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AQUATIC HYPHOMYCETES IN A TRIBUTARY OF THE MORGÓ STREAM, BÖRZSÖNY MTS, NE HUNGARY

J. GÖNCZÖL and Á. RÉVAY

Dept. Botany, Hungarian Natural History Museum
H–1476 Budapest, Pf. 222, Hungary

Conidial populations of the Csömöle stream, Börzsöny Mts were sampled by membrane filtration. This tributary of the Morgó stream is a moderately hardwater stream with a riparian vegetation dominated by *Carpinus betulus* and *Fagus sylvatica*. In total 45 fungal species were collected of which 10 were detected throughout the study. *Filosporella* sp. was the only species dominant on every sampling date. The highest conidial concentrations occurred in December and the lowest in January. Unusually high proportions of the scolecospores were obtained in the conidial populations. Similarity indices reflected only moderate similarity between the fungal communities of the Csömöle stream and the lower section of the Morgó stream.

Key words: aquatic hyphomycetes, conidial populations, scolecospores, tributary stream

INTRODUCTION

Aquatic hyphomycetes or Ingoldian fungi are important members of stream organisms colonising and decomposing allochtonous leaf and woody litter (BÄRLOCHER 1992). Spatial and temporal distribution of conidial communities of aquatic hyphomycetes has been studied in various types of streams in various climatic and geographical regions of the world.

The spatial distribution of these fungi has recently been categorized by the scale on which they are detected (BÄRLOCHER 1987, FABRE 1998*c*). The distribution of aquatic hyphomycetes on a global or world scale appears to be decisively influenced by the climatic zones (INGOLD 1975, WOOD-EGGENSCHWILER and BÄRLOCHER 1985). Within the same climatic zone water chemistry, especially pH, has a controlling effect for the number of species coexisting in a stream (BÄRLOCHER and ROSSET 1981, WOOD-EGGENSCHWILER and BÄRLOCHER 1983, CHAUVET 1991). Spatial distribution of the aquatic hyphomycetes in a small area, for example in a stream or in a stream system has also been studied (GÖNCZÖL 1975, SHEARER and WEBSTER 1985, THOMAS *et al.* 1989, 1991, FABRE 1996, 1998*a*, *b*, *c*). Nevertheless our knowledge in this field is yet insufficient and further studies need to recognise general patterns of spatial dynamics of individual species in different kinds of streams or in stream systems.

Spatial and temporal distribution of conidial communities of aquatic hyphomycetes of the Morgó stream system has been studied largely in the main channel of this stream system (GÖNCZÖL 1975, RÉVAY and GÖNCZÖL 1990, GÖNCZÖL and RÉVAY 1993, GÖNCZÖL *et al.* 1999, GÖNCZÖL and RÉVAY 1999). Little is known, however, about the aquatic hyphomycetes of the tributaries.

The main goal of this study was to compare conidial communities of aquatic hyphomycetes of a tributary and the main channel of the Morgó stream. From the comparison of aquatic fungal communities of sites different in their water chemistry and/or riparian vegetation was hoped to get further data about the ecological requirements of individual species.

MATERIALS AND METHODS

Sampling site and technique

The study was conducted at the Csömöle stream, a second order tributary of the Morgó stream. This is a small, generally 1 m wide and 10–20 cm deep, slowly flowing and slightly meandering stream of rocky bed and with low but fairly constant discharge. One sampling site (Site Cs) was chosen approximately midway along the stream (Fig. 1). Water temperature, conductivity, pH and total hardness were measured in the field on every sampling occasion. The measuring methods and instruments were the same as those published earlier (RÉVAY and GÖNCZÖL 1990).

Two water samples (250–250 ml) were taken on the following dates: 9 April, 5 June, 15 August, 25 October, 5 December 1997 and 21 January 1998. Immediately after collection the water samples were passed through Whatman Isopore polycarbonate membrane filters (25 mm diam, 8 µm pore size) using pneumatic pumps (Antlia Pressure Filtration System, Schleicher and Schuell, Dassel, Germany). The conidia retained on the filter surface were stained with cotton blue in lactic acid. The entire surface of each filter was thoroughly scanned and at 250–400× magnification the conidia identified and counted. The number of conidia per litre of water was then calculated.

The species composition of the leaf litter in the stream bed was analysed. 500–500 leaves were randomly collected from the stream around the sampling site on 25 October 1997 and on 6 November 1998. The leaves were identified, counted and their relative frequencies calculated.

To compare the aquatic hyphomycete communities detected in the Csömöle stream and at six sites of the Morgó stream studied earlier (GÖNCZÖL *et al.* 1999) two similarity indices were calculated. Sørensen's index = 2c/a+b * 100, with a+b = sum of the number of species of two sites, and c = number of species in

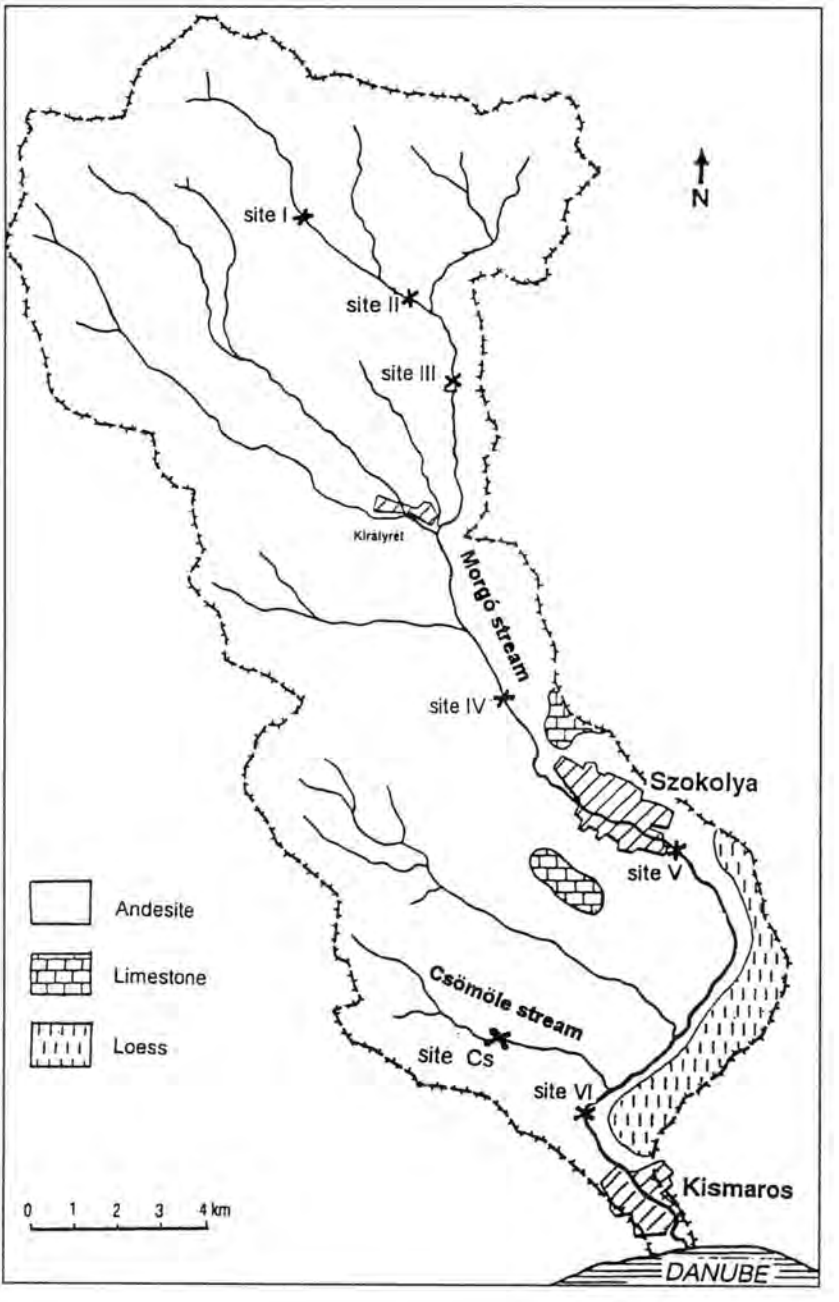


Fig. 1. Watershed area of the Morgó stream system and the sampling sites.

common to both sites, Kendall's index was calculated from the sum of the lower percentages of occurrence in either of the two communities:

$$\sum_{i=1}^{s} \min [\, x_{ij}, x_{ik} \,]$$

where x_{ij} and x_{ik} are the proportion of total sample belonging to *i*th species in samples j and k, s = number of species.

RESULTS

Physicochemical characteristics of the Csömöle stream at the studied site are summarized in Table 1. The chemical data show that this tributary can be classified as a moderately hardwater stream with high conductivity and alkaline pH.

Analysis of the leaf substratum collected from the stream bed shows that the Csömöle stream around the study site is lined by several tree species, the most common amongst them being *Carpinus betulus* and *Fagus sylvatica* (Table 2).

The fungal species encountered on the six sampling occasions and their proportions in the stream spora are listed in Table 3. In total 45 fungal species were detected by water filtration. Thirty-three are described, a further 9 were identified to genus and the remaining 3 were of unknown affinities.

The total number of species recorded varied temporally during the study. The highest species number occurred in October and the lowest in June.

The highest conidial concentrations occurred in December and the lowest were found in January. In April, June and October the conidial numbers were almost the same (Table 3). A high proportion (48%) of the stream spora (sum of all

Table 1. Physicochemical and hydrological characteristics of the sampling site at the Csömöle stream.

Site Cs	data
altitude (m)	190
distance from the spring (km)	2.07
channel gradient (%)	3.82–4.43
stream order	second
temperature (°C)	0–17
pH	7.8–8.3
total hardness (d°)	13.5–17.5
conductivity (μS/cm)	400–720

Table 2. Species composition of the leaf litter in the stream bed.

Species	average	%
Acer pseudoplatanus L.	26.5	5.3
Carpinus betulus L.	226.0	45.2
Fagus sylvatica L.	159.0	31.8
Quercus cerris L	16.5	3.3
Quercus petraea (Mattuschka) Lieblein	9.5	1.9
Salix caprea L.	3.5	0.7
Salix cinerea L.	18.0	3.6
Tilia cordata Miller	39.0	7.8
Tilia platyphyllos Scop.	2.0	0.4

conidia collected in the six samples) belonged to scolecosporous species. Extremely high proportions of scolecospores were obtained in the summer samples (93.7% in June, and 89.4% in August).

Altogether 10 species were observed as being present throughout the study but with different conidial numbers. The most prolific species were – *Alatospora acuminata* s.l., *Filosporella* sp., *Tricladium angulatum*, *Flagellospora leucorhynchos* and *Anguillospora* sp. 1 – which together accounted more than 80% of the conidia collected during the study. Of these only one species, *Filosporella* sp., occurred among the top-ranked species on every sampling occasion. The other four species varied in the timing of their maximum conidial production. *Anguillospora* sp. 1 peaked in April and June, whereas *Tricladium angulatum* was most abundant in October and December. The number of conidia of *Alatospora acuminata* s.l. and *Flagellospora leucorhynchos* was extremely high in December. Further 7 species occurred frequently (proportion of conidia greater than 5% of total at least one occasion) in the water samples (Fig. 2). The maximum number of conidia of *Lemonniera aquatica* at Site Cs (245/l) was similar to those of at Sites V and VI (251.5/l; 192/l) of the Morgó stream, but because of the large conidial production of other species its relative proportion was lower than 5% in the Csömöle stream.

In the comparison of the Csömöle stream with the six sites of the Morgó stream the similarity indices showed high similarity between their fungal communities only on the basis of presence and absence of species. However, when the relative frequencies of occurrence were taken into account, the similarity indices considerably decreased. On the basis of relative frequencies of species the structure of fungal communities of the Csömöle stream is most similar to the most lower site of the Morgó stream. The relatively high similarity value (45.01)

Table 3. Percentage distribution of fungal species filtered on each sampling occasion in the Csömöle stream.

Species	Apr.	Jun.	Aug.	Oct.	Dec.	Jan.
Alatospora acuminata Ingold	16.65	2.96	0.74	7.71	48.31	16.58
Alatospora flagellata (Gönczöl) Marvanová	0.21	0.11			0.14	0.53
Anguillospora crassa Ingold			0.55	0.10		
Anguillospora longissima (de Wild.) Ingold	5.41	5.71	3.11	2.71	0.22	3.48
Anguillospora rosea Descals et Marvanová sp. ined.	0.94	1.52	1.83	0.68	0.56	0.53
Anguillospora sp. 1	39.75	13.46	7.14	4.48	0.81	2.67
Anguillospora sp. 2				4.16	0.04	
Articulospora tetracladia Ingold	0.05			0.05		0.27
Camposporium marylandicum Shearer				0.10		
Camposporium pellucidum (Grove) Hughes						1.07
Clavariopsis aquatica de Wild.		0.27	4.76	4.48	0.02	5.35
Clavatospora longibrachiata (Ingold) Marvanová et S. Nilsson		0.22		0.16	0.07	0.53
Clavatospora sp.					0.02	
Cylindrocarpon sp.	0.21	0.32	0.74	0.26		
Dimorphospora foliicola Tubaki	0.05			0.16	0.02	
Filosporella annelidica (Shearer et Crane) Crane et Shearer	0.94	0.86	1.28	2.19	1.15	13.10
Filosporella sp.	14.05	71.38	57.69	47.39	8.08	31.02
Flagellospora curvula Ingold	0.62		1.28	1.25	5.26	3.74
Flagellospora leucorhynchos Marvanová				1.88	15.88	1.07
Fusarium sp.	0.31	0.32	9.52	0.16	0.02	
Heliscella stellata (Ingold et Cox) Marvanová	1.77				0.37	12.30
Heliscus lugdunensis Sacc. et Therry	7.60	0.16	0.18	1.78	0.16	0.80
Lemonniera aquatica de Wild.			0.74	1.78	4.14	0.27
Lemonniera cornuta Ranzoni				0.78	0.02	
Lemonniera terrestris Tubaki	0.05			0.83	0.01	
Mirandina sp.	1.04	0.16	1.83	0.68	0.03	0.53
Sigmoidea praelonga Marvanová					0.17	
Stenocladiella neglecta (Marvanová et Descals) Marvanová et Descals	0.10	0.05		0.16	0.02	
Tetrachaetum elegans Ingold				0.16		

Table 3 (continued)

Species	Apr.	Jun.	Aug.	Oct.	Dec.	Jan.
Tetracladium marchalianum de Wild.	0.68	0.11	0.37	2.08	0.96	0.27
Tetracladium maxilliforme (Rostrup) Ingold	0.05				0.02	
Tetracladium setigerum (Grove) Ingold				0.05	0.07	
Tricellula aquatica Webster					0.01	
Trichocladium angelicum Roldán et Honrubia		0.11	1.47	0.16	0.02	0.80
Tricladium angulatum Ingold	7.29	0.48	0.18	10.93	13.32	0.27
Tricladium sp.	0.10	0.05				
Tricladium splendens Ingold						0.27
Triscelophorus monosporus Ingold		0.11		0.05		
Triscelophorus sp.	0.16	0.05			0.03	
Tumularia aquatica (Ingold) Descals et Marvanová	1.14		2.20	0.57	0.02	2.14
Tumularia tuberculata (Gönczöl) Descals et Marvanová	0.62	0.16		0.26		
Vargamyces aquaticus (Dudka) Tóth	0.21	0.43	2.38	0.26		2.41
Unidentified				1.03	0.51	
Sigmoid 1				0.52		
Sigmoid 2			2.01			
Number of conidia/l	3844	3716	1092	3840	23688	748
Number of species	25	22	20	34	32	23

between Site II and Site Cs is due to the exceptionally high conidial concentrations of *Alatospora acuminata* s.l. (Table 4).

DISCUSSION

Because of the spatial closeness of the Csömöle stream and downstream portion of the Morgó stream, predictable conidial communities were expected during this study. In spite of this expectation between the conidial communities at the Site Cs and the sites along the Morgó stream very low similarities were detected. The strikingly high proportion of the scolecoconidia, the absence or very low proportion of conidia of some species predominantly occurring in conidial populations of the Morgó stream, and finally the substantial occurrence of conidia of aquatic hyphomycete species not detected so far in the Morgó stream were the major distinctive characteristics of aquatic hyphomycete communities in the Csömöle stream.

Table 4. Similarity comparisons of the fungal spora found in the Csömöle stream and at six sampling sites of the Morgó stream. Upper number: similarity values, in %, based on Sørensen's index; lower number, in brackets: similarity values based on Kendall's index.

	Morgó stream					
	Site I	Site II	Site III	Site IV	Site V	Site VI
Csömöle stream	69.88	70.21	80.00	78.35	80.89	80.00
	(22.85)	(45.01)	(28.09)	(32.36)	(34.27)	(42.86)

The highest number of conidia (23688/l) encountered in this study was more than twofold of the highest value (10926/l) obtained earlier in the main channel (GÖNCZÖL *et al.* 1999). The surprisingly low conidial concentrations in October and the strikingly high concentrations in December differ from the

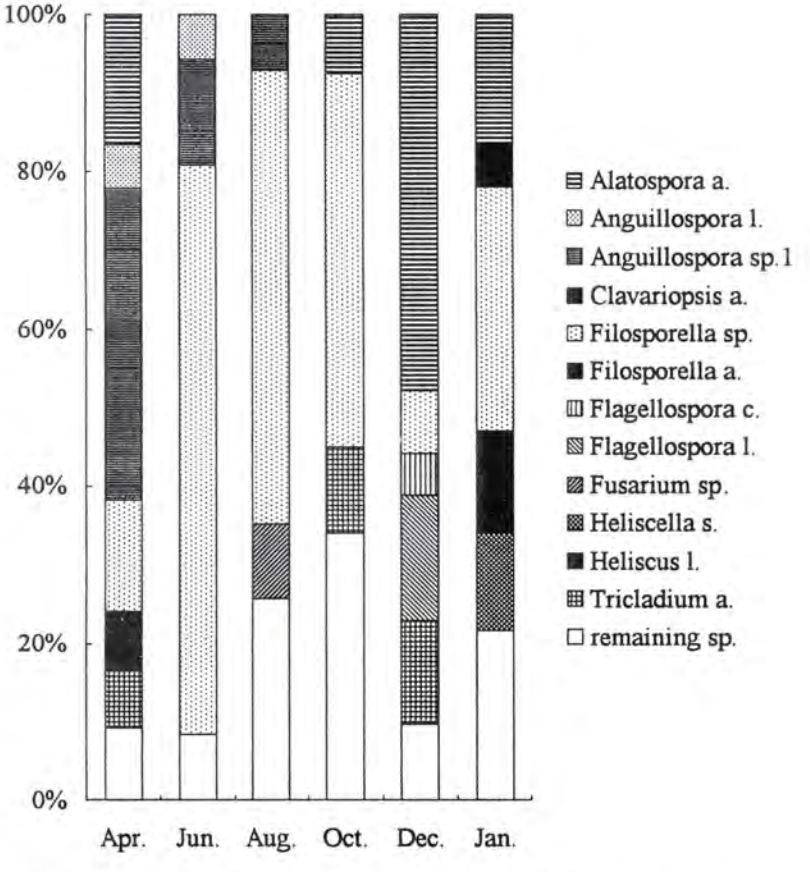


Fig. 2. Relative proportions of conidia of dominant (>5% of the total collected) species in each sample. (see Table 3 for species names).

general pattern of the temporal changes of conidial concentrations recorded in most streams in temperate regions (IQBAL and WEBSTER 1973, BÄRLOCHER and ROSSET 1981, CHAMIER and DIXON 1982, SHEARER and WEBSTER 1985). Delayed appearance of the peak in conidial number may be partly due to the hydrological feature of this stream (i.e. meandering stream bed, low current velocity and constantly low discharge) inducing a certainly high, litter retentive capability. The main reason for the relatively high conidial concentration still in June may be the same. The minimum conidial concentration (748/l) in January can be attributed to the almost entirely frozen stream and the restricted water movement.

The proportion of scolecoconidia in the conidial populations in the Csömöle stream was strikingly high. The analysis showed that scolecoconidia accounted for 48% (19 species) and 29.5% (21 species) of the conidia collected in the Csömöle stream and the Morgó stream, respectively. No reasonable explanation for this structure of the conidial pools could be found. Nevertheless, as one speculation comes up that low discharge combined with very low current speed in a woodland stream may be preferred by scolecosporous species. Whether hydrological feature may select species in particular stream habitats certainly requires further studies.

The total number of species (45) is comparable to the species numbers detected at any, especially the two lowermost sites (Site V = 44, Site VI = 45) of the Morgó stream (GÖNCZÖL *et al.* 1999). The slightly alkaline character of the stream appears not to diminish the fungal species number. Considering taxonomic difficulties in the identification of conidia the actual number of species is certainly even higher. The present investigation, like some earlier studies, also confirms that softwater and hardwater streams in various geographical areas in Hungary support fungal communities with closely similar species numbers (GÖNCZÖL 1987, GÖNCZÖL and RÉVAY 1992).

Two species, *Flagellospora leucorhynchos* and *Sigmoidea praelonga*, have not been found yet in the Morgó stream, but had already been reported from two hardwater streams of the Aggtelek National Park, Hungary (GÖNCZÖL and RÉVAY 1992). The identification of *Flagellospora leucorhynchos* is somewhat difficult since it may easily be confused with *F. curvula*. Whether its abundant occurrence is restricted to small streams with similar hydrological features to those of Csömöle, Patkós and Kecske-kút streams (Aggtelek Mts) require further investigations.

Extremely high proportion (48.3%) of *Alatospora acuminata* was detected in December. A similarly high percentage (42.6%) of this species was obtained earlier in an October sample at Site II of the Morgó stream. These high values at both sites coincided with the annual peak concentration of the stream spora.

Tricladium angulatum proved to be a dominant species in April, October and December. Its considerable occurrence in this stream further confirms our as-

sumption that low altitudes and/or hardwater may be preferred habitats by this species (ROSSET and BÄRLOCHER 1985, CHAUVET 1991).

At the same time *Tetracladium marchalianum* classified also as a species typical in hardwater (ROSSET and BÄRLOCHER 1985) and/or in lowland streams (CHAUVET 1991) occurred only with very low proportion in the conidial communities throughout the year. This finding is a further contribution to the knowledge of the spatial distribution of this species. Considering both the altitude (190 m) and the chemical character of the stream at Site Cs a higher occurrence of *T. marchalianum* would be expected. An explanation for the limited role of *T. marchalianum* at this site may be in connection with the absence of alder (*Alnus glutinosa*) and the dominance of beech (*Fagus sylvatica*) in the riparian vegetation. Co-occurrence of *T. marchalianum* and alder leaf substratum have been pointed out in several streams in Hungary (GÖNCZÖL and RÉVAY 1992).

Because of the spatial closeness of the downstream sites of the Morgó stream where *Clavatospora tentacula* is a consistent species in the summer and early autumn conidial communities (GÖNCZÖL 1971, 1975, GÖNCZÖL *et al.* 1999) its absence at Site Cs in the Csömöle stream was striking. The influence of the annual temperature range, being more limited than that of the Morgó stream, can be suspected as one of the reasons for the different patterns of the distribution of *C. tentacula*.

The hardly detectable presence of *Tetrachaetum elegans* and *Tumularia tuberculata*, might be explained with the unfavourable chemical character of this stream. Both species are considered as typical in softwater streams (BÄRLOCHER and ROSSET 1981, GÖNCZÖL 1987).

Amongst the species with scolecoid conidia *Filosporella* sp. and *Anguillospora* sp. 1 were permanently present with high percentage distribution in most of the samples. *Filosporella* sp., a widely distributed species in the downstream portion of the Morgó stream (as *Filosporella* sp. 1 in GÖNCZÖL *et al.* 1999), appeared with extremely high proportions in summer and early autumn samples at Site Cs. The conidia of *Anguillospora* sp. 1 have been collected several times from hardwater streams in Aggtelek Mts (GÖNCZÖL and RÉVAY 1992) and this species was pointed out as a late colonist on submerged wood immersed at hardwater portion of the Morgó stream (RÉVAY and GÖNCZÖL 1990, GÖNCZÖL and RÉVAY 1993). The identification of these two important species is warranted both in taxonomic and ecological respect.

* * *

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