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Editorial: Partitioning the Effects of Urbanization on Biodiversity: Beyond Wildlife Behavioural Responses to a Multilevel Assessment of Community Changes in Taxonomic, Functional and Phylogenetic Diversity

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Editorial on the Research Topic

Partitioning the Effects of Urbanization on Biodiversity: Beyond Wildlife Behavioural Responses to a Multilevel Assessment of Community Changes in Taxonomic, Functional and Phylogenetic Diversity

THE CHALLENGE OF BIODIVERSITY CONSERVATION IN THE ANTHROPOCENE

We are living in the Anthropocene, where the effects of urbanization on biodiversity are increasingly important for global conservation (Aronson et al., 2014; Pickett et al., 2016). Cities can be considered refuges for some species but more likely ecological traps for others, because urban spaces constitute poor habitats offering little opportunity for reproductive success despite their apparent suitability. In this special Frontiers issue, we investigate a broad range of characteristics of cities in order to get a better understanding of the underlying mechanisms driving species distribution and abundance, and also the consequences of such proximate mechanisms for gaining a better understanding of the effects of urbanization on biodiversity.

Synurbanization is commonly defined as the process that leads the occupation of wildlife from rural to urban habitats, which can lead to an increase in the relative diversity of urban species. Urban habitats present new ecological challenges for animals, potentially filtering some species (Aronson et al., 2016). However, the diversity of urban habitat in terms of species composition can change depending on many aspects such as geographic location, buildings density, weather characteristics of the cities, and seasonal changes in communities. In this Research Topic, we tried to explore some of these potential factors and mechanisms driving changes in the behavior and composition of bird and mammal species assemblages.

Suhonen and Jokimäki examined whether urbanization has effects on the bird species wintering occupancy, distribution and abundance-occupancy relationship, and if such patterns varied between winters, considering the size of towns and other aspects of the Finnish landscape. The authors highlighted how three bird species were the core species during all winters, independently of the size of town or geographical latitude. Additionally, Suhonen and Jokimäki showed that the species abundance-occupancy relationship pattern was relatively stable over winters and across the sizes of towns.

On a different spatial scale and going deeper into the effects of urbanization on the gut microbiome of urban birds, Phillips et al. tested whether urbanization of habitats affects gut microbial composition and diversity in White-crowned Sparrows (*Zonotrichia leucophrys*). The authors found evidence that the birds' gut microbiome tends to be more diverse in urban than in rural environments, probably due to a higher variability of land cover types in cities than in farmlands. This evidence supports the statement that anthropogenic changes can affect species assemblages at multiple levels.

An interesting message for urban planning comes from the study of Hensley et al. focusing on comparison of biological traits between bird assemblages in three cities in south-western United States and their regional species pools. In two of three cities, namely Fresno, California and Tucson, Arizona, urban bird assemblages showed overrepresentation of granivores and omnivores, whereas insectivores were underrepresented relative to the regional species pool. This was not the case for Phoenix, Arizona, the largest of the focal cities, were representation of biological traits did not differ between the urban bird assemblage and the regional species pool. These striking contrasts between cities can be explained by local habitat composition: whereas the two smaller cities do not sample some of the surrounding native habitats, Phoenix contains protected mountain areas within the urban matrix of the city. This example shows how the inclusion of native habitats within the city borders can improve environmental conditions for urban biodiversity. On the other hand, Hensley et al. found that Fresno showed stronger filtering effects on the avifauna with the urban bird assemblage showing lower similarity with the regional species pool compared to Tucson or Phoenix. This may be driven by differences in urban water use policies resulting in greater extent of lawns causing Fresno to diverge from the more arid natural surroundings (Katti et al., 2017); Tucson (and to a lesser extent, Phoenix) on the other hand has stronger water conservation measures resulting in more xeriscaped yards, reducing the contrast with the desert habitats of the larger landscape matrix around that city. These findings highlight a role for more intentional careful landscape design and planning in modulating the filtering effect of urbanization on regional biodiversity.

However, the effects of urbanization are also evident for groups other than birds, such as, for example, mammals. Focusing on a typical adaptive behavior, Stillfried et al., have explored the risk perception and escape-behavior adjustment to urbanization in wild boar *Sus scrofa*. The authors used GPS tracking technology to monitor 11 wild boars from the metropolitan area of Berlin, in Germany. These data made it possible to predict hotspots of potential human-wildlife conflicts. Finally, the authors also highlighted the behavioral plasticity of this species, which was able to adjust its escape behavior to human-dominated environments. This fact supports the statement that animals living in urban habitats are characterized by their acceptance of close proximity to humans (Hediger, 1934; Hemmingsen, 1951). The shorter flight initiation distance when approached by humans, perhaps reflecting a broader reduction in fear, constitute integral parts of the syndrome that characterizes urban animals (Morelli et al., 2018; Sol et al., 2018).

Changes in behavior, affected by urbanization processes, are visible not only during daylight, but also at night. And this problem is addressed by Straka et al. studying bats. Bats occur in urban areas around the world and nocturnal animals such as bats could be restricted in their activity by artificial light (Hopkins et al., 2018). Hence, understanding the impact of artificial light at night on this strictly nocturnal taxon is important for effective bat conservation in urban areas. The novelty of this study was the analysis of bat activity and light pollution in connection with tree cover density. They found a mitigating effect of tree cover for high-flying bat species in areas with high number of LED streetlamps. The study also reveals the complexity of the connections between artificial light and vegetation. The scientists recommend that tree-rich areas should only be illuminated sparingly and that trees should be planted in heavily illuminated areas to compensate. This could be a substantial contribution to the protection of urban bats and possible other nocturnal animals which can bring more nature to our cities.

CONCLUSION

Many of the focal factors in the collection of studies presented in this special issue impact on realized interactions between urban fauna and people. Urban areas attract biodiversity due to abundant food resources and heterogeneous habitats (McKinney, 2002), increasing the potential for wildlife-human interactions and conflicts. Considering the perspectives of urban ecology under future scenarios of land use and climate change, we highlight the necessity to articulate urban ecology as a multidisciplinary approach to better focus and assess the complexity of urban ecosystems (Pickett et al., 2016). We hope that the collection of studies provided in this special issue can help facilitate an understanding that even if cities are inexorably changing nature, many species are also adapting to urban environments, and in turn, this response from nature is also changing our perception of city life.

Our broad goal for this Research Topic was to take a deeper look at the effects of urbanization on biodiversity, going beyond descriptions of patterns to examine some of the important ecological, behavioral, and evolutionary mechanisms that drive species occurrence and interactions, and in turn, the species composition of urban communities. The papers in this collection offer a good sample of the variety of tools and approaches being employed to measure and analyse the diverse and complex effects of urbanization on biodiversity. While urban evolutionary ecology remains a relatively young

field, researchers are beginning to conduct deeper analyses of the recurrent patterns observed in the diversity and distribution of many taxa, testing both the generality of such patterns across cities, and uncovering key drivers and mechanisms that help explain the observed patterns. We expect future research to continue this trend, moving from phenomenological to mechanistic understandings of species occurrence and community dynamics in the context of urbanization. We also expect more sophisticated multivariate analytical models and experimental approaches to address the complex interactions and feedbacks between human activities and biodiversity, with the goal of developing better approaches for managing urban ecosystems in ways that reduce conflict and help reconcile human development and biodiversity conservation. As cities are becoming the preferred home of humanity, ecological, and evolutionary research must continue to expand its scope beyond "natural" ecosystems and into the novel mixtures of natural and anthropogenic habitats that characterize cities as social-ecological systems. We suggest that this kind of research is in urgent need during this century of rapid global change, climate destabilization, and the ongoing mass extinction crisis.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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