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Short Communication

Hyphomycetes fungi in rainwater falling from building roofs

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The presence of 33 Hyphomycetes species was noted in rainwater falling from six roof types. The following fungi were recorded for the first time from Poland: *Dactylaria lunata*, *Hyaloscypha zalewskii*, *Scolecobasidium flagelliferum* and *Wiesneriomyces laurinus*.

Key Words——building roofs; Hyphomycetes; rainwater.

Spores of typical Hyphomycetes were initially reckoned among algae and frequently described as new species (Reunsch, 1888). A few years later, the presence of several Hyphomycetes species was detected in the aquatic environment (de Wildeman, 1893). However, systematic studies of this group were launched not earlier than with Ingold's report (Ingold, 1942) on great numbers of conidial fungi, now included among Hyphomycetes, that grew on leaves that had fallen into water. This stormy period of studies on the aquatic Hyphomycetes (see Dudka, 1985; Bärlocher, 1992), revealed that certain Hyphomycetes species occurred in two environments. It was established that beside the aquatic environment, a number of Hyphomycetes species could be found on decayed leaves (Bandoni, 1972; Singh and Musa, 1977), on tree roots in soil (Waid, 1954; Nemec, 1969; Fisher and Petrini, 1989), in forest bedding (Dyko, 1976; Gönczöl and Révay, 1983), on blades of grass (Mäkelä, 1972), on forest tree leaves (Dyko, 1976) and on trees growing separately (Czeczuga and Orłowska, 1994). Recent studies showed that rainwater falling from trees also had conidia of a number of Hyphomycetes species (Ando and Tubaki, 1984a, b; Czeczuga and Orłowska, 1994).

In our studies on the aquatic Hyphomycetes (Czeczuga et al., 1989; Czeczuga and Orłowska, 1993, 1995, 1996) and aero-aquatic fungi (Czeczuga and Orłowska, 1994) in northeastern Poland, we focused on the occurrence of Hyphomycetes conidia in rainwater falling from urban building roofs. The studies were carried out in September 1995 in the vicinity of Białystok (22°43′ E, 53°21′N; 150 m above sea level). Average annual rainfall is 600 mm and insolation 22.4 kJ cm^{-2}. Mean annual temperature is 6.4°C (maximum 18.4°C in July and minimum −4.3°C in January). Rain water draining during a storm was collected from the following six roof types: sheet copper (A), sheet zinc (B), red tiled (C), asbestic tiled (D), tar paper (E) and thatch (F). Just before the storm, a sterilized dish (40 × 30 cm) was situated under a gutter of each of the roofs to collect the required amount of rainwater.

To determine the presence of conidia of Hyphomycetes species in the rainwater, two procedures were employed: part of each sample of rainwater was examined by the method described by Ando and Tubaki (1984a); a second part (300 ml) was poured into a sterilized 500-ml beaker, and cellophane and snake exuviae were added as bait. The baits were cut into small pieces and boiled several times, each time with fresh water. During a 1-mo period, any cluster formed on the bottom or side walls of the beaker, and the surface film of the water, were examined under a light microscope. The rules of the fungus culture included in the work of Dudka (1985) were obeyed. Identification of respective species was based on morphology and biometric data of conidia, contained in the keys (Nilsson, 1964; Dudka, 1974; Ingold, 1975; Bråthen, 1984; Matsushima, 1993) and in the works of the authors who were the first to describe a respective species.

In rainwater falling from six roof types, 33 fungus species of the Hyphomycetes were identified (Table 1). A few species belong to the aquatic group, but the majority belong to the non-aquatic group. The aquatic Hyphomycetes included such species as *Angulospora aquatica* Nilsson, *Clavariana aquatica* Nawawi, *Colispora elongata* Marvanová, *Gyoerffyella tricapillata* (Ingold) Marvanová, *Sporidesmiella hyalosperma* (Corda) Kirk, *Tricladium procerum* Marvanová and *Wiesneriomyces laurinus* (Tassi) Kirk. The non-aquatic fungi included rare species, like *Acrodictys similis* Holubová-Jechová, *Arborispora palma* Ando, *Beverwykella pulmonaria* (van Beverwijk) Tubaki, *Corynesporella superioramifera* Matsushima, *Hyaloscypha lignicola* Abdullah et Webster, *Pithomyces obscuriseptatus* Matsushima and *Veramyces manuensis* Matsushima. Four species, *Dactylaria lunata* Tzean et Chen, *Hyaloscypha zalewskii* Descals et Webster, *Scolecobasidium flagelliferum* Matsushima and *W. laurinus*, were new to Poland.

Table 1. Hyphomycetes found in rainwater falling from six roof types.

Species	Roof type[a]					
	A	B	C	D	E	F
Acrodictys similis	x					x
Actinospora megalospora					x	
Angulospora aquatica		x		x	x	
Arborispora palma			x			
Arbusculina irregularis	x		x	x	x	
Beverwykella pulmonaria	x		x		x	
Canalisporium caribense	x	x	x	x	x	x
Catenomycopsis rosea	x		x			
Clavariana aquatica	x		x			x
Colispora elongata			x			
Corynespora cubensis			x			
Corynesporella superioramifera		x		x		
Dactylaria lunata						x
Gyoerffyella tricapillata			x			
Heliscus lugdunensis	x			x		
Hyaloscypha lingicola	x		x			
Hyaloscypha zalewskii						x
Lunulospora curvula						x
Mirandina corticola				x		
Neta patuxentica			x			
Ordus tribrachiatus	x					
Pithomyces obscuriseptatus		x				
Scolecobasidium flagelliferum				x		
Speiropsis pedatospora	x	x		x	x	
Sporidesmiella hyalosperma	x					
Titaea clarkeae				x	x	
Tricellula aquatica	x					
Tricelulla inaequalis	x	x			x	
Tricladium procerum					x	
Trinacrium subtile			x			x
Tripospermum infalcatum	x					
Veramyces manuensis		x		x	x	
Wiesneriomyces laurinus	x					
Number of species	15	7	12	10	10	7

a) A: sheet copper; B: sheet zinc; C: red tiled; D: asbestic tiled; E: tar paper; F: thatch.

Angulospora aquatica was described by Nilsson (1962) from leaves decaying in water in Venezuela. Later, it was observed in Malaysian waters (Dudka, 1985). *Clavariana aquatica* was also reported from stream foam samples in Malaysia (Descals et al., 1976). The present study is the first to report the occurrence of these fungi on the roofs as new habitats. We found *A. aquatica* in rain water falling from sheet zinc, asbestic tiled and tar paper roofs, and *C. aquatica* in samples collected from red tiled, sheet copper and thatched roofs. *Colispora elongata* and *Tricladium procerum* were first isolated by Marvanová (1988) from stream water in the Low Carpathians in Slovakia. Other species of the genus *Tricladium* have been frequently observed in the terrestrial conditions (Ando, 1992). *Gyoerffyella tricapillata* was initially described as *Ingoldia tricapillata* Ingold from decaying leaves in water in Great Britain (Ingold, 1964), and later it was found in several waterflows in the former Soviet Union (Dudka, 1985). Therefore, it is regarded as a typical aquatic fungus, one of the seven species of the genus *Gyoerffyella* (Dudka and Melnik, 1990). Its presence in rainwater falling from a red tiled roof is the first report of this fungus in non-aquatic conditions.

Sporidesmiella hyalosperma and *W. laurinus* were observed in rainwater falling from a sheet copper roof. The former was first described from leaves in a stream in Malaysia (Kuthubutheen and Nawawi, 1993), while the

latter was encountered at several different sites (Kirk, 1984; Kuthubutheen and Nawawi, 1988), mostly on fallen leaves.

Acrodictys similis was observed in samples of rainwater collected from sheet copper and thatched roofs. This species was found on dead bamboo twigs on Juventud island in Cuba (Holubová-Jechová and Mercado Sierra, 1984). Rainwater falling from a red tiled roof also displayed the presence of *A. palma*, which was first described by Ando and Kawamoto (1986) from rainwater falling from an oak *Quercus* sp. in Japan. Our finding is the second site of this fungus. *Beverwykella pulmonaria*, first found in Holland and England on fallen birch leaves in rainwater (van Beverwijk, 1954) and later on fallen leaves in Japan (Tubaki, 1975; Tubaki and Takamura, 1985), was observed in our studies in rainwater falling from sheet copper, red tiled and tar paper roofs. *Hyaloscypha zalewskii* is also an interesting fungus, described in the previous century as *Clathrosphaera spirifera* Zalewski (Zalewski, 1888). It turned out to be a holomorphic species, in which *Clathrosphaerina zalewskii* van Beverwijk (van Beverwijk, 1951) and *H. zalewskii* were included (Descals and Webster, 1976). We observed the growth of *H. zalewskii* in rainwater falling from a thatched roof. Two other species of fungus were also found in roof rainwater that had previously been observed exclusively in land conditions (petiolo putrescenti in Park). These were *C. superioramifera* (in Cuyabeno National Park, Ecuador) and *V. manuensis* (in Manu National Park, Peru). On the other hand, *P. obscuriseptatus* and *S. flagelliferum* were found on a decaying petiole in the tributary of Rio Amazonas (Matsushima, 1993). Worth noting is also the finding of two speceis of the genus *Tricellula* van Beverwijk in rainwater falling from roofs. We found *T. aquatica* Webster only in sheet copper roof water, and *T. inaequalis* van Beverwijk in the water falling from sheet copper, sheet zinc and tar paper roofs. *Tricellula aquatica* was previously encountered on leaves decaying in water in England (Webster, 1959) and in other countries, although always in the aquatic environment (Carmichael et al., 1980; Dudka, 1985). This fungus is also known to occur in soil (Domsch and Gams, 1970), on fallen leaves (Hudson and Sutton, 1964) and on cultivated grass leaves (Mäkelä, 1972). On the other hand, *T. inaequalis* was found in the air in Norway (van Beverwijk, 1954) and later in other land conditions (Koske and Duncan, 1974; Matsushima, 1987).

We should also focus our attention on *D. lunata* and *Neta patuxentica* Shearer et Crane. We observed *D. lunata* in rainwater falling from a thatched roof, and *N. patuxentica* from a red tiled roof. *Dactylaria lunata* was first described from fallen parts of twigs in a recreation forest in Taiwan (Tzean and Chen, 1991). *Neta patuxentica* was found in the water of the Patuxent River in the USA (Shearer and Crane, 1971), and later it was observed in forest bedding in Hungary (Gönczöl and Révay, 1983).

Canalisporium caribense (Holubová-Jechová et Mercado Sierra) Nawawi et Kuthubutheen was found to grow in rainwater of all the six roofs examined. This fungus was first described in terrestrial conditions in Cuba (Holubová-Jechová and Mercado Sierra, 1984), then encountered on branches immersed in a stream in Malaysia (Nawawi and Kuthubutheen, 1989). In our study of hyphomycetes of several dozen springs of the Knyszyńska Forest in various seasons of the year, *C. caribense* was quite common (Czeczuga and Orłowska, 1996). However, it was found in spring water only in summer.

The present study reveals that certain Hyphomycetes species can grow on the roofs of buildings covered with different materials both in rural and urban areas. The fungi found included some having other habitats, e.g., tree leaves, and their conidia were carried to roofs by wind. However, for most of the Hyphomycetes species found, organic matter lodged in irregularities in the roof's surface provides a substratum, and short-lasting morning damp and rainwater may help in sporification (Tubaki et al., 1985). It can be assumed that not only conidia but also mycelia of these fungi are able to survive dry weather periods. This supposition is substantiated by the data obtained in recent years by Sridhar and Kaveriappa (1988). It was found that aquatic fungi growing on *Coffea arabica* Linnaeus and *Hevea brasiliensis* Mueller et Argan, leaves collected from the water of a small stream and then kept in the laboratory under dry conditions for 360 d, continued to grow on being returned to an aquatic environment. These were aquatic fungi of the Hyphomycetes genus. The data provide evidence of the mechanisms of adaptation of aquatic fungi to habitats in waters which periodically dry up during the year. In such cases, the fungi begin to develop as soon as the water returns.

Most Hyphomycetes species were found to develop in rainwater samples from sheet copper, the fewest from sheet zinc and thatch. This finding is difficult to interpret, but it may be associated with the size and degree of unevenness of the roof surface (which can facilitate the arrest of organic matter and conidia). Among the roofs examined, sheet copper had the largest and most uneven surface, which was connected with the roof construction, and sheet zinc was the smoothest, while the thatched roof was the smallest. The texture of each roof may also be a factor which affects the number and flora of inhabiting fungi. Thus, the number of species found is probably a result of all these factors.

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