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Artificial light at night decreases biomass and alters community composition of benthic primary producers in a sub-alpine stream

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Abstract

Artificial light at night (ALAN) is recognized as a contributor to environmental change and a biodiversity threat on a global scale. Despite its widespread use and numerous potential ecological effects, few studies have investigated the impacts on aquatic ecosystems and primary producers. Light is a source of energy and information for benthic autotrophs that form the basis of food webs in clear, shallow waters. Artificial night-time illumination may thus affect biomass and community composition of primary producers. We experimentally mimicked the light conditions of a light-polluted area (approximately 20 lux, white LED) in streamside flumes on a sub-alpine stream. We compared the biomass and community composition of periphyton grown under ALAN with periphyton grown under a natural light regime in two seasons using communities in early (up to 3 weeks) and later (4–6 weeks) developmental stages. In early periphyton, ALAN decreased the biomass of autotrophs in both spring (57% at 3 weeks) and autumn (43% at 2 weeks), decreased the proportion of cyanobacteria in spring (54%), and altered the proportion of diatoms in autumn (11% decrease at 2 weeks and 5% increase at 3 weeks). No effects of ALAN were observed for later periphyton. Further work is needed to test whether streams with frequent physical disturbances that reset the successional development of periphyton are more affected by ALAN than streams with more stable conditions. As periphyton is a fundamental component of stream ecosystems, the impact of ALAN might propagate to higher trophic levels and/or affect critical ecosystem functions.

Light pollution that results from the extensive use of artificial light at night (ALAN) is a global phenomenon and one of the fastest-spreading environmental alterations induced by humans (Hölker et al. 2010*a*; Falchi et al. 2016). ALAN can have several effects on the natural environment (Longcore and Rich 2004; Hölker et al. 2010*b*). So far, ecological effects of ALAN have been commonly examined at the level of single species (Gaston et al. 2015) while fewer studies address higher ecological levels such as communities or ecosystems functions (e.g., Davies et al. 2012; Becker et al. 2013; Meyer and Sullivan 2013). Moreover, studies of ecological effects of ALAN have largely focused on terrestrial habitats, while the interest in aquatic systems is relatively recent (Perkin et al. 2014*a*; Brüning et al. 2015; Hölker et al. 2015; Honnen et al. 2016) despite the fact that freshwaters are often exposed to ALAN from adjacent urban and sub-urban areas (Ceola et al. 2015).

Light serves as a source of both energy and environmental information for primary producers (Hegemann et al. 2001). The intensity, spectral quality, timing and duration of light all affect photosynthesis and growth of aquatic primary producers as well as their biochemistry and community composition (Richardson et al. 1983; Falkowski and Laroche 1991; Khoeyi et al. 2012). As a result of human population growth and increased urbanization, previously ALAN-naïve freshwater environments, e.g., streams, rivers, and littoral habitats of lakes are increasingly exposed to artificial illumination at night. In such shallow, clear waters, periphyton often forms the base of the food web (Stevenson 1996). Periphyton is a complex benthic community of algae, bacteria, and fungi embedded in a polysaccharide matrix (Wetzel 2001). These benthic communities are predominantly composed of

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