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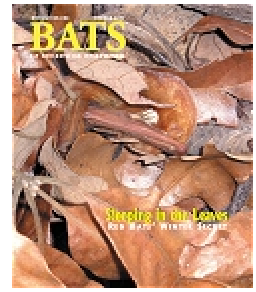

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Dueling in the Dark
What moths tell bats in the heat of battle
Nickolay Hristov

As night falls and light gives way to darkness, bats and moths take wing – the moths to find a mate, the bats to find food. The night skies fill with countless, merciless dogfights between predator and prey. Each side brings to bear all the weapons and guile that nature has given it.

The interactions between insectivorous bats and tiger moths are considered a classic example of the coevolution of predators and prey. Moths arrived first on the evolutionary stage, roaming the skies freely for millions of years – until bats became airborne and pierced the darkness with their echolocation cries.
Forced to change or die, some moths evolved ears to hear the approach of a bat, while others acquired distasteful chemicals that gave them a repugnant or poisonous taste. Some insects – the tiger moths – combined both approaches, then added an ability to produce sounds that seem to confuse, and sometimes thwart, an attacking bat.

Using their "tymbals," modified versions of the hard plates that make up the exoskeleton, these moths can direct a string of ultrasound clicks back at an echolocating bat, often holding the bat at bay. Exactly why these clicks work against bats has not been entirely clear.

The fact that tiger moths make sound has been known since 1864, when the French naturalist Laboulbene observed a pair of tiger moths exchanging trains of ultrasonic clicks as a prelude to mating. It was not until the seminal work of Dorothy Dunning and Kenneth Roeder a century later, however, that the moths' sound production was associated with defense against bats – a conclusion that is now generally accepted.

Yet conflicting evidence from four decades of research has not explained conclusively why tiger moths generate sounds that answer echolocating bats. Three hypotheses have been proposed to explain this acoustic defense:

• The jamming hypothesis: The sounds confuse the bat by interfering with its echolocation system;

• The startle hypothesis: The sounds elicit the mammalian startle reflex in the bat that deters its attack long enough for the moth to escape;

• The acoustic aposematism (warning) hypothesis: The sounds are aposematic – an acoustic warning to the bat that the moth is toxic or distasteful. (Toxic organisms, including tiger moths, often use bright colors to notify potential visual predators that they are inedible. But colors would be of little value at night, when bats are on the hunt.)

A recent study at Wake Forest University revisited the question, but this time with a twist. The experiment combined the interests and expertise of an entomologist (Professor William E. Conner) and a bat biologist (me).

Working together to unravel the mystery of the interaction, we tried to reconstruct the bat-moth interaction in the lab by studying how young bats that had never encountered a tiger moth learn to interact with the insects. We first developed four groups of tiger moths with distinctly different combinations of inedibility (which we dubbed "chemical defense" or C) and sound production (S). One group was both unpalatable and sound producing (C+S+); another was unpalatable and silent (C+S-); a third was palatable and sound producing (C-S+); while the fourth was palatable and silent (C-S-).

We used young big brown bats (*Eptesicus fuscus*) that were born in captivity and conducted the seven-day experiment in a bat chamber with sound-deadening walls. The acoustic and flight behaviors of the interacting bats and moths were recorded simultaneously by a pair of infrared-sensitive, high-speed cameras and a high-frequency bat detector.

Careful analysis of the audio and video information allowed us – for the first time – to peek into the very-detailed nature of this intriguing predator-prey interaction. Our preliminary results strongly suggest that the moths in our study are not interfering with these bats' echolocation beams; they are, instead, warning that they taste dreadful and are bad to eat.

We had hypothesized that if the tiger moths used their answering calls to jam or startle the bats, the young bats would not be able to capture sound-producing moths and would respond the same way regardless of edibility. That did not occur among our bats and moths.

If, on the other hand, the sounds warn bats of the moth's chemical defense, we would expect the young bats initially to capture both sets of sound-producing moths but to learn over time to reject those that are unpalatable. The bats should continue to capture and eat palatable moths, even those that produce sound.

That is exactly what we found: Our bats, after first catching and tasting both palatable and unpalatable sound-producers, began avoiding the nasty-tasting moths but kept right on eating the palatable version.

It is as yet unclear whether our results can be generalized to all bat-tiger moth interactions, but they certainly suggest that the clicks of tiger moths effectively deter bat attacks only in combination with a chemical defense. That fits rather neatly with the acoustic aposematism hypothesis of warning calls.

This also suggests that perhaps we should not look for an ultimate winner in this biological arms race between bats and moths. For now, at least, nature seems to have settled on a bilateral détente that benefits both sides of the conflict.

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All articles in this issue: