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Chronoecology of the Cave Dwelling Orb-Weaver Spider, Meta ovalis (Araneae: Tetragnathidae)

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Chronoecology of the cave dwelling orb-weaver spider, *Meta ovalis* (Araneae: Tetragnathidae)

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A "Spiders on the Clock" Project

Abstract

Circadian clocks are endogenous time keeping mechanisms that are ubiquitous among animals. They enable coordination of many essential biological and metabolic processes in relation to the 24 hour light cycle on earth. However, there are many habitats on earth that are not subject to this light cycle. This study aims to look at the potential genetic drift of the circadian rhythm of a subterranean spider, *Meta ovalis*, (Fig 1) as well as gathering general natural history information on this under-studied spider. This study will fill general gaps in knowledge of this spider and its habitat, highlight the importance of studying organisms within a subterranean environment, and place importance on cave conservation and acquiring knowledge of these specialized, and sensitive species. This study integrates circadian and foraging theory to evaluate species as circadian specialists and generalists based on how narrowly or widely their activity is spread over the 24 h cycle (Fig 3). We suggest that *M. ovalis* benefits from a generalist strategy, showing small bursts of focused activity widely dispersed across the 24 h cycle, allowing it to capture prey opportunistically whenever it is available. Live spiders were collected from area caves, monitored in an environment controlled for light and temperature, and returned to their cave of origin. The activity of each spider was analyzed for differences in circadian activity among and between populations to determine if there is a significant drift of the circadian strategy between isolated populations of *Meta ovalis.* We expect to see a different circadian strategy implemented between populations due to drift from the spiders being isolated from other populations.

Introduction

Circadian Clocks in Spiders:

- Circadian clocks are ubiquitous among animals, including spiders[2,7,11-13]
- Circadian clocks may allow spiders to adaptively shift foraging behavior based on prey availability[5]
- Caves create isolated populations, potentially allowing genetic drift or local adaptation of the circadian clock

History of *M. ovalis:*

- Very understudied spider
- Found along Appalachian mountain range along eastern United States, within cave systems[9]

Circadian Specialist vs. Generalist Theory

- Spiders should adjust circadian strategy, based on the predictability of prey items (Fig 3)
- If the foraging window is narrow and predictable, a specialist strategy will be adopted (Fig 3 left)
- If the foraging window is broad and unpredictable, a clumped, even distribution will be adopted (Fig 3 right)

Research Question:

- How does living in an environment that does not oscillate between night and day affect an organism's circadian rhythm?
  - A) Under relaxed selection, free running period (FRP) should drift among isolated population
  - B) FRP should adaptively lengthen to reduce energetic costs of web-replacement
- Do organisms show different circadian strategies based on predictability of prey items?
  - A) *Meta ovalis* will show a generalist circadian strategy, showing small bursts of focused activity widely dispersed across the 24 h cycle, allowing it to capture prey opportunistically whenever it is available

Fig 1 Female *Meta ovalis*

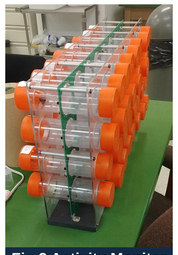
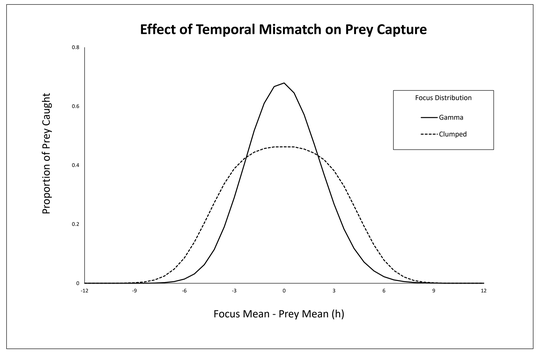


Fig 2 Activity Monitor set-up

Meta ovalis egg sack

Methods

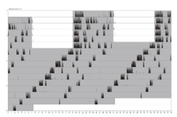
- Locate populations, collect specimens, and note depth from cave mouth for each
  - Specimens collected between June 2017 and January 2019
- Place spiders in activity monitor (Fig 2) recording 5 days of 12:12 Light Dark (LD), then 10 days of DD (total dark) to get free running period (FRP)
- Release spiders back in cave of origin at original depth



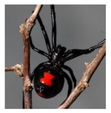
Gamma (& normal) distribution favored when foraging window is narrow and predictable

Clumped even distribution favored when foraging window is broad and unpredictable

Metazygia wittfeldae



Latrodectus mactans



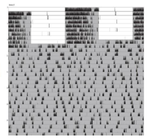
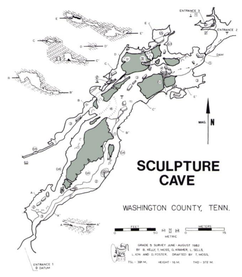
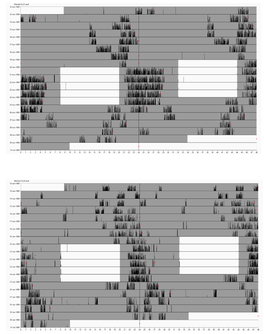


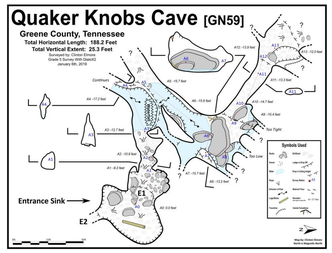
Fig 3. Specialist vs. Generalist foraging theory

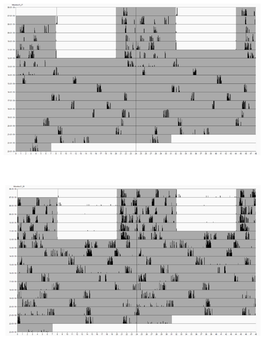




Samples from Sculpture Cave, Limestone TN: n=32

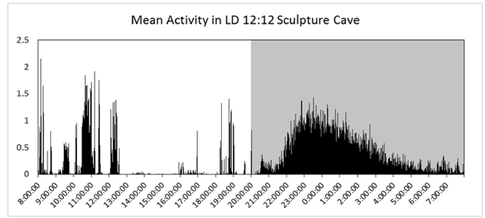
Show nocturnal activity under LD, but have significant variability between individuals

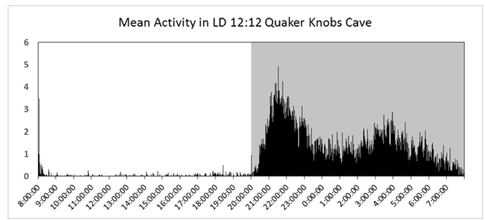




Samples from Quaker Knobs Cave, Chuckey TN: n=30

Show long (~27 hour) freerunning periods

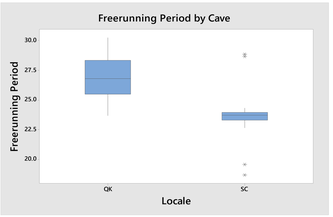




Entrainment Profiles

Results

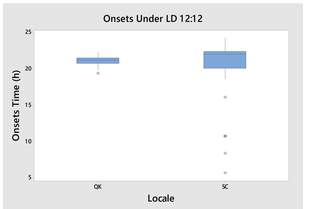
- Freerunning periods are significantly different between populations inhabiting Quaker Knobs Cave and Sculpture Cave (30 miles/ 48 kilometers between locations)

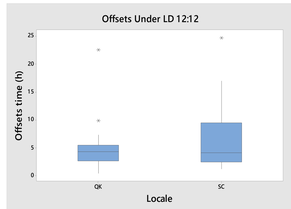


Locale	N	Mean	StDev
Quaker Knobs	25	26.89	1.71
Sculpture Cave	21	23.71	2.19

Analysis of Variance P-Value < 0.001

- Onsets and offsets of activity are not significantly different between locations





	Locale	N	Mean	StDev
Onsets	Quaker Knobs	29	21.18	0.67
	Sculpture Cave	25	19.81	5.16
Offsets	Quaker Knobs	29	4.90	3.96
	Sculpture Cave	25	6.92	5.87

Conclusions and Future Work

Conclusions:

- This research shows significant difference between populations of *M. ovalis* freerunning periods
- Sculpture cave shows nocturnal activity, with broadly spaced groupings of activity over a wide range during the 24 hour period
- Quaker Knobs cave shows an overall trend of long (~27 hr) freerunning periods

Future Studies:

- Locate additional caves to compare populations
- Comparative work with other species that dwell in the same type of environment
- Test prey capture reaction time in the field to test generalist vs. specialist working hypothesis
- Genetic analysis of circadian genes between populations
- Use of infrared cameras within natural habitat to analyze normal activity patterns, as well as general natural history

References and Acknowledgements

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ETSU Spider Lab

ETSU Fall 2017 Arachnology Course