EDITORIAL
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Editorial: Effects of Artificial Light at Night on Organisms: From Mechanisms to Function

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Editorial on the Research Topic

Effects of Artificial Light at Night on Organisms: From Mechanisms to Function

Artificial light at night (hereafter, ALAN) has brought benefits to humans and was first perceived as a technological advancement that would increase the comfort and wellbeing of modern civilizations. However, it is now increasingly accepted by the scientific community that it also results in damaging effects to living organisms, including humans, and is an ever-increasing global pollutant that threatens biodiversity at multiple scales (Hölker et al., 2010; Swaddle et al., 2015; see below). Because ALAN reaches not only areas close to its sources, but also far away sites through sky-glow, it can have far-reaching impacts on organisms and ecosystems. Furthermore, its impact can potentially be seen at all levels of biodiversity from genes (e.g., Golden, 1995), individuals (e.g., Dominoni et al., 2013), populations and communities (e.g., Bennie et al., 2018), to ecosystems and landscapes (e.g., Perkin et al., 2011). ALAN affects both nocturnal and diurnal organisms (Rich and Longcore, 2006) by influencing gene expression (e.g., Gilmartin et al., 1990; Haim and Zubidat, 2015) and production of melatonin (van Geijlswijk et al., 2010), a crucial hormone regulating the sleep-awake cycle on which many animals depend (Ferguson et al., 2010). Indeed, ALAN effects have been documented on a wide variety of species, including unicellular organisms (Quraishi and Spencer, 1971), plants (Bennie et al., 2016), invertebrates (Van den Broeck et al., 2021), and vertebrates (Wilson et al., 2018).

In this Research Topic we aimed to compile studies that included a large variety of species and different approaches, which together address the mechanisms (e.g., hormonal changes) by which ALAN affect organisms and the possible biological consequences (e.g., in behavior, development, survival, reproductive success, population, and community changes). We have collected 12 papers representing state-of-the-art knowledge on the effects of ALAN on fishes (Mondal et al.), birds (van Dis et al.; Bani Assadi and Fraser; Kumar et al.; Rodríguez et al.), crickets and grass (Crump et al.), beetles (Kaunath and Eccard), other invertebrates (Hey et al.; Coetzee et al.), and rodents (Hoffmann et al.). We have collected both studies at the individual level and at the community level, as well as from proximate and ultimate perspectives.

At the individual level, Mondal et al. investigate the effect of different photoperiods on the expression of appetite-regulating hormones and enzymes in the zebrafish (*Danio rerio*), providing a mechanistic explanation for changes in feeding behavior in altered light conditions. van Dis et al. address the effects of different light wavelengths (white, green, red, and control) on the temperature of great tit (*Parus major*)'s nests, incubation behavior and a possible link with fitness. Bani Assadi and Fraser show that artificial light impacts nestlings' development and departure times from the nest,

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with green light having a lesser impact on chicks than white light. Kumar et al. show how exposure to ALAN at different periods during the night has different behavioral and physiological effects on a migratory songbird. Kaunath and Eccard investigate the attraction effects that ALAN can have on three genera of beetles (Coleoptera: Carabidae), and show a differential response associated with the level of light exposure to which these beetles are exposed in their habitat. Hoffmann et al. investigate the effects of ALAN on the nocturnal and subsequent diurnal foraging behavior of a small mammal, the bank vole (*Myodes glareolus*). The authors find changes in nocturnal foraging activity and link these effects to vole personalities; the study also shows that ALAN can have carry-over effects into daytime foraging behavior. Finally, Rodríguez et al. investigate the influence of ALAN on a well-known phenomenon in seabirds: bird fallouts, where migratory birds are grounded before reaching their destinations. Using GPS they address how ALAN may interact with intrinsic (e.g., down abundance, body mass, and body condition), and extrinsic factors (e.g., flight behavior) of Cory's shearwater *Calonectris borealis* fledglings, to predict their probability of fallouts.

At a community level, Hey et al. investigate the possible effects of ALAN on the structure and trophic interactions of an invertebrates-plant community, looking, among other aspects, at changes in abundance of secondary and tertiary consumers. On the other hand, Crump et al. study the effects of low-level ALAN and the action of an herbivore (crickets, *Acheta domesticus*) on growth rate and physiology of Kentucky bluegrass (*Poa pratensis*).

The Research Topic also provides a summary and a synthesis of research on ALAN, with two reviews and a perspective. Halfwerk and Jerem review the current evidence that ALAN affects animals in conjunction with another urban pollutant that normally co-occurs with ALAN: anthropogenic noise. In this way, they undertake a multisensory approach to investigate different possible outcomes, such as additive and interactive effects (i.e., antagonistic, synergistic, and emergent). The review by Coetzee et al. considers both mechanisms and functions to understand how artificial light can impact the behavior of disease vectors (mosquitoes) and thus the probability of disease propagation; the authors discuss how we may use light to mitigate the spread of these diseases. Hölker et al. summarize what are some of the most important questions that we need to answer if we are to reduce the damaging effects of ALAN on biodiversity. Although valuable steps have been put forward to understand how ALAN affects organisms at different levels of organization and scales, as discussed by Hölker et al., this is a relatively new field of research and more work is needed to better understand how ALAN impacts biodiversity in a broad sense, and what we can do to mitigate its effects. Hölker et al.'s discussion stems from a workshop on the effects of ALAN on biodiversity that took place during the first World Biodiversity Forum in Davos, Switzerland.

Though further work is needed to illuminate how the effects of ALAN scale across biological levels, this Research Topic gives insight into the mechanisms and consequences of ALAN at individual and community levels in a wide variety of taxa. This body of work combines studies from both basic and applied science perspectives, addresses the complexity of the possible outcomes that ALAN may have on biological systems, and discusses the next steps we should take in order to mitigate its effects.

AUTHOR CONTRIBUTIONS

AR-C conceived the Research Topic of this compilation and wrote the first draft of this editorial. All authors contributed equally in editing and improving this Editorial.

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