The effects of anthropogenic noise on nest defense behaviors in eastern bluebirds (*Sialia sialis*)

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Abstract

Behavior is an important way to determine how different ecological circumstances such as urbanization, pollution, deforestation, etc., can affect an individual. Individual personality behaviors can affect fitness by constraining behavioral plasticity, which may affect an individual's response to a sudden environmental change. Studies have shown that anthropogenic noise, or the noise produced by humans, can affect learning capabilities, reproduction, and levels of aggression. However, few studies have examined how anthropogenic noise affects personality behaviors. This study examined how anthropogenic noise due to urbanization can affect eastern bluebirds (*Sialia sialis*) in terms of their levels of aggression. The goal of this study was to provide support for the hypothesis that, with increasing anthropogenic noise, bluebird aggression would increase as well. We used both simulated territorial intrusions (STI) and human territorial intrusions (HTI) for obtaining this aggression data and tested whether or not HTI trials could serve as a replacement for STI trials. We also examined if body condition was affected by anthropogenic noise. We found no correlation between levels of anthropogenic noise and aggression, but female body condition was found to be negatively correlated to low disturbance frequencies. This diminished body condition could result in less energy available for aggression, possibly explaining why no relationship between anthropogenic noise and aggression was found. We also found that the HTI elicited different responses than the STI and concluded that it could not serve as a substitute.

Keywords: Anthropogenic noise, Aggresion levels, Eastern Bluebirds, Disturbance Frequencies, STI and HTI trials

Introduction

An effective approach in determining if a specific factor is causing behavioral fluctuations is to compare different individuals' reactions to their environments (Sih and Bell 2008). It is important to take note of repeating behavioral differences within individuals of nonhuman species given they can impact the likelihood of survival. For example, a study conducted on male western bluebirds (*Sialia mexicana*) found that more aggressive individuals had fewer nestlings fledge as a result of feeding their mates less frequently (Burtka *et al.* 2014). Personality is a term often used to describe this consistency in individual behavior (Gosling 2001) and has been demonstrated in behaviors such as aggression and boldness (Sih and Bell 2008).

A variety of factors can affect behavior and ultimately personality, including human development and disturbance (Sih *et al.* 2011). Urban environments cause disturbances that can have both physiological and morphological effects on surrounding wildlife. Scales *et al.* (2011) found song sparrows (*Melospiza melodia*) in urban environments were both bolder and more aggressive towards humans. A study conducted on eastern grey squirrels (*Sciurus carolinensis*) was done to depict how urban animals must adapt to their environments to be successful (Bateman and Fleming 2014). The squirrels adjusted their behavior according to the level of risk they perceived from interaction with humans. They altered their behavior by becoming bolder in their new environment as a result of the greater abundance of resources, predators, etc.

Anthropogenic noise is seemingly unavoidable and can greatly impact surrounding wildlife (Meillère *et al.* 2015). Not only does anthropogenic noise have an effect on learning capabilities and reproduction, but it also can influence levels of aggression (Brumm 2014). Varied levels of anthropogenic disturbances were used to determine if western bluebirds (*S. mexicana*) changed their levels of aggression towards both competitors and non-competitors (Bhardwaj *et al.* 2015). They found that, with the competitive house wren, the aggressive response did not vary across disturbance categories (Bhardwaj *et al.* 2015). The aggressive

*=Mentor

response to the American goldfinch, however, changed as the level of anthropogenic disturbance varied (Bhardwaj *et al.* 2015). This study looks mainly at how anthropogenic disturbances, not anthropogenic noise, can affect behavior. Anthropogenic noise has been shown to affect singing, physiology, etc., but not many people have examined the direct influences of anthropogenic noise on behavior.

Figure 1 *- Map of the nesting sites across Stillwater, OK*

In this study, I examined how aggression in eastern bluebirds differed across field sites with varied levels of anthropogenic noise. I expected to find that with increased levels of anthropogenic noise, the level of aggression in the eastern bluebirds would increase. We conducted this experiment on eastern bluebirds, because they are a model organism for ecological, evolutionary, hormonal, and morphological studies (Gowaty and Plissner 2005). They use artificial nest sites as well as forage in the open, making them easy to study in the field. There is a population of eastern bluebirds in Stillwater, OK, that nest in a gradient of anthropogenic noise (Figure 1). We were interested in learning how suburban environments can affect behavior and how anthropogenic noise can affect overall fitness of the bluebirds. We measured this by conducting simulated territorial intrusions (STI) with a known secondary cavity competitor of the eastern bluebird, the house sparrow (*Passer domesticus*). We then determined the level of bluebird aggression by collecting data from aggressive displays such as the number of dives, calls, and hovers and compared the results. Not only did we use the house sparrow as a nest box intruder, but we also conducted human territorial intrusions (HTIs) that served as an alternative measure of aggression to see if similar responses were elicited by the bluebirds.

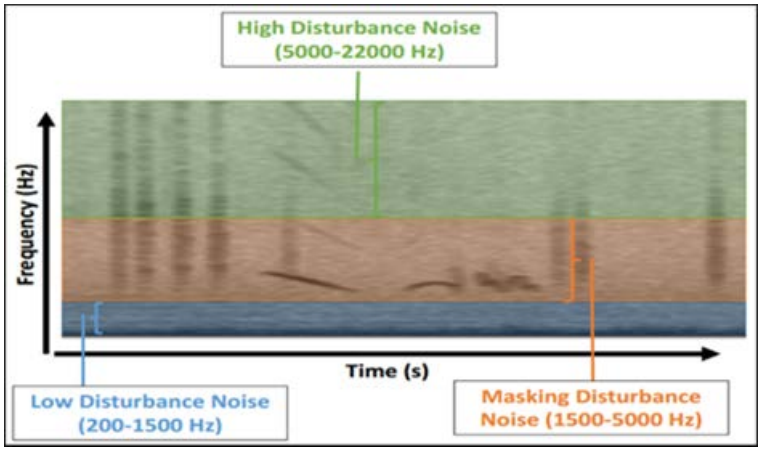

Figure 2 *- Ranges of anthropogenic noise measurements. HTI aggressing recordings were converted to spectrograms and ambient noise was measured.*

Methods

Study Site

Prior to beginning any of our aggression trials, we captured the pairs of males and females at each nesting site included in this study. We did this by placing a trap door in the nest boxes so when an adult flew in, the trap door would close, enclosing them in the nest box for us to capture. After retrieving the adult, we measured overall body size and condition (body mass, wing length, and tarsus length) and used the measurements to determine if body condition had a relationship with anthropogenic noise levels. To determine the levels of aggression among the eastern bluebirds, we monitored subjects' responses to the natural secondary-cavity competitor, the house sparrow. The house sparrow and the eastern blue bird act aggressively toward one another, because they both use secondary cavity nesting sites. Bluebirds defend the sites they inhabit from competitors such as the house sparrow (Gowaty 1981), making them a prime candidate to test aggressive personalities.

Simulated Territorial Intrusions

To measure bluebird aggression, we conducted an STI with a live male house sparrow. We began by capturing a male house sparrow and placing it in a metal cage. When we arrived at the focal nest box, we placed the cage covered with a towel on top of the nest box. Once the male or female bluebird was within 20 m, we removed the towel and recorded the behaviors displayed by the male and

female with a shotgun microphone and digital audio recorder. We conducted the STIs 7-9 days post-hatch. We scored aggressive behaviors such as the number of times spent flying/hovering and the number of attacks. These behaviors were used to create an aggregate aggression score (Burtka and Grindstaff 2015).

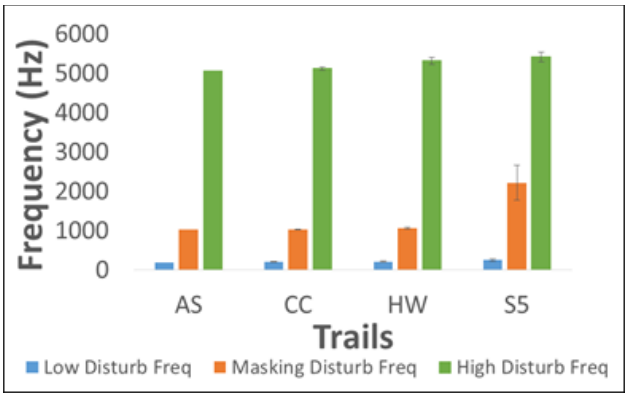

Figure 3 *- Average anthropogenic noise levels across the various nesting sites where HTI trials were performed.*

Human Territorial Intrusions

House sparrows, although an efficient means of naturally testing bluebird aggression in the presence of a competitor, can quickly become difficult to use in trials. Once house sparrows have been trapped, they are likely to develop "trap-shyness" (Fitzwater 1994). Trap-shyness refers to the tendency house sparrows will have from that point forward to stay away from anything resembling a trap. This tendency reduced the pool of house sparrows able to be used in our trials. For this reason, we utilized the HTIs as a possible alternative method to measuring bluebird aggression. The HTI is similar to the house sparrow STI, but instead of using a live house sparrow, a human observer acted as the aggressor. The recorder then stated any aggressive behaviors displayed by the parents. With this data, an aggregate aggression score was calculated based on the aggression scoring done in the study by Burtka and Grindstaff (2015) (Table 1).

Anthropogenic Noise Measurements

The ambient noise in each aggression trial recording was also analyzed to find the level of anthropogenic noise at that location. We created plot spectrums in Audacity to analyze the peak frequency in 0.5 s noise intervals. We classified different disturbance frequencies based on the frequency range of bluebird vocalizations (Figures 2 and 3). Low disturbance frequencies consist of things such as the sound of a car driving by, masking disturbance frequencies consist of noise that overlaps with bluebird songs, and high disturbance frequencies consist of the noise metal makes when hitting something.

Results

We analyzed 13 pairs of adults in the STI and HTI trials. Neither males nor females exhibited a significant aggressive response in the HTI trials, but some variation was seen in the STI trials (Figures 4 and 5). We conducted correlation tests between the different levels of anthropogenic noise and the HOSP STI aggressive behaviors. We found that no significant relationship existed between aggression levels and levels of anthropogenic noise, i.e. as anthropogenic noise levels increased, we did not see the expected increase in aggression levels. We found a trend between female body condition and anthropogenic noise (Figures 6 and 7) that approached significance: females wing length and body mass were negatively correlated with disturbance frequencies (wing length: n = 13, r = -

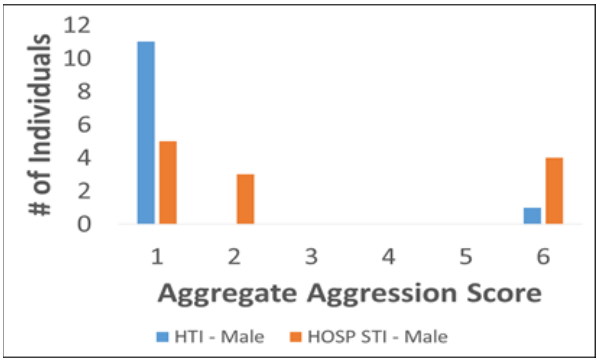

Figure 5 *- Comparison of adult male bluebird aggression levels between a human territorial intrusion (HTI) and a house sparrow simulated territorial intrusion (STI).*

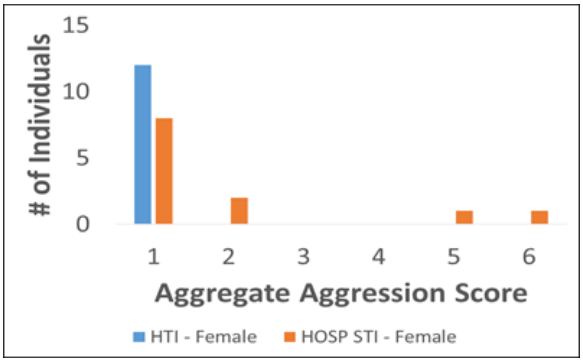

Figure 4 *- Comparison of adult female bluebird aggression levels between a human territorial intrusion (HTI) and a house sparrow simulated territorial intrusion (STI).*

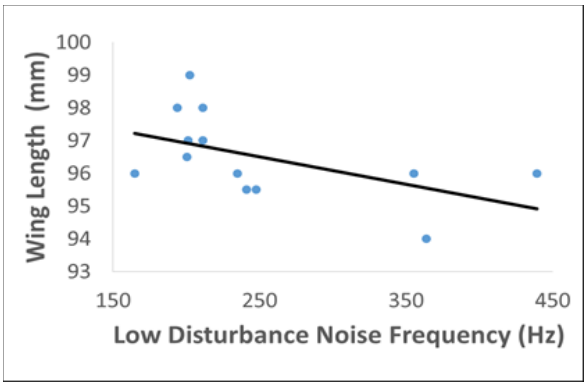

Figure 6 *- Scatter plot depicting the negative relationship between wing length of females and low disturbance frequency.*

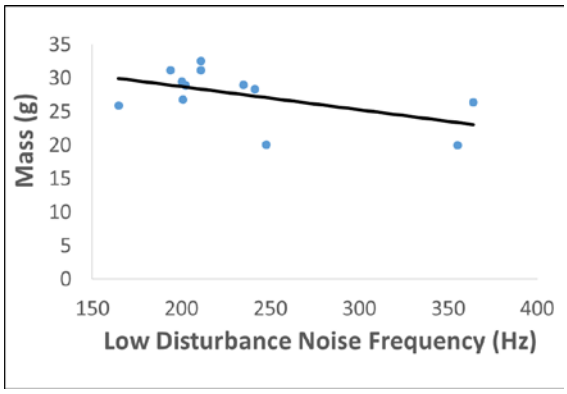

Figure 7 *- Scatter plot depicting the negative relationship between mass of females and low disturbance frequency.*

0.5255, $p = 0.065$; body length: n = 13, r = -0.5379, $p = 0.071$, respectively).

Discussion

The purpose of this study was to determine if anthropogenic noise had an effect on nest defense behaviors, in particular aggression towards a secondary cavity competitor. We did not find increased levels of aggression from the eastern bluebirds at nesting sites with higher levels of anthropogenic noise. One reason we may not have found the relationship we expected was our limited sample size. We only conducted studies on 13 pairs of adults along four of the bluebird nestbox trails in Stillwater. Conducting a study with an increased sample size would give us a better representation of the relationship that exists (or does not exist) between aggression and anthropogenic noise.

Individual bluebirds varied in their aggressive response to the STI trials, but there was little to no variation among bluebirds in response to the HTI trials. For this reason, the HTI assay was not appropriate for studying aggressive behaviors in bluebirds (Figures 4 and 5). It is still important to find another means of gathering aggression data since house sparrows can be difficult to catch. In a future study, we could use a clay model of a house sparrow as well as a recorder that plays back house sparrow songs. A study similar to this was done by Murphy *et al.* (2009) in which a taxidermic model was used in a simulated territorial intrusion. Instead of the HTI trial, we could use this assay and compare the results to the STI trial to determine if it is an appropriate alternative.

Although the relationship was not significant (perhaps because of a small sample size), the negative correlation between female wing length/body mass and low disturbance frequencies suggests overall female body condition decreases with increased noise (Figures 6 and 7). This diminished body condition could result in less energy available for aggression, possibly explaining why no relationship was found between anthropogenic noise and aggression. Previous studies have found that males are typically bolder in suburban environments (Pandit *unpublished data*). Males may not have deteriorated like females, since they respond to anthropogenic noise differently. Anthropogenic noise may act as an additional stressor that increases

Table 1 *- Key used to determine the aggression score of individual adults.*

1	0	-	Not aggressive
2	1-5	-	Minimal response, moderately aggressive
3	>5	-	Moderate response, moderately aggressive
4	-	1-5	Moderate response, highly aggressive
5	-	6-9	High response, highly aggressive
6	-	>9	Very high response, very aggressive

energetic demands on adults and may, as a consequence, lead to reduced investment in offspring. Not only is this stressor directly affecting adult physical health, it has the potential to affect their physiology since greater amounts of stress hormones may be being released. The chronic elevation of this hormone could also be a cause of the deterioration in body condition as seen in the eastern bluebirds (Wingfield and Kitaysky 2002).

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