SPECIES OF *PYTHIUM* IN QUEENSLAND

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SUMMARY

Fourteen species of *Pythium* have been recorded in Queensland. Notes are given on the morphological and cultural characters found useful in identifying these species.

Growth-temperature studies confirm that maximum temperature can be used as an aid to morphology in identification.

An annotated host index for Queensland is presented.

I. INTRODUCTION

During the investigation of some root diseases in Queensland, it became apparent that more species of *Pythium* were present than had previously been recorded for this State. Prior to the commencement of this investigation in 1954, three species of *Pythium* had been recognised. *Pythium ultimum* Trow was recorded from root and trunk rot of papaw (Simmonds 1937), *P. aphanidermatum* (Eds.) Fitzp. from transport rot of beans (Simmonds 1950), and *P. periilum* Drechsl. from root rot of sugar-cane (unpublished records, Queensland Bureau of Sugar Experiment Stations, Brisbane).

The present paper deals with the more recent work on identifying members of this genus, as a result of which a further 11 species have been added to the list and the host range greatly extended.

II. PROCEDURE

Isolates were identified in the light of the monograph on the genus *Pythium* by Middleton (1943). Descriptions in this paper are therefore limited to growth-temperature relations (Table 1), a summary of the morphological dimensions of the oogonia and oospores (Table 2), and notes setting out the main characters used in distinguishing the species studied.

To ensure that the material used in identification was as genetically pure as possible, all cultures obtained were subjected to hyphal tip subculturing. Hyphal tips were grown on potato-dextrose agar, on which all cultures grew well and best displayed their growth-habit characteristics. Photographs illustrating the several growth habits encountered are given in Figure 1.

Most isolates produced sexual and asexual reproductive organs in 3-20 days when grown on water agar, potato-dextrose agar, and cornmeal agar. With isolates reticent in forming reproductive bodies, special treatment was often necessary. In these cases recourse was made to original descriptions of species and to Middleton's

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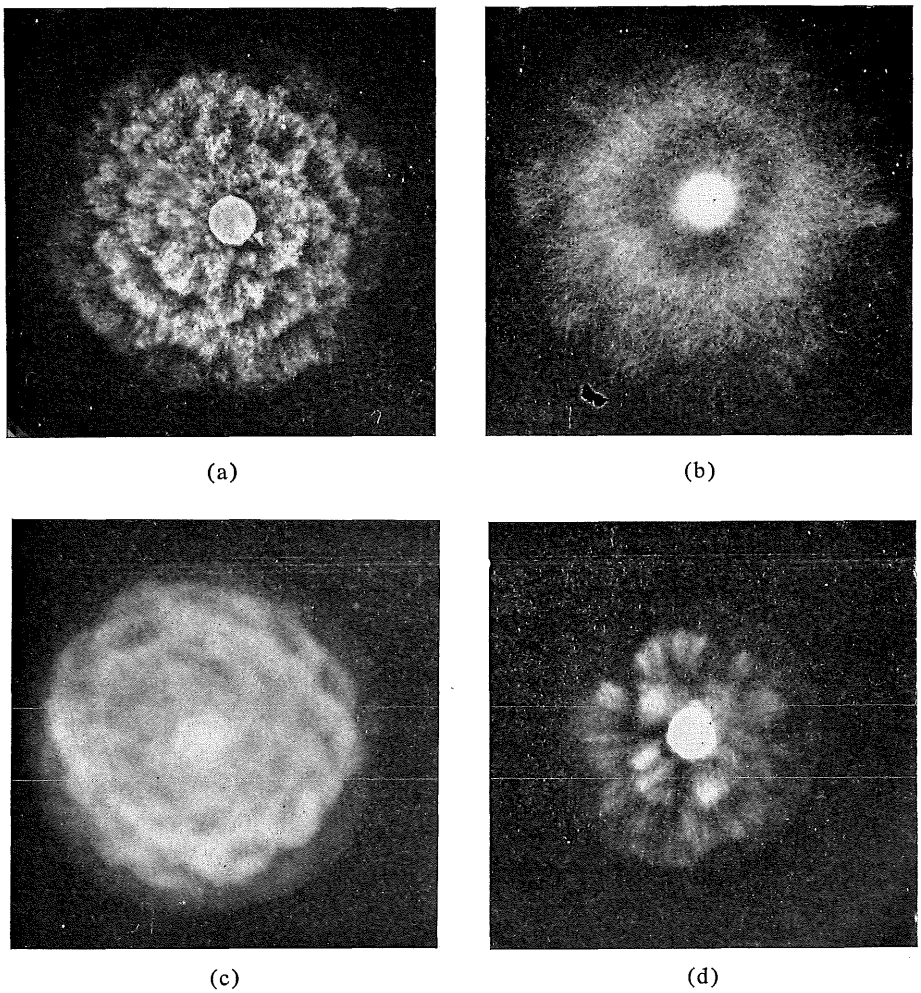

(a) (b)

(c) (d)

Fig. 1.—Growth habits of species of *Pythium*. One to two days on potato-dextrose agar. (a) *Pythium acanthicum*—cumulous-rosette; (b) *Pythium aphanidermatum*—arachnoid; (c) *Pythium torulosum*—rosette; (d) *Pythium vexans*—rosette.

monograph for appropriate techniques. Even so, some isolates failed to produce either their sexual or asexual fruiting bodies; few isolates could be induced to form zoospores. Fortunately, in many of these incompletely studied isolates, indentification was possible from certain distinctive characters.

III. GROWTH–TEMPERATURE RELATIONS

Middleton (1943) found growth-temperature relations to be a valuable adjunct to morphological characteristics in specific identification. He found that the behaviour of conspecific isolates was most uniform at their upper temperature limit; the minimum and optimum values were more variable.

Table 1

MYCELIAL GROWTH OF PYTHIUM SPP. ON CORNMEAL AGAR AT VARIOUS TEMPERATURES
Average Growth in Millimeters over 24-hour Period

Organism	Temperature (°C)																			
	6	8	11	12·5	14	15·5	17·5	19	20·5	22	23·5	25·5	27	28·5	30·5	32	34·5	36·5	38·5	43·5
P. acanthicum ..	t	1	4	..	7	9	11	14	..	15	17	21	22	23	25	24	24	18	4	0
P. aphanidermatum ..	0	0	3	..	7	12	15	19	22	25	27	33	34	37	43	48	51	48	36	1
P. debaryanum ..	t	4	11	12	13	18	20	..	23	26	29	31	28	32	34	30	6	t	0	0
P. dissotocum ..	1	5	8	10	13	16	18	21	23	25	29	31	31	34	34	28	8	2	t	0
P. helicoides	0	t	3	5	8	12	14	18	19	22	24	25	31	32	38	35	35	32	14	1
P. irregulare	5	9	11	15	..	17	20	22	24	28	29	29	29	31	30	24	14	1	0	0
P. myriotylum ..	0	1	4	6	8	9	14	18	21	24	28	30	39	38	43	46	49	47	24	1
P. oligandrum ..	0	0	4	7	11	14	16	20	22	23	25	31	34	36	40	35	33	13	t	0
P. periilum	2	5	6	..	8	9	10	11	..	11	12	14	15	15	14	12	8	2	t	0
P. spinosum	4	8	13	..	14	20	22	24	..	28	28	31	32	31	28	12	3	1	0	0
P. splendens	1	3	9	13	..	18	23	29	35	37	39	45	51	49	49	35	25	2	0	0
P. torulosum	t	3	4	..	5	6	7	8	..	10	10	11	13	13	14	14	13	6	1	0
P. ultimum	2	6	10	..	15	19	20	26	..	29	..	32	33	35	35	31	8	2	1	0
P. vexans	t	1	1	..	3	7	11	13	..	16	18	19	19	20	19	4	2	t	0	0

t = trace.

In Queensland, growth-temperature studies were carried out with one or more isolates of each species of *Pythium* for comparison with the results obtained by Middleton. The method used was as follows:

Flat-sided glass bottles, with sides measuring about 4 cm by 10 cm, were partly filled with 20 ml cornmeal agar, which was allowed to solidify to a uniform depth with the bottle in a horizontal position. Bottles were inoculated near the mouth with 6 mm discs cut with a cork borer from just behind the advancing margins of potato-dextrose agar cultures. Inoculated bottles were left at room temperature for 16–24 hours, the extent of the growth at the close of that period being indicated by a wax pencil mark on the bottle; subsequent measurements were made from this point. Two bottles of each culture were placed upright in each of the 20 chambers of a multi-temperature incubator which ranged from 6° to 44°C at approximately 2°C intervals. Cultures were incubated for 72 hours, and growth and temperature readings were taken each 24 hours. Variation in temperature within compartments over the 72 hours was usually 1°C or less.

The average daily growth of the fungi at the various temperatures is presented in Table 1. The temperatures given are correct to within 1°C.

IV. DISCUSSION OF SPECIES

There follows a brief description of the species of *Pythium* found in Queensland together with the site from which they were isolated. Morphological and other characters are given only when these differed from those normally associated with the species or were found useful in identification. Acknowledgement of records made by other workers is made in the annotated Host Index.

Table 2

MEASUREMENTS OF OOGONIA AND OOSPORES OF SPECIES OF PYTHIUM FOUND IN QUEENSLAND

Organism	Diameter of Oogonia (μ)		Diameter of Oospores (μ)	
	Range*	Average	Range*	Average
P. acanthicum	14–30	24	..	..
P. aphanidermatum ..	19–27	23	13–27	21
P. debaryanum	13–30	25	17–25	22
P. dissotocum	18–30	24	15–23	19
P. helicoides	22–34	29	24–32	28
P. irregulare	14–22	20	13–20	17
P. myriotylum	20–40	30	16–32	23
P. oligandrum	18–30	24	15–25	21
P. periilum	17–28	21	..	..
P. spinosum	12–22	16	..	..
P. torulosum	14–26	20	..	..
P. ultimum	17–27	21	15–24	19
P. vexans	14–24	18	12–19	16

* 50 measured.

Pythium acanthicum Drechsl.

The fungus had a distinctive cumulous-rosette growth habit (Figure 1a). Only meagre aerial growth was made. Oogonia formed readily on agar media, but sporangia were observed only on watermelon fruit. Wager (1941) also reported difficulty in obtaining the asexual stage.

This fungus was identified mainly on the basis of its distinctive growth habit, growth-temperature relations and spinal characters. Middleton (1943) stated that the short, conical, obtusely-tipped oogonial protuberances of *Pythium acanthicum* are peculiar to the species.

Occurrence in Queensland:

Brassica oleracea L.—Pre-emergence damping-off.

Citrullus vulgaris Schrad.—Blossom-end rot.

Pythium aphanidermatum (Eds.) Fitzp.

The mycelium was abundant, tough and arachnoid (Figure 1b). Inflated filamentous sporangia were produced when mycelium or infected papaw seedlings were transferred to sterile water. In the latter case, zoospores were produced. Sexual fruiting bodies were formed readily on agar media.

A high maximum temperature for growth and the presence of large, barrel-shaped, sessile antheridia typify the species.

Occurrence in Queensland:

Brassica oleracea L.—Rotting roots.

Carica papaya Gaertn.—Damping-off, root rot.

Chloris gayana Kunth—Damping-off.

Cucumis melo L.—Damping-off.

C. sativus L.—Fruit rot.

Dichanthium sericeum (R.Br.) A. Camus—Damping-off.

Hordeum vulgare L.—Stem rot.

Lycopersicon esculentum Mill.—Damping-off, stem rot of transplants.

Medicago sativa L.—Rotting roots.

Nicotiana tabacum L.—Stem rot.

Panicum maximum var. *trichoglume* (K. Schum.) Eyles—Damping-off.

Phaseolus vulgaris L.—Pod rot, stem rot.

Solanum tuberosum L.—Base rot.

Zea mays L.—Stem rot.

Pythium debaryanum Hesse

The growth habit was arachnoid, and the mycelium moderately abundant. Usually spheroidal sporangia and oogonia with monoclinous or diclinous antheridia formed readily on agar media.

Occurrence in Queensland:

Ananas comosus (L.) Merr.—Root rot.

Brassica oleracea.—Damping-off.

Carica papaya—Root and base rot.

Daucus carotae L.—Root rot.

Lupinus angustifolius L.—Root rot.

Lycopersicon esculentum—Damping-off, root rot.

Matthiola incana (L.) R.Br.—Damping-off.

Medicago sativa—Damping-off, root rot.

Passiflora edulis Sims—Root rot.

Persea gratissima Gaertn.—Root rot.

Phaseolus vulgaris—Base rot.

Pinus elliotti Engelm.—Rotting roots on seedlings.

Sesamum indicum L.—Damping-off.

Trifolium incarnatum L.—Damping-off.

Pythium dissotocum Drechsl.

An abundant, arachnoid mycelium was produced. Oogonia were produced readily on agar media, and when mycelium was transferred to sterile water or

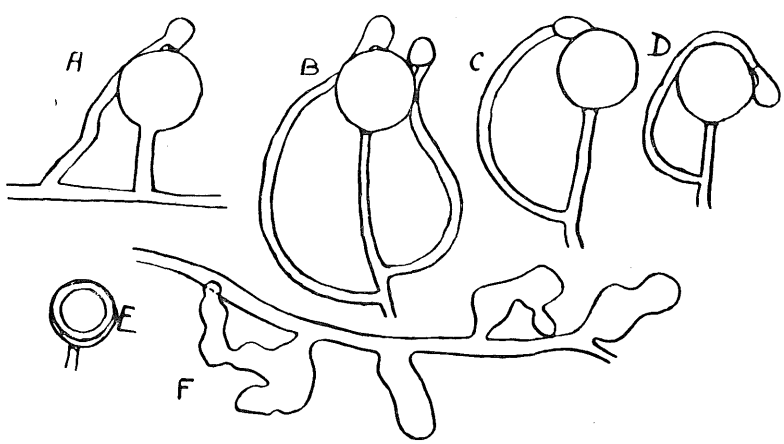

Fig. 2.—Morphological characters of *Pythium dissotocum*. A-D, oogonia and antheridia; E, oogonium with nearly plerotic oospore; F, slightly inflated hyphal elements resembling a sporangium

Petri solution. By analogy with other species of *Pythium* it was assumed that slightly inflated filamentous bodies present in liquid culture were sporangia, but zoospores were not produced.

Oospores were typically plerotic. Antheridia were 1-3 per oogonium, usually monoclinous but occasionally diclinous (Figure 2).

Occurrence in Queensland:

Lupinus digitatus Forsk.—Rotting roots.

Medicago sativa—Damped-off seedlings.

Pythium helicoides Drechsl.

A moderately abundant arachnoid mycelium is formed. No fruiting bodies were formed on potato-dextrose and water agars, but sexual organs were produced on cornmeal agar. Sporangia developed in limited numbers when cornmeal agar blocks containing young mycelium were placed in sterile water for several days. Sporangial proliferation was not observed by the writer, but was reported by Waterhouse (1956).

The large, elongate, cylindrical, intimately-applied antheridial cells with the antheridial stalks often helicoid around the oogonial stalk are characteristic features. A high temperature maximum for growth also typifies this species.

Occurrence in Queensland:

Gossypium sp.—Damped-off seedlings.

Medicago sativa—Damped-off seedlings.

Pinus elliottii—Damped-off seedlings.

Pythium irregulare Buisman

This species produces a moderately-abundant, arachnoid mycelium. Fruiting bodies were formed readily on agar media. The spines of this species are usually few in number, and of irregular size, shape and distribution on the oogonial wall.

Occurrence in Queensland:

Carica papaya—Rotting roots.

Lactuca sativa L.—Rotting roots.

Medicago denticulata Willd.—Damped-off seedlings.

M. sativa—Damped-off seedlings.

M. tribuloides Desr.—Damped-off seedlings.

Trifolium incarnatum—Damped-off seedlings.

Pythium myriotylum Drechsl.

An abundant arachnoid mycelium was produced. Sexual reproductive organs tended to form in clusters on water agar and, more readily, on cornmeal agar. Many oogonia did not contain oospores. Mature oogonia were yellowish-brown in colour. Inflated filamentous sporangia were produced by cultures grown on water agar to which tomato leaf tissue had been added, and also by inoculated lucerne seedlings placed in sterile water.

Besides the high maximum temperature for growth, the species is typified by the crook-necked antheridial cells which make basal and apical contact with the oogonium.

Occurrence in Queensland:

Lupinus digitatus—Damping-off.

Lycopersicon esculentum—Tap-root rot.

Medicago sativa—Damping-off, root rot.

Nicotiana tabacum L.—Damping-off.

Pisum sativum L.—Damping-off.

Pythium oligandrum Drechsl.

This species produced a meagre aerial growth of mycelium which, after a few days, took on a dense woolly appearance. Sexual reproductive structures were produced readily on agar media, but sporangia were not seen.

The species is characterised by conical, acutely-tipped oogonial protuberances and a pulvinate growth habit.

Occurrence in Queensland:

Carica papaya—Rotting roots.

Gerbera jamesonii Bolus—Rotting roots.

Persea gratissima—Rotting roots.

Pythium periilum Drechsl.

A Pythium regarded by Middleton (1959) as probably belonging to this species had a pulvinate growth habit. Oogonia and diclinous antheridia were produced on cornmeal agar, but the proportion of oogonia with oospores was always small. Inflated filamentous sporangia were produced on irrigation of cultures growing on water agar in which lucerne tissue had been incorporated.

Occurrence in Queensland:

Medicago sativa—Rotting roots.

Saccharum officinarum L.—Roots (Isolated by Queensland Bureau of Sugar Experiment Stations and identified by Rands (1939)).

Pythium spinosum Saw.

This had an abundant, arachnoid mycelium. Reproductive structures formed readily on agar media, and when mycelium was placed in sterile water.

Long, digitate, obtusely-tipped oogonial protuberances typify the species.

Occurrence in Queensland:

Ananas comosus—Rotting roots.

Brassica oleracea—Damping-off.

Camellia japonica L.—Rotting roots.

Carica papaya—Rotting roots.

Cucurbita maxima L.—Damping-off.

Passiflora edulis—Rotting roots.

Persea gratissima—Rotting roots.

Phaseolus vulgaris—Seed rot and damping-off.

Pinus elliottii—Rotting roots on seedlings.

Pythium splendens Braun.

The mycelium was arachnoid and moderately abundant. Sporangia were produced readily on cornmeal agar, water agar and potato-dextrose agar, but oogonia failed to form in four weeks on these media. Middleton (1943) and Wager (1941) also reported difficulty in obtaining the sexual stage.

The species was identified on the basis of its sporangial, growth-temperature and cultural characteristics. According to Middleton (1943) the large, spherical, densely-granular, terminal sporangia are unique.

Occurrence in Queensland:

Annona squamosa L.—Root rot.

Pinus elliottii—Root rot.

Pisum sativum—Damping-off.

P. splendens was isolated on several occasions from soil, using the apple technique devised by Campbell (1949).

Pythium torulosum Coker and Patterson

This fungus has a fairly dense appressed, broadly-rosette growth habit (Figure 1c), and was the slowest growing species studied. Inflated filamentous sporangia were formed following the irrigation of cultures growing on water agar in which lucerne tissue had been incorporated. Oogonia were produced scantily on agar media; they measured somewhat larger (14–26μ) than the 12-19μ quoted by Middleton (1943). The monoclinous antheridia, one or two per oogonium and arising fairly close to the oogonium, were typical of the species (Figure 3). The maximum temperature was somewhat higher (39°C) than the 34-37°C given by Middleton (1943).

Occurrence in Queensland:

Medicago sativa—Rotting roots.

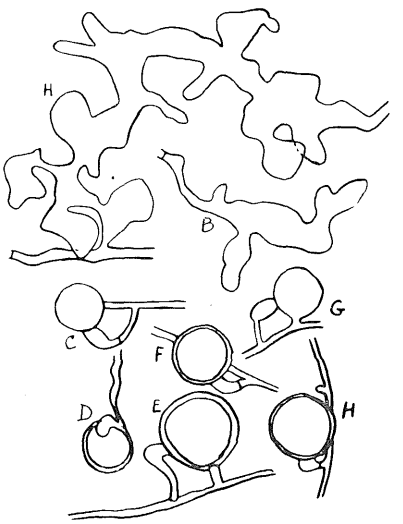

Fig. 3.—Morphological characters of *Pythium torulosum*. A, B, sporangia; C-H, oogonia and antheridia.

Pythium ultimum Trow.

This species had an abundant, arachnoid mycelium. Reproductive organs were usually produced readily on agar media. A single, swollen, sausage-shaped antheridium arising very close to the oogonium typifies the species.

Occurrence in Queensland:

Alyssum maritimum L.—Damping-off.

Antirrhinum majus L.—Base rot.

Aster sp.—Damping-off.

Brassica oleracea—Damping-off.

Carica papaya—Damping-off; root and base rot.

Linum usitatissimum L.—Damping-off.

Lupinus angustifolius L.—Root and base rot.

Lycopersicon esculentum—Damping-off, base rot.

Medicago sativa—Root rot.

Persea gratissima—Rotting roots.

Phaseolus vulgaris—Stem rot, tip blight.

Pinus elliottii—Damping-off.

P. patula Schlecht & Cham.—Seedling root rot.

Pisum sativum—Damping-off.

Solanum tuberosum—Base rot.

Vigna sinensis (L.) Endl. ex Hassk.—Damping-off.

Pythium vexans de Bary.

This species had a characteristic rosette growth habit and a "combed silk" margin (Figure 1d). Sporangia were usually produced readily on agar media; small oogonia with cylindrical, broadly-attached antheridia sometimes formed sparsely on water agar after long incubation, but were more readily produced on cornmeal agar (Figure 4). Some isolates which agreed with *P. vexans* in cultural and sporangial characters failed to produce oogonia on any agar media used.

Occurrence in Queensland:

Annona squamosa—Rotting roots.

Brassica oleracea—Rotting roots.

Carica papaya—Rotting roots and bases.

Medicago sativa—Damping-off.

Persea gratissima—Rotting roots.

It was also frequently isolated from soil by Campbell's (1949) technique.

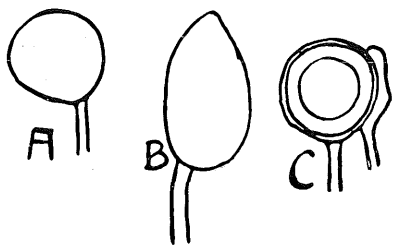

Fig. 4.—Morphological characters of *Pythium vexans*. A, B, terminal sporangia; C, oogonium and antheridium.

V. PRESENTATION OF DATA IN THE HOST INDEX

The host list which follows is presented with the botanical families in alphabetical order.

Where the host record is not listed by Middleton (1943) the species name of the *Pythium* concerned is preceded by an asterisk.

Where it is considered that the fungus was a primary pathogen, this is indicated by a +. Where pathogenicity is doubtful the + sign is omitted. Where inoculation experiments have confirmed the pathogenicity the symbol ++ is used.

Unpublished records contributed by other workers are acknowledged by inserting the contributor's name after the record. Records appearing in published articles are referred to the References in the usual way.

ANNOTATED HOST INDEX

Annonaceae

Annona muricata L. (sour sop)

**Pythium* sp.	damping-off++ (G. S. Purss).

Annona squamosa L. (custard apple)

**P. splendens*	damping-off+.
**P. vexans*	root rot.

Bromeliaceae

Ananas comosus (L.) Merr. (pineapple)

P. debaryanum	root rot.
**P. spinosum*	root rot.

Cactaceae

Opuntia inermis DC. (prickly pear)

**Pythium* sp.	root rot+ (Tryon 1912).

Caricaceae

Carica papaya Gaertn. (papaw)

P. aphanidermatum	damping-off, root rot+ (Teakle 1957).
P. debaryanum	root-rot+ (Teakle 1957) and base rot++ (J. H. Simmonds).
P. irregulare	root rot (Teakle 1957).
**P. oligandrum*	root rot (Teakle 1957).
P. spinosum	root rot (Teakle 1957).
P. ultimum	damping-off+; root and base rot++ (Ashby 1935; Simmonds 1937).
P. vexans	root and base rot (Teakle 1957).
Pythium sp.	ground rot of fruit+ (G. D. Bowen).

Chenopodiaceae

Beta vulgaris L. (beetroot, silverbeet)

Pythium sp.	damping-off+.

Compositae

Aster sp. (aster)

**P. ultimum*	damping-off+.

Gerbera jamesonii Bolus. (gerbera)

**P. oligandrum*	root rot (B. L. Winks).

Lactuca sativa L. (lettuce)

**P. irregulare*	root rot.

Cruciferae

Alyssum maritimum L. (alyssum)

**P. ultimum*	damping-off+.

Brassica oleracea L. (cabbage, cauliflower, broccoli)

**P. acanthicum*	damping-off.
P. aphanidermatum	root rot.
P. debaryanum	damping-off+.
P. spinosum	damping-off.
P. ultimum	damping-off++.
**P. vexans*	root rot.

Matthiola incana L. (stock)

**P. debaryanum*	damping-off+.

Cucurbitaceae

Citrullus vulgaris Schrad. (watermelon)

P. acanthicum	fruit rot.

Cucumis melo L. (rockmelon)

P. aphanidermatum	damping-off+.
P. spinosum	damping-off+ (B. L. Winks).

Cucumis sativus L. (cucumber)

P. aphanidermatum	fruit rot++ (J. C. Johnson).
Pythium sp.	fruit rot+.

Cucurbita maxima L. (pumpkin)

**P. spinosum*	damping-off+.

Gramineae

Chloris gayana Kunth. (Rhodes grass)

**P. aphanidermatum*	damping-off+ (J. K. Leslie).

Dichanthium sericeum (R.Br.) A. Camus (Queensland blue grass)

**P. aphanidermatum*	damping-off++ (J. K. Leslie).

Hordeum vulgare L. (barley)

**P. aphanidermatum*	stem rot+ (B. L. Winks).

Panicum maximum var. *trichoglume* (K. Schum.) Eyles (green panic)

**P. aphanidermatum*	damping-off+ (J. K. Leslie).

Saccharum officinarum L. (sugar-cane)

P. periilum	root rot++ (Bureau of Sugar Experiment Stations).

Zea mays L. (maize)

P. aphanidermatum	stem rot+ (B. L. Winks).

Lauraceae

Persea gratissima Gaertn. (avocado)

**P. debaryanum*	root rot.
**P. oligandrum*	root rot.
**P. spinosum*	root rot.
**P. ultimum*	root rot.
P. vexans	root rot.

Leguminosae

Lupinus angustifolius L. (New Zealand blue lupin)	
P. debaryanum	root rot+.
**P. ultimum*	root and base rot+.
L. digitatus Forsk. (West Australian blue lupin)	
P. dissotocum	root rot+.
**P. myriotylum*	damping-off+.
Medicago denticulata Willd. (burr medic)	
**P. irregulare*	damping-off+.
M. sativa L. (lucerne)	
**P. aphanidermatum*	rotting roots.
**P. debaryanum*	damping-off and root rot+.
P dissotocum	damping-off++.
**P. helicoides*	damping-off+.
**P. irregulare*	damping-off+.
**P. myriotylum*	root rot++ (Teakle 1956).
**P. periilum*	root rot.
**P. torulosum*	root rot.
P. ultimum	root rot.
P. vexans	damping-off.
M. tribuloides Desr. (barrel medic)	
**P. irregulare*	damping-off+.
Melilotus indica All. (hexham-scent)	
Pythium sp.	root rot.
Phaseolus vulgaris L. (french bean)	
P. aphanidermatum	pod rot++ (J. C. Johnson) and stem rot+ (Simmonds 1950).
P. debaryanum	base rot+.
**P. spinosum*	seed rot, damping-off+.
P. ultimum	tip blight, stem, base and root rot+.
Pisum sativum L. (pea)	
**P. myriotylum*	damping-off+.
**P. splendens*	damping-off+.
P. ultimum	damping-off++.
Trifolium incarnatum L. (crimson clover)	
**P. debaryanum*	damping-off+.
**P. irregulare*	damping-off+.
Vigna sinensis (L.) Endl. ex. Hassk. (cowpea)	
**P. ultimum*	damping-off+.

Linaceae

Linum usitatissimum L. (linseed)	
P. ultimum	damping-off+.

Malvaceae
Gossypium hirsutum L. (cotton)
**P. helicoides* — damping-off+.

Musaceae
Musa sp. (banana)
Pythium sp. — root rot.

Myrtaceae
Eucalyptus pilularis Sm. (blackbutt)
**Pythium* sp. — damping-off (Simmonds 1951).

Passifloraceae
Passiflora edulis Sims (passion fruit).
**P. debaryanum* — root rot.
**P. spinosum* — root rot.

Pedaliaceae
Sesamum indicum L. (sesame)
**P. debaryanum* — damping-off+.

Pinaceae
Pinus elliottii Engelm. (slash pine)
**P. spinosum* — rotting roots on seedlings
**P. splendens* — rotting roots on seedlings
**P. ultimum* — damping-off++. (B. L. Winks.)
P. radiata D. Don. (radiata pine)
P. ultimum — damping-off++. (B. L. Winks.)

Rubiaceae
Pentas sp.
Pythium sp. — stem rot.

Rutaceae
Citrus sp.
Pythium sp. — damping-off+.

Scrophulariaceae
Antirrhinum majus L. (snapdragon)
P. ultimum — base rot+.

Solanaceae
Capsicum frutescens L. (chili)
Pythium sp. — stem rot.
Lycopersicon esculentum Mill. (tomato)
P. aphanidermatum — damping-off, stem rot of transplants+; fruit rot+. (B. L. Winks.)
P. debaryanum — damping-off, root and base rot+.
P. myriotylum — stem rot of transplants+.
P. ultimum — damping-off, root and base rot+.

Nicotiana tabacum L. (tobacco)

P. aphanidermatum	stem rot (W. Pont).
P. myriotylum	damping-off+.

Petunia hybrida Vilm.

Pythium sp.	stem rot+.

Solanum tuberosum L. (potato)

P. aphanidermatum	base rot+.
P. ultimum	base rot, soft rot of tuber+.

Theaceae

Camellia japonica L. (camellia)

**P. spinosum*	root rot.

Umbelliferae

Daucus carota L. var. *sativa* DC. (carrot)

P. debaryanum	root rot.

Zingiberaceae

Zingiber officinale Rosc. (ginger)

P. spinosum	rhizome rot (secondary to *Fusarium oxysporum*).

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REFERENCES

ASHBY, S. F. (1935).—Private communication to J. H. Simmonds, Department of Agriculture and Stock, Brisbane.

CAMPBELL, W. A. (1949).—A method of isolating *Phytophthora cinnamomi* directly from soil. *Plant. Dis. Reptr* 33: 134–5.

MIDDLETON, J. T. (1943).—The taxonomy, host range and geographic distribution of the genus *Pythium*. *Mem. Torrey Bot. Cl.* 20 (1).

MIDDLETON, J. T. (1959).—Private communication.

RANDS, R. D. (1939).—Private communication to Assistant Director, Bureau of Sugar Experiment Stations, Brisbane.

SIMMONDS, J. H. (1937).—Diseases of the papaw. *Qd Agric. J.* 48: 544–52.

SIMMONDS, J. H. (1950).—Report of the Science Branch. In *Rep. Dep. Agric. Qd* 1949-50: 34–5.

SIMMONDS, J. H. (1951).—Science Branch. In *Rep. Dep. Agri. Qd* 1950-51: 27–9.

TEALKE, D. S. (1956).—A lucerne rot caused by *Pythium myriotylum*. *Qd J. Agric. Sci.* 13: 241–3.

TEAKLE, D. S. (1957).—Papaw root rot caused by *Pyhtophthora palmivora* Butl. *Qd J. Agric. Sci.* 14: 81–91.

TRYON, H. (1912).—Vegetable Pathology. In *Rep. Dep. Agric. Qd* 1911-12: 8–11.

WAGER, V. A. (1941).—Descriptions of the South African Pythiaceae with records of their occurrence. *Bothalia* 4: 3–35.

WATERHOUSE, G. M. (1956).—Private communication to J. H. Simmonds, Department of Agriculture and Stock, Brisbane.

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