KEY TO THE SPECIES OF *PYTHIUM* ...with some new species added

Based on:Van Der Plaats-Niterink, A. J. 1981. Monograph of the genus *Pythium*. Monograph No. 21. Baarn. Centraalbureau voor Schimmelcultures. 242 pp. with some new species added by Moorman

1	Oogonia produced in single cultures	2
	Oogonia not or scarcely produced in single cultures	104
2(1)	Oogonial wall ornamented with obtuse or blunt projections	3
	Oogonial wall smooth or occasionally with few projections	25
	SPECIES WITH ORNAMENTED OOGONIA	
3(2)	Oogonia on average 30 µm or more in diameter	4
	Oogonia on average less than 30 µm diameter	9
4(3)	Sporangia unknown	*P. buismaniae*
	Sporangia present	5
5(4)	Sporangia (sub)globose, ellipsoidal or irregular, not proliferating	6
	Sporangia proliferating	8
6(5)	Oogonia on average 40 µm or more in diameter	*P. polymastum*
	Oogonia on average less than 40 µm in diameter	7
7(6)	Antheridial cells mostly single; oogonia on average 38.5 µm diameter	*P. mastophorum*
	Antheridial cells 1-8; oogonia on average 34 µm diameter	*P. uncinulatum*
8(5)	Large chlamydospores present	*P. dimorphum*
	Chlamydospores absent	*P. megalacanthum*
9(3)	Sporangia unknown	10
	Sporangia present	12
10(9)	Oogonial projections less than 3 µm long	*P. acanthophoron*
	Oogonial projections more than 3 µm long	11
11(10)	Oogonial projections acute; antheridia 1(-2), hypogynous	*P. hydnosporum*
	Oogonial projections blunt, cylindrical; antheridia 1(-3), usually monoclinous	*P. spinosum* also see *P. betae* and *P. regulare*
12(9)	Sporangia filamentous	13
	Sporangial (sub)globose, oval, ellipsoidal, or elongated	14
13(12)	Sporangia not inflated; antheridia absent; oogonial projections few, blunt	*P. papillatum*
	Sporangia inflated; antheridia present; oogonial projections numerous, blunt	*P. periplocum*
14(12)	Sporangia not proliferating	15
	Sporangia proliferating	21
15(14)	Sporangia consisting of irregular complexes of (sub)globose and filamentous elements	16
	Sporangia single, not forming complexes	17
16(15)	oogonial projections acute, 5-7(-11) µm long	*P. oligandrum* see also *P. amasculinum* and *P. sinense*
	Oogonial projections blunt, 1-2(-5) µm long	*P. acanthicum*
17(15)	Antheridia mostly hypogynous	*P. echinulatum*
	Antheridia mostly monoclinous or diclinous	18
18(17)	Antheridia usually entwining the oogonial stalk and base	*P. helicandrum*

	Antheridia not entwining the oogonial stalk and base	19
19(18)	Oogonial projections blunt, usually cylindrical, irregular; antheridia mostly monoclinous, occasionally diclinous or hypogynous	*P. irregulare* or *P. cryptoirregulare*, see also *P. regulare*
	Oogonial projections conical, sometimes curved; antheridial mono- or diclinous	20
20(19)	Antheridia monoclinous; oogonial projections conical, blunt	*P.mamillatum*
	Antheridia diclinous; oogonial projections mostly acute	*P. erinaceus*
21(14)	Oogonial projections at maturity blunt, cylindrical, widening or dichotomously branched at tip	*P. polypapillatum*
	Oogonial projections conical or mammiform	22
22(21)	Antheridia absent	*P. anandrum*
	Antheridia 1(-4), monoclinous or diclinous	23
23(22)	Antheridia diclinous, making broad contact with oogonia; antheridial stalks forming a tangled mass	*P. prolatum*
	Antheridia monoclinous or diclinous, making apical contact with oogonia; antheridial stalks never a tangled mass	24
24(23)	Sporangia average 30 X 25 µm	*P. paddicum*
	Sporangia average 87 X 27 µm	*Phytophthora stellata*

SPECIES WITH SMOOTH-WALLED OOGONIA

25(2)	Sporangia filamentous, inflated or not	26
	Sporangia (sub)globose), proliferating or not, or absent (sometimes only hyphal swellings present	58
26(25)	Sporangia not or slightly inflated	27
	Sporangia inflated, forming lobes, diverticles, or toruloid structures	43

SPORANGIA FILAMENTOUS, NON-INFLATED

27(26)	Oogonia usually only produced in dual cultures (heterothallic species)	107
	Oogonia commonly produced in single cultures	28
28(27)	Antheridia absent; oogonia smooth or with a few papillae	*P. papillatum*
	Antheridia present	29
29(28)	Oospores plerotic	30
	Oospores aplerotic	32
30(29)	Antheridia single, diclinous; oogonia terminal	*P. marinum*
	Antheridia 1-2(-4), mono- and diclinous; oogonia terminal or intercalary	31
31(30)	Antheridia both mono- and diclinous; oogonia terminal and intercalary	*P. monospermum*
	Antheridia diclinous; oogonia mostly intercalary, rarely terminal; in marine algae	*P. porphyrae*
32(29)	Oospores reticulate	*P. dictyosporum*
	Oospores smooth-walled	33
33(32)	Daily growth rate on cellulosic substrates 0.5-2 mm. no growth on corn meal agar	34
	Daily growth rate on cellulosic substrates 10-20 mm; grows well on common agar media	35
34(33)	Colonies peach to flesh color; gaily growth rate 1.5-2.0 mm	*P. fluminum* var. *fluminum*
	Colonies yellowish; daily growth rate 0.5-1.0 mm	*P. fluminum* var. *flavum*

35(33)	Antheridia 1(-2), monoclinous	*P. aquatile*
	Antheridia 1-2(-4), at least partly diclinous	36
36(35)	Antheridia diclinous	37
	Antheridia both mono- and diclinous	38
37(36)	Antheridial cells 1-4 per oogonium, originating from one stalk; rarely more than one antheridial stalk	*P. adhaerens*
	Antheridia 1-2 per oogonium on simple unbranched stalks	*P. diclinum*; see also *P. apleroticum*
38(36)	Antheridial stalks unbranched	39
	Antheridial stalks branched	41
39(38)	Antheridia often sessile	*P. dissotocum*
	Antheridia not sessile	40
40(39)	Catenulate hyphal swellings present	*P. perniciosum*
	Catenulate hyphal swellings absent	*P. tenue*
41(38)	Oospore wall 2-4 µm thick, pale lilac; oospores yellowish	*P. coloratum*
	Oospore wall 1-2 µm thick; oospores uncolored	42
42(41)	Antheridial cells large, very variable in size, usually with folds and furrows; oospores 14.5 µm average diameter	*P. sulcatum*
	Antheridial cells about 8.5 X 5 µm, without furrows; oospores average 18 µm diameter	*P. angustatum*

SPORANGIA FILAMENTOUS, INFLATED

43(26)	Oogonia usually only produced in dual cultures (heterothallic)	108
	Oogonia commonly produced in single cultures	44
44(43)	Antheridia absent or rare and then hypogynous	*P. dissimile*
	Antheridia present, monoclinous, diclinous or intercalary	45
45(44)	Antheridia often intercalary	46
	Antheridia usually not intercalary	47
46(45)	Oogonial stalks mostly curved toward the antheridia	*P. deliense*
	Oogonial stalks straight	*P. aphanidermatum*
47(45)	Sporangia consisting of inflated filamentous parts and discrete globose or pyriform elements	*P. pyrilobum*
	No discrete globose or pyriform sporangia present	48
48(47)	Oogonia on average about 30 µm or more in diameter	49
	Oogonia on average less that 25 µm in diameter	52
	Many oogonia containing multiple oospores	*P. plurisporum*
49(48)	Oospores plerotic or nearly so; up to 15-20 antheridia per oogonium	*P. arrhenomanes*
	Oospores aplerotic or nearly so; less than 10 antheridia per oogonium	50
50(49)	Maximum temperature above 40C	*P. myriotylum*
	Maximum temperature below 40C	51
51(50)	Antheridia both mono- and diclinous; daily growth rate 22-25 mm	*P. aristosporum*
	Antheridia usually diclinous; daily growth rate 10-16 mm	*P. volutum*, see also *P. plurisporum*
52(48)	Catenulate hyphal swellings present	*P. catenulatum*
	Catenulate hyphal swellings absent	53
53(52)	Sporangia consisting partly of inflated finger-like and partly of undifferentiated mycelial elements;	

	temperature maximum above 40C	*P. periilum*
	Sporangia consisting of toruloid inflated inflated elements throughout; temperature maximum below 40C	54
54(53)	Oospores aplerotic	*P. indigoferae*
	Oospores plerotic or nearly so	55
55(54)	Antheridia diclinous	*P. inflatum*
	Antheridia monoclinous, occasionally diclinous	56
56(55)	Antheridia 1-3(-6); oogonia mostly 21-24 µm diameter	*P. graminicola*
	Antheridia 1-2(-3); oogonia mostly 14-21 µm diameter	57
57(56)	Antheridia usually originating 1-5 µm below the oogonium; oospore wall up to 2 µm thick; sporangia consisting of branched inflated elements	*P. torulosum*
	Antheridia usually originating 15-25 µm below the oogonium; oospore wall 2-4 µm thick; sporangia consisting of catenulate complexes of subglobose unbranched outgrowths	*P. vanterpoolii*
58(25)	Sporangia (sub)globose, proliferating or not	59
	Sporangia never observed	93
59(58)	Sporangia not proliferating	60
	Sporangia proliferating	81

SPORANGIA (SUB)GLOBOSE, NON-PROLIFERATING

60(59)	Oogonia usually only produced in dual cultures (heterothallic)	110
	Oogonia produced in single cultures	61
61(60)	Oospores reticulate	*P. pythioides*
	Oospores smooth-walled	62
62(61)	Sporangia large, up to 130 µm long, transversely attached to the subtending hyphae, papillate	*P. grandisporangium*
	Sporangia usually less than 50 µm long	63
63(62)	Sporangia consisting of both globose or pyriform elements and inflated filamentous parts	*P. pyrilobum*
	Sporangia consisting only of (sub)globose) elements	64
64(63)	Oospores plerotic or nearly so	65
	Oospores definitely aplerotic	70
65(64)	Antheridia typically hypogynous	*P. selbyi*, *P. hypogynum*; see also *P. acrogynum*
	Antheridia mono- or diclinous, occasionally hypogynous or absent	66
66(65)	Antheridia monoclinous, often sessile or hypogynous; oogonia usually intercalary, occasionally terminal	*P. rostratum*
	Antheridia never hypogynous, occasionally absent; oogonia terminal or intercalary	67
67(66)	Oogonia usually intercalary, often catenulate, occasionally terminal; antheridia often absent	*P. salpingophorum* see also *P. cylindrosporum*
	Oogonia usually terminal, occasionally intercalary	68
68(67)	Temperature maximum above 40C	*P. orthogonon*
	Temperature maximum below 40C	69
69(68)	Oospore walls up to 3 µm thick; thick-walled chlamydospores sometimes present	*P. tracheiphilum*
	Oospore walls less than 1.5µm thick; chlamydospores absent	*P. salinum*, *P. schmitthenneri*, see also *P. cylindrosporum*

70(64)	Antheridia monoclinous, bell-shaped or lobed	71
	Antheridia neither bell-shaped or lobed	72
71(70)	Antheridia typically bell-shaped, not lobed; oospores on average 21µm diameter	*P. perplexum*
	Antheridia typically bell-shaped and lobed; sporangia occasionally proliferating; oospores on average 17 µm diameter	*P. vexans*
72(70)	Sporangia over 40 µm diameter	73
	Sporangia less than 40 µm diameter	75
73(72)	Antheridia hypogynous, occasionally mono- or diclinous	*P. pulchrum*
	Antheridia not hypogynous	74
74(73)	Oogonia often irregularly shaped, terminal; chlamydospores absent	*P. jirovecii*
	Oogonia globose, intercalary; thick-walled chlamydospores present	*P. iwayamai*
75(72)	Antheridia large, irregular, making broad lengthwise contact with the oogonia near the stalk	*P. chamaehyphon*
	Antheridia small, stalked or sessile, making apical contact with the oogonia	76
76(75)	Oogonia intercalary or terminal; oospore wall 1.0-1.5 µm thick	77
	Oogonia usually terminal; oospore wall 2 µm or more thick	78
77(76)	Oogonia sometimes catenulate, without projections	*P. paroecandrum*, see also *P. cylindrosporum*
	Oogonia never catenulate, occasionally with blunt, irregulare projections	*P. irregulare* or *P. cryptoirregulare*
78(76)	Antheridia diclinous	*P. macrosporum*
	Antheridia monoclinous, rarely diclinous	79
79(78)	Antheridial stalks often swollen, originating at a distance of 5-15 µm below the oogonia	*P. okanoganense*
	Antheridial stalks never swollen, originating immediately below the oogonia	80
80(79)	Sporangia and zoospores produced at room temperature	*P. ultimum* var. *sporangiiferum*
	Sporangia and zoospores not produced at room temperature, hyphal swellings germinating with germ tubes only	*P. ultimum* var. *ultimum*

SPORANGIA PROLIFERATING

81(59)	Oogonia not produced in single cultures	111
	Oogonia commonly produced in single cultures	82
82(81)	Oogonia often containing 2 or more oospores	*P. multisporum*
	Oogonia containing a single oospore	83
83(82)	Oogonia on average 30 µm diameter or more	84
	Oogonia n average less than 30 µm diameter	89
84(83)	Antheridia making broad apical contact with the oogonia	*P. marsipium*
	Antheridia applied lengthwise to the oogonia	85
85(84)	Oospores plerotic or nearly so; antheridia usually monoclinous	*P. ostracodes*
	Oospores aplerotic; antheridia usually diclinous	86
86(85)	Antheridia long cylindrical, without waves or furrows; oospore wall 4-6 µm thick	*P. helicoides*
	Amtheridia wavy or furrowed; oospore wall up to 3.5 µm thick	87
87(86)	Oogonia usually terminal, rarely intercalary	*P. oedochilum*
	Oogonia terminal, intercalary or laterally sessile	88
88(87)	Sporangia subglobose or ovoid, terminal on long unbranched hyphae, sometimes in sympodial	

	succession arising from immediately below a sporangium; antheridial stalks often enwrapping the oogonial stalk	*P. palingenes*
	Sporangia (sub)globose terminal intercalary or laterally sessile; antheridial stalks rarely enwrapping the oogonial stalk	*P. polytylum*
89(83)	Oospores plerotic; oogonia mostly intercalary, often catenulate	*P. salpingophorum*
	Oospores aplerotic	90
90(89)	Oogonia usually intercalary, occasionally terminal	*P. middletonii*
	Oogonia usually terminal, rarely intercalary	91
91(90)	Antheridia bell-shaped or lobed	*P. vexans*
	Antheridia make broad, lengthwise contact	*P. delawarense*
	Antheridia globose or clavate	92
92(91)	Oospore wall less than 1 µm thick; oospores 12-19 µm diameter	*P. nagaii*
	Oospore wall up to 3 µm thick; oospores 22-27 µm diameter	*P. okanoganense*

SPORANGIA AND ZOOSPORES UNKNOWN

93(58)	Oogonia produced usually only in dual cultures (heterothallic)	113
	Oogonia produced in single cultures	94
94(93)	Colonies on cellulosic substrates saffron to pale yellow; no gowth on cornmeal agar	*P. uladhum*
	Colonies white or colorless; growing well on corn meal agar	95
95(94)	Antheridia often sessile	96
	Antheridia usually stalked	97
96(95)	Oogonia on average about 21 µm; antheridial stalks not branched	*P. ultimum* var. *ultimum* (aplerotic) see also *P. segnitium* (plerotic)
	Oogonia on average about 29 µm; antheridial stalks sometimes branched	*P. violae*
97(95)	Oospores plerotic	98
	Oospores aplerotic	100
98(97)	oogonia on average 30 µm in diameter or more	*P. hemmianum*
	Oogonia on average less than 30 µm diameter	99
99(98)	Antheridia monoclinous	*P. connatum*
	Antheridia both mono- and diclinous	*P. pleroticum*, see also *P. segnitium*
100(97)	Globose hyphal swellings absent	101
	Globose hyphal swellings present	102
101(100)	Filamentous inflated hyphal swellings present; antheridial stalks not coiling around oogonia	*P. tardicrescens*
	Filamentous inflated hyphal swellings absent; antheridial stalks entangling the oogonia	*P. scleroteichum*
102(100)	Hyphal swellings large, often 30-40 µm in diameter	*P. splendens*
	Hyphal swellings, if present, on average less than 30 µm in diameter	103
103(102)	Aerial mycelium on corn meal agar profusely cottony; daily growth rate at 25C, 30 mm	*P. sylvaticum*
	Some aerial mycelium on corn meal agar; daily growth rate at 25C, 20 mm	*P. heterothallicum*

HETERTHALLIC SPECIES AND SPECIES WITHOUT OOGONIA

104(1)	Sporangia present	105
	Sporangia not formed, hyphal swellings often present	113

105(104)	Sporangia filamentous, inflated or not	106
	Sporangia globose, proliferating or not	109
106(105)	Sporangia filamentous, non-inflated	107
	Sporangia filamentous, inflated	108
107(27, 106)	Oogonia formed in dual cultures; daily growth rate 7-10 mm; colonies on potato carrot agar with chrysanthemum pattern	*P. flevoense*
	Oogonia not formed in dual culture	*Pythium* 'group F'
108(43, 106)	Oogonia formed in dual cultures; catenulate hyphal swellings present	*P. catenulatum*
	Oogonia not formed in dual cultures; hyphal swellings absent	*Pythium* 'group T'
109(105)	Sporangia globose to elongate, non-proliferating	110
	Sporangia globose to elongate, proliferating	111
110(60, 109)	Oogonia formed in dual cultures; hyphal swellings absent	*P. macrosporum*
	Oogonia not formed in dual cultures; hyphal swellings present or absent	*Pythium* 'group G' also see *P. elongatum*
111(81, 109)	Sporangia large, up to more than 100 µm long; thick-walled chlamydospores present	*P. undulatum*
	Sporangia smaller (20-30 µm)	112
112(111)	Catenulate hyphal swelling present	*P. carolinianum*
	Catenulate hyphal swellings absent	*Pythium* 'group P'
113(93, 104)	Hyphal swellings large, often 30-40 µm diameter; oogonia formed in dual cultures	*P. splendens*
	Hyphal swellings, if present, on average less than 30 µm in diameter	114
114(113)	Deciduous catenulate hyphal swellings present; oogonia formed in dual cultures	*P. intermedium*
	Hyphal swellings not catenulate	115
115(114)	Oogonia formed in dual cultures	116
	Oogonia not formed in dual cultures	*Pythium* 'group HS'
116(115)	Aerial mycelium on cornmeal agar profusely cottony; daily growth rate at 25C 30 mm	*P. sylvaticum*
	Some aerial mycelium on corn meal agar; daily growth rate at 25C 20 mm	*P. heterothallicum*