EVOLUTIONARY TAILS

Going to Bat for Moth Research

By SHERRY SQUIRES

The luna moth can live just seven days, assuming it can evade its most voracious predator — the bat.

Part of the family of giant silkworm moths, luna moths don't eat; they don't even have a mouth. But despite their short lifespan, their ability to reveal to scientists long-held secrets about how species evolve and adapt is great.

"We're studying an ancient battle between moths and bats," said Dr. Jesse Barber, an assistant professor with the Department of Biological Sciences at Boise State University and an expert on bat-moth interactions.

Eye spots on the bottom of hind wings of butterflies, or blue lizard tails, are designed to foil their predators' attacks. "Moths have acoustic predators, and we're learning that some moths use acoustic tricks to divert echolocating bats."

With regard to where this basic science work might lead, Barber notes, "These small nervous systems have solved complicated computational problems that may inform future technology."

Barber's work on ultrasound-producing moths most recently caught the attention of National Geographic, and his latest research on how luna moths use their tails to evade a deadly bat attack has received attention from the New York Times, Science News, Popular Science and more.

JOHN KELLY PHOTO

PREDATOR AND PREY

Bats and moths have been going at it for a very long time, and throughout their embattled history both have evolved more sophisticated tools for hunting and evading.

Barber has been studying bat behavior since he was a graduate student. For his master's work, he studied a gleaning bat that hunts scorpions on the ground.

In his doctoral work, he revealed that several species of moths produce ultrasound to warn bats of bad taste and unrelated moth species produce similar sounds to mimic each other, the auditory equivalent of the matching color patterns of butterflies.

In 2009, Barber was part of the team that discovered that ultrasound-producing tiger moths can temporarily jam a bat's sonar system, allowing the moth time to escape. He also has published extensive research on the impacts of human-caused noise on the natural world. Most recently his work on how traffic noise impacts the critical fat composition of migrating songbirds has been featured on BBC radio and in The Atlantic.

In his current bat-moth research, Barber is exploring how luna moths' tails have evolved into acoustic decoys, and building on his collection of work to figure out, across all moths, how their tails vibrate to make sounds back at bats when they are attacked.

"Unraveling the spectacular mega-diversity of nocturnal insects depends upon understanding the historical battle between bats and their prey," Barber said. "I've always wanted to study natural history in an area that was poorly known, and we know about as much about the night sky as we do the deep ocean."

IN THE WAR ROOM

Because bat-moth battles take place at night, they are rarely seen. Much of Barber's observations take place in an indoor laboratory, complete with a flight room and a bat cave, where he uses high-speed, infrared cameras and ultrasonic microphones to capture the behavior and hunting success of bats.

There is a tremendous diversity of shapes, sizes and facets just within the silkmoth family. Luna moths are huge, with white bodies and pale green wings that span up to four and a half inches. It was previously thought that their long tails might be used to impress females, but when the bats begin to hunt in Barber's lab, a symphony of lunges and failed attempts at capturing the moths reveals that something else might also be going on. Often, the bats are drawn to the moth's tail — an expendable part of the body that breaks off and allows the moth to escape.

This entire family of moths is non-eared, meaning they can't hear the cries of an approaching bat, so they must rely on alternative means to evade their predators. In Barber's lab, graduate student Juliette Rubin artificially lengthens and shortens the moths' tails, among other efforts, to see how the bats respond.

"Bats and moths present a fascinating framework for asking these evolutionary questions because they have been locked in these predator-prey dynamics for at least 65 million years, leading to some really neat adaptations and counter-adaptations to each others' tactics," Rubin said.

In Barber's study, luna moths with tails experienced an almost 50 percent higher survival advantage over moths without tails, which is about the same benefit moths with ears that are specialized for detecting the sonar signal of echolocating bats receive. While more than half of the 140,000 species of nocturnal moths have sonar-detecting ears, more than 65,000 lack this defense.

"It's remarkable that hind wing tails have independently lengthened to spectacular proportions four times throughout the evolutionary history of the Saturniidae (silkworm) family of moths," said Barber, further suggesting that the tails may be advantageous to moth species as tools for avoiding predators. "Understanding nocturnal animal interactions is essential at a time when human activities are having major impacts on the natural world."

A WINDOW IS CLOSING

Luna moths were once very common, but are now thought to be declining across their range, mainly due to loss of habitat and pollution. Barber will be in Gorongosa National Park in Africa later this year, looking at bat-insect interactions in the tropics. Tropical habitats within which bats and moths coexist also are quickly disappearing.

"At the rate of species extinctions on the planet, projects like this where we try to map out the way life unfolded are only going to be possible for another generation or so," Barber said. "We are in a golden age for biology. While our planet is in trouble, there are still enough species around to map the course of evolution."

"Combining behavioral data from the lab, along with life history data from the field, gives us the opportunity to see the full story and to communicate to future generations how our ecosystems evolved and functioned," Rubin added.

While studying this co-evolutionary battle and determining why bats are lured into striking a false target could have implications on sonar development for the military, piecing together evolutionary questions are at the heart of Barber's work.

"This is natural history at its core," he said. "We have the ability to investigate and describe our natural world with the help of modern technology and that is certainly a worthy endeavor." B

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JOHN KELLY PHOTO

Biologist Jesse Barber with a big brown bat, *Eptesicus Fuscus*.

STUDENT PROFILE

JULIETTE RUBIN

ALLISON CORONA PHOTO

HOMETOWN: **Nashville, Tennessee**

DEGREE PROGRAM: **Master of Science in Biology**

ADVISOR: **Dr. Jesse Barber**

RESEARCH: **"The Evolution of Alternative Predator-Evasion Strategies in Moon Moths"**

Rubin received the Michael Butler award for her research on the evolution of anti-bat strategies in non-eared moths. She also created the Biology Graduate Student Association to unite students in sharing their interests and research techniques across biological disciplines. Students in the department study everything from Alzheimer's disease and cancer progression to raptor physiology and plant phylogenetics.

"I was specifically drawn to Dr. Barber's lab because of the creative and encompassing questions that he poses about natural systems and the sensory context in which he seeks to answer them," she said. "And because of the opportunity for integration across fields at Boise State, I will be better equipped to enter a broad-scope, multidisciplinary Ph.D. program that matches my interests, and then develop a research lab of my own that will hopefully inspire other young scientists."