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Longitudinal distribution and colonization patterns of wood-inhabiting fungi in a mountain stream in Hungary

by

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Abstract: The longitudinal distribution and colonization patterns of wood-inhabiting fungi were studied in the Morgó-stream in Hungary during the period April 1988 to June 1989. The survey of the wood-inhabiting fungi occurring at two stations, collection on both naturally occurring wood and submerged beech and alder twig baits revealed a total of 70 species. Distinct differences were obtained between the species composition of fungal communities of leaf- and wood-inhabiting fungi. Differences were obtained in the case of several species at softwater and hardwater sections of the stream. The most frequent species showed little substratum specificity.

Introduction

Plant litter of freshwater streams includes leaf, stem and wood debris. Aquatic hyphomycetes which play an important role in processing of deciduous leaves have been studied extensively in recent years. Even though woody substrata entering streams are estimated to comprise up to 30% of the total plant litter according to Bray & Gorham (1964) we have little information about the fate of woody substrata in freshwater streams. Jones (1981) presented a review of the fungi known on timber in freshwater habitats and their role in the decay of wood. With the exceptions of some recent investigations (Willoughby & Archer 1973, Lamore & Goos 1978, Shearer & Bodman 1983) little information is available about the woody substrata-fungal relationships in fresh-water habitats.

The composition of aquatic hyphomycete communities of the Morgó-stream of the Börzsöny Mts has been investigated for many years. Observations were reported on the longitudinal distribution pattern of the species communities of aquatic hyphomycetes of the Morgó-stream (Gönczöl 1975). A further study has recently been made on the Morgó-stream to look for a relationship between the longitudinal distribution of some aquatic hyphomycete species and the water hardness of the stream (Gönczöl 1987). The purpose of another study was to compare the fungal communities on alder and beech leaves, using leaf packs, both at upstream and downstream sites (Gönczöl 1989).

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The aims of the present study were: 1.) to identify the fungi which are active in the decomposition of wood in the Morgó-stream and to examine the pattern of succession during the decomposition, 2.) to compare the fungal communities on alder and beech twigs both at upstream and downstream sites, 3.) to compare the fungal communities associated with decomposing twigs and leaves.

Material and methods

A detailed description (geological, hydrological and riparian vegetation) of the Morgó-stream in the Börzsöny Mts (northern Hungary) has been given earlier (Gönczöl 1975, 1987).

The two sampling sites chosen for this study, Site I at the upper course at the entrance of the beech stand and Site II at the lower course in the alder stand, were the same as where the leaf pack experiments were made earlier (Gönczöl 1989).

Water temperature, conductivity, pH and total hardness were measured at each sampling occasion and values are given in Table 1. Complexometric titration with Titriplex^R III against mixed indicator tablets (Aquamerk^R 8011, E. Merck, Darmstadt, W-Germany) was used for determination of total hardness. The values of water hardness are given in Germany degrees (1 °d = 10 mg CaO/l = 0.18 mmol/l of alkaline earth ions). Conductivity and pH were measured and using digital field instruments (Möbus, W-Germany).

Twig packs were used to characterize the fungal species composition on the most important tree types (*Alnus glutinosa, Fagus sylvatica*) of the riparian vegetation of the stream. Twigs were cut from living branches in April and August, 1988. Twigs up to 2 cm in diam. were cut into about 10 cm lengths with sloping ends and arranged in packs containing five twigs with bark intact, of each species. These packs were placed inside nylon nets with a mesh size of 1.5 mm and these nets were attached with nylon line to the rocks of the stream bed. The whole experiment was originally laid out in April 1988. However in August 1988 simultaneously with the first experiment we began a second one, using sterile and non-sterile twigs of both tree types. Our first aim was to examine sterile twigs parallel with non-sterile ones. The other purpose of the second experiment was whether there was a significant effect of the season of the year when an experiment began.

One part of the twigs were used in the second experiment before submergence were autoclaved for 1 h on each of two successive days. The experiments were stopped earlier than originally planned because the

Table 1. Comparison of temperature (C), pH, total hardness (°d) and conductivity (μS) ranges at each site during 1988-1989

Date	Site I				Site II			
	temp. (C)	pH	total hard. (°d)	cond. (µS)	temp. (C)	pH	total hard. (°d)	cond. (µS)
1988 May	15.0	7.7	4.0	180	12.0	8.2	12.0	530
1988 June	19.0	7.8	3.0	210	14.0	8.0	17.0	720
1988 Aug.	20.0	7.8	4.0	210	19.0	7.9	20.0	920
1988 Oct.	9.0	7.7	3.0	160	10.0	8.0	16.0	740
1989 Jan.	0.2	6.9	3.0	110	0.1	8.3	13.0	420
1989 Febr.	3.0	6.8	3.0	130	4.0	7.7	8.0	280
1989 Apr.	10.5	7.4	4.0	170	11.5	8.8	13.0	500
1989 June	16.0	8.1	4.0	210	15.0	8.2	15.0	700

samples at the Site I were lost in June 1989. First monthly (April to June) than at bi-monthly intervals two packs, containing five beech and five alder twigs were removed at each sampling site, placed in some stream water in sterilized containers and returned immediately to the laboratory. On return to the laboratory twigs were washed and then placed singly in plastic boxes filled with distilled water and were aerated for some days in a refrigerator (temperature 8 °C). All twigs were examined under a dissecting microscope, and scrapes of twig surface and cut ends were made. The presence of conidia does not necessarily means that these conidia were produced by fungi growing on these twigs, but we examined numerous samples and found several species with their conidiophores as well. After direct examination all twigs were placed in a sterilized moist chamber (well moistened filter paper in a deep Petri dish) and incubated at room temperature and in summer in a refrigerator for almost a year. All wood samples were examined at bi-weekly intervals and remoistened with necessary.

Simultanesously with the retrieval of twig packs, naturally occurring submerged wood debris was also collected around the sampling sites. These samples were examined only directly for the presence of fungi, but not characterized with numerical values.

Results and discussion

Processing coefficients for twigs were not calculated but only mechanical changes in the structure were observed. To compare the processing rate of twigs there were considerable differences between the two tree types, the two habitats and also between the two experiments. In both experiments alder processed more quickly at both sites than beech twigs. During the first experiment, started April 1988, relatively soon after submersion (17-week samples) the bark of alder twigs in the Site I samples separated from the wood tissue but still remained attached to the twigs, but by January 1989 (38-week samples) alder twigs had become completely debarked and only bare woody tissue remained. During the second experiment, started August 1988, the processing rate of alder twigs was not so quick as in the first one. Twigs of beech retained their bark in Site II samples throughout the study while several twigs began to lose their bark by the end of the study in the Site I smaples. The results of the earlier leaf-pack experiment correspond with the results of the present study. Alder leaves disappeared more quickly than beech leaves, especially in summer samples.

Colonization of twigs by aquatic hyphomycetes

According to the results of many years observations the lower course of the Morgó-stream was characterized by *Tetracladium marchalianum* and *Tricladium angulatum,* species predominantly present during the whole year. *Anguillospora crassa, Tumularia aquatica* and *Tumularia tuberculata* are the most common species in the upper course of the stream according to foam sample analysis. During the present study twenty-five species of Ingoldian aquatic hyphomycetes and several species of *Fusarium* and *Cylindrocarpon* were recorded. All the common species which characterize the fungal community of Morgó-stream were present in the twig samples but only one of them, *Anguillospora crassa* proved to be a prominent wood colonizer. The other four species, which are known as important colonizers on leaves, were represented only in some samples. *Tetrachaetum elegans, Heliscella stellata,*

Table 2. Species collected from submerged twigs in packs or naturally occurring twigs at two sampling sites. A = *Alnus glutinosa*, F = *Fagus sylvatica*, N = naturally occurring twig

Species	Site I	Site II
Hyphomycetes		
Acrogenospora sphaerocephala (Berk. & Br.) M.B. Ellis	F	-
Aegerita candida Pers. ex Fr.	A	AF
Alatospora acuminata Ingold	AFN	AFN
Alatospora flagellata (Gönczöl) Marvanová	N	-
Alysidium resinae (Fr.) M.B. Ellis	-	F
Anavirga dendromorpha Descals & Sutton	AFN	-
Anguillospora crassa Ingold	AFN	-
Anguillospora furtiva ined. Webster & Descals	AF	AF
Anguillospora longissima (Sacc. & Syd.) Ingold	AFN	AFN
Anguillospora sp.	FN	AFN
Bactrodesmiella masonii (Hughes) M.B. Ellis	-	F
Bactrodesmium obovatum (Oudem.) M.B. Ellis	F	-
Bactrodesmium spilomeum (Berk. & Br.) Mason & Hughes	AFN	AF
Camposporium cambrense Hughes	N	-
Camposporium pellucidum (Grove) Hughes	AFN	N
Clavariopsis aquatica de Wildeman	AFN	AF
Cylindrocarpon spp.	AF	AF
Dendryphion nanum (C.G. Nees ex S.F. Gray) Hughes	A	-
Dictyosporium toruloides (Corda) Guéguen	AFN	F
Dimorphospora foliicola Tubaki	A	-
Diplocladiella scalaroides Arnaud ex M.B. Ellis	-	A
Endophragmiella collapsa (Sutton) Hughes	A	-
Filosporella annelidica (Shearer & Crane) Crane & Shearer	AF	AF
Filosporella sp.	F	AF
Fusarium spp.	AF	AF
Helicodendron paradoxum Peyronel	-	F
Heliscella stellata (Ingold & Cox) Marvanová	-	N
Heliscus lugdunensis Sacc. & Thérry	AFN	AF
Isthmotricladia britannica Descals	N	-
Lemonniera aquatica de Wildeman	-	F
Lemonniera terrestris Tubaki	N	-
Mammaria echinobotryoides Ces.	F	AF
Mirandina sp.	A	AF
Phragmocephala elliptica (Berk. & Br.) Hughes	-	N
Pleurophragmium simplex (Berk. & Br.) Hughes	-	A
Pleurotheciopsis bramleyi Sutton	-	AFN
Sigmoidea aurantiaca Descals	-	AF
Septotrullula bacilligera Höhnel	F	AF
Speiropsis sp.	A	-
Sporidesmiella hyalosperma (Corda) P.M. Kirk. var. *hyalosperma*	AF	-
Tetracladium marchalianum de Wildeman	-	AF
Tetracladium setigerum (Grove) Ingold	N	-
Tricladium angulatum Ingold	-	AF
Tricladium splendens Ingold	AFN	N
Triadelphia uniseptata (Berk. & Br.) P.M. Kirk	A	-
Triscelophorus sp.	FN	-
Trichocladium angelicum Roldán & Honrubia	-	AF
Tumularia aquatica (Ingold) Descals & Marv.	AFN	AFN
Tumularia tuberculata (Gönczöl) Descals & Marvanová	AFN	-
Vargamyces aquaticus (Dudka) Tóth	-	AFN
Unknown sp 1	-	A
Coelomycetes		
Asterosporium asterospermum (Pers. ex Gray) Hughes	F	-
Chaetomella raphigera Swift	-	A
Cornutispora sp.	AF	-
Ascomycetes		
Apostemidium fiscellum (Karst.) Karst.	-	A
Ceratostomella sp.	AF	AF
Cercophora sp.	-	AF
Hymenoscyphus foliicola Abdullah, Descals & Webster	A	-
Hymenoscyphus sp.	A	A
Massarina sp.	AF	AF
Mollisia sp.	AF	-
Nectria coccinea (Pers. ex Fr.) Fr.	F	F
Nectria sp.	AF	AF
Pseudohalonectria lignicola Minoura & Muroi	AF	AF
Schizothecium sp.	-	F
Trematosphaeria pertusa (Pers. ex Fr.) Fuck.	AF	F
Trematosphaeria vindelicorum (Rehm) Sacc.	A	AF
Trematosphaeria britzelmayriana (Rehm) Sacc.	N	-
Trematosphaeria sp.	F	-
Unknown sp. 2	-	F

Flagellospora curvula, Stenocladiella neglecta, Bacillispora aquatica and *Clavatospora tentacula* were also found as frequent species according to the leaf-pack experiments, were not represented on twigs.

Our investigations in many respects seem to confirm the results of Willoughby & Archer (1973). Their study of twigs in Smooth Beck (England) recovered twenty-three aquatic hyphomycete species. The four top ranked species in their study were *Fusarium* spp., *Heliscus lugdunensis, Anguillospora longissima* and *Clavariopsis aquatica*. Fourteen of the species listed by them were found in the twig samples of the present study. If the hyphomycete species, which colonized at least four or more twigs, are arranged in descending order of percentage occurrence it is seen that *Heliscus lugdunensis* was a very important colonizer, followed by *Cylindrocarpon* spp., *Anguillospora longissima* and *Fusarium* spp. (Table 3). *Heliscus lugdunensis, Cylindrocarpon* spp. and *Fusarium* spp. were early colonizers, their growth was detected after four weeks' submergence. The frequency of occurrence of *Heliscus lugdunensis* and *Cylindrocarpon* spp. were high throughout the study with the exception of those, mainly alder twigs, which lost their bark (Tables 4, 5). Although *Cylindrocarpon* spp. were present throughout the study on both tree types, they always sporulated much more abundantly on beech than alder. *Fusarium* spp. showed their best growth during the first four mounths. Willoughby & Archer

Table 3. The percentage of twigs which each hyphomycete species colonized four or more times during the study

Species	%
Heliscus lugdunensis	80.4
Cylindrocarpon spp.	70.0
Anguillospora longissima	59.1
Fusarium spp.	54.1
Clavariopsis aquatica	32.5
Anguillospora furtiva	28.3
Vargamyces aquaticus	20.0
Pleurotheciopsis bramleyi	17.2
Alatospora acuminata	14.5
Septotrullula bacilligera	14.0
Dictyosporium toruloides	12.7
Bactrodesmium spilomeum	10.6
Mirandina sp.	10.4
Filosporella annelidica	10.0
Dimorphospora foliicola	9.1
Anguillospora crassa	7.5
Anguillospora sp.	5.4
Tumularia aquatica	5.4
Trichocladium angelicum	5.4
Camposporium pellucidum	5.2
Aegerita candida	3.8
Tetracladium marchalianum	3.3
Anavirga dendromorpha	3.3
Mammaria echinobotryoides	3.3
Filosporella sp.	2.9
Tricladium splendens	2.5
Helicodendron paradoxum	2.0
Tumularia tuberculata	2.0
Tricladium angulatum	1.6

Table 4. Frequencies of occurrence of species which occurred on the five twigs examined directly after removal during the first experiment. F = *Fagus sylvatica*, A = *Alnus glutinosa*, SI = Site I, SII = Site II

Species	1988 May 13 SI		1988 May 13 SII		1988 Jun. 27 SI		1988 Jun. 27 SII		1988 Aug. 11 SI		1988 Aug. 11 SII		1988 Oct. 21 SI		1988 Oct. 21 SII		1989 Jan. 3 SI		1989 Jan. 3 SII		1989 Febr. 23 SI		1989 Febr. 23 SII		1989 Apr. 24 SI		1989 Apr. 24 SII		1989 Jun. 30 SI		1989 Jun. 30 SII	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Fusarium	5	5	5	5	5	5	5	5	5	3	3	5	3		2	3	3		1	1	2		2	2									
Heliscus lugdunensis	5	3	5	5	4	5	4	4	4	4	4	5	4	4	4	5	3		5	5	3	1	4	4	2	2	4	4			4	3
Alatospora acuminata	3	1	2	2	2	2			1	3	3		3	2									1								2	
Tricladium splendens	2								1												2											
Tetracladium marchalianum			2												2				1				1				2					
Triscelophorus sp.	1																				1											
Anguillospora longissima					3	1	1		3	3	3	3	2		3	1	4	5	4	3	4	4	4	4	4	4	4	5			5	4
Cylindrocarpon spp.					4	4	4	2	5	3	5	4	4	2	4	3	4		4	5	4		5	5	3		5	4			5	4
Dimorphospora foliicola									5				3				4				4				5							
Clavariopsis aquatica									4	4	4		3	2	3		3	2	2	2	3	2	2		2		2				2	
Tumularia tuberculata									2	2			1																			
Tumularia aquatica									2	1			1				2	1	1		2											
Anguillospora crassa									1	2			3				2	1			2	1			2	1						
Filosporella annelidica									2									3			3	4					3					
Anguillospora furtiva													1				3	3	2	1	3	1	2		3	5	2	3			3	
Vargamyces aquaticus															1	2			3	3			3	3			3	3			4	4
Anavirga dendromorpha																	2				3				1							
Trichocladium angelicum																			2	1			2				3	1			2	2
Lemonniera aquatica																			1													
Anguillospora sp.																							2				2	3				
Asterosporium asterospermum																					1											
Dictyosporium toruloides																					2	1			2						2	1
Bactrodesmium spilomeum																					3	1			3	1	1				1	1
Filosporella sp.																							2	3								1
Acrogenospora sphaerocephala																					1											
Mirandina sp.																											3	3			3	2
Speiropsis sp.																									2							
Alysidium resinae																											1				1	
Sigmoidea aurantiaca																															2	
Trematosphaeria vindelicorum																																1
Massarina sp.																															1	
Unknown sp. 2																															1	

Table 5. Frequencies of occurrence of species which occurred on the five twigs examined directly after removal during the second experiment

Species	1988 Oct. 21 SI		1988 Oct. 21 SII		1989 Jan. 3 SI		1989 Jan. 3 SII		1989 Febr. 23 SI		1989 Febr. 23 SII		1989 Apr. 24 SI		1989 Apr. 24 SII		1989 Jun. 30 SI		1989 Jun. 30 SII	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Fusarium spp.	5	5	4	2	3	4	2	2	4	3	3	3	4	4	3	2			2	
Heliscus lugdunensis	5	4	4	3	5	5	5	5	5	3	4	5	5	5	3	5			4	5
Cylindrocarpon spp.	2	2	2	2	5	5	5	5	5	4	5	5	5	4	5	5			5	5
Clavariopsis aquatica	3	4			2	3	2		3	3	3		4	2	3	2			2	
Anguillospora longissima			3	2	4	4	5	4	4	4	4	3	4	5	2	5			4	4
Alatospora acuminata	1				2								1	2						
Anguillospora furtiva					2	1	3		2	3	2	2	4	4	4				4	5
Vargamyces aquaticus							2				3	2			3	3			3	3
Filosporella annelidica						3			2	2			2							
Tumularia aquatica					1		2													
Tricladium angulatum							1								2				1	
Tricladium splendens									1											
Anguillospora sp.											2		2						2	
Anguillospora crassa									2				1							
Cornutispora lichenicola									1	1										
Filosporella sp.									1											
Mirandina sp.													2	1	4				3	4
Anavirga dendromorpha													1	1						
Alysidium resinae														1					2	
Dimorphospora foliicola													1							
Dictyosporium toruloides													2	2					2	
Sigmoidea aurantiaca													1							
Mammaria echinobotryoides																			2	

reported the presence of abundant macroscopic pustules of *Heliscus lugdunensis* and *Fusarium* spp. on many twigs after overnight damp chamber incubation. During our laboratory observations it was also a very common event in the early samples after one day incubation. Lamore & Goos (1978) reported *Heliscus lugdunensis* as a rare species, which was recovered only once during their study on a maple bait from a Rhode Island river. One possible reason for the disparity between our findings may be that Lamore and Goos used for colonization dead decorticated twigs. In our samples the frequency of occurrences of the early colonists declined when the twigs began to lose their bark. Most species of *Fusarium* and *Cylindrocarpon* are soil fungi with cosmopolitan distribution and some of them are plant parasites. During our earlier observations we had only a few records about their occurrence in aquatic habitats. The main reason of their absence in our former samples may be that especially sceletonized leaves and old decorticated twigs were observed, and on these type of substrata their importance may be restricted. According to the results of the present and some earlier published studies some species of *Fusarium* and *Cylindrocarpon* may be considered significant component of the leaf- and wood-inhabiting community in freshwater in the early stages of the decomposition. Willoughby & Archer (1973) reported *Fusarium* spp. as one of the most important early colonists. Shearer & Bodman (1983) detected *Cylindrocarpon lucidum* and several species of *Fusarium* after 12 day submersion. Chamier et al. (1984) also reported *Fusarium* spp. as important early colonizers on submerged alder leaves. Beside *Cylindrocarpon* spp., *Fusarium* spp. and *Heliscus lugdunensis* the mycoflora recovered on twigs consists mostly of species of those genera which have sigmoid conidia. The identification of species with sigmoid conidia was often very difficult on the basis of detached conidia. Among the species of *Anguillospora, Anguillospora longissima* occurred most frequently with abundant sporulation with the exception of the first two months. This is a very common species colonising woods in both stagnant water and fast flowing, clean streams (Abdullah & Webster 1980). *Anguillospora crassa* was recorded on both tree types, but only at the upper course of the stream (Site I). According to many years observations *Anguillospora crassa* is a very common member of aquatic hyphomycete community at Site I, found especially on very old debarked twigs and branches (Plate 1a). During the present study it was never found in abundance, was recorded only after 4 or 6 months, especially on those twigs which had partly lost their bark or were completely debarked. The results of this study and of earlier tentative investigations on naturally occurring woody debris suggest that *Anguillospora crassa* is a late colonizer, its importance grows with immersion time. Willoughby & Archer (1973) recorded *A. crassa* after 3 and 4 months of exposure especially on decorticated willow twigs. The frequency of occurrence of *Anguillospora furtiva* was not so high than those of *Anguillospora longissima* but it was recovered on almost every sample after some months submergence. *Anguillospora* sp. was a late colonizer, found in both parallel investigations from February (after ten- or six-month immersion). The conidia of *Anguillospora* sp. resemble those of *Anguillospora crassa* and are somewhat similar to unidentified *Anguillospora* sp. reported from Austria by Regelsberger et al. (1987, Fig. 8D). Conidia 140-180 × 7-9(11) μm. *Anguillospora* sp. is known from some other Hungarian streams also, found on debarked twigs (Plate 1b).

Clavariopsis aquatica was also a frequent species throughout the study but it was always found more abundantly sporulating at cut ends where wood was exposed than on twig bark. The frequency of occurrence of *Clavariopsis aquatica* on leaves was similar to those on twigs. It was always present among the ten top ranked species (Plate 1 c). Other aquatic hyphomycete species were obtained less frequently. *Alatospora acuminata* was a primary colonizer, but was never found in abundance. Willoughby & Archer (1973) found oak twigs to be the most satisfactory substrate for *Alatospora acuminata* in comparison with others such as alder, ash and willow. Shearer and Bodman's study of twigs (1983) recovered eight aquatic hyphomycete species. Among these, *Anguillospora* sp. and *Filosporella annelidica* occurred most frequently throughout their study. In our study *Filosporella annelidica* was a less prominent colonizer, found after 4 months submergence with a limited abundance mainly in the samples collected at Site I. After 6 and 11 months exposure we found another species of *Filosporella,* which is probably identical with the *Filosporella* sp. found on skeletonized leaves of *Quercus* sp. collected from Smooth Beck, England (Webster & Descals 1979). The conidia of *Filosporella* sp. in our study are 100-160 × 4.2-5.4 μm.

Dimorphospora foliicola preferred alder as the substratum and its occurrence was restricted to the upper course of the stream. It fruited on alder twigs after 4 months in the first experiment and became one of the most important species on alder twigs at Site I. During the second experiment *Dimorphospora foliicola* was present only 8 months submergence. *D. foliicola* is a late colonizer, it could colonize alder so quickly because of the rapid processing rate of alder twigs during summer months. In the samples removed in August 1988, when *D. foliicola* was first detected, alder twigs were already partly debarked. In the winter samples alder twigs began to loose their bark much later and *D. foliicola* was observed also later. It is questionable if this species is closely associated with alder twigs as the present study suggests. Possibly it was not recovered on beech twigs because of their much slower processing rate.

Tricladium splendens was found abundantly sporulating in some, mainly Site I samples. The occurrence of *Tumularia tuberculata, Tumularia aquatica, Tetracladium marchalianum* and *Tricladium angulatum* on twigs was infrequent. According to the results of earlier leaf-pack experiment their preferred substrate are leaves rather than wood.

We found a species of *Mirandina* very abundantly sporulating on both tree types only in the two last samples (collected April and June 1989). Conidia of *Mirandina* sp. filiform, straight or curved, densely septate, with 15-25 septa, 120-167 × 3.5-4.8 μm (Plate 1 d).

Lemonniera aquatica, Sigmoidea aurantiaca, Speiropsis sp. and *Triscelophorus* sp. were all recorded only once or twice on the twigs.

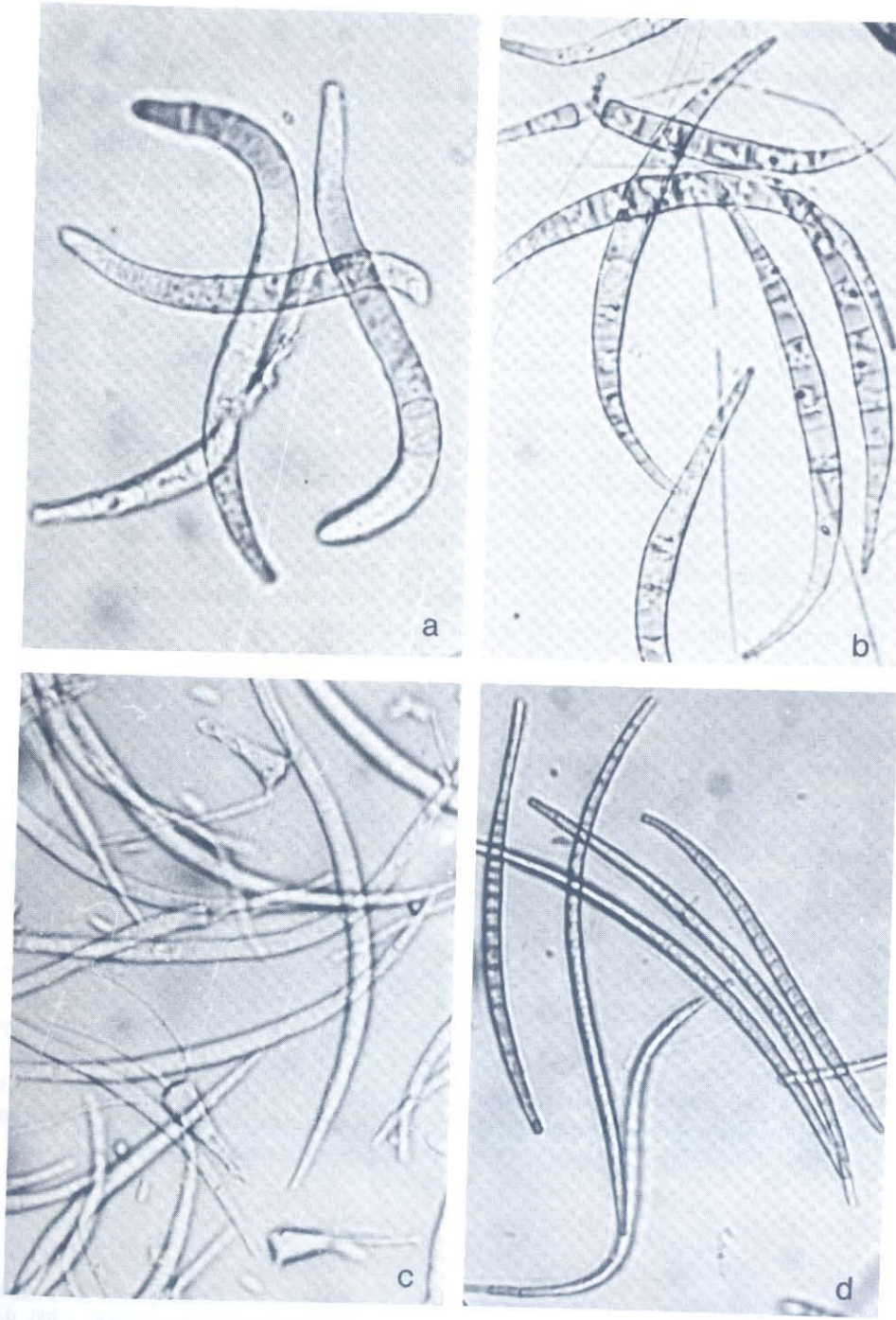


Plate 1: a.) *Anguillospora crassa* Ingold - conidia, ×400. b.) *Anguillospora* sp. - conidia, ×400. c.) *Anguillospora longissima* (Sacc. & Syd.) Ingold and *Clavariopsis aquatica* de Wildeman - conidia, ×500. d.) *Mirandina* sp. - conidia, ×500.

Colonization of the twigs by dematiaceous hyphomycetes

Twenty-four dematiaceous hyphomycete species were recovered throughout this study. Three of these were sporulating only on naturally occurring twigs and the others on twig baits. Some of these species *Acrogenospora sphaerocephala, Anavirga dendromorpha, Camposporium pellucidum, Dendryphion nanum, Dictyosporium toruloides, Mammaria echinobotryoides, Sporidesmiella hyalosperma* var. *hyalosperma* and *Trichocladium angelicum* have been reported from wood in other stream systems (Shearer 1972, Willoughby & Archer 1973, Descals & Sutton 1976, Lamore & Goos 1978, Kane 1978, Shearer & Bodman 1983, Hamad & Webster 1987, Roldán & Honrubia 1989). Eight species, *Acrogenospora sphaerocephala, Alysidium resinae, Anavirga dendromorpha, Bactrodesmium spilomeum, Dictyosporium toruloides, Mammaria echinobotryoides, Trichocladium angelicum* and *Vargamyces aquaticus* were detected at the time of sampling, the others became apparent only after following damp incubation. The most frequent species were *Vargamyces aquaticus, Pleurotheciopsis bramleyi, Septotrullula bacilligera* and *Dictyosporium toruloides*. The longitudinal distribution of *Vargamyces aquaticus, Pleurotheciopsis bramyleyi* and *Trichocladium angelicum* was distinctly restricted to the lower course of the stream. According to many years observations *Vargamyces aquaticus* is a significant component of wood- and leaf-inhabiting communities in freshwater streams in Hungary (Plate 2c). It is a late colonizer occurred after 5 or 6 months submersion and increased in frequency of occurrence towards the end of the study. *Vargamyces aquaticus* occurred primarily on woody tissue or at cut ends of the twigs. It appeared to be indifferent to leaf or twig types.

Trichocladium angelicum has lately been isolated and described from submerged wood test blocks in a freshwater stream in Spain (Roldán & Honrubia 1989). The present collection agrees with the holotype in all respects except the conidia in our collections are usually 3-4 septate, while the conidia of the holotype are 3-5 septate (Plate 2a). *Trichocladium angelicum* is a late colonizer, it was regularly observed on both tree types after 8 months exposure. It is interesting to note that *T. angelicum* was isolated for the first time in Spain in a hardwater stream, and it showed a fairly good correlation with hardwater in the Morgó-stream, too.

Detached conidia of *Anavirga dendromorpha* have been well known for some years from submerged leaf samples collected at Site I. On one occasion it was found sporulating abundantly on decorticated twigs of *Fagus sylvatica* at the same locality (Révay 1988). *Anavirga dendromorpha* is a late colonizer and was recorded especially on debarked alder twigs after 8 months exposure. Its longitudinal distribution is restricted to the upper course of the stream. Its infrequent appearance on beech in the present study may be related to the slow rate of disappearance of beech.

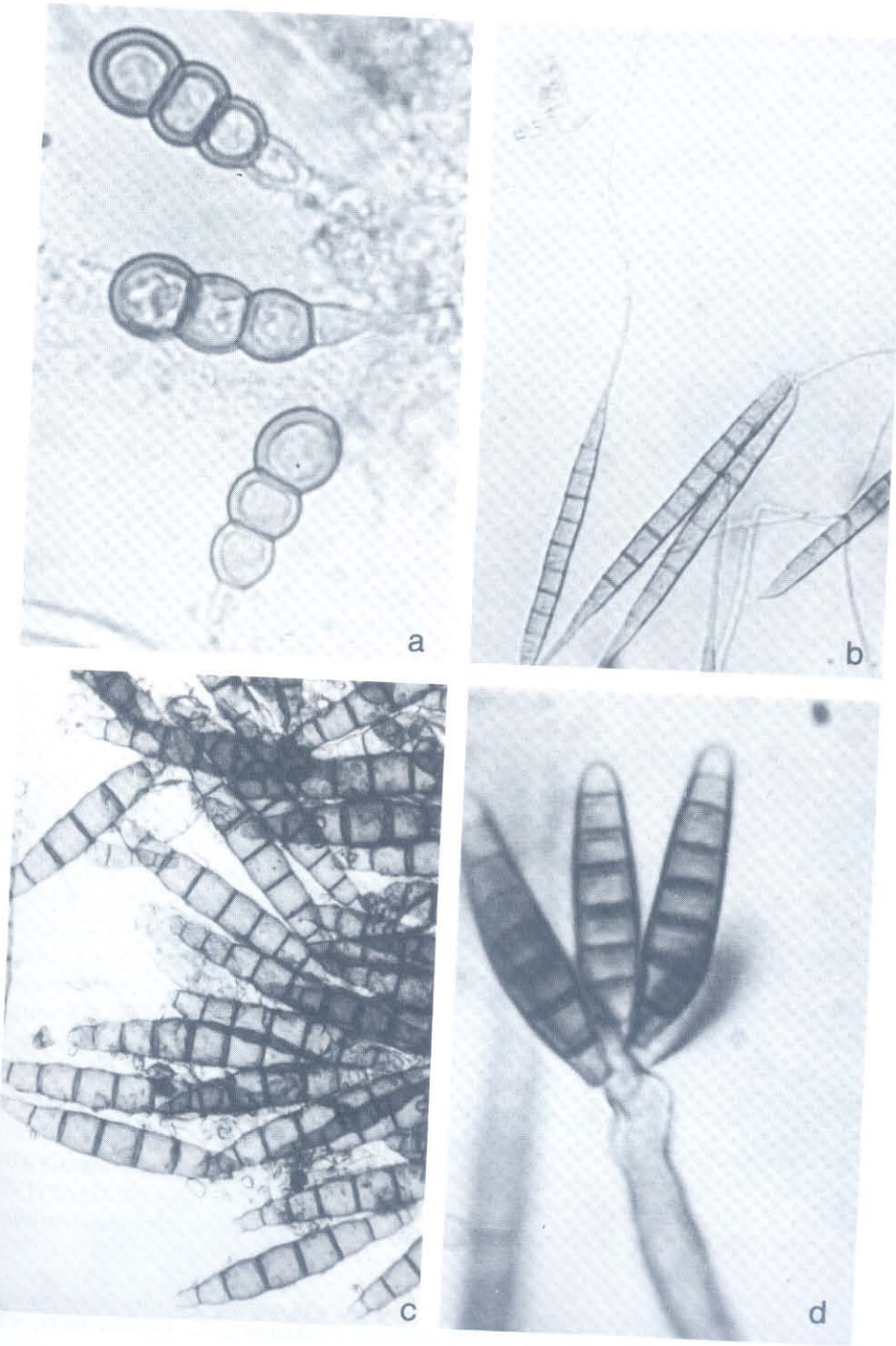


Plate 2: a.) *Trichocladium angelicum* Roldán & Honrubia - conidia, ×700. b.) *Camposporium pellucidum* (Grove) Hughes - conidia, ×300. c.) *Vargamyces aquaticus* (Dudka) Tóth - conidia, ×300. d.) Unkown sp. 1 - conidiophore with conidia, ×1000.

Although, *Diplocladiella scalaroides* is a well-known species from aquatic habitats in Hungary (Gönczöl & Tóth 1974), and Shearer & Bodman (1983) found it regularly throughout their study, it was recovered only once during the present study from alder at Site II.

Camposporium pellucidum is a quite common species both on leaves and wood in Hungary. Several times we found abundantly sporulating colonies of *Camposporium pellucidum* with much longer appendages (up to 260 μm long) (Plate 2b) than reported by many other authors (Hughes 1951, Ellis 1971, Kirk 1981).

A further dematiaceous hyphomycete species encountered in this study was unknown sp.1., which was recovered only one occasion from an alder twig exposed for 12 months followed by a long period of damp incubation. Conidiophores dark brown, paler towards the apex 140-150 × 5-6 μm, conidiogenous cell sympodial, terminal, conidia dark brown, apical cell paler, cylindrical, straight or somewhat curved, 6-8 septate, 31-39 × 6-8 μm (Plate 2d).

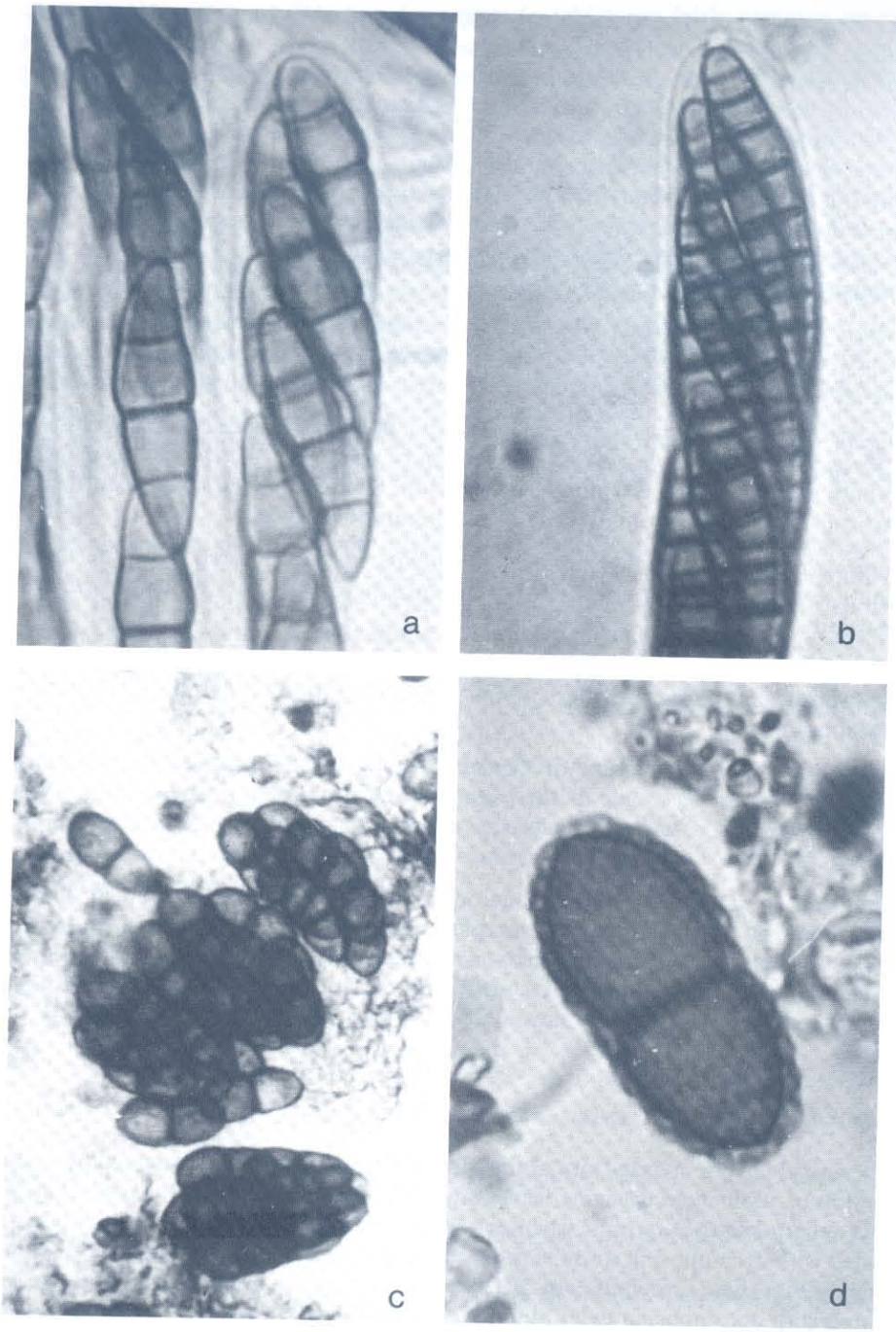
Colonization of twigs by Coelomycetes

Three species, namely *Asterosporium asterospermum, Cornutispora* sp. and *Chaetomella raphigera* were obtained from twigs. The two former species were apparent at the time of sampling. The conidia of *Cornutispora* sp. are known from earlier foam sample analysis.

Colonization of twigs by Ascomycetes

The species of Ascomycetes collected are listed in Table 2. Some of these species, namely *Massarina* sp., *Pseudohalonectria lignicola* and *Trematosphaeria pertusa* have been reported from other aquatic habitats (Eaton 1972, Willoughby & Archer 1973, Minoura & Muroi 1978, Shearer & Bodman 1983). *Hymenoscyphus foliicola, Massarina* sp., *Pseudohalonectria lignicola, Trematosphaeria vindelicorum* (Plate 3a) and *Trematosphaeria britzelmayriana* (Plate 3b) are reported from Hungary for the first time. Direct observation of twigs yielded low numbers and frequencies of occurrence of Ascomycetes. More species were observed after damp chamber incubation and their number and frequecies increased towards the end of the atudy. Three species, *Massarina* sp., *Trematosphaeria vindelicorum* and Unknown sp. 2. were apparent on one occasion at the time of sampling and the twigs in question had been exposed for 12-14 months. Discomycetes occurred less frequently on beech twigs than on alder twigs, but the other frequent species showed little substratum specificity. Discomycetes were never found fruiting on twigs examined directly after removal from the stream. Willoughby & Archer (1973) and Lamore & Goos (1978) found species of *Apostemidium* at the time of recovery. In our study *Apostemidium*

Plate 3: a.) *Trematosphaeria vindelicorum* (Rehm) Sacc. - asci with spores, ×1100. b.) *Trematosphaeria britzelmayriana* (Rehm) Sacc. - asci with spores, ×1000. c-d.) Unknown sp. 2. - asci with spores, ×360, one spore, ×1600.



fiscellum, which was found on alder twigs, developed after 2 months of damp incubation. *Mollisia* sp. occurred only on those twigs which were submerged at Site I. It may be related with the cleanness of the water. Lamore & Goos (1978) reported that Discomycetes seemed to be favored by a clean environment. Shearer & Bodman (1983) also suggested that it could be that a polluted stream is not suitable for certain species of aquatic Discomycetes. The upper course of the Morgó-stream (Site I) is much cleaner than the lower course of the stream, which is lined by weekend cottages. *Hymenoscyphus foliicola* the perfect state of *Dimorphospora foliicola* occurred on almost every debarked alder twig retrieved at Site I after 2 months of damp incubation.

Pseudohalonectria lignicola was an early colonist, occurred primarily on woody tissue. Among the Ascomycete species recovered during this study *Pseudohalonectria lignicola* occurred most frequently on both tree types at both sampling sites.

The species of *Nectria* were also early colonists. *Nectria coccinea* occurred frequently throughout the first year of submersion on beech twigs. *Nectria* sp. was detected on both twig types after 2-6 months submersion. Species of *Nectria* were confined to bark and disappeared from twigs after they became debarked.

Ceratostomella sp. and the species of *Trematosphaeria* occurred from the fourth month and increased in frequency of occurrence thereafter. They occurred primarily on woody tissue of twigs.

Massarina sp. the perfect state of *Anguillospora longissima* became also frequent as the twigs began to lose their bark and was apparent after 2-3 months incubation in the laboratory.

The longitudinal distribution of *Cercophora* sp. and *Schizothecium* sp. was restricted to the lower course of the stream. These two species proved to be a very slow-growing late colonists, which require a long period of time before they produce perithecia.

Unknown sp. 2. was found only one occasion on a beech twig examined directly after removal. Ascocarps superficial, globose, black, thin walled, 117-136 × 136-167 μm. Asci short-stalked, bitunicate, saccate or clavate, 8-spored, 58-62 × 27-36 μm. Spores 1-septate, slightly constricted, obovoid, hyaline, later dark brown, roughened with a conspicuous sheath, 28-31 × 12.8-14.4 μm (Plate 3c, d).

Summary

The aquatic hyphomycete flora of the Morgó-stream has been investigated by examination of submerged decaying leaves and foam for many years. Our present study was undertaken to determine whether a distinctive hyphomycete community is associated with decomposing wood in this stream. The results obtained during this study suggest that there are significant differencies between the fungal communities associated with decomposing twigs and leaves. Many species, namely *Tumularia tuberculata, Tetrachaetum elegans, Flagellospora curvula, Tetracladium marchalianum,*

Tricladium angulatum, Clavatospora tentacula, which are fairly common on submerged leaves were absent or infrequent on twigs. *Tumularia aquatica* according to its frequent recovery from foam is a prominent member of the upper course fungal community. It was found several times on naturally occurring leaves, but was never among the most frequent species on the formerly examined leaf-packs. *Tumularia aquatica* was infrequently found on both tree types. Since foam records suggest that it is a prolific sporeproducer, a specific substrate or the necessity for an immersion time of longer than one year is suspected.

Five of the most common species (*Anguillospora crassa, Dimorphospora foliicola, Vargamyces aquaticus, Pleurotheciopsis bramleyi, Trichocladium angelicum*) were found with noticeable correlation to habitats and one species *Dimorphospora foliicola* showed association with tree types. The majority of species showed little substratum specificity. During our study terrestrial wood-rotting dematiaceous hypomycete species were collected with great regularity. Their common appearance and the fact that a number of the same species were reported from other aquatic habitats suggest that they may have an important role in decomposition of wood in freshwater.

It was not the aim of the present study to collect and identify species of Mastigomycotina. Many Saprolegniaceous and Pythiaceous fungi were present throughout the study, mainly in Site II samples. Their greatest growths was detected in the early samples and they were especially found on lenticels and at cut ends.

We examined simultaneously twigs submerged from spring and autumn, using parallel sterilized and non-sterilized twigs in the second experiment. Great differences were obtained in the processing rate of the twigs between the two parallel experiments. During the first experiment started in April the twigs processed much faster and several species were detected earlier than during the second one. Since some Hyphomycete and Ascomycete species occurred exclusively on either bark or woody tissue, the rates at which twigs became debarked may have affected the patterns of occurrence of several species.

No significant differences were obtained between the fungus flora found on sterile and non-sterile twigs. The general sequence of events was the same on sterile and non-sterile twigs.

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Morphometrics of tubiform apical apparatus in Lecideaceae, Micareaceae, Porpidiaceae and allied families (lichenized Ascomycetes, Lecanorales): limitations and perspectives of statistical inference

by

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With 13 figures, 2 plates and 4 tables

Pietschmann, M. (1990): Morphometrics of tubiform apical apparatus in Lecideaceae, Micareaceae, Porpidiaceae and allied families (lichenized Ascomycetes, Lecanorales): limitations and perspectives of statistical inference. - Nova Hedwigia 51: 521-549.

Abstract: Tubiform apical apparatus in 272 species based on intensive LM studies are analysed numerically in a well structured way. 19 morphological characters of mixed type are to describe morphological variation within tholi. Local density maxima of OTU's are used to identify tube types in order to summarize variation patterns present within the data. Subsequent analyses of logical character dependencies and character state predictivity are performed. Significantly predicting character states are present within the following characters: relative tholus height, relative extension of tholus and degree of the tube prominence at base. By stating 'outgroups' in the form of members of *Helotiales* and non-tube exhibiting *Lecanorales* the presence or absence of distinct I+ dome-shaped lamels within the tholus was identified as major structural component of 'true' tubes. The following taxonomic indications are revealed: *Micarea* and *Mycobilimbia* are polyphyletic genera. *Farnoldia,* the genera of *Lecideaceae* s.str. (*Cecidonia, Lecidea, Rhizolecia*) and/or *Melanolecia,* are paraphyletic. A criticism of typifying the apical apparatus is outlined. The use of tholus types in taxonomic practice is running the risk to explain existing variability solely due to random variation. On the contrary, the explicit statement of logically independent characters can serve as a basis for detecting small-scale transformations of single characters, which in turn can be taken as a valuable set of characters useful in taxonomy of higher units. The hypothesis is put forward that within *Lecideaceae* s.str. a transformation series of tholus characters is very probable. It is proposed to base descriptions of the apical apparatus on mean values and/or early and late stages of the ascus development. Limitations of statistical inference are mainly due to limitations of LM studies in general. Perspectives of statistical inference, in this case, can be achieved by reaching a sound data basis to derive the 'natural' order of tholus types, which in turn is a necessity, to draw phylogenetical conclusions, as sound as possible.

Introduction

Since the works of Chadefoud et al. (1969), Eigler (1969), Henssen and Jahns (1974) and Honegger (1978), studies of the apical tholus by the light microscope are well integrated in the taxonomy of *Lecanorales* at the level of suborders. The classification of *Lecanorales* into 'natural' families proposed by Hafellner (1984) mainly uses

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