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"AERIAL WARS":

Competition and evolution of predator/prey interactions in echolocating Microchiroptera

Objectives

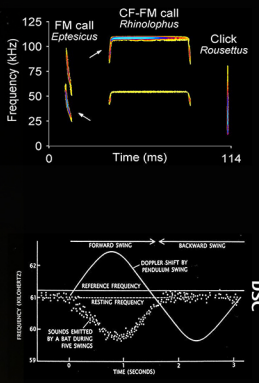
To describe the meaning, types and mechanisms of echolocation.
To determine the physiological adaptations related to echolocation in Microchiroptera.
To analyse the evolution of the predator/prey interactions between Microchiroptera and moths.
To develope the intraespecific competition in echolocating Microchiroptera.

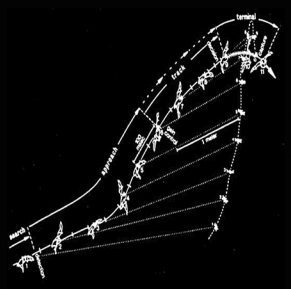
Introduction

Echolocation or biosonar is an active process, used by some species when the vision is ineffective. It requires the **production of the sound**, but also **the reception and process of the echoes** of the emitted sound. By comparing the emitted sound with the echo the echolocating species' brain can produce images of the surroundings.

It is used primarily for **orientation**, although there are some bats and toothed whales that used echolocation to **find their prey.**

The most sophisticated version of echolocation is found on **bats and toothed** whales, although there are primitive forms of this process used by some nocturnal mammals like some species of the Soricidae family or genere Rattus, but also by some birds like ***Steatorni caripensis*** or ***Collocalia linchi.***





- Bigger and thicker **basilar membrane.**
- **Cochlear nucleus** larger than in non-echolocating species, tuned to echolocation frequencies.
- **Tectorial membrane** is weakly hooked to the sensory cells.
- Adapted **nerve cells** to the emission frequency of each specie. Some are capable of processing the emission and echo at the same time.
- The **auditory cortex** detects and processes a different range of frequencies in each specie.
- The **inner ear bones** are adapted to avoid damaging their eardrums while emitting a sound.
- Two adapted nucleus: **lemniscus nucleus** and **superior olivary complex.**

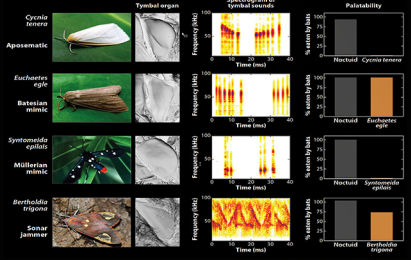
The arms race

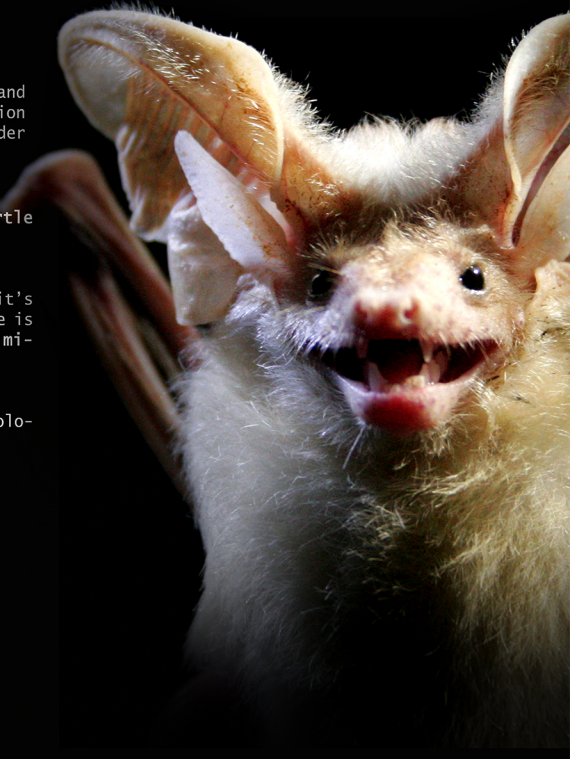
The **predator/prey interactions** between bats and moths have been going on for more than 60 million years. Both of them have had adaptations in order to survive in different ways.

Startle hypothesis:
The sounds produced by moths elicit the startle **reflex**, so the moths have time to escape.

Aposematism hypothesis:
The sounds emitted by moths alert the bat of it's **unpalatability**. Based on this hypothesis, there is the mimicry hypothesis, divided in **Batesian** mimicry and **Müllerian mimicry.**

Jamming hypothesis:
The sounds emitted by moths **interfere** the echolocation sonar.

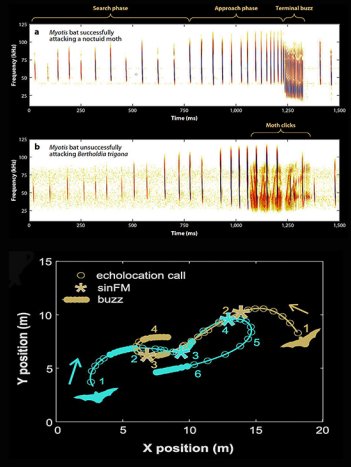




Adapted ears:
Timpanic organs sensible to ultrasounds have been developed in nocturnal lepidopters. These species who have developed timpanic organs are able to hear the echolocation calls from bats which is an advantage to survive.

Producing ultrasounds
Individuals from the Arctiinae subfamily are able to **produce short and repetitive clicks** as an answer to the echolocation calls produced by bats. The organs that make this sounds are the **timbals**. Moths also produce some microclicks in-between the clicks by the **microtymbals.**

Chemical defenses
Some moths are capable of **producing chemical substances or obtaining them from plants, that work as a defense.** The moths most known for having chemical defenses are the Arctiidae family. PAs and CGs are important for their potency and both of this substances are effective to avoid bat predation.



Allotonic frequency hypothesis:
Proposed by Fullard, bats **lower or increase the frequency** of their echolocation sonar to make difficult for the moths to detect them.

Stealth:
This strategy is based on lowering 10 to 100 times the intensity of the echolocation call more than the other bats, so it **decreases the distance at which the moth detects its predator.**

Intraspecific competition

As well as moths, conspecifics can interfere the echolocation sonar of bats. To avoid this jamming:

JAR:
Bats lower or increase call frequency.

Silence:
Bats stop their calls during more than 0.2s(200ms).

Conclusions

Echolocation is an active process which objective is to orient the animals who use it. Some animals such as Microchiroptera and toothed whales also use it to look for their prey. Both of these animals have the most sophisticated form of echolocation. In Microchiroptera there are different types of calls that are used depending on the specie, phase or place. To be capable of using echolocation they have developed specific adaptations to emit and process ultrasounds.
There is an **evolutionary arms race between moths and bats** that has been going on for more than 60 million years. The acoustic interactions are still being studied and there have been numerous hypothesis explaining them.
This interactions are the reason why both of them have developed numerous adaptations in order to survive. Moths have developed very sophisticated ears which has a high metabolic cost, some of them are capable of producing ultrasounds themselves. Furthermore, some moths can produce or extract chemicals from plants as a defense.
As a response to this adaptations, bats are thought to have changed their frequencies or to have lowered so much that their prey cannot detect them. In addition, bats receive interference from their conspecifics too, which creates another issue to resolve in the air.

Selected references

Conner, W. E., Corcoran, A. J. Sound Strategies: The 65-Million-Year-Old Battle Between Bats and Insects (2012). Annual Review of Entomology, 57: 21-39
Chiu, C., Xian, W., Moss, C. F. Flying in silence: Echolocating bats cease vocalizing to avoid sonar jamming (2008). PNAS, 105 (35): 13116-13121
Gillam, E. H., Ulanovsky, N., McCracken, G. G. Rapid jamming avoidance in biosonar (2007) Proceedings of The Royal Society B, 274: 651-660

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