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Attractiveness of Ephemeroptera insect order to light colour temperature

Theme: Biology and Ecology

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Introduction

Lighting the night became ubiquitous at the end of the 19th century and, thanks to technological advances, is now widespread (Falchi *et al.*, 2016). Artificial light at night was proven to have an effect on human circadian cycle - the alternance of night and day that has physiological effects – and then on health and behaviour (Navara & Nelson, 2007). There is as well an effect on the vision of stars that is blurred (Falchi *et al.*, 2016). Anthropogenic light is therefore synonymous with light pollution (Bullough, 2021; Riegel, 1973). This light pollution also has an impact on plants (Singhal *et al.*, 2018), birds (Degen *et al.*, 2022), fishes (Foster *et al.*, 2016) or insects (Seymoure *et al.*, 2021).

Insects represent 80 % of animal biodiversity (Mawdsley & Stork, 1995). If we add to this their high attractiveness to artificial light (Seymoure *et al.*, 2021), they take the lead role for light pollution studies. The Ephemeroptera order seemed interesting to us as the adults have two kinds of eyes. Females possess lateral eyes, as males have an additional dorsal eye (Horridge & McLean, 1978). Their vision, and maybe attractiveness to artificial light, might be different. It is indeed the case in bibliography with mostly the females attracted by street lamps (Egri *et al.*, 2017).

Our goal here is to evaluate the attractiveness for different artificial light sources. Spectral power distribution (SPD) from 360 to 780 nm influences the correlated colour temperature (CCT). The correlation between CCT and spectral distribution is not unique, but we can consider CCT as a discriminating factor. Furthermore, CCT definition lies on physics and has very few anthropic biases. The idea is to combine the insects eye response (action function) with SPD to quantify light attraction. For some studies, the ecological impact of color temperature does not exist on mayflies (Durmus *et al.*, 2021; Pawson & Bader, 2014) but they stopped their observations and calculations to 6500 K. This abstract is a preliminary work carried out in the framework of the PhD thesis entitled “Quantitative evaluation of the impacts of anthropogenic light pollution on biotopes and nocturnal fauna”.

Methods and results

Starting from classic photometric definitions, adapted to insects’ vision, we have chosen seven LED lamps, all with different colour temperature between 2500 K and 9000 K. The spectra of LEDs are coming from LAPLACE databases, then normalized for a maximum of 1. The visual functions of dorsal eye (Horridge & McLean, 1978) and lateral eyes (Durmus *et al.*, 2021) were extracted from these studies, also normalized and gave some action functions $A(\lambda)$ (fig. 1).

In our study we defined, among others, a similarity factor, ξ_{θ} , between the SPD and the action function. This factor is defined as the scalar product between SPD and $A(\lambda)$. The closer this value is to 0, the weaker is the correlation and so the less attractivity effect is expected. On the contrary, the closer the result is to 1, the stronger is the correlation between the two functions, and then the more impact of light on insects is

anticipated. The calculations were made for each eye type and for each LED, figure 2 shows our results. It can be seen that the lateral eyes are more sensitive to light till ~6000 K but then the tendency is reversed, on the opposite, dorsal eyes seem to have a different reaction to light that can help to explain the observed different behaviors of male and female Ephemeroptera.

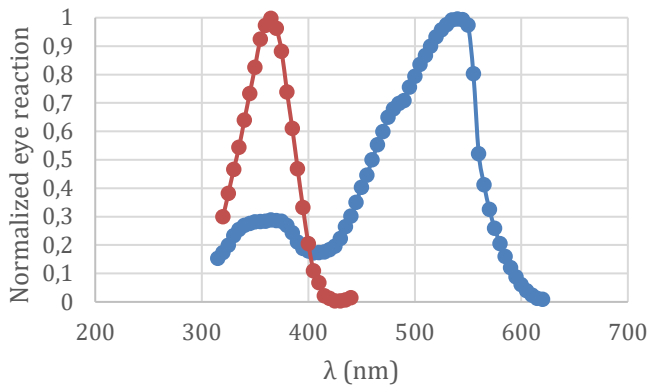


Fig.1: Normalized spectral visual responses of Ephemeroptera's lateral eyes (blue) and dorsal eye (orange).

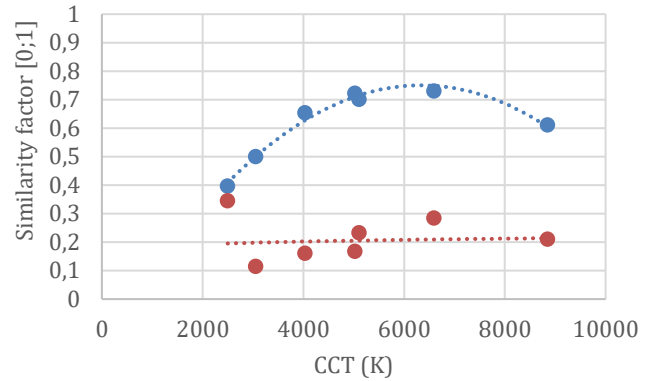


Fig.2: Trend line of the similarity factor, ξ_{θ} , allowing to deduce attraction of insects to different CCTs, for the lateral eyes (blue) and the dorsal eye of male mayflies (x150) (orange).

Conclusions

Here we investigate the relation between the color temperature of LEDs and the reaction of the dorsal and lateral eyes of Ephemeroptera. It seems that for an increasing colour temperature, reaction of the lateral eyes is increasing too. But when a certain level is exceeded, this attractiveness decreases. The dorsal eye tends to have different reaction, but the similarity factor is too low for us to say that there is an impact. Colour temperature is only one among multiples light indicators. Many others need to be investigated in order to be able to quantitatively assess the attractivity of light pollution on insects. This is the objective of our future work.

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