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Light pollution and Habitat Disruption on Nocturnal Insects: A Literature Review

Abstract

Light pollution refers to unnecessary or excessive outdoor illumination at night. It affects nocturnal organisms by forcing them to translocate to places that receive more natural light. Artificial light not only disrupts the living environment of these organisms, but it propels them to abandon their natural habitat. Since specific processes and activities are required for natural habitats to function successfully, it is important to specify the different activities disrupted by light pollution and to discover how these disruptions influence the translocation of nocturnal insect communities. This research is necessary to prevent biodiversity loss and to generate possible solutions for the future.

Introduction

The most common type of artificial light used for streetlamps is low-pressure sodium light (with a bright yellow color), which has a narrower-spectrum lighting and better transmission than LED (light-emitting diode) light (Boyes H. et al. 2021). However, LED light has higher energy efficiency and illuminates a greater area (Bennie et al. 2018; Boyes H. et al. 2021). As more people implement them as their main source of lighting, natural habitats become exposed to a superfluous amount of artificial illumination. Research has shown that light pollution impacts both inter and intra relationships such as food attainment and mating activities,

predator-prey relationships, and trophic equilibrium in nocturnal insects' communities very differently (Bennie et al. 2018; Firebaugh and Haynes 2019; Boyes H. et al. 2021). These effects originate from the varying wavelengths emitted by modern lighting technology (Douglass H. et al. 2021). Current research on understanding light pollution's different effects on biodiversity demonstrates the importance of diminishing natural habitat interference by minimizing light pollution (Bennie et al. 2018; Firebaugh and Haynes 2019; Boyes H. et al. 2021). Therefore, the purpose of this review is to specify the effects that light pollution has on biotic interactions within nocturnal insect communities and to discover how these effects influence their translocation.

Food attainment

Food availability is a crucial component of all ecosystems. When organisms experience a food shortage, their natural habitat becomes more vulnerable to invasion, and fierce competition for survival surges (Bennie et al. 2018). To such a degree, this influences an insect community's local abundance (Bennie et al. 2018) and feeding behavior (Boyes H. et al. 2021). Research has shown, however, that light pollution is responsible for altering the food abundance of nocturnal insect populations in particular (Bennie et al. 2018; Boyes H. et al. 2021). This is mostly because outdoor lighting (including artificially lit fields and street lighting) interrupts the daily cycles of sunlight and darkness to which plants and other organisms have assimilated (Bennie et al. 2018). Moreover, nocturnal insects, which carry out most of their inter and intra relationships at night, often experience unregular lighting patterns and are unable to find food (Firebaugh and Haynes 2019; Boyes H. et al. 2021).

Bennie et al. (2018) conducted an experiment to determine how artificial illumination (monochromatic amber light and white LEDs) interfered with the vegetation cover, food source,

and predator-prey relationships of organisms living in the grassland communities. The organisms studied in the experiment were mainly grassland plants (Lotus corniculatus, Lotus pedunculatus, Trifolium dubium, Trifolium pratense, etc.) and invertebrate herbivores, as well as predators. Bennie et al. (2018) conducted the experiment and gathered results by using 54 mesocosms (outdoor systems ideal for environmental and biological experiments) and recorded their observations at night for three years. The different systems were divided equally and exposed to both, white and amber light, as well as natural lighting at night. These are common forms of streetlights and in this instance, were used to simulate the roadside vegetation of many artificially lit fields at night and to identify the extent to which the varying light wavelengths alter grassland ecosystems. In the end, monochromatic amber light decreased the overall number of herbivores by 17% and the main reason was that it diminished the total amount of vegetation cover and flowers of their main food plant inside the mesocosms. All in all, Bennie et al. (2018) found a positive correlation between light pollution and lack of food resources within grassland communities.

Prey-Predator Relationships

The local population of an ecosystem is mainly balanced by predator-prey interactions (Bennie et al. 2018; Firebaugh and Haynes 2019). However, when artificial light interferes with predation or prey survival, the local population is disrupted (Bennie et al. 2018). Light pollution often benefits visual predators by bringing out to light the defenseless prey from its usual hiding place (Bennie et al. 2018). Consequently, many organisms from different natural habitats have to translocate to other areas where natural light is ampler and where other visual predators are not as dangerous (Bennie et al. 2018). As outdoor artificial lights expand (LED especially), more

predations occur, and correspondingly, the local abundance of organisms decreases. In the end, this results in the constant translocation of different insect communities.

Under artificial light, various insect, and grassland communities such as moths, slugs, and aphids decrease their population mainly by predation (Bennie et al. 2018; Firebaugh and Haynes 2019). In 2018, a study that mainly studied grassland plants and invertebrate herbivores, as well as predators, showed that white LED lights decreased the overall number of herbivores by 55% when a predator was added (Bennie et al. 2018). The main conclusion of this experiment was that light pollution alters ecosystems and directly affects trophic levels. Most of these effects depend on the wavelength of the different types of artificial light. Although it was found that predator-prey relationships were not affected by light pollution within firefly communities (Photuris Versicolor firefly as the predator species and the P. Pyralis firefly as the prey species), encounter rates with other visual predators increased (Firebaugh and Haynes 2019).

Courtship

In 2019, a study by Firebaugh and Haynes (2019) which involved two types of fireflies, the Photuris Versicolor firefly and the P. Pyralis firefly, revealed that courtship in insect communities is also influenced by light pollution. Under the presence of artificial light, the Photuris Versicolor fireflies did not light up or showed any mating patterns, whereas, in spaces with natural lighting, they lit up at least once and presented lighting patterns that resembled mating activities. Light pollution dwindled flashes of the P. Pyralis fireflies by 25 percent and female P. Pyralis mated twice as much in natural lighting. The main objective of the investigation was to find out how light pollution affects the attraction and repulsion of nocturnal insects and to identify how it alters daily interactions like courtship (mating behavior) and predator-prey relationships. To determine if artificial lights attracted fireflies, they counted the

number of fireflies captured inside 15 pairs of lit and unlit traps throughout 14 nights. To quantify the number of recurrent flashes and analyze the mating behavior of the Photuris Versicolor firefly (the predator species), they separated them into two containers with and without artificial illumination. They scrutinized the mating behavior of the P. Pyralis fireflies and the predator-prey interactions between both species by using a manipulative outdoor experimental system with and without artificial illumination. In the end, they found a positive correlation between low mating rates and light pollution among insect communities.

Conclusion

Overall, light pollution impacts both inter-and intra-specific processes such as food attainment and mating activities, predator-prey relationships, and trophic equilibrium in insect communities. As more artificial lighting is used (whether LED or low-pressure sodium light), the translocation of different insect communities to different areas intensifies, and the habitable space for them to flourish decreases. It is important to understand the different effects that light pollution has on the living environment of nocturnal insects because further understanding can help generate possible alternatives for preventing biodiversity loss.