

From Chaos to Information – Communication in a Crowd of Bats

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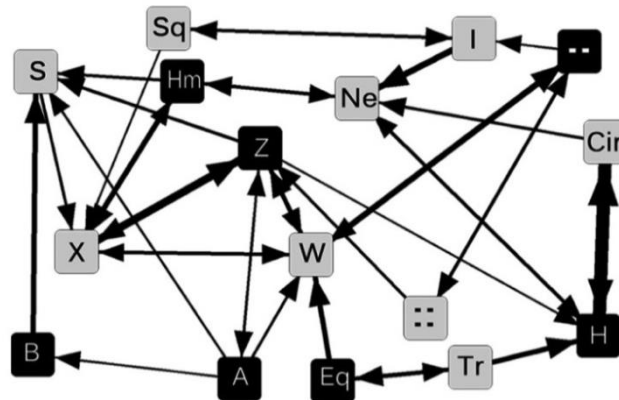
Information Transfer in the Roost

Producers

Scroungers



L. harten

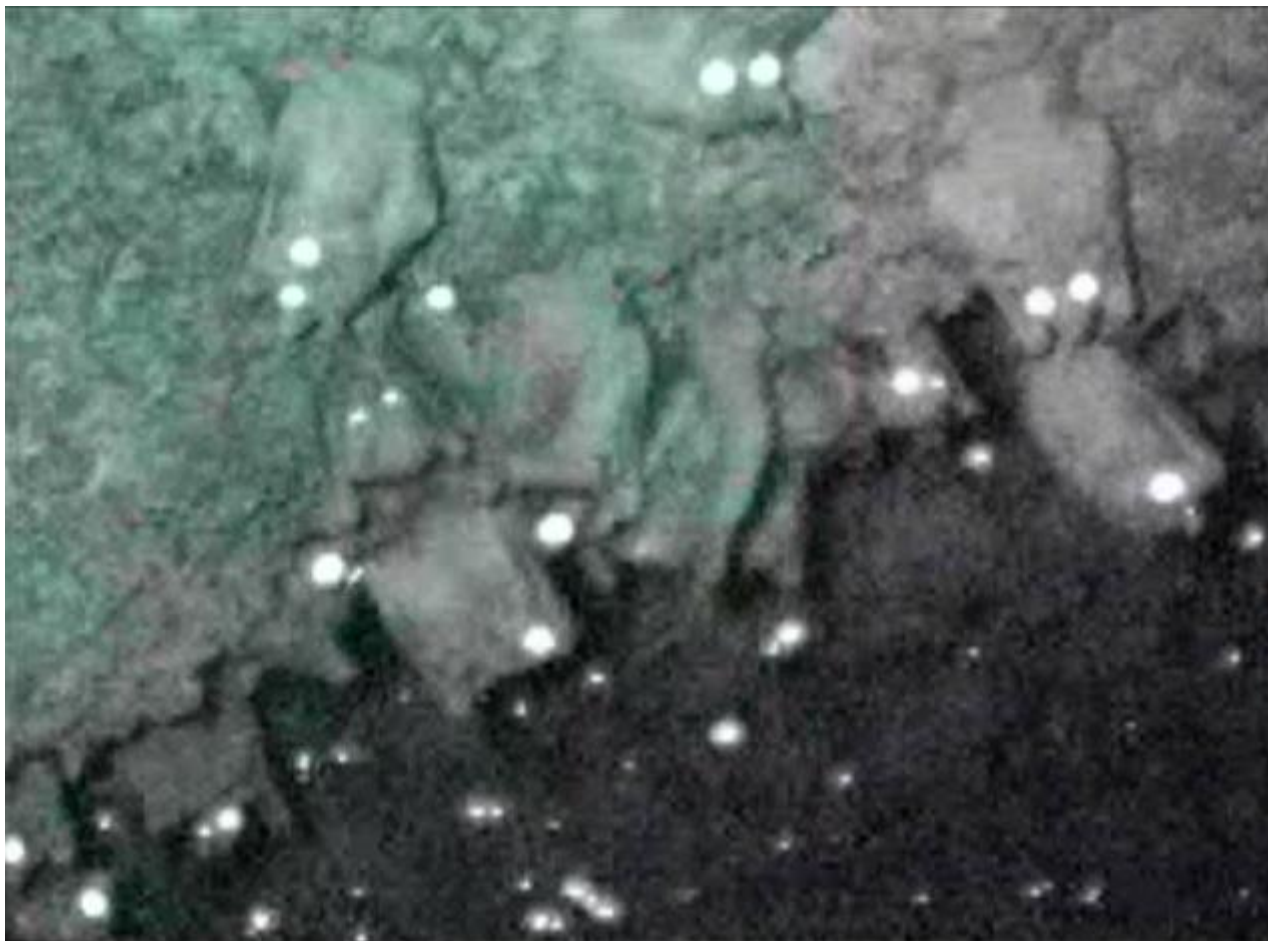


Harten et al. *Science Adv.* 2018

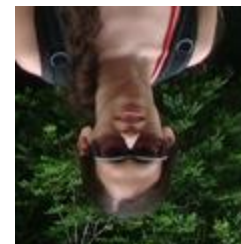
The Egyptian fruit bat – an extremely social and vocal and species



Social vocalizations in the roost



Yosef Prat



Mor Taub



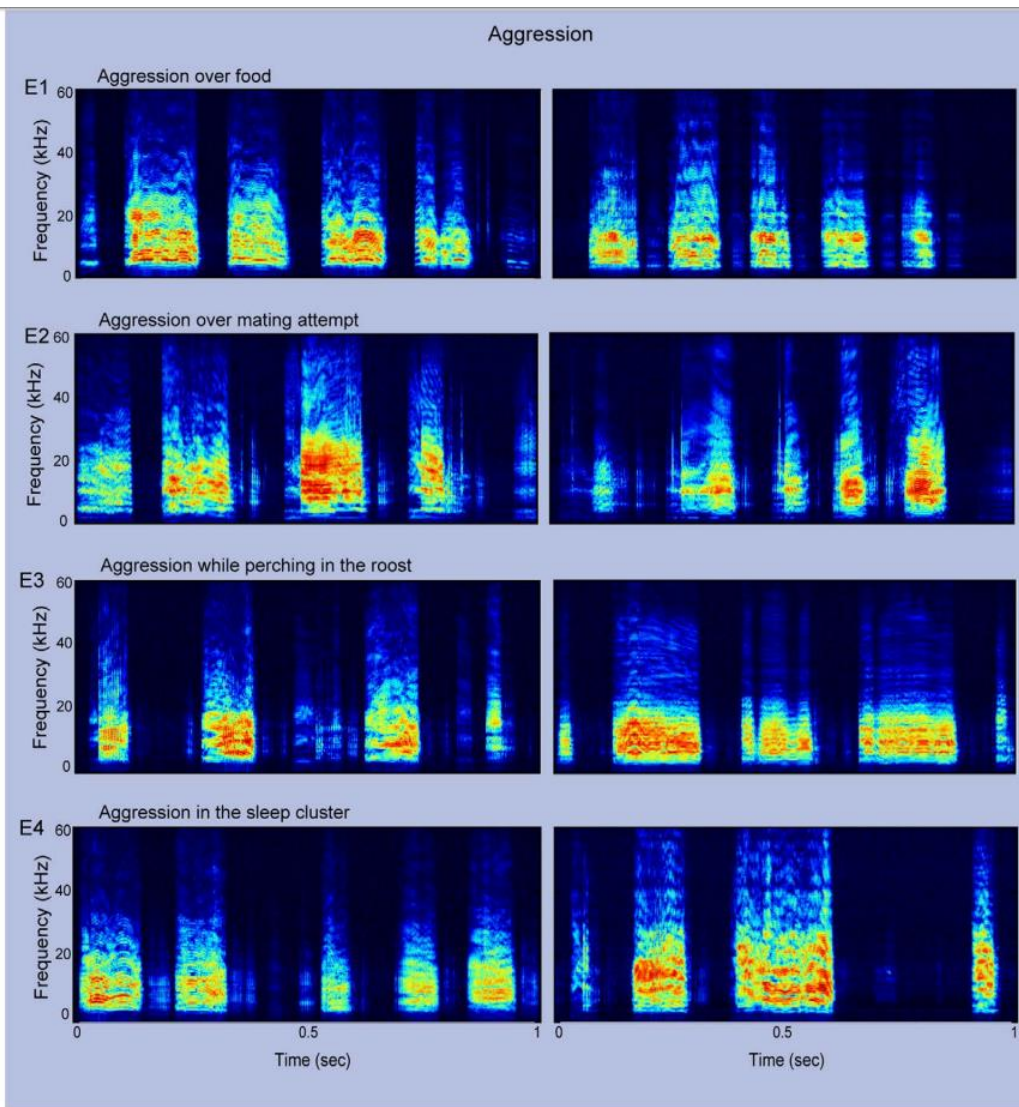
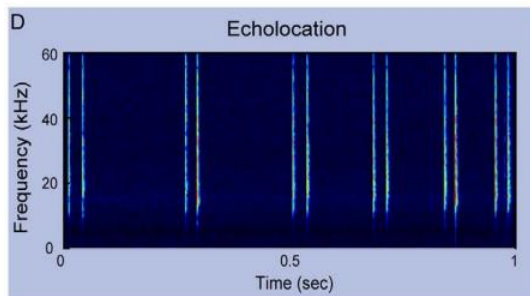
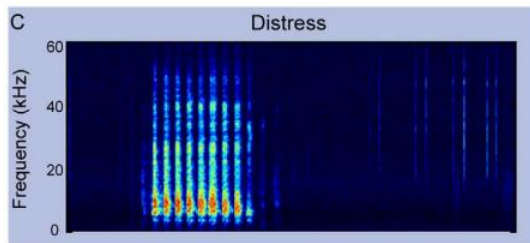
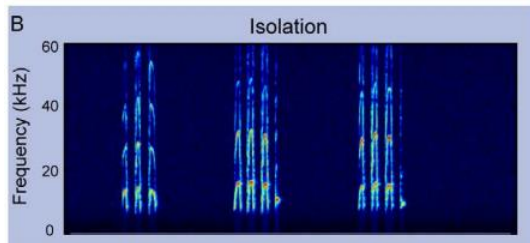
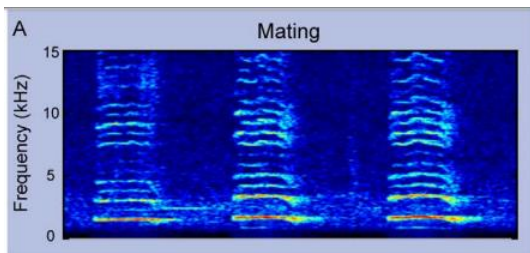
What information is encapsulated in bat social vocalizations?

Encapsulated information:

the potential knowledge that can be extracted
from the acoustics alone

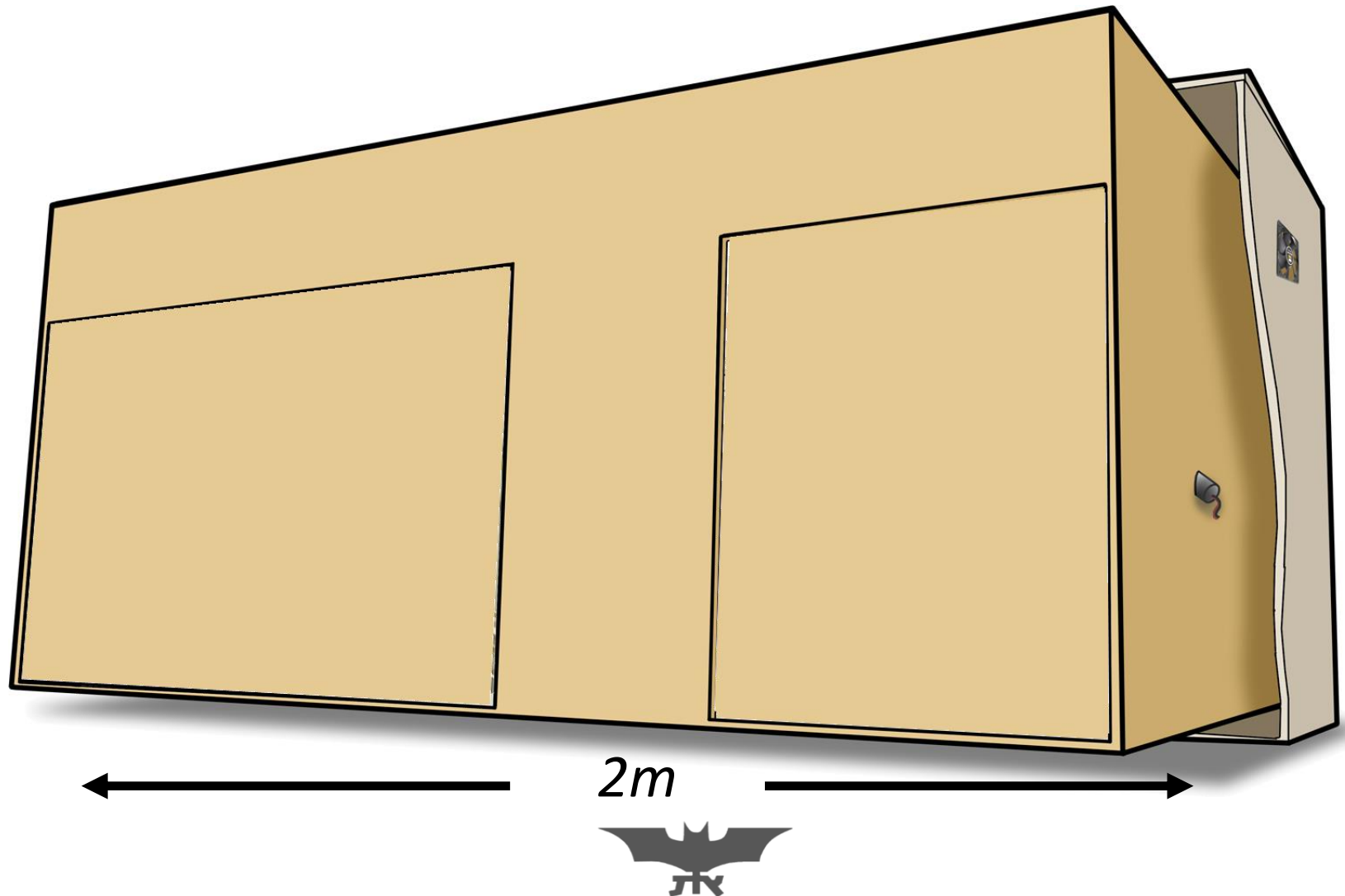


Focusing on agonistic vocalizations



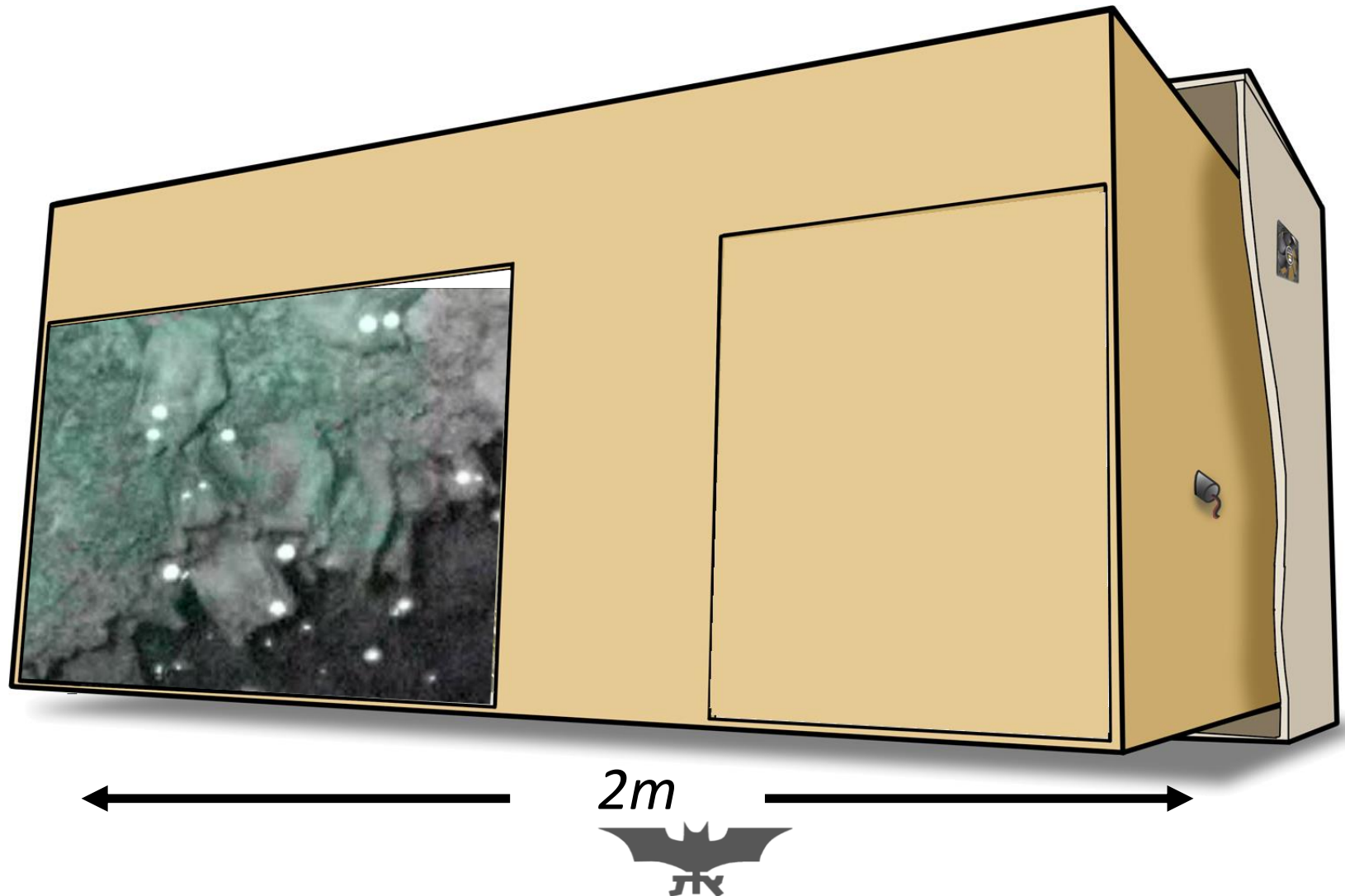
Experimental setup

A cage simulating a roost and a foraging ground



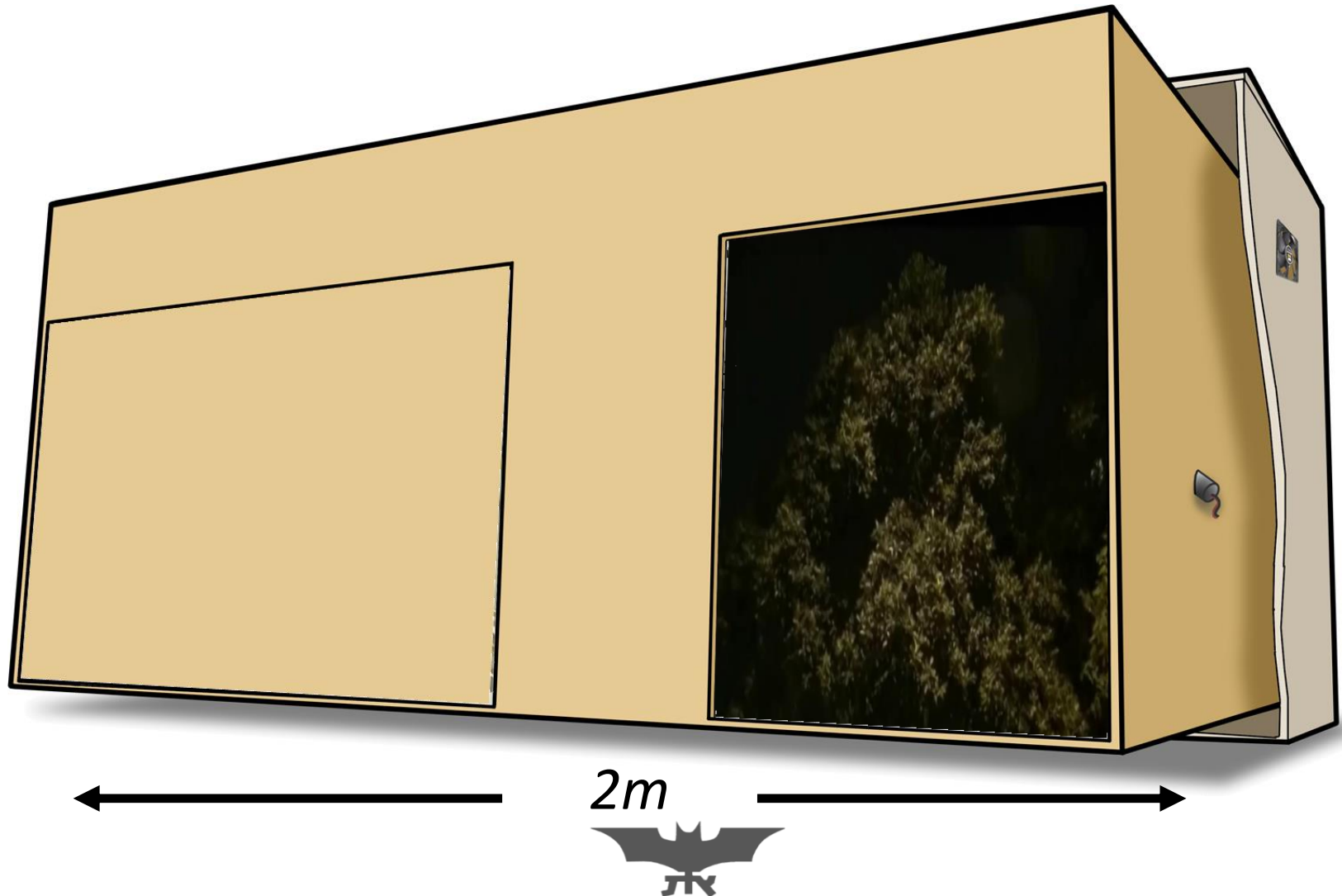
Experimental setup

A cage simulating a **roost** and a foraging ground



Experimental setup

A cage simulating a roost and a **foraging ground**



Experimental setup

Acoustically isolated, IR-cameras, microphones



← 2m →



Experimental setup

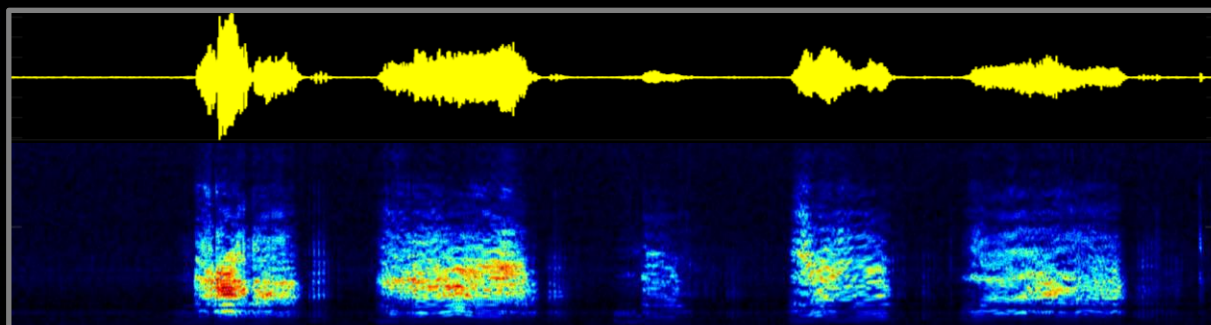
- Continuous audio and video recording (24/7)
- Covering the complete repertoire
- 2.5 Months



Collected Data

- 75 recording days of 22 bats
- ~160,000 vocalizations
- ~20,000 annotated vocalizations:
Emitter, addressee, context
- ~15,000 vocalizations from 7 adult females
included in the analysis





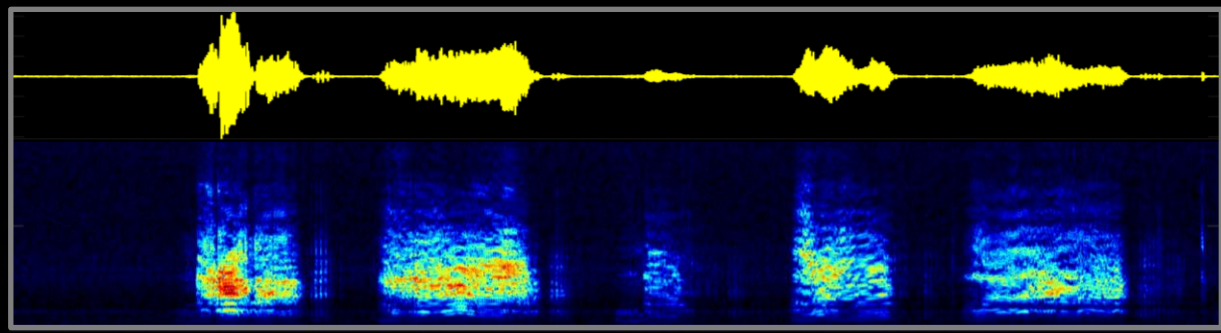
Who said that?

What are you talking about?

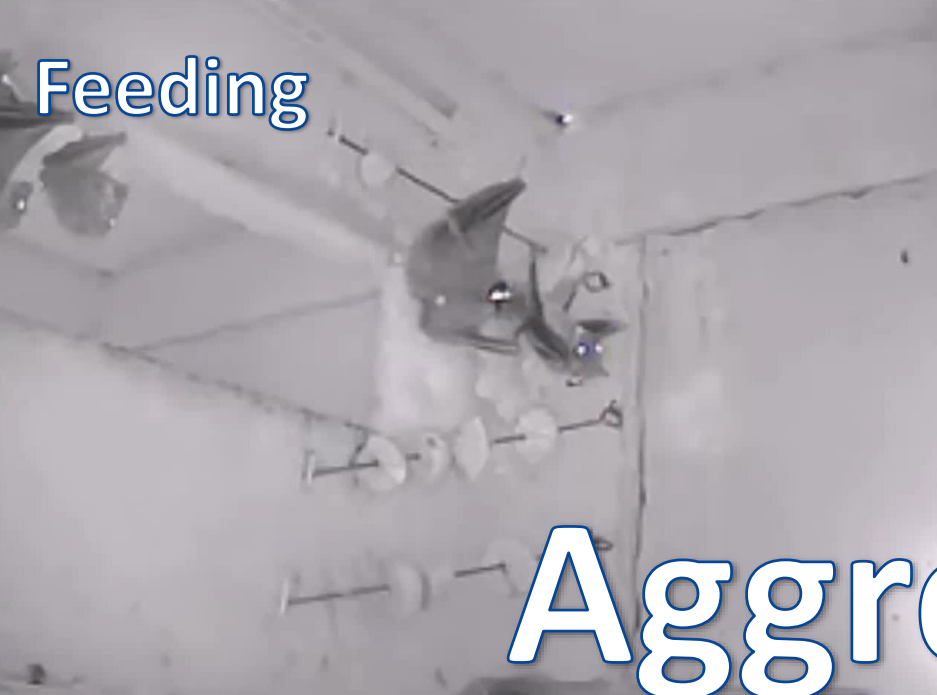
Are you talking to me?

What should I do about it?

USER-PC Ca
06/12/2012 15:02:20



Feeding



Mating



Aggressive

Fight

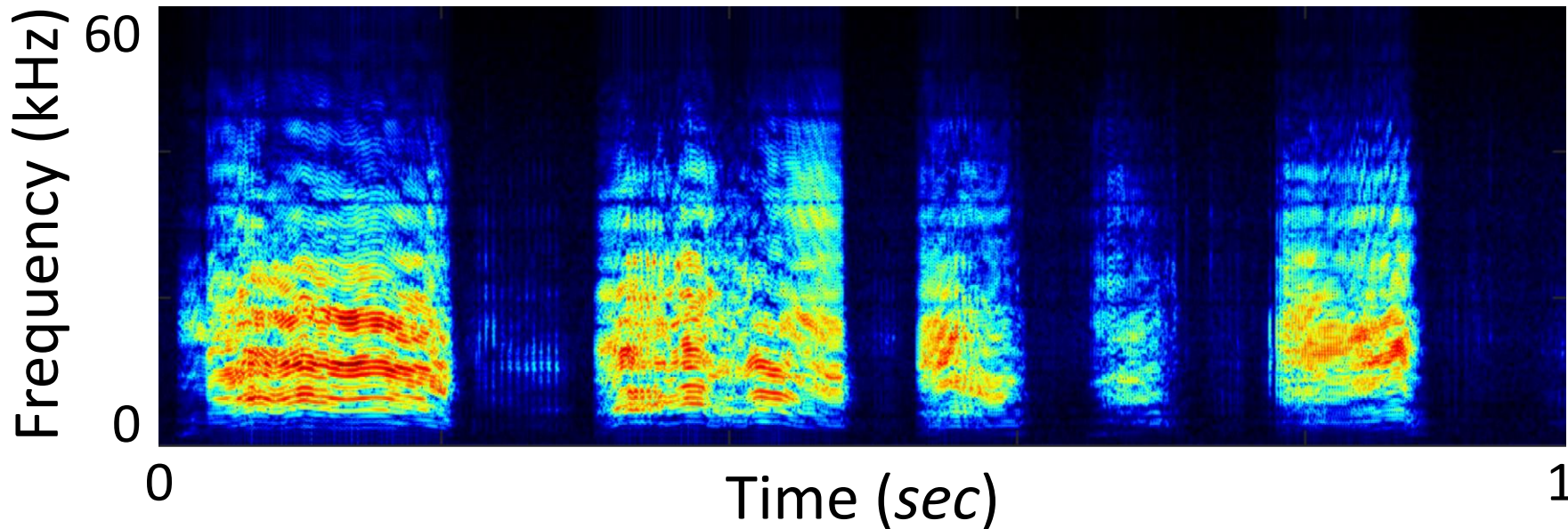


Contexts

Slyer



A Machine Learning Approach



We wish to build a **classifier** and test its accuracy

Features: Mel-Frequency Cepstral Coeff. (MFCC)

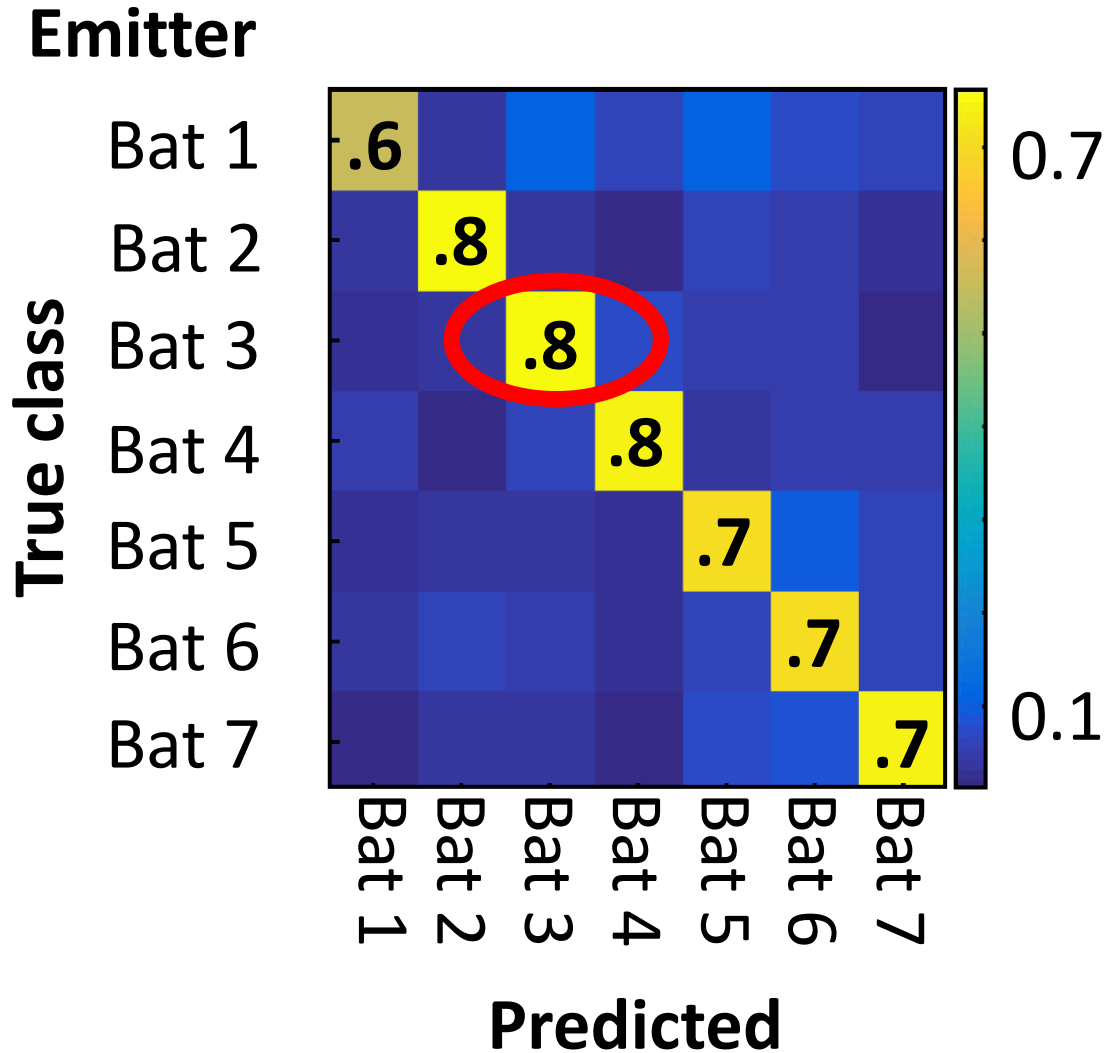
Method: GMM-UBM, speech processing tool



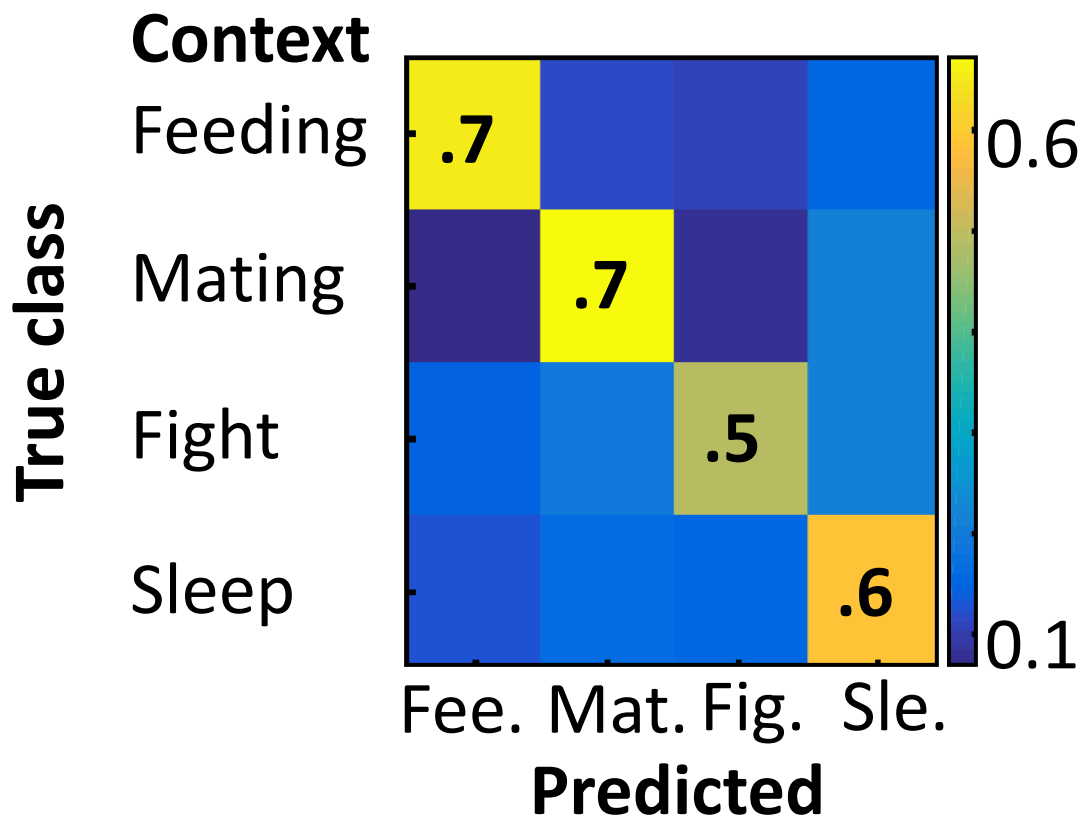
Results



Emitter identification: 71% accuracy (vs. 14% chance)



Context classification: 61% accuracy (vs. 25%)

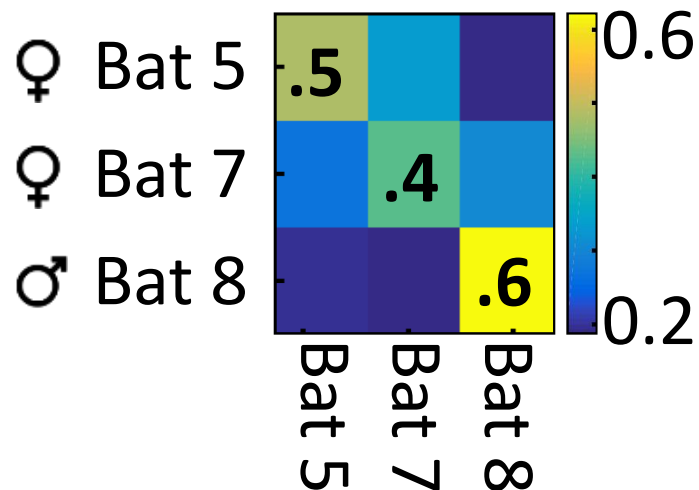


Information about the addressee

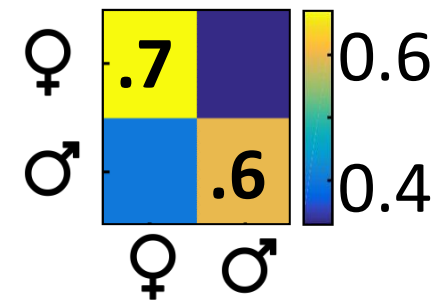
- Addressee:

Male or Female? **63%** accuracy (chance is 50%)

Addressee (of emitter Bat 6)



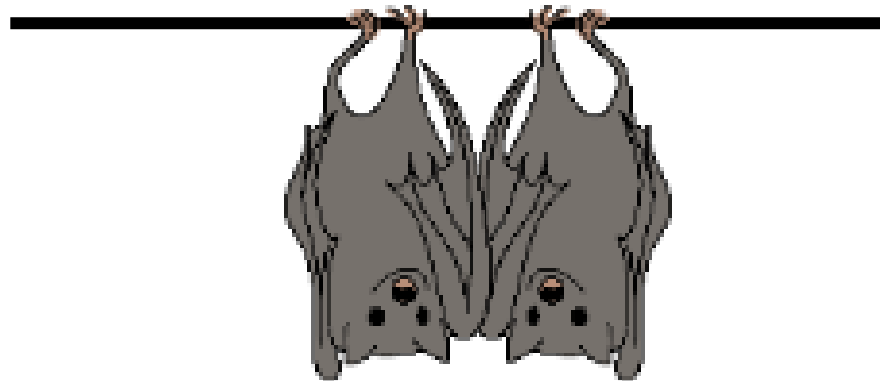
Addressee's sex (all emitters)



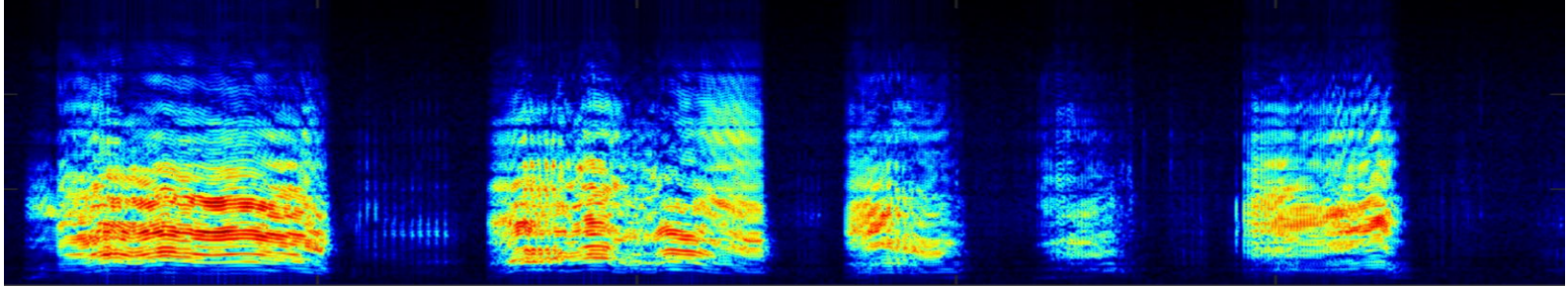
Information about the outcome

- **Outcome:** Stayed together or split?

Accuracy of **62%** (chance is 50%)



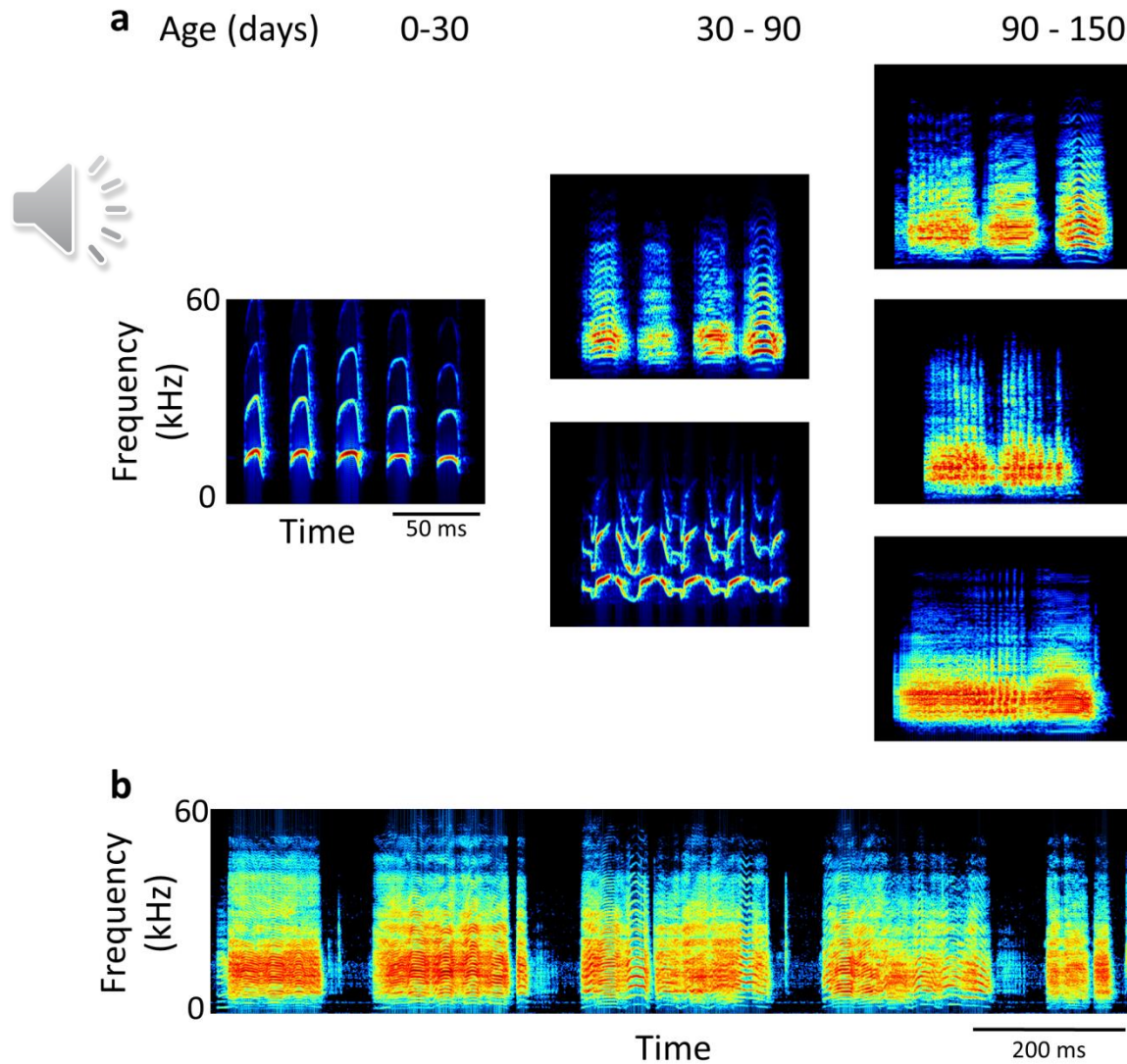
Multilayered Information



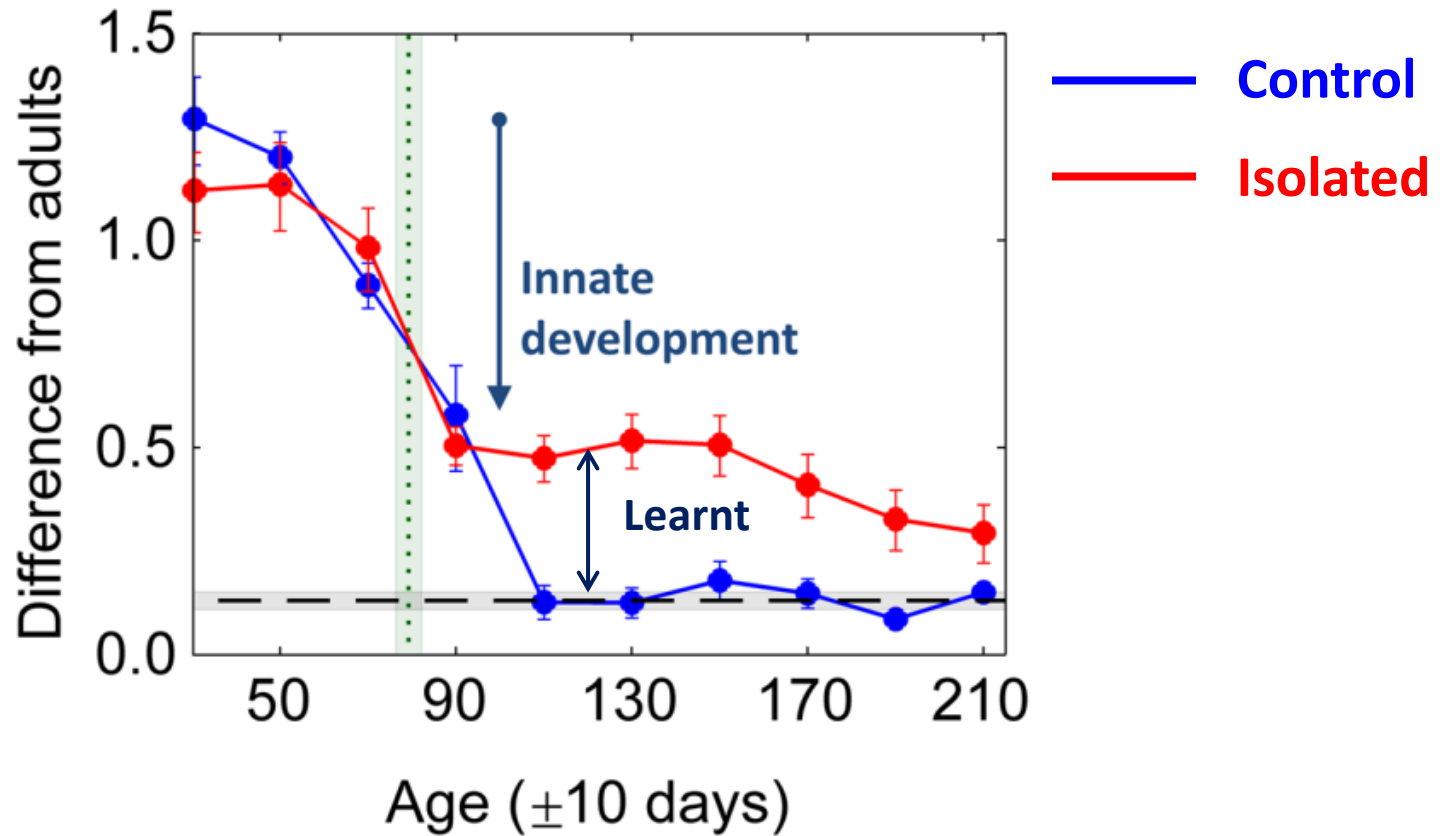
- **A single vocalization** carries information about:
emitter, context, addressee, outcome



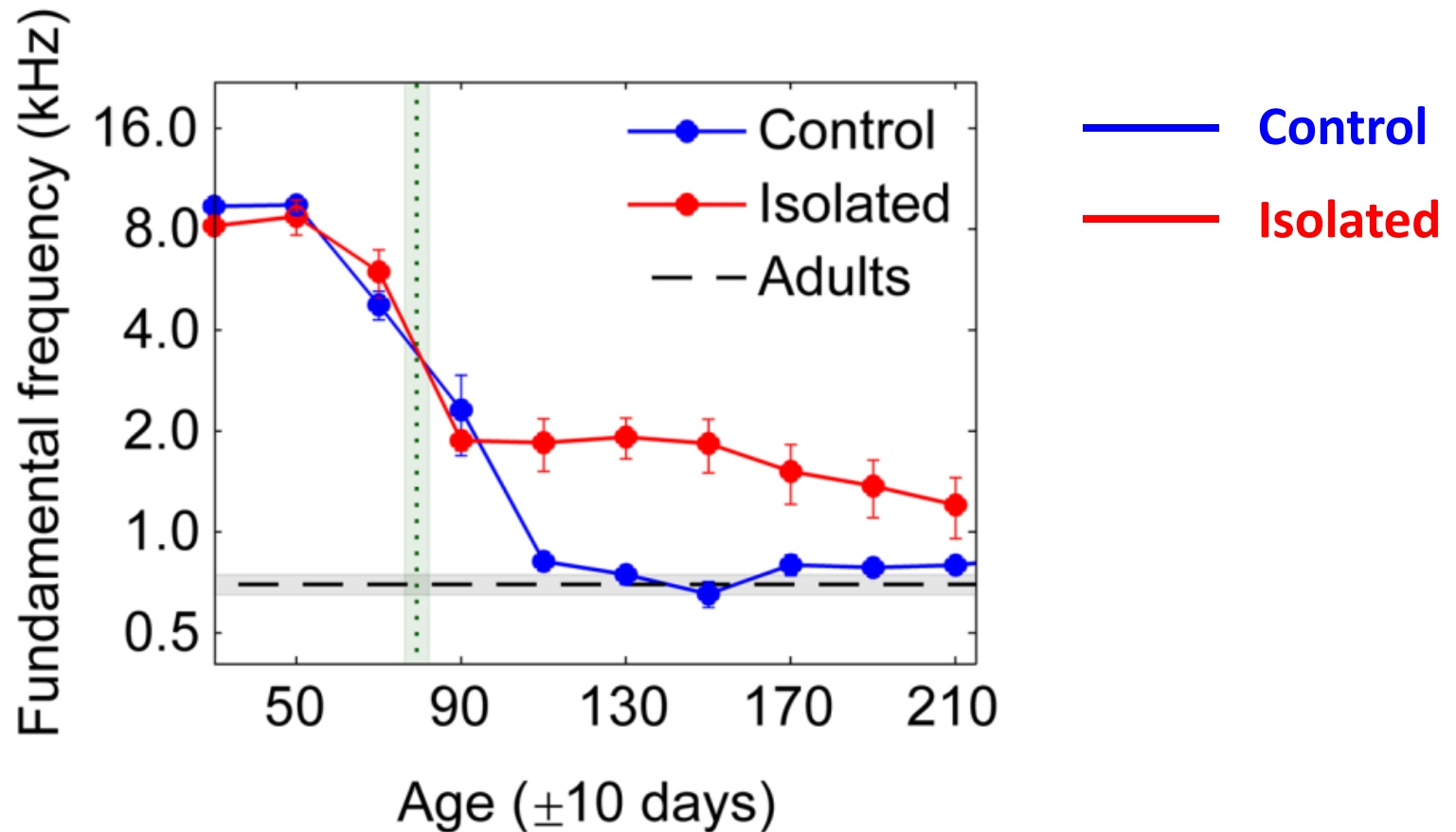
Vocal Ontogeny in Fruit-bats



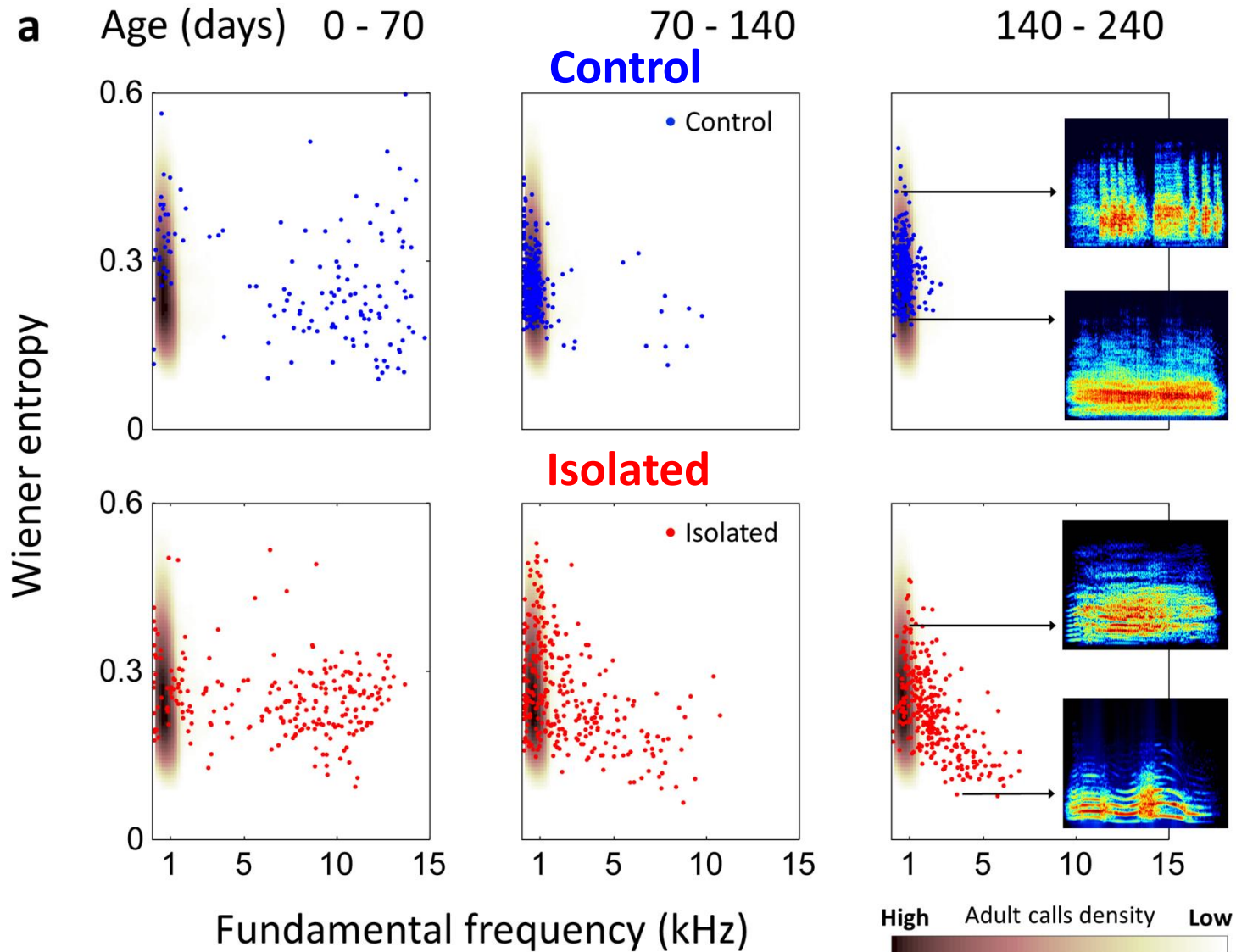
Vocal learning in Fruit bats



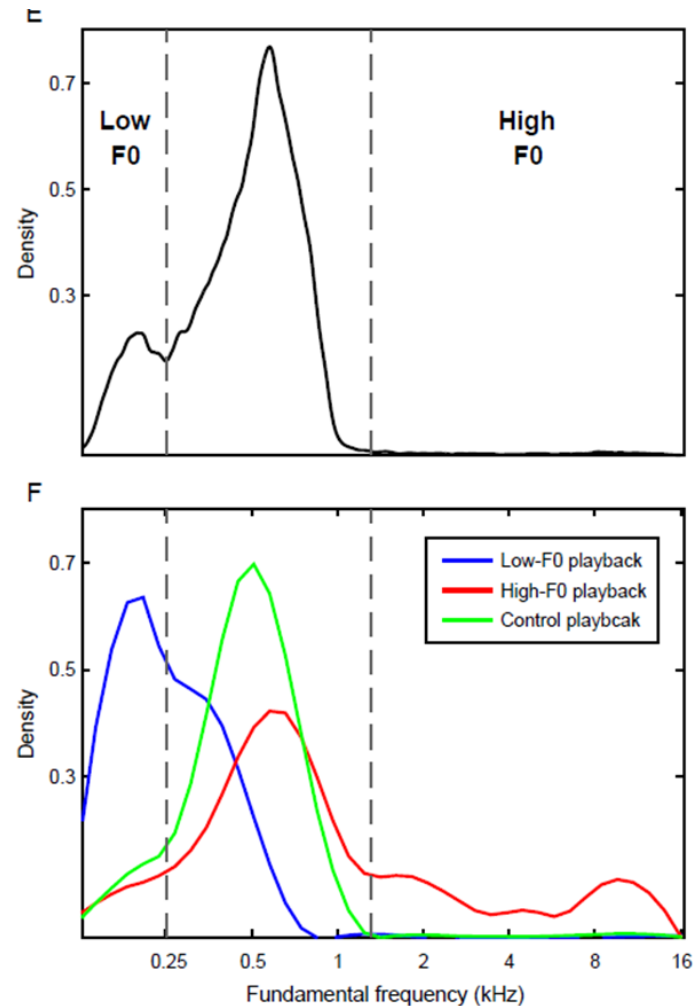
Vocal learning in Fruit bats



Isolated Bats Keep Emitting Pup-like Calls

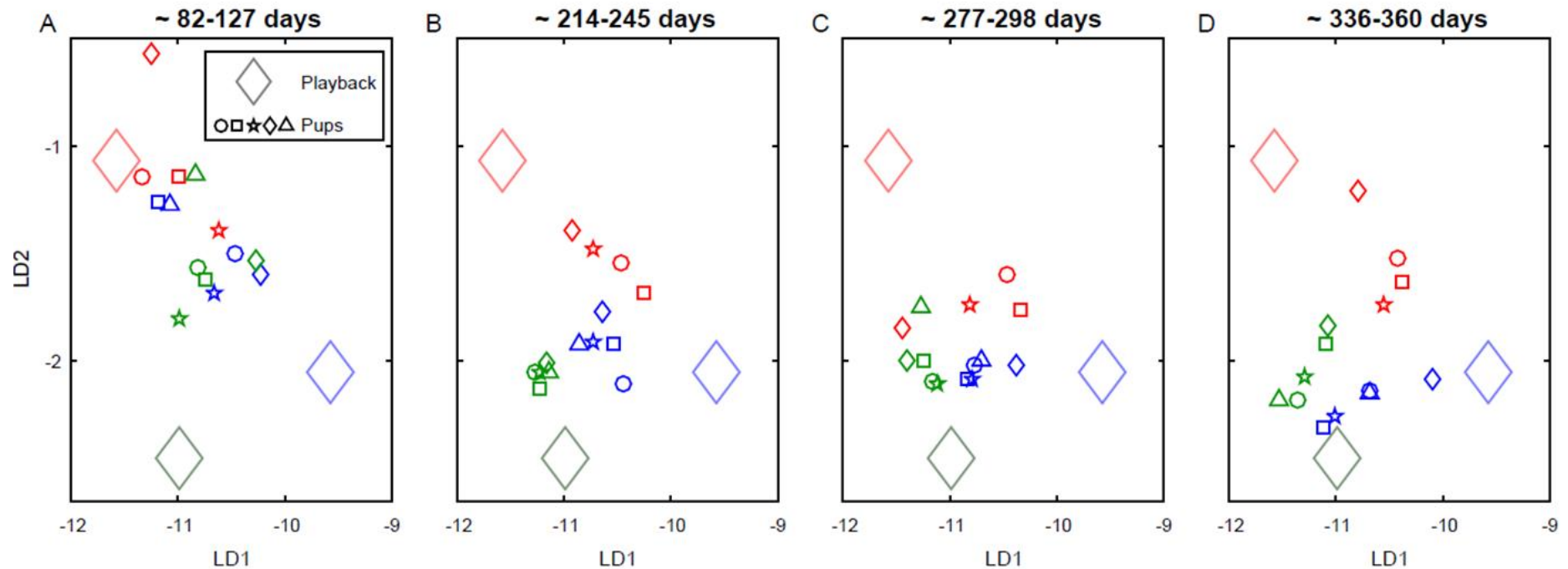


Generating vocal accents using playback

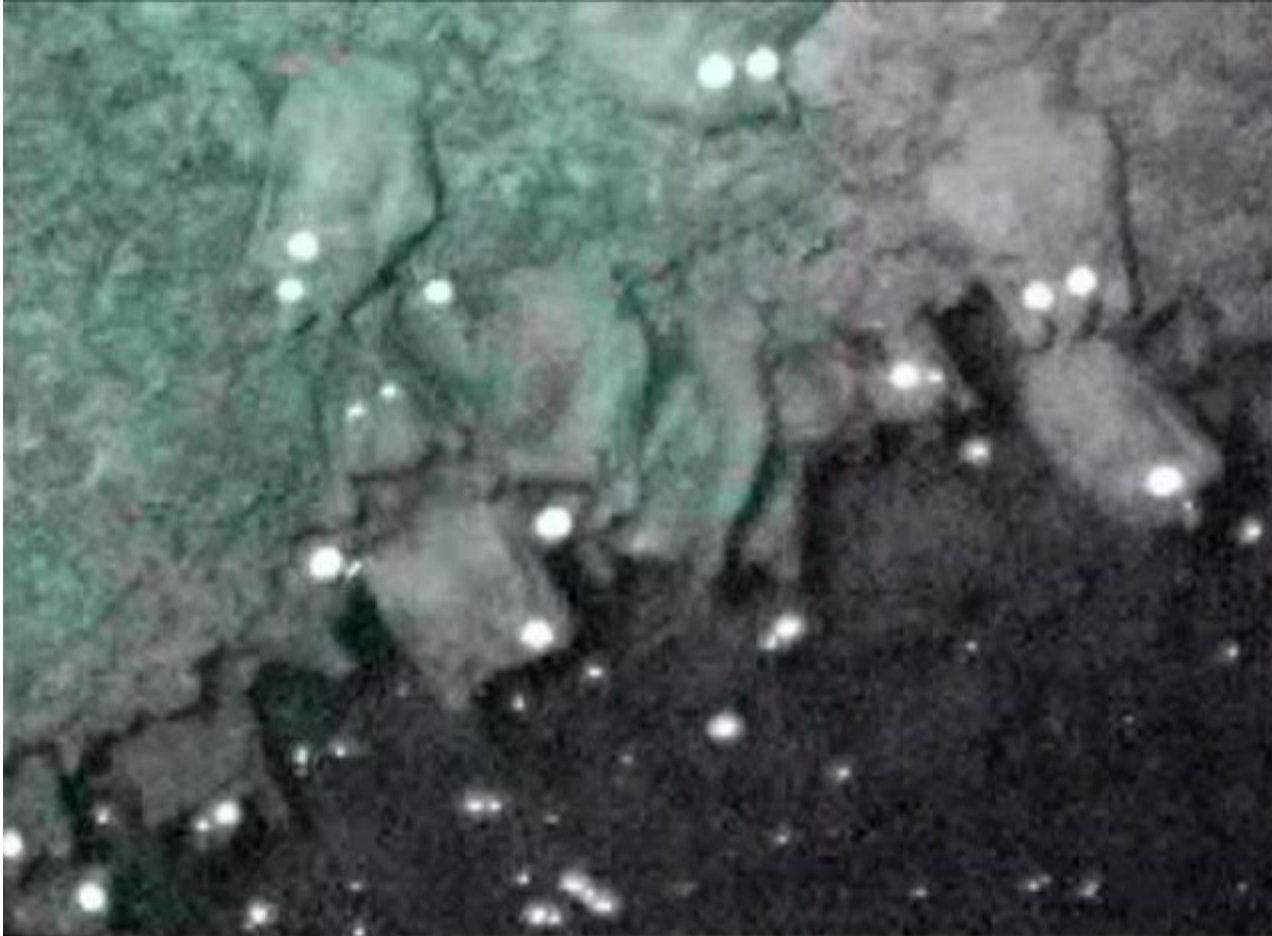


Generating vocal accents using playback

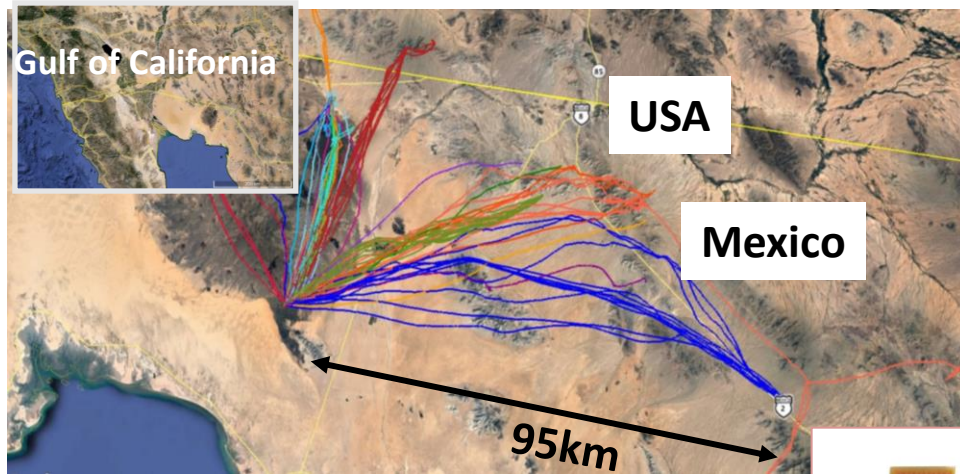
Crowd Vocal Learning



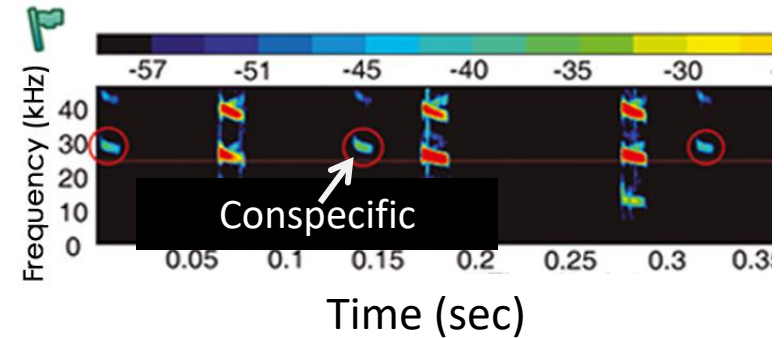
Crowd Vocal Learning



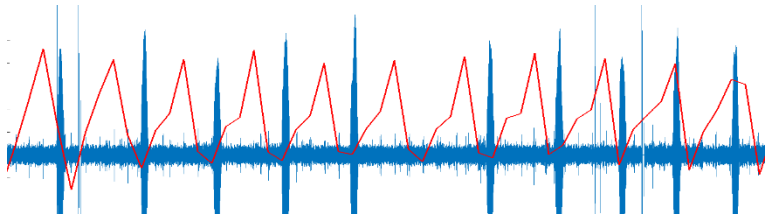
Developing a miniature logger



Interactions with Conspecifics



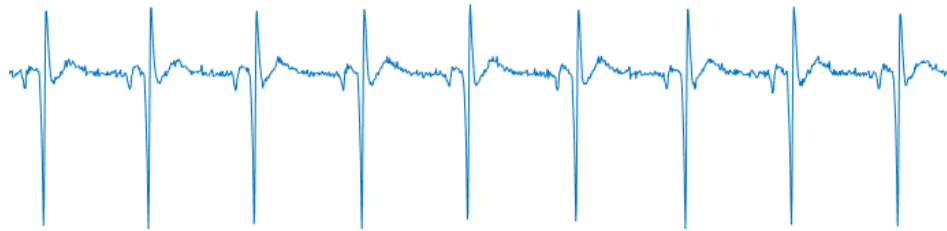
Acceleration



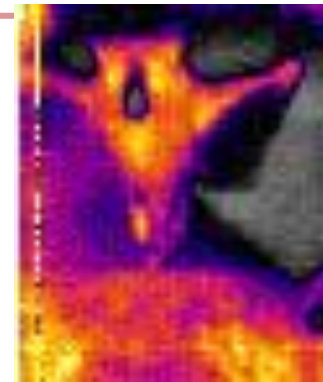
Vesper (1.5gr)



EEG and ECG Recording in Flight

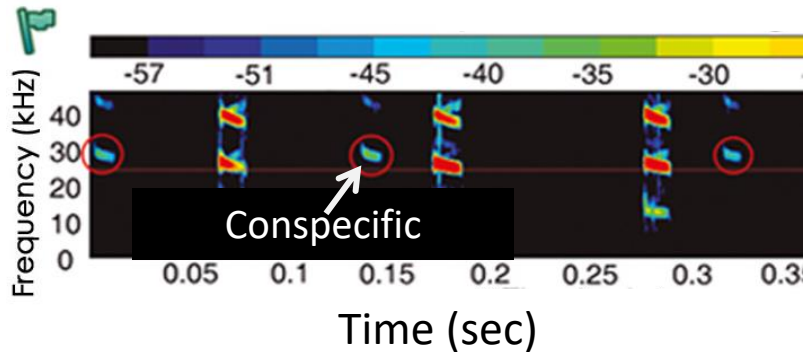


On-board Camera

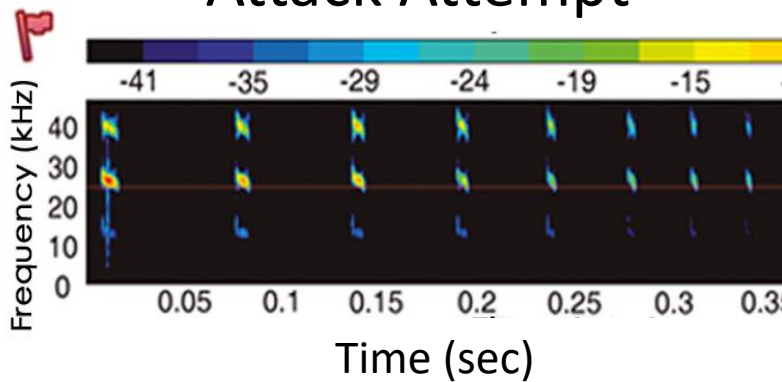


Inferring Animal Behavior using sound

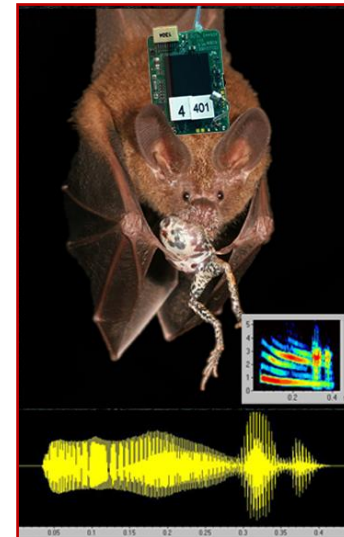
Interactions with Conspecifics



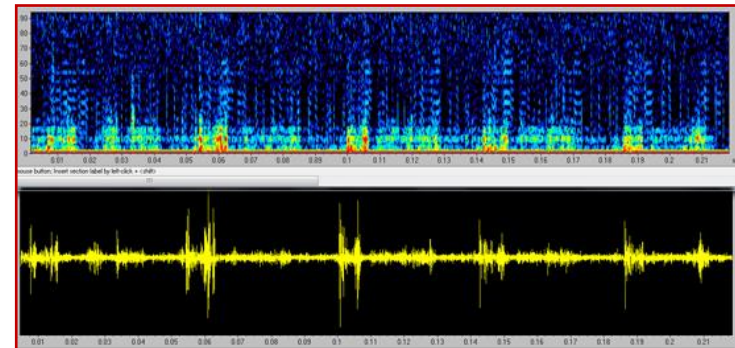
Attack Attempt



Predator Prey Interactions



Attack Success



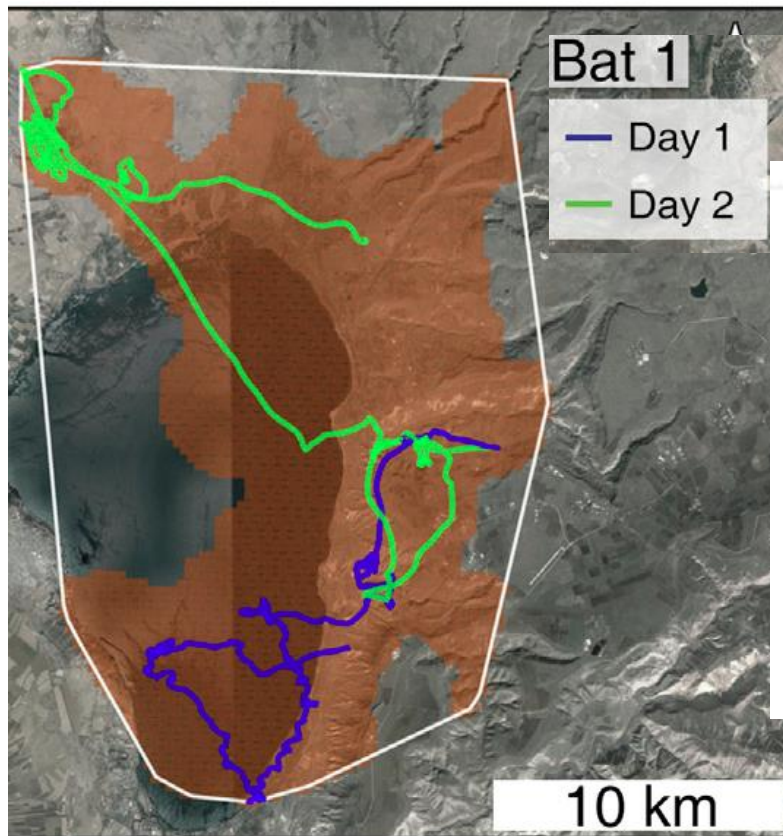
Collective Decision Making in Bats



- 1) How do they avoid jamming? (eLife 2020)
- 2) Do they search collectively?

Ephemerality Drives Social Foraging

(1) Bats must search for food exhaustively



N. cvikel

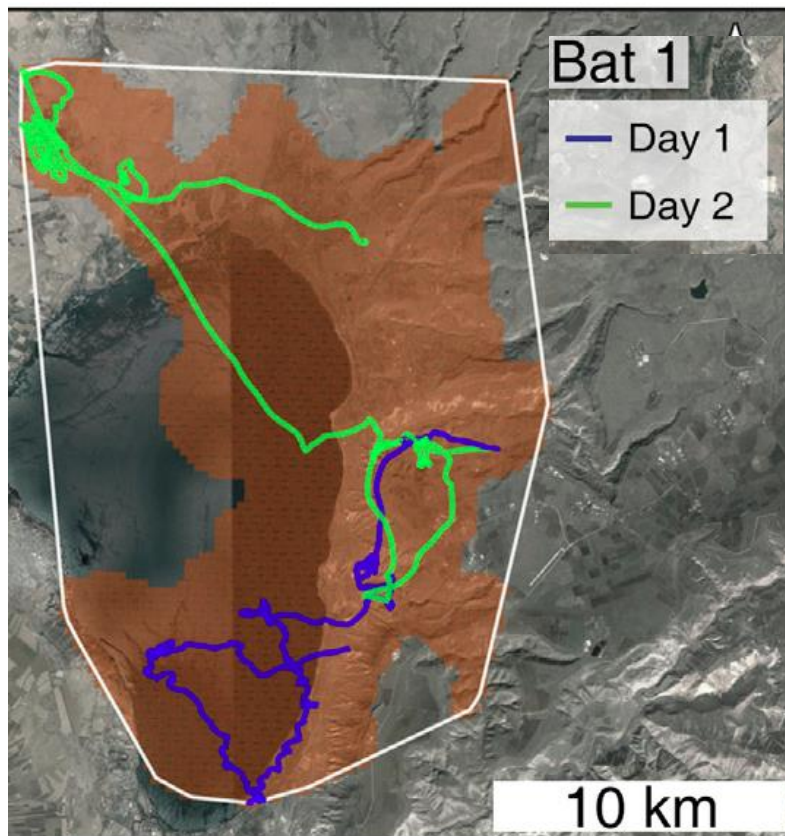


Rhinopoma microphyllum – 35 gr bat

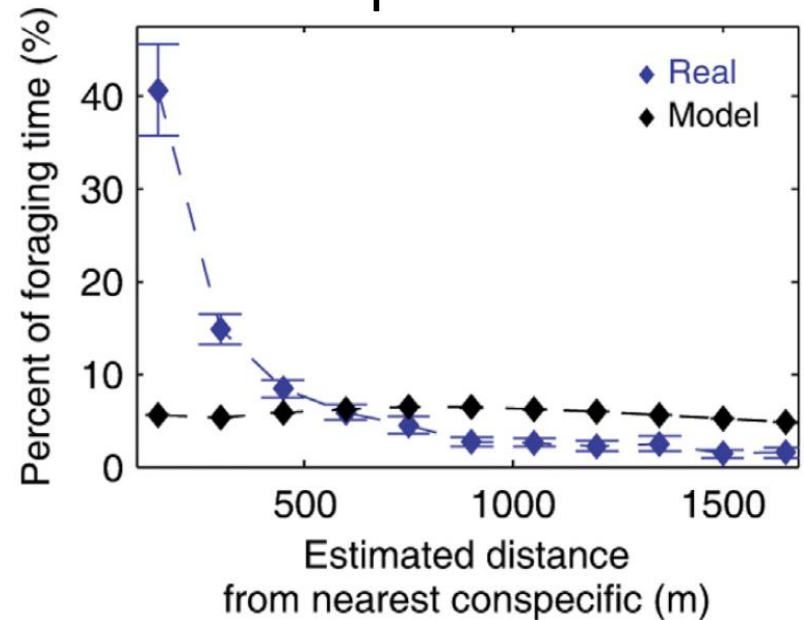


Ephemerality Drives Social Foraging

(1) Bats must search for food exhaustively

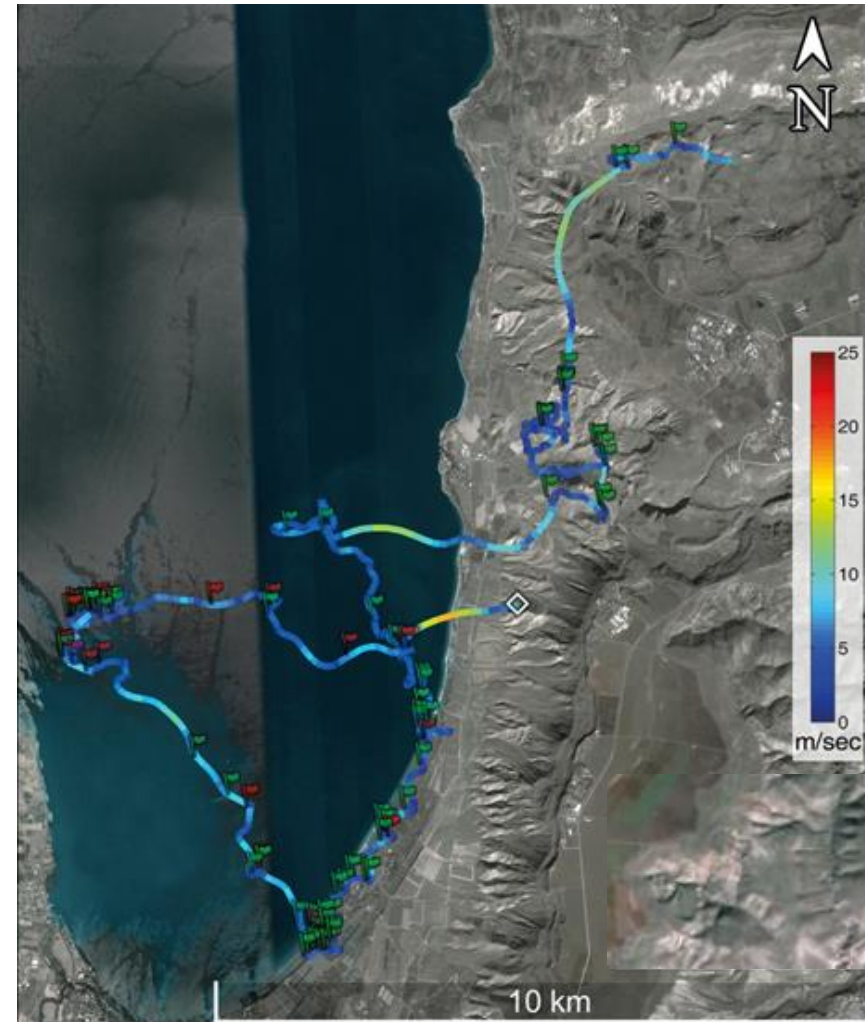
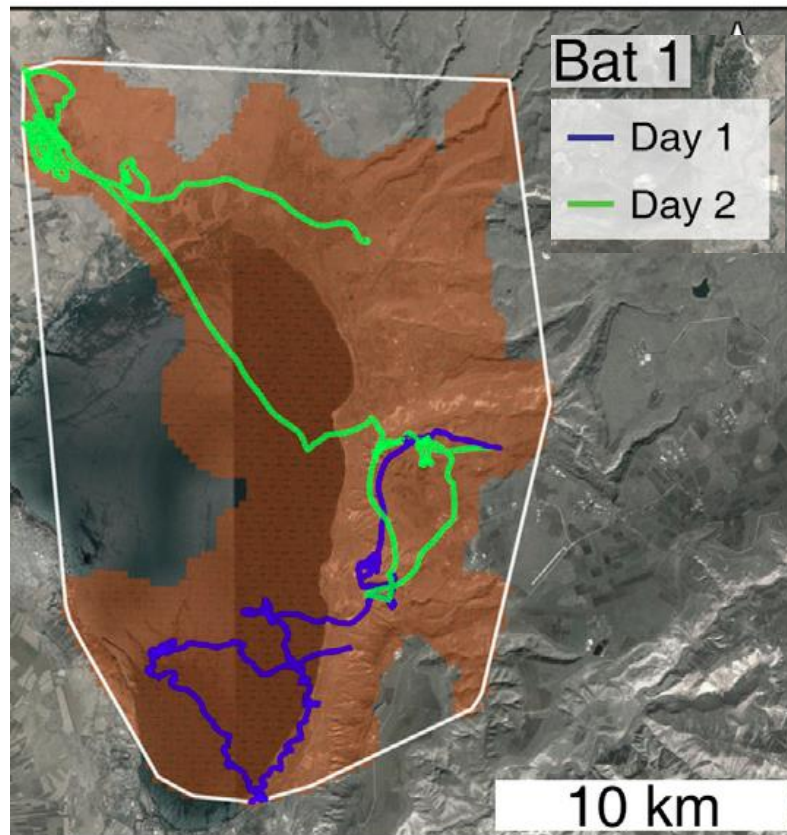


(2) Bat density is higher than expected

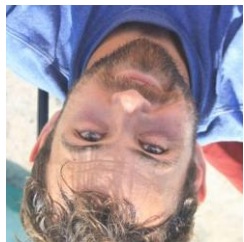


Ephemerality Drives Social Foraging

(1) Bats must search for food exhaustively



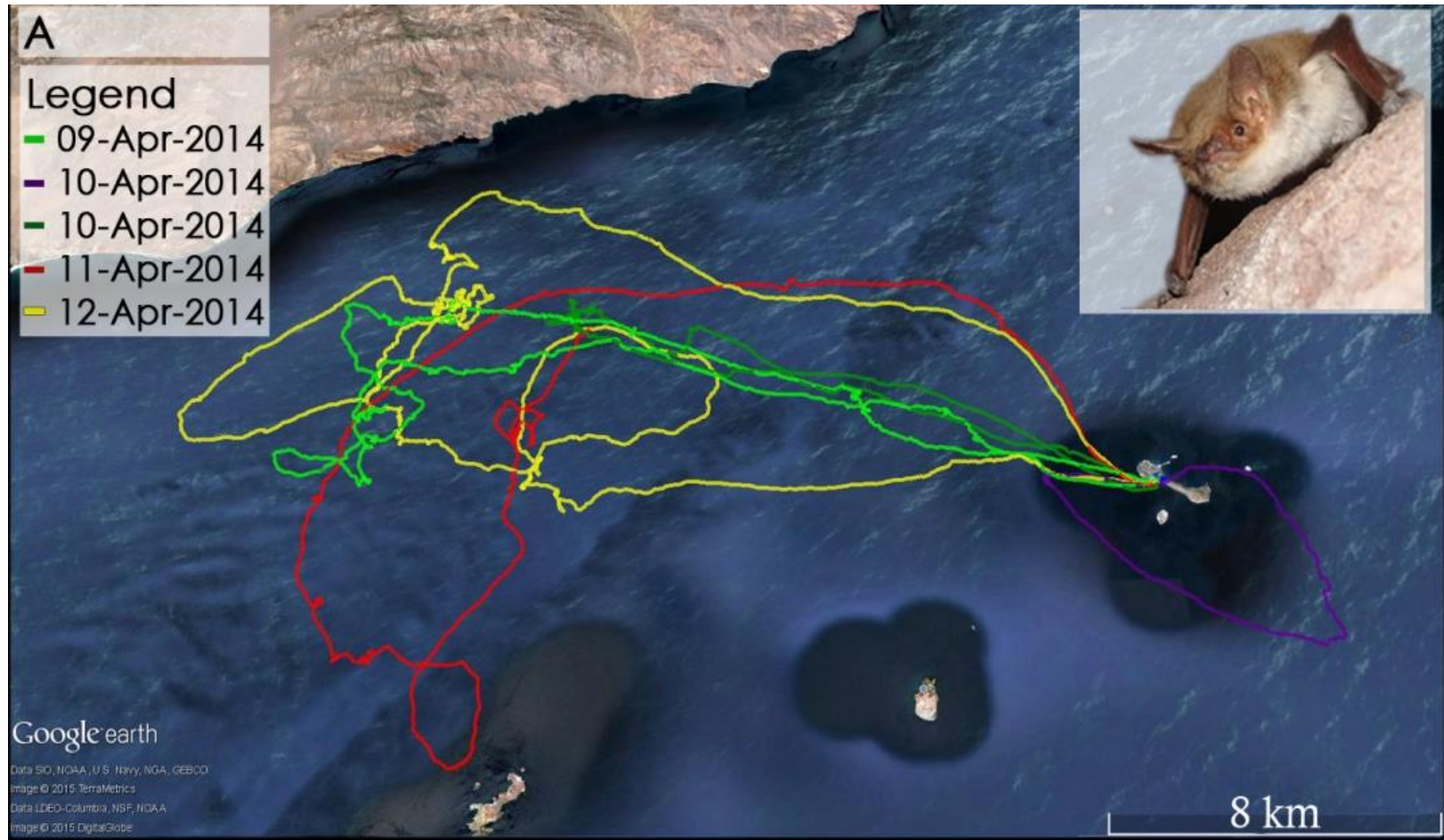
Mexican Fish-Eating Bats Forage in Groups



E. hurme



Ephemerality Drives Social Foraging

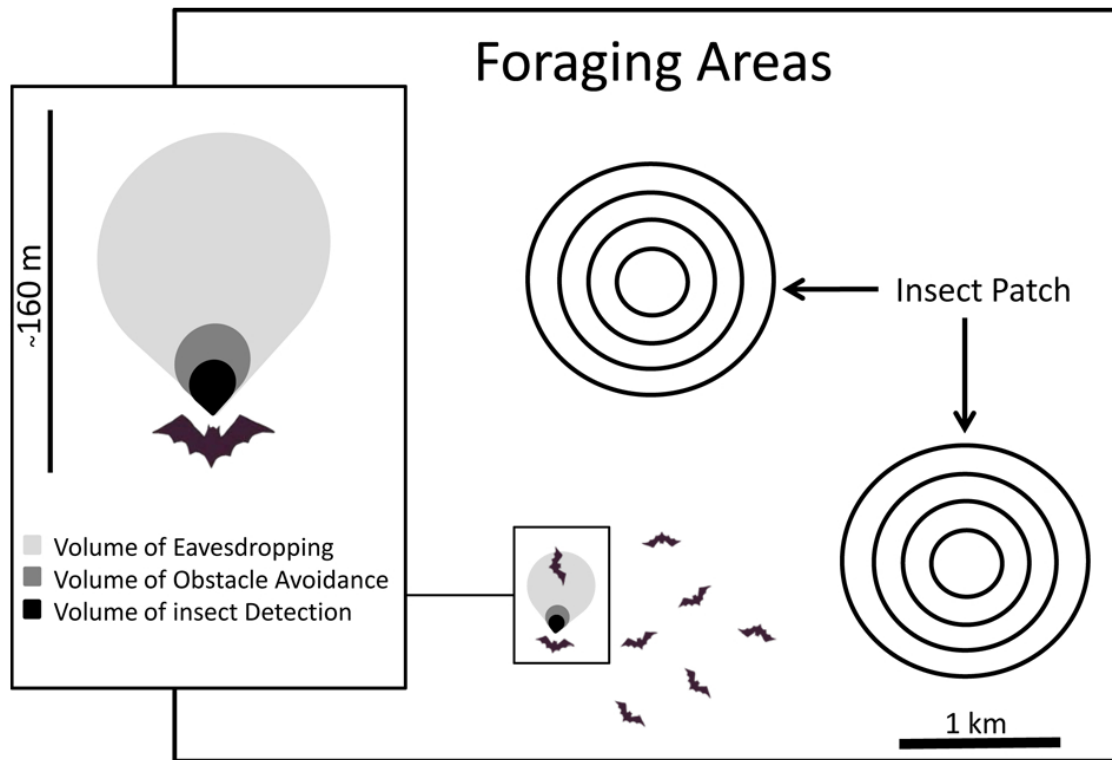


Ephemerality Drives Social Foraging



An Active-Passive Searching Swarm

The 'bag of chips effect'



An Active-Passive Searching Swarm

Social Search ($\rho = 0.6$)

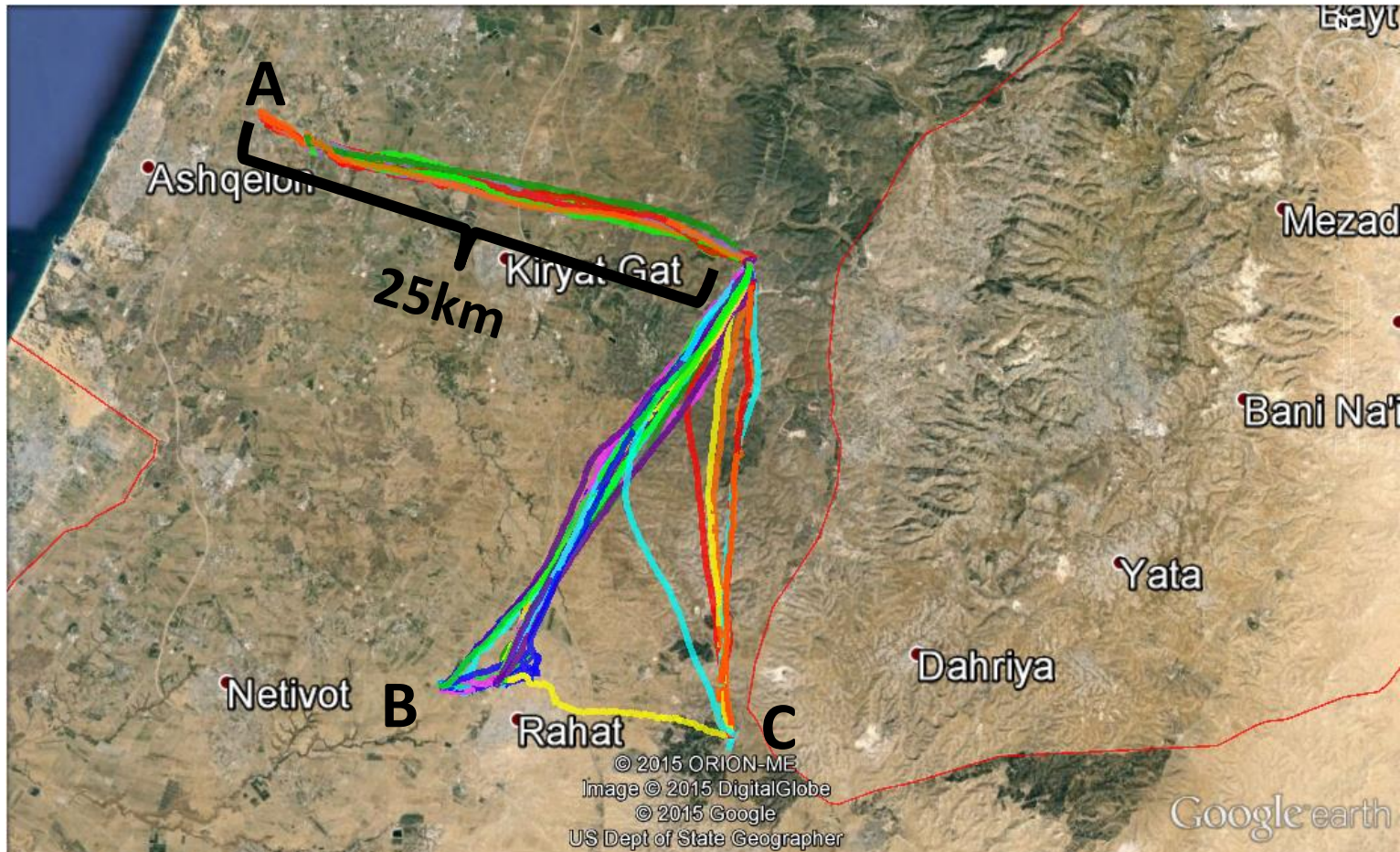
50 Agents, 1 Target

Area Size: $5km * 5km$

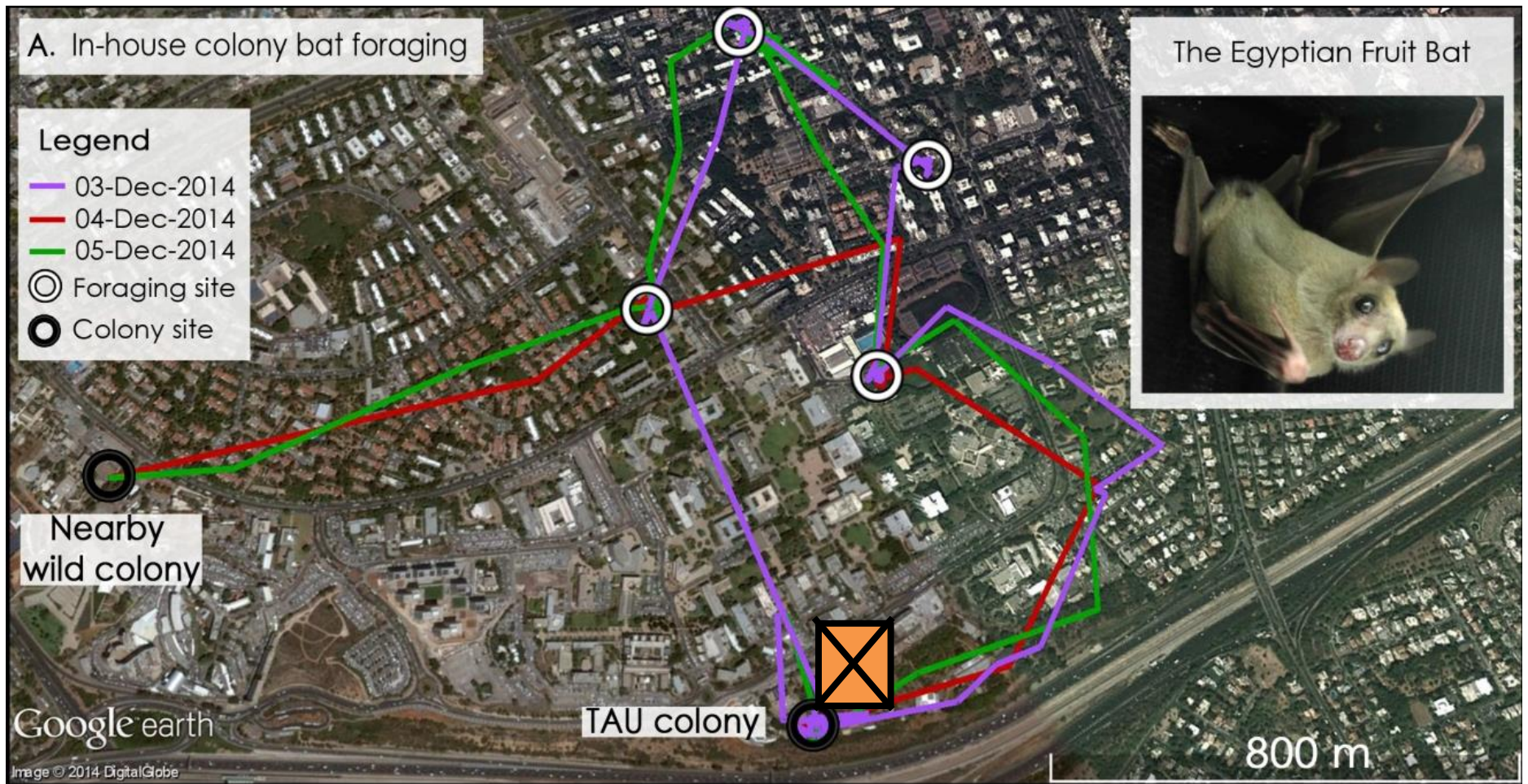


Studying Cognitive Maps in the Wild

~100 nights



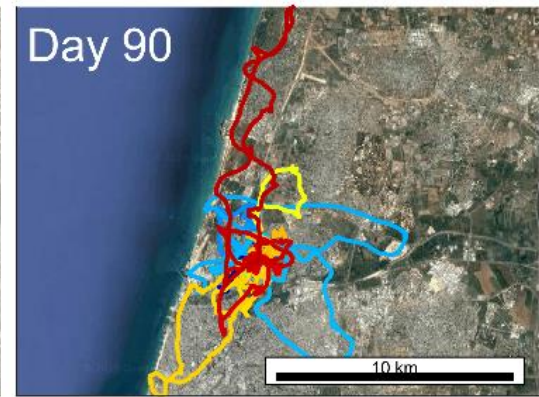
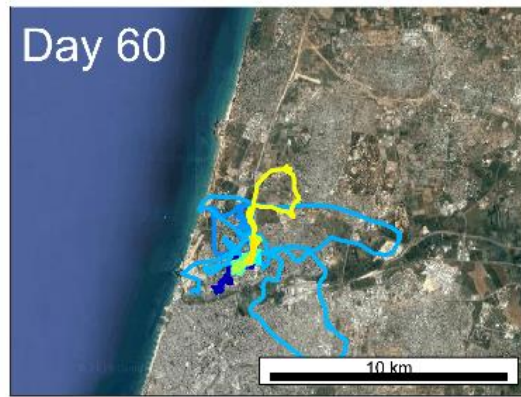
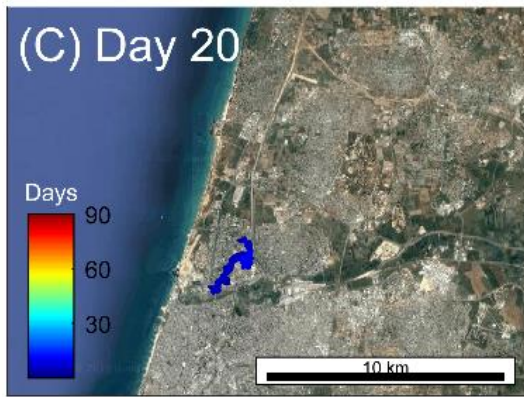
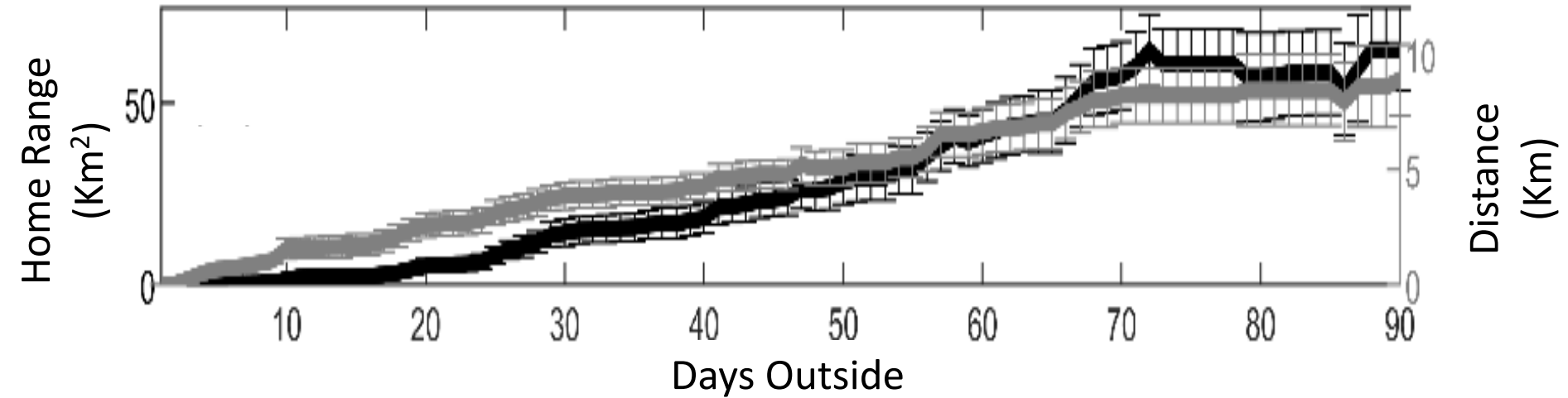
Our In-house Wild Colony



The 'Big Brother' approach



The Ontogeny of a Cognitive Map

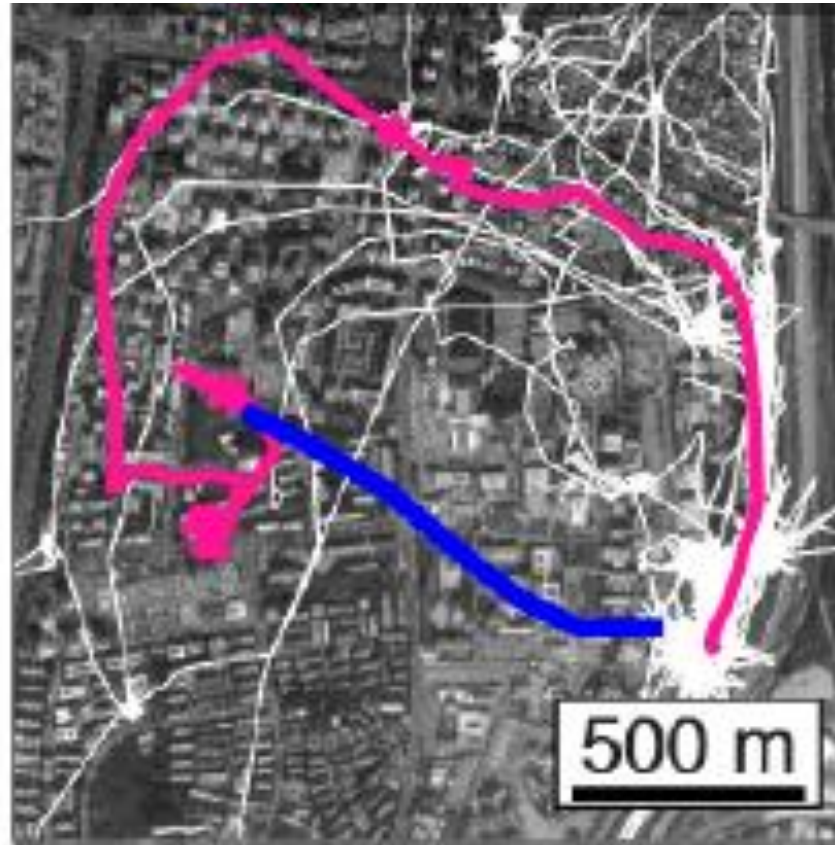


Bats Discover and Return to Familiar Trees

>1000 Trees Mapped



Bats Perform Novel Short-cuts

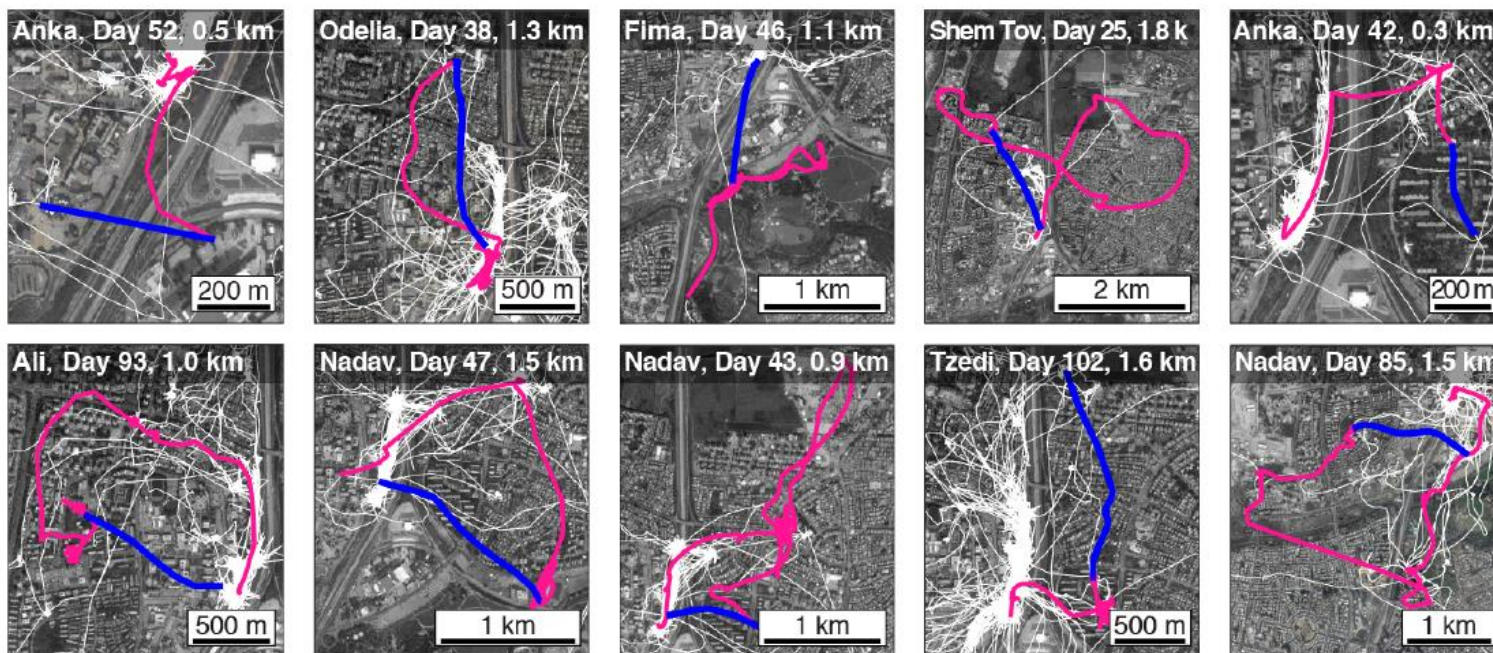


Harten et al. *Science*, (2020)



Bats Perform Novel Short-cuts

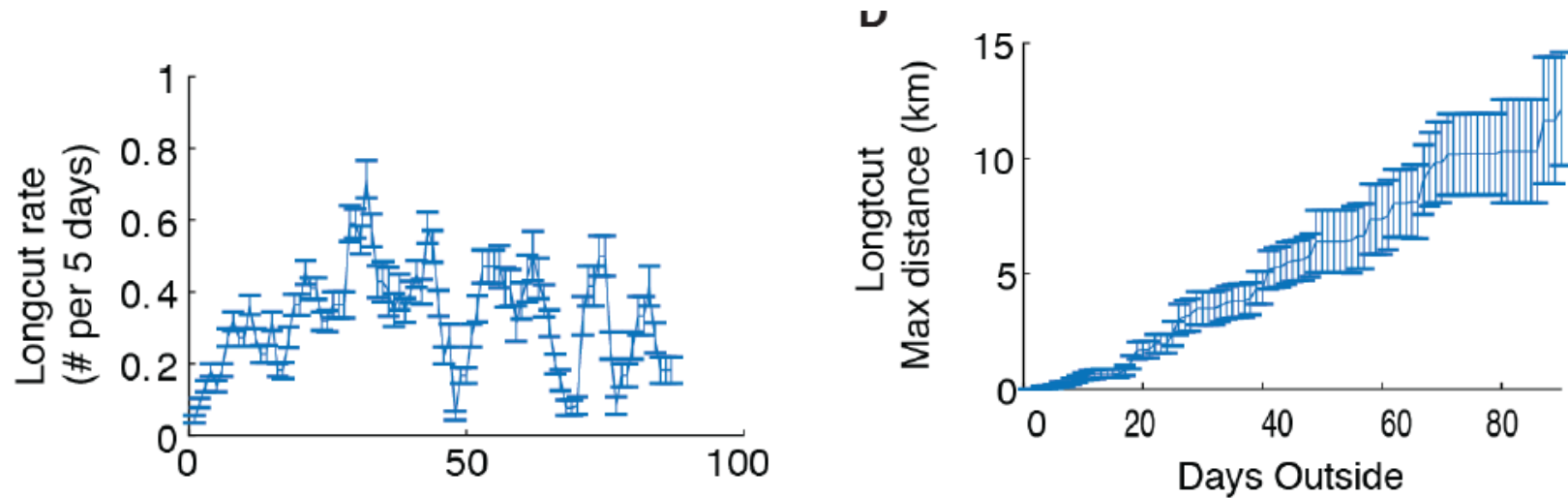
>100 Shortcuts detected, one every 8-9 days



Harten et al. *Science*, (2020)



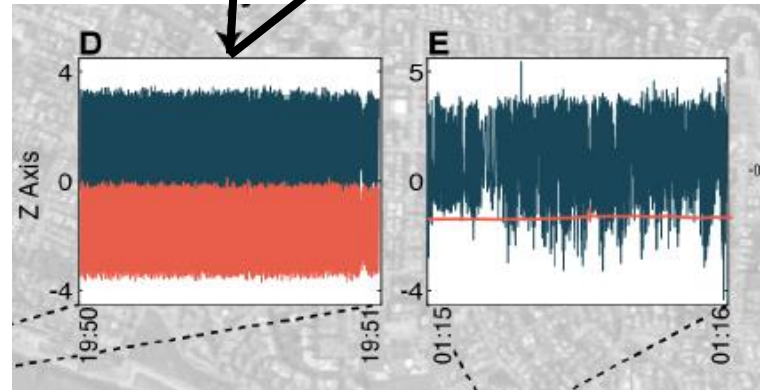
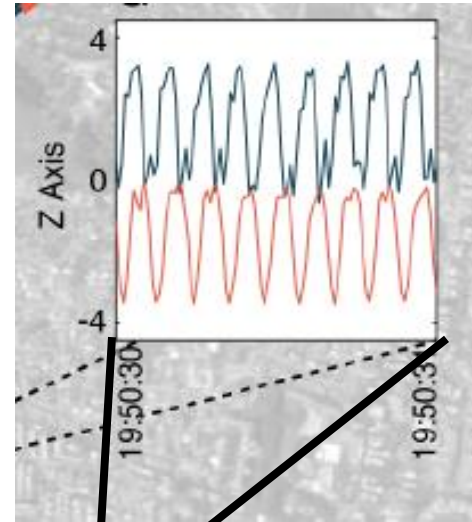
Short-cuts and Long-cuts are Performed from Day 1



Harten et al. *Science*, (2020)



Learning Upside Down



Our team

Yosef Prat, Eran Amichai, Noam Cvikel, Arjan Boonman, Katya Egert-Berg, Orit Dashevski, Lee Harten, Sasha Danilovitch, Aya Goldstein, Ofri Eitan, Mor Taub, Lindsay Azulay, Maya Weinberg, Stefan Greif, Edwards Hurme, Gal Schechter, Elad Asia, Michal Handel, Amir Zwiran, Shannon Currie.



Collaborators: N. Ulanovsky, G.Kosa, R.Page, R. Medellin, J. Rydell, H. Goerlitz, T. Weiss, G. Herrera, N. Bar, C. Moss, C. Voigt and D. Johnstone



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