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Variation in conidial concentration of freshwater hyphomycetes in a semi-tropical canal water habitat

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Abstract

The freshwater hyphomycete conidial numbers showed a characteristic pattern of fluctuation under the influence of temperature and biomass deposition in the Lahore Branch of the BRB canal. The conidial numbers showed a gradual increase from 2% in June to 39% in October. The clearing of the substratum from the canal in January played a significant role in the decline of conidial concentration from 13% in December to 6% in February. The total number of hyphomycete species showed an increase from 20 in April to 39 in December.

Introduction

The seasonal occurrence of freshwater hyphomycetes has been reported on submerged leaves from canal waters, a semi-tropical niche for aquatic hyphomycetes (Firdaus-e-Bareen and Iqbal, 1994). The canal water hyphomycetes on submerged fallen leaves were divided into three groups, the summer species that predominated during summer, autumn species that increased with the building up of the substratum and winter species that appeared periodically in winter and remained absent in rest of the year.

The inoculum size of the freshwater hyphomycetes in water is important factor responsible for the fungal colonization of submerged leaves. The hyphomycete spora in water is most dependent on the physical factors influencing their concentration in water. An attempt was made to elucidate the effect of physical factors on the hyphomycete spora in a canal water habitat.

Materials and Methods

The details of the sampling site are given in Firdaus-e-Bareen and Iqbal (1994). The fluctuation in conidial numbers was monitored daily in the Lahore Branch of the BRB canal following Iqbal and Webster (1973).

The canal water was filtered at the spot through Millipore membrane filters of 8 µm pore size. The water was taken up in 100 ml glass beakers and passed through Millipore filtration apparatus containing membrane filters of 4.7 cm diameter. The flask of the filtration apparatus was connected to a modified foot operated tyre pump. Enough water was filtered though the membrane till it became difficult to exert more pressure. At least 6 filters were prepared daily during the period from October, 1991 to September, 1993.During the days when water was very turbid, water was filtered through more than 6 filter membranes depending on the degree of turbidity present. However there were some days when greater turbidity did not allow more than 10 ml of water to pass through and it was impossible to observe the conidia on filters.

After filtration the filter membranes were taken in small petridishes and flooded with 0.05 % Trypan Blue stain prepared in lactophenol. They were left overnight at room temperature so that the conidia fully acquired the stain. The next day, three 1 cm square pieces were randomly cut from each filter membrane and mounted on glass slides under the same stain. The total number of conidia of each species was counted and recorded under the compound microscope. The total number of conidia obtained on all filters was pooled and the amount of conidia per liter of water was calculated daily. The percentage frequency of occurrence of each species was calculated from the total number of conidia observed. The mean frequency values were calculated for every month and the yearly data was recorded in the form of a table.

The physical properties (temperature, pH, electrical conductivity and turbidity) of the canal water were monitored daily from October 1991 to September 1993. The temperature of water was recorded daily both in the morning and evening by a maximum and minimum thermometer. The average temperature of water was calculated everyday. The pH of canal water was determined daily on a pH meter having a glass electrode (Hanna model Solu Bridge). The conductivity values (mS/m) were also monitored daily on a conductivity meter (Hanna model AGB 1000). The

turbidity and the amount of dissolved solutes was determined both by filtration and evaporation methods.

The flow rate of water remained almost constant throughout the year. An average flow rate in the center and along both banks was calculated. The time taken by water to travel one m was calculated. It was observed that the maximum organic matter traveled with water in the upper 20 cm layer. A wooden sampler, 1m broad and 20 cm in height was suspended in water for 15 minutes. The wooden frame of the sampler had a nylon net fitted in it so that all the organic matter was collected in the net as the water traveled through the net. Three samples at the center and three near the banks were collected and taken into the laboratory. This organic matter was spread on a blotting paper and then allowed to dry in an oven for 24 hours at 60 °C. The mean value of dry biomass was calculated for everyday and expressed as dry weight in grams per square meter area of water.

Weekly samples of water from canal were analyzed for chemical characteristics at the laboratory of SCARPS Monitoring Organization (SMO), WAPDA (Water and Power Development Authority, Lahore).

Results

The physical properties of water in the canal are given in Table 1. The minimum monthly average temperature was recorded in December (11.87°C) and the maximum in August (25.00°C). The pH values remained almost constant throughout the year and fluctuated between 6.87 and 7.69. The conductivity values were maximum in February (0.47 mS/cm) and minimum in July (0.15 mS/cm). In general, the conductivity values showed a decline from February till December. The dry biomass showed an increase from February (0.0236 gm/m^2) till December (3.4653 gm/m^2). The turbidity values were maximum in September (1.1470 gm/liter) and minimum (0.0043 gm/liter) in December.

The chemical characteristics are given in Table 2. The total dissolved solutes formed a peak in August to October.

A total of 63 conidial species was detected by filtration of water (Table 3). Three genera namely, *Entomophthora, Fusarium and Helicomyces* belonged to other groups of conidial fungi. Rest of the fungi belonged to the freshwater hyphomycetes.

Among the freshwater hyphomycetes, twenty-eight known species were recorded and thirty-two species appeared to be new. Some of the species were not identified even up to the generic level.

The species of hyphomycetes observed in water throughout the year were *Anguillospora* sp. A, *Articulospora proliferata, Bacillispora inflata, Campylospora chaetocladia, Cylindrocarpon aquaticum, Flagellospora curvula, Tetracladium marchalianum and Triscelophorus monosporus.* Some of the species appeared only when the temperature regime was lowest like *Alatospora acuminata, Anguillospora longissima, Articulospora tetracladia, Lemmoniera aquatica,* L. *centrosphaera, Sympodiocladium frondosum and Tetrachaetum elegans.* Other species which appeared with increasing deposition of substrate

Table 1: Physical properties of water in the Lahore Branch of the BRB Canal during different months.

Physical Characteristics		Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)	Mean	13.71± 0.034	16.29± 0.028	19.23± 0.037	19.93± 0.035	20.97± 0.027	22.77± 0.033	25.0± 0.051	24.58± 0.041	20.73± 0.046	15.92± 0.045	11.87± 0.068
	Range	11.5-16.0	15.0-18.0	17.5-21.5	18.0-21.5	19.5-23.0	21.0-25.0	21.0-27.0	22.5-27.0	18.0-23.6	13.0-18.0	9.5-13.5
PH	Mean	7.69± 0.001	7.57± 0.012	7.23± 0.007	6.87± 0.028	7.21± 0.008	7.04± 0.009	6.93± 0.006	7.12± 0.003	7.11± 0.004	7.21± 0.006	7.52± 0.008
	Range	7.20-8.24	7.14-8.19	6.73-7.80	3.12-7.83	6.93-7.85	6.34-7.60	6.43-7.22	6.89-7.35	6.81-7.33	6.65-7.33	7.11-8.36
Conductivity (mS/cm)	Mean	0.47± 0.056	0.30± 0.001	0.36± 0.001	0.30± 0.005	0.20± 0.002	0.15± 0.0008	0.17± 0.0005	0.20± 0.0006	0.18± 0.0006	0.18± 0.0006	0.19± 0.0005
	Range	0.07-0.34	0.25-0.36	0.30-0.42	0.15-0.82	0.13-0.41	0.10-0.19	0.13-0.20	0.16-0.25	0.16-0.21	0.16-0.23	0.17-0.22
Dry Biomass (gms/m^2)	Mean	0.0236± 0.0121	0.0946± 0.0022	0.2356± 0.0030	0.3680± 0.0040	0.4748± 0.0035	0.3047± 0.0322	0.4869± 0.0060	0.5462± 0.0050	0.7838± 0.0040	1.8856± 0.0040	3.4653± 0.0182
	Range	0.0092-0.0761	0.0432-0.0994	0.1535-0.2736	0.1954-0.4545	0.3700-0.5199	0.1445-0.4963	0.2542-0.8839	0.3145-0.8570	0.5280-0.9410	0.9631-2.5360	1.6856-5.6653
Turbidity (gms/litre)	Mean	0.3249± 0.0161	0.4802± 0.0211	0.2899± 0.0213	0.4163± 0.0070	0.4512± 0.0104	0.6225± 0.0118	1.1320± 0.0336	1.1470± 0.0718	0.1600± 0.0020	0.0152± 0.0010	0.0043± 0.0004
	Range	0.0300-0.7100	0.0290-1.7200	0.0830-1.833	0.0830-0.7290	0.1720-1.0000	0.0630-1.2870	0.2130-4.2660	0.2230-72360	0.0660-0.2680	0.0006-0.0480	0.0006-0.0083

and during rainfall included *Anguillospora* sp. C, *Flagellospora* sp. B, *Heliscus tentaculus, Lunulospora cymbiformis, Pyramidospora casuarinae, Sporidesmium ensiforme, Tetrachaetum* sp.I and an unknown sp. III.

Most of the unidentified species were recorded during October to December. The maximum total and average number of species was also recorded during these three months. The conidial number in water was maximum in December, when leaf deposition is also assumed to be maximum and during July when average rainfall was maximum. However there was a significant decrease in conidial numbers in February after clearing of the substratum in January (Fig.1). The percent conidial numbers showed a gradual increase from April (3%) towards December (19%) and were maximum in October (39%).

The decrease in conidial numbers was very sudden and significant (6%) in February, indicating the effect of substrate, that was removed in January. However, the concentration of conidia was greater in February (6%) and March (5%). A sudden elevation in July (7%) during the rainy season was observed. The minimum number of conidia per liter and species was observed during June. The number of species appeared to decline with increasing temperature.

Brief comments on unidentified species follow.

1. *Anguillospora* sp. A (Fig.2: a,a′): This species had large and broad conidia with septa not very specific and a lesser degree of sigmoidy than *Anguillospora gigantea* Ranzoni.
2. *Anguillospora* sp.B (Fig.2: b,b′):The conidia of this species were hockey-shaped/hook-shaped at the upper end in a single plane i.e. they were not sigmoid.
3. *Anguillospora* sp. C (Fig.2: c,c′): The conidia were highly sigmoid, hyaline with tapering ends and characteristically constricted at three places in the center, dividing the conidium into four parts, two central parts of uniform thickness and two tapering ends.
4. *Anguillospora* sp. D (Fig. 2:d): These conidia were very large and elongated.

Table 2: Chemical characteristics of water in the Lahore Branch of the BRB Canal during different months.

Amount (mg/l)		Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
C_3	Mean	14.03± 1.00	12.42± 0.22	10.02± 0.50	21.54± 2.16	24.05± 0.70	23.65± 0.70	22.04± 1.96	21.54± 1.96	29.40± 1.66	14.53± 1.06	10.42± 0.80
	Range	12.02-16.03	12.02-14.03	8.02-12.02	12.02-33.27	20.04-28.06	20.04-28.06	20.04-30.06	20.04-24.05	24.05-36.07	12.02-16.03	8.02-12.02
Mg	Mean	1.22± 0.61	2.13± 0.13	1.82± 0.15	6.08± 1.43	6.38± 0.25	5.59± 0.29	13.98± 0.66	13.38± 0.52	12.16± 1.75	2.37± 0.66	1.82± 0.13
	Range	0.00-2.43	1.22-2.43	0.24-1.70	1.22-4.86	4.86-7.30	3.65-7.30	9.73-17.02	9.73-14.59	7.30-19.46	1.97-3.97	0.24-1.38
Na	Mean	0.92± 0.00	1.15± 0.01	1.72± 0.26	5.98± 1.40	2.81± 0.02	1.93± 0.01	9.36± 1.49	9.89± 1.26	13.18± 0.29	5.75± 0.44	2.76± 0.26
	Range	0.92-0.92	0.92-1.38	0.46-3.22	0.46-1.38	1.61-4.14	1.38-2.07	3.22-13.80	3.22-17.48	11.96-13.80	3.22-7.45	1.61-3.22
K	Mean	0.78± 0.00	0.98± 0.00	0.88± 0.01	1.66± 0.02	1.37± 0.00	1.41± 0.00	1.27± 0.00	0.98± 0.01	1.43± 0.00	0.78± 0.00	0.39± 0.00
	Range	0.78-0.78	0.78-1.17	0.39-1.17	0.78-3.52	1.17-1.56	1.17-1.56	1.17-1.56	0.39-1.56	1.17-1.56	0.39-1.02	0.39-0.39
CO_3	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCO_3	Mean	1.22± 0.00	1.52± 0.01	12.20± 0.00	73.21± 15.86	91.51± 3.42	90.29± 2.93	138.80± 2.93	138.80± 5.61	164.73± 5.00	136.05± 4.46	106.77± 0.23
	Range	1.22-1.22	1.22-1.83	1.22-1.22	1.22-158.86	73.32-109.98	73.32-109.98	128.31-158.86	109.98-171.08	146.64-183.30	128.24-160.75	98.76-109.98
Cl	Mean	0.71± 0.00	7.98± 0.39	7.09± 0.00	9.75± 0.74	7.09± 0.00	7.09± 0.00	12.41± 0.76	10.64± 0.89	11.81± 1.10	9.57± 0.90	7.45± 0.35
	Range	0.71-0.71	0.71-10.64	7.09-7.09	7.09-14.18	7.09-7.09	7.09-7.09	8.22-14.25	7.09-14.18	7.09-14.18	7.09-12.68	7.09-10.64
SO_4	Mean	21.61± 0.02	20.17± 0.03	16.81± 0.65	25.31± 1.58	8.88± 2.59	4.03± 0.53	3.70± 0.03	2.88± 0.04	5.14± 1.30	45.63± 2.60	31.22± 0.66
	Range	21.13-22.09	18.25-22.09	14.41-21.13	19.21-34.10	1.44-26.90	0.96-6.24	1.92-5.76	0.96-5.76	1.92-10.57	34.10-49.60	26.90-34.10
NO_3	Mean	2.85± 0.00	4.65± 0.66	5.08± 0.86	5.70± 0.99	7.44± 1.67	7.75± 1.89	3.72± 0.99	0.62± 0.34	1.24± 0.69	0.62± 0.00	0.62± 0.00
	Range	2.85-2.85	3.72-5.70	4.65-7.44	4.65-7.75	5.70-11.69	5.70-12.67	2.85-5.70	0.34-2.34	0.62-3.72	0.62-0.62	0.62-0.62
Dissolved solutes	Mean	53.00± 0.50	53.75± 0.60	43.50± 1.29	119.50± 17.70	114.00± 2.49	106.40± 2.47	160.75± 2.40	158.75± 5.67	164.00± 5.17	104.20± 6.30	75.00± 1.60
	Range	52.0-54.0	51.0-57.0	38.0-52.0	51.0-224.0	99.0-123.0	92.0-123.0	149.0-176.0	122.0-179.0	145.0-183.0	88.0-115.0	71.0-87.0

Table 3: Average frequency (%) values of canal water hyphomycetes detected by filtration of water in different months of the year. The number in parenthesis indicates number of conidia.

Conidial Species	Months of the year (October 1991 – September 1993)										
	Feb.	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Alatospora acuminata Ingold	2.01 (23)	1.57 (14)	0.66 (3)	-	-	-	-	-	0.25 (9)	0.56 (28)	2.45 (104)
Anguillospora crassa Ingold	-	-	-	-	-	0.11 (1)	-	-	-	-	0.02 (1)
A. longissima (Sacc. & Syd.) Ingold	0.09 (1)	0.45 (4)	-	-	-	-	-	0.13 (1)	0.11 (4)	0.16 (8)	0.49 (21)
Anguillospora sp.A	2.45 (28)	3.36 (20)	4.39 (20)	4.27 (25)	3.18 (13)	0.97 (9)	0.53 (3)	0.53 (4)	0.33 (12)	0.32 (16)	0.54 (23)
Anguillospora sp.B	-	0.11 (1)	-	0.17 (1)	0.49 (2)	0.32 (3)	0.71 (4)	0.66 (5)	0.22 (8)	0.06 (3)	0.05 (2)
Anguillospora sp.C	0.35 (4)	-	-	-	1.98 (4)	0.21 (2)	0.89 (5)	0.53 (4)	0.33 (12)	0.26 (13)	0.19 (8)
Anguillospora sp.D	0.35 (4)	0.79 (7)	-	-	0.73 (3)	-	0.71 (4)	0.13 (1)	0.44 (16)	0.18 (9)	0.31 (13)
Anguillospora sp.E	1.84 (21)	3.69 (33)	2.20 (10)	-	-	1.19 (11)	1.96 (11)	1.71 (13)	1.71 (62)	1.90 (95)	2.03 (86)
Anguillospora sp.F	0.09 (1)	-	-	-	-	-	-	-	-	-	-
Anguillospora sp.G	-	-	-	-	0.17 (1)	-	-	-	-	-	-
Anguillospora sp.H	-	-	-	-	-	-	-	-	0.03 (1)	-	-
Anguillospora sp.I	-	-	-	-	-	-	-	-	-	-	0.02 (1)
Articulospora proliferata Jooste *et al*.	3.50 (40)	2.46 (22)	3.74 (17)	3.41 (10)	2.44 (10)	0.97 (9)	0.53 (3)	0.26 (2)	2.57Z (93)	11.75 (586)	7.68 (326)
A. tetracladia Ingold	0.26 (3)	0.33 (3)	0.44 (2)	-	-	-	-	-	0.52 (19)	0.44 (20)	0.31 (13)
Bacillispora inflata Iqbal & Bhatty	0.44 (5)	0.33 (3)	0.22 (1)	0.85 (5)	0.49 (2)	0.32 (3)	0.89 (5)	0.79 (6)	1.02 (37)	0.62 (31)	0.02 (1)
Campylospora chaetocladia Ranzoni	0.52 (6)	1.12 (10)	1.54 (7)	1.19 (7)	0.98 (4)	1.08 (10)	0.71 (4)	0.13 (1)	1.30 (47)	1.54 (77)	1.06 (45)
Campylospora sp.I	-	-	-	-	0.24 (1)	-	-	-	-	-	-
Clavariopsis aquatica de Wild.	6.91 (79)	10.08 (90)	5.49 (25)	0.85 (5)	0.73 (3)	0.75 (7)	-	-	0.44 (16)	1.38 (69)	5.40 (229)
Clavariopsis sp.I	-	-	-	-	-	-	-	-	-	-	0.02(1)
Cylindrocarpon aquaticum (Nilss.) Marv. & Desc.	3.06 (35)	4.25 (38)	5.71 (25)	4.27 (25)	5.38 (22)	4.85 (45)	6.25 (35)	5.05 (46)	4.63 (168)	1.20 (60)	1.53 (65)
Dacylella submersa (Ingold) Nilss.	0.09 (1)	-	-	0.85 (5)	0.24 (1)	0.65 (6)	-	0.26 (2)	0.14 (5)	0.34 (17)	0.05 (2)
Dwayaangam sp.I	-	-	-	-	-	-	-	-	0.03 (1)		
Entomophthora sp.I	0.26 (3)	0.22 (2)	-	-	-	-	-	-	-	-	0.05 (2)
Flagellospora curvula Ingold	3.1513 (6)	3.02 (27)	2.64 (12)	2.39 (14)	2.44 (10)	1.40 (13)	0.71 (4)	1.84 (14)	3.361 (122)	5.03 (251)	2.21 (94)
F. fusarioides Iqbal	2.36 (27)	2.01 (18)	2.42 (11)	3.07 (18)	1.71 (7)	0.65 (6)	0.36 (2)	0.92 (7)	3.92 (142)	3.37 (142)	3.32 (141)
F. minuta Iqbal & Bhatty	-	0.11 (1)	2.22 (1)	-	-	-	-	-	-	-	-
F. penicillioides Infold	12.68 (145).	11.09 (99)	23.06 (105)	24.06 (141)	22.00 (90)	22.87 (212)	29.82 (167)	21.84 (166)	23.80 (863)	12.91 (644)	4.12 (175)
Flagellospora sp.B	-	-	-	-	-	-	-	0.39 (3)	0.22 (8)	0.10 (5)	-
Flagellospora sp. C	-	-	-	-	-	-	-	-	0.14 (5)	0.02 (1)	-

Fusarium sp.	4.99 (57)	8.40 (75)	9.89 (45)	12.12 (71)	12.22 (50)	23.95 (222)	24.26 (137)	22.24 (169)	10.98 (398)	5.09 (254)	3.60 (153)
Helicomyces sp.A	-	-	-	-	-	0.11 (1)	-	-	-	-	-
Heliscus lugdunensis Sacc. & Therry	-	0.11 (1)	0.22 (1)	0.34 (2)	0.24 (1)	-	-	-	0.08 (3)	0.14 (7)	0.02 (1)
Heliscus tentaculus Umph.	0.26 (3)	-	-	0.34 (2)	0.49 (2)	1.40 (13)	1.61 (9)	5.53 (42)	10.48 (380)	6.05 (302)	1.48 (63)
Hydrocentrospora sp.I	-	-	-	-	-	-	-	0.13 (1)	-	0.04 (2)	-
Lemonniera aquatica de Wild.	0.09 (1)	0.45 (4)	0.44 (2)	0.34 (2)	-	-	-	-	-	0.08 (4)	0.14 (6)
L. centrosphaera Marv.	-	0.1 (1)	-	-	-	-	-	-	-	-	0.05 (2)
Lunulospora curvula Ingold	34.12 (390)	39.08 (349)	31.43 (143)	37.88 (222)	38.39 (157)	29.66 (275)	20.36 (114)	28.95 (220)	26.17 (949)	36.27 (1809)	40.72(1728)
L. cymbiformis Miura	-	-	-	0.34 (2)	1.47 (6)	0.86 (8)	1.25 (7)	0.39 (7)	0.05 (2)	0.09 (3)	-
Mycocentrospora acerina Deighton	0.09 (1)	0.02 (2)	-	0.17 (1)	0.24 (1)	-	-	-	-	-	0.05 (2)
M. iqbalii sp. ined.	0.17 (2)	0.22 (2)	0.44 (2)	0.34 (2)	-	0.75 (7)	1.43 (8)	0.79 (6)	0.69 (25)	0.14 (7)	0.07 (3)
Mycocentrospora sp.A	-	-	-	-	0.24 (1)	-	-	-	-	-	-
Mycocentrospora sp.B	-	-	-	-	-	0.11 (1)	-	-	-	-	-
Mycocentrospora sp.C	-	-	-	-	-	-	-	-	0.08 (2)	-	0.02 (1)
Pyramidospora casuarinae Nilss.	-	-	-	-	-	0.11 (1)	0.18 (1)	0.13 (1)	0.05 (2)	0.02 (1)	-
Scorpiosporium sp.I	-	-	-	-	0.24 (1)	0.11 91)	0.53 (3)	0.66 (5)	0.08 (3)	0.06 (3)	0.07 (3)
Sporidesmium ensiforme Desc.	-	-	-	-	-	0.11 (1)	2.14 (12)	2.10 (616)	0.52 (19)	0.22 (11)	0.02 (1)
Sympodiocladium frondosum Desc.	3.32 (38)	0.67 (6)	-	-	-	-	-	0.39 (3)	0.11 (4)	0.20 (10)	0.78 (33)
Tetrachaetum elegans Ingold	-	0.11(1)	-	-	-	-	-	-	0.05 (2)	0.06 (3)	0.19 (8)
Tetrachaetum sp.I	-	-	-	-	-	0.21 (2)	0.71 (4)	0.92 (7)	0.27 (10)	-	-
Tetracladium marchalianum de Wild.	15.57 (178)	4.23 (44)	3.74 (17)	1.71 (10)	0.24 (1)	0.43 (4)	0.36 (2)	0.53 (4)	2.37 (86)	7.66 (382)	19.89 (844)
Tetracladium sp.I	-	-	-	-	-	-	-	-	0.08 (3)	-	0.05 (2)
Triscelophorus monosporus Ingold	1.05 (12)	0.67 (6)	1.10 (5)	0.85 (5)	4.16 (17)	0.75 (7)	2.50 (14)	0.66 (5)	1.32 (48)	1.58 (79)	0.89 (38)
Species I	-	-	-	-	-	4.96 (46)	-	-	0.52 (19)	0.18 (9)	-
Species II	-	-	-	-	-	0.11 (1)	0.18 (1)	0.39 (3)	0.11 (4)	-	-
Species A	-	-	-	-	-	-	0.18 (1)	-	-	-	-
Species III	-	-	-	-	-	-	-	-	0.36 (3)	-	-
Species IV	-	-	-	-	-	-	-	-	0.03 (1)	-	-
Species V	-	-	-	-	-	-	-	-	0.03 (1)	-	-
Species VI	-	-	-	-	-	-	-	-	0.03 (1)	-	-
Species B	-	-	-	-	-	-	-	-	0.03 (1)	-	-
Species VII	-	-	-	-	-	-	-	-	-	0.02 (1)	-
Species VIII	-	-	-	-	-	-	-	-	-	-	0.02 (1)
Species IX	-	-	-	-	-	-	-	-	-	-	0.02 (1)

Total No. of species	27	28	20	22	24	29	25	29	44	36	39
Average No. of species	9.31	8.55	6.43	6.35	5.76	9.35	6.37	7.24	15.06	15.40	15.00
Average No. of conidia/L	779	662	412	520	324	1020	673	875	1194	1360	1757
Average Temperature (°C)	13.74± 0.034	16.28± 0.028	19.23± 0.037	19.94± 0.035	20.96± 0.027	22.79± 0.033	24.97± 0.051	24.58± 0.041	20.75± 0.046	15.92± 0.045	11.86± 0.068
Average pH	7.69± 0.001	7.57± 0.012	7.22± 0.007	6.88± 0.028	7.21± 0.008	7.04± 0.009	6.93± 0.006	7.12± 0.003	7.11± 0.004	7.20± 0.006	7.48± 0.008
Average conductivity (mS/cm)	0.14± 0.056	0.30± 0.001	0.36± 0.001	0.29± 0.005	0.20± 0.002	0.15± 0.0008	0.17± 0.0005	0.20± 0.0006	0.18± 0.0006	0.18± 0.0006	0.19± 0.0005

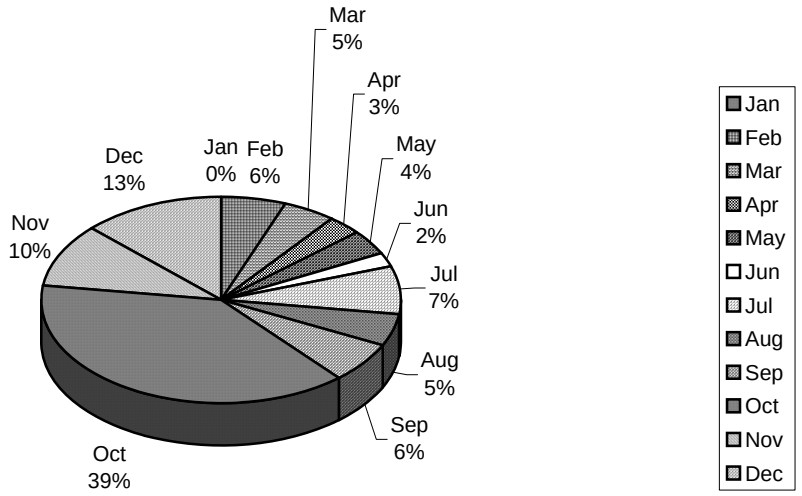

Fig.1: The conidial concentrations of canal water hyphomycetes in the Lahore Branch of the BRB Canal during the years 1991-1993

5. *Anguillospora* sp. E (Fig. 2: e,e′): This species of *Anguillospora* had very thin and highly sigmoid conidia of uniform thickness.
6. *Anguillospora* sp. G (Fig. 2: g,g′): The conidium of this species of *Anguillospora* was curved in a single plane and tapering towards the ends.
7. *Anguillospora* sp. H (Fig.2: h): The conidia of this species, only detected on filter membranes were highly sigmoid and filiform, but much longer than *Anguillospora filiformis* Greathead.
8. *Anguillospora* sp.I (Fig.2: i): The conidium of this species, only detected on filters was almost uniform in thickness and C-shaped but not in a single plane.
9. *Campylospora* sp.I (Fig. 2: j): This species of *Campylospora* was much larger than *Campylospora chaetocladia.* The central part was similar to *C.chaetocladia* but the four arms were about three times longer.
10. *Clavariopsis* sp. I (Fig. 2: k): The size of the radiating arms of this species was almost double than *Clavariopsis aquatica*. The main body was also more bulbous than *C. aquatica.*
11. *Dwayaangam* sp. I (Fig.3: l): Although this

species appears to be quite similar to *Dwayaangam cornuta* Descals in size but the upper two arms are significantly different in being uniseptate and curved. A single conidium was observed just once on a filter membrane.

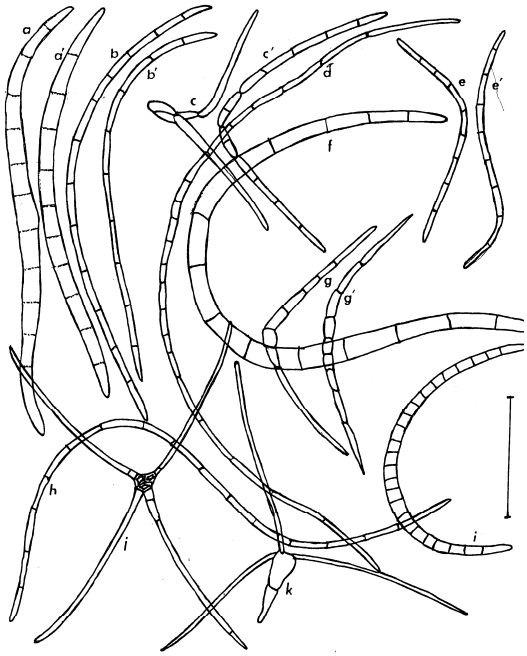

Fig. 2: Unknown species of freshwater hyphomycetes in canal water. a,a′: Conidia of *Anguillospora* sp. A; b,b′: *Anguillospora* sp. B; c,c′: *Anguillospora* sp. C; d,d′: *Anguillospora* sp. D; e,e′: *Anguillospora* sp. E; f: *Anguillospora* sp. F; g,g′: *Anguillospora* sp. G; h: *Anguillospora* sp. H; i: *Anguillospora* sp. I; j: *Campylospora* sp.I; k: *Clavariopsis* sp. I. (Scale line=50 μm)

12. *Entomophthora* sp. I (Fig. 3: m): The conidia of this species were almost similar in dimension with *Heliscus* but with three thin radiating arms. The conidia were yellowish green in colour when not stained.
13. *Flagellospora sp*. A (Fig.3: n,n′): This species of *Flagellospora* was very common in the canal especially during the summer indicating its sub-tropical habitat. The size of conidia did not conform to any known species of *Flagellospora.*
14. *Flagellospora* sp. B (Fig.3: o,o′): The conidia of this species were similar in size and shape to the genus *Flagellospora.* The conidia were characteristically uniseptate.
15. *Helicomyces* sp. A: These helicoids conidia were very thin and uniform in breadth and belong to aero-aquatic fungi.
16. *Hydrometrospora* sp. I. (Fig.3: p): The conidia of this species were smaller than *Hydrometrospora symmetrica* Gonc. and Revay.
17. *Mycocentrospora* sp.A (Fig.3: q,q′): the conidia of this species of *Mycocentrospora* were lunar-shaped. The basal whips and the upper attenuated ends indicate that they belong to the genus *Mycocentrospora.*
18. *Mycocentrospora* sp. B (Fig.3: r,r′): These conidia of *Mycocentrospora* showed some superficial resemblance with *Mycocentrospora acerina* but were smaller in size.
19. *Mycocentrospora* sp. C (Fig.3: s,s′): It appeared to be an unknown species very different from all known species of the genus.

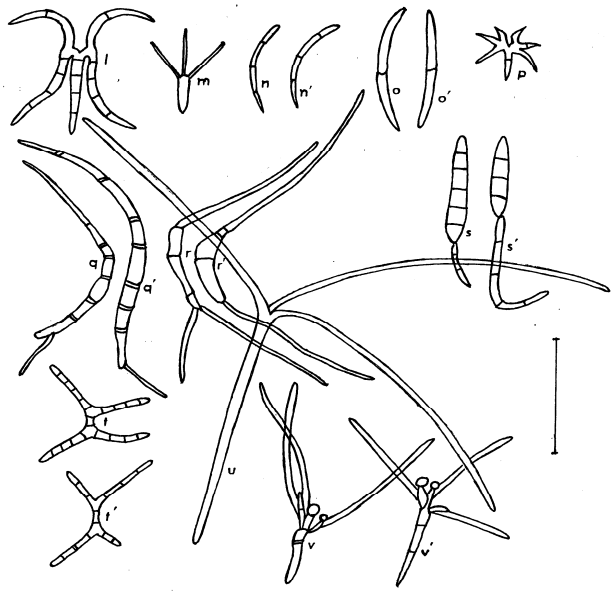

Fig. 3: Unknown species of freshwater hyphomycetes in canal water. l: *Dwayaangam* sp.I; m: *Entomophthora* sp. I; n,n′: *Flagellospora* sp. A; o,o′: *Flagellospora* sp. B; pp,pp′,pp″: *Helicomyces* sp.A; p: *Hydrometrospora* sp.I; q,q′: *Mycocentrospora* sp. A; r,r′: *Mycocentrospora* sp.B; s,s′: *Mycocentrospora* sp.C; t,t′: *Scorpiosporium* sp.I; u: *Tetrachaetum* sp.I; v,v′: *Tetracladium* sp.I. (Scale line=50 μm).

20. *Scorpiosporium* sp.I (fig.3: t,t′): This species with a scorpioid axis was common in the canal from July till the end of December.
21. *Tetrachaetum* sp. I (Fig.3: u): This species showed a preference for high temperature because it appeared only during the high temperature regime. The morphology of this conidium conforms to *Alatospora flagellata* (Gonc.) Marv. The main axis of conidium thins out from the point where the lateral arms formed, so that there is a bulbous central part with three thinner radiating arms.
22. *Tetracladium* sp. I (Fig.3: v,v′): The

conidia of this species were observed just once on a filter membrane. The conidia were larger than *Tetracladium marchalianum.* These conidia had three central elongated knobs, two of them having secondary rounded knobs.

24. Species I (Fig.3: w,w′): These stellate conidia were observed on membrane filters. They might belong to dematiaceous hyphomycetes.
23. Species II (Fig. 4: x,x′): These H or K-shaped small conidia, occasionally observed on filters and may belong to dematiaceous hyphomycetes.
24. Species A (Fig.4:y): This unknown conidium may belong to other groups of fungi. Both ends of the conidium were tapering.
25. Species III (Fig. 4: z,z′): These tetraradiate conidia, occasionally observed on filters may belong to dematiaceous hyphomycetes. Among the aquatic hyphomycetes they appear nearest to the genus *Lemmoniera*

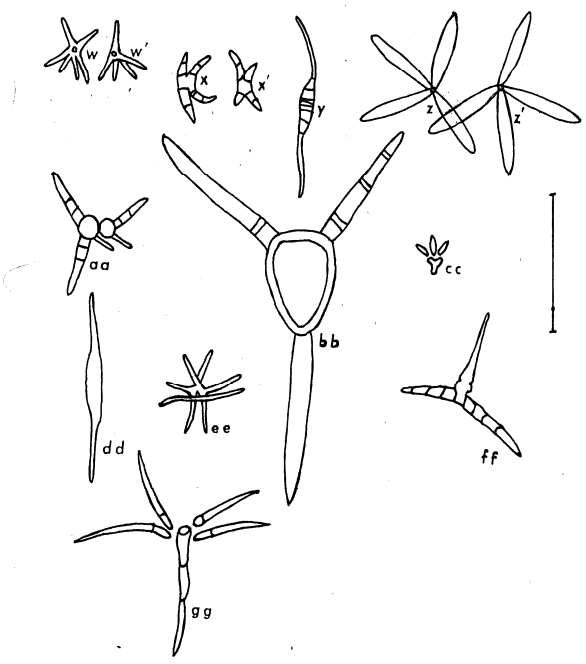

Fig. 4: Unknown genera of freshwater hyphomycetes in canal water. w,w′: Species I; x,x′,x″: Species II; y: Species A; z,z′: Species III; aa: Species IV; bb: Species V; cc: Species VI; dd: Species B; ee: Species VII; ff: Species VIII; gg: Species IX. (Scale line=50 μm)

26. Species IV (Fig.4: aa): This conidium was observed just once on a filter membrane.
27. Species V (Fig.4: bb): This triradiate conidium was observed just once on a filter membrane.
28. Species VI (Fig.4: cc): This small conidium is nearest to *Volucrispora* and *Tricellula.* Similar conidia of *V. aurantiaca* Haskins have been reported by Aimer and Segedin (1985) from New Zealand but this conidium is much smaller in size.
29. Species B (Fig.4: dd): This unknown conidium with tapering ends was once observed on filter membrane.
30. Species VII (Fig.4: ee): This stellate conidium, observed just once has no affinity with any of the known species.
31. Species VIII Fig.4: ff): This conidium with a single characteristic lateral arm is nearest to *Tricellula* in morphology but is much larger than the known species. It observed just once.
32. Species IX (Fig.4: gg): This conidium with four arms was observed just once on a filter membrane.

Discussion

The conidial dynamics in canal waters represents a unique model for freshwater hyphomycetes. The prevailing temperature regime is high and fluctuates little during the year. Because of the massiveness of the canal, the diurnal fluctuation is also little. The studies carried out in tropical streams do not indicate a diversity of species. They generally appear to be summer species.. In Florida, only 13 species were observed during a year (Akeridge and Koehn, 1987). In India on a number of bait leaves, only 18 species were observed (Sridhar and Kaveriappa, 1989). In the temperate rivers like the river Teign in Britain up to 59 species have been observed by Shearer and Webster (1985). In the canal a large number of species may be attributed to the semi tropical habitat. Some of the species are exclusive to this habitat and many unidentified species are observed.

The semi tropical canal water habitat is characterized by species like *Flagellospora penicillioides, Lunulospora curvula, Tetracladium marchalianum* and *Triscelophorus monosporus.* Three species out of these are typical summer species (Suberkropp, 1984; Barlocher, 1992; Gessner et al., 1993). The species prevalent in the temperate streams like *Anguillospora longissima, Articulospora tetracladia, Lemmoniera aquatica, L. centrosphaera* and *Tetrachaetum elegans* are absent for most of the year and appear periodically during the low temperature regime and most of these are known winter species. The case is just the reverse in temperate cold water streams, where the summer species appear periodically under the

high temperature regime (Firdaus-e-Bareen and Iqbal, 1994).

Some of the species in the canal were more influenced by the amount of substratum than by temperature. These species showed gradual increase in their frequency of occurrence and conidial concentration with the increase in the amount of the substratum. The common ones among them were *Anguillospora* sp.C, *Campylospora chaetocladia*, *Heliscus tentaculus*, *Mycocentrospora iqbalii*, *Pyramidospora casuarinae* and *Scorpiosporium* sp. I.

Some of the species whose behavior has been different in the canal include *Flagellospora curvula*. It is known for its affinity in low temperature but was observed throughout the year in the canal. Other species not known from such habitat but present in the canal include *Articulospora proliferata* and *Lunulospora cymbiformis*. They can possibly be considered new ecological variants of the existing types, having preference for relatively high temperature.

The maximum number of conidia in water was observed to be 1757 per liter during December when the lowest temperature was recorded accompanied by maximum deposition of leaves. In Lahore, leaf fall overlaps winter (Firdaus-e-Bareen,1994).In general the percentage conidial concentration is gradually increased from April (4%) till December (19%). The minimum conidial concentration (3%) was observed during June. The sudden abrupt elevation in July may be attributed to the rainy season. The rainfall stimulates conidiogenesis obviously because raindrops induce turbulence in water. Similar elevations have been observed by Iqbal and Bhatty (1979) in April in temperate streams of Murree Hills.

The effect of substratum build-up on the number of species and conidial concentration can be emphasized by the fact that maximum conidial concentration was observed in December (19%) and was significantly reduced to 8% in February. After removal of substratum in January, during closure of canal, the water temperature was still favourable for most of the species to sporulate. In fact in the canal, among the physical factors, the significantly varying and influential factors seem to be the temperature, the amount of substratum and turbidity. The changes in conidial concentration in the canal are clearly visible under the influence of these three factors.

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