

MATERNAL PERSONALITY MAY MITIGATE THE NEGATIVE IMPACTS OF ANTHROPOGENIC  
NOISE ON A FREE-LIVING BIRD

A Thesis  
by  
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Submitted to the School of Graduate Studies  
at Appalachian State University  
in partial fulfillment of the requirements for the degree of  
MASTER OF SCIENCE

May 2020  
Department of Biology

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## **Abstract**

### **MATERNAL PERSONALITY MAY MITIGATE THE NEGATIVE IMPACTS OF ANTHROPOGENIC NOISE ON A FREE-LIVING BIRD**

Taylor Paige Fulk

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Although the effects of anthropogenic noise pollution on wildlife populations are well documented, little research has focused on the importance of animal personality in mitigating these impacts. Bold individuals may be less likely to suffer than meek individuals from such disturbance. In the present study, I tested whether the personality type of parents can mitigate the negative effects of traffic noise on reproductive output, nestling growth and physiology using a wild population of tree swallows (*Tachycineta bicolor*). I randomly assigned nests to control versus an experimental traffic noise treatment of 65 dBA at a field site with an average ambient noise of 49 dBA. I quantified personality along a bold to meek spectrum by presenting breeding adults to a stimulated intrusion of a nestling predator, defining the parent as bold if they came within 1m of the mock predator. I measured parental fitness as number of offspring fledged, nestling mass, glucocorticoid signaling and oxidative stress. Nestlings reared under experimental noise treatment were smaller only if reared by meek females. I found no effects of male personality on nestling condition nor did I find that nestling glucocorticoid signaling and oxidative stress were sensitive to treatment or parent personality. These results suggest that personality type can mitigate the negative impacts of anthropogenic disturbance on reproductive parameters in birds. If bolder parents achieve higher fitness in noisy environments, human encroachment may be selecting for bolder phenotypes. Assessment of

animal personality may improve our understanding of how animal populations will respond to anthropogenic change.

*Lay Summary:* In this experimental study I manipulated noise, but these effects are also going to become more prevalent in a natural setting as road networks continue to expand. Animal population responses to noise pollution have been well documented in past research. To avoid masking individual differences, this study addressed individualistic responses within populations. Quantifying personality within populations may allow researchers to explain important variation in how individuals respond to anthropogenic disturbance.

*Key words:* **maternal personality, tree swallow, anthropogenic noise, conservation, noise pollution.**

## **Acknowledgements**

I would like to thank the Cratis D. Williams School of Graduate Studies as well as the College of Arts and Sciences at Appalachian State for their funding opportunities. I would also like to thank the High Country Audubon Society for giving me the opportunity to fund my research as well as immersing me in their group and allowing me to serve as a board member for the past two years. Additionally, I would like to acknowledge Jon Wells for his help in conducting the physiological assays in house as well as Sam Fritz for his help in introducing me to the statistical program R. A special thanks to Dr. Lynn Siefferman for her guidance over the past two years. Dr. Siefferman welcomed me into her lab with open arms and gave me the tools I needed to succeed. She believed in me as a student, researcher, and a scientist. I want to thank her for giving my dreams the fuel they needed to come true. I will never forget all the lessons she has taught me and the memories that will last a lifetime. I would also like to thank my other two committee members, Dr. Barbara Ballentine and Dr. Jon Davenport for their input throughout this process. Lastly, I would like to acknowledge all of my field technicians who assisted me in collecting field data over the tree swallow breeding season. I appreciate all of their hard work and dedication and will happily be a reference for them for future jobs.

## **Dedication**

I would like to dedicate this work to my parents, Keith and Elaine Fulk. They both have supported me through my educational journey that led me to graduate school. They are prime examples for what dedication and hard work mean and continue to bring out my highest potential. From birth until now, I owe all that I am to them. To my dad, who has worked tirelessly to ensure I have a successful future, and to my mom, who has been the backbone of our family, all of these words go out to you and your never ending love.

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## **Foreword**

This thesis will be submitted to *Behavioral Ecology*, a bimonthly peer-reviewed scientific journal published by Oxford University press on behalf of the International Society for Behavioral Ecology; it has been formatted according to the style guide for that journal.

## INTRODUCTION

Across the world, as human activities become more widespread, noise pollution is negatively impacting wildlife populations (Shannon, McKenna, Angeloni, et al. 2016) and has implications for conservation management plans (Barber, Crooks, Fristrup 2010; Francis and Barber 2013). Anthropogenic noise reallocates an animal's finite attention, effectively distracting it and preventing it from responding to salient cues involved in detecting predators (Chan, Giraldo-Perez, Smith, et al. 2010), finding food (Wale, Simpson, and Radford 2013; McClure, Ware, Carlisle, et al. 2017), and communicating (Halfwerk, Bot, Buikx, et al. 2011). Avian parents may perceive anthropogenic noise as increased threat of predation (Owens, Stec, and O'Hatnick 2012; Kern and Radford 2016; Potvin 2017). Parents must divide their attention (Dukas 2004) or time (Lima and Bednekoff 1999) between necessary tasks (e.g. foraging, provisioning offspring) and antipredator behavior (e.g. aggression). If noise exposure during the breeding period alters parental behavior, nestlings could suffer from reduced provisioning during this critical developmental stage. Further, given that nestlings cannot escape from noise-exposed nests during development (Shors, Seib, Levine, et al. 1989; Starck 1993), it is also possible that noise could directly affect their stress levels and body condition (Injaian et al. 2018a; Injaian, Taff, Pearson, et al. 2018b; Injaian, Gonzalez-Gomez, Taff, et al. 2019).

Glucocorticoid or stress hormones, such as corticosterone (CORT) mediate how individuals respond to environmental changes and can result in multiple physiological effects on the body and behavior (Sellers et al. 1988; Rebuffé-Scrive et al. 1992; Romero 2002). At baseline concentrations, CORT has metabolic functions including regulating energy intake, storage, and mobilization (Sapolsky 2000; Landys et al. 2006). Nestlings exposed to noise

exposure may show elevated baseline CORT (Crino et al. 2011; Injaian et al. 2018a, Injaian et al. 2018c) and increased oxidative stress (Injaian et al. 2018b). Oxidative stress occurs when there are more pro-oxidants than anti-oxidants, leading to damage of biomolecules (Halliwell and Gutteridge 2007; Costantini 2008). In birds, anti-oxidant concentrations are an effective predictor of an animal's ability to resist oxidative stress under stressful stimuli (Cohen et al. 2007; Wilcoxon et al. 2015). Nestlings reared in noise-exposed habitats may be susceptible to higher levels of stress reducing immune response or survivorship (Padgett and Glaser 2003). Indeed, house sparrow (*Passer domesticus*) nestlings exposed to noise show reduced fledging and recruitment (Schroeder et al. 2012). Additionally, nestlings may grow more slowly when subjected to traffic noise (Potvin and MacDougall-Shackleton 2015; Injaian et al. 2018a; 2018b; 2019). Reduced growth and body size in nestlings can increase their vulnerability to negative life-long consequences (Richner et al. 1989).

Interestingly, within wildlife populations, some individuals seem better able to deal with human disturbance and may thrive in highly-developed environments (Harding et al. 2019; Naguib et al. 2013). Thus, to consider only the mean response of populations or species to anthropogenic disturbance could mask important within-population differences in how animals cope (Harding et al. 2019). Animal personality refers to population level differences in behavior accompanied by within-individual consistency in behavior (van Oers and Naguib 2013). In behavioral ecology, traits such as aggression and exploration are common measures of personality type. Individuals differ non-randomly in how they deal with stressors and novelties and appear to vary along a behavioral continuum from meek to bold (Wilson et al. 1993; 1994; Verbeek et al. 1994; Schwabl 1995). For example, bold individuals that possess aggressive and exploratory phenotypes have reduced neophobia to objects and food and are more likely to tolerate anthropogenic disturbances (Sih et al. 2004), move through human-modified landscapes (Duckworth and Badyaev 2007), and colonize new areas (Sol et al. 2013). To date,

however, little research has addressed whether parental personality influences reproductive success in the face of anthropogenic noise (reviewed in Harding et al. 2019 and see responses to it, Naguib et al. 2013).

Here, I investigate whether parent personality mitigates the expected negative impacts of experimental noise on reproductive output, nestling growth and measures of nestling stress physiology in tree swallows (*Tachycineta bicolor*). I predict that parents with bold personalities may achieve greater fitness in the face of anthropogenic stressors. Bolder birds take more risks and are less vigilant in urban environments (Ducatez et al. 2017), thus should perform better and undergo less distraction when subjected to anthropogenic noise. Because behavior mediates interactions between an individual and its environment, the ability of parents to behave appropriately under these new conditions is crucial for determining their immediate success or failure in these modified environments (Sih et al. 2011).

## MATERIALS AND METHODS

### **Study Species**

I studied a natural population of tree swallows, a socially monogamous passerine, in Watauga County, North Carolina (36° 12' 41"N, 81° 40'7"W) between April and July in 2018. The study site includes hayfields, pastures and occasional light residential and public parks. Tree swallows readily accept nestboxes (Robertson et al. 1992) and are particularly appropriate for behavioral research because their aggressive behavior is consistent and thus they exhibit animal personality as measured by aggression towards same-sex conspecifics (Rosvall 2008) and parental defense aggression (Betini and Norris 2012; Content 2018). Moreover, aggression in females, but not males, predicts resource holding potential (Rosvall 2008) while highly aggressive parents having higher reproductive success in response to sudden environmental changes (Betini and Norris 2012). Experimental evidence demonstrates that noise can alter parent-offspring interactions among tree swallows and interfere with parental responses to begging calls (Leonard et al. 2015).

### **General Field Methods**

I monitored nestboxes every 3 days to record laying date and clutch size. Upon clutch completion, I predicted the expected hatch date and monitored nests daily to record hatch date (nestling age day 1) and brood size. I considered nestlings to have successfully fledged if they were no longer present in the nest box after day 18-post hatch. I captured adult females in their nestboxes when nestlings were age 9 days and used evidence of brood patch or cloacal protuberance to identify sex (Stutchbury and Robertson 1988). I gave females a unique numbered USGS aluminum band and color band and, I painted 1 cm of the 3<sup>rd</sup> primary feather with non-toxic acrylic paint (see Bentz et al. 2019) to facilitate identification during behavioral observations.



### **Noise Broadcast**

Upon hatching, I randomly assigned nests to control (n=15) or noise (n=10) treatment. By broadcasting noise only during the rearing stage, I avoided exposure effects on adult settlement patterns and female incubation behavior, which has been shown to alter tree swallow nestling growth post-hatch (Ardia et al. 2010). Given that tree swallow broods hatch asynchronously (Zach 1982), I began the treatment 1 day after the last nestling hatched to avoid variance in noise impacts on early versus late-hatching nestlings. For nests under noise treatment, I broadcasted a 6-hour traffic noise playback using outdoor speakers (Mini H20, Altec Lansing, New York, NY, USA) connected to an MP3 player (Clip Sport Plus; SanDisk Co., Milpitas, CA, USA) between the hours of 0700-1300 every other day from nestling age day 2 to day 14 (a similar noise regime as previous work; Meillère et al. 2015). Both the speakers and MP3 players were powered by lithium polymer batteries that were recharged every day to ensure full battery capacity for the next playback. I placed speakers 1m in front of the nestbox and broadcast noise at 65 dBA SPL (Leonard et al. 2015), which is equivalent to noise 90-100 m from a four-lane highway (Dooling and Popper 2007). Due to limited amount of noise equipment and other logistical constraints, noise playbacks could not be run daily. However, our noise playback regime is still biologically relevant given that traffic patterns often vary day by day (i.e. weekend versus weekday). To avoid inadvertently broadcasting noise to nearby nests, I only used nests that were > 30m buffer from experimental or control nests. This separation also prevented aggression associated with territory overlap in this species (Winkler 1994). At control nests, I placed similar audio playback equipment 1m in front of the nestbox but did not broadcast noise (Blickley et al. 2012).

### **Parent Personality**

When nestlings were age 10 days, I conducted a behavioral assay of parental boldness in response to a simulated nest predator (modified from Winkler 1992; Winkler 1994) a decoy American crow (*Corvus brachyrhynchos*), an avian nest predator that is widespread in North America. I suspended the decoy 0.3 m above the nest using a wire and pole, such that it moved in a semi-natural flight position. I began trials by first visually identifying the male and female, deploying the decoy, and then leaving the immediate vicinity of the nest. I took behavioral observations from ~50 m that consisted of recording the identity of each parent and whether it dove at the mock predator (swooped within 1 m) during the 5-min trial (Betini and Norris 2012). If a parent dove within 1 m of the mock crow, it was classified as having 'attacked' and the bird considered to be 'bold'. Parents that did not dive with 1 m of the mock crow were considered 'meek'. Although I only measured parent personality one time, past research with this population demonstrates that parental boldness is highly repeatable and does not vary with environmental conditions (Content 2018).

### **Nestling Measurements**

At age 12 days, I measured nestling (n=131) mass ( $\pm 0.01$ g). I chose day 12 because some nestling older than day 12 lose mass in preparation for fledging (Zach and Mayoh 1982). At age 14 days, I removed two nestlings chosen at random to sample blood for baseline CORT and antioxidant defense. Within 3 min of handling, I collected 100  $\mu$ l of blood from each nestling via brachial venipuncture using heparinized microhematocrit capillary tubes. I stored blood on ice and centrifuged (speed of 800 RPM for 10 minutes) within 5 hrs of collection. I stored plasma at  $-80^{\circ}\text{C}$  until further analysis. To account for fledging success, I considered nestlings to have successfully fledged if they were no longer present in the nest box after day 18-post hatch. All failures to fledge (i.e. predation or nestlings perishing inside of box) were recorded.

### **Ambient Noise**

Once all nestlings had fledged (June 25-June 29), I measured natural variation in background noise at each nestbox by using a sound level datalogger (Model 407760, Extech, Waltham, MA, USA). I waited until after nestlings had successfully fledged the nest to prevent any sound interference from the birds' song (i.e. alarm calls due to human presence) that might bias the representation of accurate dBA levels. Between 0700-0900, I recorded a 5-min reading at each box using the slow time, dBA weighting. A-weighting was chosen as this is the sound pressure level scale best weighted towards avian hearing (Dooling and Popper 2007). Noise levels for my field site are considered normal for wooded and lightly used residential areas (Leq average of 49.93 dBA; California Public Utilities 2013).

### **Corticosterone Levels**

To determine nestling baseline CORT levels, I quantified plasma CORT using enzyme immunoassay kits (Model 501320, Cayman Chemical, Ann Arbor, MI, USA; assay sensitivity 30 pg/mL). This assay is based on the competition between CORT and a CORT-acetylcholinesterase (AChE) for a limited amount of CORT antiserum. It has been used to measure plasma corticosterone in multiple songbird species with comparable CORT levels (see Lutyk et al. 2017; Virgin and Rosvall 2018; Weber et al. 2018). I followed the kit instructions with only minor adjustments (e.g. Rosvall et al. 2012). Each plate contained up to 36 reconstituted samples in duplicate, in addition to an 8-point standard curve, blank, maximum binding, non-specific binding, and total activity controls. I read absorbance at 412 nm using a SpectraMax M3 Multi-Mode Microplate Reader (v2.1.35, Molecular Devices, San Jose, CA, USA). Intra-plate variability ranged from 8.4-12.2% (mean: 10.8%).

### **Total Antioxidant Capacity**

To evaluate nestling antioxidant defense, I used the OxiSelect™ Total Antioxidant Capacity (TAC) Assay Kit (STA-360, Cell Bio Labs, San Diego, CA, USA). I compared the samples to a known concentration of uric acid standard within a 96-well microtiter plate format. I used 10  $\mu$ l of plasma as well as known concentrations of uric acid standards, both of which were pipetted into separate wells on a 96-well microplate. I diluted the samples and the standards with 180  $\mu$ l of reaction buffer. I obtained an initial absorbance reading at 490nm using a SpectraMax M3 Multi-Mode Microplate Reader (v2.1.35, Molecular Devices, San Jose, CA, USA) and then added 50  $\mu$ l of the copper ion to each well, followed by a 5-min incubation on an orbital shaker. I stopped the reaction using 50  $\mu$ l of stop solution and obtained a final reading. I determined antioxidant capacity by comparison with the uric acid standards.

### **Statistical Analyses**

I log transformed nestling CORT and TAC levels to achieve normality (Cohen et al. 2007). Sample sizes vary because I was not able to sample blood from all nestlings within 3 min of handling and I failed to identify some parents during behavioral trials. Additionally, I excluded three nests with a brood size lower than three and seven nestlings with mass  $>3$  SD from the mean.

I analyzed the data in R (version 3.6.2). To identify the top models, I compared Akaike Information Criterion values (AICc; a version of Akaike Information Criterion that has a correction for small sample size) and summed Akaike weights. Model averaging based on AICc has been shown to be effective for variables that have a real effect on the response (Burnham and Anderson 2002; see also Anderson 2008 for detailed example). For the best-ranked model, I extracted the  $\beta$  parameter estimates and the 95% confidence intervals (CI) to assess the importance of effect sizes as 'statistically significant' if the 95% CI did not overlap zero. In

addition, I used summed Akaike weights as an additional criterion to identify important predictors (Burnham and Anderson 2002; Giam and Olden 2016). First, I determined that there was no multicollinearity between predictors (female personality, noise) using the `cor` function in R. To test the effect of parental personality and noise on reproductive success, I ran generalized linear models (GLM) assuming a Poisson distribution. I included the following predictors: noise treatment, female personality, male personality, same personality and interactions including: female personality\*noise treatment, male personality\*noise treatment, and same personality\*noise treatment.

I used three separate linear mixed models (`lme4` package: Bates et al. 2015) to measure predictors on nestling mass, CORT levels, and TAC levels. For each dependent variable, my predictors included the same as above and I also included a fixed effect of 'brood size' because previous studies show that brood size alters the allocation of food per nestling in tree swallows (Leffelaar and Robertson 1986). Further, I included 'nestbox ID' as a random effect to account for multiple nestlings within nests.

## RESULTS

### **Reproductive Success**

Brood reduction was rare; one nestling died in each of two nests, however, both these nests were noise treatments reared by meek females. The best predictor of the number of offspring fledged was the null model which received 43% of the total model weight, thus, fledging success was not influenced by the noise treatment or parental personality (Table 1).

### **Nestling Body Mass**

The top model predicting nestling mass, which received 82% of the total model weight, included the parameter interactions of 'female personality \* noise treatment' and 'female personality \* brood size' (Table 2). Nestlings reared by meek females under noise treatment suffered reduced body mass, however, those reared by bold females were not negatively affected by the noise treatment (Figure 1; Table 2). Further, nestlings reared by meek females were smaller if reared in large broods (>4 nestlings; Figure 2). When reared by bold females, however, nestlings in large broods did not suffer reduced mass (Figure 2).

### **Nestling Stress**

I found no evidence that noise treatment, parent personality or their interaction influenced nestling baseline CORT levels (Table 3). The top model for nestling baseline CORT was the null model and held 93% of the total model weight (Table 3). Moreover, I found no indication that noise treatment, parental personality or their interaction influenced nestling antioxidant levels (Table 3). The top model for nestling TAC was the null model and held 98% of the total model weight (Table 3).

## DISCUSSION

Nestlings reared by meek females suffered reduced body mass when exposed to the noise treatment, however, offspring of bold mothers were not affected by the noise treatment. Thus, these data suggest that the female's personality mitigates the negative effects of anthropogenic influences on nestling growth. Male personality, however, did not predict how nestlings would fare. Further, despite reduced body mass at day 12, I found no evidence that noise impacted physiological proxies of nestling stress including baseline CORT and antioxidant defense. I found some weak and anecdotal evidence of impacts on nestling survival. In general, nestling survival to fledging was high; yet the only nests that experienced brood reduction were noise treatments reared by meek females. Finally, in general, meek females appear less able to keep up with the demands of nestling provisioning in large broods; as brood size increased, offspring size decreased.

Nestlings reared by bold mothers did not suffer reduced growth like those reared by meek mothers suggesting that bold females are less negatively affected by anthropogenic noise. To date, little research has investigated whether personality can mitigate the negative impacts of anthropogenic disturbance- only one other study has investigated interactions between noise treatment and parental personality. A study of great tits (*Parus major*), used a short-term noise manipulation, quantified parental personality and measured provisioning to offspring. In females, bolder individuals, but in males meeker individuals, reduced total visits during noise; these personality scores were quantified as exploratory behavioral scale during in the non-breeding season in a controlled setting (Naguib et al. 2013). In great tits, birds that are bolder defend resources more aggressively (Amy et al. 2010), and are more likely to win dominance interactions (Verbeek et al. 1996). Based on the assumption that parents that show more exploratory behavior would also defend offspring more boldly, my data would be consistent with that of the male great tits. Future studies should assess multiple measures of personality in

tree swallows to verify that parental defense behavior, territorial aggression and exploratory behavior covary like in great tits. My findings of an interaction between noise treatment and maternal personality on nestling growth suggests that nestling provisioning was affected by the treatment and could be explained by multiple mechanisms including: parent-offspring communication, vigilance-foraging tradeoffs, or habitat quality. Unfortunately, I did not measure feeding rates or vigilance behavior.

The level of background noise and the signal-to-noise ratio plays an important role in the detection and recognition of signals (Klump 1996; Wiley 2006). In the presence of extra stimulation, the difference between noise and signals meant for parents narrows and becomes more difficult to decipher (Pohl et al. 2009). If meek females spend less time near the nest, they may experience greater disruption of foraging or provisioning and communication between themselves and their young as suggested by past research focusing on tree swallows. Experimental noise leads to interference with parental responses to nestling begging calls (Leonard et al. 2015), changes in nestling call structure (Leonard and Horn 2008) and reduced nestling begging responses to parental cues (Leonard and Horn 2012). However, Injaian, Taff, and Patricelli (2018a) found that noise did not reduce parental feeding rates. It's also possible that noise could lead to reduced nestling growth without a direct effect on parent-offspring communication. Leonard et al. (2015) found that noise treatment caused nestlings to beg more and argued that this extra effort could be energetically physiologically costly and lead to reduced growth. It is also possible that meek females are more vigilant and thus are more likely to tradeoff foraging for vigilance behavior under noise treatment. For example, Quinn et al. (2006) broadcast noise and found that chaffinches (*Fringilla coelebs*) increased their vigilance behavior and decreased foraging. Feeding efficiency is directly related to vigilance; time spent in vigilance cannot be spent foraging (Burger and Gochfeld 1991).



It is also possible that bold females mitigate the negative effects of noise because they win early season contests for high-quality nesting habitat. Indeed, Rosvall (2008) showed that female conspecific aggression is repeatable and predicts the outcome of competition for nesting sites. High-quality habitat could allow parents to provision offspring adequately even in the face of noise disturbance. Past research on tree swallows suggests equivocal effects of experimental noise treatment on nestling growth: Leonard and Horn (2008) found no effect while Injaian et al. (2018a, 2018b, 2019) showed reduced growth. This discrepancy could be attributed to variation in environmental conditions or population-level differences in behavior and growth. My results, however, also suggest that measuring the mean response of populations to anthropogenic disturbance could mask important within-population differences in how animals cope with disturbance. Quantifying parental personality may allow researchers to explain important variation in how individuals respond to anthropogenic disturbance. I found no evidence that the baseline or stress-induced measure of sera CORT varied with treatment, mother personality, or their interaction. My data differ from those of Injaian et al.'s (2018a; 2018b; 2019); in California population, nestlings exposed to a similar noise treatment as mine showed increased baseline CORT, oxidative stress and telomere attrition. This discrepancy could be explained by differences in population-based variation in food resources (Isaksson et al. 2017) or selection pressures that vary with geography. For example, stress profiles and boldness of adult tree swallows vary with geography (Albers 2016). Finally, it maybe that there is little selection pressure for nestlings to develop fully functioning glucocorticoid responses because most of the acute challenges that nestlings face are ones for which successful coping is unlikely to be aided by elevated glucocorticoids (Vitousek et al. 2019).

In addition to my finding that meek females reared smaller young in noisy environments, a second line of evidence suggests that meek females suffer more from

environmental stress. I found that meek females with broods larger than four nestlings reared small nestlings while large broods reared by bold females did not suffer reduced growth. The reduced condition of nestlings in larger broods suggests that meek females may be unable to keep up with the food demands of a large brood. Studies across multiple contexts have shown reduced growth of nestlings reared in larger brood (Dijkstra et al. 1990; Musgrove et al. 2017; Ruhs et al. 2020).

Unlike the effect of maternal personality on growth, paternal personality did not mitigate the negative effects of anthropogenic noise on nestling mass. Because males and females differ in behavioral and life history strategies and experience differential selection pressures, personality-dependent sex differences may be adaptive. Male tree swallows tend to feed young less often than do females (Whittingham et al. 2003) thus their personality type may not be as good a predictor of total parental effort in the face of noise. This is expected in species, like tree swallows, with 50-90% of broods containing extra-pair young (Lifjeld et al. 1993; Dunn et al. 1994; Kempenaers et al. 2001). Males likely benefit from spending time and energy seeking extra-pair mates at the cost of reduced parental care toward their mate's brood (Trivers 1972). It is also possible that bolder females are better equipped to pick up the slack for poor performing mates. Additionally, it could be that bold males are not as likely as bold females to secure high-quality territories (Rosvall 2008). The opposite sex-dependent interactions between personality and fitness found between my study and that of the great tits (Naguib et al. 2013) could be explained by differing roles that females have in territory defense. Male great tits defend the territory, like most socially monogamous birds, whereas tree swallows show some sex-role reversal such that female take on a larger role than males in territorial defense (Rosvall 2008).

Although meek females under noise treatment produced smaller chicks, we found little evidence that our overall measure of reproductive success- number of offspring fledged- was

impacted by noise treatment or parental personality. However, in this population, nestling mortality was rare and, importantly, it only occurred in nests that were reared by meek mothers under noise treatment. It is possible that a lack of variation in fledgling success could account for failing to find an effect of treatment.

## CONCLUSION

In the face of noise treatment, bold females produced larger young, and because faster growing nestlings are expected to have better likelihood of survival to adulthood (Leniowski and Wergrzyn 2018), it is possible that anthropogenic noise may select for bolder phenotypes. My research suggests that a consideration of animal personality traits may allow researchers to better develop conservation plans to mitigate human impacts on animal populations.

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## APPENDIX

**Table 1**  
**Mixed-effect candidate models for number of offspring fledged as a response to noise treatment and parental personality in tree swallows. Only top 5 models are shown.**

Model	K <sup>a</sup>	$\Delta\text{AICc}^b$	$\text{AICcWt}^c$
<i>Null model</i> : Fledged	1	0	0.43
Fledged ~ Female Personality	2	2.3	0.14
Fledged ~ Noise	2	2.3	0.14
Fledged ~ Male Personality	2	2.4	0.13
Fledged ~ Same Personality	2	2.4	0.13

<sup>a</sup>Number of parameters in the model.

<sup>b</sup>Difference in Akaike Information Criterion (AICc) values from the top ranking model.

<sup>c</sup>Relative weight (out of 1) based on AICc value.

**Table 2**  
**Mixed-effect candidate models for nestling mass(g) on day 12 post-hatch as a response to noise exposure and parent personality in tree swallows. Only top 5 models are shown.**

Model	K <sup>a</sup>	$\Delta\text{AICc}^b$	$\text{AICcWt}^c$
Mass ~ Female Personality*Noise + Female Personality*Brood	8	0	0.82
Mass ~ Female Personality*Noise + Brood	8	5.6	0.05
Mass ~ Noise + Brood	7	7.0	0.03
Mass ~ Same Personality*Noise + Brood	5	7.3	0.03
<i>Null model</i> : Mass	3	8.4	0.02

<sup>a</sup>Number of parameters in the model.

<sup>b</sup>Difference in Akaike Information Criterion (AICc) values from the top ranking model.

<sup>c</sup>Relative weight (out of 1) based on AICc value.

**Table 3**  
**Mixed-effect candidate models for nestling corticosterone (CORT) as a response to noise treatment and parent personality in nestling tree swallows. Only top 5 models are shown.**

Model	K <sup>a</sup>	$\Delta$ AICc <sup>b</sup>	AICcWt <sup>c</sup>
<i>Null model</i> : Time 0 CORT	8	0	0.95
Time 0 CORT ~ Male Personality + Brood	8	8.8	0.01
Time 0 CORT ~ Same Personality + Brood	7	8.9	0.01
Time 0 CORT ~ Female Personality + Brood	5	8.9	0.01
Time 0 CORT ~ Noise + Brood	3	9.0	0.01

<sup>a</sup>Number of parameters in the model.

<sup>b</sup>Difference in Akaike Information Criterion (AICc) values from the top ranking model.

<sup>c</sup>Relative weight (out of 1) based on AICc value.

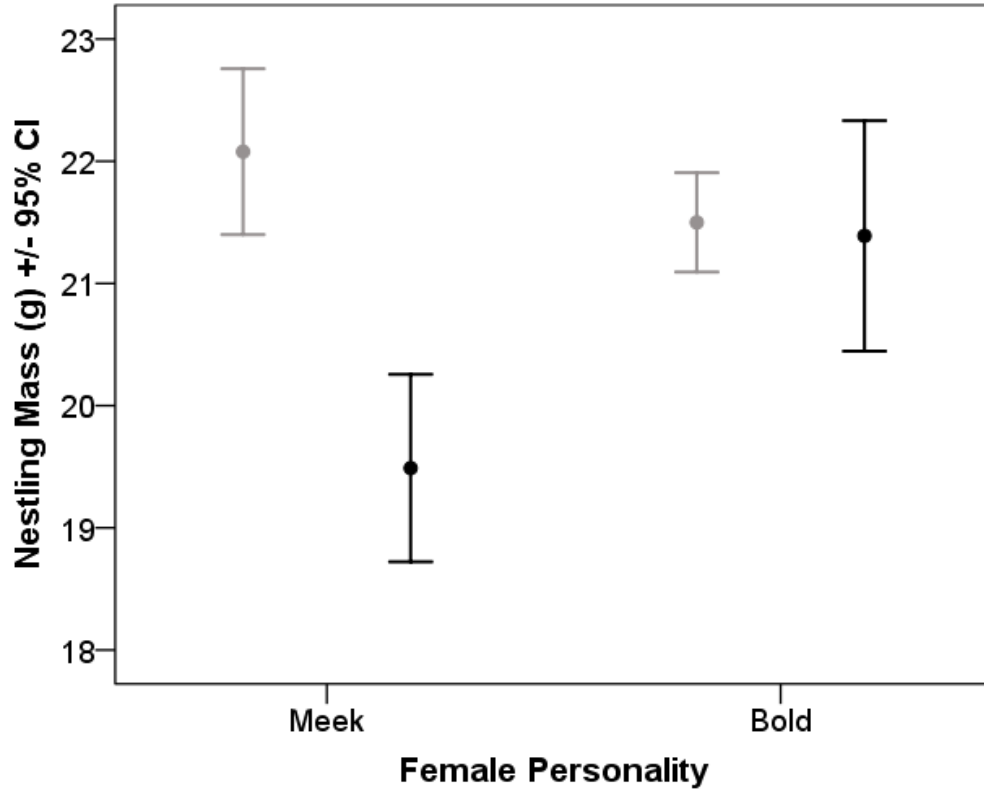
**Table 4**  
**Mixed-effect candidate models for nestling antioxidant defense (TAC) as a response to noise treatment and parent personality in nestling tree swallows. Only top 5 models are shown.**

Model	K <sup>a</sup>	$\Delta$ AICc <sup>b</sup>	AICcWt <sup>c</sup>
<i>Null model</i> : TAC	3	0	0.98
TAC ~ Same Personality + Brood	5	10.0	0.01
TAC ~ Female Personality + Brood	5	11.3	0.00
TAC ~ Noise + Brood	5	12.0	0.00
TAC ~ Male Personality	5	12.1	0.00

<sup>a</sup>Number of parameters in the model.

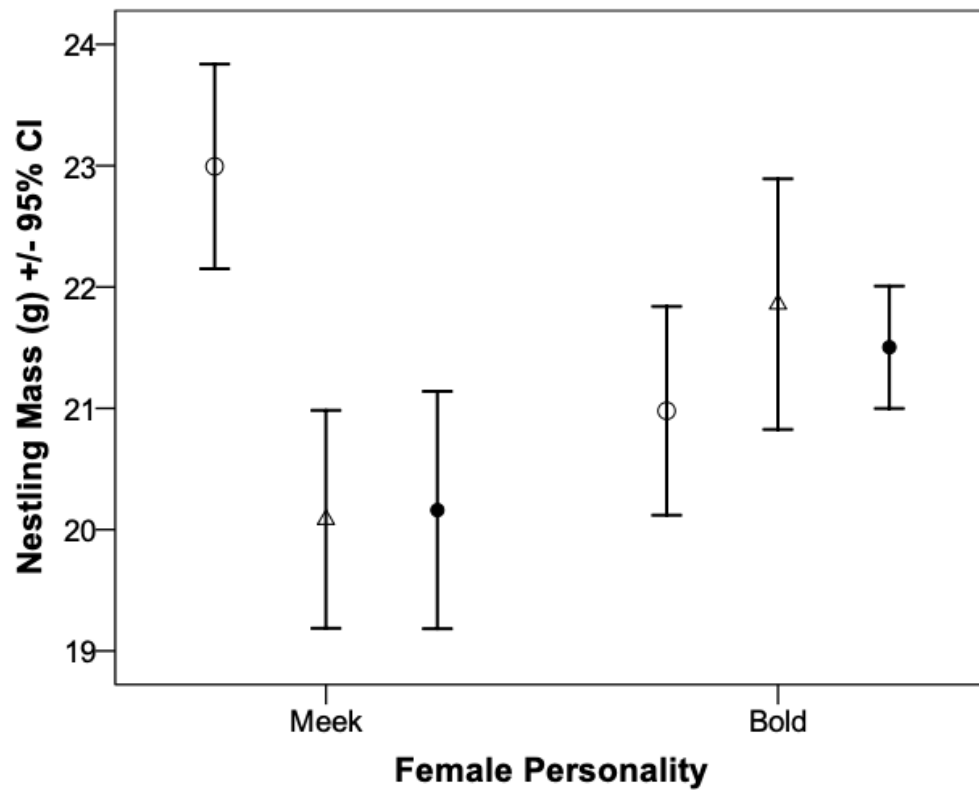
<sup>b</sup>Difference in Akaike Information Criterion (AICc) values from the top ranking model.

<sup>c</sup>Relative weight (out of 1) based on AICc value.



**Figure 1**

The interaction of female personality and treatment on tree swallow nestling mass at day 12. Grey bars represent nestlings in control nests; black bars represent nestlings in noise exposed nests.



**Figure 2**

The interaction of female personality and brood size on tree swallow nestling mass at day 12. White circles represent brood size of 4; triangles represent brood size of 5; black circles represent brood size of 6.

### **Vita**

Taylor P. Fulk was born in Winston-Salem, North Carolina in 1995. She attended elementary, middle, and high school in Lexington, NC. She enrolled in college at Appalachian State University in 2013 and graduated in 2017 with a Bachelor of Science degree in Biology. In the summer of 2017, she began working in the Siefferman Lab and began her Master of Science degree at Appalachian State University in January 2018. She received her Master of Science degree in Ecology & Evolutionary Biology in May 2020