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EDITORIAL

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Abstract

Artificial light at night (ALAN) is exponentially increasing and several studies highlight detrimental effects on both humans and wildlife, including their reproductive and metabolic systems, cancer risk, and mental health. This Collection aims to explore the effects and underlying mechanisms in humans and other organisms.

Main text

For millions of years, light cycles have been constant – daily, lunar and yearly light cycles. These have regulated the activities of organisms, from the timing of reproduction to daily activities such as when to search for food and when to rest. The invention of artificial light, and its increased use, has changed that. Artificial light is now lighting up the night, both indoors and outdoors. This is eroding natural light cycles and threatening the natural rhythms in both humans and other organisms [1]. During the last century, the use of artificial light at night (ALAN) has increased exponentially, and the use is expected to further increase in parallel with global human population growth. The invention of light-emitting diodes, LEDs, has further exacerbated the problem. These are inexpensive to use, and their light intensities are often higher, with a spectrum closer to natural light, compared to traditional lamps, such as incandescent indoor light bulbs and high pressure sodium street lights [1, 2].

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Because of artificial light, it is now possible for humans to work around the clock. However, several epidemiological studies, initially conducted on night-shift workers, indicated adverse effects in humans, especially a higher ratio of cancer cases [3]. In particular, high levels of ALAN has been associated with increased risk of breast cancer and possibly prostate cancer, but positive association was reported also for non-Hodgkin lymphoma and colorectal, pancreatic and thyroid cancer [3–5]. Apart from night-shift work, ALAN has been associated with increased risk of sleep disturbances, diabetes, obesity and other cardiovascular risk factors [6, 7]. More recent findings also suggested detrimental effects on mental health, including depression, mood disorders and cognitive impairment [8–10].

Artificial light influences not only humans but also wildlife, impacting both species exposed to direct light (e.g., birds in cities and mammals near highways), and wildlife far from light sources. This occurs through skyglow, where light radiating upwards from light sources (e.g., urban areas), is diverted back to Earth through scattering, illuminating areas far from the original light source [11]. A growing number of studies show that direct and indirect light affects the physiology, behavior and life history of animals, with consequences for their development, survival and reproductive success. For instance, insects are attracted to nocturnal lights, which also attracts their predators, especially bats [12]. Unnatural presence of light can affect migrating fish like salmons and eels that may take more time and energy

with negative impact on the reproductive success [13]. Glow-worm females have difficulties attracting males, decreasing their reproductive success [14, 15]. Changes in behavior, survival and reproductive success can, in turn, influence the abundance and distribution of species and, hence, biodiversity, species interactions, and ultimately the functioning of the ecosystem, such as nutrient cycling, pollination and seed dispersal. Such changes can also negatively affect human society, considering that we rely on these ecosystem services (e.g., pollination and primary production) for our wellbeing and quality of life.

The effects of light pollution on living organisms can be multifaceted. On the one hand, light pollution can disrupt the reception of information such as daily light cycles, the environment or individual traits. For instance, the visibility of the glow-worm's glow can be diminished and reduce mating success. On the other hand, light pollution can change the use of light as a resource, such as in photosynthesis or daily activity patterns [16]. In particular, the disruption of the circadian cycle can influence an organism's physiology, especially through changes in melatonin levels and the endocrine system. Many hormones, pheromones and metabolites are under circadian control and their disruption can have both short term and longer-term effects on health and the wellbeing of organisms.

An increasingly important topic in our human-disturbed world, is how to mitigate the negative effects of artificial light on life forms. Light is needed for many human activities and for increasing safety, but its intensity and spread are over-dimensioned. By limiting the use of artificial light to essential purposes, times and places (e.g., through the use of timers and shades) and by adjusting the light's spectrum and intensity, negative effects can be significantly reduced. More research is now needed on the effectiveness of these measures and on the developments and technology needed to achieve these goals.

The aim of this Collection is to explore and explain the different ways in which ALAN can influence both humans and other organisms, and to discuss the effects the light can have on the natural world, as well as the possibility of mitigating negative effects. With this, we hope to inspire further research into this important topic, to ensure a wise use of artificial light in the future, which would safeguard a healthy and well-functioning world also for coming generations.

Abbreviation
ALAN Artificial light at night

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Authors' contributions
UC and TF contributed to the conception and drafting of the manuscript. Both authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
Ulrika Candolin and Tommaso Filippini are Guest Editors of the collection *Light pollution and its impact on human health and wildlife*.

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