Vibrational noise influences reproductive behavior in a subsoil-breeding necrophilous insect

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STUDY OBJECTIVES

To assess the effect of wind turbine-induced vibration on the reproductive behavior in the subsoil-breeding Nicrophorine burying beetles (*N. marginatus, N. americanus)*.

Introduction

Wind turbines are becoming increasingly common throughout the U.S. as sources of alternative energy. Wind turbines are known to produce substrate-borne (seismic) vibrations due to the motion of the rotors, and the effects of low frequency (infrasound) vibrational noise on humans has been widely studied in Europe (Pedersen & Waye 2008; Wayne & Ohrstrom 2002). Most research related to animal behavior in North America has been focused on bird and bat migration and wind turbine related mortality rates (Barclay et al 2007; Barrios & Rodriguez 2004; Horn et al 2008; Jain et al 2010; Johnson et al 2003, 2004; Kunz et al 2007; Kuvlesky et al 2007; Osborn et al 2000; Rydel et al 2011). Findings from these studies show that mortalities caused by wind turbines may lead to the creation of an ephemeral "carrion buffet" beneath them, which could attract scavenging species and create an ecological trap.

Figure 1. A pair of American burying beetles preparing to bury a quail carcass.

Nicrophorus americanus (the American burying beetle; Fig 1), an endangered species, and *N. marginatus* , both use vertebrate carrion (30-200g) as their main food and breeding source. After a pair locates and buries a carrion source, the female deposits her eggs nearby, and both parents provide extended bi-parental care of their brood. Adults of these species are thought to communicate with the larvae through stridulatory vibrations, and thus, a noisy subsoil environment could obscure the reception of these signals (sensory pollution) and affect parent-offspring communication.

In seeking to understand the effect of long-term exposure to wind turbine-induced vibrations on the reproductive behavior of two *Nicrophorus* burying beetles, we investigated the following questions:

1. Do wind turbine-induced seismic vibrations influence the choice to breed on a carrion source?
2. Do these low frequency vibrations influence carrion burial latency?
3. Do wind turbine-induced vibrations influence fecundity in *Nicrophorus* beetles?

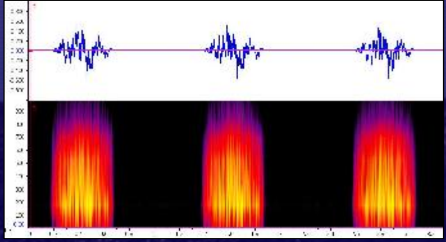

Figure 2. Oscillogram (top) and spectrogram (bottom) of vibrational signals synthesized to replicate the vibrational signature of a modern wind turbine. We generated the signal at 18 rpm, with 3 pulses of filtered sound per rotation of the 3 blades of the turbine. An FFT filter was used to produce infrasonic components 20 dB higher than the components above 40Hz, with a 500 Hz low pass filter to reduce the remaining sonic signature of the vibration file.

Methods

Recordings of wind turbine-induced vibrations were collected from a single turbine (Goldwind Science & Technology Ltd. 1.5 megawatt direct drive 77/1500 type) at the Uilk wind farm in Pipestone, MN (N 46.730, W 94.686) using laser Doppler vibrometry. Recordings were made at the base of the turbine and at increments of 12.5 m, 25 m, 50 m, 100 m, and 200 m from the base. Sub-soil vibrations were recorded from the polished surface of a 1.0 cm aluminum rod 25 cm long, with the rod set to a depth of 20 cm into the soil. We used our field recordings and published intensities (Bellhouse 2004; Hubbard & Shepherd 1991; Jakobsen 2005) to produce a replicate synthetic vibrational signal to employ in our breeding experiments (Fig. 2). We constructed twenty 18.9 L breeding containers, each with an electromagnetic vibration source (Fig. 3) and 20 cm of soil, and calibrated the vibrational environments in the treatment preps at 80-100 VdB, in 5 VdB increments (n = 4 ea.).

N. americanus and *N. marginatus* adults were collected using baited pit-fall traps at TNC's Tallgrass Prairie Preserve located in Osage County, Oklahoma (N36.8456, W096.4189; Fig. 4). Twenty male-female pairs were placed into the activated preps with a single quail (*N. americanus*; 130-140 g) or mouse carcass (*N. marginatus*; 30-40 g) of standardized mass. Preparations were monitored four times daily, (Fig. 3) and data were recorded on reproductive status (carcass buried: Y/N), reproductive latency (time to burial), fecundity (number of offspring), and emergence latency (time for offspring to emerge). Data were analyzed using the unequal variance T-test, Kruskal-Wallis Rank Sums Test, and ANOVA on a bivariate logistic regression using JMP Ver. 7.0 statistical software.

Figure 3 (left): Lauren Yares and Kenzie Lee with the array of vibrational preparations in which breeding pairs of *Nicrophorus* beetles were sequestered for this study. We found that exposure to vibration significantly increased the time required to bury a carcass, but did not reduce brood size or alter brood sex ratio.

Results

Due to low abundances of *N. americanus* at the study site, only the controls and three treatment classes (80, 95, 100 VdB) were tested. In all treatments and control preps, parental beetles successfully buried the carcasses, but took significantly longer to bury the carcass in the vibrational treatments versus control (Fig. 5; Unequal variance T-test, T-ratio = 3.43, D.F. = 10, P = 0.006). The number of offspring however, did not differ between any treatment and control (Fig. 6; Kruskal-Wallis Chi^2 = 3.54, D.F. = 3, P = 0.32).

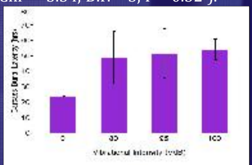

Figure 5. Vibrational treatments induce increased latency to bury carcasses in *N. americanus*.

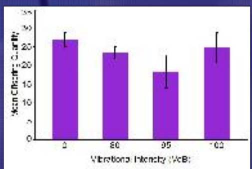

Figure 6. Vibration did not affect fecundity in *N. americanus*. All treatments yielded similar broods.

N. marginatus was collected at the study site and was tested in controls and five treatment classes (80, 85, 90, 95, 100 VdB). Data show that all parental beetles successfully buried the carcasses in every control and experimental treatment. However, parental beetles subject to any intensity of vibration took significantly longer to bury the carcasses compared to the controls (Fig. 7; Kruskal- Wallis, Chi^2 = 12.53, D.F. = 5, P = 0.028). The number of offspring however, did not differ between any treatment and control (Fig. 8; Kruskal-Wallis, Chi^2 = 8.91, D.F. = 5, P = 0.11).

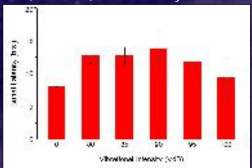

Figure 7. Vibrational treatments induce increased latency to bury in *N. marginatus*.

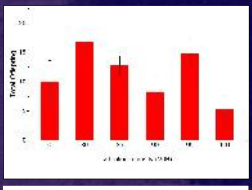

Figure 8. Vibrational treatments did not influence fecundity in *N. marginatus*.

MAIN FINDINGS

1. Wind turbine-induced seismic vibrations do not prevent the burying beetles *N. americanus* or *N. marginatus* from breeding on a carrion source.
2. Carcass burial latency was significantly influenced by the presence of vibration.
3. Fecundity in *N. americanus* and *N. marginatus* is not influenced by the presence of vibration.

Discussion

Data from this study reveal that wind turbine vibrations do not prevent *Nicrophorus* burying beetles from burying their carrion source; however, burial latency is significantly increased when the beetles are subject to any intensity of vibration. This is ecologically relevant as the longer it takes to successfully secure and bury a carcass, the more likely reproduction will fail due to discovery of the carcass by vertebrate scavengers or other invertebrate necrophagous competitors. This potential competitive shift could have important implications for the recovery of this endangered species.

Our results show that seismic noise can obstruct communication and alter cooperative behavior in a subsoil breeding insect model. The vibrational stimulus used in the treatments likely acted as a signal masking agent, reducing the amount of information available for processing in the animal's central nervous system. Our ongoing study will determine if vibration influences the number of offspring produced in a brood, and will identify the neurophysiological range of sensitivity to vibration in this model.

Additional study is required to understand the neurophysiological mechanisms that underlay the documented changes in reproductive behavior in this group of animals.

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Figure 9. 2014 research team (from left), Elisabeth Jorde, Rachel Jorde, Adrienne Conley, Kenzie Lee, Chandler Nielsen, Dr. Carrie Hall, Lauren Yares, and Dr. Daniel Howard.

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