

THE EFFECTS OF URBANISATION ON THE DEMOGRAPHIC PROCESSES IN BIRD POPULATIONS

THESES OF THE PHD DISSERTATION



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INTRODUCTION AND AIMS

The conversion of natural and semi-natural habitats into human settlements is one of the key drivers of habitat loss and threats to global biodiversity (Beninde et al., 2015; Sol et al., 2017). Urban areas have grown rapidly as more people become city-dwellers; a majority (55%) of the global human population resided in urban areas in 2018 and this proportion is projected to reach 68% by 2050 (United Nations 2018). Expansion of urban areas has complex and often negative effects on wildlife populations (Aronson et al., 2014; Ibáñez-Álamo et al., 2016), and the impacts will likely increase in the near future.

Ecological conditions can vary across the rural-urban gradient with variation in food resources, disease exposure, predation risk, and the climatic environment. Many species experience reduced reproductive success in urban environments, primarily attributed to the decreased availability of natural food resources (Branston et al., 2021; Rodewald & Gehrt, 2014; Vaugoyeau et al., 2016). When compared to more natural habitats, natural food resources are more limited during the breeding season for urban songbirds that rely on arthropods to feed nestlings (Seress et al., 2018; Sinkovics et al., 2021). On the other hand, supplemental feeding from bird feeders, garden plants, and other anthropogenic sources may provide extra and reliable food sources that may reduce the risk of starvation and increase survival for resident birds that are capable of exploiting these resources (Robb et al. 2008; Tryjanowski et al. 2018).

In addition to the consequences of food limitation, alteration of other biotic interactions can significantly impact mortality rates in urban populations, particularly concerning exposure to parasites, pathogens, and predators. Many studies suggest that animal populations may exhibit a higher prevalence of disease in urban settings (Bradley & Altizer, 2007), where bird feeders may act as hotspots for disease transmission (but see Frątczak et al., 2021). However, urbanisation may not increase exposure to parasites, and exposure to tick-transmitted diseases and avian malaria infections tends to be lower in urban areas (Bichet et al., 2020; Evans et al., 2009). Similarly, predation rates may also vary across the rural-urban gradient. Domestic cats can reach high densities (Loss & Marra, 2017; van Heezik et al., 2010), but the diversity and densities of specialist avian predators may be reduced in urban landscapes (Rodewald & Gehrt, 2014; Loss et al., 2015). It is currently uncertain how the combined effect of these changes influences the overall predation risk in urban areas, especially for adult birds (Morozov, 2022).

The survival probability of birds is also affected by at least two abiotic factors that vary significantly along the urban-rural continuum (Loss et al., 2015; Wilby & Perry, 2006). The

urban heat island effect is caused by the absorption and retention of heat by concrete buildings and infrastructure (Debbage & Shepherd 2015; Deilamnthi et al. 2018). The resulting milder winter climate in temperate region cities relative to surrounding less urbanised landscapes may increase the overwinter survival of urban birds. On the other hand, heat island effects also amplify the intensity of summer heat waves, which have been linked to increased avian mortality (Pipoly et al. 2020; Bourne et al. 2022; Conradie et al. 2019). Birds are also vulnerable to increased mortality in urban environments due to collisions with vehicles and anthropogenic structures such as building windows, power lines, and telecommunication towers (Loss et al., 2015).

Species richness and population density are commonly used metrics to characterize the overall impact of urbanisation on local wildlife communities (Aronson et al., 2017; Batáry et al., 2018), but quantifying demographic responses provides a more direct understanding of how urbanisation affects the viability of populations (Evans, 2010). A better understanding of demographic responses across the rural-urban gradient is therefore crucial if we are to preserve biodiversity in urban habitats (Banks, 2004; Crawford et al., 2018). It remains unclear, however, whether populations of species that have high densities in urban settings are self-sustaining or are maintained by immigration (Beninde et al., 2015; Chamberlain et al., 2009).

In my work, I investigated the demographic parameters of urban and forest great tit populations, as well as the food sources available to adult birds in urban areas during the breeding season and wintertime. In the course of my research, 1) I compared the annual breeding success of forest and urban great tit populations; 2) I compared the apparent annual survival probability of adult birds between forest and urban populations; 3) I mapped the territory use and vegetation preference of urban birds during the chick-rearing period; 4) I surveyed the winter bird feeders in various urban habitats.

SUMMARY OF RESEARCH METHODS

During my doctoral studies, I studied great tits breeding in nest boxes at two urban (Veszprém, Balatonfüred) and two forest sites (Szentgál, Vilma-pusztá) in Hungary from 2013 to 2021. With other members of the Behavioral Ecology Research Group, we monitored the breeding of great tits in the artificial nest boxes by a standard protocol that we followed throughout the whole study period in all sites and the following data were recorded: the date of the first egg laid, the number of eggs, and the date and number of chicks hatched. Additionally, we typically ringed each nestling at day 14-16 post-hatch with a numbered metal ring. Also, we captured most parent great tits in their nest box during brood-rearing and marked each bird with a unique combination of one metal and three plastic colour rings. Upon capturing, we determined the birds' sex and age based on their plumage characteristics. We video-recorded nests during the brood-rearing period and used 1 hours long videos to individually identify colour-ringed parents (ringed in earlier years).

Furthermore, in 2021, we equipped seven female birds with custom-made radio transmitters during chick-rearing period and tracked the tagged individuals 4-7 times, recording their behavior and exact location. After the breeding season, we conducted detailed vegetation mapping in each territories of the tagged birds. Finally, we conducted field surveys during the winter of 2021-22. We surveyed bird feeders placed by residents in five sites in Veszprém and five sites in Budapest. We surveyed each site three times and recorded the location and other characteristics (size, type) of the feeders we saw, as well as the species and number of birds feeding on them.

THESIS POINTS

1. Using great tits as a model system, I showed, that a higher ratio of second broods within one breeding season can not compensate for birds' lower breeding success in urban habitats. I found that urban birds tend to have a slightly higher probability of double-brooding (44% of females) compared to forest birds (36%), but this difference was not statistically significant and consistent between the two urban study sites. At the same time, double-brooded urban females produced a similar number of fledglings per season as single-brooded forest females. My results showed that both single- and double-brooded females produced significantly fewer fledglings annually in the cities than in the forests.
2. I used mark-recapture modelling to estimate the apparent survival probabilities of adult great tits in two urban and two forest breeding populations. My results showed that urbanisation did not have a consistent effect on survival, because both the lowest and highest survival estimates were obtained for urban sites and estimates for the two forest sites were in between. I found that the study year affected the birds' survival and males usually have slightly higher survival during the study period in all four sites. The age of the birds did not have a strong effect in the forest, only in the urban sites, and the nest box occupancy rate (an estimate for breeding density) did not appear to affect annual survival.
3. We successfully employed radio-telemetry tracking to characterize urban-breeding great tits' habitat use. Moreover, we combined the radio tracking with real-time field observations, video recordings of nestlings' diet, and detailed plant surveys. Parent birds were more likely to forage on and deliver nestling food from large native trees, foraged less on and collected fewer prey items from the most abundant tree species, and generally avoided non-native plants, particularly broadleaved species. Interestingly, we found that birds frequently foraged on the ground. We also found that the availability of bird feeders strongly affected birds' habitat use.
4. We successfully surveyed the active winter bird feeders in two cities, and nearby peri-urban woodlands. I found that the density of feeders was higher in Veszprém than in Budapest, but I did not find this difference between the two peri-urban woodlands. In both cities, the most frequent food types were fat balls, seed mix, and sunflower seeds. I found that the type of the feeder, but not the city, significantly affected both the number of individuals and species visiting bird feeders.

LIST OF PUBLICATIONS

Publications:

Boglárka Bukor; Gábor Seress; Ivett Pipoly; Krisztina Sándor; Csenge Sinkovics; Ernő Vincze; András Liker (2021) *Double-brooding and annual breeding success of great tits in urban and forest habitats*. Current Zoology, 2021 1-9. doi: <https://doi.org/10.1093/cz/zoab096>

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Boglárka Bukor, Veronika Bókony, Tamás Hammer, Sándor Papp, Ivett Pipoly, Bálint Preiszner, Gábor Seress, Csenge Sinkovics, Ernő Vincze, András Liker; *The frequency of re-nesting in forest and urban populations of Great Tit*; Magyar Biológiai Társaság Állattani Szakosztályának 1038. előadó ülése, Budapest, 2017. 03. 1.

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Boglárka Bukor; *Annual survival of adult Great Tits in different types of breeding habitat*; Tudományos Diákköri Konferencia, Budapest, 2018. 11. 21. Biological Institute special prize

Boglárka Bukor; Nóra Czikkelyné Ágh, Ivett Pipoly, Krisztina Sándor, Gábor Seress, Csenge Sinkovics, Ernő Vincze, András Liker; *Annual survival of adult Great Tits in different types of breeding habitat*; XX. Magyar Etológus Találkozó, Kolozsvár, 2018. 11. 23-25.

Boglárka Bukor; *Annual survival of adult Great Tits in different types of breeding habitat*; XXXIV OTDK Biológia Szekció, Budapest, 2019. 04. 15-17. Animal ecology II section special prize

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