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Revision of the *Verrucaria elaeomelaena* species complex and morphologically similar freshwater lichens (Verrucariaceae, Ascomycota)

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Abstract

The freshwater lichens *Verrucaria elaeomelaena*, *V. alpicola,* and *V. funckii* (Verrucariaceae/Ascomycota) have long been confused with *V. margacea* and *V. placida* and conclusions on the substratum preference and distribution have been obscured due to misidentifications. Independent phylogenetic analyses of a multigene dataset (*RPB*1, mtSSU, nuLSU) and an ITS-dataset combined with morphological and ecological characters confirm that the *Verrucaria elaeomelaena* agg. consists of several cryptic taxa. It includes *V. elaeomelaena* s.str. with mostly grey to mid-brown thalli and transparent exciple base which cannot be distinguished morphologically from several other unnamed clades from low elevations, the semi-cryptic *V. humida spec. nov.*, which is characterised by smaller perithecia, shorter and more elongated spores compared to other species in this group and *V. alpicola* with specimens mostly from high elevations, dark brown to black thalli, a brown exciple base and large ascospores. While *Verrucaria funckii* is confirmed to be restricted to siliceous substrata, limestone and siliceous substrata are both colonised by *V. elaeomelaena* s.str. as well as by representatives of various other clades. The substratum type cannot be seen as a diagnostic character for taxa within this species group. The taxa included in *Verrucaria elaeomelaena* agg. are closely related to *V. submersella* and together with *V. funckii* they form a sister clade to the "*Endocarpon*-group" in the Verrucariaceae. *Verrucaria margacea* is superficially similar to some specimens of *V. elaeomelaena* agg. It is nested within an unresolved larger clade with *Dermatocarpon*, the subclades of the *Endocarpon*- and the *V. elaeomelaena*-group. *Verrucaria margacea* can be distinguished from most of the specimens in the *V. elaeomelaena* group by its generally non subgelatinous thallus, often with distinct cracks, narrowly ellipsoidal ascospores and the general absence of a black basal layer or dark pigments in the exciple base. The form and size of the ascospores distinguish *V. placida* from most specimens in the *V. elaeomelaena* complex, but there is overlap with some forms of *V. alpicola*. Epitypes are proposed for *V. elaeomelaena, V. alpicola* and *V. margacea* and a European key to the species of subgelatinous freshwater *Verrucaria* with spreading involucrellum and large ascospores is provided.

Keywords: Alps, Central Europe, aquatic lichen, cryptic species, Norway, Finland, Poland, Germany, United Kingdom, taxonomy, typification

Introduction

Freshwater lichens are facing strong physical stress on all surface structures due to the impact of the water current and the scouring effect of sediments drifting over the lichen thallus. The frequent and long periods of full water saturation add physiological stress hindering the diffusion of dissolved gases such as oxygen and carbon dioxide inside the lichen thallus. Favoured life forms under these conditions are generally thin crustose thalli, which facilitate gas exchange and minimise physical stress, and ascocarps which are small and immersed in the thallus (eg. in *Hydropunctaria*) or surrounded by a protective structure such as an involucrellum (most freshwater species with large perithecia). Ecological constraints limit morphological differentiation and may partly explain the high degree of homoplasic characters in aquatic lichens as revealed by molecular studies eg. for the family Verrucariaceae (Gueidan *et al.* 2007). *Verrucaria* is the largest genus within the family but the type species, *Verrucaria rupestris* Schrad., is only distantly related to most other species of the genus and the need of a revision of generic boundaries in the family has become obvious (Gueidan *et al.* 2007). For two distinct clades of hydrophilic species with small ascospores the new genera

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