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# AQUATIC HYPHOMYCETES IN TWO STREAMS DIFFERING IN DISCHARGE AND DISTRIBUTION OF LEAF LITTER

J. GÖNCZÖL and Á. RÉVAY

*Department of Botany, Hungarian Natural History Museum*
*H-1476 Budapest, Pf. 222, Hungary;*
*E-mail: gonczol@bot.nhmus.hu, revay@bot.nhmus.hu*

Aquatic hyphomycete conidia in transport at four sites in two second-order streams in the Börzsöny Mountains, Hungary were analysed in April, October and November. The streams differed in discharge, water chemistry, distribution and composition of leaf litter in the streambed. Both the conidial concentrations and the numbers of aquatic hyphomycete species were significantly higher in the moderately hardwater, slow-flowing Deszkametsző stream than in the softwater, fast-flowing Bagolybükk stream. Opposite patterns of changes in conidial concentrations in a downstream direction were obtained in the two tributaries. Conidial numbers and discharge changed in a contrary direction in both streams. The relatively high conidial concentrations (more than 20,000 conidia $L^{-1}$) appear to be a general pattern in low-order streams with slow-flowing shallow water, low discharge and meandering streambed filled with a continuous layer of leaf litter. In total 66 fungal species were distinguished whose 60% occurred in both streams. Four species – *Alatospora acuminata, Clavariopsis aquatica, Flagellospora curvula* and *Tetrachaetum elegans* – occurred among the top-ranked species at all sites of the two streams.

Key words: aquatic hyphomycetes, conidial populations, discharge, leaf litter

## INTRODUCTION

Aquatic hyphomycetes (INGOLD 1942) are one of the groups of stream microorganisms decomposing allochthonous plant litter in woodland streams (BÄRLOCHER 1992*a*). To understand better their spatial and temporal distribution in different types of streams species composition and concentrations of the conidia in transport have been studied for a long time. From many studies it is obvious that water chemistry plays an important role in structuring fungal communities (BÄRLOCHER and ROSSET 1981, WOOD-EGGENSCHWILER and BÄRLOCHER 1983, MARVANOVÁ 1984, BÄRLOCHER 1987). Some other studies suggested the importance of altitude or factors associated with it (CHAUVET 1991, FABRE 1996). The effect of the composition of allochthonous litter and stream hydraulics on the occurrence and abundance of aquatic hyphomycetes in streams is less known.

Spatial distribution of the aquatic hyphomycetes on eleven sites in the catchment area of the Morgó stream has recently been studied (GÖNCZÖL *et al.* 1999, GÖNCZÖL and RÉVAY 1999, 2003). A comprehensive statistical analysis of earlier data suggested that the effect of abiotic habitat variables and substrate composition in determining fungal communities were both important, but not to the same degree (GÖNCZÖL *et al.* 2003). The results of canonical correspondence analysis suggested that altitude, water hardness and conductivity were the major factors correlated with the distribution of individual species. At the same time we still know little about the composition of conidial communities and conidial concentrations in low-order, small streams in the Morgó stream system. There are little data in the literature on conidial concentrations, amount of allochthonous substrates and discharge in small streams. It is well known that the major peak in conidial numbers in forested streams in temperate climates coincides with leaf fall (IQBAL and WEBSTER 1973, BÄRLOCHER and ROSSET 1981, SHEARER and WEBSTER 1985*b*). However, we know little how stream hydraulics affects the structure and quantity of substrates and the spore concentrations in stream water.

Therefore the objectives of this study were: 1) to survey the structure and estimate quantity of the leaf litter in two second-order tributaries differing in hydrological features in the Morgó stream system, and 2) to analyse the species composition and conidial numbers of aquatic hyphomycetes in these small streams.

## MATERIALS AND METHODS

The study was conducted on the Deszkametsző and Bagolybükk streams, two second-order tributaries of the Morgó stream (Börzsöny Mts, Hungary). Two sampling sites were chosen in each stream (D1, D2, B1, B2 in Fig. 1).

Five water samples (5 × 150 ml) were taken at each sampling site on 21 April, 25 October and 29 November 2001. 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 & Schuell, Dassel, Germany). The conidia trapped on the filters were stained with cotton blue in lactic acid. The entire surface of each filter was thoroughly scanned at 250–400× magnification and the conidia were identified and counted. The number of conidia per litre of water was then calculated.

The stream sites were characterised by geographical and some physicochemical parameters. Water temperature, pH, conductivity, total hardness and discharge were measured in the field on each sampling occasion (Table 1). Discharge was calculated by measuring the current velocity with a propeller-type current meter (FP 101 Flow Probe, Global Water Instrumentation, USA).

The species composition of the leaf litter in the streambed was estimated by randomly taking 500 pieces of leaves collected in October and November from *ca* 300–500 m long sections of the streams above each sampling site. The leaves were identified, counted and their relative frequencies were calculated (Table 2).

The *t*-test was used for testing differences in water chemistry and in total number of species between streams and for comparison of conidial concentrations at the sites of each stream.

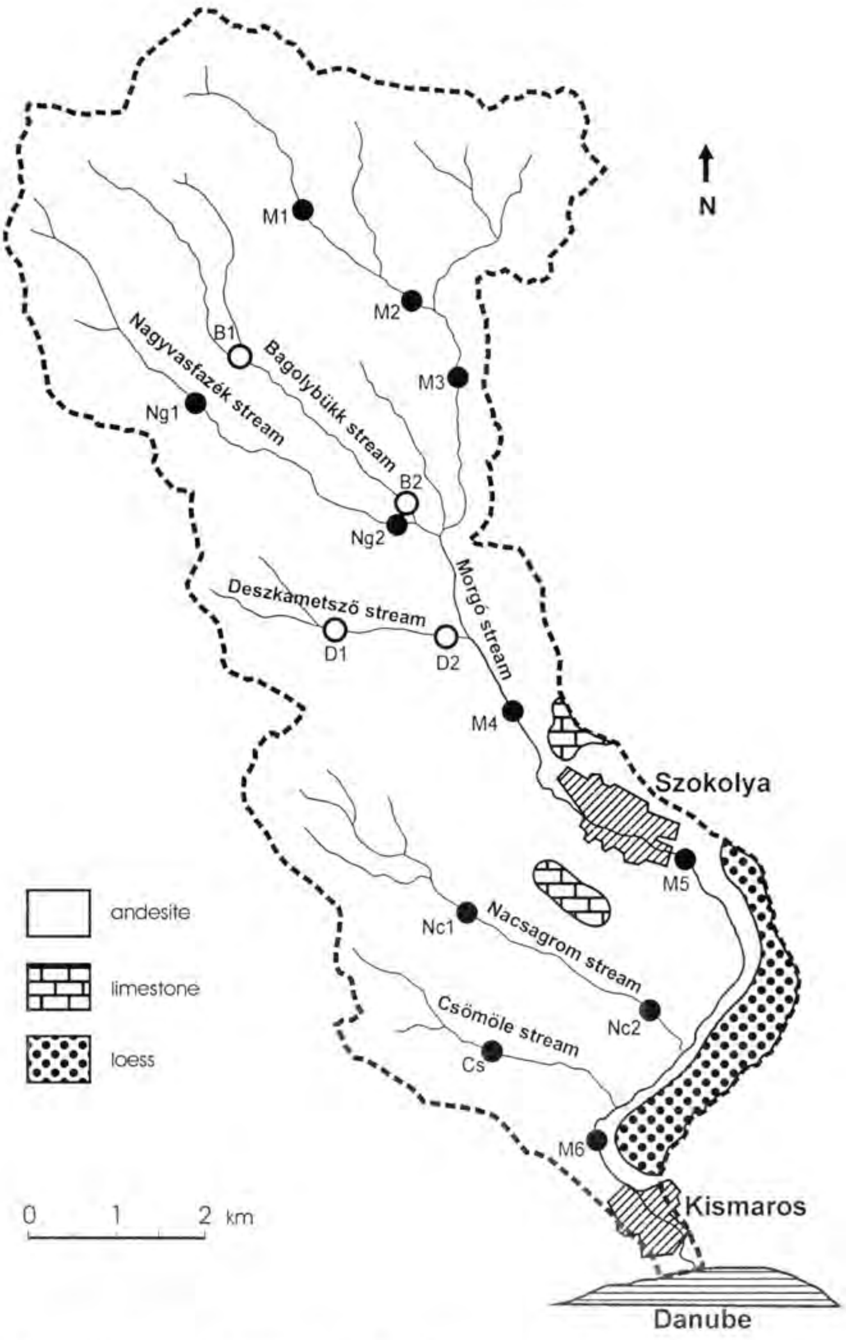

Fig. 1. Location of the sampling sites in the Morgó catchment area. Dashed line = boundary of the catchment area. Oblique hatching = village. ○ = Sites in the present study, ● = previously studied sites.

**Table 1.** Physicochemical and hydrological data of the sampling sites at the Deszkametsző (Desz) and Bagolybükk (Bag) streams (* = $P < 0.05$; ** = $P < 0.01$, t = Desz v. Bag).

| | Desz-1 | Desz-2 | Bag-1 | Bag-2 | t |
|---|---|---|---|---|---|
| altitude (m) | 305 | 235 | 408 | 293 | |
| distance from the spring (km) | 1.3 | 3.2 | 3.0 | 5.6 | |
| temperature (°C) | 3.5–9.2 | 1.0–9.4 | 2.0–8.1 | 4.0–9.8 | |
| discharge (L $s^{-1}$) mean | 0.8 | 8.8 | 9.2 | 5.0 | |
| pH, mean | 7.9 | 8.2 | 7.4 | 7.4 | 2.69* |
| conductivity (μS $cm^{-1}$), mean | 260 | 270 | 117 | 127 | 5.17** |
| total hardness (°d), mean | 11.6 | 9.8 | 5.5 | 6.3 | 3.64* |

## RESULTS

The physicochemical and hydrological characteristics of the two streams at the sampling sites are given in Table 1. The chemical data show that the Deszkametsző is a moderately hardwater stream, whereas the Bagolybükk is a typical softwater stream. The means for pH, conductivity and total hardness were significantly different between the streams. Stream discharge was generally the lowest at the upper site of the Deszkametsző and the highest at the upper site of the Bagolybükk.

The analysis of the leaf substratum collected from the streambed above the study sites showed differences in the composition of leaf litter not only between the two streams but also between the sites along each stream, especially in the Bagolybükk stream (Table 2). The leaves of hornbeam (*Carpinus betulus*), beech (*Fagus sylvatica*) and linden (*Tilia cordata*) were the main components of the litter in the streambed at both sites of the Deszkametsző. The leaves of hornbeam and beech were most abundant at the upper site of the Bagolybükk, while maple (*Acer campestre*) and alder (*Alnus glutinosa*) were the most frequent tree species at the lower site of this stream.

The fungal species encountered in the streams are listed in Table 3. A total of 66 fungal species was distinguished, 11 of which could not be identified at the generic level. Significantly higher numbers of species were observed in the Deszkametsző than in the other stream, however the species number of the samples collected in November were closely similar to each other (Table 4). The total number of species was 58 in the Deszkametsző and 49 in the Bagolybükk (Table 3).

The average numbers of conidia per litre of stream water were always considerably higher in the Deszkametsző than in the Bagolybükk. The highest conidial

**Table 2.** Percentage composition of the leaf litter in the streambed above the sampling sites of the two streams.

| Species | Deszkametsző | | | | Bagolybükk | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 1 | | 2 | |
| | Oct. | Nov. | Oct. | Nov. | Oct. | Nov. | Oct. | Nov. |
| *Acer campestre* | | 0.2 | 0.6 | 8.1 | | 2.2 | 20.4 | 20.6 |
| *Alnus glutinosa* | | | 8.6 | 17.4 | | | 45.1 | 40.0 |
| *Carpinus betulus* | 41.5 | 35.7 | 32.1 | 14.0 | 67.6 | 55.8 | 5.9 | 11.1 |
| *Cerasus avium* | | | | | 0.8 | | | |
| *Cornus sanguinea* | | | | 1.2 | | 0.1 | | 1.9 |
| *Corylus avellana* | | 4.5 | 0.9 | 2.4 | | | 1.9 | 2.1 |
| *Crataegus monogyna* | | | | | | | 2.4 | 2.1 |
| *Fagus sylvatica* | 0.6 | 33.8 | 24.6 | 36.9 | 15.8 | 23.2 | | |
| *Populus tremula* | 9.2 | | | | | | | 0.8 |
| *Pyrus* sp. | | | | 1 | | | | |
| *Quercus cerris* | 8.3 | 4.1 | | 7.2 | 4.5 | 3.8 | | 0.4 |
| *Quercus petraea* | | 0.9 | 1.3 | 0.4 | 1.8 | 10.3 | 0.5 | 4.3 |
| *Robinia pseudacacia* | | | 4.3 | 7.1 | | | | |
| *Salix* sp. | 11.4 | 3.6 | | 0.4 | 6.3 | 0.3 | 17.8 | 7.2 |
| *Sorbus torminalis* | 0.3 | 0.4 | | | 0.9 | 1.4 | | |
| *Tilia cordata* | 24.6 | 16.4 | 25.9 | 2.9 | 3.2 | 1.8 | 1.7 | 6.8 |
| *Tilia platyphyllos* | 2.8 | 0.4 | 1.7 | 2.1 | | | | |
| *Ulmus laevis* | | | | | | | 4.3 | 2.7 |

concentrations occurred in November in both streams. Great differences in mean number of conidia per litre were found between sites in the autumn samples. The longitudinal change of conidial numbers showed opposite trends in the two streams. The numbers of conidia in October and November were significantly higher at site 1 (upstream) than at site 2 (downstream) in the Deszkametsző, whereas in the Bagolybükk significantly higher numbers of conidia were found at site 2 than at site 1 in November (Table 4).

Although 60% of the encountered species occurred in both streams, there were differences between the composition of the conidial populations (Table 5). Altogether 12 species occurred frequently (more than 5% of the total collected on at least one occasion) in both streams. Four species – *Alatospora acuminata*,

**Table 3.** Fungal species detected at each sampling site of the Deszkametsző and Bagolybükk streams.

| | Desz-1 | Desz-2 | Bag-1 | Bag-2 |
|---|---|---|---|---|
| *Actinospora megalospora* Ingold | + | – | – | – |
| *Alatospora acuminata* Ingold | + | + | + | + |
| *Alatospora flagellata* (Gönczöl) Marvanová | – | – | + | + |
| *Anavirga dendromorpha* Descals et Sutton | + | + | + | + |
| *Anguillospora crassa* Ingold | + | + | + | + |
| *Anguillospora furtiva* Webster et Descals | + | – | + | + |
| *Anguillospora longissima* (Sacc. et P. Syd.) Ingold | + | + | + | + |
| *Anguillospora mediocris* Gönczöl et Marvanová | + | + | + | + |
| *Anguillospora rosea* Webster et Descals | + | + | + | + |
| *Anguillospora* sp. 1 | + | + | + | + |
| *Anguillospora* sp. 2 | + | + | + | – |
| *Articulospora tetracladia* Ingold | + | + | + | + |
| *Camposporium pellucidum* (Grove) Hughes | + | + | + | – |
| *Clavariopsis aquatica* de Wild. | + | + | + | + |
| *Clavatospora longibrachiata* (Ingold) Marvanová et S. Nilsson | + | + | + | + |
| *Clavatospora tentacula* (Umphlett) S. Nilsson | + | + | – | – |
| *Clavatospora* sp. | – | + | – | + |
| *Colispora elongata* Marvanová | + | + | + | + |
| *Cylindrocarpon* spp. | + | + | + | + |
| *Dimorphospora foliicola* Tubaki | + | + | + | + |
| *Filosporella annelidica* (Shearer et Crane) Crane et Shearer | + | + | – | – |
| *Filosporella* sp. | + | + | + | + |
| *Flagellospora curvula* Ingold | + | + | + | + |
| *Flagellospora leucorhynchos* Marvanová | – | + | – | – |
| *Fusarium* spp. | + | + | + | + |
| *Heliscella stellata* (Ingold et Cox) Marvanová | + | + | + | + |
| *Heliscus lugdunensis* Sacc. et Therry | + | + | + | + |
| *Isthmolongispora minima* Matsushima | + | – | – | – |
| *Lemonniera aquatica* de Wild. | + | + | + | + |
| *Lemonniera cornuta* Ranzoni | + | + | + | + |
| *Lemonniera terrestris* Tubaki | + | + | + | + |
| *Lemonniera* sp. | – | – | – | + |
| *Magdalaenaea monogramma* Arnaud | + | – | – | – |
| *Margaritispora aquatica* Ingold | + | + | + | + |
| *Mirandina* sp. | + | + | + | + |
| *Mycocentrospora* sp. | – | + | – | – |
| *Mycofalcella calcarata* Marvanová | + | – | + | + |
| *Naiadella fluitans* Marvanová et Bandoni | + | – | – | – |
| *Pachycladina mutabilis* Marvanová | + | – | – | – |
| *Stenocladiella neglecta* (Marvanová et Descals) Marvanová et Descals | + | + | + | + |
| *Tetrachaetum elegans* Ingold | + | + | + | + |
| *Tetracladium marchalianum* de Wild. | + | + | + | + |
| *Tetracladium setigerum* (Grove) Ingold | – | + | – | – |
| *Trichocladium angelicum* Roldán et Honrubia | + | + | – | – |
| *Tricladium angulatum* Ingold | + | + | – | – |
| *Tricladium gracile* Ingold | + | + | – | – |

**Table 3** (continued)

| | Desz-1 | Desz-2 | Bag-1 | Bag-2 |
|---|---|---|---|---|
| *Tricladium splendens* Ingold | + | + | + | + |
| *Tricladium* sp. | – | – | + | + |
| *Trinacrium* sp. | – | + | + | + |
| *Tripospermum camelopardus* Ingold, Dann et McDougall | – | + | – | + |
| *Tripospermum myrti* (Lind.) S. Hughes | + | – | + | + |
| *Triscelophorus* sp. | + | + | – | + |
| *Tumularia aquatica* (Ingold) Descals et Marvanová | + | + | + | + |
| *Tumularia tuberculata* (Gönczöl) Descals et Marvanová | + | + | + | + |
| *Vargamyces aquaticus* (Dudka) Tóth | + | + | + | + |
| Sigmoid 1 | + | + | – | – |
| Sigmoid 2 | + | – | – | – |
| Sigmoid 3 | + | + | + | + |
| Sigmoid 4 | – | – | – | + |
| Sigmoid 5 | + | + | + | + |
| Unknown 1 | – | – | + | + |
| Unknown 2 | – | – | + | + |
| Unknown 3 | – | – | + | + |
| Unknown 4 | + | – | – | – |
| Unknown 5 | – | – | + | – |
| Unknown 6 | + | + | – | – |
| Number of species | 52 | 48 | 44 | 46 |
| Total number of species in a stream | 58 | | 49 | |

*Clavariopsis aquatica*, *Flagellospora curvula* and *Tetrachaetum elegans* – occurred among the top-ranked species at all sites of the two streams. From the dominant species *Flagellospora leucorhynchos* were found exclusively in the Deszkametsző. *Anguillospora mediocris* occurred in both streams, but it accounted for high proportions of the total spores found only in the Deszkametsző. Although in the November samples the conidial numbers of *Clavatospora longibrachiata* were actually higher in the Deszkametsző, its relative importance was higher in the Bagolybükk. The conidia of *Margaritispora aquatica* and *Tumularia tuberculata* were detected in both streams, they were relatively more important in the Bagolybükk. The majority of frequent species varied in the timing of their maximum conidial production.

## DISCUSSION

In the present and two earlier studies (GÖNCZÖL and RÉVAY 1999, 2003) the species richness and the conidial numbers of the aquatic hyphomycetes have been

**Table 4**. Mean number of conidia per sample (150 ml) and litre and total number of aquatic hyphomycete species found at each sampling site in different sampling times. (Desz = Deszkametsző, Bag = Bagolybükk, * = $P < 0.05$; ** = $P < 0.001$, t = Desz-1 v. Desz-2 or Bag-1 v. Bag-2).

| | April | | | October | | | | November | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | mean number of conidia | | | | | | | | | | |
| | 150 ml | s.d. | litre | 150 ml | s.d. | t | litre | 150 ml | s.d. | t | litre |
| Desz-1 | 149.0 | 20.4 | 993.3 | 2,213.0 | 432.2 | | 14,754.7 | 4,199.0 | 988.2 | | 27,992.0 |
| Desz-2 | 230.4 | 32.5 | 1,536.0 | 1,140.4 | 179.8 | 5.1** | 7,602.7 | 1,640.0 | 251.2 | 5.6** | 10,933.3 |
| Bag-1 | 114.4 | 11.9 | 762.7 | 291.6 | 76.9 | | 1,944.0 | 415.4 | 67.8 | | 2,769.3 |
| Bag-2 | 113.0 | 26.5 | 753.0 | 348.4 | 95.8 | | 2,322.7 | 999.0 | 154.7 | 7.7** | 6,660.0 |
| | total number of species | | | | | | | | | | |
| | | no. | | | no. | | | | no. | t Desz v. Bag | |
| Desz-1 | | 40 | | | 41 | | | | 39 | 3.4* | |
| Desz-2 | | 40 | | | 37 | | | | 38 | | |
| Bag-1 | | 34 | | | 34 | | | | 38 | | |
| Bag-2 | | 34 | | | 33 | | | | 39 | | |

**Table 5**. Mean number of conidia per sample (150 ml) and relative proportions of conidia of dominant (>5% of the total collected) species on each sampling date in the Deszkametsző and Bagolybükk streams. (s.d. = standard deviation).

| Species | mean | s.d. | % | mean | s.d. | % |
|---|---|---|---|---|---|---|
| | April | | | | | |
| | Deszkametsző-1 | | | Deszkametsző-2 | | |
| *Alatospora acuminata* | 13.8 | 2.9 | 9.2 | 22.6 | 9.9 | 9.8 |
| *Anguillospora longissima* | 10.0 | 2.9 | 6.7 | | | |
| *Anguillospora mediocris* | 28.6 | 17.3 | 19.2 | 65.6 | 11.3 | 28.5 |
| *Clavariopsis aquatica* | 25.6 | 5.7 | 17.2 | 46.2 | 20.0 | 20.1 |
| *Tetrachaetum elegans* | 8.0 | 4.4 | 5.4 | | | |
| Remaining species | | | 42.3 | | | 41.6 |
| | Bagolybükk-1 | | | Bagolybükk-2 | | |
| *Alatospora acuminata* | 15.0 | 6.9 | 13.1 | 17.4 | 3.4 | 15.4 |
| *Anguillospora longissima* | 6.0 | 2.7 | 5.2 | 10.0 | 2.4 | 8.9 |
| *Clavariopsis aquatica* | 23.6 | 8.7 | 20.6 | 16.4 | 1.7 | 14.5 |
| *Clavatospora longibrachiata* | | | | 10.8 | 3.8 | 9.6 |
| *Heliscus lugdunensis* | 14.8 | 5.8 | 12.9 | 7.6 | 2.9 | 6.7 |
| *Tumularia tuberculata* | 9.6 | 3.9 | 8.4 | | | |
| Sigmoid 3 | | | | 7.2 | 6.0 | 6.4 |
| Remaining species | | | 39.8 | | | 38.5 |
| | October | | | | | |
| | Deszkametsző-1 | | | Deszkametsző-2 | | |
| *Alatospora acuminata* | 212.6 | 72.1 | 9.6 | 69.6 | 17.7 | 6.1 |
| *Anguillospora mediocris* | 145.2 | 37.6 | 6.6 | 350.6 | 47.4 | 30.7 |
| *Clavariopsis aquatica* | 255.6 | 25.9 | 11.6 | 108.6 | 7.9 | 9.5 |
| *Filosporella annelidica* | 142.0 | 39.9 | 6.4 | | | |
| *Flagellospora curvula* | 224.8 | 19.3 | 10.2 | 163.0 | 39.1 | 14.3 |
| *Lemonniera cornuta* | 285.4 | 83.1 | 12.9 | | | |
| *Stenocladiella neglecta* | | | | 86.8 | 26.5 | 7.6 |
| *Tetrachaetum elegans* | 372.8 | 32.3 | 16.9 | 184.6 | 37.6 | 16.2 |
| *Tetracladium marchalianum* | 210.8 | 87.5 | 9.5 | | | |
| Remaining species | | | 16.3 | | | 15.6 |

**Table 5** (continued)

| Species | mean | s.d. | % | mean | s.d. | % |
|---|---|---|---|---|---|---|
| | Bagolybükk-1 | | | Bagolybükk-2 | | |
| *Alatospora acuminata* | 23.6 | 3.8 | 8.1 | 38.4 | 9.6 | 11.0 |
| *Clavariopsis aquatica* | 64.4 | 26.4 | 22.1 | | | |
| *Clavatospora longibrachiata* | | | | 29.8 | 8.6 | 8.6 |
| *Flagellospora curvula* | 46.2 | 18.4 | 15.8 | 89.8 | 26.6 | 25.8 |
| *Margaritispora aquatica* | 22.8 | 9.5 | 7.8 | | | |
| *Stenocladiella neglecta* | 28.2 | 9.8 | 9.7 | | | |
| *Tetrachaetum elegans* | 63.8 | 11.9 | 21.9 | 72.2 | 21.5 | 20.7 |
| Remaining species | | | 14.6 | | | 33.9 |
| | November | | | | | |
| | Deszkametsző-1 | | | Deszkametsző-2 | | |
| *Alatospora acuminata* | 324.4 | 125.5 | 7.7 | 184.4 | 17.8 | 11.2 |
| *Anguillospora mediocris* | | | | 565.2 | 101.8 | 34.5 |
| *Clavariopsis aquatica* | 387.6 | 94.9 | 9.2 | | | |
| *Flagellospora curvula* | 626.8 | 127.1 | 14.9 | 248.6 | 59.0 | 15.2 |
| *Flagellospora leucorhynchos* | | | | 118.2 | 60.8 | 7.2 |
| *Lemonniera cornuta* | 711.6 | 212.6 | 16.9 | 142.0 | 52.5 | 8.7 |
| *Lemonniera terrestris* | 210.6 | 59.6 | 5.0 | | | |
| *Stenocladiella neglecta* | | | | 102.4 | 10.9 | 6.2 |
| *Tetrachaetum elegans* | 949.6 | 213.6 | 22.6 | | | |
| Remaining species | | | 23.7 | | | 17.0 |
| | Bagolybükk-1 | | | Bagolybükk-2 | | |
| *Alatospora acuminata* | 36.6 | 12.4 | 8.8 | 256.0 | 54.5 | 25.6 |
| *Clavariopsis aquatica* | 33.6 | 5.8 | 8.1 | | | |
| *Clavatospora longibrachiata* | | | | 103.4 | 11.9 | 10.4 |
| *Flagellospora curvula* | 54.4 | 23.3 | 13.1 | 229.2 | 24.1 | 22.9 |
| *Heliscus lugdunensis* | 30.8 | 6.1 | 7.4 | | | |
| *Lemonniera cornuta* | | | | 112.6 | 29.7 | 11.3 |
| *Margaritispora aquatica* | 56.4 | 15.1 | 13.6 | 92.8 | 24.8 | 9.3 |
| *Tetrachaetum elegans* | 31.0 | 9.5 | 7.5 | | | |
| *Tumularia tuberculata* | 33.0 | 11.6 | 7.9 | | | |
| Remaining species | | | 33.6 | | | 20.5 |

analysed altogether in five tributaries of the Morgó stream system. We concluded that low-order streams had hyphomycete communities with specific features noticeably differing from each other as well as from those in higher-order stream sections of this system (GÖNCZÖL and RÉVAY 2003). The results of the present and earlier studies showed that the total number of the fungal species in a given tributary was generally similar to that of the stream section where the tributary enters the main stream (GÖNCZÖL *et al.* 1999). Somewhat more species occurred in the softwater than in the hardwater tributaries, but this pattern was not clear-cut. Higher numbers of species (48–52) occurred at the sites of Deszkametsző, a slightly alkaline tributary (pH 7.5–8.4) than at the sites of Bagolybükk (44–46 species, pH 7.0–8.1).

Higher species numbers in the circumneutral than in the hardwater streams have for a long time been recognised and confirmed in many studies (BÄRLOCHER and ROSSET 1981, WOOD-EGGENSCHWILER and BÄRLOCHER 1983, MARVANOVÁ 1984, BÄRLOCHER 1987, CASAS and DESCALS 1997). Some other studies suggest that high diversity of the riparian vegetation is also correlated positively with the species richness of aquatic hyphomycete conidia in transport (FABRE 1996, CASAS and DESCALS 1997, GÖNCZÖL *et al.* 2003). Whether the unfavourable effect of alkaline stream water to species number may be compensated by the high diversity of substrates is not known presently. We still know little how these confounding effects control the structures of fungal communities in different stream habitats.

The amount of leaf and wood litter in the stream sections studied could not be determined either in the present or in earlier studies. To our knowledge there is not an accepted sampling method to reliably estimate the quantity of litter (either leaf or wood or even both) in a given reach of a stream. A survey of the submerged litter in the two tributaries revealed a well recognisable difference in the position and the quantity of leaf litter in the studied reaches of Deszkametsző and Bagolybükk. A continuous, loose layer of leaves covered the streambed at Deszkametsző-1, while a typical patchy distribution of leaves being aggregated in packs was observed at Bagolybükk-1. Due to these differences in the structure of leaf litter we estimated that greater amount of leaf litter per water volume was present in Deszkametsző than in Bagolybükk. We also considered that thick but loose layer of leaves on the streambed at Deszkametsző-1 provides more favourable conditions for fungal sporulation than tightly aggregated leaf packs in Bagolybükk-1. Consequently a higher conidial concentration in stream water in Deszkametsző, at least at site 1, than Bagolybükk-1 was anticipated.

The conidial concentrations at the sampling sites differed greatly in the two tributaries. These differences were most pronounced in the November samples.

The relatively high conidial concentration (27,992 conidia $L^{-1}$) at site 1 decreased to 10,933 $L^{-1}$ at site 2, while the discharge (0.8 L $s^{-1}$ at site 1) increased more than tenfold (8.8 L $s^{-1}$ at site 2) in the Deszkametsző. On the contrary in the Bagolybükk, which is a relatively fast flowing stream, with a more or less straight streambed, the number of conidia increased downstream, from 2,769 $L^{-1}$ at site 1 to 6,660 $L^{-1}$ at site 2, while discharge decreased by almost 50% between the two sites. An opposite trend in the downstream changes in conidial concentrations was also observed in two other second-order tributaries of the Morgó stream system in a former study (GÖNCZÖL and RÉVAY 2003) but no discharge was measured in these tributaries. The conidial concentration and discharge between the upper and lower sites in the Csömöle stream, a previously studied tributary, changed similarly to those in Deszkametsző. The conidial numbers decreased downstream from 23,644 $L^{-1}$ to 4,224 $L^{-1}$ between the two sites of the Csömöle stream, while the discharge increased by about 50% (1.0 L $s^{-1}$ to 2.1 L $s^{-1}$) (GÖNCZÖL and RÉVAY 1999, and unpubl. obs.). The upper reaches of both streams are very similar to each other in some characteristics, *i.e.* slowly flowing shallow water, low discharge and meandering streambed loosely filled with a continuous layer of leaf litter. We concluded that some 20,000 or more conidia $L^{-1}$ in November and December seems to be a general pattern in the upper reaches of these slowly flowing, small streams. This may be mainly due to the very effective retentive capability of these streams. The amount of litter and discharge are evidently crucial factors to control conidial concentration in a given reach of a stream (BÄRLOCHER 1992*a*). Our results obtained for five second-order tributaries in the Morgó stream system suggest that discharge, the amount and structure of litter are important factors to determine conidial concentrations in headwater streams.

Relatively few data are found in the literature about the effect of discharge and changes in type and quantity of allochthonous litter on conidial concentration in streams. SHEARER and WEBSTER (1985*a*) studied the longitudinal variation in aquatic hyphomycetes at three sites along the River Teign (England). They found that conidial numbers increased in a downstream direction. The amount of allochthonous material was probably an important factor in determining numbers of conidia as it was always lesser at the most upstream site than the two lower sites. In a study of aquatic hyphomycetes at two sites of the Catamaran Brook (Canada) a significant downstream decrease in conidial numbers was found by BÄRLOCHER (2000). He concluded that the decline of conidial numbers might be due to dilution since water discharge increased considerably between the two sites.

SUBERKROPP (1997) found that spore concentrations in a small woodland stream, Walker Branch (Tennessee, USA) were significantly correlated with the amount of leaf material present. Spore concentration one to four spores $ml^{-1}$

throughout most of the year increased to eighteen spores $ml^{-1}$ after the greatest amount of leaf litter was present in the stream during November. Quite different results about stimulating effect of leaf litter on the spore concentration were obtained in another study. The role of leaf litter to conidial concentration was examined in a litter-exclusion and a reference stream in the Appalachian Mountains (North Carolina, USA) (GULIS and SUBERKROPP 2003). Both streams had low mean discharge (about 2 L $s^{-1}$). The authors anticipated that litter-exclusion would have a drastic effect on reproduction of aquatic hyphomycetes, but only seasonal differences in maximum conidial concentration were observed in the two streams. Total conidial concentration was not significantly affected by the litter-exclusion treatment. The studied streams in the Appalachian and Börzsöny Mountains are very similar in the low mean discharge (1–2 L $s^{-1}$) other, possibly important factors may be highly different. For example the very low conidial numbers in the Appalachian streams (about 110 to 1,400 conidia $L^{-1}$) are uncommon in our woodland streams. By the authors' opinion this may be due to the short distance between the sampling sites and the sources.

Increasing amount of leaf litter from the beginning of October till the end of November followed by increasing conidial concentrations is a general pattern in forested streams in temperate regions (WEBSTER and DESCALS 1981, BÄRLOCHER 1992*b*). The results obtained for conidial concentrations in five small tributaries after leaf-fall strongly suggest that leaf litter input is a major factor affecting conidial concentrations in transport. The increase in the conidial numbers in these small streams in October and November may be drastic (Deszkametsző stream) or moderate (Bagolybükk stream) probably due to the complex effect of amount of leaf litter in the stream and actual discharge. Nevertheless small streams with very low discharge require further studies to understand better the spatial and temporal dynamics of conidial pools.

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