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ORIGINAL ARTICLE

Ecological and taxonomic characterisation of *Trentepohlia umbrina* (Kützing) Bornet growing on stone surfaces in Lazio (Italy)

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Abstract

Purpose The colonisation of building material by photosynthetic organisms is highly dependent on the environmental conditions and the nature of the substrate. The growths of red-orange phototrophic biofilms have been widely reported in the literature and have commonly been associated with the order Trentepohliales, whose ecological and taxonomical information needs to be improved. Considering the recurrent presence of such biofilms throughout the Lazio region, we would identify the occurring species and define their favourable environmental conditions, through morphological, genetic and ecological analyses.

Results Biofilms were collected across an altitude range of 0 to 860 m asl, occurring from the coast to 60-km inland. A dominant presence of the filamentous terrestrial green alga *Trentepohlia umbrina* (Kützing) Bornet was confirmed in all sites sometimes mixed with cyanobacteria of the genus *Gloeocapsa*. The distribution of Trentepohliales is generally given as pan-tropical, but some species, such as *T. umbrina*, are also distributed in temperate climates. Here, it is reported for the first time a Mediterranean occurrence of the species. Low humidity and light conditions, such as those occurring on vertical surfaces with mainly northern aspects, are the preferred environmental conditions. Coastal areas were more favourable for its growth, probably due to the higher nocturnal condensation that occurs here. Concrete and mortars were particularly bioreceptive to *T. umbrina*, but marble and trachyte were also colonised under favourable conditions.

Conclusions The findings better define the ecological range of this species, suggesting a wider biogeographic distribution, and adding information on morphological features and genetic data.

Keywords Biodeterioration patterns · Building material · Biofilm · Reddish patinas · Green algae · *Trentepohlia umbrina*

Introduction

Green subaerial microalgae can colonise natural and artificial substrata to form biofilms (Ricci and Pietrini 1994; Bellinzoni et al. 2003; Tomaselli et al. 2000; Rindi and Guiry 2004). Advanced growths of these biofilms are visible to the naked eye, forming patinas of different colours, such as green, grey and reddish, and giving rise to characteristic biodeterioration patterns (BP) (Caneva et al. 2016). They can often be considered as aesthetical biodeteriogens, but the potential for structural deterioration, caused by physical and biochemical process, may have started before biofilms are even visible (Eggert et al. 2006; Scheerer et al. 2009; Bartoli et al. 2014). The occurrence of green algae and cyanobacteria biofilms on outdoor stone monuments and other artificial substrata, such as roof tiles, concrete or building facades, can exacerbate natural weathering phenomena (Caneva et al. 1992; Albertano 1995; Gaylarde and Morton 1999; Tomaselli et al. 2000; Gaylarde et al. 2004). Apart from the aesthetical impact of phototrophic biofilms, in some cases, they can also be considered as bioprotective of stone materials, even if this role has not been comprehensively demonstrated (Cutler and Viles 2010; Ramirez et al. 2010; Pinna 2014).

The occurrence of red-orange biofilms is often associated with the green algal order Trentepohliales, whose colour is resulting from their large production of ß-carotene and haematochrome pigments. The order includes one family (Trentepohliaceae) and five genera (*Trentepohlia*, *Printzina*, *Phycopeltis*, *Chephaleuarus*, *Stomatochroon*), and originally had a pan-tropical distribution. The genus *Trentepohlia* comprises an

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