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OCCURRENCE OF TWO MATING GROUPS IN *PHYTOPHTHORA MEADII* CAUSING ABNORMAL LEAF FALL DISEASE OF RUBBER IN SOUTH INDIA

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Heterothallism has been demonstrated in Indian isolates of *Phytophthora meadii* from rubber. Thirty-two isolates were mating type A_1, 24 were A_2, 2 were homothallic and 4 sterile.

Abnormal leaf fall caused by *Phytophthora* spp. is a very serious disease of rubber in India, and four taxa are reported as causing the disease. In South India the pathogen was identified as *Phytophthora meadii* by McRae (1919). Later, Petch suggested that two species of *Phytophthora*, *P. faberi* (synonymous with *P. palmivora*) and *P. meadii*, were involved (Petch, 1921), and he was of the opinion that the damage caused by *P. meadii* was greater than that caused by *P. faberi*. Studies carried out the Rubber Research Institute of India also showed that both *P. palmivora* and *P. meadii* play an important role in causing the disease (Ramakrishnan & Radhakrishna Pillai, 1961; Thankamma, George & George, 1968). Subsequently *Phytophthora nicotianae* var. *parasitica* and *P. botryosa* were reported on rubber in India (Thomson & George, 1976, 1980). Present studies indicate that *P. meadii* is the dominant species mainly responsible for abnormal leaf fall in South India.

Of the four taxa mentioned, *P. palmivora*, *P. botryosa* and *P. nicotianae* var. *parasitica* are heterothallic (Ashby, 1922; Gadd, 1924; Turner, 1960; Zentmyer *et al.*, 1973; Suzuii, Kueprakone & Kamhangrid-Thirong, 1978; Shepherd, 1979) while *P. meadii* is considered to be homothallic (Waterhouse, 1974). The frequent failure to obtain oospores in single sporangial cultures of many isolates of *P. meadii* led to the present study of their mating behaviour.

Phytophthora isolates for the study were made from petiole lesions of rubber leaves infected by abnormal leaf fall disease. Sixty-two isolates were used: 50 'regional' isolates, numbered R1 to R50, made from various parts of South India, and 12 'local' isolates, numbered L1 to L12, collected from different parts of the experimental station of the Rubber Research Institute of India. Single sporangial cultures of the above isolates were made and maintained on potato dextrose agar slants. 'Isolate 4' and 'isolate 7' from the Institute's culture collection produced oospores in abundance when inter-crossed; they were used as the standards for the study. Isolate 4 was sent to CMI, England, and identified as *P. meadii* (A_2 mating group, IMI 269757). Isolate 7 belonged to the A_1 group. All the 62 *Phytophthora* isolates included in the study were mated with both isolates 4 and 7 and examined for their mating behaviour. The pairing studies were made in Petri dishes of carrot extract agar medium. Each isolate was first inoculated singly on the medium and examined for oospore production. If oospores were not formed in single cultures after 10 days, the isolate was studied in paired culture. Inocula of the isolate under test and

Table 1. *Mating behaviour and oospore diameter of 'regional' isolates of* P. meadii

Isolate	Mating group	Oospore diam (μm) Average	Range
R1	A_1	34·48	24·0–50·0
R2	A_1	35·50	22·0–50·0
R3	A_1	34·16	22·0–48·0
R4	A_1	38·58	30·0–50·0
R5	A_2	39·22	26·0–50·0
R6	A_1	34·56	28·0–44·0
R7	A_2	32·96	22·0–44·0
R8	A_2	33·22	26·0–44·0
R9	A_1	38·86	26·0–50·0
R10	A_2	36·00	26·0–42·0
R11	A_1	32·50	26·0–40·0
R12	A_1	44·70	34·0–62·0
R13	A_1	34·22	26·0–40·0
R14	A_2	33·06	26·0–40·0
R15	A_2	35·20	28·0–40·0
R16	A_1	36·74	28·0–44·0
R17	A_1	34·64	28·0–40·0
R18	A_1	31·72	28·0–38·0
R19	A_1	36·82	28·0–52·0
R20	A_1	37·06	26·0–46·0
R21	A_1	40·88	30·0–60·0
R22	A_1	32·66	24·0–42·0
R23	A_1	37·12	28·0–64·0
R24	A_1	36·54	26·0–46·0
R25	A_2	34·84	28·0–44·0
R26	A_1	28·74	24·0–36·0
R27	A_2	36·44	28·0–46·0
R28	A_1	30·52	24·0–46·0
R29	A_2	37·24	30·0–50·0
R30	A_1	41·50	28·0–44·0
R31	A_1	36·92	28·0–44·0
*R32		36·22	22·0–44·0
*R33		35·14	30·0–40·0
R34	A_2	34·46	24·0–40·0
R35	A_1	34·00	28·0–40·0
R36	A_2	33·78	26·0–42·0
R37	A_2	35·90	24·0–48·0
R38	A_1	33·70	24·0–44·0
R39	A_1	39·90	30·0–44·0
R40	A_1	33·64	26·0–42·0
R41	A_1	32·62	26·0–42·0
†R42			
†R43			
R44	A_2	39·94	30·0–52·0
†R45			
‡R46	A_1		
R47	A_1	32·36	26·0–44·0
‡R48	A_1		
‡R49	A_1		
‡R50	A_2		

Fifty oospores of each isolate were measured. The pooled variance within isolates is 25·31.
* Oospores formed in single culture. † Oospores not formed. ‡ Oospore measurement not recorded.

of isolate 4 or isolate 7 were placed 3 cm apart on the medium. The culture plates, where dual inoculations were made, were examined on the sixth day after inoculation for their mating behaviour and oospore production. Based on oospore formation with either isolate 4 or isolate 7, the cultures were classified into A_1 or A_2 mating groups. Mating behaviour of the isolates of each group was also studied by selecting sets of two isolates from each group at random and crossing them. Ten sets of such matings were done from each group. Wherever oospore formation was not noticed the plates were examined again after ten days to confirm the absence of oospores. The size of the oospores was also recorded by measuring the diameter using a Visopan Lanameter. Oospore measurements were not recorded in the case of 4 regional isolates and 12 local isolates.

The mating behaviour of the isolates was quite characteristic. Isolates which formed oospores when mated with isolate 4 did not form oospores when mated with isolate 7 and vice versa. In the case of complementary strains there was an attraction between the isolates. When isolates belonging to the same mating type were paired there was repulsion between the isolates as they grew and approached each other. Of the 50 regional isolates studied, 31 formed oospores with isolate 4 and belonged to A_1 mating group, and 14 formed oospores with isolate 7 and belonged to the A_2 mating group. Two isolates were homothallic, producing oospores in single culture, and 3 isolates did not form oospores either in single culture or when mated with any of the standard types (Table 1). Among the 12 'local' isolates, 10 were A_2 and one (L 11) A_1. One isolate (L 8) did not form oospores either in single culture or on pairing with the standard isolates. Isolates belonging to the same group did not form oospores among themselves.

Heterothallism in *Phytophthora* isolates from rubber was first observed by Gadd (1924) (cf. Zentmyer *et al.*, 1973). Two compatibility groups were distinguished among isolates of *P. palmivora* in Sri Lanka (Sachuthananthavale, 1963) but these isolates were later reported to include cultures of *P. meadii* (Peries & Dantanarayana, 1965). Sexual compatibility studies have been carried out in India between *P. meadii* and *P. palmivora* (Thankamma & Radhakrishna Pillai, 1970). In the present study it has been observed that *P. meadii* includes isolates which are homothallic as well as heterothallic, the latter being more common. Among the 'regional' isolates A_1 mating group was observed to be predominant, while among the 'local' isolates A_2 was predominant. The presence of two mating groups in *P. meadii* in South India and their presence in the same locality provide ample chances for hybridization in nature and formation of new strains. This possibility is further supported by observations on oospore formation in nature on infected plant parts of the rubber tree and their germination (George & Thomson, 1975). Even interspecific hybridization and germination of oospores thus formed have been noticed among *Phytophthora* isolates affecting rubber (Thankamma, 1969; Thankamma & Radhakrishna Pillai, 1970). The variation in the size of oospores formed in matings of different combinations (Table 1) also suggests that the mating groups play a role in the variation observed within the species of *Phytophthora*.

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OBSERVATIONS ON MARINE FUNGI IN SINGAPORE AND PENANG (MALAYSIA)

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Five marine higher fungi, *Aniptodera chesapeakensis*, *Clavariopsis bulbosa*, *Corollospora intermedia*, *Lignicola longirostris* and *Nia vibrissa* are reported from Singapore and Penang (Malaysia).

The mycogeographical distribution of marine fungi may be categorized into five littoral zones, namely arctic, temperate, subtropical, tropical and antarctic (Hughes, 1974). Data on geographical distribution, however, are scarce and incomplete, with most collections having been centred in Europe and North America (Kohlmeyer, 1983). Comparatively little information on the occurrence of marine fungi in the tropics is available and much less so around Singapore, an island situated 1° 20′ north of the Equator between the Indian Ocean and the South China Sea.

In May 1984, intertidal sand samples were collected from the East Coast Park and Changi in Singapore and baited in the laboratory with pieces of sterilized balsa wood, feather and cotton cloth. Washed-up beach debris was also collected for incubation (Kohlmeyer & Kohlmeyer, 1979). Intertidal sand samples were also collected from Batu Ferringhi beach in Penang (about 774 km north of Singapore) and brought back to Singapore for baiting. Observations of the baits and incubated debris showed the presence of five species of marine fungi.

Aniptodera chesapeakensis Shearer & Miller. From Singapore (Changi), on twigs collected from a mangrove swamp. The immersed greyish brown perithecia were detected by the white, tiny 'ribbons' of ascospores oozing from the ostioles. In the tropics, this fungus has been reported from Central America (Belize) and from Sri Lanka in the Indian Ocean (Kohlmeyer, 1984).

Clavariopsis bulbosa Anastasiou. Observed on incubated washed-up unidentified leaves on Singapore beach (East Coast Park). The teleomorph, *Corollospora pulchella*, has been observed in India (Kohlmeyer & Kohlmeyer, 1979) and Sri Lanka (Koch, 1982) in the Indian Ocean, the Philippines (Gacutan & Uyenco, 1983) and Hong Kong (Vrijmoed, Hodgekiss & Thrower, 1982) in the South China Sea, and in Thailand (Kohlmeyer, 1984).

Corollospora intermedia I. Schmidt. From Singapore (Changi) and Penang. The black ascocarps were abundantly formed on wood and cotton baits, on sand grains and incubated washed-up 'raffia' cords. Kohlmeyer & Kohlmeyer (1979) gave the Atlantic Ocean and the Baltic Sea as the distribution range of this species. Not much is known of its occurrence in this part of the tropics.

Lignicola longirostris (Cribb & Cribb) Kohlm. The brown long-necked ascocarps were abundant on incubated washed-up twigs collected from Singapore (Changi). This species has not been