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STUDIES ON SOME WATER MOULDS OCCURRING IN CERTAIN SOILS OF GORAKHPUR (INDIA)[1],[2]

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ABSTRACT

Quadrat technique has been employed to determine the distribution of lower fungi in the soils of four different sites of Gorakhpur. Twenty-nine species, collected during the study belonging to Blastocladiales, Saprolegniales and Peronosporales, were grouped into constant species, low temperature species, moderate temperature species and high temperature species. A distinct seasonal variation in occurrence of these species has been noted although individual periodicity is variable. Two peaks of occurrence one during December-January and another in July-August, were recorded. The temperature was found to govern the periodicity not the season. Seasonal fluctuations have been shown to be independent of the relative frequencies of species isolated. Non-saprolegniaceous forms have higher degree of tolerance for dryness and high temperature than the members of Saprolegniaceae. Almost all the species of Saprolegniaceae isolated possessed eccentric oospores. At a particular site aquatic fungal flora was found to be constant.

INTRODUCTION

Harvey (1925) was the first to make a study of the water-moulds occurring in the soil. Dick and Newby (1961) employed a quadrat technique for monthly sampling of permanently marked soil areas for the presence of the members of Saprolegniaceae and demonstrated their occurrence in a number of different types of soils. Further they found that there is a seasonal fluctuation in the recorded frequency of these fungi, with maxima in spring and autumn; and that the fluctuations are independent of the relative frequencies of species isolated from any given quadrat and of the identity of the species recorded.

Corresponding with the findings of Forbes (1935) and Waterhouse (1942), Srivastava (1967) recorded the maximum abundance of water-moulds in winter. He does not agree with the observations of Perrott (1960), Dick and Newby (1961) and Roberts (1963) who have found two periods of maximum occurrence-one in autumn and the other in spring. Khulbe and Bhargava (1977) have also given two maxima-for temperate lakes during summer and autumn and for subtropical lakes during spring and autumn. But they have indicated

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that periodicity is governed by the temperature and not by the seasons.

Indian work regarding the ecology of water-moulds is very meagre. It includes those of Dayal and Tandon (1963), Srivastava (1967) and Khulbe and Bhargava (1977).

In the proposed investigations studies have been undertaken to determine if the water-moulds form part of of the fungal flora of the soil. Ecological studies about the phenology (seasonal occurrence) have been made.

GENERAL ECOLOGY OF THE SITES AND METHODS

The district of Gorakhpur is situated in the north-east "tarai" region of Uttar Pradesh (India) and lies between 26°45'N lat. and 83°22'E long. having an altitude of 102 meters above sea level. It is remarkable for its large perennial lakes and ponds that support luxuriant growth of aquatic fungal flora (Srivastava, 1967).

During the course of present investigation it could not be possible to differentiate between the different phases of the fungi, for example, resting spores, zoospores, gemmae or vegetative mycelia which separately or collectively provided inocula in isolation methods.

The following four different sites (Fig. 1) were selected for detailed study by monthly sampling—

(*a*) Environs of Jalwania Pond, North-east of National Highway, Gorakhpur (Series (JQ).

(*b*) Environs of Ramgarh Lake, South of Kasia Road, Gorakhpur (Series RQ).

(*c*) Environs of Asuran-ka-pokhra Pond, North of Gorakhpur city (Series AQ).

(*d*) Soils of St. Andrew's College campus, Gorakhpur (Series SQ).

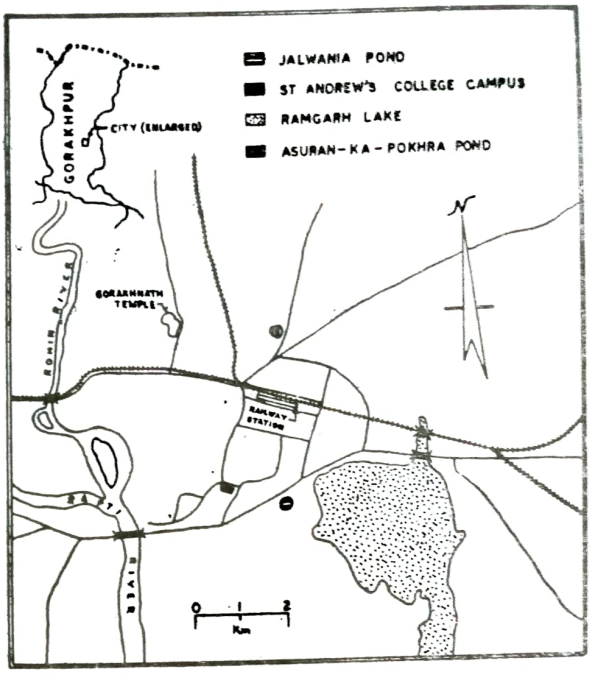

Fig. 1. Map of Gorakhpur showing the sampling sites.

A relatively flat area was chosen on each selected site. The quadrat sampling technique (Dick and Newby, 1961) has been employed during the present study. Quadrat of one meter square was permanently marked with stakes. At the time of sampling the quadrat area was sub-divided with the help of a string-grid into sixteen sub-divisions each site of which measured 25 cm. Five samples were taken out from each sub-division.

Sampling from all the sites (Series RQ, JQ, SQ and AQ) were done throughout the year at monthly intervals and the data presented here are based on the above collections. Each month the RQ, JQ, SQ and AQ series were sampled in the 1st., 2nd., 3rd. and 4th week respectively.

Frequency and duration of Sampling:

Out of the four sites the soils of the environs of Asuran-ka-pokhra Pond

and of St. Andrew's College campus present wettest and the driest types restively. At St. Andrew's College campus three quadrats (SQ1, SQ2, and SQ3) were sampled in view of the fact that the conditions were approximately constant throughout. Six quadrats each were taken at the remaining three sites (JQ1 to JQ6, RQ1, to RQ6 and AQ1 to AQ6). Two quadrats sampled near the bank of Jalwania Pond (JQ5 and JQ6) and three quadrats at Ramgarh Lake (RQ1, RQ2 and RQ5) became inundated during the months of July and August and therefore the sampling was discontinued at these quadrats. All the six quadrats situated at Asuran-ka-pokhra Pond were sampled throughout the year.

Method of Recording Isolates:

From each sub-division of the quadrat, soil samples were taken out at fixed points and the record of every point was kept separately. The terms 'Species Totals' and 'Quadrat Totals', following Dick and Newby (1961), have been used to denote 'the sum of records for species for given quadrat area' and 'the sum of the counts for all species recorded from a given quadrat area' respectively.

Collection and Treatment of Soil Samples:

Soil sampling was done with the help of a cork borer (20 mm in diameter) up to a depth of 4-5 cm. The core of soil was removed and placed in a sterile 100 ml flask. Before each sampling the borer was washed in absolute ethyl alcohol. The vegetational cover of the soil was removed, leaving the litter layers, prior to sampling. The method of treatment of soil samples was similar to Harvey (1926) and Dick and Newby (1961).

Identification :

Each bait showing mycelial growth contained more than one fungus. Therefore, unifungal, bacteria-free cultures were obtained by usual methods. The isolates were identified with the help of the keys provided by Coker (1923), Middleton (1943), Johnson (1956), Sparrow (1960) and Scott (1961). The specific identity of three isolates could not be determined and they have been, therefore, referred to as *Achlya* sp., *Brevilegnia* sp. and *Leptolegnia* sp.

In addition to sampling and maintenance of the cultures, the temperature of the soil (at 5 cm of depth) was also noted at the time of sampling.

RESULTS AND DISCUSSION

Data from Figs. 2-5 indicates a clear high or low degree of fluctuation in quadrat totals from month to month for a given area. Tests of significance have shown such fluctuations to be significant at 5% level of probability.

Out of twenty-nine species recorded, *Aphanomyces laevis* (most common member of Saprolegniaceae) and *Pythium aphanidermatum* (most common non-saprolegniaceous form) indicate presence in all the quadrats irrespective of their phenology.

An examination of Table I indicates that in Series JQ one or the other fungus was recorded every month. Although the saprolegniaceous and non-saprolegniaceous forms occurred throughout the year, considerable variationxin the species totals was apparent. The graphic representation of the data (Figs. 2-5) shows a parallel variaton in the number of species with the fluctuation of the quadrat totals. Moreover, these fluctuations in species totals, in relation to the number of species, are approximately

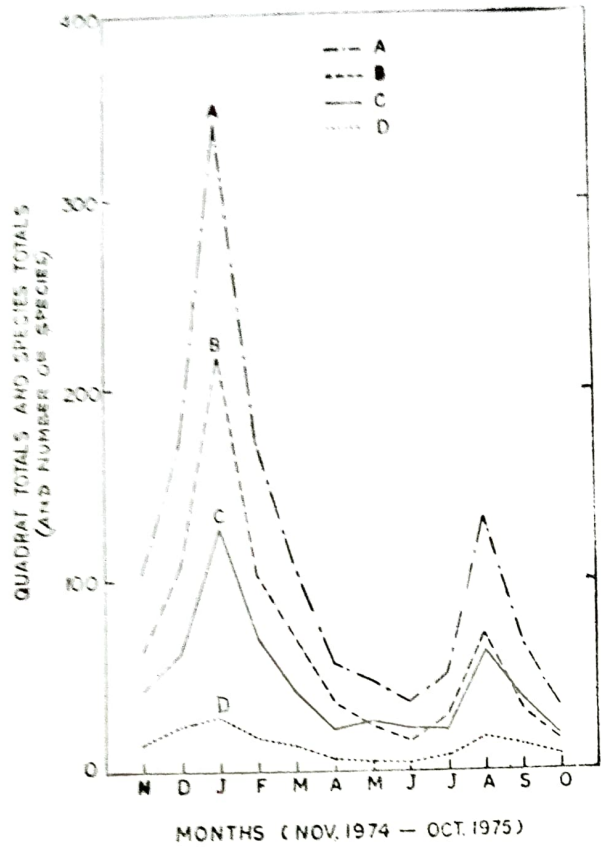

Fig. 2. Graphic representation of data from JQ series. A=Quadrat totals. B=Species totals for saprolegniaceous forms. C=Species totals for non-saprolegniaceous forms. D=Number of species.

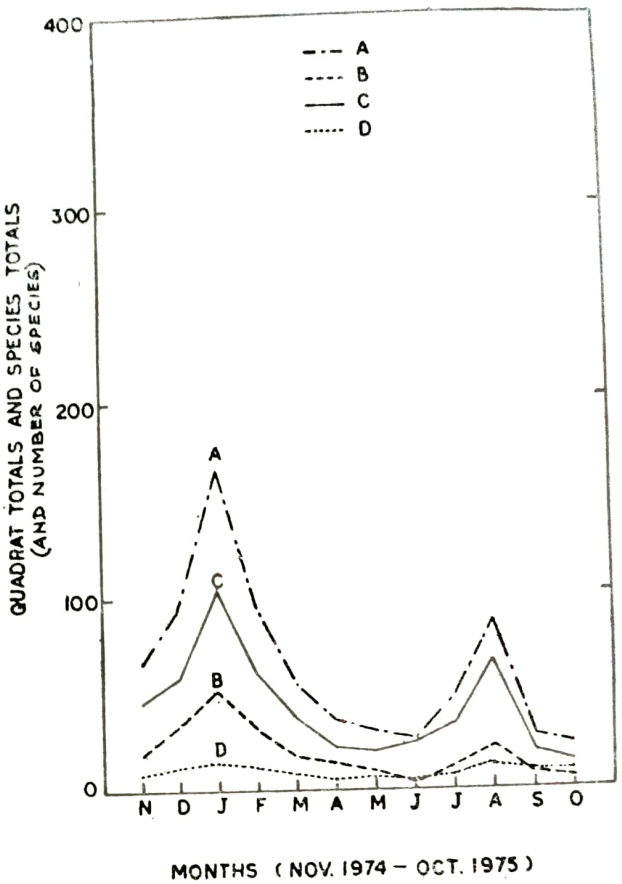

Fig. 3. Graphic representation of data from SQ series. A=Quadrat totals. B=Species totals for saprolegniaceous forms. C=Species totals for non-saprolegniaceous forms. D=Number of species.

parallel irrespective of the forms either saprolegniaceous or non-saprolegniaceous.

The data from different quadrats exhibit, in general, a common trend in fluctuation of the quadrat totals. There are "peaks" during December-January (soil temperature 19-22°C) and July-August (soil temperature 26-28°C); and there is "trough" during the period of May-June (soil temperature 32-35°C). However, the peak is more pronounced during December and January. Due to suitable temperature, the winter period provides the best time for the growth of water-moulds. In the summer season situation is contrary to the winter, i.e. high temperature and less moisture which are unsuitable for the survival of the propagules of aquatic fungi. The seasonal occurrence of the members of Saprolegniaceae has been presented in the form of an Ecological Clock in Fig. 8.

It is further indicated that the members of Saprolegniaceae and non-saprolegniaceous forms exhibit variable occurrence in the soils of different sites. In series JQ and RQ the species totals for saprolegniaceous forms are higher than non-saprolegniaceous froms except in June when they are either

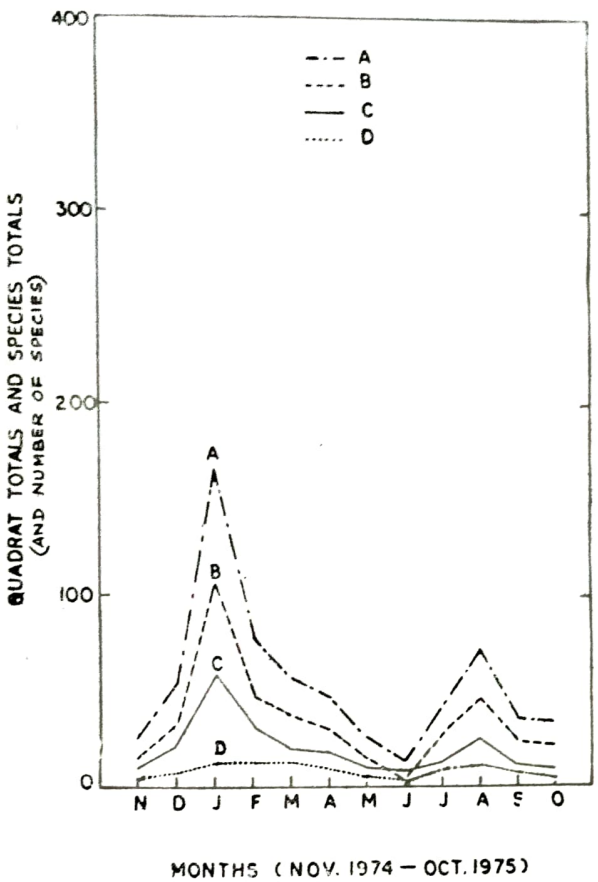

Fig. 4. Graphic representation of data from RQ series. A=Quadrat totals. B=Species totals for saprolegniaceous forms. C= Species totals for non-saprolegniaceous forms. D=Number of species.

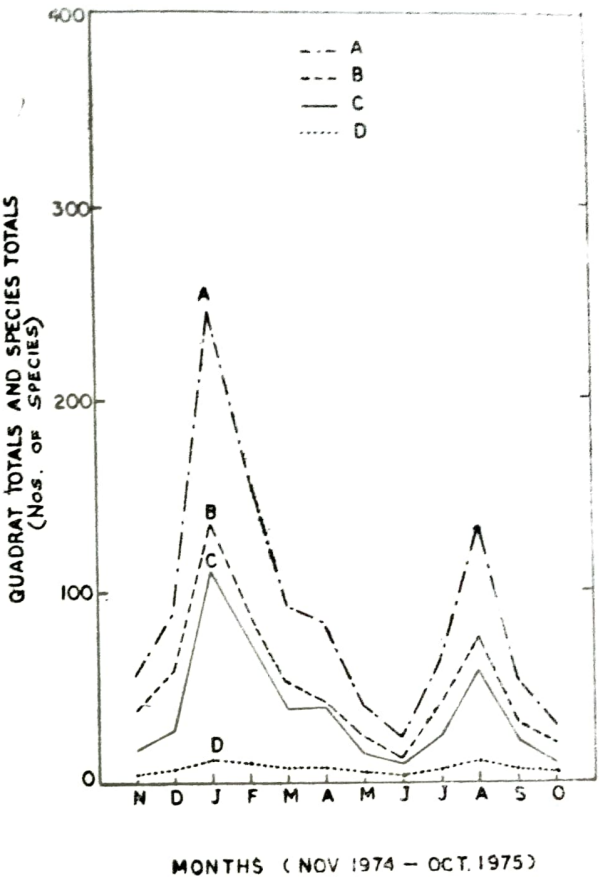

Fig. 5. Graphic representation of data from AQ series. A=Quadrat totals. B=Species totals for saprolegniaceous forms. C= Species totals for non-saprolegniaceous forms. D=Number of species.

equal or non-saprolegniaceous species dominate. In SQ series, the driest of all the sites, the species totals for non-saprolegniaceous forms are continuously higher than the members of Saprolegniaceae. However, the wettest site, i.e. AQ series shows the dominance of Saprolegniaceae over non-saprolegniaceous forms throughout the year. The family Pythiaceae is transitional so far as habitat (aquatic or terrestrial) is concerned (Sparrow, 1960). Therefore, non-saprolegniaceous forms (particularly the members of Pythiaceae) have higher degree of tolerance for dryness and high temperature than the members of Saprolegniaceae which are primarily aquatic.

Examination of Fig. 6 reveals that eccentric forms of Saprolegniaceae occur throughout the year and have a wide range of fluctuations in species total while the centric form (*Pythiopsis humphreyana*) has a restricted occurrence (only during soil temperature 19—22°C) and least fluctuation in species totals. Fig. 7, however, represents the occurrence of different eccentric species of *Achlya* for quadrat JQ1. Most common species is *A. orion* and least represented is *A. klebsiana*. Moreover, *A. orion* *A. diffusa* and *A. prolifera* indicate

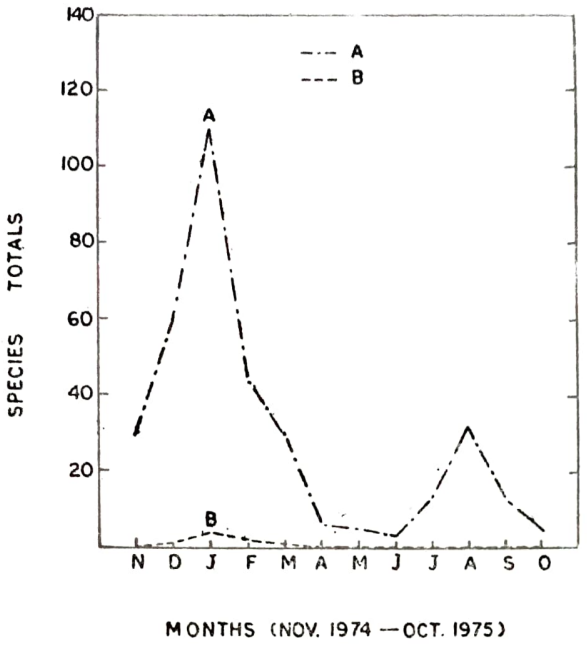

Fig. 6. Graphic representation of data from JQ1 of saprolegniaceous forms. A=Species totals for eccentric forms. B=Species totals for centric & subcentric forms.

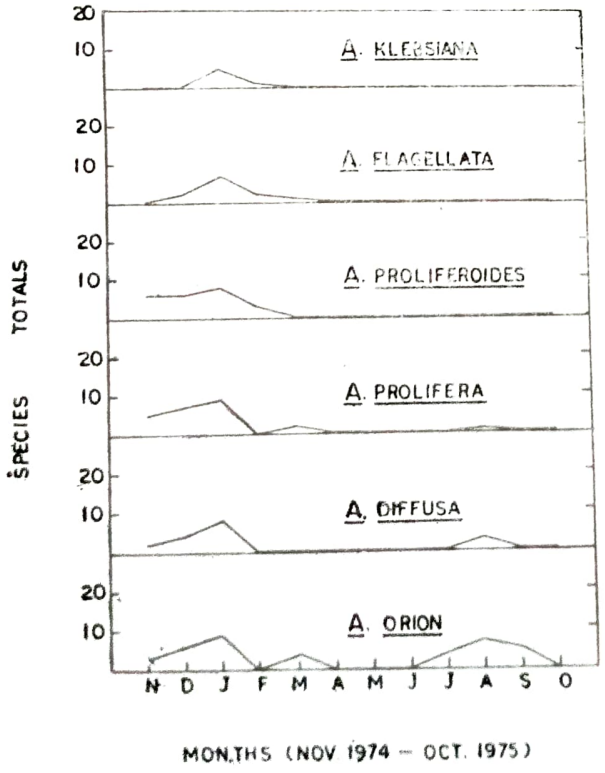

Fig. 7. Graphic representation of data from JQ1 of different eccentric species of *Achlya*.

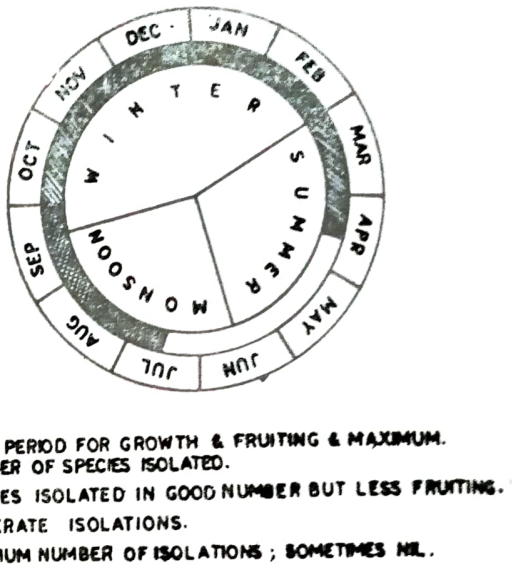

Fig. 8. Ecological clock for the seasonal occurrence for the members of saprolegniaceae.

two peaks of occurrence-one during soil temperature range 19—22°C and another during 26—28°C while *A. proliferoides*, *A. flagellata* and *A. klebsiana* exhibit only one peak (soil temperature 19—22°C).

Forbes (1935) and Waterhouse (1942) have shown that maximum yield of water-moulds was obtained during winter (December-February) and minimum in summer (May-June). The results of the present study very well agree with their findings but are quite different from that of Milovtsova (1935) who found maximum water-moulds during June and July. However Khulbe and Bhargava (1977) found maximum yield in temperate lakes during summer (May-June) at 17.5 23.5°C. In the present study highest yield was recorded at soil temperature 19—22°C during December and January. Similarity in temperature and difference in season of maximum abundance of water-moulds (in present study

and that of Khulbe and Bhargava, 1977) clearly confirm the view that the temperature, not the season, is decisive factor for the occurrence of aquatic fungi.

The findings of the present investigation also confirm the view advanced by Hughes (1962) that eccentric forms are more frequent in tropical climates and centric and subcentric forms in temperate climates. The view is supported by the observations of Rossy-Valdderrama (1956), Ziegler (1958), Roberts (1963), Srivastava (1967), Alabi (1971) and Khulbe and Bhargava (1977). All the species of Saprolegniaceae (except *Pythiopsis humphreyana*), recorded during the present study, had eccentric oospores.

Hughes (1962) placed all his collected species under two groups, *viz.*, winter samples (collected from water samples below 22°C) and summer samples (collected from water at 22°C or higher). Roberts (1963) grouped saprolegniaceous forms into three groups-constant species (occurring throughout the year), summer species (occurring during May-July) and winter species (occurring during January-March) while Srivastava (1967) classified the species collected by him into two groups: constant species occurring round the year and low temperature species which are not recorded when the temperature is very high during the months of April to June.

In the present study classification of the collected forms has been done on the basis of temperature into four groups, *viz.*, constant species (19—35°C) low temperature species (19—24°C) moderate temperature species (25—30°C) and high temperature species (31—35°C). *Aphanomyces hellicoides*, *A. laevis*, *Pythium aphanidermatum*, *P. butleri*, *P. deBaryanum* and *P. ultimum* were recorded throughout the year and thus grouped under constant species. Low temperature species include *Achlya proliferoides*, *A. flagellata* *A. klebsiana*, *Dictyuchus sterile*, *Leptolegnia* sp., *Pythiopsis humphreyana* and *Saprolegnia luxurians* while *Blastocladiella variabilis*, *Allomyces arbuscula*, *A. moniliformis*, *Achlya orion*, *A. diffusa*, *A. prolifera*, *Achlya* sp., *Saprolegnia ferax*, *Pythium echinulatum* *P. mammillatum*, *P. multisporum* and *P. aquatile* comprise the moderate temperature species. No species was recorded exclusively under high temperature conditions (31—35°C). Alabi (1971) recorded *Aphanomyces laevis* as high temperature and dry season species. However, in the present study as well as in those of Srivastava (1967) and Khulbe and Bhargava (1977) this form has been grouped under constant species.

A perusal of Table I shows that nine species, viz., *Allomyces arbuscula*, *A. moniliformis*, *Achlya orion*, *A. diffusa*, *A. prolifera*, *Aphanomyces laevis*, *Pythium aphanidermatum*, *P. aquatile* and *P. butleri* are common to all sites, while eight species, viz., *Blastocladiella variabilis*, *Achlya proliferoides*, *Brevilegnia subclavata*, *Saprolegnia ferax*, *S. luxurians*, *Leptolegnia* sp., *Pythiopsis humphreyana* and *Pythium multisporum* are confined to Jalwania site.

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