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Artificial light at night affects biomass and community composition of freshwater primary producers

Theme: Biology & Ecology

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Introduction

Artificial light at night is recognized as a contributor to environmental change at the global scale (Cinzano et al. 2001) and a biodiversity threat (Hölker et al. 2010). Increasing research efforts have demonstrated numerous adverse effects on aquatic and terrestrial animals (e.g. Moore et al. 2000, Perkin et al. 2014), microorganisms (Poulin et al. 2013, Hölker et al. 2015), and plants (Bennie et al. 2015). Aquatic primary producers, however, have rarely been studied and the impacts on benthic autotrophs are poorly understood.

Benthic autotrophs, such as diatoms, green algae and cyanobacteria, grow attached to underwater surfaces and form the basis of the food web in many streams and clear, shallow waters (Stevenson 1996). They use light both as a source of energy for photosynthesis and growth, and as an information cue for the regulation of physiological processes, especially those that display a circadian rhythm (Kianianmomeni & Hallmann 2014). Further, the major autotroph groups differ in their preferences for light conditions (Richardson et al. 1983), therefore the alteration in light regimes may cause changes in community composition.

Fig 1. Outdoor flume system fed by a pristine sub-alpine stream

We conducted experiments in two different freshwater systems: an outdoor flume system mimicking a sub-alpine stream (Bruno et al. 2016, Fig.1) and a low-land agricultural drainage ditch, the Westhavelland experimental site (Holzhauer et al. 2015, Fig.2). We simulated the night-time light conditions of a waterbody in a light-polluted area (approx. 20 lux at the water surface), and compared the biomass and community composition with those grown under natural nights. The experiments were performed in different seasons in both ecosystems in order to account for seasonal differences in community composition. Two light sources, warm-white LEDs and high-pressure sodium (HPS) lamps, were used in the experiments in the Westhavelland site while only warm-white LEDs were used in the sub-alpine stream.

Fig 2. Low-land agricultural drainage ditch

The LED-based nighttime illumination over three to six weeks resulted in a decrease of autotroph biomass in both aquatic systems. Community composition was also affected by LED, but the effect varied between the systems, seasons and developmental stage of the community. Primary producers did not respond to HPS-based illumination, likely a result of different spectral composition. Our results show that artificial light can have profound effects on the primary producers of aquatic ecosystems. By negatively affecting the biomass and altering community composition, artificial light at night may hinder primary production as a vital ecosystem function and therefore negatively impact the resilience of aquatic ecosystems. This effect is likely to increase with the current shift from sodium lights to white LED.

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