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Report of the Intersessional Working Group on Bats and Light Pollution

After the 23rd meeting of the AC, the IWG on Bats and Light Pollution finalised guidelines for consideration of bats in lighting projects. The guidelines were published in autumn 2018 as EUROBATS Publication Series No. 8. Further, the IWG drafted a resolution for submission to the EUROBATS Meeting of Parties that took place in Monaco in October 2018. The resolution was adopted without any significant changes. The IWG compiled a list of publications that have been published since the release of the guidelines (see below).

Artificial light at night and bats: A list of papers published since the release of the EUROBATS Guidelines No. 8, compiled by Christian C. Voigt (status 25.3.2019):

Spoelstra, K., Ramakers, J. J., van Dis, N. E., & Visser, M. E. (2018). No effect of artificial light of different colors on commuting Daubenton's bats (Myotis daubentonii) in a choice experiment. Journal of Experimental Zoology Part A: Ecological and Integrative Physiology, 329(8-9), 506-510.

Progressive illumination at night poses an increasing threat to species worldwide. Light at night is particularly problematic for bats as most species are nocturnal and often cross relatively large distances when commuting between roosts and foraging grounds. Earlier studies have shown that illumination of linear structures in the landscape disturbs commuting bats, and that the response of bats to light may strongly depend on the light spectrum. Here, we studied the impact of white, green, and red light on commuting Daubenton's bats (*Myotis daubentonii*). We used a unique location where commuting bats cross a road by flying through two identical, parallel culverts underneath. We illuminated the culverts with white, red, and green light, with an intensity of 5 lux at the water surface. Bats had to choose between the two culverts, each with a different lighting condition every night. We presented all paired combinations of white, green, and red light and dark control in a factorial design. Contrary to our expectations, the number of bat passes through a culvert was unaffected by the presence of light. Furthermore, bats did not show any

preference for light color. These results show that the response of commuting Daubenton's bats to different colors of light at night with a realistic intensity may be limited when passing through culverts.

Zeale, M. R., Stone, E. L., Zeale, E., Browne, W. J., Harris, S., & Jones, G. (2018). Experimentally manipulating light spectra reveals the importance of dark corridors for commuting bats. Global change biology, 24(12), 5909-5918.

The rapid global spread of artificial light at night is causing unprecedented disruption to ecosystems. In otherwise dark environments, street lights restrict the use of major flight routes by some bats, including the threatened lesser horseshoe bat *Rhinolophus hipposideros*, and may disrupt foraging. Using radio tracking, we examined the response of individual female *R. hipposideros* to experimental street lights placed on hedgerows used as major flight routes. Hedgerows were illuminated on one side over four nights using lights with different emission spectra, while the opposite side of the hedge was not illuminated. Automated bat detectors were used to examine changes in overall bat activity by *R. hipposideros* and other bat species present. *R. hipposideros* activity reduced significantly under all light types, including red light, challenging a previously held assumption that red light is safe for bats. Despite this, *R. hipposideros* rapidly adapted to the presence of lights by switching their flight paths to the dark side of the hedgerow, enabling them to reach foraging sites without restriction. Red light had no effect on the activity of the other species present. Slow-flying *Myotis* spp. avoided orange, white and green light, while more agile *Pipistrellus* spp. were significantly more active at these light types compared to dark controls, most probably in response to accumulations of insect prey. No effect of any light type was found for *Nyctalus* or *Eptesicus* spp. Our findings demonstrate that caution must be used when promoting forms of lighting that are thought to be safe for wildlife before they are tested more widely. We argue that it is essential to preserve dark corridors to mitigate the impacts of artificial light at night on bat activity and movements

Pauwels, J., Le Viol, I., Azam, C., Valet, N., Julien, J.-F., Bas, Y., Lemarchand, C., Sanchez de Miguel, A. & Kerbiriou, C. (2019). Accounting for artificial light impact on bat activity for a biodiversity-friendly urban planning. Landscape and Urban Planning, 183, 12-25.

Light pollution constitutes a major threat to biodiversity by decreasing habitat quality and landscape connectivity for nocturnal species. While there is an increasing consideration of biodiversity in urban management policies, the impact of artificial light is poorly

accounted for. This is in a large part due to the lack of quantitative information and relevant guidelines to limit its negative effects. Here we compared the potential of two sources of information on light pollution, remote sensing (nocturnal picture taken from the International Space Station ISS) and ground-based (location of streetlights) data, to measure its impact on bats. Our aims were to (i) evaluate how light pollution affected *Pipistrellus pipistrellus* activity at the city scale, (ii) determine which source of information was the most relevant to measure light pollution's effect and (iii) define a reproducible methodology applicable in land management to account for biodiversity in lighting planning. We used citizen science data to model the activity of *P. pipistrellus*, a species considered light tolerant, within three cities of France while accounting for artificial light through a variable based on either source of information. We showed that at the city scale, *P. pipistrellus* activity is negatively impacted by light pollution irrespective of the light variable used. This detrimental effect was better described by variables based on ISS pictures than on streetlights location. Our methodology can be easily reproduced and used in urban planning to help take the impact of light pollution into consideration and promote a biodiversity-friendly management of artificial light.

Cravens, Z. M., Brown, V. A., Divoll, T. J., & Boyles, J. G. (2018). Illuminating prey selection in an insectivorous bat community exposed to artificial light at night. Journal of Applied Ecology, 55(2), 705-713.

Light pollution has been increasing around the globe and threatens to disturb natural rhythms of wildlife species. Artificial light impacts the behaviour of insectivorous bats in numerous ways, including foraging behaviour, which may in turn lead to altered prey selection. 2. In a manipulative field experiment, we collected faecal samples from six species of insectivorous bats in naturally dark and artificially lit conditions and identified prey items using molecular methods to investigate effects of light pollution on prey selection. 3. Proportional differences in identified prey were not consistent and appeared to be species specific. Red bats, little brown bats and grey bats exhibited expected increases in moths at lit sites. Beetle-specialist big brown bats had a sizeable increase in beetle consumption around lights, while tri-coloured bats and evening bats showed little change in moth consumption between experimental conditions. Dietary overlap was high between experimental conditions within each species, and dietary breadth only changed significantly between experimental conditions in one species, the little brown bat. 4. Policy implications. Our results, building on others, demonstrate that bat–insect interactions may be more nuanced than the common assertion that moth consumption increases around lights. They highlight the need for a greater mechanistic understanding of bat–light

interactions to predict which species will be most affected by light pollution. Given differences in bat and insect communities, we advocate biologists, land stewards and civil planners work collaboratively to determine lighting solutions that minimize changes in foraging behaviour of species in the local bat community. Such efforts may allow stakeholders to more effectively craft management strategies to minimize unnatural shifts in prey selection caused by artificial lights.

Azam, C., Le Viol, I., Bas, Y., Zissis, G., Vernet, A., Julien, J. F., & Kerbiriou, C. (2018). Evidence for distance and illuminance thresholds in the effects of artificial lighting on bat activity. Landscape and urban planning, 175, 123-135.

Light pollution is a major threat to biodiversity worldwide. There is a crucial need to elaborate artificial lighting recommendations to mitigate its impact on wildlife. In the present study, we investigated how streetlight spatial position and light trespass impacted the use of ecological corridors by transiting bats in anthropogenic landscapes. Through a paired, in situ experiment, we estimated how streetlight distance of impact and vertical and horizontal illuminance influenced the transiting activity of 6 species and 2 genera of bats. We selected 27 pairs composed of 1 lit site and 1 control unlit site in areas practicing either part-night or full-night lighting. We recorded bat activity at 0, 10, 25, 50 and 100 m, and measured vertical and horizontal light illuminance at the 5 distance steps (range = 0.1–30.2 lx). While streetlight attraction effect was mostly limited to a 10 m radius for *Pipistrellus* sp. and *Nyctalus* sp., streetlight avoidance was detected at up to 25 and 50 m for *Myotis* sp. and *Eptesicus serotinus*, respectively. Streetlight effects on *Myotis* sp. and *Nyctalus* sp. remained after lamps were turned-off. Illuminance had a negative effect on *Myotis* sp. below 1 lx, a mixed effect on *E. serotinus*, and a positive effect on the other species, although a peak of activity was observed between 1 and 5 lx for *P. pipistrellus* and *N. leisleri*. We recommend separating streetlights from ecological corridors by at least 50 m and avoiding vertical light trespass beyond 0.1 lx to ensure their use by light-sensitive bats.

Rowse, E. G., Harris, S., & Jones, G. (2018). Effects of dimming light-emitting diode street lights on light-opportunistic and light-averse bats in suburban habitats. Royal Society open science, 5(6), 180205.

Emerging lighting technologies provide opportunities for reducing carbon footprints, and for biodiversity conservation. In addition to installing light-emitting diode street lights, many local authorities are also dimming street lights. This might benefit light-averse bat species by creating dark refuges for these bats to forage and commute in human-

dominated habitats. We conducted a field experiment to determine how light intensity affects the activity of the light-opportunistic *Pipistrellus pipistrellus* and light-averse bats in the genus *Myotis*. We used four lighting levels controlled under a central management system at existing street lights in a suburban environment (0, 25, 50 and 100% of the original output). Higher light intensities (50 and 100% of original output) increased the activity of light-opportunistic species but reduced the activity of light-averse bats. Compared to the unlit treatment, the 25% lighting level did not significantly affect either *P. pipistrellus* or *Myotis* spp. Our results suggest that it is possible to achieve a light intensity that provides both economic and ecological benefits by providing sufficient light for human requirements while not deterring light-averse bats.

Straka, T. M., Wolf, M., Gras, P., Buchholz, S., & Voigt, C. C. (2019). Tree cover mediates the effect of artificial light on urban bats. Frontiers in Ecology and Evolution, 7, 91.

With urban areas growing worldwide, so does artificial light at night (ALAN) which negatively affects many nocturnal animals, including bats. The response of bats to ALAN ranges from some opportunistic species taking advantage of insect aggregations around street lamps, particularly those emitting ultraviolet (UV) light, to others avoiding lit areas at all. Tree cover has been suggested to mitigate the negative effects of ALAN on bats by shielding areas against light scatter. Here, we investigated the effect of tree cover on the relationship between ALAN and bats in Berlin, Germany. In particular, we asked if this interaction varies with the UV light spectrum of street lamps and also across urban bat species. We expected trees next to street lamps to block ALAN, making the adjacent habitat more suitable for all species, irrespective of the wavelength spectrum of the light source. Additionally, we expected UV emitting lights next to trees to attract insects and thus, opportunistic bats. In summer 2017, we recorded bat activity at 22 green open spaces in Berlin using automated ultrasonic detectors. We analyzed bat activity patterns and landscape variables (number of street lamps with and without UV light emission, an estimate of light pollution and tree cover density around each recording site within different spatial scales) using generalized linear mixed-effects models with a negative binomial distribution. We found a species-specific response of bats to street lamps with and without UV light, providing a more detailed picture of ALAN impacts than simply total light radiance. Moreover, we found that dense tree cover dampened the negative effect of street lamps without UV for open-space foraging bats of the genera *Nyctalus*, *Eptesicus* and *Vespertilio*, yet it amplified the already existing negative or positive effect of street lamps with or without UV on *Pipistrellus pipistrellus*, *P. pygmaeus* and *Myotis* spp. Our study underpins the importance of minimizing artificial light at night close to vegetation,

particularly for bats adapted to spatial complexity in the environment (i.e. clutter-adapted species), and to increase dense vegetation in urban landscape to provide, besides roosting opportunities, protection against ALAN for open-space foraging bats in city landscapes.