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Effects of Anthropogenic Noise on Body Mass in Gryllodes sigillatus

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EFFECTS OF ANTHROPOGENIC NOISE ON BODY MASS IN *GRYLLODES SIGILLATUS*

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Abstract

Insects use vibrational structures to produce and sense airborne sounds in intraspecific communication. These signals are important in courtship as well as defensive behavior against predators. For example, insects can detect the presence of nearby predators using vibrations. With an increase in anthropogenic activity, processing these signals and the constant threat they represent may increase stress on insects, subsequently affecting their behavior and physiology. Our experiment was designed to determine whether anthropogenic noise, possibly perceived as a stressor, will decrease the body mass of banded crickets, *Gryllodes sigillatus*. We predicted that the anthropogenic noise would stress the crickets, leading to a decrease in body mass and increase in mortality rate. In this study, we subjected crickets to three different levels of anthropogenic activity for three days: high, low, and negligible. We found no significant difference in body mass or mortality throughout the duration of the experiment.

Keywords: crickets, anthropogenic noise, food intake, weight, body mass, stress

Introduction

Anthropogenic noise is a harmful global pollutant that is disruptive to many species. It differs from natural noise (wind, water) in that it's typically spontaneous, louder, more frequent, and more intense (Kight & Swaddle, 2011). In terrestrial environments, expansion of roadways and transportation, along with increases in natural resource extraction, have become common sources of noise pollution (Barber et al., 2010). As anthropogenic noise has increased with expanding populations and development, research has highlighted its effect on animal behavior, physiology, and resultant reproductive success (Kight & Swaddle, 2011).

Humans and animals alike are affected by exposure to anthropogenic noise through its effects on physiology and behavior. In humans, links have been found to impaired cognition, disrupted sleep, increased coronary disease risk, and impairment of the endocrine system (Morley et al., 2014). In fish, eggs and embryos experienced increased mortality in these noisy environments, along with slower growth rates for those that survived (Banner & Hyatt 1973). As a result of anthropogenic noise, animals may also increase hiding behaviors and alertness, increasing energy costs and leaving less time for foraging. In rats, exposure to 30 days of anthropogenic noise led to decreased food intake and decreased body mass (Alario et al., 1987). Noise-stressed brown shrimp ate less food and gained less mass compared to those that were not exposed to noise stress (Lagardère, 1982). Similar results were found in seahorses, with noise stress being linked to decreased mass and overall condition (Anderson et al., 2011). These results suggest that anthropogenic noise has a physiological and behavioral impact on many species.

Crickets and other insects use visual, auditory, olfactory, or other cues to detect stimuli in their environments. These cues are important for con- and heterospecific interactions, specifically allowing species to adapt their behaviors for self-preservation (Coss, 2019) and to increase mating opportunities (Virant-Doberlet & Cokl, 2004). In the context of predation in particular, auditory cues can be detected over long distances, allowing for proactive responses to predator cues (Breviglieri & Romero, 2019). Predator detection can induce phenotypic changes in prey that increase the chance of survival. These induced traits can be physiological, behavioral, developmental, or morphological but come at a high energy cost (Werner & Peacor, 2003). Species decrease their food intake when they detect a predator, resulting in a decreased growth rate in the presence of predators (McPeek et al., 2001). For example, grasshoppers exposed to nonlethal predators consumed forbs, which were safer to eat but not as energetically rewarding as grasses. This energy debt led to an increased mortality rate (Beckerman et al., 1997). It is possible that crickets would interpret anthropogenic noise as potential predator cues, which would increase stress, leading to decreased food intake, decreased body mass, and increased mortality rate.

Much of the current research on anthropogenic noise in insects focuses on the masking of these acoustic signals, but the effects of this noise stress on physiology is not often considered, despite its known physiological effects on other species. The goal of this study is therefore to investigate the effects of various levels of anthropogenic noise on body mass in *Gryllodes sigillatus* (banded crickets). It's possible that the crickets use auditory and vibrational communication to sense anthropogenic activity nearby, which potentially induces stress when detected (Virant-Doberlet & Cokl, 2004). We predicted that three days of exposure to anthropogenic noise would cause stress in crickets, affecting feeding behavior and subsequent mass and mortality. Further, we predicted that if the crickets from the treatment groups were exposed to higher levels of anthropogenic noise than were the crickets in the control group, the former groups of crickets would have lower body mass and higher mortality.

Materials and Methods

The crickets used in this experiment were raised and shipped from a commercial vendor (www.ghanns.com). Once received, individuals were housed in a 10-gallon tank at ambient light and room temperature, with cardboard egg cartons as hides and with ad-lib food (commercial dry cat food) and gel water.

This experiment consisted of two treatment groups and one control group. One treatment group (Busy) was exposed to the presence of human activity in a classroom, for 269 person-hours per week and 78 unique people. The other treatment group (Less busy) was exposed to lower levels of human activity in a research laboratory, for 24 person-hours per week and 4 unique people. The control group (Control) was isolated and exposed to 0 humans and 0 hours of human activity in a separate animal care room. These numbers of human contacts and human activity hours do not include exposure to the experimenters during the feeding and data collection times, which was consistent across all three groups.

Each of the three treatment groups had four replicate containers (22 cm x 13 cm x 14.5 cm), with five banded crickets per container (n = 60 total, n = 55 at the conclusion of the study). Each container was provided ad-lib commercially available cat food, water gel, and egg carton hides. Containers were housed under a 40-watt heat lamp with a 12-hour on/off cycle, which was used to provide light and maintain the circadian rhythm. Data were collected for 3 days, as it has been demonstrated that 3 days is sufficient for induced stress to affect body mass in crickets (Adamo & Baker, 2011). The body mass data were collected every day using a precision balance scale. The mass of all live crickets per container was measured, then the average body mass was calculated.

We analyzed the change in average body mass between the first and last days of treatment. Levene's test confirmed that change in average body mass conformed to the assumptions of equality of error variances (p = .772); we therefore used a one-way analysis of variance (ANOVA) to assess the effects of treatment on body mass. We also assessed mortality among the treatment groups. The data were not normal, even after transformation (Levene's test, p = .001). Consequently, we used a nonparametric independent-sample Kruskal-Wallis test to assess the effect of treatment on mortality. All analyses were conducted with SPSS (version 25.0, IBM Corp., Armonk, NY, USA) with an $\alpha = 0.05$.

Results

We found that after 3 days, there was no significant difference in the change in average body mass across the three treatments ($F_{2,8} = 0.320$, p = .735; Figure 1).

There was also no significant difference in mortality among the treatment groups (H_2 = 0.169, p = .919).

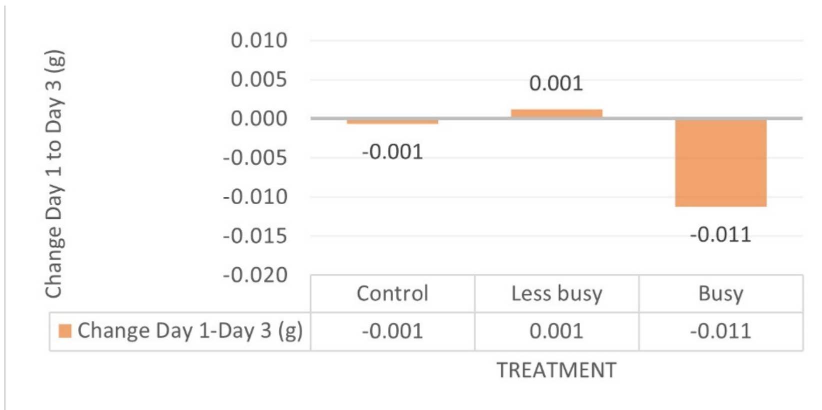

Figure 1. Average Change in Mass Among Treatment Groups

Note. No significant differences in mass existed among treatment groups.

Discussion

Our results did not support our prediction that crickets exposed to anthropogenic noise would have a lower body mass and higher mortality rate. The Busy treatment group had the largest average change in mass, at −0.011g, but this change was not significantly different from the Less busy and Control groups. Further, mortality was not significantly different among the treatment groups. Based on these results in the context of this study, we reject our hypothesis that anthropogenic noise negatively affects body mass and mortality.

There may be several explanations that might inform our results. First, the captive crickets used for this experiment may have already been acclimated to anthropogenic noise, therefore receiving no additional stress from the presence of humans. These crickets were reared by humans and thus have experienced anthropogenic noise for generations. It's been shown that auditory neurons of crickets demonstrate sensory habituation, with trains of sound pulses leading to a decline in response strength (Givois & Pollack, 2000). These captive-bred crickets may therefore have habituated to any anthropogenic noise arising from human interactions.

An alternative possibility is that the noise environment in our study was sensed but not perceived as stressful to the crickets. Previous studies noted that the effects of noise stress were found between 85 and 130 dB (Anderson et al., 2011; Kight & Swaddle, 2011). Although we did not measure noise level in the rooms in this study, a previous study found that an occupied K–12 classroom during the day had an average noise level of 60.75 dB that dropped to 43.55 dB at night and on the weekends (Gremp & Easterbrooks, 2018). The noise level in our classroom therefore may not have been high enough to negatively affect cricket body mass. Similarly, it's possible that because these crickets received resources from humans, they have adapted physiologically and behaviorally to no longer seeing humans as predators.

Although it's been shown that the detection of predator cues leads to changes in behavior that affect food consumption and metabolism (Beckerman et al., 1997; McPeek et al., 2001; Werner & Peacor, 2003), it's also been noted that prey alter other physiological and behavioral attributes to contend with predation. For example, when exposed to a predator, tobacco hornworm caterpillars reduced feeding by 30%–40% but developed more quickly, gaining the same mass as unthreatened caterpillars (Thaler et al., 2012). This accelerated development, accomplished through greater efficiency at extracting nitrogen from their food source, allowed them to move through vulnerable larval stages and decrease risk of predation (Thaler et al., 2012). Alternatively, some studies that analyzed the link between noise stress and mass found that stressed individuals gained less mass than nonstressed individuals but gained mass, nonetheless (Anderson et al., 2011; Banner & Hyatt, 1973; Lagardère, 1982). Perhaps noise stress doesn't always decrease feeding behavior to the point of mass loss but enough to deplete energy reserves allotted for growth, which would be more evident over time. As such, the crickets in our study may have a compensatory mechanism that we didn't measure that allows them to maintain mass while decreasing food intake during periods of stress.

Finally, the sample size in this study was relatively low (four replicates per treatment group), and we therefore may not have had the power to detect smaller effects of human activity on cricket body mass, if they exist. Previous studies that found physiological and behavioral changes in response to noise had larger sample sizes than this study (Adamo & Baker, 2011; Anderson et al., 2011); therefore, it may be a lack of power to detect differences, and an increase in sample size may provide more clarity in future studies. Further, in the future, this experiment could benefit from replication over a longer period and at a higher decibel noise level to garner a more comprehensive picture of the impact that chronic anthropogenic noise stress has on mass.

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