Occurrence of Water Borne Conidial Fungi in Relation to Some Physico-Chemical Parameters in a Fresh Water Stream

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ABSTRACT: Relative effect of some physico-chemical parameters of water to the occurrence of water borne conidial fungi was studied in a high altitudinal fresh water stream. A total of 30 species belonging to 21 genera were isolated. The number of conidial fungal species was enumerated in water samples collected monthly during the period of March 2007-February 2008. There was marked seasonal fluctuation in the occurrence of the species. The maximum number of species was found during spring to early summer and winter, while there was a decline in the number of species during late summer, rainy and early autumn seasons. Species richness was correlated with seven different water quality variables measured for each sample period, viz., temperature, pH, dissolved oxygen, organic and inorganic content, phosphate and sulphate concentration. The data were analyzed statistically for correlation and these factors were found to be significant for the occurrence of water borne conidial fungi. [Nature and Science. 2009;7(4):20-28]. (ISSN: 1545-0740).

Key words: aquatic hyphomycetes, occurrence, physico-chemical parameters

INTRODUCTION

The aquatic ecosystem comprises of variety of biota. Fungal community is one of them. Several physico-chemical factors of aquatic ecosystem influence the composition and activity of the fungal community. Of these, fluctuation in temperature, hydrogen – ion concentration, oxygen content, dissolved organic and inorganic matter, phosphate and sulphate concentration have been found to be important factors for the occurrence and distribution of individual species of water borne conidial fungi in the fresh water stream (Ingold, 1975; Nilsson, 1964). Within a stream site differences are closely correlated with altitude or other factors associated with it, which may include differences in water chemistry (Fabre, 1998; Raviraja et al., 1998).

Species assemblage of aquatic hyphomycetes varies seasonally and site to site and these changes are thought to occur mainly due to differences in water temperature (Barlocher & Kendrick, 1974; Suberkropp, 1992). Temperature range of 10-25°C favors the growth and multiplication of conidial fungi in water bodies. The optimum temperature for the growth of *Tricladium chaetocladium* and *Lunulospora curvula* was within the range of 15-20°C (Iqbal & Webster, 1973). Ingold (1975) and others from temperate countries have found abundant conidia in autumn, winter and early spring and abundance decreased in the late spring and summer.

pH greatly affects the decompositional activities of aquatic hyphomycetes in running fresh water bodies. The occurrence and degradative ability of water borne conidial fungi colonizing on submerged leaf litter is influenced by the hydrogen ion concentration (pH) of water (McKinley & Vestal, 1982). While working in an arctic lake they found a progressive decline of fungi with increasing acidity and their almost complete absence at pH 4.0-3.0.

These fungi require a fresh oxygenated environment for their occurrence (Webster & Towfic, 1972). Increase in fungal species number is related with increasing dissolve oxygen and dissolve organic matter of the stream (Kaushik & Hynes, 1971).

Several studies indicate that in lotic ecosystems, leaf litter decomposition and fungal activity can be affected by the concentration of nutrients (e.g. nitrogen and phosphorus) in the water (Suberkropp & Chauvet, 1995; Sridhar & Barlocher, 2000; Grattan & Suberkropp, 2001; Rosemond et al., 2002). Aquatic hyphomycetes might obtain inorganic nutrients (nitrogen and phosphorus) not only from their organic substrate (leaf litter, wood debris etc.) but also directly from water passing by ravine areas (Suberkropp, 1995; Suberkropp & Chauvet, 1995).

The presence of these fungi in the sulphide containing water bodies indicates the importance of these salts for the growth of aquatic hyphomycetes (Field & Webster, 1985). Recently (Gulis & Suberkropp, 2003, 2004; & Gulis et al., 2004) have initiated some studies on the effect of nutrients on aquatic hyphomycetes in the American streams.

The present work was carried out to study the relation of physico-chemical factors to the occurrence and distribution of water borne conidial fungi in a fresh water high altitudinal stream of Kumaun Himalaya.

METHODOLOGY

Study Area

Vinayak stream (1200 m asl), of Kumaun Himalaya was selected for the present work. It is nearly 25 Km away from Nainital (Fig. 1). This stream passes through well-canopied oak and pine trees forest area.

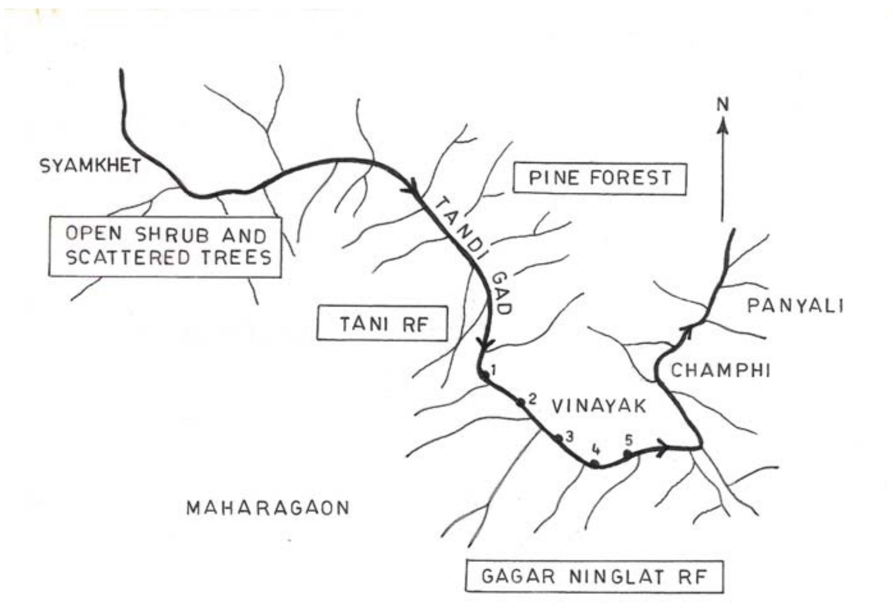

Figure 1. Location map with the sampling sites along the Vinayak stream (29° 22′ N latitude and 79° 33′ E longitude).

Sampling

Monthly five samples were made from the five selected sites (Fig. 1) in the study area for a period of one year (March 2007 to February 2008). Samples of five sites were taken as five replicates and collected in sterilized bags and were processed as described by Nilsson (1964). Species were identified using relevant monographs and literature. Conidia of species were taken as an index of occurrence. Stream water was analyzed to determine the seasonal variation, frequency of occurrence (%), and relative frequency of water borne conidial fungi by using following formula:

$$\% \text{ Frequency} = \frac{\text{Occurrence of Conidia in samples}}{\text{Total no. of samples analyzed}} \times 100, \quad \text{Relative Frequency} = \frac{\text{Frequency of Occurrence}}{\text{Total of Frequency}} \times 100$$

Analysis of water quality

The physico-chemical parameters of water viz., stream temperature (° C), water pH, dissolve oxygen (mg l^{-1}), dissolve organic matter (mg l^{-1}), dissolve inorganic matter (mg l^{-1}), sulphate (mg l^{-1}) and phosphate (mg l^{-1}) were analyzed following the methods of Trivedi and Goel (1986) and A.P.H.A. (1989).

Temperature was measured by using a centigrade thermometer by dipping it at a depth of 5-8 cm in water for 5 minutes, at the time of sample collection. pH was recorded on spot with the help of a digital portable pH meter (*Hanna*) periodically at the time of collection of samples.

Dissolve oxygen content (mg l^{-1}) was determined on the spot by making a composite sampling of water at each month following the Winkler method (Welch, 1948). Dissolve organic and inorganic matter (mg l^{-1}), phosphate and sulphate content (mg l^{-1}) were analyzed by following A.P.H.A. (1989).

Statistical analysis

Each physico-chemical factors of water were analyzed statistically for the relationship with the occurrence of water borne conidial fungi on the basis of coefficient of correlation (r).

RESULTS

A total of 30 species belonging to 21 genera of water borne conidial fungi viz., *Alatospora*, *Anguillospora*, *Camposporium*, *Campylospora*, *Clavariopsis*, *Dimorphospora*, *Diplocladiella*, *Flagellospora*, *Heliscella*, *Heliscus*, *Lemonniera*, *Lunulospora*, *Pestalotiopsis*, *Pleurophragmium*, *Setosynnema*, *Speiropsis*, *Tetrachaetum*, *Tetracladium*, *Tricladium*, *Tripospermum* and *Triscelophorus* were isolated from Vinayak stream (Table 1). These species were isolated from different decomposed leaf litter of known and unknown species and foam.

Seasonal variation in species composition

During the course of present study a seasonal fluctuation in the occurrence of water borne conidial fungi was observed. The total fungal population was higher during late spring and winter seasons (16-24 species), than early summer season (with 20 species). However, the decline in their occurrence was found during rainy to autumn seasons (10-15 species).

It was interesting to note that some species appeared in particular seasons, *Camposporium pellucidum* occurred only in late spring to summer. *Campylospora parvula* and *Heliscella stellatacula* appeared only in spring. *Pleurophragmium sonam* occurred only in summer. *Tricladium chaetocladium* occurred during rainy and late winter seasons. *Tripospermum myrti* appeared from late rainy to early winter seasons. *Campylospora chaetocladia*, *Clavariopsis aquatica*, *Lunulospora cymbiformis*, *Tetracladium marchalianum* and *Triscelophorus monosporus* appeared throughout the year in every season and can be regarded as temperature tolerant species, while other species were found during maximum seasons.

Frequency of occurrence

Frequency of occurrence and relative frequency of occurrence is summarized in table 1. As evident from this table *Triscelophorus monosporus* occurred throughout the year and showed maximum frequency of occurrence (100 %) with 6.32 % relative frequency followed by *Tetracladium marchalianum* with 91.66 % frequency of occurrence (5.79 % relative frequency) and *Campylospora chaetocladia*, *Clavariopsis aquatica* and *Lunulospora cymbiformis* with 83.33 % frequency of occurrence (5.26 % relative frequency) each. 14 species showed 41-80 % of frequency of occurrence which appeared to be moderate species in occurrence, these species were viz., *Alatospora acuminata*, *Anguillospora crassa*, *A. longissima*, *Flagellospora penicillioides*, *Lemonniera terrestris*, *L. cornuta*, *Lunulospora curvula*, *Pestalotiopsis submersus*, *Setosynnema isthmosporum*, *Speiropsis scopiformis*, *Tetrachaetum elegans*, *Tetracladium apiense*, *T. setigerum* and *Triscelophorus acuminatus*. 9 species viz., *Alatospora pulchella*, *Camposporium pellucidum*, *Campylospora parvula*, *Dimorphospora foliicola*, *Heliscella stellatacula*, *Heliscus lugdunensis*, *Lemonniera pseudofloscula*, *Tricladium chaetocladium* and *Tripospermum myrti* showed low frequency of occurrence i.e. < 40 %. *Diplocladiella longibrachiata* and *Pleurophragmium sonam* represented less than 20 % frequency of occurrence and were regarded as rare species with 0.53 -1.05 % of relative frequency.

The average value of temperature, pH, dissolve oxygen, organic matter, inorganic matter, phosphate and sulphate of five samples collected from five different sites is given in table 2.

The results of different physico-chemical water parameters of species are summarized as below:

i. Temperature: Water temperature of stream recorded during the study period indicates a marked seasonal variation (Table 2). The temperature of the stream water ranges between 8-24.3 ° C. Fungal species were found temperature dependent, as fluctuation in the temperature also change the species composition of water borne conidial fungi. Statistical analysis indicated a negative correlation (r = - 0.06454) of the fungal species with temperature. It was noted that species number declines with the rising of water temperature (Fig. 2).

ii. Hydrogen- ion concentration (pH): pH of water ranged between 7.6- 8.8 (Table 2), with minimum in March and maximum in May (Fig. 2). Water pH had a close relationship with the occurrence of water borne conidial fungi. The number of fungal species had a negative correlation with pH, having values of (r = - 0.26817).

iii. Dissolved Oxygen (DO): Dissolved oxygen content of water ranged between 4.3 – 12.5 mg/l (Table 2), with maximum in December and minimum in September. A negative correlation (r = - 0.22985) was found between the dissolved oxygen content of water and occurrence of species.

iv. Organic Matter: Organic matter ranged between 57 – 200 mg/l (Table 2.). The maximum species flourished during winter to late spring when the organic matter ranges between 100 – 200 mg l^{-1}. A positive correlation (r = 0.66198) was obtained between organic matter and fungal species during the coarse of present study.

v. Inorganic Matter: Inorganic content of water ranged between 60 – 200 mg/l (Table 2.). The observation of the present study indicate occurrence of greater number of species in winter and spring seasons coincided with the higher values of inorganic matter, i.e., 107 – 200 mg l^{-1}, while species number decreased with a fall in the inorganic content. A positive correlation (r = 0.78148) was found between the occurrence of species and inorganic matter of water (Fig. 2).

vi. Phosphate: The Phosphate content of the water varied between 0.200 – 0.966 mg/l (Table 2.). The minimum value was recorded in November and January (Fig. 2). Statistical analysis showed a positive correlation (r = 0.77061) with the occurrence of species. It was noted that the maximum number of species occurred in winter, spring and early summer seasons when phosphate content of water was higher (0.415 – 0.966 mg l^{-1}).

vii. Sulphate: The values of Sulphate content of water ranges between 1.200 – 16.10 mg/l (Table 2.). It was observed that the number of species increase with the increase in the sulphate content. A positive correlation (r = 0.41001) was obtained between number of species and sulphate content of water (Fig. 2).

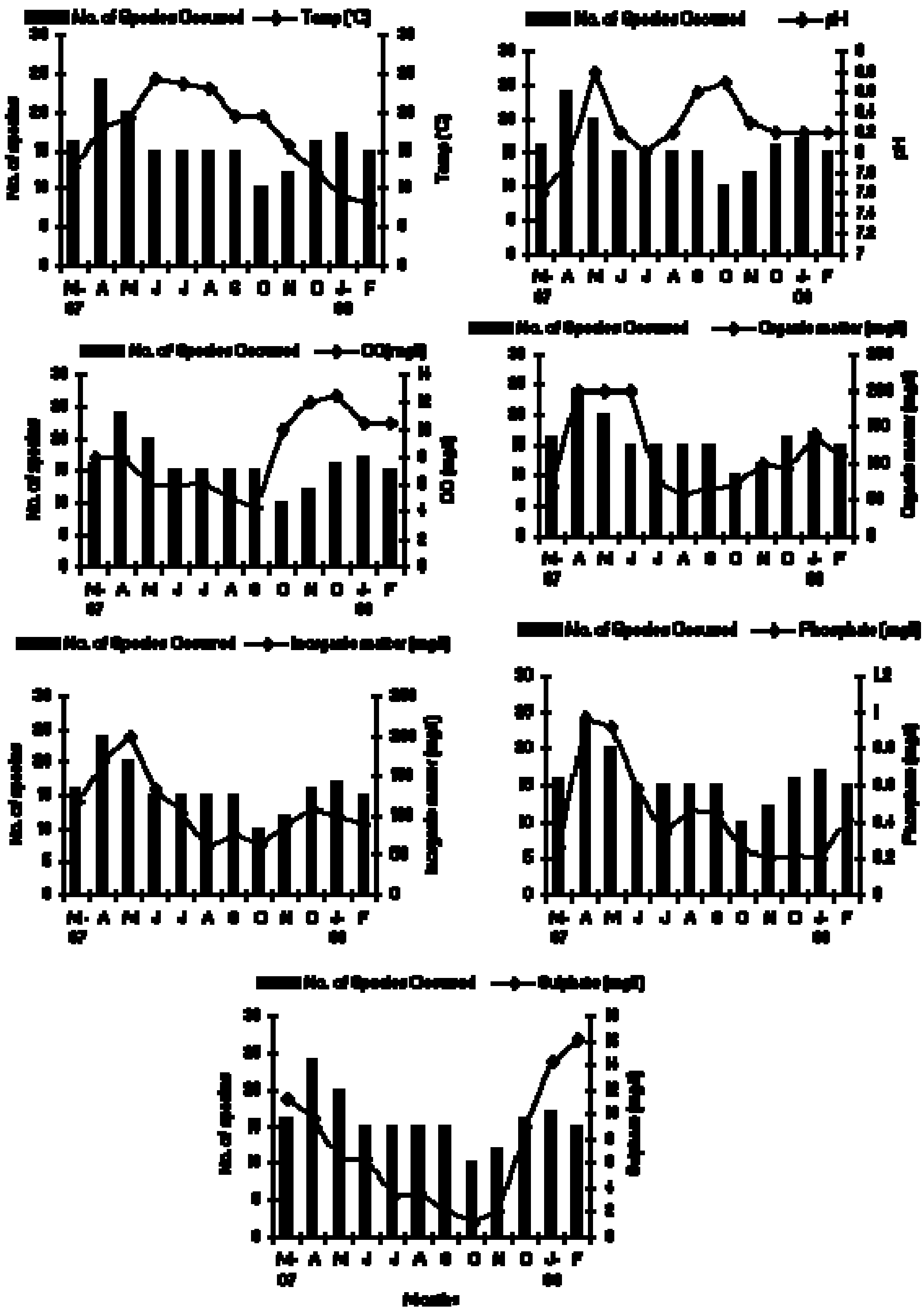

Figure 2. Relationship between number of fungal species and different physico-chemical parameters. (Temperature, pH, Dissolved Oxygen, Organic, Inorganic, Phosphate and Sulphate matter)

Table 1. Seasonal fluctuation in species composition, % frequency and % relative frequency of occurrence of water borne conidial fungi of a fresh water stream Vinayak, Kumaun Himalaya during March 2007 to February 2008

		Spring		**Summer**		**Rainy**			**Autumn**		**Winter**					
		M-07	Ap	My	Jn	Jul	A	S	O	N	D	J-08	F	Occurrence	% Frequency	% Relative Frequency
	Temp.	13.0	17.9	19.3	24.3	23.7	23.0	19.5	19.5	15.5	12.0	9.0	8.0			
	pH	7.6	7.9	8.8	8.2	8.0	8.2	8.6	8.7	8.3	8.2	8.2	8.2			
S.No.	Name of fungi															
1.	*Alatospora acuminata* Ingold	+	+	+	+	+	-	-	+	-	+	+	+	9	75.00	4.74
2.	*Alatospora pulchella* Marvanova	-	+	+	-	-	+	-	-	-	-	-	-	3	25.00	1.58
3.	*Anguillospora crassa* Ingold	+	-	+	+	-	-	+	+	-	+	+	+	8	66.66	4.21
4.	*Anguillospora longissima* (Sacc. & Therry) Ingold	+	+	+	-	-	-	-	-	+	+	+	+	7	58.33	3.68
5.	*Camposporium pellucidum* (Grove) Hughes	-	+	+	+	-	-	-	-	-	-	-	-	3	25.00	1.58
6.	*Campylospora chaetocladia* Ranzoni	-	+	+	+	+	+	+	+	+	+	+	-	10	83.33	5.26
7.	*Campylospora parvula* Kuzaha	+	+	+	-	-	-	-	-	-	-	-	-	3	25.00	1.58
8.	*Clavariopsis aquatica* de Wildeman	+	+	+	+	+	+	-	-	+	+	+	+	10	83.33	5.26
9.	*Dimorphospora foliicola* Tubaki	+	+	-	-	-	-	-	-	-	-	+	+	4	33.33	2.11
10.	*Diplocladiella longibrachiata* Nawawi & Kuthub.	-	+	+	-	-	-	-	-	-	-	-	-	2	16.66	1.05
11.	*Flagellospora penicillioides* Ingold	-	+	-	+	+	+	+	-	-	-	-	+	6	50.00	3.16
12.	*Heliscella stellatacula* Marvanova	+	+	+	-	-	-	-	-	-	-	-	-	3	25.00	1.58
13.	*Heliscus lugdunensis* Sacc. & Therry	+	+	+	-	+	-	-	-	-	-	-	-	4	33.33	2.11
14.	*Lemonniera terrestris* Tubaki	+	-	-	-	-	-	-	-	+	+	+	+	5	41.66	2.63
15.	*Lemonniera cornuta* Ranzoni	+	+	-	-	-	+	-	-	+	+	+	+	7	58.33	3.68
16.	*Lemonniera pseudofloscula* Dyko	+	+	-	-	-	-	-	-	-	+	+	-	4	33.33	2.11
17.	*Lunulospora curvula* Ingold	+	+	-	-	+	-	+	+	+	+	+	+	9	75.00	4.74
18.	*Lunulospora cymbiformis* Miura	+	+	-	+	+	+	+	+	+	+	+	-	10	83.33	5.26
19.	*Pestalotiopsis submersus* Sati & Tiwari	-	-	+	+	+	+	+	-	-	+	+	-	7	58.33	3.68
20.	*Pleurophragmium sonam* Sati & Tiwari	-	-	+	-	-	-	-	-	-	-	-	-	1	08.33	0.53
21.	*Setosynnema isthmosporum* Shaw & Sutton	-	+	+	+	+	+	+	+	-	-	+	-	8	66.66	4.21
22.	*Speiropsis scopiformis* Kuthub.& Nawawi	-	+	+	+	+	+	+	-	-	-	-	+	7	58.33	3.68
23.	*Tetrachaetum elegans* Ingold	+	+	+	+	-	-	-	+	+	+	+	+	9	75.00	4.74
24.	*Tetracladium apiense* Sinclair & Eicker	-	+	+	+	+	+	+	-	-	-	-	-	6	50.00	3.16
25.	*Tetracladium marchalianum* de Wildman	+	+	+	+	-	+	+	+	+	+	+	+	11	91.66	5.79
26.	*Tetracladium setigerum* (Grove) Ingold	-	+	+	-	+	+	+	-	-	-	-	-	5	41.66	2.63
27.	*Tricladium chaetocladium* Ingold	-	-	-	-	+	+	+	-	-	-	-	+	4	33.33	2.11
28.	*Tripospermum myrti* (Lind)Hughes	-	-	-	-	-	-	+	+	+	+	-	-	4	33.33	2.11
29.	*Triscelophorus acuminatus* Nawawi	-	+	-	+	+	+	+	-	+	+	+	+	9	75.00	4.74
30.	*Triscelophorus monosporus* Ingold	+	+	+	+	+	+	+	+	+	+	+	+	12	100	6.32
	Total	16	24	20	15	15	15	15	10	12	16	17	15			

M= March, Ap= April, My= May, Jn= June, Jul= July, A= August, S= September, O= October, N= November
D= December, J= January, F= February, + = Species present, - = Species absent

Table 2. Occurrence of water borne conidial fungi and water physiochemical characters of Vinayak Stream of Kumaun Himalaya during March 2007 to February 2008 *

S. No.	Months Name	No. of Species Occurred	Temp(° C)	pH	DO (mg/l)	Organic matter (mg/l)	Inorganic matter (mg/l)	Phosphate (mg/l)	Sulphate (mg/l)
1.	March-2007	16	13.0	7.6	8.0	70	117	0.262	11.214
2.	April	24	17.9	7.9	8.0	200	167	0.966	9.605
3.	May	20	19.3	8.8	6.0	200	200	0.927	6.385
4.	June	15	24.3	8.2	6.0	200	133	0.580	6.385
5.	July	15	23.7	8.0	6.2	73	103	0.346	3.340
6	August	15	23.0	8.2	5.0	57	60	0.473	3.580
7.	September	15	19.5	8.6	4.3	67	77	0.452	2.000
8.	October	10	19.5	8.7	10.0	70	63	0.251	1.200
9.	November	12	15.5	8.3	12.0	100	90	0.200	2.100
10.	December	16	12.0	8.2	12.5	93	107	0.226	9.000
11.	January-2008	17	09.0	8.2	10.5	140	100	0.200	14.30
12.	February	15	08.0	8.2	10.5	110	90	0.415	16.10

DO = Dissolved Oxygen
* Average values of five samples studied at five sites

DISCUSSION

The result obtained during present investigation revealed that the species composition of the water borne conidial fungi varied considerably from seasons to seasons, that would be attributed to the variation in physico-chemical characteristics of the habitat which have profound influence on the occurrence and distribution of water borne conidial fungi.

A perusal of seasonal occurrence of different species in the habitat indicates that the water borne conidial fungi show a marked seasonal fluctuation in their occurrence. A maximum number of the fungal species was found during spring to early summer and winter seasons, while number of species decline in summer to early autumn seasons (May - Oct). Sridhar and Kaveriappa (1989) also observed that the total number of aquatic hyphomycetes was lowest during summer season. Occurrence of maximum number of species during winter and spring seasons in the present study might be due to moderate temperature and slightly higher percentage of organic and inorganic matter. Many investigators have observed similar maxima during post monsoon periods (Sridhar & Kaveriappa, 1984) and suggested that after rainfall the large amounts of various leaf detritus get transferred into the stream through rain wash from distant places and stream gets greater abundance of these fungi. Figure 2 summarizes the relationship between number of fungal species and different physico-chemical parameters (Temperature, pH, Dissolved Oxygen, Organic, Inorganic, Phosphate and Sulphate) of Vinayak stream.

There was a negative correlation with species number and pH within certain range (r = - 0.26817). This indicates that both high and low pH might not be suitable for these fungi. Barlocher and Rosset (1981) suggested that pH close to 7.0 favour higher numbers of fungal species. The occurrences of water borne conidial fungi also show negative correlation with temperature (r = -0.06454). This finding was found to be in support of Mer and Sati (1989) and Raviraja et al., (1998).

Water borne conidial fungi obtain phosphate and sulphate not only from the leaf litter, wood debris but also directly from water passing by ravine areas (Suberkropp, 1995; Suberkropp & Chauvet, 1995). During the observation a positive correlation was found between the occurrence of aquatic hyphomycetes and the sulphate concentration of water (r = 0.41001)). However, the previous work of Field and Webster (1985) shows reduction in the survival of Ingoldian aquatic hyphomycetes with increasing concentration of sulphide.

The result of the investigation shows a positive correlation between phosphate concentration and species occurrence species (r = 0.77061). It justifies the findings of Krauss et al., (2001), who also reported the stimulation of fungus activity at high P concentrations.

The physico – chemical characters of the water were found much influenced to the occurrence and distribution of water borne conidial fungi in a fast flowing stream (Field & Webster, 1985; Sridhar & Kaveriappa, 1989; Sridhar et al., 2001; Webster & Descals, 1981).

Out of the 30 species isolated from the fast flowing stream of Vinayak, *Campylospora chaetocladia, Clavariopsis aquatica, Lunulospora cymbiformis, Tetracladium marchalianum* and *Triscelophorus monosporus* occur throughout the year, having maximum abundance. They may be regarded as temperature tolerant species and common species of the stream and can be concluded, as their appearance does not seem to be affected by different physico-chemical factors.

In the present study, the impact of temperature, pH, dissolved oxygen, organic and inorganic matter, phosphate and sulphate content showed a marked influence on the occurrence and distribution of the water borne conidial fungi. Relying upon the data observed it can be conclude that occurrence and distribution of the water borne conidial fungi is governed by interaction of temperature, pH, dissolved oxygen, organic, inorganic, phosphate and sulphate matter of the stream water.

Acknowledgements

The authors are thankful to DST, New Delhi for financial support and to the Head, Department of Botany, Kumaun University, Nainital, for providing lab facility.

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