The University of Nevada, Reno

Food Availability Influencing Songbird Fitness in Urbanized Landscapes

A thesis submitted in partial fulfillment
of the requirements for the degree of

Bachelor of Science in Biology and the Honors Program

by

Jacquelynn P.V. Tran

Dr. Jenny Ouyang, Thesis Advisor

May 2020

UNIVERSITY
OF NEVADA
RENO

THE HONORS PROGRAM

We recommend that the thesis
prepared under our supervision by

Jacquelynn Tran P.V. Tran

entitled

Food Availability Influencing Songbird Fitness in Urbanized Landscapes

be accepted in partial fulfillment of the
requirements for the degree of

BACHELOR OF SCIENCE, BIOLOGY

_____
Jenny Ouyang, Ph.D., Thesis Advisor

_____
Matthew Means, P.S., Director, **Honors Program**

May 2020

Abstract

Urbanization can have negative impacts on wildlife diversity through habitat destruction and threats to dependable food sources. In this study, we investigate caterpillars, a food source birds rely on to feed their young, and their abundance patterns. We aimed to determine whether urban areas experience earlier caterpillar peak seasons than rural sites and if this may be correlated with differing vegetation types and lesser House wren (*Troglodytes aedon*) fledgling viability. We compared data from one rural and two urban field sites around the Reno, Nevada metropolitan area collected in April – July 2019. We found that our urban site experienced a greater caterpillar abundance and earlier caterpillar peak seasons. Wren fledglings at urban sites also weighed less than rural fledglings. Our study strongly indicates that earlier caterpillar peaks in urban sites led to smaller fledgling weights. While we found differences in vegetation composition between our rural and urban sites, it might be more useful to look at leaf emergence to compare that with the timing of caterpillar peaks. We suggest that further study should be done on leaf emergence and possibly on parental provisioning rates, to provide more insight on this tri-trophic interaction.

Acknowledgements

I would like to thank my thesis mentor, Dr. Jenny Ouyang, for guiding me through the thesis writing process and the field season. I would also like to thank Davide Dominoni for providing his data on vegetation composition and fledging weights. In addition, I am grateful for Jia-Yi Cen, Kimberlee Kiep, and Michelle Schilling for assisting me in the field with data collection. Finally, this project received funding from NSF EPSCoR's Undergraduate Research Opportunity Program (UROP).

Table of Contents

Introduction 1
Methods 4
Surveying sites 4
Frass collection and processing 4
Tree sampling and characterization 5
Offspring viability check and measurement 5
Results 6
Frass Biomass 6
Vegetation Composition 7
Offspring Viability Check 9
Discussion 10
References 13

List of Tables

Table 1. Location, tree abundance, and vegetation composition of study sites..... 8

List of Figures

Figure 1. Caterpillar frass mass across urban and rural sites 6

Figure 2. Average chick weight across urban and rural sites 9

Introduction

Urbanization is rapidly expanding and has caused major threats to biodiversity through natural habitat destruction and a decrease in bird species richness (Filloy, J. et al. 2018). A recent study reports a loss of 3 billion birds (30% decline) since 1970 across North America (Rosenberg, K. et al. 2019). Urban areas are also associated with a smaller caterpillar biomass, a critical food supply for avian offspring growth, compared to rural areas (Seress, G. et al. 2018). This difference in caterpillar biomass is crucial for bird populations because breeding seasons are usually timed to be in sync with when these caterpillar biomass amounts reaches its seasonal peak. If avian offspring's maximum food requirements occur before or after the caterpillar peak, and there are no stable, immediate food replacements such as winged invertebrates, offspring viability is at risk (Maziarz, M. Wesolowski, T. 2010). The timing of these peaks may be in correlation with environmental factors in the surrounding area, specifically the vegetation composition. Urban landscapes tend to favor land sparing, with designated areas for buildings scattered with concentrated green patches of biodiversity in between (Ibanez-Alamo, JD. et al. 2020). These green patches tend to contain non-native trees and this difference in tree composition may have a correlation with the earlier caterpillar peak season we predict will be seen in urban areas (Shutt, JD. et al. 2019). This earlier caterpillar peak season may have negative implications for offspring fitness, specifically a decline in offspring fitness in urban areas.

The greater difficulty of foraging in urban areas is a major stressor on avian parents, who invest their time and energy in reproducing. A study found that provisioning rates were negatively associated with prey size, alluding to a trade-off between prey

abundance and prey size. Parents provisioning a larger clutch size with smaller prey were less likely to breed again due to their large investment (Bowers, K. et al. 2014). Offspring presented with a limited food source, which is lacking in quality and must be shared among the brood, are susceptible to compromises in body size, survival to fledgling maturity, and recruitment back to the breeding population (Rodriguez, C. et al. 2008). This risk of a decrease in offspring population would contribute to the existing issue of declining bird species. In the case of the house sparrow, *Passer domesticus*, a common songbird across the globe, there has been a rapid decline over the past decades, even in North America, where they are considered invasive (Marzal, A. et al. 2011). With the conversion of rural sites to urban developments, house sparrows, who constituted 32-58% of the bird community in the rural site, experienced an approximate 34% decrease in population density from 2005-2010 (Ciach, M. 2012). Another study showed that, for our studied species, the House Wren (*Troglodytes aedon*), offspring in urban nests weighed less and had a smaller body size compared to those in rural nests (Newhouse, MJ. et al. 2008). The goal of our study is to characterize caterpillar abundance and timing and correlate these data with vegetation composition and offspring fitness among rural and urban sites around Northern Nevada. It is especially pertinent with rapid urban development in the Reno area and the greater need to accommodate these demographic pressures. To preserve avian species in this region, this study will generate an accurate indication of the regional differences, so conservation efforts can be adapted locally (Ibanez-Alamo, JD. et al. 2016).

In this study, we categorize (i) tree composition, (ii) insect peaks and general abundance, by looking at frass or caterpillar excreta, and (iii) effects on offspring mass

between our urban and rural field sites (Table 1). We predict that, between urban and rural areas, differences in landscaping, tree composition, and insect abundance will have effects on wren offspring mass. We expect urban areas will have both lower insect abundance and lighter chick weights.

Methods

Surveying sites

We conducted our study over a summer field season in the April-July months of 2019. Surveying occurred around the Reno, Nevada, USA metropolitan area. A total of three main field sites were divided into urban and rural subcategories. Each site contained a range from one to three nets to collect the frass. For the urban areas, there were two field sites. One was on University of Nevada Reno's main campus near the CABNR building, holding one frass net. The other site was a public park within the Caughlin Ranch residential area containing three frass nets placed around different areas of the park. The rural site was UNR's Main Station ranch with two frass nets set up at different parts of the farmland (Table 1).

All the field site areas had different species of beech trees, with some areas having a larger proportion of them than others. The weather conditions in the field season were relatively moderate from the beginning to the middle of the season, with temperatures and wind levels starting to rise in mid-June and lasting until the end of the field season in mid-July. Humidity levels were relatively consistent throughout the three months, except for in May where levels were 10-20% higher than usual.

Frass collection and processing

We collected frass, and its biomass indicated the prevalence of caterpillar abundance in surrounding trees. We made nets, used to collect the falling frass, from cheesecloth folded into a 1 m^2 square with metal stakes holding it down under the tree's canopy. There were six frass nets placed at each of the six stations around the field sites.

We retrieved frass weekly at the same time and day, to keep the measurements as

accurate as possible. We scooped frass from all the debris before taking each amount from the nets to the lab for in-depth separation analyses. Any moisture was removed by placing the samples in an oven at 50 °C for two hours. Once dry, we placed samples on a scale to measure its mass and afterwards, stored the samples at room temperature.

Tree sampling and characterization

Between the urban and rural sites, we characterized vegetation composition by going to each site and manually counting all trees located within the field site near the nest boxes. Then, the ratio of deciduous and coniferous is determined within the total number of trees accounted for.

Offspring viability check and measurement

We checked nest boxes of nest house wrens regularly for nest activity. The nest boxes are categorized by the urban or rural site they were located at. Using the data collected during the frass collection field season, the average chick weight from the rural and urban nest boxes were recorded at day 15 (fledgling weight) to the nearest 0.1g.

Results

Frass Biomass

The objective of this study was not only to see whether the rural or urban sites had a greater amount of frass, which indicates a larger abundance of caterpillars, but to see which site experienced an earlier peak season of caterpillars. Of the three main field sites, CABNR (urban) had the greatest abundance and two major frass peaks in late April and mid-May. The UNR farm (rural) had the second greatest abundance and experienced their two major peaks, later in the field season, in mid-May and mid-June. The Caughlin Ranch (urban) field site experienced the least amount of productivity with the lowest levels of frass collected and a peak level of ~0.05 g frass collected in late May. Caughlin Ranch's peak level is minor compared to CABNR's peak of ~0.33 g and UNR farm's ~0.2 g, respectively.

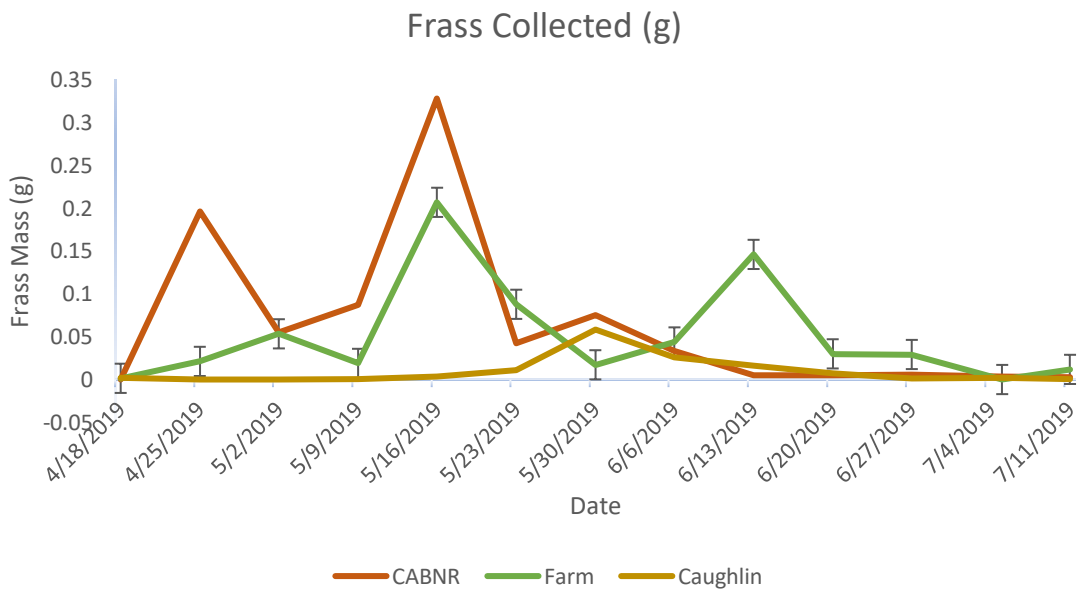

Figure 1. Caterpillar frass mass(g) collected weekly at our three field sites (2 urban, 1 rural). Farm sites contain standard error bars from utilizing two nests at Farm (see Table 1 for coordinates of each site).

Vegetation Composition

We found a different vegetation composition between urban and rural field sites with rural sites dominated by deciduous trees and urban sites dominated by coniferous trees.

Table 1. Location, tree abundance, and vegetation composition of the three study sites completed.

	Site Name	Latitude (N)	Longitude (W)	Total tree abundance	Vegetation composition
Rural	Agricultural Experiment Station, University of Nevada, Reno	39°30' 50"	119°51' 43"	179	81% deciduous trees (n:145); 19% coniferous trees (n:34)
Urban	CABNR, University of Nevada, Reno	39°53' 72"	119°80' 73"	21	38% deciduous trees (n:8); 62% coniferous trees (n:13)
Urban	Caughlin Ranch	39°30' 3"	119°50' 00"	206	33% deciduous trees (n:68); 67% coniferous trees (n:138)

Offspring Viability Check

Urban house wren chicks had a lower mass than rural house wrens (p=1.14e-06)

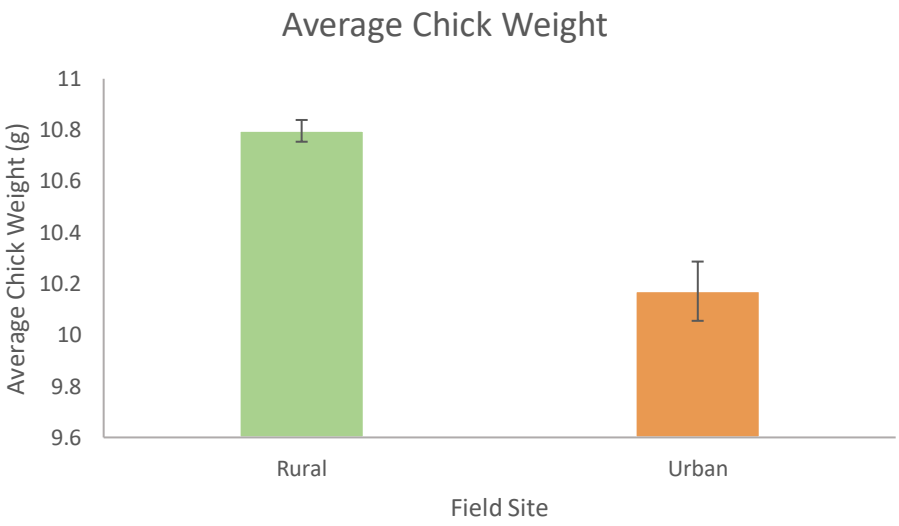

Figure 2. Average chick weights(g) taken between Apr 22 – May 10, 2019 at our rural and urban field sites (see Table 1). Bars represent standard error.

Discussion

Global-scale urbanization is on the rise and is causing detrimental effects to many wildlife species. Greater urban cover influences bird abundance, richness, and species composition. It supports fewer insectivores, ground-nesters, and forest-associated birds (Mayorga, I. et al. 2020). This decrease may be due to food shortages and habitat alteration as urbanization is also associated with smaller caterpillar biomass, a food source bird offspring depends on, and the presence of non-native tree species.

Out of the three sites (Table 1), one of our urban sites, CABNR, had the largest caterpillar abundance while our other urban site, Caughlin, had the smallest caterpillar abundance. So, with our urban sites seeing both the least and greatest amount of caterpillars, we could not draw a conclusive correlation between urban areas and lesser caterpillar abundance.

We did however observe earlier peaks in our urban sites compared to our rural sites (Table 1), as expected. Our CABNR (urban) site experienced its first caterpillar peak three weeks earlier than our UNR Farm (rural) site. This may be related to tree composition differences. Urban landscaping often incorporates green spaces with non-native trees that influence native insect population and abundance across varying tree taxa (Shutt, JD. et al. 2019).

We found that rural sites were dominated by deciduous trees, while our urban sites were predominately populated by native coniferous trees. This could be a factor influencing greater caterpillar abundance, as a larger native tree proportions causes a greater accumulation of caterpillars (Clem & Held. 2018). However, when looking at the timing of caterpillar peaks, it is difficult to draw a conclusive correlation between those

peaks and tree type, without looking at the timing of leaf emergence on those trees. A possible follow-up study, comparing the timing of leaf emergence of trees between urban and rural sites with caterpillar peaks would be useful.

To see the effects of a difference in the timing of caterpillar peaks between urban and rural sites, we also observed chick weights from those sites to check offspring viability. We observed that rural chick weight average was greater than that of urban chick weight average by ~0.6 g. While this does show that rural sites yield larger chicks, to prove more conclusive whether this was the result of mismatched timing between caterpillar peaks and bird breeding seasons, it would be helpful to look at parent-bird provisioning rates and prey composition.

Despite possible modifications to food-provisioning rhythms and utilizing human food waste into bird diet, urban nestlings receive insufficient food supply compared to rural bird populations. This also results in parents producing reduced young sizes in urban sectors (Mennechez & Clergeau. 2006). If there was a follow-up study looking at parent provisioning traits, we could observe if there is an accurate synchronization between caterpillar peak seasons and breeding.

We were able to conclude that urban sites do experience earlier caterpillar peak seasons than our rural sites (Table 1). This difference in caterpillar phenology between the two sites may be due to the tree composition difference we also observed. Most urban planning favors land sparing that does promote native tree populations better than the alternative, land sharing (Collas, L. et al. 2017). However, land developers and homeowners continue to plant non-native tree species, affecting native populations of caterpillars and birds that depend on them, like the house wrens (*Troglodytes aedon*) we

studied (Nitoslawski & Duinker. 2016). We observed lower chick weights in urban lands with fewer native trees and earlier caterpillar peak seasons than at our rural site. Especially in the Reno metropolitan area, where land development and the conversion to urban land is on the rise, it is vital that we continue studying the relationship between non-native trees and caterpillar peak seasons to see what conservation efforts should be made on the local scale.

References

Bowers, E. K., Nietz, D., Thompson, C. F., & Sakaluk, S. K. (2014). Parental provisioning in house wrens: Effects of varying brood size and consequences for offspring. *Behavioral Ecology,25*(6), 1485-1493. doi:10.1093/beheco/aru153

Clem, C. S., & Held, D. W. (2018). Associational Interactions Between Urban Trees: Are Native Neighbors Better Than Non-Natives? *Environmental Entomology*, *47*(4), 881–889. doi: 10.1093/ee/nvy071

Collas, L., Green, R. E., Ross, A., Wastell, J. H., & Balmford, A. (2017). Urban development, land sharing and land sparing: the importance of considering restoration. *Journal of Applied Ecology*, *54*(6), 1865–1873. doi: 10.1111/1365-2664.12908

Filloy, J., Zurita, G. A., & Bellocq, M. I. (2018). Bird Diversity in Urban Ecosystems: The Role of the Biome and Land Use Along Urbanization Gradients. *Ecosystems,22*(1), 213-227. doi:10.1007/s10021-018-0264-y

Fischbacher, M., Naef-Daenzer, B., Naef-Daenzer, L. (1998). Estimating caterpillar density on trees by collection of frass droppings. *Ardea,86*(1), 121-129.

Ibáñez-Álamo, J. D., Morelli, F., Benedetti, Y., Rubio, E., Jokimäki, J., Pérez-Contreras, T., … Díaz, M. (2020). Biodiversity within the city: Effects of land sharing and land sparing urban development on avian diversity. *Science of The Total Environment*, *707*, 135477. doi: 10.1016/j.scitotenv.2019.135477

Ibáñez-Álamo, J. D., Rubio, E., Benedetti, Y., & Morelli, F. (2016). Global loss of avian evolutionary uniqueness in urban areas. *Global Change Biology,23*(8), 2990-2998. doi:10.1111/gcb.13567

Marzal, A., Ricklefs, R. E., Valkiūnas, G., Albayrak, T., Arriero, E., Bonneaud, C., … Bensch, S. (2011). Diversity, Loss, and Gain of Malaria Parasites in a Globally Invasive Bird. *PLoS ONE*, *6*(7). doi: 10.1371/journal.pone.0021905

Maziarz, M., & Wesołowski, T. (2010). Timing of breeding and nestling diet of Wood Warbler Phylloscopus sibilatrixin relation to changing food supply. *Bird Study,57*(4), 540-552. doi:10.1080/00063657.2010.512954

Mayorga, I., Bichier, P., & Philpott, S. M. (2020). Local and landscape drivers of bird abundance, species richness, and trait composition in urban agroecosystems. *Urban Ecosystems*. doi: 10.1007/s11252-020-00934-2

Mennechez, G., & Clergeau, P. (2006). Effect of urbanisation on habitat generalists: starlings not so flexible? *Acta Oecologica*, *30*(2), 182–191. doi: 10.1016/j.actao.2006.03.002

Newhouse, M. J., Marra, P. P., & Johnson, L. S. (2008). Reproductive Success of House Wrens in Suburban and Rural Landscapes. *The Wilson Journal of Ornithology*, *120*(1), 99–104. doi: 10.1676/06-156.1

Nitoslawski, S. A., & Duinker, P. N. (2016). Managing tree diversity: A comparison of suburban development in two Canadian cities. *Forests, 7*(6), 119. doi: 10.3390/f7060119

Rodríguez, C., Johst, K., & Bustamante, J. (2008). Parental versus offspring control on food division within the brood: The role of hatching asynchrony. *Oikos,117*(5), 719-728. doi:10.1111/j.0030-1299.2008.16404.x

Rosenberg, K. V., Dokter, A. M., Blancher, P. J., Sauer, J. R., Smith, A. C., Smith, P. A., … Marra, P. P. (2019). Decline of the North American avifauna. *Science*. doi: 10.1126/science.aaw1313

Seress, G., Hammer, T., Bókony, V., Vincze, E., Preiszner, B., Pipoly, I., . . . Liker, A. (2018). Impact of urbanization on abundance and phenology of caterpillars and consequences for breeding in an insectivorous bird. *Ecological Applications,28*(5), 1143-1156. doi:10.1002/eap.1730

Shutt, J. D., Burgess, M. D., & Phillimore, A. B. (2019). A Spatial Perspective on the Phenological Distribution of the Spring Woodland Caterpillar Peak. *The American Naturalist, 194*(5). doi: 10.1086/705241