

Introduction

Bats are highly evolved for using biological sonar (or echolocation) for nocturnal navigation. However, bats' reliance on sonar was questioned by a recent study by Corcoran and Weller (2018) showing that hoary bats (*Lasiurus cinereus*) use a previously unknown short and quiet call type called micro calls and also that hoary bats fly without echolocating.

This previous study was done with arrays of microphones and cameras recording bats flying through a riparian corridor. To build on this study, we attached mini (2.7g) ultrasound and acceleration recording tags on 10 wild hoary bats. The tags were later recovered used ground and aerial telemetry (Figure 1).

We aimed to test the following hypotheses:

- 1) Hoary bats switch between normal echolocation, micro calls and flying in silence
- 2) Silence and micro calls will be associated with conspecific chases, indicating a social function
- 3) Because of reduced sensory abilities, hoary bats will exhibit less maneuvering when silent than when echolocating

Methods

Ultrasound methods

1. A custom Matlab program (AudioBrowser) was used to visualize and categorize sound files.
2. Over 2000 Files were categorized as either 1) Normal calls, 2) micro calls, 3) silence, 4) feeding buzz or 5) bat chase based on call time and frequency structure.

Acceleration Methods

1. The Matlab program AccelVis was programed and used to visualize and quantify the acceleration data of over 2000 files to determine flight or no flight as well as the degree of maneuvering.
2. A 0.1-4 Hz bandpass filter was applied to all files to isolate flight maneuvers



Figure 1: Miniature tags were deployed on wild hoary bats and later recovered using aerial and ground radio telemetry

Results

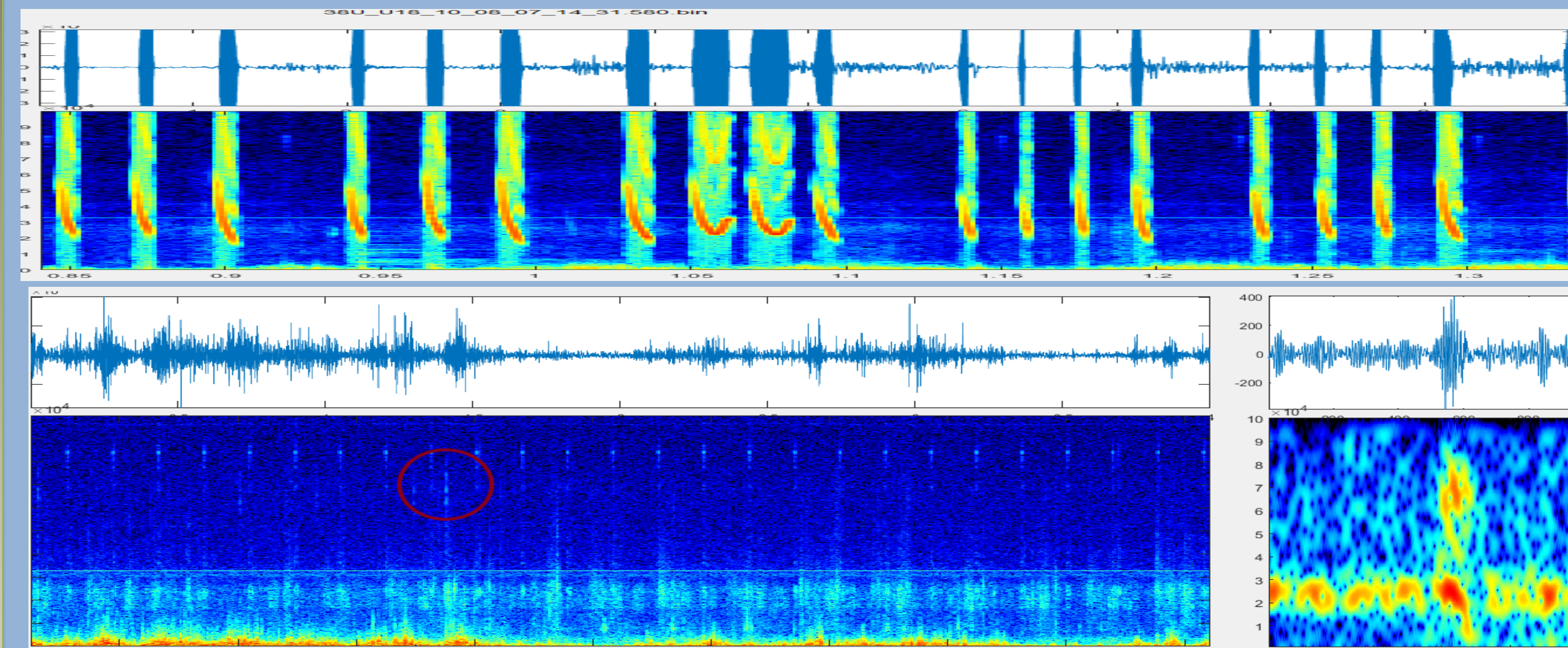


Figure 2: Example acoustic recordings showing social calls used in conspecific chases (top) and micro calls (bottom). The micro call circled in red is shown at a higher magnification to illustrate the frequency structure.

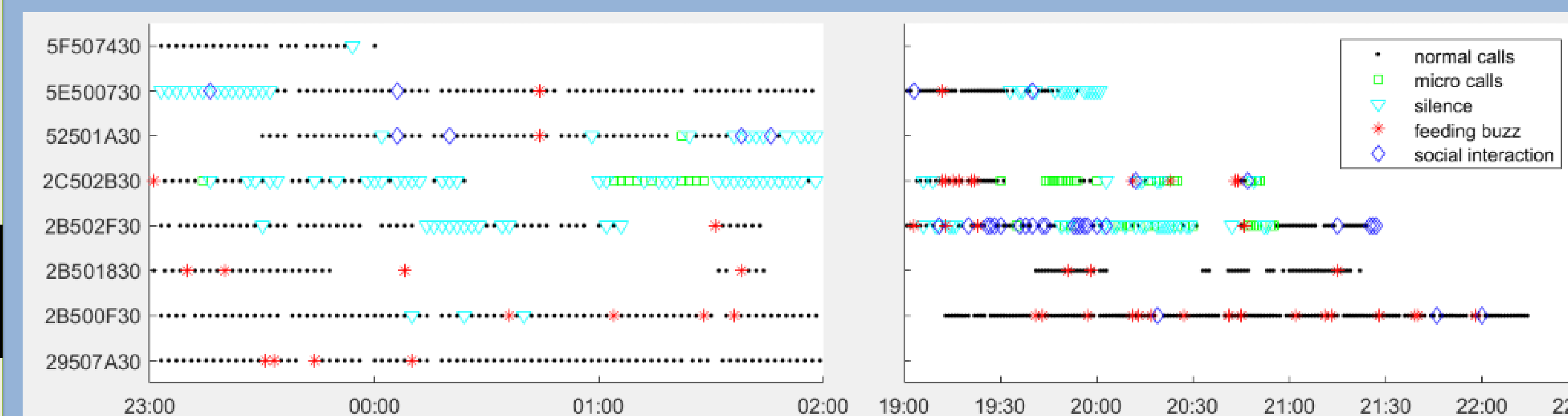


Figure 3: Time course of echolocation behaviors over the first (left) and second (right) nights of recording for eight individual hoary bats. Individual bat IDs are shown on the Y-axis and time of night is shown on the X-axis. Note that normal calls were the most frequent behavior observed (82.0% of recordings).

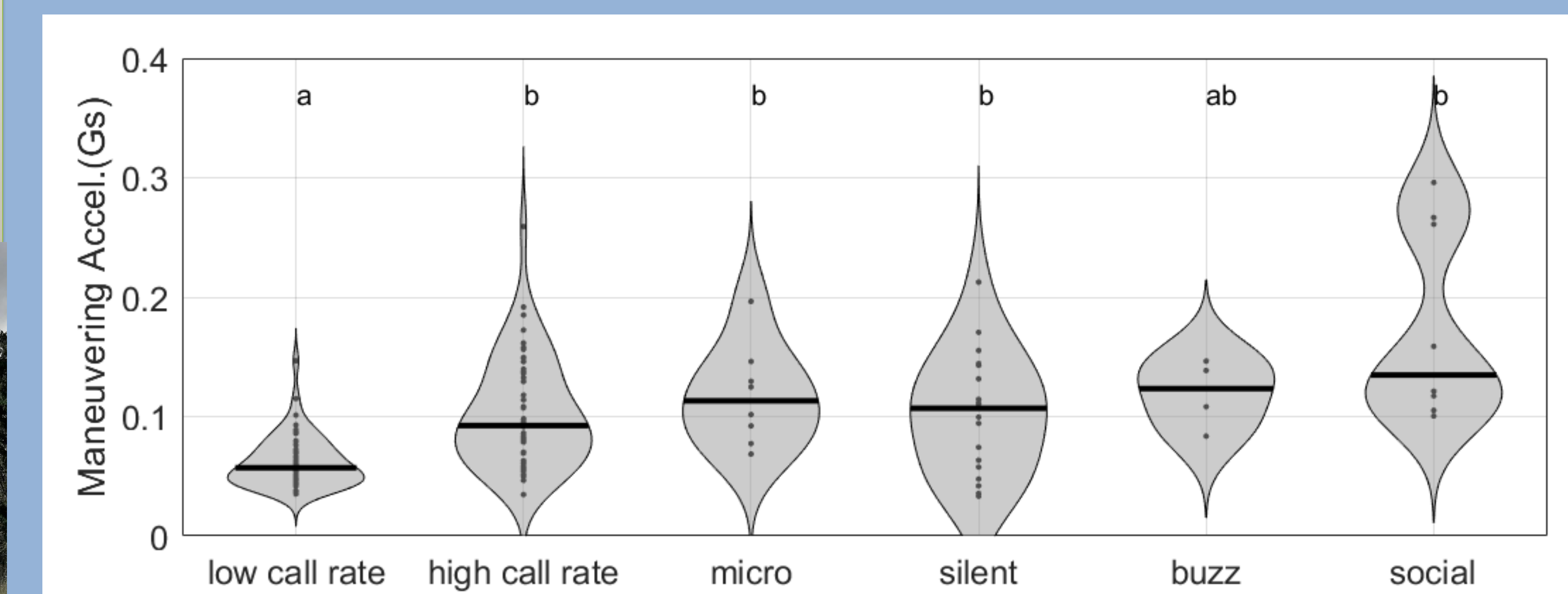


Figure 4: Violin plots show maneuvering acceleration of bats exhibiting different acoustic behaviors. Note that bats exhibited the lowest accelerations when making normal calls at low call rates.

Discussion

Broadly, we found support for our first two hypotheses—hoary bats do indeed fly in silence as well as use normal echolocation and micro echolocation. **This is the strongest evidence to date that bats fly without echolocation for extended periods of time.**

Why do hoary bats exhibit these behaviors? Both this study Corcoran and Weller (2018) found an association between silence and micro calls and conspecific chasing behavior. Inspection of figure 3 shows that social interactions (or chases) were more likely to occur when during periods when bats were using silence or micro calls. In contrast, bats were more likely to make feeding buzzes when using normal echolocation. This suggests that bats require echolocation for hunting, but use silence and micro calls for social interaction, perhaps to avoid detection by potential mates and competitors.

We did not find support for our third hypothesis, that bats would exhibit lower maneuvering when flying in silence. In fact, we found that bats exhibited lowest accelerations when using normal echolocation calls with low calling rates. This suggests that micro calls and silence are not reserved for straight, commuting flight.

These results demonstrate that bats are much less reliant on echolocation than previously known. They also have important implications for conserving bats at wind turbines, as hoary bats are the species killed most frequently at turbines in North America.

References

- Corcoran, A. J. and T. J. Weller (2018). Inconspicuous echolocation in hoary bats (*Lasiurus cinereus*). *Proceedings of the Royal Society B*. 285.
- Corcoran, A. J., and C. F. Moss (2017). Sensing in a noisy world: lessons from auditory specialists, echolocating bats. *Journal of Experimental Biology*. 220: 4554-4566.

Acknowledgments

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