Nocturnally-migrating birds traverse Earth's most light-polluted regions, and bright lights confound their habitat use *en route*

Theme: Biology & Ecology

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Nearly half of the world's bird species undertake migrations twice yearly, traversing large expanses of land at up to continental scales and often under great selective pressure to reach their destinations in a timely manner. Most birds migrate at night, and therefore need to repeatedly locate suitable stopover habitats to rest and rebuild energy reserves. Given the extensive and increasing encroachment of artificial light at night (ALAN) globally, we evaluated 1) the annual mean intensity of ALAN over land within the geographic ranges of nocturnally-migrating terrestrial bird species from around the world (Cabrera-Cruz et al., 2018) and 2) how light pollution affects stopover distributions of nocturnal migrants in the northeastern United States. (McLaren et al., 2018).

We assessed how ALAN varied among 298 species worldwide with respect to five factors: 1) season of the year (i.e., migration, breeding, non-breeding), migration distance, range size, global hemisphere, and IUCN category of conservation concern. ALAN was relatively greater within migration routes over stationary ranges, for shorter-distance migrants, for species with smaller ranges, and for species in the western hemisphere, but did not differ by conservation concern. Hence, during migration, many long-distance migrants that spend the stationary periods of the year at extreme latitudes with low levels of light pollution must traverse mid-latitudes between 30°N and 45°N where human urban development is most prevalent and widespread ALAN is the brightest. The novel exposure to bright light pollution for birds during migration may enhance its influence on their behavior, particularly for juvenile birds during their first autumn migration.

The influence of ALAN on migratory birds likely reaches beyond the extent of urban areas. The skyglow of large cities can be perceived by migrating birds aloft from hundreds of kilometers away. Brightly-lit structures at a local scale can attract airborne migrants and lead to collisions, but skyglow might also influence broad-scale selection of stopover sites and ultimately acquisition of food resources for migrants. We demonstrate that autumnal bird stopover density increased at regional scales with proximity to bright areas using multi-year weather radar measurements of nocturnal migrants across the northeastern United States. Our findings imply broad-scale attraction to city skyglow by birds while airborne confounds their selection for high-quality extensively forested stopover habitat away from cities. Given that high-quality stopover habitat is critical to successful migration, and hindrances during migration can decrease fitness, light pollution presents a potentially heightened conservation concern for migratory bird populations. Others have found urban sources of ALAN are associated with higher levels of migrant stopover abundance both within green spaces at the interior of urban areas and along urban boundaries (Bonter et al., 2009; Buler & Dawson, 2014; La Sorte et al., 2017), supporting the conclusion that observed associations

with urban areas during migration are driven, at least in part, by broad-scale attraction to urban light pollution. In contrast, areas containing high levels of ALAN are generally avoided by migratory birds during the breeding and non-breeding seasons (Zuckerberg et al., 2016; La Sorte et al., 2017). Thus, urban sources of ALAN broadly effect migratory behavior and may have a role in shaping migratory routes of individual species, emphasizing the need to better understand the implications of ALAN for migratory bird populations.

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