A Study of the Functions of Multimodal Signaling in Insects

Jean Ross[1], Ciara Kernan[2], Hannah ter Hofstede[2] (Research Mentor: Dr. Jen Hamel[1])

Elon Department of Biology[1], Dartmouth College Department of Biological Sciences[2]

Background

Animals communicate about key activities such as survival and mating using different modalities, including sound, visual signals, chemical signals, and substrate-borne vibrations. In species ranging from chimpanzees to insects, various modalities are used in combination (Leavens *et al.* 2010; Higham and Hebets 2013). Multimodal communication is a focus of study in behavioral ecology because findings about why animals use multiple kinds of signals vary, and general principles are still being developed.

Here, we tested the functions of multimodal signal use for a focal insect species (Fig. 1) in which males produce airborne signals (chirps) and both males and females produce substrate-borne vibrations (tremulations) in a mating context. We tested whether two signal modalities are complementary or redundant in the information they provide to receivers (*sensu* Hebets & Papaj 2005).

Research Question

Why do many insect species use two communication modes (airborne sound and substrate-borne vibrations)?

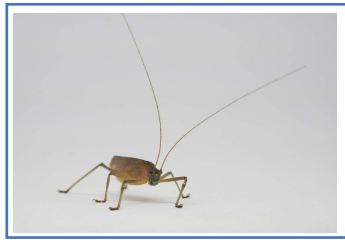

Figure 1. Study subject, the blue-faced katydid (*Docidocercus gigliotosi),* which communicates using both vibrational and airborne signals.

Methods

We tested the functions of male chirps and male and female tremulations with three experiments. This research was conducted at the Smithsonian Tropical Research Institute on Barro Colorado Island in the Republic of Panama.

Experiment 1: Acoustic Playbacks to Females

Hypothesis

Male chirps provide directional information to females and serve to recruit potential mates over long distances.

Prediction

Females will search and exhibit phonotaxis in response to conspecific male chirps.

Methods

Male chirps (conspecific, heterospecific) and silence were played to each female from an ultrasonic speaker. Female behavioral responses were video-recorded. Female tremulations were detected via micro accelerometer.

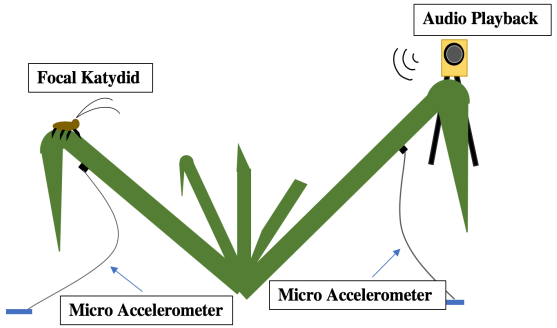

Figure 2. *Left:* Diagram of experimental setup for acoustic playbacks**.** *Right:* Utrasonic speaker (Avisoft Ultrasonic Dynamic Speaker, 60108), which was placed at the top of a frond to simulate a male calling from a focal point of the bromeliad *Aechmea magdalenae* .

Experiment 2: Vibration Playbacks to Females

Hypothesis

Male tremulations indicate the presence of a male on a plant, but not necessarily his specific location on the plant.

Prediction

Females will tremulate in response to male tremulations, and may search and exhibit vibrotaxis.

Methods

Vibrational signals (conspecific, heterospecific) and silence were imparted into host plants, where they could be detected by females, using a sub-amplifier and custom minishaker.

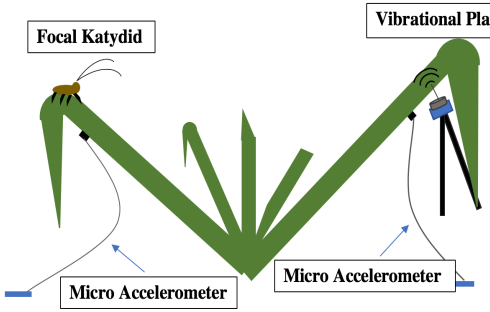

Figure 3. *Left:* Diagram of experimental setup for vibrational playbacks**.** *Right:* Custom mini-shaker attached to the bromeliad frond via an insect pin and soft accelerometer wax to simulate either a male or female individual katydid tremulating from a focal point of the bromeliad.

Experiment 3: Vibration Playbacks to Males

Hypothesis

Female tremulations indicate the local presence of a female on a plant, but not necessarily her specific location on the plant.

Prediction

Female tremulations will elicit male tremulations and courtship duets.

Methods

Methods for Experiment 3 were identical to those of Experiment 2, except for the signals being played. Female vibrational signals were used in this experiment.

Acknowledgments

We thank STRI BCI and Rachel Page for facilities and support. This work was funded through a Glen Raven Endowed Scholarship (JR), the Elon Center for Research on Global Engagement (JR), Elon College Fellows (JR), and Elon FR&D (JH).

References

Hebets EA, Papaj DR. 2005. Complex signal function: developing a framework of testable hypotheses. Behav Ecol Sociobiol. 57:197–214.
Higham JP, Hebets EA. 2013. An introduction to multimodal communication. Behav Ecol Sociobiol. 67:1381–1388.
Leavens DA, Russell JL, Hopkins WD. 2010. Multimodal communication by captive chimpanzees (*Pan troglodytes*). Anim Cogn. 13:33–40.