University of Nevada, Reno

Pair Coordination of House Wrens, *Troglodytes aedon*, in Rural and Urban Environments

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Abstract

Urbanization of the environment poses many challenges to biparental avian species, however, it is unknown if urbanization affects pair coordination of provisioning behavior. We observed the parental behavior of pairs of house wrens (*Troglodytes aedon*) at active nests in an urban and rural site to explore whether alternation and synchrony differed between urban and rural environments. The urban site had significantly fewer parental visits than the rural site. Pair coordination, measured by alternation and synchrony, was significantly lower at the urban site. We provide evidence that pair coordination is decreased in urban environments, supporting the idea that urbanization may have a negative effect on the fitness of biparental avian species.

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Introduction

Urbanization is known to contribute to the loss of biodiversity (Sol, et al., 2014). Urban environments offer unique challenges to avian species including novel predators, resource loss, habitat narrowing, differing thermal ranges, air pollution, and stressors including increased noise and light pollution (Reynolds et al. 2019). The effects of urbanization on animal behavior is a widely researched area.

Behavioral phenotypes between urban and rural animals are a focus of urban ecology as it might explain why urban environments contain specific individuals or populations. In most mammals and birds, parental care is associated with better offspring outcomes (Clutton-Brock, 1991). Great tit (*Parus major*) pairs have shown a significant tendency in taking turns to visit the nest (Johnstone et al., 2014). Nest visit synchrony and alternation are behavioral patterns of provisioning used to describe pair coordination (Baldan & Griggio, 2019; Johnstone et al., 2014; Savage et al. 2017). Nest visit synchrony occurs when parents coordinate their visits and arrive at the nest at the same, or nearly the same time (Mariette & Griffith, 2015). Numerous biparental bird species including long-tailed finch (*Poephila acuticauda*) have been found to exhibit synchrony of offspring care (van Rooij & Griffith, 2013).

Parental alternation is a provisioning pattern in which the visit of one parent to the nest is followed by a visit by the other parent (Baldan, et al., 2019; Bebbington & Hatchwell, 2016; Savage et al. 2017). Alternation of offspring care in biparental species has been previously associated with increased provisions and decreased predation risk (Bebbington & Hatchwell, 2016). Alternation of nest provisioning benefits fitness due to the shared cost of parental investment (Bebbington & Hatchwell, 2016). By coordinating nest visits, pairs are able to decrease parental costs including predation risk, and increase the offspring's care. Predator attraction increases because of parental activity, but synchronized visits reduce time spent at the nest (Bebbington & Hatchwell, 2016).

Whether pair coordination in biparental avian species is affected by urbanization remains unclear. House wren (*Troglodytes aedon*) is a small song bird widely found throughout the Americas. House wrens inhabit diverse environments including both rural and urban, and are a biparental species. I expected urbanization to disrupt pair coordination due to several environmental differences from natural environments, including resource loss, increased distance to resources, increased noise, and light pollution. I hypothesized pair coordination, measured by alternation and synchrony, would be decreased in urban populations compared to rural populations. Alternation and synchrony are behavioral patterns that result from a partner's response to the other's behavior (Baldan et al., 2019). As urban environments pose unique challenges that affect the ability of parents to monitor the other's behavior such as increased distance from resources, I expected there to be less alternation and synchrony in urban environments. Lastly, due to the increased distance to resources, I predicted there will be less total nest visits in urban environments.

Methods

Data was collected in 2018 on a breeding population of house wrens in urban (39º49´98″N, 119˚85´91″W) and rural (39º51´36″N, 119º74´15″W) locations in Reno, Nevada. House wren behavior in active nests was recorded in person by trained behaviorists. Parental nest visit data was collected at 19 different nests (9 urban and 10 rural). The nests were visited daily to determine the number of offspring during observation. Behavioral observations of the parents were made, including how often the male and female returned to the nest to feed their offspring to the nearest second.

Synchrony Score Calculation

A visit was considered synchronous if the male and female visited the nest within a one-minute window. This method proved to be a successful measure of synchrony in previous studies (Baldan, et al., 2019; Bebbington & Hatchwell, 2016). The proportion of synchronized visits was calculated as the number of synchronized visits over the total number of visits.

Alternation Score Calculation

The alternation score that was used measures the deviation of observed alternation from expected alternation based upon the pair's visits (Baldan, et al., 2019). An observed alternated visit was recorded if the parents alternated visits, returning to the nest after its mate. An observed nonalternate visit was recorded if the parents did not alternate visits. The alternation score was calculated using the following equations, as utilized in previous studies (Baldan, et al., 2019).

$$Expected\ number\ of\ altenated\ visits = \frac{(v_{na,m} + v_{a,m})(v_{a,m} + v_{na,f}) + (v_{a,f} + v_{na,f})(v_{na,m} + v_{a,f})}{V}$$

$$Expected\ number\ of\ nonaltenated\ visits = \frac{(v_{na,m} + v_{a,m})(v_{na,m} + v_{a,f}) + (v_{a,f} + v_{na,f})(v_{a,m} + v_{na,f})}{V}$$

$$Alternation\ score = log\left(\frac{observed\ number\ alternated\ visits}{observed\ number\ non\text{-}alternated\ visits}\right) - log\left(\frac{expected\ number\ alternated\ visits}{expected\ number\ non\text{-}alternated\ visits}\right)$$

An alternation score of zero is the amount expected by chance. A negative score means observed alternation is lower than expected by chance and a positive score means observed alternation is greater than expected by chance.

Statistical Analysis

Data analysis of the data gathered at the 19 nests was conducted in the R environment version 3.2.3 (R Development Core Team, 2017). ANOVA analysis was performed on brood

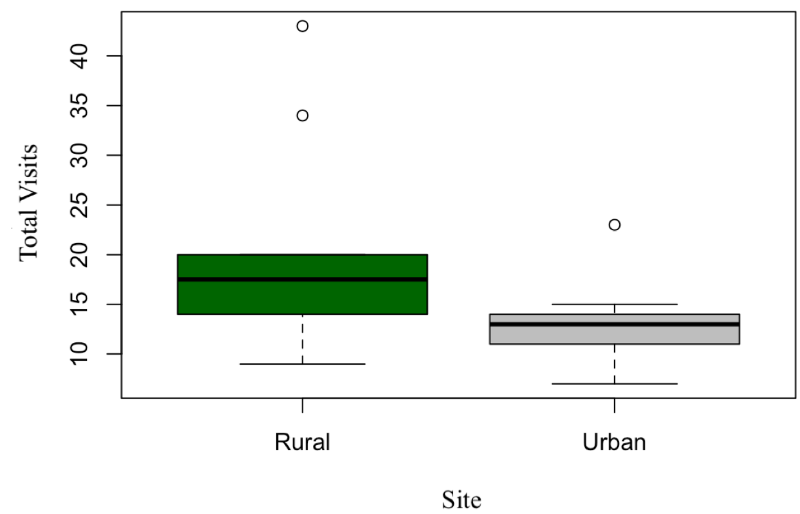

Figure 1. Total visits in rural and urban sites. There were more total visits in rural sites than urban sites (F_1 = 3.6512, P-value = 0.07304).

size and total nest visits to determine if there were differences between site type. Total nest visits were plotted against site type. Alternation scores were calculated and t-tests were performed to determine if the alternation scores in the urban and rural environment differed from 0. ANOVA analysis was performed to determine if there were significant differences in alternation score versus site type. A plot of alternation score versus site type was also derived.

The proportion of synchronous visits was calculated and plotted against site type to determine if there were differences in synchrony between sites. Lastly, linear mixed modeling of synchrony for rural sites, urban sites and total visits was performed.

Results

In total, 19 nests were observed (9 urban and 10 rural). Brood size ranged from 5-7 ($\bar{x}$ = 5.4). There was no significant difference in brood size between rural and urban sites (F_1 = 0.3441, P-value = 0.5652). The total nest visits were higher in rural sites (Figure 1). The t-tests performed for rural sites (t_9 = 4.6365, P-value = 0.001225) and urban sites (t_8 = 0.54122, P-value = 0.6031) demonstrated alternation scores were not zero for both sites. Alternation score differed between rural and urban environments (Figure 2A). Alternation score was significantly higher in rural sites (Figure 2A).

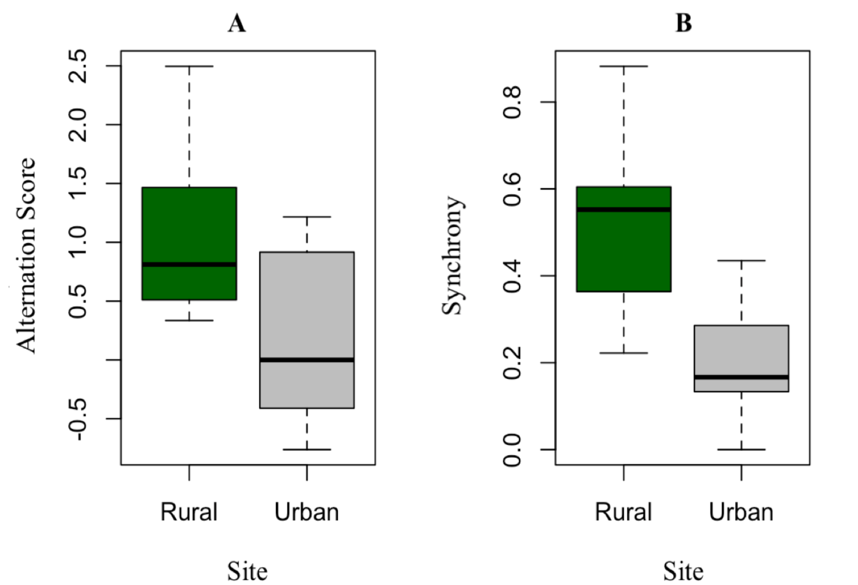

Figure 2. Alternation scores and synchrony in rural and urban sites. A) Rural sites had significantly higher alternation compared to urban sites (F_1 = 0.3441, P-value = 0.01618). **B)** Rural sites had significantly higher synchrony than urban sites (z = -2.140, P-value = 0.03248).

Rural nest sites were found to have significantly higher synchronicity (Figure 2B). Linear mixed modeling showed synchrony to have significant differences in rural sites, urban sites, and total visits (Table 1). Synchrony in urban sites and total visits were the most significantly different from the estimate.

Table 1. Linear mixed modeling investigating the differences in synchrony between rural sites, urban sites, and total visits. Synchrony differed significantly from the estimates in rural and urban sites as well as total visits.

Variable	Estimate	SE	z-value	Pr(>|z|)
Rural site	-0.71941	0.33616	-2.140	0.032348 *
Urban Site	-1.87159	0.29343	-6.1378	1.79e-10 ***
Total visits	0.04379	0.01272	3.443	0.000575 ***

Discussion

In this study, we observed bi-parental breeding house wrens to determine if rural and urban environments affected pair alternation and synchrony by analyzing parental nest visits. We found pair alternation and synchrony to be significantly higher in rural sites. We also found total nest visits to be higher in rural sites. Brood size was determined not to have a significant effect on total nest visits as they were not significantly different between rural and urban sites.

Linear mixed modeling demonstrated that synchrony varied significantly in rural sites and urban sites. This suggests the environment has a significant effect on pair synchrony. Bebbington & Hatchwell (2016) found significant alternation between the same pairs caring at the same nest suggesting alternation has an association with the nest environment. In this study, we studied the effect of rural and urban nest environment on alternation and synchrony. Pairs in rural environments visited the nest more times than in urban environments. Rural environments had significantly more alternation and synchrony than urban environments, suggesting decreased pair coordination in urban environments.

Urban environments pose challenges to provisioning parents such as increased distance from food resources which may lead to decreased pair coordination. The observed decreased pair coordination in urban environments may be due to increased foraging distance. It has been previously suggested that parents monitor their partner's parental investment (Bebbington &

Hatchwell, 2016) through direct observation of the nest to ensure an equal share of the work. If parents are foraging for food farther away they may be less able to monitor their partner's investment. In addition to increased distance from resources, increased noise and artificial light may also have roles in reducing pair coordination in urban environments.

An alternate explanation for the difference seen between pair coordination in rural and urban environments may be differences in offspring. Although brood size was not significantly different, offspring behavior may be different in rural and urban environments. Offspring behavior such as begging has been shown to have an effect on parental provisioning (Kilner, 1995).

Our results suggest house wren pairs in urban environments have different offspring provisioning behaviors than in rural environments. Pair coordination is suggested to be a behavioral adaptation that alleviates parental costs as well as increases fitness (Bebbington & Hatchwell, 2016). Our results demonstrate pair coordination in house wrens is decreased in urban environments. In future studies it would be of interest to determine if this different pair coordination results in differing fitness by analyzing parental survival or reproductive success. The effects of urbanization on pair behavior, and therefore fitness, remains an important area of study as urbanization continues.

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