Aquatic Fungi of Kumaun Himalaya, India: *Pythium* Pringsheim

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Abstract. — A total of twenty one isolates belonging to different species of *Pythium* were isolated and studied from water and soil of Kumaun Himalaya, India. Of these, one species viz., *P. pulchrum* Minden is a new record for India and ten species viz., *P. aphanidermatum* (Edson) Fitz., *P. artotrogus* de Bary, *P. debaryanum* Hesse, *P. dissotocum* Drechsler, *P. echinulatum* Matthews, *P. gracile* Schenk, *P. middletonii* Sparrow, *P. paroecandrum* Drechsler, *P. spinosum* Sawada ap. Sawada & Chen and *P. ultimum* Trow are being reported from Kumaun Himalaya for the first time.

Introduction

In India Butler (1907) was the first who reported eight species of *Pythium*. After his work, some of the important contributions on the study of *Pythium* have been made by a number of workers including Dastur (1935), Bhargava (1941), Balkrishnan (1948 a, b), Ramkrishnan (1949), Mahmud (1950, 1951, 1952), Prakash & Saksena (1952), Sharma & Neema (1952), Ramkrishnan (1955), Srinivasan (1956), Dayal & Tandon (1962), Rao (1963), Deshpande & Deshpande (1964), Srivastava (1964), Bhargava & Singh (1965), Rajgopalan & Ramkrishnan (1967—68), Aulakh (1971), Prabhuji & Srivastava (1976), Manoharachary & Rao (1978), Khulbe (1979), Chowdhry & Agarwal (1981), Manoharachary (1981) and Mer & Khulbe (1983). But the Kumaun region in the Himalayas remained almost unexplored. In the present pursuit, different representatives of twenty one species of *Pythium* were isolated and studied from water, soil and infected roots of crops over a period of three years.

Materials and Methods

Samples of water, soil and infected roots of different crops were collected from a number of selected sites in the Kumaun Himalaya. Isolation of species was exercised by following the method used by Robertson (1980).

Subsequently, the isolates were grown on hempseed halves in sterile distilled water. Preserved specimens of all the species have been deposited in the collections in the museum of Botany Department, Kumaun University, Nainital. Moreover, a few important taxa viz. *Pythium echinulatum* Matthews (IMI 255016), *Pythium gracile* Schenk (IMI 255013), *P. hypogynum* Middleton (IMI 277403), *P. middletonii* Sparrow (IMI 255019

& 255018), *P. rostratum* BUTLER (IMI 277406), *P. spinosum* SAWADA ap. SAWADA & CHEN (IMI 277405) and *P. vexans* var. *minuta* MER & KHULBE (IMI 255017) have been deposited in the Herbarium, CMI, Kew, England.

Key to the Himalayan species of *Pythium* PRINGSHEIM

1. Sporangia filamentous, irregularly lobulate or digitate 3
2. Sporangia spherical, ovoid or ellipsoidal 4
   3a. Sex organs present 5
   3b. Sex organs absent ..... *P. afertile* (1)
4a. Sex organs present 6
4b. Sex organs absent 7
   5a. Antheridia strictly diclinous 8
   5b. Antheridia diclinous and androgynous 9
   5c. Antheridia diclinous and monoclinous 10
6a. Oogonia smooth walled 11
6b. Oogonia spiny 12
   7a. Hyphae undulating, sporangia ellipsoidal .. *P. undulatum* (20)
   7b. Hyphae not undulating, sporangia not ellipsoidal .... *P. elongatum* (7)
8a. Oospore aplerotic ..... *P. gracile* (8)
8b. Oospore plerotic ..... *P. inflatum* (10)
   9a. Oospore aplerotic ..... *P. dissotocum* (5)
   9b. Oospore plerotic ..... *P. monospermum* (12)
10a. Oospore aplerotic ..... *P. aphanidermatum* (2)
10b. Oospore plerotic ..... *P. torulosum* (18)
   11a. Antheridia sessile ..... *P. ultimum* (19)
   11b. Antheridia not as above 13
12a. Antheridia monoclinous, diclinous and hypogynous in addition to androgynous 14
12b. Antheridia strictly hypogynous ..... *P. artotrogum* (3)
   13a. Antheridia diclinous 15
   13b. Antheridia monoclinous 16
   13c. Antheridia strictly hypogynous 17
   13d. Antheridia bell-shaped, hypogynous as well as diclinous ..... *P. vexans* var. *minutum* (21)
14a. Oospore aplerotic ..... *P. echinulatum* (6)
14b. Oospore plerotic ..... *P. spinosum* (17)
   15a. Oogonia terminal, oospore single ..... *P. debaryanum* (4)
   15b. Oospore 1—2 ..... *P. middletonii* (11)
16a. Oogonia usually intercalary ..... *P. paroecandrum* (13)
16b. Oogonia not intercalary 18
   17a. Oospore plerotic ..... *P. hypogynum* (9)
   17b. Oospore aplerotic ..... *P. pulchrum* (15)
18a. Oospore plerotic ..... *P. rostratum* (16)
18b. Oospore aplerotic ..... *P. proliferum* (14)

1. *Pythium afertile* KANOUSE & HUMPHREY in Papers Mich. Acad. 8: 129—140, 1927. — Pl.1, fig. 1

Principal hyphae slender, 3—11.2 µm thick at base and 3—3.7 µm at the tip; zoosporangia filamentous, simple or slightly branched, 41—250 µm long and 3—95 µm in diameter; vesicle spherical, sessile, 18—45 µm in diameter, mostly 30 µm; primary zoospores 8—25 in number, 7.5—11 µm in diameter; gemmae abundant, filamentous with bead-like structures, act as zoosporangia; sex organs not developed.

Isolated from Ram Tal water and soil.

This species was observed in India by KHULBE (1979).

2. *Pythium aphanidermatum* (EDSON) FITZPATRICK in Jour. Agri. Res. 4: 279—292, 1915. — Pl. 1, fig. 19, 20

Colony well developed on hempseed halves; hyphae non-septate, branched, 4—7 µm in diameter; sporangia inflated, filamentous, terminal and sometimes lateral in position, 25—210 µm in length and 8—19 µm in diameter; zoospores reniform, formed within the vesicle, encysted primary zoospores 10 µm in diameter; oogonia spherical, terminal, rarely intercalary, 21 to 28.5 µm in diameter; antheridia monoclinous and diclinous, one to two per oogonium; antheridial cells barrel shaped or dome shaped; oospore single, eccentric, aplerotic, 17—20.5 µm in diameter.

Isolated from soil of Khatima.

In India, this species was observed by SUBRAMANIAM (1919), MITRA (1927), RAMKRISHNA (1929), MAHMUD (1950), GATTANI & KAUL (1951), JAIN (1952), SHARMA & NEMA (1952), BHARGAVA & GUPTA (1957), SHARMA & ASTHANA (1958), RAO (1963), RAGHUNATHAN (1968), RAMKRISHNAN & al. (1973), MUTHUSAMY & al. (1974), DIWAKAR & PAYAK (1975). This species is very close to the description given by WATERHOUSE (1967) with the exception in having zoosporangia of smaller size.

3. *Pythium artotrogum* (MONT.) de BARY in Abh. Senckenb. Naturf. Ges. 12: 225—340, 1881. — Pl. 2, fig. 1, 2

= *P. hydnosporum* (MONT.) SCHRÖTER in ENGL. & PRANTL, Nat. Pfl. 1: 104—105, 1897.

= *P. artotrogum* var. *macranthum* SIDERIS, Mycologia 24: 14—61, 1932.

Mycelium showing aerial development; hyphae branched, 4—8 µm in diameter; conidia spherical to sub-spherical, 30—35 µm in diameter, mostly intercalary; oogonia spiny, terminal, 23—28 µm in diameter excluding the spines; antheridia unicellular, cylindrical to clubshaped, tapering, 10—23 µm in length by 5—12 µm in diameter, hypogynous; oospore echinulate or smooth walled, spherical, 18—23 µm in diameter without the spines.

Isolated from soil of Ganai.

In India, this species is observed by BLATTER (1911), BUTLER (1907) and SYDOW & BUTLER (1907).

4. *Pythium debaryanum* Hesse in Inaug. Diss., Halle, 14—34, 1874. — Pl. 2, fig. 5

Principal hyphae branched, non septate, 4—6 µm in diameter; sporangia terminal or intercalary, spherical to subspherical, 15—29 µm, mostly 22 µm in diameter; encysted primary zoospores 8—9 µm in diameter; oogonia terminal or intercalary, spherical, 16—27 µm in diameter, mostly 21 µm; antheridia monoclinous and diclinous, one to four per oogonium; oospore single, eccentric, aplerotic, 12—18 µm in diameter.

Isolated from rice roots and soil of Nanakmatta.

This species has been recorded in India by Butler (1913), Ramkrishnan (1941), Vasudeva (1948), Singh & Gupta (1951), Mahmud (1951), Bhargava & Gupta (1957) and Rao (1963). The isolate shows almost complete agreement with the description given by Rao (1963).

5. *Pythium dissotocum* Drechsler in Jour. Wash. Acad. 20: 398—418, 1930. — Pl. 1, fig. 2, 3

Hyphae slender, branched moderatly, 3—7.5 µm in diameter, predominantly 3.7 µm; primary zoosporangia abundant, filamentous as well as lobulated, 28—125 µm long and 3.7 µm in diameter; gemmae abundant, lobulated, act as sporangia; oogonia abundant, terminal on short lateral branches, spherical, smooth walled, 13—23 µm in diameter, predominantly 20 µm; antheridia androgynous and diclinous, mostly androgynous, 1—3 in number per oogonium; oospore single, smooth walled, spherical, eccentric, aplerotic or nearly so, 10—19 µm in diameter, mostly 16.5 µm.

Isolated from Ram Tal soil and diseased roots and seedlings of *Trigonella foenum-graecum* L. near Nal-Damayanti Tal.

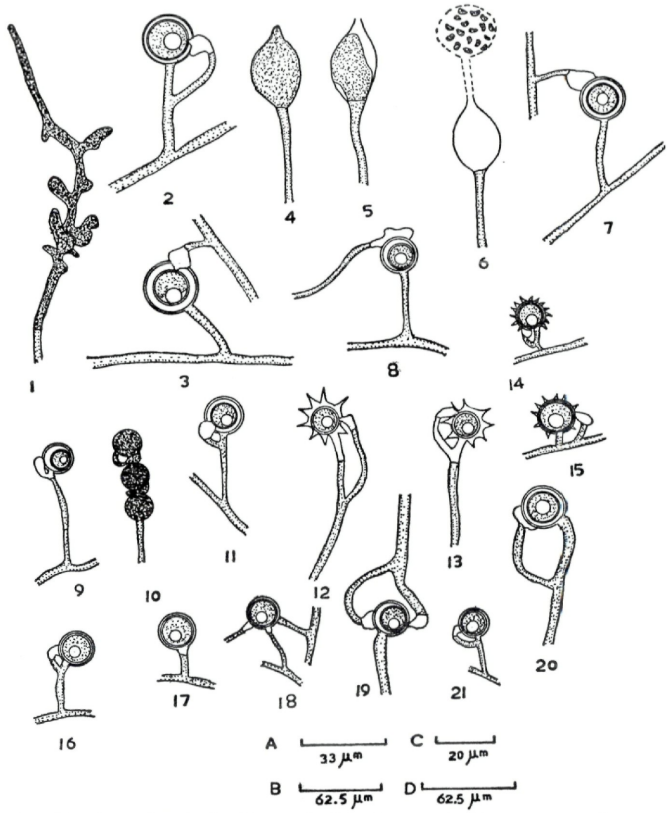
This species has been reported from India by Chowdhry & Agarwal (1981).

6. *Pythium echinulatum* Matthews in Univ. N. Carol. Press, 136 pp. 1931. — Pl. 1, fig. 12, 13

Hyphae long, slender, frequently branched, 3—11 µm in diameter, predominantly 3—3.7 µm; zoosporangia terminal or intercalary, mostly oval, spherical, rarely sub-spherical, 20—30 µm in diameter, germinate by 1—3 germ tubes; zoospores not observed; oogonia formed abundantly, terminal or on lateral branches or intercalary, spherical, oval or subspherical, predominantly spherical, 16—29 µm in diameter, mostly 18—29 µm exclusive of the spines; spines many, acute, 3.7—13 µm long, predominantly 7.5—11 µm; antheridia mostly androgynous, rarely diclinous and monoclinous, 1—3 per oogonia; oospores single, spherical, eccentric, aplerotic, 14—25 µm in diameter, predominantly 19 µm.

Isolated from Ram-Tal soil. The culture has been deposited in the herbarium CMI (IMI-255016), Kew, England.

This species has been reported from India by Prabhuji & Srivastava (1976) and Manoharachar'a & Rao (1978). This isolate differs from



Pl. 1: Fig. 1 (scale B): *Pythium afertile* Kanouse & Humphrey. — Gemmae. 2, 3 (scale A): *P. dissotocum* Drechsler. — 2. Mature oogonium with androgynous antheridium. — 3. Mature oogonium with diclinous antheridium.
4, 5 (scale B): *P. undulatum* Peterson. — 4. Young sporangia. — 5. Formation of secondary sporangium by internal proliferation.
6 (scale C): *P elongatum* Matthews. — Mature zooporangium with zoospores in the vesicle.
7 (scale C): *P. monospermum* Pringsheim. — Mature oogonium with diclinous antheridium.
8 (scale D): *P. gracile* Schenk. — Mature oogonium with diclinous antheridium.
9, 10 (scale B): *P. pulchrum* Minden. — 9. Mature oogonium with hypogynous antheridium. — 10. Catenulate oogonia.

the description given by PRABHUJI (1979) in having the preponderance of androgynous antheridial branches.

7. *Pythium elongatum* MATTHEWS in Studies on the genus *Pythium*. Univ. N. Carol. Press 106: 1931. — Pl. 1, fig. 6

Hyphae long, branched, 3—6 µm in diameter; sporangia terminal or intercalary, pyriform, cylindrical or spherical, 10—16 µm in diameter; zoospores produced in a vesicle with a long basal tube; encysted zoospores 5—10 µm in diameter; sex organs not developed.

Isolated from soil of Naina Peak, Nainital.

This species has been observed in India by MANOHARACHARY (1981) and KHULBE (1983).

8. *Pythium gracile* SCHENK in Verh. Phys. Med. Ges. Würzb. 9: 13—20, 1859. — Pl. 1, fig. 8

Hyphae slender, branched moderately, 3.5—7.5 µm in diameter; zoosporangia mostly terminal and rarely lateral, filamentous, mostly branched, 375—800 µm long and 7.5—18 µm in diameter; zoospores formed within a vesicle at the tip of the zoosporangium, 7.5—12 µm in diameter, 10—20 in number; gemmae abundant, branched, often deciduous, act as zoosporangia; oogonia lateral, abundant, formed intramatrically, spherical, 10.7—30 µm in diameter, predominantly 16—26.5 µm; oogonial wall smooth; antheridia strictly diclinous, one to two per oogonium; oospheres always maturing; oospore single, spherical and smooth walled, eccentric, aplerotic, 6.5—20.5 µm in diameter, predominantly 13—16.5 µm.

Isolated from Ram Tal water and gills of *Puntius ticto* L. from Naini Tal.

In India, this species was observed by SYDOW & BUTLER (1907). This species is being reported from the temperate region of India for the first time.

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11 (scale D): *P. ultimum* TROW. — Mature oogonium with androgynous antheridium.

12, 13 (scale D): *P. echinulatum* MATTHEWS. — 12. Mature oogonium with androgynous antheridium and aplerotic oospore. — 13. Mature oogonium with hypogynous antheridium.

14, 15 (scale D): *P. spinosum* SAWADA ap. SAWADA & CHEN. — 14. Mature oogonium with plerotic oospore and androgynous antheridium. — 15. Oogonium with monoclinous antheridium.

16 (scale D): *P. rostratum* BUTLER. Mature oogonium with androgynous antheridium and plerotic oospore.

17, 18 (scale D): *P. inflatum* MATTHEWS. — 17. Mature oogonium with plerotic oospore and hypogynous antheridium. — 18. Oogonium with diclinous antheridia.

19, 20 (scale D): *P. aphanidermatum* (EDS.) FITZ. — 19. Mature oogonium with diclinous antheridium. — 20. Oogonium with androgynous antheridium.

21 (scale D): *P. torulosum* COKER & PATTERSON. — Mature oogonium with plerotic oospore and androgynous antheridium.

9. *Pythium hypogynum* Middleton in Mem. Torrey bot. Club 20: 69, 1943. — Pl. 2, fig. 3

Hyphae long, non-septate, branched with luxuriant growth on hempseed, 2—8.5 µm in diameter, mostly 5 µm; sporangia terminal, spherical to oval, thin-walled, 8.5—37.5 µm in diameter, mostly 22—30 µm; zoospore reniform, encysted zoospores 9—12 µm in diameter; oogonia terminal on short lateral branches, spherical to sub-spherical, smooth walled, 12.5—33 µm in diameter, mostly 22.5 µm; antheridia single, hypogynous, antheridial cells small, 3—8,5 µm wide; oospore single, spherical, eccentric, plerotic, 11—32 µm in diameter, mostly 21 µm.

Isolated from the diseased roots of *Triticum aestivum* L. and soil of Khatima. The culture has been deposited in the herbarium CMI (IMI-277403), Kew, England. This isolate shows almost complete agreement with the description given by Middleton (1943).

10. *Pythium inflatum* Matthews in Univ. N. Carol. Press. 45: 136, 1931. — Pl. 1, fig. 17, 18

Mycelium well developed on Schmitthenner's agar; sporangia inflated or toruloid, complex structure, 8—21 µm in diameter; zoospores not observed in culture; sex organs produced in Schmitthenner's agar but not developed in water culture; oogonia terminal or intercalary, spherical, 18—24 µm in diameter; antheridia rarely formed, 1—2 per oogonium when present, diclinous; oospore single, spherical, eccentric, plerotic, 14—22 µm in diameter.

Isolated from diseased roots of tomato and soil of Khatima and Nagartarai.

This species is very close to the description given by Robertson (1980).

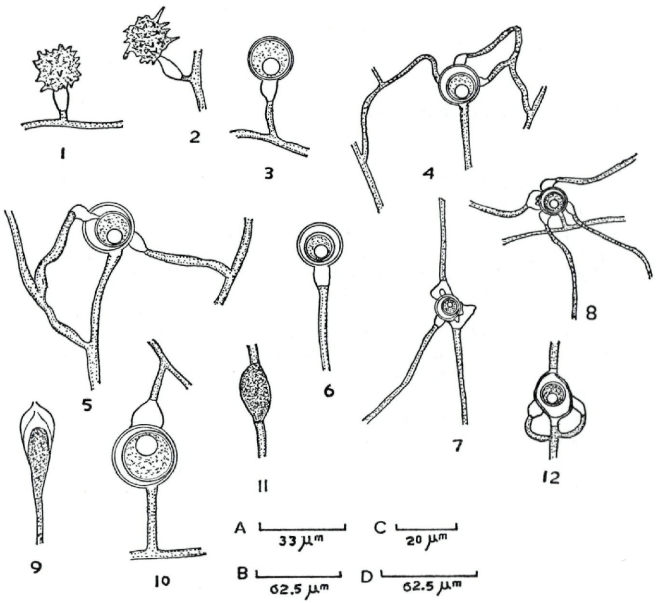
11. *Pythium middletonii* Sparrow in Aquatic Phycomycetes (Univ. of Michigan Press), p. 1187, 1960. — Pl. 2, fig. 4

Hyphae slender, frequently branched, 2.5—9.5 µm in diameter, predominantly 3.3—5 µm; zoosporangia abundant, papillated, terminal on lateral branches, spherical subspherical or sometimes ellipsoidal, 19—40 µm in diameter, predominantly 25—36 µm, renewed by internal proliferation; encysted primary zoospores 8—11 µm in diameter; chlamydospores are of same shape and size like that of sporangia, act as sporangia; oogonia formed abundantly, in some isolates it is delayed, spherical 13.5—32 µm in diameter, predominantly 18.5—25 µm; antheridia androgynous, diclinous and hypogynous, predominantly diclinous, 1—3 per oogonium; oospores 1—2, mostly one, eccentric, aplerotic, 9.5—22 µm in diameter.

Isolated from Ram Tal water and soil.

The first report of this species from India was by Rajgopalan & Ramkrishnan 1967—68). Recently, Manoharachary & Rao (1978) reported this species from pond waters and soil of Vikarabad (Hyderabad). But it is being reported from the temparate region of Kumaon for the first time. During the present study of Pythiaceous fungi, this

species was found dominant in all the collections. The present isolate differs from the description given by RAJGOPALAN & RAMKRISHNAN (1967—68) in having mostly androgynous and hypogynous antheridia in addition to diclinous antheridia and also in the size slightly larger as oogonia.



Pl. 2: Fig. 1, 2 (scale D): *Pythium artotrogus* (MONT.) de BARY. — Oogonia with hypogynous antheridia.

3 (scale D): *P. hypogynum* MIDDLETON. — Mature oogonium with plerotic oospore and hypogynous antheridium.

4 (scale B): *P. middletonii* SPARROW. — Mature oogonium with aplerotic oospore and diclinous antheridia.

5 (scale D): *P. debaryanum* HESSE. — Mature oogonium with aplerotic oospore and androgynous and diclinous antheridia.

6 (scale A) and 7, 8 (scale B): *P. vexans* var. *minutum* MER & KHULBE. — 6. Mature oogonium with hypogynous antheridiam. — 7. Oogonium with hypogynous and diclinous antheridia. — 8. Oogonium with diclinous antheridia.

9, 10 (scale C): *P. proliferum* de BARY. — 9. Sporangium showing internal proliferation. — 10. Oogonium with diclinous antheridium.

11, 12 (scale D): *P. paroecandrum* DRECHSLER. — 11. Intercalary sporangium. — 12. Intercalary oogonium with androgynous antheridia.

12. *Pythium monospermum* Pringsheim in Jahrb. Win. Bot. 1: 284—306, 1868. — Pl. 1, fig. 7

Hyphae long, slender, frequently branched, 2.5—5 μm in diameter; sporangia terminal or lateral, filamentous, branched or unbranched, 25—121 μm long by 2.5—5.5 μm in diameter, wavy in outline; zoospores 4—30, reniform, encysted primary zoospores 9—11.5 μm in diameter, predominantly 11 μm; oogonia terminal, sometimes intercalary, spherical, 13.2—26.4 μm in diameter, mostly 23 μm; oogonial wall smooth, thin; antheridial branches diclinous, sometimes monoclinous, 1—2 per oogonium, clavate; oospore plerotic, single, occasionally two, eccentric, spherical, 11—16.5 μm in diameter, predominantly 13 μm.

Isolated on apple and tomato fruits and hempseed from Khurpatal water.

13. *Pythium paroecandrum* Drechsler in J. Wash. Acad. Sci. 20: 407—407, 1930. — Pl. 2, fig. 11, 12

Colony well developed on hempseed; hyphae measuring 3—8 μm in diameter; sporangia spherical to ellipsoidal, typically intercalary, occasionally terminal on short to long branches, spherical sporangia 15—30 μm in diameter, mostly 23 μm, ellipsoidal sporangia 18—36 μm long and 14—24 μm in diameter; zoospores reniform, encysted, primary zoospores 9—11 μm in diameter; oogonia usually intercalary, smooth, sub-spherical, 11—28 μm in diameter, mostly 22 μm; antheridia 1—3 per oogonium, androgynous or diclinous; oospore single, aplerotic, smooth walled, spherical 10—22 μm in diameter, mostly 18 μm.

Isolated from diseased roots of cabbage and cauliflower and soil of Nagaratarai.

In India this species has been reported by Balkrishnan (1948) and Rao (1963).

14. *Pythium proliferum* de Bary in Jahr. Wiss. Bot. 2: 169—192, 1860. — Pl. 2, fig. 9, 10

Hyphae slender, branched, 2.5—4.5 μm in diameter; sporangia terminal, spherical or ovoid, papillate, 25—55 μm in diameter, renewed internally and laterally; vesicle sessile, some with short stalk; zoospores reniform; encysted zoospores 8—11.5 μm in diameter; oogonia terminal or lateral, sometimes intercalary, spherical, 15.5—35 μm in diameter; oogonial wall smooth, thin; antheridia usually monoclinous, rarely diclinous, 1—3 per oogonium, clavate, tuberous; oospore single, aplerotic, 13—21 μm in diameter, predominantly 19.6 μm, eccentric.

Isolated on apple fruit and hempseed from Bhimtal and Naukuchiatal lakes.

15. *Pythium pulchrum* Minden in Mykol. Unters. Ber. 1: 227—228, 1923. — Pl. 1, fig. 9, 10

Main hyphae long, branched, 4.5—7 μm in diameter; zoosporangia spherical to sub-spherical, terminal or intercalary, 20—33 μm in diameter, predominantly 24 μm; zoospores reniform, encysted zoospores 9—11 μm in diameter; oogonia spherical to sub-spherical, terminal or intercalary,

single or catenulate, 1—4 in chains, 18—25 µm in diameter, mostly 22 µm; antheridia mostly hypogynous, barrel shaped; oospores spherical, 1—2 µm in number, mostly single, eccentric, aplerotic, 12.5—18 µm in diameter, predominantly 15 µm.

Isolated from infected seedlings of *Hibiscus esculentus* L. near Nal Damayanti Tal, Naini Tal.

This species had mostly hypogynous antheridial branches which are similar to the description given by MIDDLETON (1943), who reported that some strains of this species produce only hypogynous antheridia. JOHNSON (1971) also found variation in the origin of antheridial branches in this species. This species is a new record for Indian aquatic fungi.

16. *Pythium rostratum* BUTLER in Mem. Dep. Agric. India Bot. Ser. 1 (5): 84—85, 1907. — Pl. 1, fig. 16

Hyphae non septate, branched, 6—8 µm in diameter; colony well developed on hempseeds; sporangia terminal or intercalary, spherical to oval, 22 to 32.5 µm in diameter, mostly 24 µm; zoospores produced within the vesicle, reniform; encysted zoospores 7—9 µm in diameter; oogonia typically intercalary or lateral, 15—24 µm, mostly 21 µm in diameter, smooth walled; antheridia generally one per oogonium, monoclinous, often hypogynous; oospore single, eccentric, plerotic, 14—23 µm in diameter.

Isolated from roots of wheat, rice, cabbage, cauliflower, tomato and soil of Khatima. The culture has been deposited in the herbarium CMI (IMI-277406), Kew England.

This isolate shows complete agreement with the description given by MIDDLETON (1943) and ROBERTSON (1980).

17. *Pythium spinosum* SAWADA ap. SAWADA & CHEN in Trans. Nat. Hist. Soc. Formosa 16: 199—200, 1926. — Pl. 1, fig. 14, 15

Hyphae branched, 3—5 µm in diameter; sporangia abundant, spherical to sub-spherical, 12—27 µm in diameter, mostly 22 µm in diameter, germinating by germ tubes; oogonia spherical to sub-spherical, generally terminal, occasionally intercalary, 13—25 µm in diameter, mostly 19 µm; oogonial wall echinulate, spines straight or curved, 4—8 µm in length; antheridia 1—2 per oogonium, monoclinous, sometimes diclinous; oospore single, plerotic, 12—23 µm in diameter, mostly 17.5 µm.

Isolated from rice field soil of Khatima. The culture has been deposited in the herbarium CMI (IMI 277405) Kew, England.

This species was recorded in India by RAMKRISHNAN (1955), RAO (1963), RAGHUNATHAN (1968) and MANOHARACHARY (1973). The characters of this isolate correspond well with the description given by MIDDLETON (1943).

18. *Pythium torulosum* COKER & PATTERSON in J. Elisha Mitchell Sci. Soc. 42: 247—50, 1927. — Pl. 1, fig. 21

Colony well developed on hempseeds, measuring up to 2.5 µm in diameter within 10 days under laboratory conditions; hyphae 2.5—4 µm in

diameter; sporangia abundant, terminal, tubular complex up to 52 µm in length and 12 µm in diameter; zoospores readily produced in water culture; oogonia mostly terminal rarely intercalary, 12—24 µm in diameter, mostly 18 µm; oogonial wall smooth; antheridia single, androgynous; oospore single, spherical, smooth-walled, eccentric, plerotic, 10—12 µm in diameter.

Isolated from wheat roots and soil of Khatima and Nanakmatta.

The culture is very close to the description given by MIDDLETON (1943).

19. *Pythium ultimum* TROW in Ann. Bot. 15: 300—301, 1901. — Pl. 1, fig. 11

Hyphae branched, 3—6.5 µm in diameter; sporangia chiefly terminal and spherical, 14—28 µm in diameter, mostly 21 µm; zoospores not observed; oogonia typically terminal, spherical, 19—26 µm in diameter, mostly 21 µm in diameter; oogonial wall smooth; antheridia single, rarely two per oogonium, typically sessile; oospore single, spherical, smooth-walled, eccentric, aplerotic, 15—22 µm in diameter, mostly 18 µm.

Isolated from wheat roots and soil of Nanakmatta.

In India this species has been reported by BHARGAVA & SINGH (1965) and CHOWDHRY & AGARWAL (1981).

20. *Pythium undulatum* PETERSON in Bot. Tidskr. 29: 394, 1909. — Pl. 1, fig. 4, 5

(Reprinted with English text in Ann. Mycol. 8: 531, 1910).

Hyphae undulating, long, measuring 3—6 µm in diameter; sporangia ellipsoidal, acrogenous, often with a small apical papilla, 80—150 µm long and 35—60 µm in diameter; zoospore readily produced in water cultures, encysted zoospores 9—12 µm in diameter; sex organs not developed.

Isolated from rice roots and soil of Khatima and Nanakmatta.

In India, this species has been observed by DAYAL & TANDON (1962), SRIVASTAVA (1964) and KHULBE (1979).

21. *Pythium vexans* de BARY var. *minutum* MER & KHULBE in Current Science 52 (15): 735—736, 1983. — Pl. 2, fig. 6, 8

Hyphae slender, frequently branched, 2—9 µm in diameter; zoosporangia formed abundantly, terminal or intercalary, spherical, pyriform, ovoid or sub-spherical, 12.5—25 µm in diameter, predominantly 16—18 µm, germinated by 1—2 germ tubes; zoospores not observed; chlamydospores are of same size and shape like sporangia when present, germinate by germ tubes; oogonia abundant, terminal on short lateral branches, occasionally intercalary, spherical, smooth walled, 13—31 µm in diameter, predominantly 15—18 µm; antheridia mostly hypogynous, but androgynous and diclinous antheridial branches are also not uncommon, bell-shaped; oospore single, smooth-walled, spherical, eccentric, mostly aplerotic, rarely plerotic, 10—16 µm in diameter, mostly 11 µm.

Isolated from Ram Tal soil. The culture has been deposited in the herbarium CMI (IMI No. 255017), Kew, England.

The first report of this variety was by MER and KHULBE (1983).

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