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Title: Shattering the illusion: can vision circumvent an acoustic anti-bat trait?

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Background

Predation is one of the most pervasive selective forces on the diversification of life. Some prey adapt to exploit the vulnerabilities in their predator's sensing system by producing sensory illusions, that is, discrepancies between what a predator perceives and reality[1–4]. Certain species within the moth family Saturniidae have long tails that spin as the moth flies, structuring the returning echoes from bat sonar to create an *acoustic* illusion (Fig 1). Tails have independently evolved within this family multiple times, and behavioral work from our lab indicates that they deflect bat attack from the body core to these expendable appendages[5,6]. So far, this anti-bat trait has only been tested in complete darkness (flight room). While this condition may be representative of a moonless night in a tropical jungle[7], it does not reflect the diversity of luminous environments that animals experience over the course of a natural moon cycle. Some bats have color-detecting cones interspersed among their densely packed rod photoreceptor populations[8] and many display evidence of UV-sensitive receptors[9,10]. Behavior studies indicate that aerial hawking bats sometimes use vision to assess their prey[11,12]. How they hierarchically weight incoming cues from different sensory systems remains to be determined, however[13]. The proposed study uses field-based, free-flight experiments to test whether bats use this alternative system – vision – to circumvent the acoustic sensory illusion propagated by spinning hindwing tails.

Figure 1. *Actias luna* (Saturniidae) with hindwing tails

Hypotheses

H_1: *Actias luna* wing radiance creates an appreciable visual cue in moonlit environments

H_2: When enough light is available, bats integrate visual and acoustic information to circumvent anti-predator sensory illusions in moths

Methods

During the summer of 2019 (Aug 1 – Oct 1) I and three undergraduate technicians will pit bats against natural and experimentally altered saturniid moths in free-flight, as defined by the following treatments: 1) <u>intact</u>: *n=40*; 2) <u>ablated:</u> *n=40* (tails removed); 3) <u>sham control</u>: *n=40* (tails removed then re-glued to the same animal to control for this procedure). Kinematic analysis reveals that altering hindwing morphology does not affect flight performance[6]. Using ultrasonic microphones, an infrared light array and synchronized high-speed cameras supplied by the Barber Lab, I will record interactions between individual bats and freely flying moths in a large (20ft^3) flight tent installed in an open field (Fig. 2). This will allow both bat and moth to have access to their full suite of aerobatic maneuvers. Moreover, the tent is made entirely of mesh, allowing the ambient natural light to permeate the interaction space. To quantify the bat's opportunity for visual cues, I will calculate the expected nocturnal irradiance by integrating information about moon face and lunar altitude (given latitude and longitude of the location and time of night of the trials) from the US Naval Observatory database. To determine the possible visual information available to the bat from moth wings, I will measure radiance from a pinned *A. luna* specimen using a sky quality meter (SQM).

I will analyze my data in a Bayesian framework, including moth treatment and radiance as predictors and nocturnal irradiance, experimental night number, and bat identity as random effects. My IACUC protocol is currently in review with Boise State University's committee.

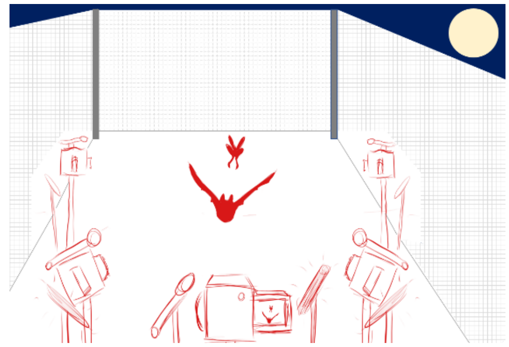

Figure 2. Free-flight interactions between bats and saturniid moths will be recorded in a flight-placed flight tent made of mesh.

Predictions

A. luna moth wings will have appreciable radiance, which will be detectable by the bat eye. We will know that bats are visualizing these prey by a change in capture success. That is, on dark nights I predict that bats will have ~50% success in capturing *A. luna* moths[6], while on moonlit nights I predict that bats will have a noticeable increase in capture success.

Broader significance

It will become increasingly important to quantify the complete sensory environment of a focal species/system. To this point, vision has historically been underestimated in echolocating bat biology. Researchers are working to fill these gaps, however, much of the work remains on the molecular level[8,14]. This project will be a revealing behavioral study into the use of vision by bats in naturally lit environments to circumvent an acoustic sensory illusion in moths. Results could lead to generalizable insight about the use of multi-sensory modalities against advanced anti-predator defenses.

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