The Acoustic World of Bats

Sonar Jamming, Stealth and Silence

Aaron J. Corcoran, Ph.D.
Assistant Professor, UC Colorado Springs
Twitter: @AaronJCorcoran
www.sonarjamming.com

"My Field For Dummies"
March 6th, 2024

What is it like to be a bat?

Thomas Nagel, 1974 *Philosophical Review*

WHAT IS IT LIKE TO BE A BAT?

CONSCIOUSNESS is what makes the mind-body problem really intractable. Perhaps that is why current discussions of the problem give it little attention or get it obviously wrong. The recent wave of reductionist euphoria has produced several analyses of mental phenomena and mental concepts designed to explain the possibility of some variety of materialism, psychophysical identification, or reduction.[1] But the problems dealt with are those common to this type of reduction and other types, and what makes the mind-body problem unique, and unlike the water-H_2O problem or the Turing machine-IBM machine problem or the lightning-electrical discharge problem or the gene-DNA problem or the oak tree-hydrocarbon problem, is ignored.

Every reductionist has his favorite analogy from modern science. It is most unlikely that any of these unrelated examples of successful reduction will shed light on the relation of mind to brain. But philosophers share the general human weakness for explanations of what is incomprehensible in terms suited for what is familiar and well understood, though entirely different. This has led to the acceptance of implausible accounts of the mental largely because they would permit familiar kinds of

Overview

Intro to bat acoustics

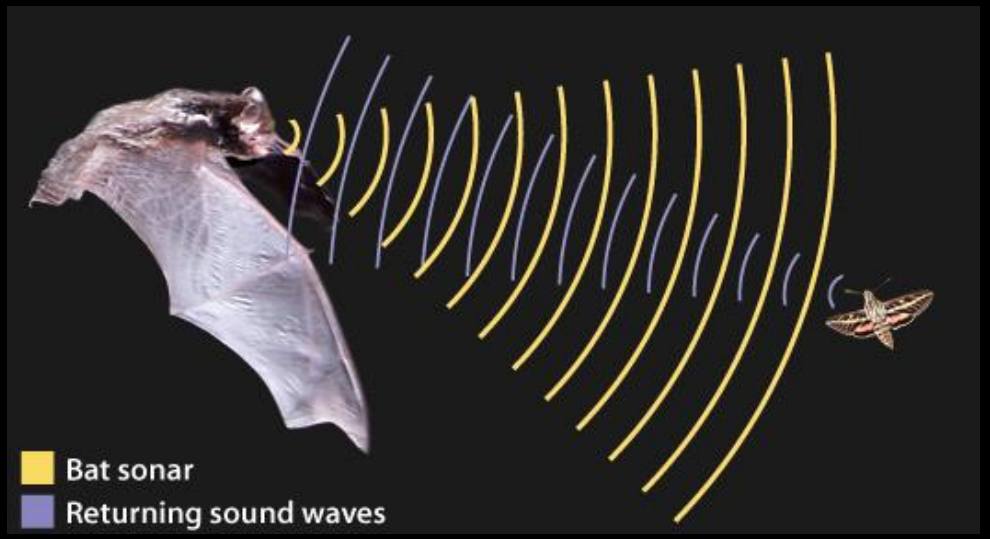
Bat-bat jamming

Stealth Echolocation

Flying in Silence

Echolocation

Azimuth
Elevation
Distance (ranging)



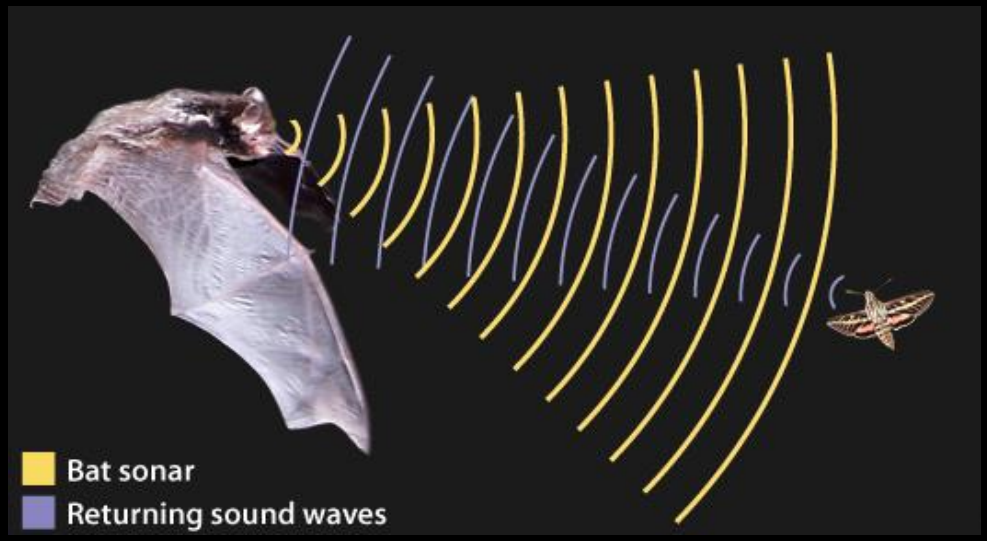
Echolocation

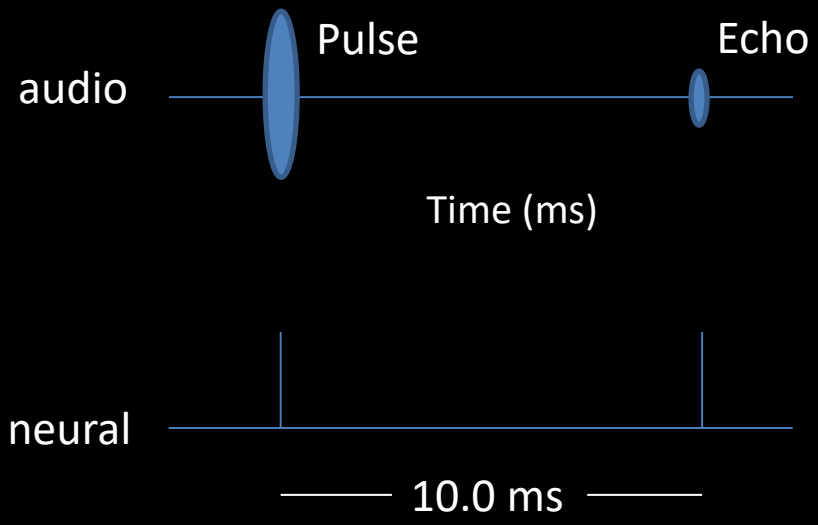
Azimuth

Elevation

Distance (ranging)

Pulse-echo time delay

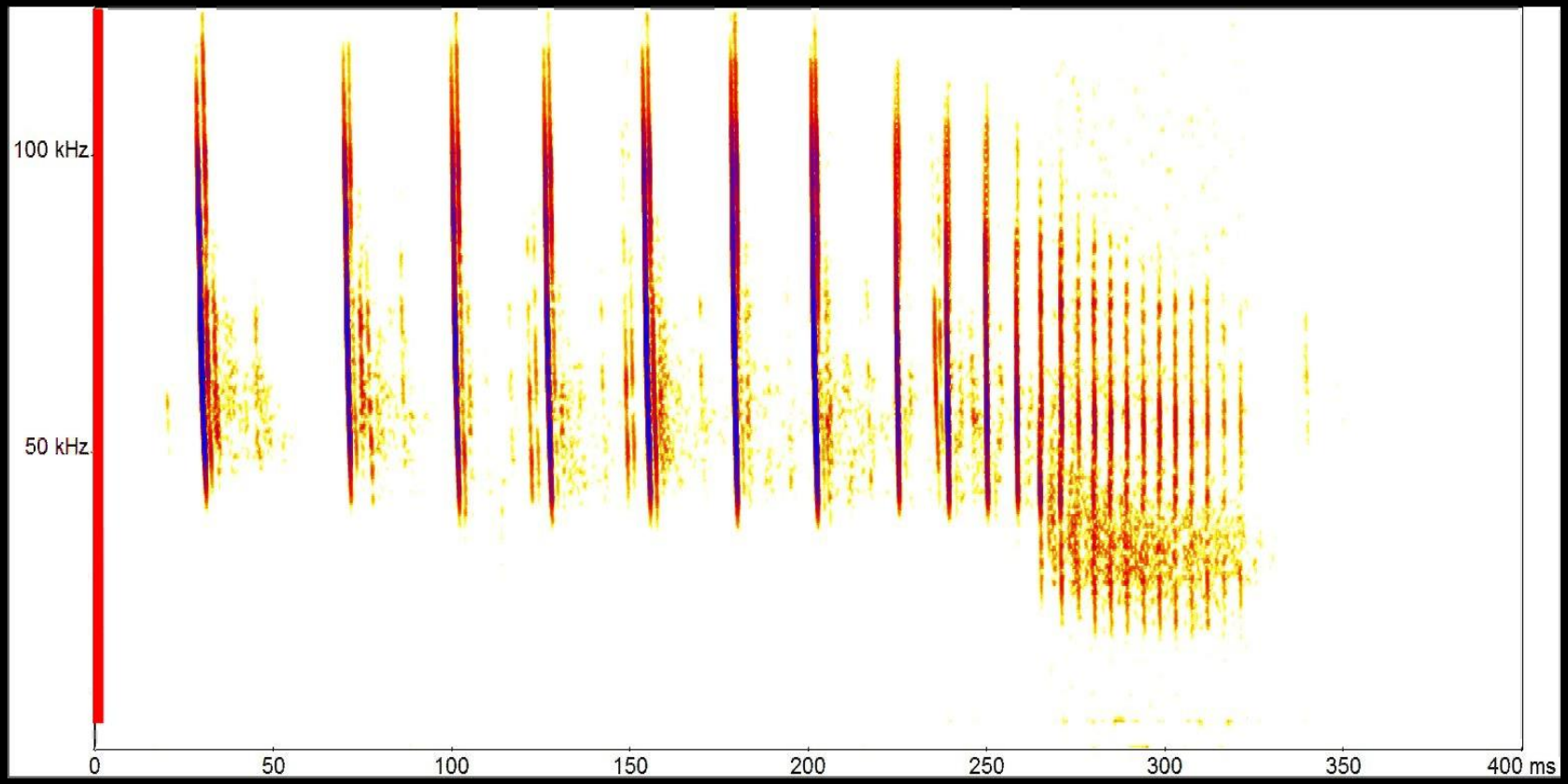




Time delay * Speed of sound = Distance

10.0 ms * 343 m/s = 3.43 m

Spectrogram of feeding buzz



Insect-eating bats

- Over 1300 species
  - 70% insectivorous
- Primary predator of nocturnal flying insects

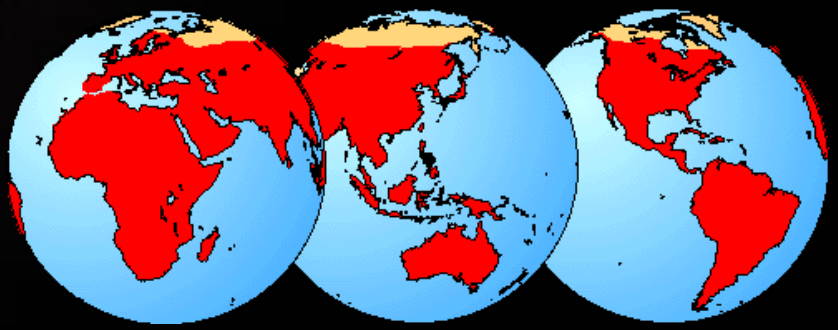
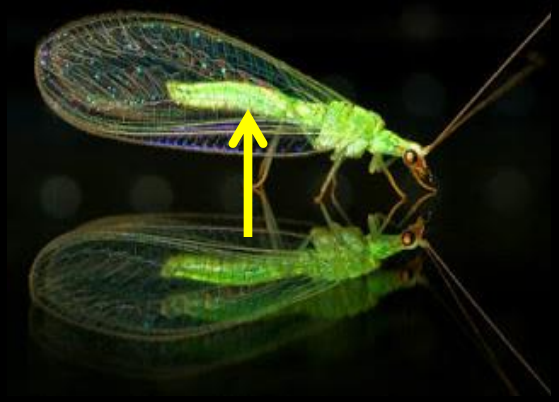
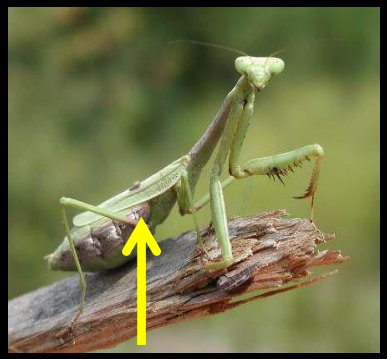
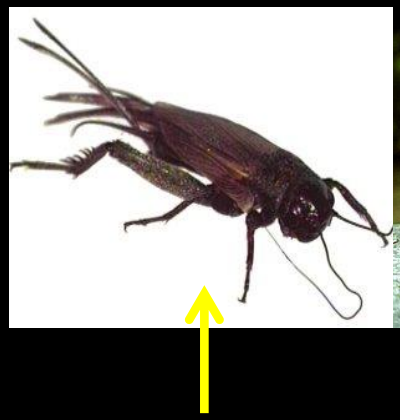


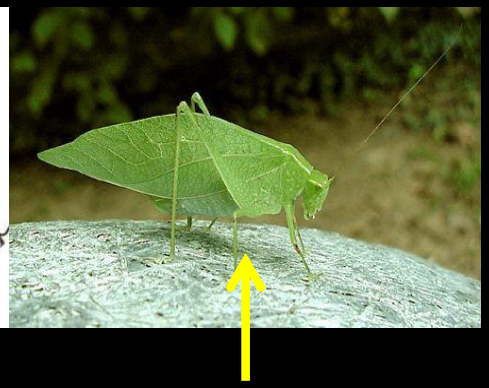
Image: N. Hristov

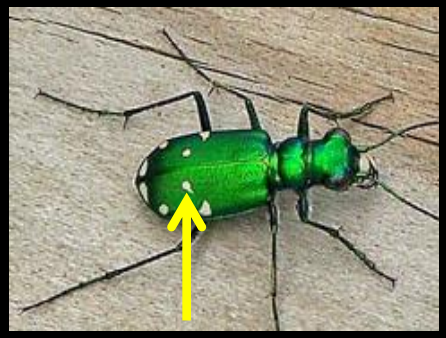
Bat-detecting insect ears



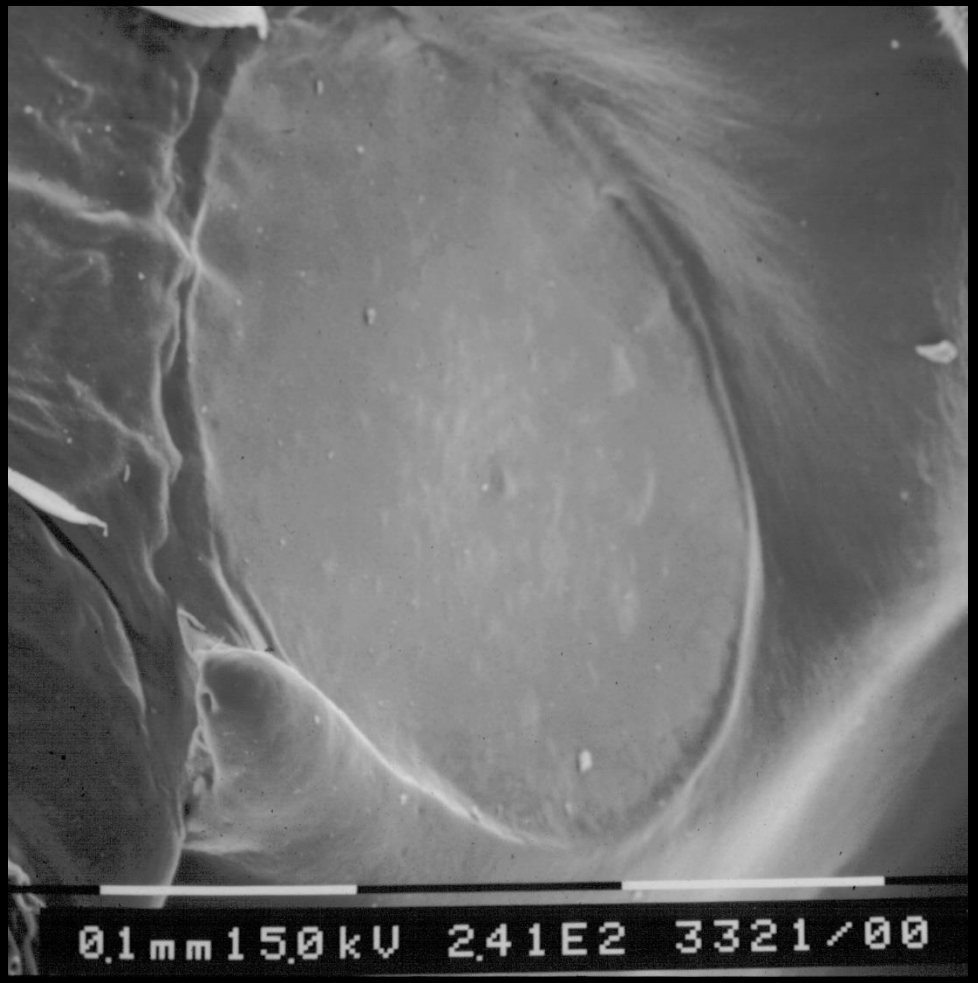


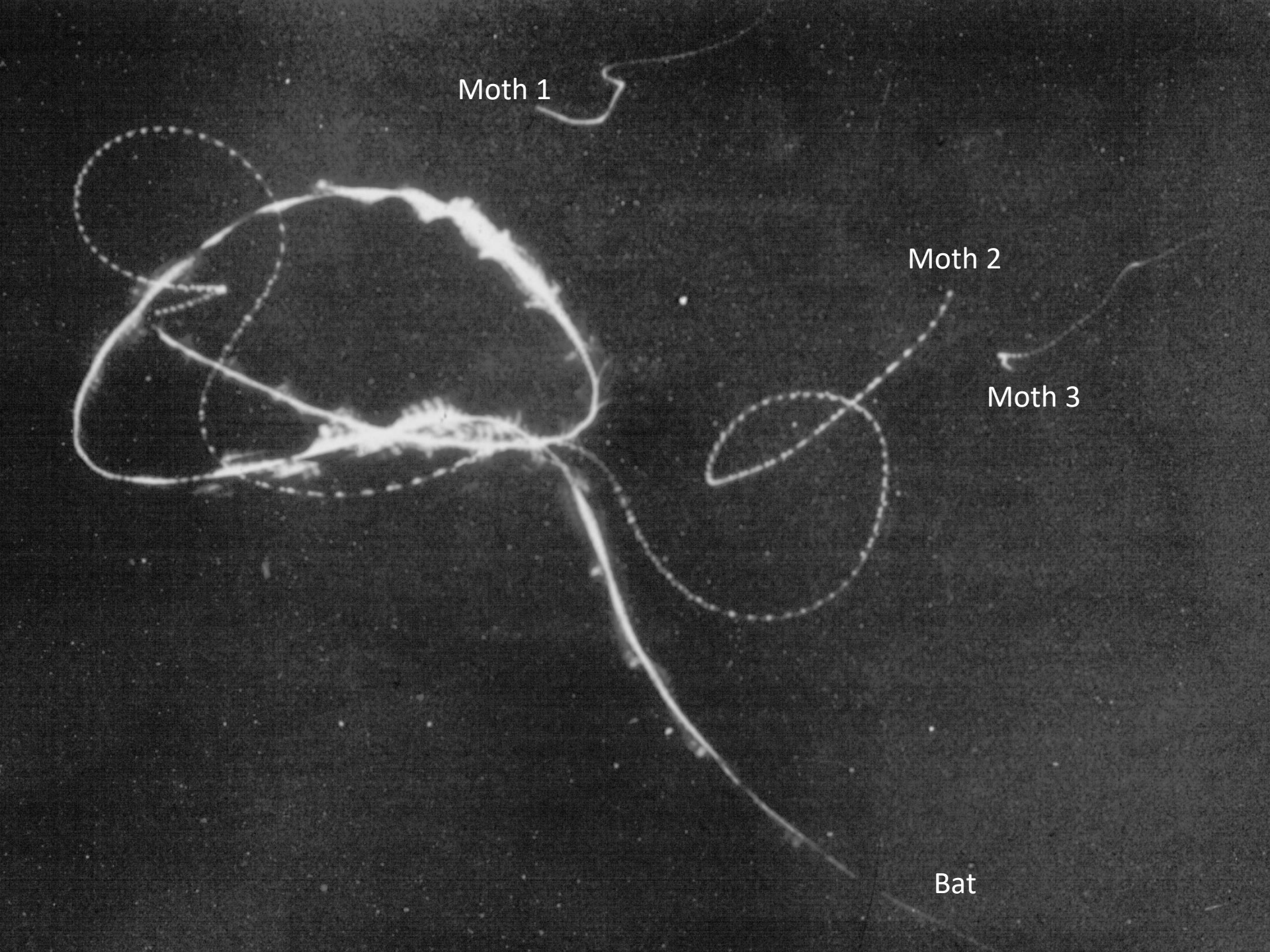




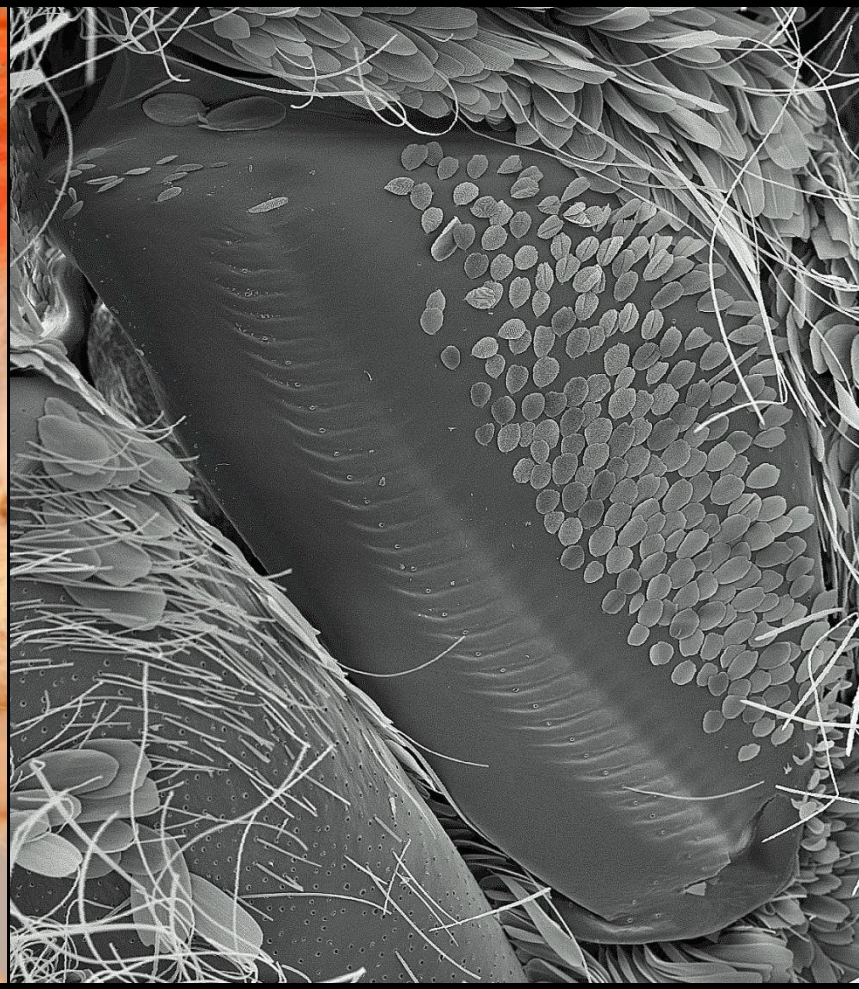


Moth Tympanum (“ear”)




Moth 1
Moth 2
Moth 3
Bat

tymbal organ



Why click?

Toxic warning
(or mimic)

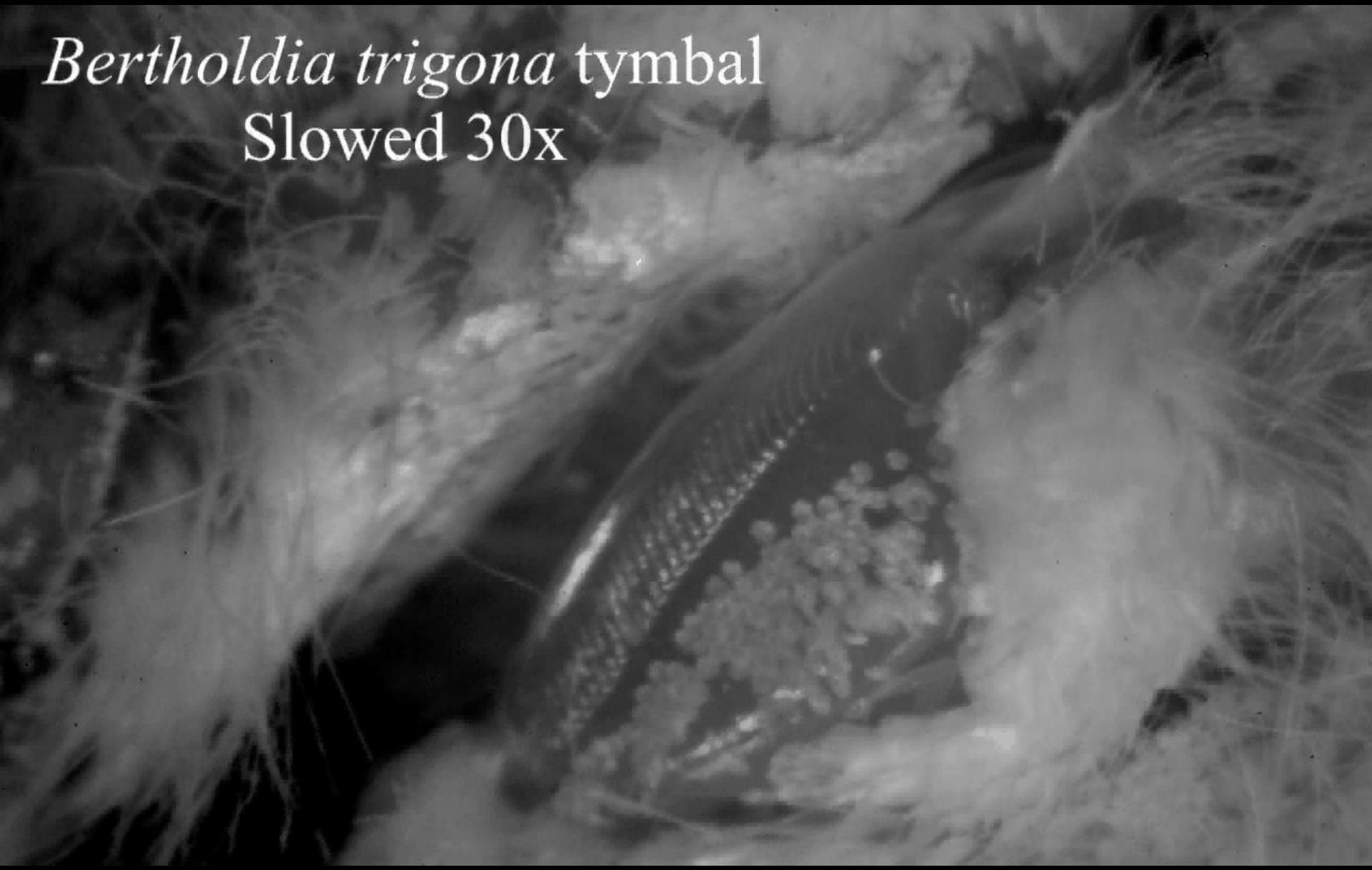
Cycnia tenera

Hristov and Conner 2005 *Naturwissenshaften*
Barber and Conner 2007 *PNAS*

Acoustic interference/
Jamming

Bertholdia trigona

Corcoran, Barber & Conner 2009 *Science*
Corcoran, Barber & Conner 2010 *Journal of Experimental Biology*
Corcoran and Conner, 2012 *Journal of Experimental Biology*


Bertholdia trigona tymbal
Slowed 30x

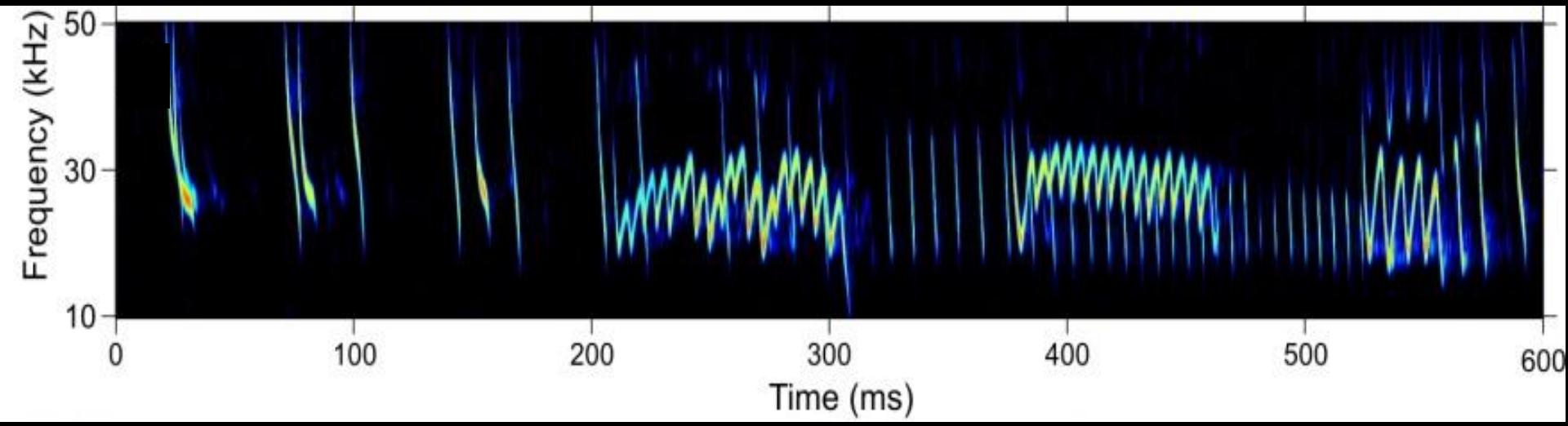
Overview

Intro

Bats jam bats?

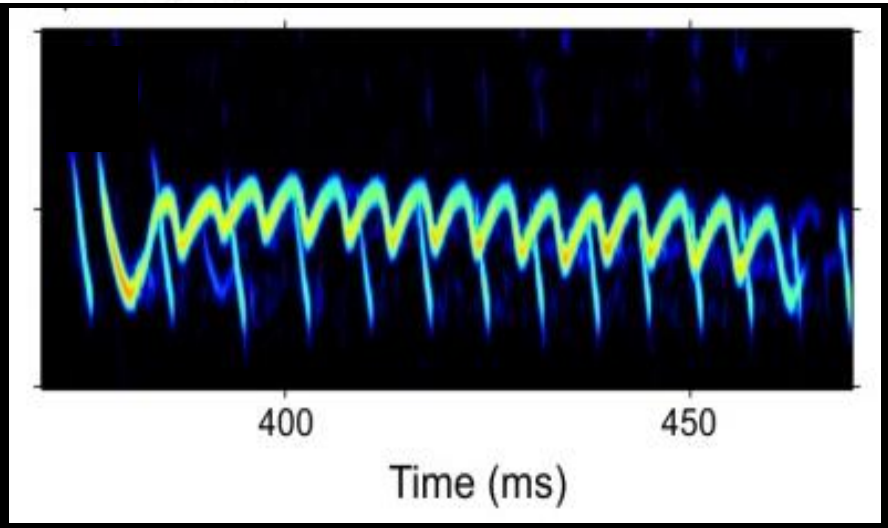
Southwestern Research Station, Portal, AZ

sinFM calls

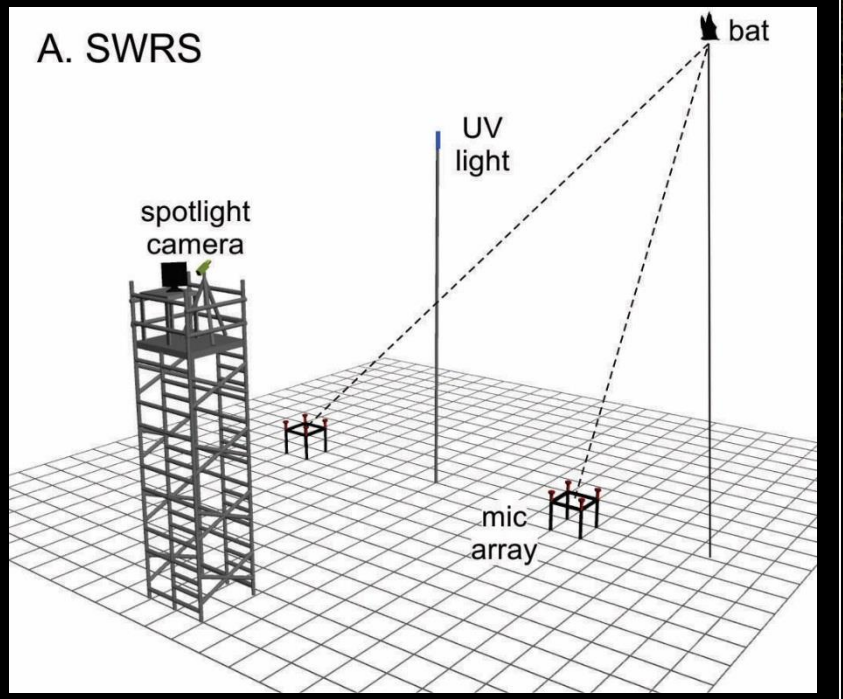


bat-bat jamming?

Food claiming?

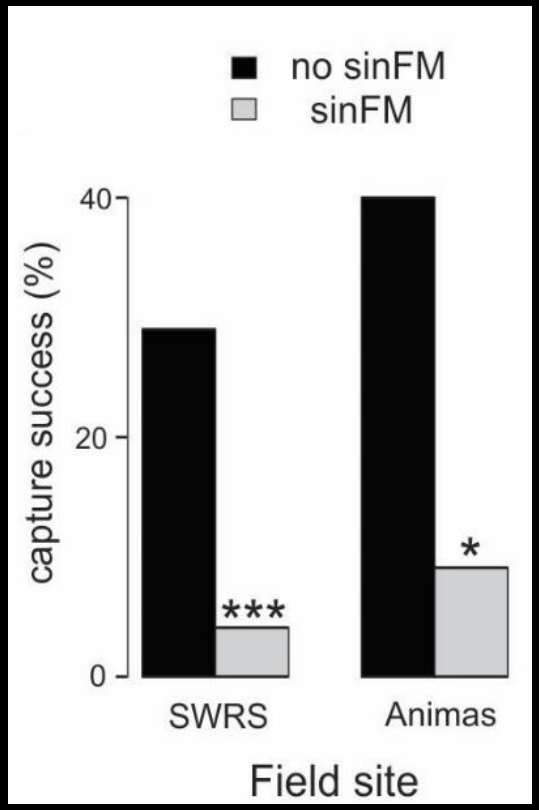


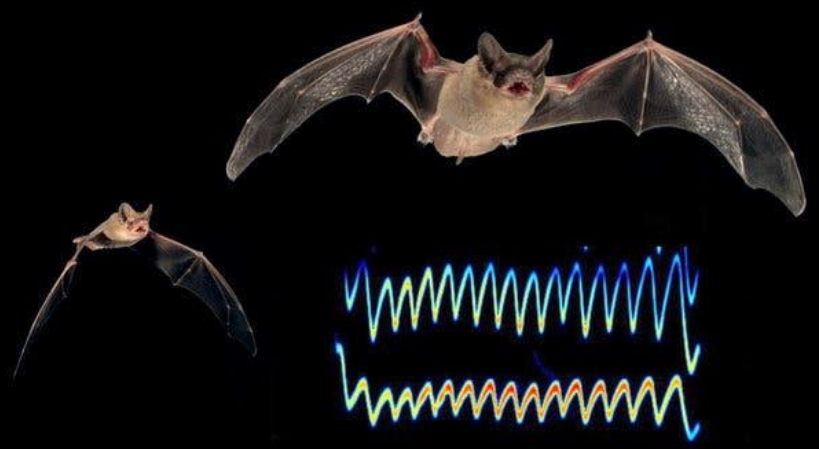
Methods—Field Setup



Corcoran and Conner 2014 *Science*

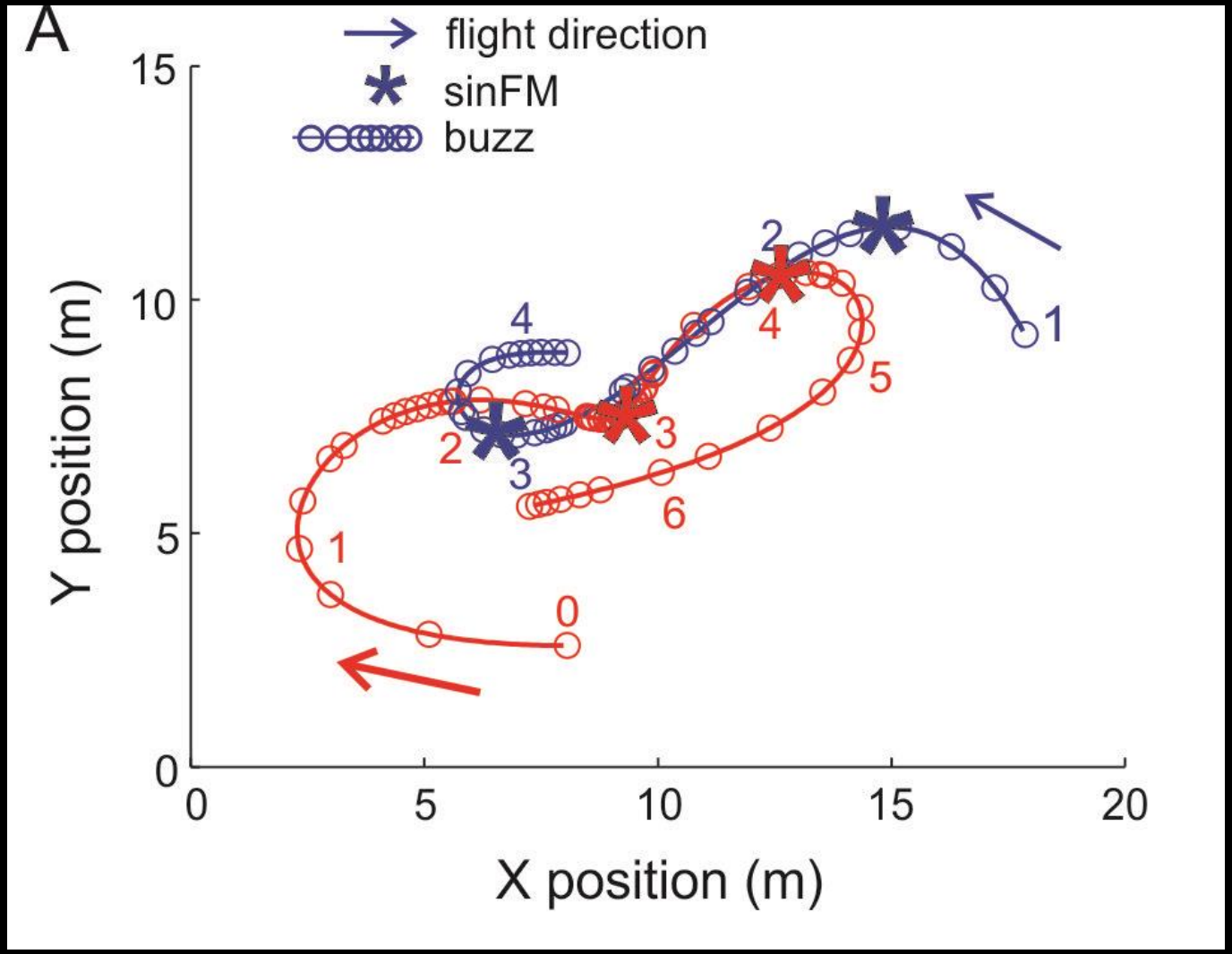
Results – Capture success





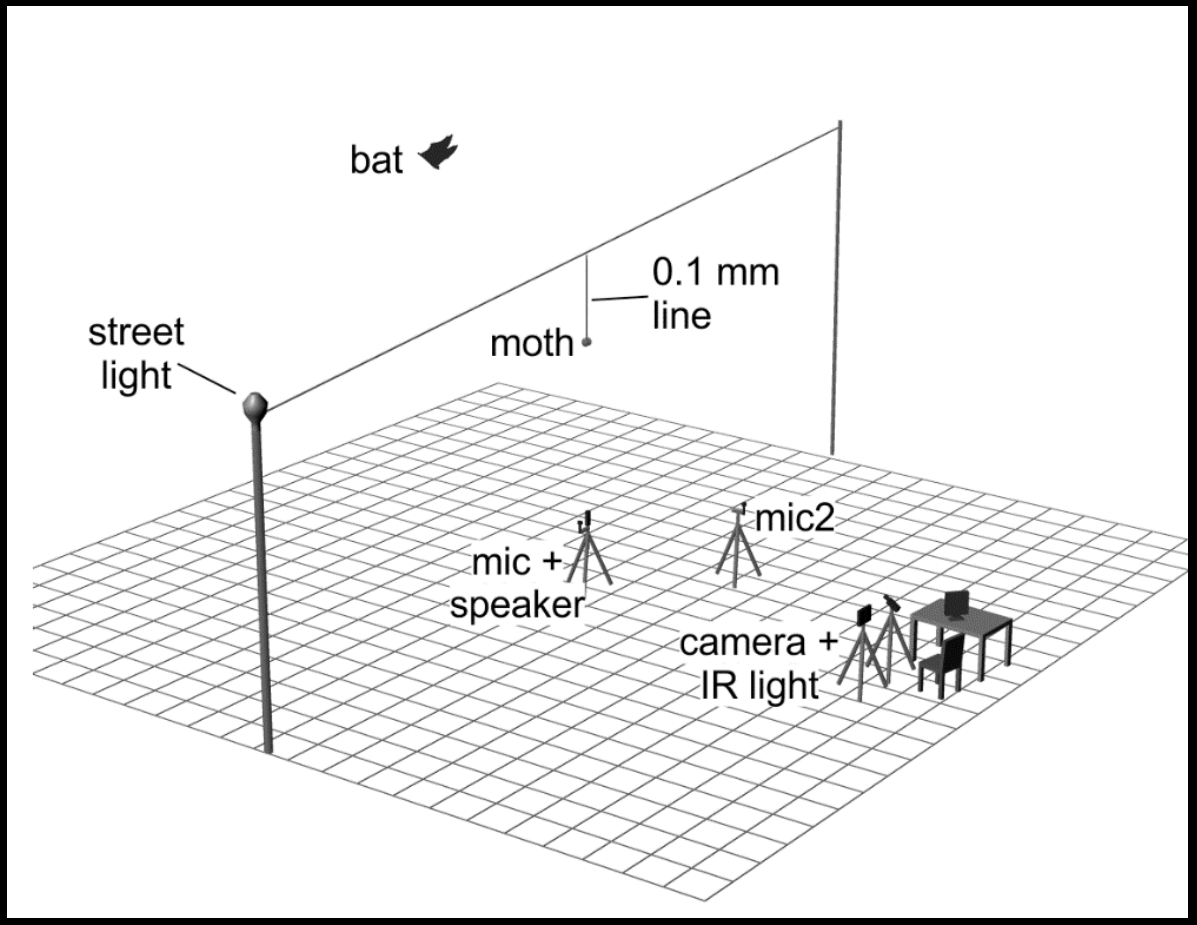
Corcoran and Conner 2014 *Science*

sinFM battle



Corcoran et al 2014 *Science*

Field playback



SinFM more effective than controls

But, only when sinFM overlaps buzz!

Corcoran et al 2014 *Science*

Bats and insects

65 million years of co-evolution

Intro

Bats jam bats

Stealth Echolocation

Have bats co-evolved with insects?

Townsend's big-eared bat
Corynorhinus townsendii

Bat Counter-adaptation?
- High/low frequency
- Low amplitude (stealth)

Image: Mark Thiessen, *National Geographic*

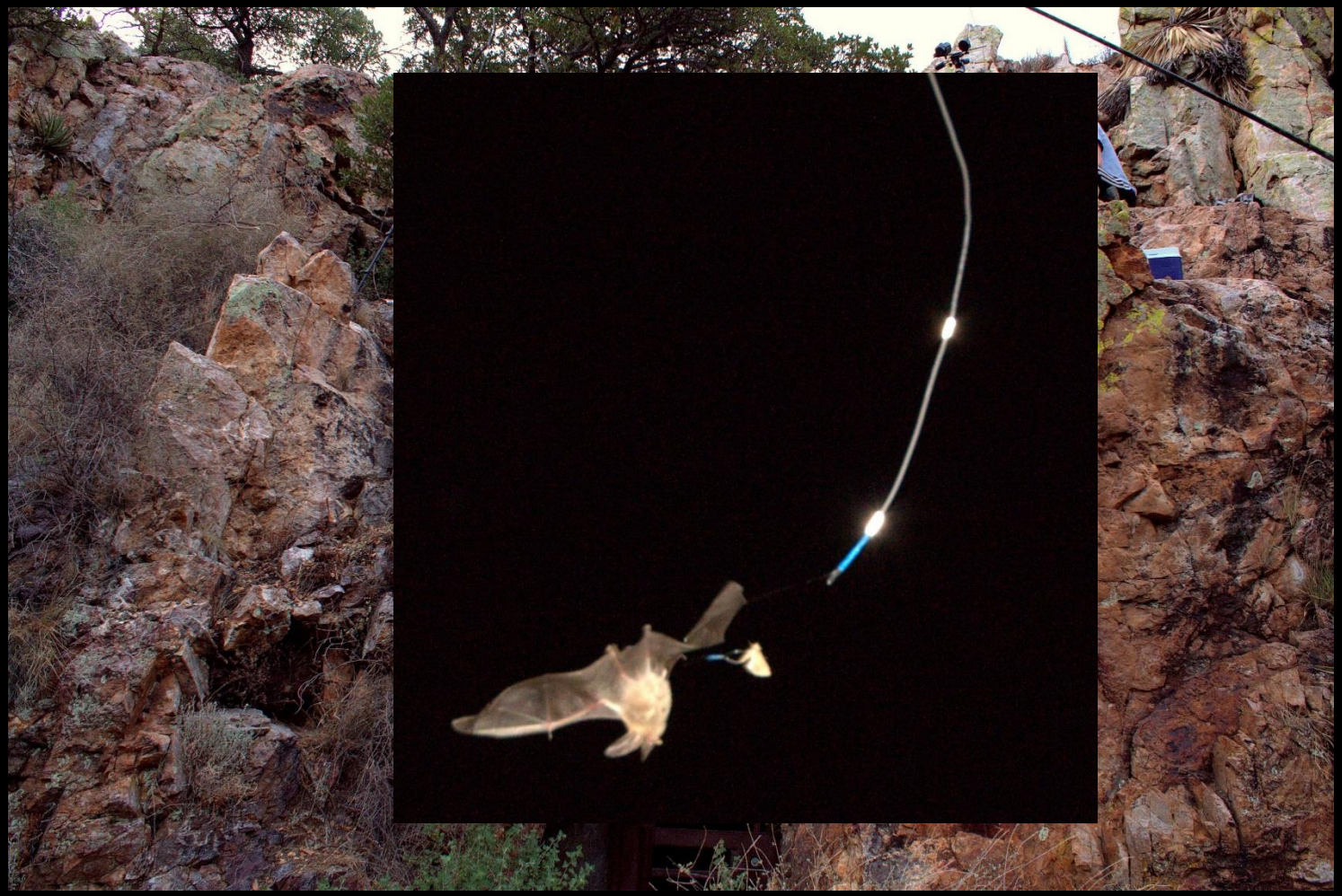
Stealth hypothesis: Questions

1. What are the call intensities during actual attacks?

2. How does stealth affect attack outcomes?

Image: Mark Thiessen, *National Geographic*

Measuring call intensities during attacks



Results: call intensities

Corynorhinus:

20-45 dB lower than other bat species in matched habitats

Image: Mark Thiessen, *National Geographic*

Corcoran and Conner, 2017 *Animal Behaviour*

Control attack by *Myotis volans*


Focal
moth

Effect of call intensity on attacks

- Reduced prey defenses (19% *vs.* 68%)
- Increased capture success (82% *vs.* 51%)
- Reduced prey detection distance (0.8 m *vs.* 3 m)

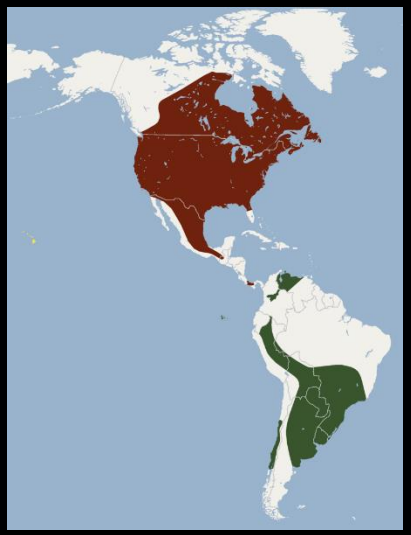
Corcoran and Conner, 2017 *Animal Behaviour*

Bats and insects

65 million years of co-evolution

- Intro
- Bats jam bats
- Stealth Echolocation
- Flying in silence?

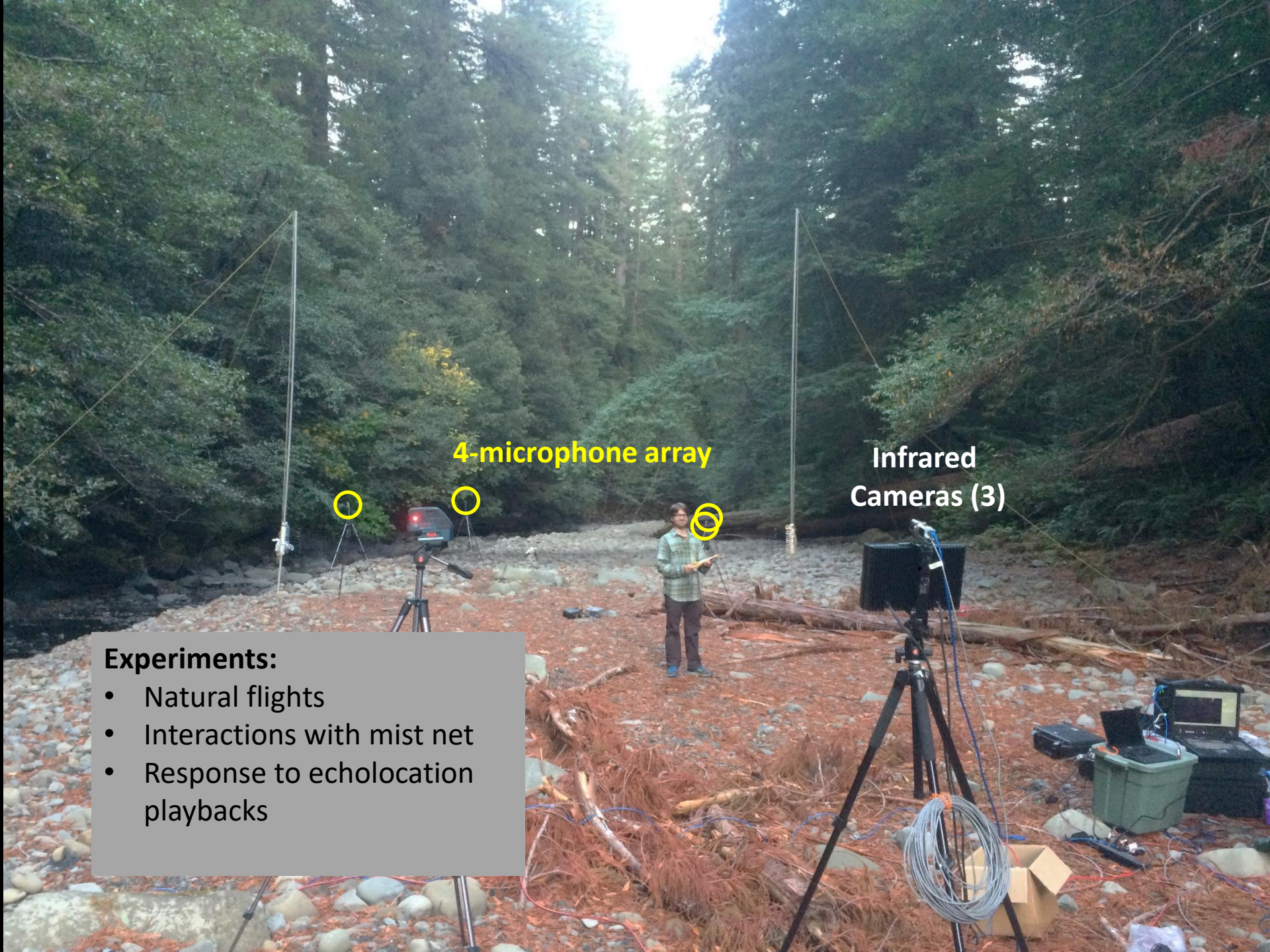
Hoary bats (*Lasiurus cinereus*)



But wait, hoary bats are loud!!!

- Barclay, 1986; Acharya et al. 1992; Obrist, 1995; Barclay et al. 1999; O'Farrell et al. 2000; Corcoran, 2007; Britzke et al. 2011…

Ted Weller, USFS

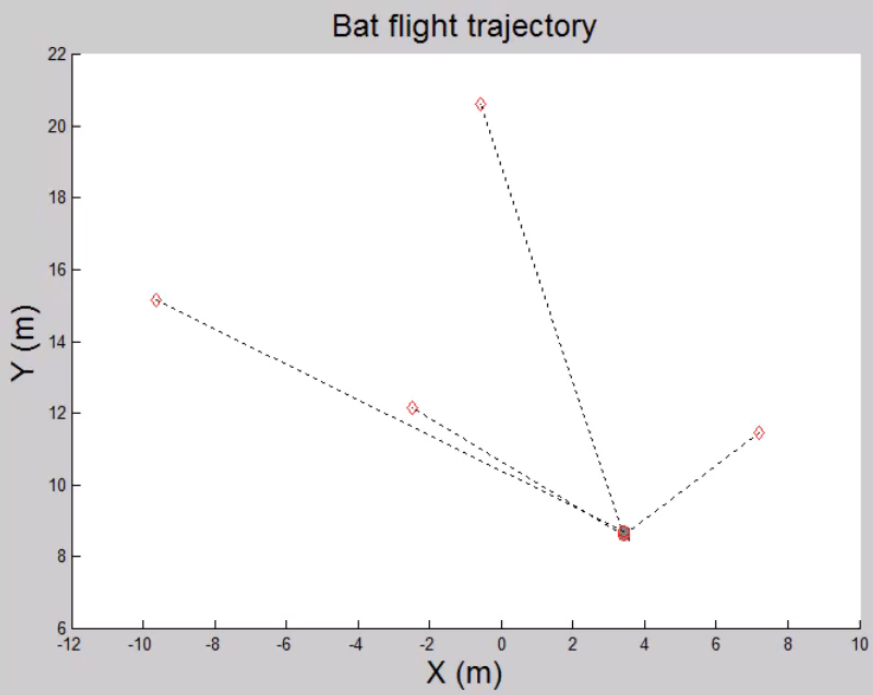


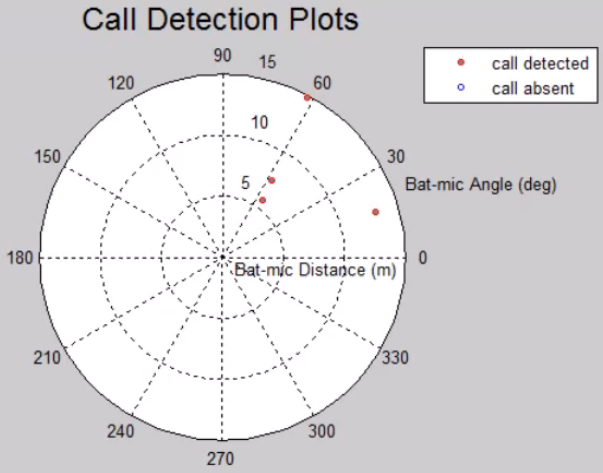
Experiments:

- Natural flights
- Interactions with mist net
- Response to echolocation playbacks

Myotis californicus flight

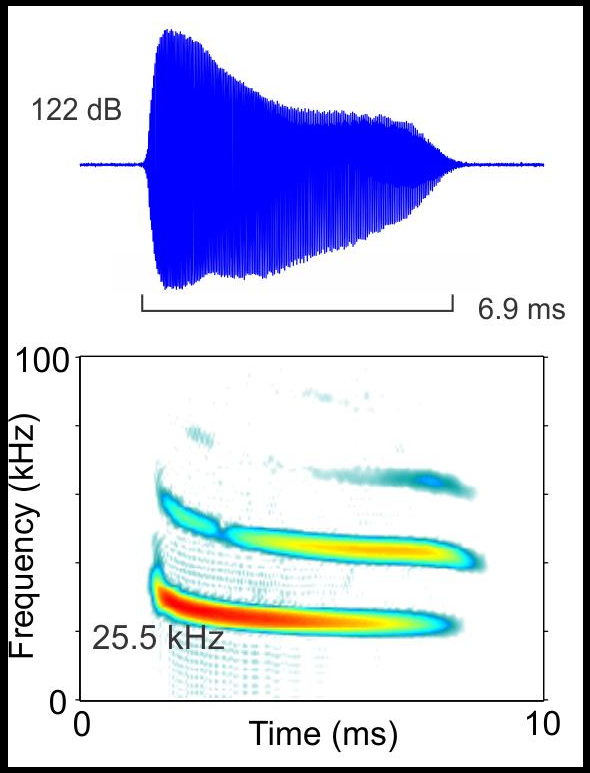
Myotis californicus flight



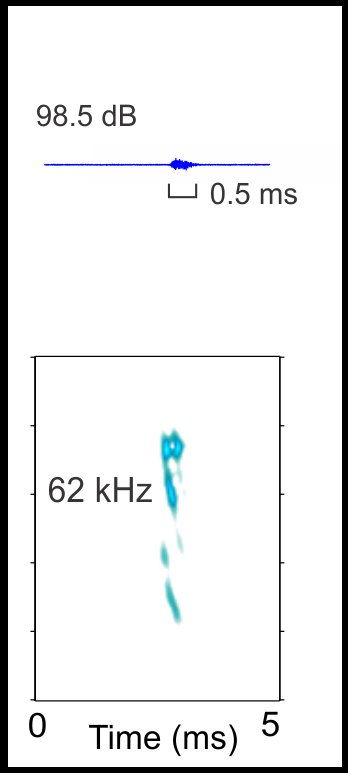


Three echolocation behaviors

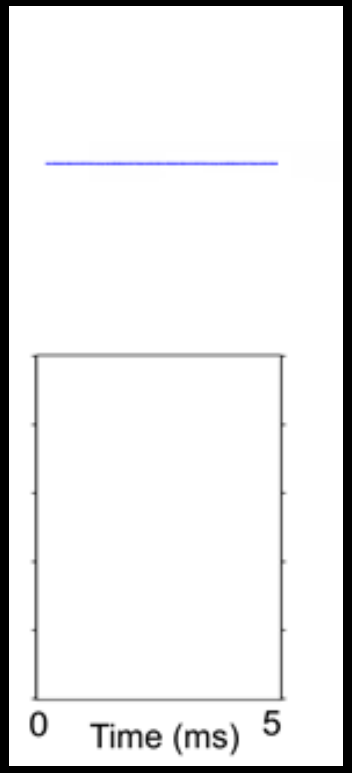
High-intensity echolocation



Micro echolocation



Silence

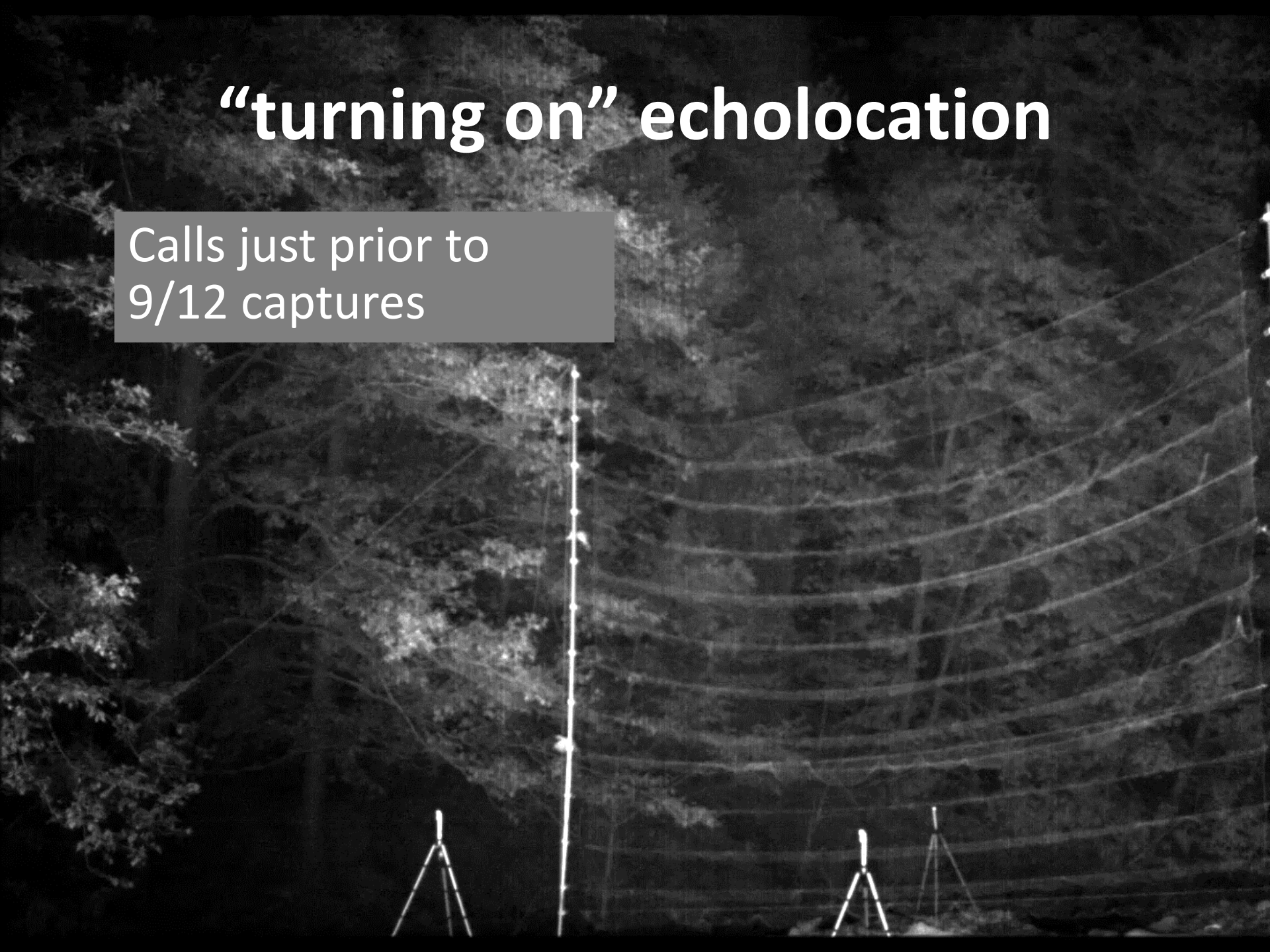


- Micro calls reduce eavesdropping range from ~100 to ~10 m
- Only capable of detecting large obstacle for last-ditch response

Corcoran and Weller, 2018 *Proc. Roy. Soc. B*

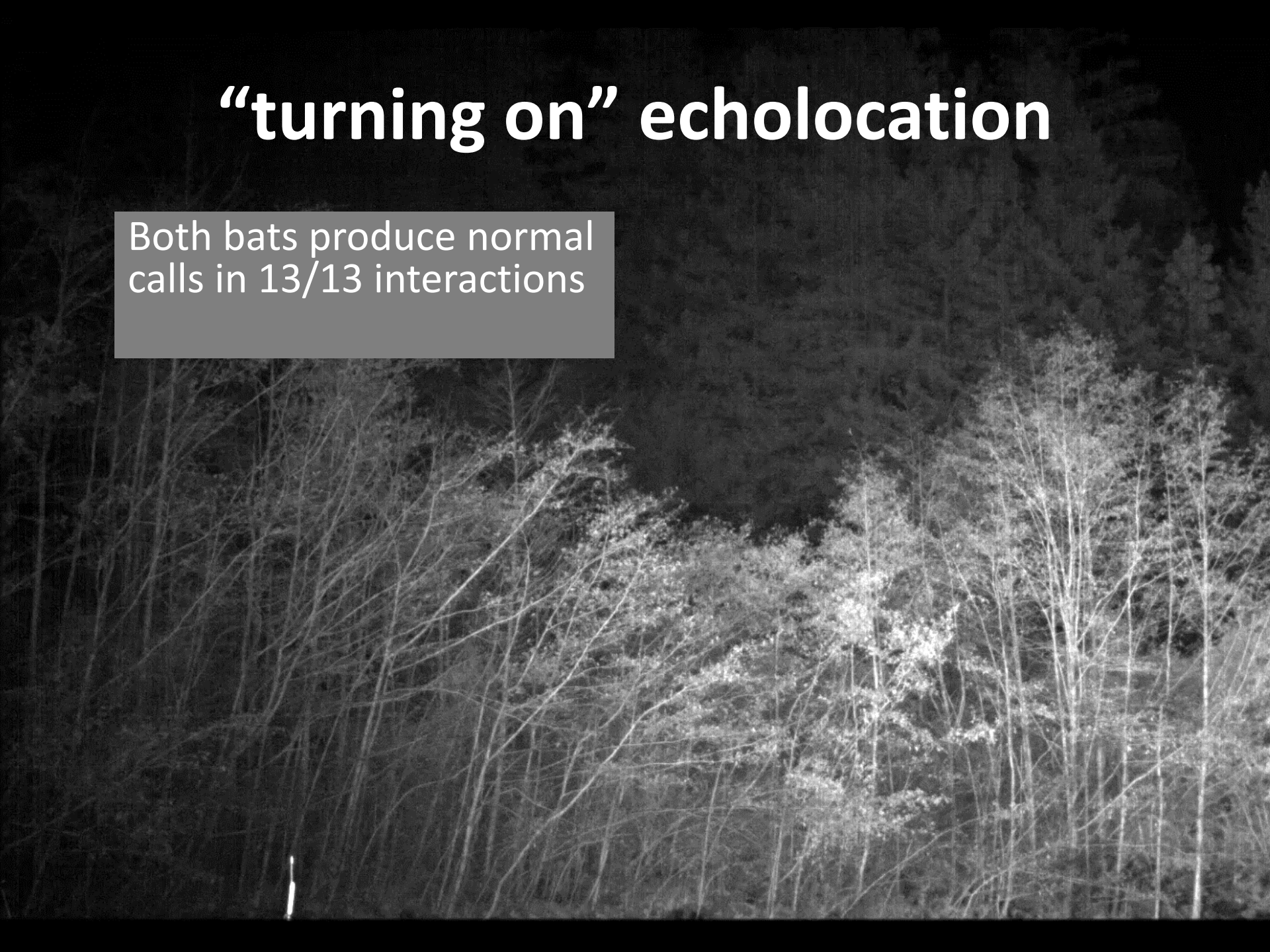
“turning on” echolocation

Calls just prior to
9/12 captures



“turning on” echolocation

Both bats produce normal calls in 13/13 interactions



Questions

Why shut off echolocation?

- Predation?
- Mating?

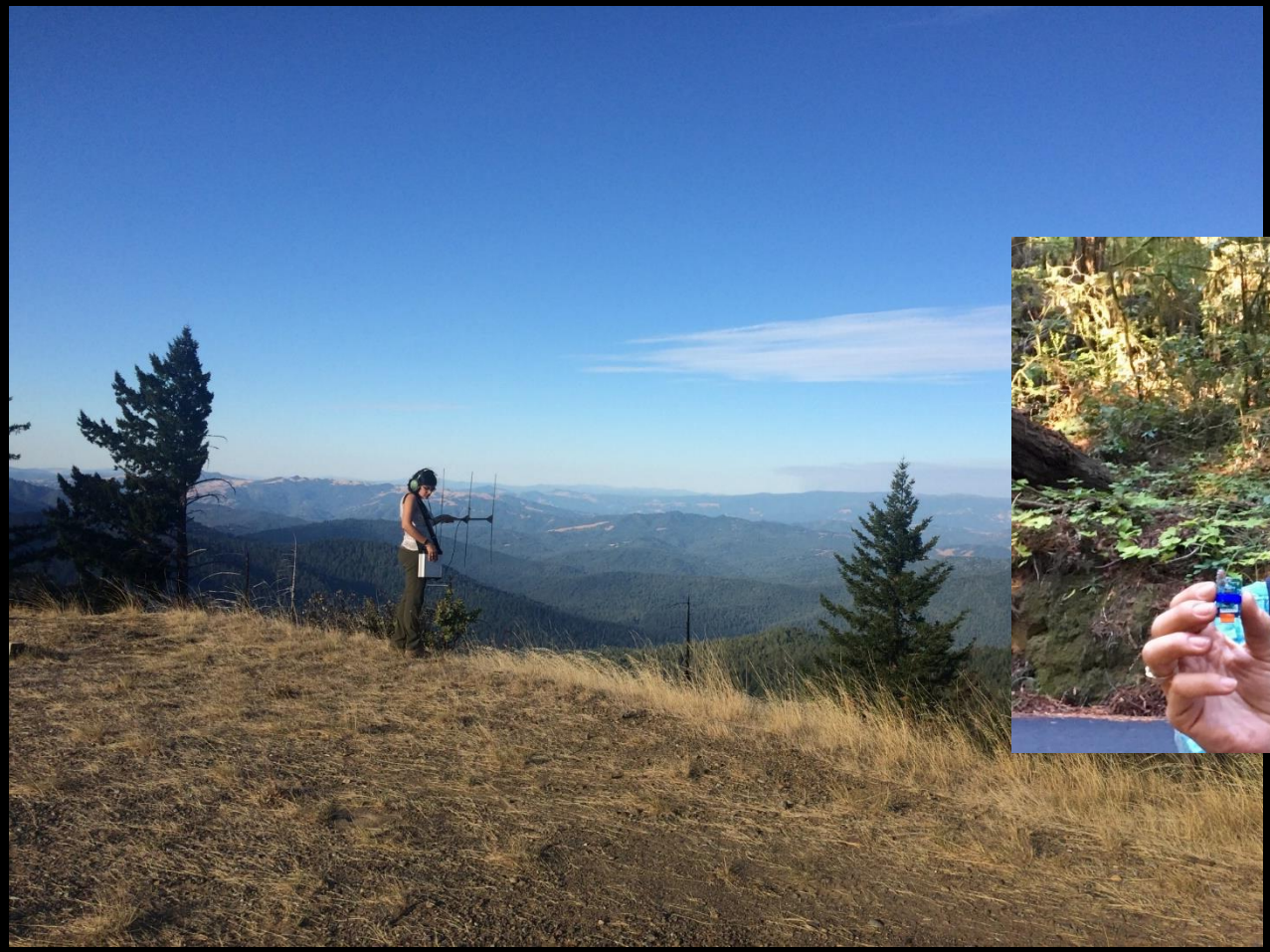
How do bats orient without echolocation?

- Vision?
- Spatial Memory?

How does sensory modality influence navigation?

Bats and Turbines

A bat’s ear view

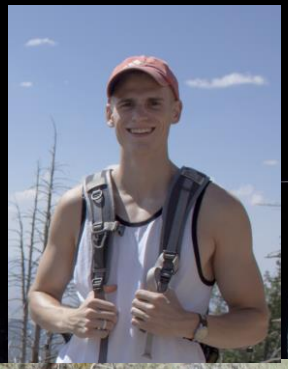


Key take-aways

- Bats fly in silence!
- Periods of normal echolocation were associated with high rates of feeding
- Periods of silence and micro calls were associated with social interactions

Corcoran et al. 2022 *Scientific Reports*

What is it like to be a bat?



Acknowledgements

Collaborators

Dr. William Conner

Dr. Jesse Barber

Dr. Nickolay Hristov

Dr. Cynthia Moss

Ted Weller

Dr. Yossi Yovel

Student Assistants

Megan Cullen

Wesley Johnson

Ryan Wagner

Zach Walker

Nick Dowdy

Jean-Paul Kennedy

Katelyn Roman

Deanna Margius

Orion Goodman

Christine Johnson

Shin Tamura

Jeremy Gotgotao

Annalise Hopkins

Kacie Quigley