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« La pollution lumineuse n’est pas une fatalité »

When ALAN crosses freshwater boundaries (extrait) 2026

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Artificial light at night (ALAN) is increasing worldwide. Yearly estimations of increase in light emission from the late twentieth century range between 3% to 6% (Hölker et al., 2010). ALAN is today widespread across the globe with approximately 80% of humans experiencing light pollution (Linares Arroyo et al., 2024). Rivers, lakes and their shores are particularly exposed to ALAN (Jechow and Hölker, 2019; Hölker et al., 2023) as human settlements are particularly concentrated alongside them (Kummu et al., 2011). In rivers ALAN can reach 70 times higher levels than the main natural light source at night: the moon (Kyba et al., 2017).

The ecological effects of ALAN in freshwaters have been observed in multiple groups from bacteria to periphyton (Poulin et al., 2014, Grubisic et al., 2018a; b), macrophytes (Segrestin et al. 2021), invertebrates and vertebrates. ALAN can disrupt zooplankton vertical migration (Moore et al., 2001) and inhibit the reproduction in the filter feeder *Daphnia* (Li et al., 2022) inducing cascading effects on primary consumers such as amphipods (Czarnecka et al., 2021) and grazing snails (Mondy et al., 2021). The life cycle of many aquatic insects depends on light cues. Aquatic insect larvae choose habitats based on light characteristic (Kühne et al. 2021) and ALAN can also directly attract or repulse insects (e.g., Ali et al. 1984; Száz et al. 2015). ALAN can also modify aquatic insect larvae dispersal in streams (Vaughan et al.,2011) by disrupting diel behaviour patterns of their drift (mass downstream movement) (e.g., Holt and Waters, 1967; Perkin et al., 2014). ALAN can also affect fish development and behaviour (Brüning et al., 2011). Many fish species are visual hunters and ALAN can extend the hunting period into the night (e.g., in rudds, *Scardinius erythrophthalmus*) (Tałanda et al., 2018).

Rivers and their the adjacent riparian ecosystems are linked by fluxes of organisms (Polis et al.,1997) among which aquatic insects are important subsidies for riparian consumers, including spiders (Paetzold et al., 2005;

Sanzone et al., 2003). Many aquatic insects (e.g., mayflies, stoneflies, caddisflies, mosquitoes, dragonflies) are in fact merolimnic, meaning they spend part of their life cycle in water as larvae or nymphs and later emerge as terrestrial or aerial adults to reproduce. For many of these species it is known that important behavioural events, such as egg eclosion and insect emergence, are regulated by the moon cycle (Andreatta and Tessmar-Raible 2020) and adult females choose oviposition sites using polarised light cues (Horváth et al. 2011). Consequently, these species are potentially vulnerable to ALAN.

Manfrin et al. (2017) observed that aquatic insect emergence increased up to 3-fold in ALAN-illuminated areas in agricultural drainage ditches in northern Germany. Moreover, the proportion of flying adult aquatic insects relative to flying terrestrial insects was up to approximately 900 times higher than at the same site before illumination began and approximately 250 times higher in illuminated areas than in adjacent dark control areas (Manfrin et al., 2017). These effects can be wide-ranging. For example, some non-biting midges (Chironomidae) were attracted to street lighting over a distance of up to 1800 metres (Manfrin et al., 2025a). However, research findings on this topic remain inconsistent and depend on species and environmental characteristics. Meyer and Sullivan (2013), in fact, found that in streams in the Midwestern region of the United States, there was no significant effect of ALAN on emergence quantity, while observing a reduction in body size and species richness.

Fluxes of adult flying aquatic insects which emerge from nearby freshwaters can account for the majority of the carbon assimilated by riparian orb-weaving spiders (Collier et al., 2002; Sanzone et al., 2003; Krell et al., 2015). For this reason, effects of ALAN in aquatic ecosystems and on aquatic insect emergence can extend into riparian food webs affecting terrestrial predators, particularly spiders. An increase in the availability of emerging aquatic prey has been associated with an average 50% higher spider abundance in illuminated areas exposed to ALAN compared with dark control sites (Parkinson et al., 2020). Spiders in lit areas also tend to be larger, with mean body mass increasing by 34% in males and 176% in females (Parkinson et al., 2020). These changes are accompanied by shifts in spider diet, with spiders relying more heavily on aquatic prey under ALAN (Manfrin et al., 2018). Because freshwater ecosystems are tightly connected to the surrounding terrestrial landscape, effective mitigation of artificial light at night (ALAN) requires an integrated, cross-ecosystem perspective. This is particularly important for merolimnic species, such as many aquatic insects and amphibians, that depend on both aquatic and terrestrial habitats during their life cycle (Petrović et al., 2025). Consequently, sustainable ALAN management should prioritize minimizing unnecessary outdoor lighting near freshwater systems, applying the principle that artificial lighting should only be installed where and when it is demonstrably needed (Hölker et al., 2023)

Exterior view of the Riparian Stream mesocosms (RSM) in Landau, Germany (RPTU Kaiserslautern-Landau, RTG SystemLink). The facility consists of replicated outdoor artificial stream channels designed for controlled experiments on riparian and stream ecosystems. During this experiment, selected stream channels were illuminated at night with artificial light at night (ALAN), whereas others remained dark and served as controls. (Photo by Alessandro Manfrin).

Interior view of the Riparian Stream mesocosms (RSM) in Landau, Germany (RPTU Kaiserslautern-Landau, RTG SystemLink). Each mesocosm consisted of an artificial stream channel surrounded by riparian habitat, supporting natural communities of aquatic insects, riparian vegetation, and terrestrial arthropods, including spiders. Half of the mesocosms were illuminated during nighttime, while the remaining mesocosms maintained under dark control conditions (photo by Alessandro Manfrin).

References

Ali, A., Stafford, S.R., Fowler, R.C., Stanley, B.H., 1984. Attraction of adult *Chironomidae* (Diptera) to incandescent light under laboratory conditions. *Environmental Entomology* 13 (4), 1004–1009.

Andreatta, G., Tessmar-Raible, K., 2020. The still dark side of the moon: molecular mechanisms of lunar-controlled rhythms and clocks. *Journal of Molecular Biology* 432 (12), 3525–3546.

Brüning, A., Hölker, F., Wolter, C., 2011. Artificial light at night: implications for early life stage development in four temperate freshwater fish species. *Aquatic Sciences* 73, 143–152.

Collier, K.J., Bury, S., Gibbs, M., 2002. A stable isotope study of linkages between stream and terrestrial food webs through spider predation. *Freshwater Biology* 47 (9), 1651–1659.

Czarnecka, M., Kobak, J., Grubisic, M., Kakareko, T., 2021. Disruptive effect of artificial light at night on leaf litter consumption, growth and activity of freshwater shredders. *Science of the Total Environment* 786, 147407.

Grubisic, M., Singer, G., Bruno, M.C., van Grunsven, R.H.A., Manfrin, A., Monaghan, M.T., et al., 2018a. A pigment composition analysis reveals community changes in pre-established stream periphyton under low-level artificial light at night. *Limnologica* 69, 55–58.

Grubisic, M., van Grunsven, R.H.A., Manfrin, A., Monaghan, M.T., Hölker, F., 2018b. A transition to white LED increases ecological impacts of nocturnal illumination on aquatic primary producers in a lowland agricultural drainage ditch. *Environmental Pollution* 240, 630–638.

Hölker, F., Moss, T., Griefahn, B., Kloas, W., Voigt, C.C., Henckel, D., et al., 2010. The dark side of light: a transdisciplinary research agenda for light pollution policy. *Ecology and Society* 15 (4), 13.

Hölker, F., Jechow, A., Schroer, S., Tockner, K., Gessner, M.O., 2023. Light pollution of freshwater ecosystems: principles, ecological impacts and remedies. *Philosophical Transactions of the Royal Society B* 378 (1892), 20220360.

Holt, C.S., Waters, T.F., 1967. Effect of light intensity on the drift of stream invertebrates. *Ecology* 48 (2), 225–234.

Horváth, G., Móra, A., Bernáth, B., Kriska, G., 2011. Polarotaxis in nonbiting midges: female chironomids are attracted to horizontally polarized light. *Physiology & Behavior* 104 (5), 1010–1015.

Jechow, A., Hölker, F., 2019. How dark is a river? Artificial light at night in aquatic systems and the need for comprehensive night-time light measurements. *Wiley Interdisciplinary Reviews: Water* 6 (6), e1388.

Krell, B., Röder, N., Link, M., Gergs, R., Entling, M.H., Schäfer, R.B., 2015. Aquatic prey subsidies to riparian spiders in a stream with different land use types. *Limnologica* 51, 1–7.

Kühne, J.L., van Grunsven, R.H.A., Jechow, A., Hölker, F., 2021. Impact of different wavelengths of artificial light at night on phototaxis in aquatic insects. *Integrative and Comparative Biology* 61 (3), 1182–1190.

Kummu, M., De Moel, H., Ward, P.J., Varis, O., 2011. How close do we live to water? A global analysis of population distance to freshwater bodies. *PLOS ONE* 6 (6), e20578.

Kyba, C.C., Kuester, T., Sánchez de Miguel, A., Baugh, K., Jechow, A., Hölker, F., Bennie, J., Elvidge, C.D., Gaston, K.J., Guanter, L., 2017. Artificially lit surface of Earth at night increasing in radiance and extent. *Science Advances* 3 (11), e1701528.

Li, D., Huang, J., Zhou, Q., Gu, L., Sun, Y., Zhang, L., et al., 2022. Artificial light pollution with different wavelengths at night interferes with development, reproduction, and antipredator defenses of *Daphnia magna*. *Environmental Science & Technology* 56 (3), 1702–1712.

Linares Arroyo, H., Abascal, A., Degen, T., Aubé, M., Espey, B.R., Gyuk, G., et al., 2024. Monitoring, trends and impacts of light pollution. *Nature Reviews Earth & Environment* 5, 417–430.

Manfrin, A., Singer, G., Larsen, S., Weiß, N., van Grunsven, R.H.A., Weiß, N.S., et al., 2017. Artificial light at night affects organism flux across ecosystem boundaries and drives community structure in the recipient ecosystem. *Frontiers in Environmental Science* 5, 61.

Manfrin, A., Lehmann, D., van Grunsven, R.H.A., Larsen, S., Syväranta, J., Wharton, G., et al., 2018. Dietary changes in predators and scavengers in a nocturnally illuminated riparian ecosystem. *Oikos* 127 (7), 960–969.

Manfrin, A., Hölker, F., Teurlincx, S., Baranov, V., van Grunsven, R.H.A., Bundschuh, M., et al., 2025a. Artificial light at night reduces emergence and attracts flying adults of aquatic Diptera. *Aquatic Sciences* 87, 38.

Meyer, L.A., Sullivan, S.M.P., 2013. Bright lights, big city: influences of ecological light pollution on reciprocal stream–riparian invertebrate fluxes. *Ecological Applications* 23 (6), 1322–1330.

Mondy, N., Boisselet, C., Poussineau, S., Vallier, F., Lengagne, T., Secondi, J., et al., 2021. Herbivory increases on freshwater plants exposed to artificial light at night. *Aquatic Botany* 175, 103447.

Moore, M.V., Pierce, S.M., Walsh, H.M., Kvalvik, S.K., Lim, J.D., 2000. Urban light pollution alters the diel vertical migration of *Daphnia*. *Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen* 27 (2), 779–782.

Paetzold, A., Schubert, C.J., Tockner, K., 2005. Aquatic terrestrial linkages along a braided-river: riparian arthropods feeding on aquatic insects. *Ecosystems* 8 (7), 748–759.

Parkinson, E., Lawson, J., Tiegs, S.D., 2020. Artificial light at night at the terrestrial–aquatic interface: effects on predators and fluxes of insect prey. *PLOS ONE* 15 (10), e0240138.

Perkin, E.K., Hölker, F., Tockner, K., Richardson, J.S., 2014. Artificial light as a disturbance to light-naïve streams. *Freshwater Biology* 59 (11), 2235–2244.

Petrović, T.G., Gavrić-Čampar, J.P., Burraco, P., Gavrilović, B.R., Despotović, S.G., Radovanović, T.B., et al., 2025. Developing under artificial light is not so bright: oxidative stress as a physiological response to light pollution across amphibian life stages. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, 111819.

Polis, G.A., Anderson, W.B., Holt, R.D., 1997. Toward an integration of landscape and food web ecology: the dynamics of spatially subsidized food webs. *Annual Review of Ecology and Systematics* 28 (1), 289–316.

Poulin, C., Bruyant, F., Laprise, M.H., Cockshutt, A.M., Marie-Rose Vandenhecke, J., et al., 2014. The impact of light pollution on diel changes in the photophysiology of *Microcystis aeruginosa*. *Journal of Plankton Research* 36 (1), 286–291.

Sanzone, D.M., Meyer, J.L., Martí, E., Gardiner, E.P., Tank, J.L., Grimm, N.B., 2003. Carbon and nitrogen transfer from a desert stream to riparian predators. *Oecologia* 134, 238–250.

Segrestin, J., Mondy, N., Boisselet, C., Guigard, L., Lengagne, T., Poussineau, S., et al., 2021. Effects of artificial light at night on the leaf functional traits of freshwater plants. *Freshwater Biology* 66 (12), 2264–2271.

Száz, D., Horváth, G., Barta, A., Robertson, B.A., Farkas, A., Egri, A., et al., 2015. Lamp-lit bridges as dual light-traps for the night-swarming mayfly, *Ephoron virgo*: interaction of polarized and unpolarized light pollution. *PLOS ONE* 10 (3), e0121194.

Tałanda, J., Maszczyk, P., Babkiewicz, E., 2018. The reaction distance of a planktivorous fish (*Scardinius erythrophthalmus*) and the evasiveness of its prey (*Daphnia pulex* × *pulicaria*) under different artificial light spectra. *Limnology* 19, 311–319.

Vaughan, I., Larsen, S., Durance, I., Ormerod, S., 2011. Student-centred experiments with stream invertebrates. *Journal of Biological Education* 45 (2), 106–111.