17th Newsletter of the UFZ Green Roof Research

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The genus *Galerina* - characteristic fungi of mossy green roofs (Photo: P. Otto)

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The option of restricting the newsletter to a specific topic will be exercised for the first issue of 2024. This time, the focus will be on fungi and mycology. The occasion is a lecture given on January 11, 24 at the 49th Green Roof Research Meeting.

It is common knowledge that fungi are omnipresent in all biotopes. As soon as organic material has sufficient water, it is in principle suitable for fungal colonization. What are the conditions for fungi on green roofs like? This complex topic is divided into five sub-aspects. The aim is also to provide basic knowledge for non-specialists.

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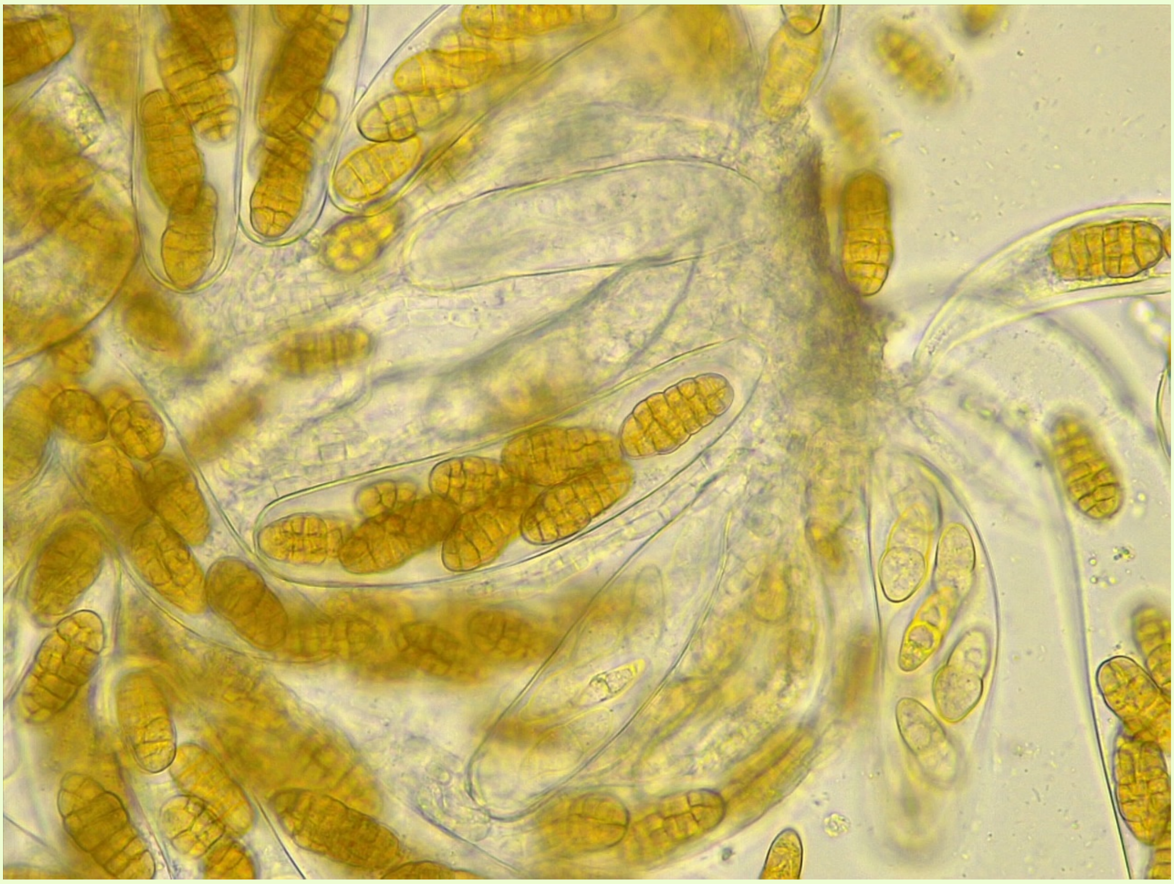

Yellowish complex-septated spores (approx. 30 µm long) in tubes (asci) of the fungus *Pleospora herbarum*. This species often colonizes dead plant stems on green roofs (photo: P. Otto).

Fungal nutritional modes and their effects on the green roof biocoenosis

The basic principle of fungal development is the **utilization and transformation of organic material**. In terms of available quantities, primarily plant matter is used - dead or alive. However, animals and the fungi's own relatives also serve as food sources. On green roofs, dead plant material up to the decomposition stage of humus is a welcome substrate for very different systematic groups of fungi. In the process of decomposition, the organic matter disappears, releasing CO_2, H_2O and minerals. The latter are essential nutrients for the development of new generations of plants. Fungi with the described way of life are called **saprobionts or decomposers**. Another form of nutrition that is also important for green roofs is **parasitism**. It is particularly relevant when cultivated plants are so severely damaged that flowering and seed production fail to occur or entire individuals even die off.

Of the five nutritional modes that are generally differentiated among fungi, **root symbiosis (mycorrhiza)** should also be mentioned as being significant for green roofs. The formation of an arbuscular mycorrhiza (AM or formerly VAM) has been proven for the vast majority of seed plants found on green roofs. Even if concrete studies on green roofs are still pending, it can be assumed that the presence and activity of such fungi in the fine roots are decisive for good plant growth.

The false cypergrass sedge is severely damaged by the rust fungus *Puccinia caricina* on the UFZ marshland roof. However, the neighboring growing marsh sedge is resistant to this parasite (Photo: P. Otto).

Differentiation of substrate qualities and their consequences

Fungi **compete** to a very high degree for the same or similar resources. Which fungal species (and sometimes which genotype of a species) prevails is decisively determined by subtle differences in substrate quality. This can occur **chemically**, e.g. via secondary plant substances or the degree of lignification, or **via moisture content and temperatures** or **via associated microorganisms**. A differentiation of the substrate quality inevitably has an impact on the process of fungal colonization and successive decomposition. Thus, there are fungal **pioneers, followers and finalists** in the decomposition of a leaf or stem. While in the initial phase of colonization there is also a high degree of specificity in the spectrum of fungal species due to specific plant constituents, in later stages of decomposition the fungi that occur are less typical of certain plant species or genera due to the disappearance of these substances. The highest specialization of fungi on certain plants is found in the obligate parasites. In some cases, knowledge of the plant species and a specific infestation pattern can be used to conclude beyond doubt which parasitic fungus must be the cause of the symptoms.

Left: The gill fungus *Omphalina pyxidata* on an approx. 10-year-old roof. Right: An atypical form of cap morel (*Morchella semilibera*) on an approx. 30-year-old roof (Photos: P. Otto).

Fungal biodiversity on green roofs traditionally captured

Different methods can be used to **determine fungal diversity in substrates or biotopes**. By using **molecular techniques**, sometimes hundreds of fungal species can be identified in the smallest amounts of substrate, e.g. one gram of humus from a green roof, by detecting their DNA. It remains to be found out which of these species are typical for the substrate and can live there actively and which were only introduced as spores by the wind, for example. In order to determine this, much more complex transcriptomic and proteomic studies must be carried out.

As an alternative to the biochemical (identification of RNA or protein patterns), the classical approach is recommended - **the visual detection of active fungal stages**, i.e. spore-forming mycelia or even complex fruit bodies. Using this method, **around 50 species of fungi have been identified on Leipzig's green roofs to date** - all of them fungi that find favorable conditions for development in this habitat. The actual number will be in the region of at least 100. The spectrum ranges from mold fungi to obligate parasites such as powdery mildews to puffball mushrooms. For the most part, these are common species that occur in various types of biotope.

In late fall after heavy rainfall, the dog sick fungus (*Mucilago crustacea*) develops on extensively greened roofs. It belongs to the group of slime molds. The picture shows the drifting of spores and lime particles. Both are not pathogenic to humans (Photos: P. Otto).

Spore formation and health risks for humans

A popular and appropriate characterization of fungi refers to their mostly concealed life in the substrate or host - **"fungi as creatures in the dark or hidden"**. When the fungal organism appears and starts to form spores, this is generally associated with **very high water availability**. Apart from the special type of wetland roof, all other types of green roof are characterized by very low to clearly limited amounts of water over longer periods of time. This results on the one hand from comparatively thin substrate layers and on the other hand from the height and exposure of roofs. High solar radiation, warm rising air and strong air movements lead to a dry and warm local climate, which is very unfavorable for the sporulation of fungi. For the reasons mentioned, this is predominantly limited to a few weeks of high precipitation from late fall to spring, especially under the climatic conditions in central Germany. A comparison with near-natural biotopes such as forests and meadows shows that far fewer fungal spores are formed and released into the air on green roofs. The mold *Aspergillus*, which is so typical of warehouses and buildings in general and could be very harmful to health, does not play a role in Central Europe as it is in nature mainly subtropical distributed.

The conclusion is as follows: at least the green roof types of extensive and intensive greening do not have a level of fungal spore production that would have to be classified as medically harmful to humans.

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Green roofs and their potential for protecting endangered fungal species

If green roofs have vegetation formed by native plant species and are **at least 10 years old**, they are home to relatively **species-rich fungal communities.** Their development requires time, as plant remains and humus accumulate and small habitats such as moss and lichen turf have to form first. Green roofs can also provide valuable substitute habitats for endangered fungi. The comparable near-natural habitat types are, for example, dry sandy and nutrient-poor grasslands, pioneer vegetation on rocks or swamps and pond banks. Several fungi that are rare in Germany and Saxony have been found on Leipzig's green roofs. In the case of the **vermilion waxcap (*Hygrocybe miniata*)**, a protected species has been identified. The targeted continuation of the mycological inventory studies will undoubtedly lead to further findings of nature conservation significance.

Left: Spore chains of *Alternaria alternata* on plant material cultivated in the laboratory from the UFZ extensive roof (image section approx. 3 x 2 mm). Right: The gill fungus *Rickenella mellea*, which is extremely rare in Saxony (Photos: P. Otto).