. Protistenk. 17 : 8.

Sphaerita endogena Dangeard, pro parte, 1886. Ann. Sci. Nat. Bot. Ser. 7, 4 : 277.

Parasitic in *Euglena viridis* from water in a pond west of the Soil Bureau laboratory, Taita, Wellington Province.

Sphaerita endogena Dangeard, pro parte, 1886. Ann. Sci. Nat. Bot. ser. 7, 4 : 277.

Parasitic in *Chaos chaos*, from silt on the Franz Joseph Glacier (WPFG), Westland Province.

Whether or not this species is *S. endogena* remains to be seen, but it is tentatively identified as such primarily because of its occurrence in a large amoeba. *Chaos chaos* occured abundantly in the silt and scree taken from this glacier, and a large number of specimens became infected in the laboratory. One stationary and apparently dying amoeba contained 22 sporangia of the parasite, and two others with 11 and 14 sporangia were found moving about in a seemingly normal manner. Dehiscence of the sporangia as well as the zoospores were not seen, although the infected amoeba were kept under observation for several hours.

In addition to the above species another one was found in a dying *Vorticella* from silt (WHR1) in the Hutt River Catchment Area, Wellington Province.

Summary

Fifteen species of the family Olpidaceae were found in soil, water, algae and microscopic animals in New Zealand. Of these, *Olpidium appendiculatum* and *Rozella longicollis,* are new species. Additional species of *Olpidium, Rozella,* and *Sphaerita were* observed but these could not be identified from the material at hand.

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Description of Plate

Figs. 1—13. *Olpidium appendiculatum;* figs. 14—20. *Olpidium* sp.; figs. 21—29. *Rozella longicollis.*

Figs. 1—3. Zoospores and infection. Figs. 4, 5. Development of thallus from end to germ tube. Figs. 6, 7, 8. Young sporangia with persistent zoospore case and germ tube and developing exit tubes. Fig. 9. Discharge of zoospores. Fig. 11—13. Variations in the sizes of resting spores zoospores case. Fig. 13. Variations in shapes of incipient sporangia.

Fig. 14. Zoospores. Figs. 15—17. Variations in shapes of incipient sporangia. Fig. 18. Discharge of zoospores from deeply lobed sporangium. Figs. 19, 20. Resting spores lying in vesicles.

Fig. 21. Zoospore. Fig. 22. Infection of incipient host sporangium. Figs. 23, 24. Enlargement of host sporangium and development of parasite within. Fig. 25. Parasite filling host cell completely. Fig. 26. Mature parasite sporangium with 5 long exit tubes just before dehiscence. Fig. 27. Discharge of zoospores. Figs. 28, 29. Free-lying resting spores.

INDEX TO NEW ZEALAND SOILS EXAMINED

Auckland Province

AK.	Clay loam soil along roadside, 3 miles north of Kaihu.
AO.	Volcanic, brown loam along roadside near Ohaeawai.
AWRKF.	Northern gley soil from bank of Waipoua River in Kauri Forest.
AWN.	Northern gley soil from Waipoua Nursery, Forest Service Station, Kauri forest.
ATKF.	Northern gley soil and debris or pukau, pH. 4.5, under kauri tree in Trunson Kauri Forest.
AW.	Northern yellow-brown soil on roadside hill overlooking Bream Bay, 2 miles south of Waipoua.
AME.	Volcanic soil from crater of Mt. Eden, Auckland.
AMA.	Volcanic soil from crater of Mt. Albert, Auckland.
ADSIR.	Volcanic soil at DSIR laboratory, Mt. Albert, Auckland.
AAD.	Soil from Auckland Domain, Auckland.
AMH.	Volcanic soil from crater of Mt. Hobson, Auckland.
ASJD.	Volcanic soil from crater of St. John Domain, Auckland.
ABS.	Beach sand flooded by tides, Maurangi Bay, Auckland.
AKT.	Acid soil and debris or pukau, pH. 4,7, under giant kauri tree near Cascade golf course, Auckland.
AOTH.	Soil from top of One-Tree Hill, Auckland.
ASB.	Soil from Sharp's Bush, Auckland.
ACH.	Very old compost heap, Auckland.
AFAD.	Soil from fernery, Auckland Domain.
AAB.	Soil from woods at Atkinson's Bay, Auckland.
ATH.	Soil along tidewater stream, Te Hanga lagoon, Auckland.
AR.	Soil from Kidney Fern Glen, Rangitoto Island Volcano, Auckland.
ATRC.	Top soil from hydrothermally altered silt, pH. 3,4, Reporoa. Coromandel, Auckland.
AKC.	Top soil from water sorted volcanic ash, pH. 3,4, Karaka, Coromandel, Auckland.
AGB1.	Soil from Great Barrier Island, Auckland.
ARBF.	Recent soil from volcanic ash from highest beech forest on Mt. Ruapehu, alt. 4000 ft.
RVAT.	Recent soil from volcanic ash with compost, hydrothermal area at Tokaana.

AHC. Hydrothermally altered clay from thermal pool, 80° C.
ARBS. Black silt and mud from pool, 50° C.
ARSR. Silica with peat from swamp in Ruapehu woods, alt. 4000 ft.
ARSM. Silica and mud from pool, 30° C.
ARFR1. Pumice soil from popular plantation, Forest Reserve Institute, Rotorua.
ARHB1. Pumice soil from under rye grass and clover, Horahora Bluffs, Rotorua.
ARHB2. Same as ARHB1 but more swampy with willow and other bushes, Rotorua.
AIBG. Pumice soil from under bramble and gorse, near a hot spring, Rotorua.
ARS. Soil from under vegetation in a swamp which was formerly a hot spring, Rotorua.
ARP. Pumice soil from overcut *Pinus radiata* plantation, Rotorua.
AMKR. Scrub and forest soil mixed with Manuka leaves, Kairua Park, Rotorua.
APR. Pumice soil covered with scrub, Rotorua.
ARSGGR. Pumice soil with sulphur, Gov't Gardens, Rotorua.
AH. Clay loam in rye grass and clover paddock, Hamilton.
AFGH. Pumice soil from under native bush, Fitzgerald Glade, Hamilton.
AT1. Black silty sand, classified as yellow-brown pumice soil derived from rhyolitic volcanic ash, under clover, 1500 ft. alt., 8 miles north of Taupo.
AT2. Same as ATI but under *Pinus radiata*.
ATK. Kaingaroa sand, classified as yellow-brown pumice soil derived from rhyolitic volcanic ash, from under *Dracophyllum sinclarii*, tussock grass and moss, 17 m. S. E. of Taupo, 2500 ft. alt.
AMBP. Sandy top soil, garden, Mt. Maunganui, Bay of Plenty.
ATHP. Soil from vegetable garden, Takarangi.
ATVG. Soil from a hill paddock, Takarangi.
ATFP. Soil from fern paddock, Takarangi.

Hawkes Bay Province

BHGF1. Soil classified as yellow-grey earths, in sheep paddock adjacent to Soil Bureau's experimental plot under rye grass, clover and *Erodium*, Glassbrook Farm near Hastings.
HBGF2. Dry soil classified as yellow-grey earths, from sheep run above experimental plot, Glassbrook Farm.
HBHW. Soil from under rye grass near *Cupressus* windbreak on Wilson's Farm, Hatuma-Waipukurau.
HBW. Steepland soil from under rye grass, Wanganui.
HBT. Steepland soil from under rye grass, Taihape, 28 miles northeast of Wanganui.
HBJF1. Soil from near Soil Bureau's experimental plot, Jury Farm, under rye grass and clover.
HBJF2. Composite soil sample from several localities on Jury Farm, under rye grass.
HBTF. Soil from underneath grass and clover on Tosswill Farm.

Wellington Provine

WW1. Waimarino sand, classified as recent soils from volcanic ash, from under *Dracophyllum sinclarii*, tussock grass and moss in

	National Park Plateau, 4 m. north of Chateau Tongariro, alt. 3000 ft.
WW2.	Same as WW1 but under rye grass and clover in a paddock.
WO.	Okahune silt loam, classified as yellow-brown loam, under rye grass and clover paddock, 4 m. south of Raetaki, alt. 1500 ft.
WAV.	Soil, classified as podzolized yellow-brown earths, from overhanging bank along roadside, Akatawara valley, 920 ft. alt.
WAVS.	Soil, classified as podzolized yellow-brown earths, from Akatawara summit, alt. 1450 ft.
WK1.	Dannevirke silt loam soil within Soil Bureau's experimental plot under clover and rye grass, Kaitoke Farm.
WK2.	Dannevirke silt loam soil outside of Soil Bureau's experimental plot, Kaitoke Farm.
WK3.	Muck soil from small swamp at stream, Kaitoke Farm.
WRFJ1.	Soil, classified as yellow-brown earth, moderately weathered and bleached, inside of Soil Bureau's experimental plot under rye grass and clover, Rangimaire Farm, Judgeford District.
WRFJ2.	Same as WRFJ1, but outside of experimental plot.
WPN.	Soil, classified as recent soils from alluvium, from *Lotus* field, DSIR, Palmerston North.
WPNL.	Soil, classified as recent soils from alluvium, from under rye grass on Dr. Latch's lawn, Palmerston North.
WSPN.	Sawdust and soil from glasshouse, Massey Univ. Palmerston North.
WT1.	Sandy soil along small stream at north end of enclosure, Soil Bureau, Taita.
WT2.	Mud from seeping bank under *Ranunculus*, Soil Bureau, Taita.
WT3.	Soil, classified as recent soils from yellow-brown earths, from steep hill above laboratory, Soil Bureau, Taita.
WT4.	Muck soil from under moss and *Marchantia* bog in sheep paddock east of laboratory, Soil Bureau, Taita.
WT5.	Sandy clay soil from edge of brook below WT4, Soil Bureau, Taita.
WT6.	Soil and debris under tree ferns west of laboratory, Soil Bureau, Taita.
WT7.	Soil from Christchurch cemetary, Taita.
WT8.	Submerged mud in pond west of laboratory, Soil Bureau, Taita.
WHR1.	Sandy soil from along Hutt River ½ mile below water wier, Hutt Catchment Area.
WHR2.	Silty soil from roadside ditch near water wier, Hutt Catchment Area.
WGB.	Muck soil from bottom of pool in rain forest, Gibb's Bache, Belmont, Wellington.

Canterbury Province

CWR.	Silty sand from bed of Waimakariri River near Christchurch.
CWRG.	Sandy loam from Waimakariri River Gorge near bridge.
CRG.	Soil from Rakaire Gorge near bridge.
CLC.	Silty soil from shore of Lake Coleridge.
CLCC.	Compost of sawdust, wheat straw and chicken droppings, Lincoln College, Canterbury.
CFC.	Compost from garden debris, Fendalton, Canterbury.
CBLC.	Soil from a bog near Lake Coleridge.
CLL.	Muddy silt from shore of Lyndon Lake.

CBG.	Soil from flower beds in Botanical Garden, Christchurch.
CAP.	Peaty soil, Arthur's Pass, near Hobson monument.
CLO1.	Water with *Chara* and *Nitella*, Lake Ohau.
CLO2.	Top soil from virgin grassland, Lake Ohau.
CLP.	Loam from around abandoned and burned homestead near road going to Mt. Cook. Lake Pukaki.
CHT.	Lateral morain soil along Hooker Track and Valley, up to 2nd swing bridge.
CTG.	Silt from Tasman Glacier, alt. 5000 ft.
CLT.	Silt and loam along shore of Lake Tekapo.
CGF.	Soil from dry, stony field with turnips and *Veronica*, Glenburn Farm near Fairlee.
CSA.	Fertilized soil from Wheatfield, south of St. Andrews.
CGB.	Soil from *Nothofagus menzeii* forest, Governor's Bush, Hermitage, Mt. Cook.

Nelson Province

NTF.	Soil from tobacco farm, Waiiti, Nelson.
NHG.	Soil from a hops garden, Marsden Farm, Waiiti, 20 m. south of Nelson.
NRG.	Soil from a rasberry garden, Marsden Farm, Waiiti, 20 m. south of Nelson.
NWR.	Soil from a ditch, Waiiti River, Waiiti Valley, Nelson.

Marlborough Province

MP.	Clay loam soil from a flower garden, Picton.

Westland Province

WPC.	Silty loam from Pegleg Creek, near Otiro Gorge.
WOG.	Soil from along roadside, Otiro Gorge, Otiro.
WFG.	Sandy silt from Franz Joseph Glacier.

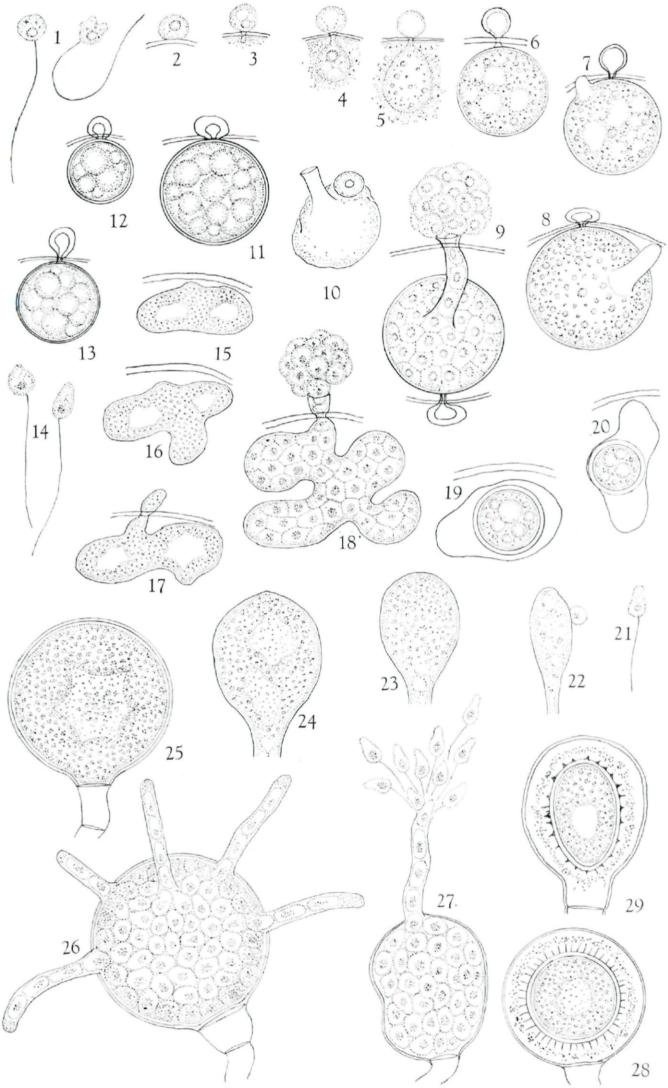
Otago Province

ODBL.	Garden soil outside of botany laboratory, Univ. of Otago, Dunedin.
ODBG.	Loam from a flower bed, Botanical Gardens, Dunedin.
ODLS.	Clay loam, Leith's Saddle, Dunedin.
ODS.	Soil and debris under lupine above Sealpoint, Dunedin.
ODSR.	Cultivated soil at turn off at Sealpoint Road, Dunedin-Portobello scenic road.
ODCT.	Soil from under *Cupressus* tree near turn off to Sealpoint road.
OHT.	Muck soil from stream at cross roads, Harrington Road and Takokopa, Catlins.
OWL.	Acid, peaty soil, pH 4,3, from under rimu and mannia trees above Wilkie Lake, Catlins.
ORC.	Black peaty soil, pH 4,7, from roadside near Wilkie Lake, Catlins.
OWR.	Soil from woods above Waiau River between Manapouri and Te Anua lakes.
OBC.	Soil from woods near water falls of Boyd's Creek, about 30 m. above Te Anua.
OKF.	Soil and *Sphagnum* muck pH 4, 1, in bog near Knobs Flats.
OGL.	Soil from beech forest, Gunn Lake.
OHL.	Soil from silver beech forest, western end of Homer Tunnel.

OMS.	Soil from stream near Bolton Falls, Milford Sound.
OTAD.	Acid Soil, pH 4,5, from Te Anua Downs bog, between Te Anua and Barkers.
OW.	Soil from Wilderness under *Rautia* vegetation.
OLW.	Soil from under grass at Staircase Creek, Lake Wakatipu.
OCR.	Soil under snow tussock, Crown Range, alt. 3680 ft.
OGB.	Soil at edge of Glenhu Bay, Wanaka Lake.
OAL.	Soil from Alexandra Lookout, alt. 900 ft.
OGD.	Soil from old gold diggers trace, Alexandra Lookout Road.
OOMR1.	Blackstone silt loam related to yellow-grey earths, moderately leached, Old Man Range, alt. 2500 ft.
OOMR2.	Carrick silt loam, shallow upland yellow-brown earth, moderately leached, Old Man Range, alt. 3500 ft.
OOMR3.	Carrick fairly hardy loam, shallow high country yellow-brown earth, strongly leached, Old Man Range, alt. 4500 ft.
OOMR4.	Obelisk strong sandy loam, shallow high country yellow-brown earth, strongly leached, Old Man Range, alt. 5500 ft.
OLWR.	Fertile soil from wheatfield along road to Mt. Cook, beyond Omarau, lower Waitaki River Valley.
ODC.	Soil from under lilac bush, Duntroon churchyard.
OHR.	Soil from along north bank of the Hakaterramea River near Kurau.
OGO.	Garden soil, 5 m. south of Omarau.
OM.	Soil from under *Cotula* sp. in a small drainage depression near old fishing pier, Moeraki.

Auckland Islands

AIRF.	Peat under southern Rata Forest, Ranui Cove, North end of main Auckland Island, Lat. 50°32′ S.
AIPT.	Peat under tussock grassland *(Poa litorosa)* Rose Island, Lat. 50°31′ S.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