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Fatal distraction: implications of anthropogenic noise on the behavior and reproductive success of mason spiders

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Abstract Many human activities produce sound (e.g. airborne, waterborne, and substrate-borne waves), or anthropogenic noise, that can be a novel stimulus for many animals and is widely recognized as an issue of environmental concern. Substrate-borne noise in particular, might be especially harmful to animals that can sense and communicate using substrate-borne waves. One way anthropogenic noise can be harmful is by distracting animals from important tasks, like providing parental care to offspring. We investigated if substrate-borne sound from traffic distracts mason spiders (*Castianeira* sp.) from the essential task of building mounds to protect their egg sacs. We conducted 60 trials across 4 treatments to examine the effects of noise and the consequences to offspring survival. Preliminary analyses indicate that noise has impacts on behavior and underlines the necessity of investigating impacts of anthropogenic activities on a variety of animals including invertebrates.

Introduction

Anthropogenic noise, or acoustic noise created by ever growing transportation networks and human activities associated with economic development, is widely recognized as an issue of environmental concern (Barber et al., 2011; Shannon et al., 2016). Noise from human activities is prevalent across most habitats on earth. For example, 63% of U.S. protected public lands have background noise levels double that of standard background noise levels (Buxton et al., 2017). Noise created by anthropogenic activities often overlaps with the frequencies that humans, wildlife, and invertebrates are able to detect but differs from environmental noise created by things like wind and rain (Hildebrand, 2009). Thus, animals are subject to novel acoustic contaminants in natural soundscapes where anthropogenic activities are present.

For the most part, research on anthropogenic noise and wildlife has centered on acoustic noise transmitted through air or water and the animals that communicate via those mediums (Shannon et al., 2016). However, most species (over 90 percent) rely on substrate-borne signals and cues, or acoustic information transmitted though solid substrates like soil or leaves (Cocroft and Rodriguez, 2005). Invertebrates use substrate-borne sound to communicate with conspecifics for mating (Ota and Čokl, 1991; Elias et al., 2005), competition (De Souza et al., 2011), cooperation (Michelsen et al., 1986), to detect prey during foraging (Pfannenstiel et al., 1995; Casas et al., 1998), to avoid predators (Castellanos and Barbosa, 2006), and to facilitate symbiotic relationships (DeVries, 1990).

At the same time, anthropogenic sources like roads, railways, and construction are known to produce substrate-borne noise (Forman, 2000; Kurzweil, 1979; Roberts et al., 2016). These sources pro-

	Field Site	
Playback Treatment	Quiet (Cream Puff)	Loud (Astoria)
Noise	Quiet w/ noise playback	Loud w/ noise playback
Silence	Quiet w/ silence	Loud w/ silence

Table 1. Experimental design to assess effects of anthropogenic noise on mason spider mound building behavior.

duce low frequency noise (<2000 Hz Forman, 2000; Kurzweil, 1979; Roberts et al., 2016) that overlaps with the frequencies used in substrate-borne communication (Cocroft and Rodriguez, 2005). Although it has not been explicitly tested, noise from these sources has the potential to impact animals in similar ways to those described with airborne or waterborne anthropogenic noise. Impacts include masking (Francis et al., 2011), physiological stress (Blickley et al., 2012), or disrupting learning and memory (Benfield et al., 2010).

In addition, anthropogenic noise can serve as a distraction for animals (Chan et al., 2010; Walsh et al., 2017). Distraction occurs when a portion of an individual's attention attends to an unimportant stimulus rather than some other important stimulus, like an approaching predator. Distracted animals have been shown to be more vulnerable prey (Chan et al., 2010) and to have trouble accurately assessing resources (Walsh et al., 2017), which can dramatically impact their survival and fitness.

Mason spiders (*Castianeira* sp.) provide parental care to their offspring by building mounds made of pebbles and leaves on top of their egg sacs. Female mason spiders spend 12-14 hours constructing mounds that are critical for the survival of offspring within the first 24 hours of completion (Raboin & Elias, in prep). Surprisingly, there is no difference between survival of offspring in egg sacs with and without mounds later in development. These results suggest that any perturbation to mound building during this critical early stage, like distraction by noise, could directly affect offspring survival.

We investigated how substrate-borne noise from roads impacts mason spider mound building and offspring survival by comparing mound building behavior at naturally loud and quiet locations where mason spiders are found. We also conducted noise playback experiments at each location to examine the ability of mason spiders to habituate to substrate-borne noise. We specifically focused on mason spider navigation to and from their mounds during mound building.

Methods

We conducted field experiments at established field sites in Bridger-Teton National Forest where mason spiders build mounds in July and August of 2018. The sites themselves vary in proximity to heavily trafficked roadways and thus noise level. We made 30-minute recordings of road noise at each site on three different days using a MicW iBoundary Condenser Microphone connected to a computer and the recording program Audacity(R) v2.2.2 (Audacity Team, 2018).

At each site, we identified egg sacs while females were laying them and randomly assigned them to either a "noise" or "silence" treatment group in a 2 by 2 experimental design (Table 1).

Speakers were placed 1 meter from the egg sac and noise playbacks were played at an average of 88 decibels, measured at the mound with a condenser microphone and the NIOSH sound level meter app on an iPhone. Noise playback treatments were made up of random arrangements of 1-10 second bouts of white noise, bandpass filtered at 8000 Hz, and silence to mimic passing vehicles on the road and were played for the entire time females were building mounds. For each treatment, females were filmed building mounds. Filming began after the female spi-

Quiet w/ noise playback: n=13	Loud w/ noise playback: n=17
Quiet with silence: n=13	Loud with silence: n=17

Table 2. Trials completed in summer 2018.

der made the first collecting trip and continued until she slowed to making one collecting trip every ten minutes (on average ~4 hours). Video was collected with GoPro recording equipment and will be analyzed using Behavioral Observation Research Interactive Software (BORIS) (Friard and Gamba, 2016) and ImageJ (Schneider et al., 2012). Videos will be analyzed to quantify various aspects of mound-building behavior including the number of trips made to complete the mound, the number of times a female is unable to locate her mound, the number of times mound building is interrupted (female stops building), and the amount of time the focal female spends doing each behavior.

Following experiments, egg sacs with mounds were left in place for two months to allow eggs to develop in natural conditions. We collected egg sacs after two months and will dissect them to evaluate mortality and life stage of spiderlings. All data will be analyzed using R software (R Core Team, 2018) and the appropriate statistical methods.

Preliminary Results

Our preliminary observations suggest that background noise from traffic on highways was on average louder, ~90 dB, at Astoria than at Cream Puff, ~70 dB. We conducted a total of 60 trials distributed across 4 treatments (Table 2).

We collected a total of ~240 hours of video of mason spiders building mounds and retrieved all egg sacs for dissection.

Discussion and Future Work

Our preliminary results suggest that there is a significant amount of anthropogenic substrate-borne noise across habitats. We found differences of about 20 decibels between quiet and loud sites. A 20 dB difference is substantial, amounting to about a ten-fold difference between sites in overall sound pressure volume and likely has profound impacts on invertebrates that communicate via substrate-borne waves. Although anthropogenic noise and its impact to wildlife has been well studied and is broadly recognized as an important environmental issue, substrate-borne anthropogenic noise has all but been left out of the conversation. This, despite the fact that most animals (over 90 percent) use some type of substrate-borne sound for communication (Cocroft and Rodriguez, 2005). We look forward to contributing new insights into the impact of substrate-borne noise on animals and helping construct a more complete understanding of anthropogenic noise. Based on the experience of conducting this study, we hope to further investigate and characterize the substrate-borne noise produced by anthropogenic sources, especially in protected areas like the Greater Yellowstone Ecosystem.

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