Spider Orb Webs as Prey Traps: Effective on Moths?

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INTRODUCTION

HISTORY OF MOTHS AND SPIDERS

A long-standing hypothesis in behavioral ecology is that the detachable scales covering moths' bodies serve as a defense mechanism against the glue droplets of orb-weaving spiders. Glue droplets on the web stick to their scales which easily flake off, allowing the moth to fly away. There exist moth specialist families of spiders, such as *C. akirai*, whose glue can penetrate the scale and attach the scale to the underlying integument making the moth unable to escape capture.

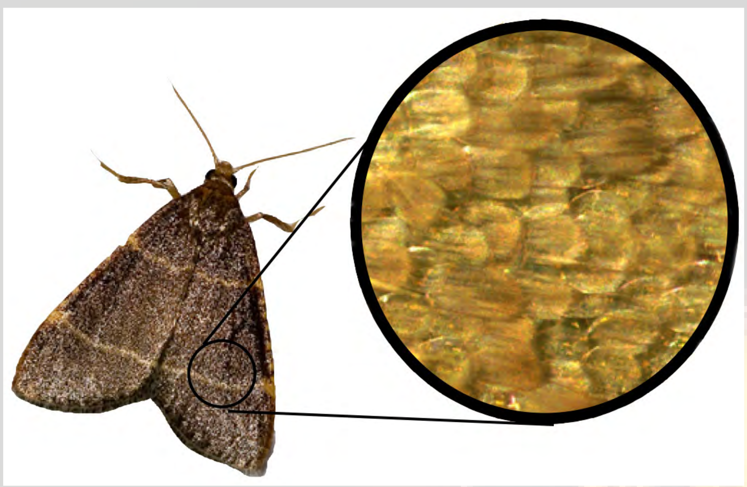

Figure 1. Closer look at the scale pattern of moths

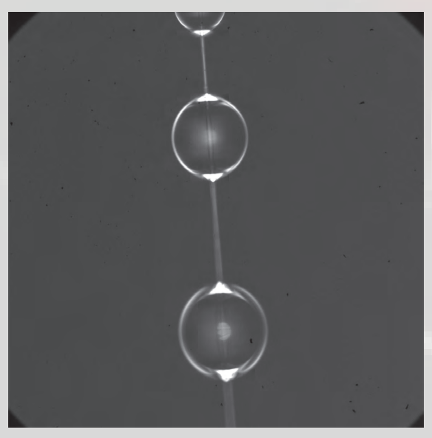

Figure 2. Aggregate glue droplets on a capture thread

IN THIS RESEARCH

Our objective is to study the behavior of moths as they are released onto spider webs and determine if moths are able to escape moth generalist webs consistently. Additionally, we want to analyze the structure and shape of various species of moth scales to deepen our understanding of the relationship between spider glue and the moth scales.

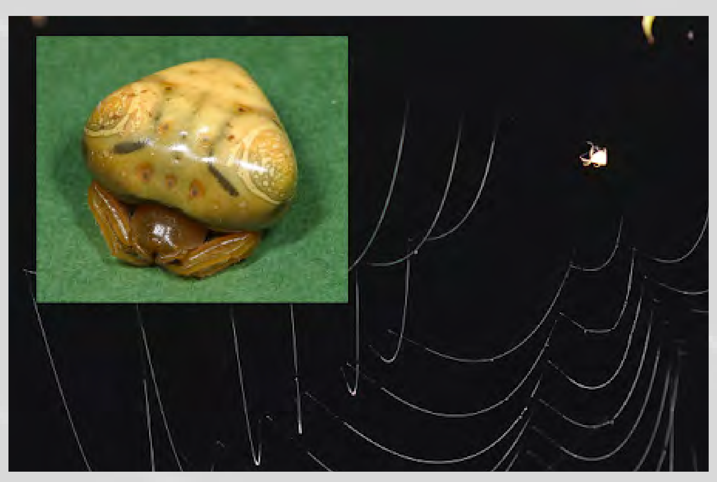

Figure 3. Moth-specialist Species, *Cyrtarachne akirai* (left)

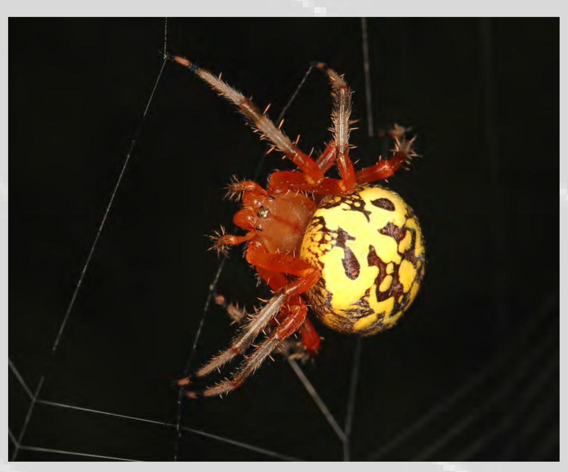

Figure 4. Traditional Orb-weaving Species, *Araneus marmoreus* (right)

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EXPERIMENTAL METHODOLOGY

1) Locate a vertical orb-web on the Vassar Farm and Ecological Preserve (42.676204, -73.894585)
2) Take weather measurements i.e. humidity, time of day, lux
3) Use a UV light to capture local moths looking for moths of similar size to the spider on the web
4) Illuminate the web using near-infrared light (careful to avoid shining directly onto the web as it might scare the spider)
5) Using a tripod set up the Basler Ace 2 -Pro NIR high-speed video camera (20 fps). Focus the camera and adjust the aperture, lighting
6) Open Python Viewer on the computer. Hit record
7) Take measurements of the web (ruler as a scale bar)
8) Release a moth onto the web; attempt to recapture
9) Collect the contacted web sample with the scales attached
10) Analyze the videos of the moths escaping for the capture rate of the moths and the retention time of moths on the web using Logger Pro
11) Analyze the photos of the web after moth collision for area of damage and area of scales left on web using ImageJ
12) Identify the families of the spiders and moths used
13) Use SEM and confocal to photograph the moth scales

Figure 3 and 4. A ruler is placed next to the web as a scale for the video (left) and a photo from the filming process (right)

RESULTS AND DISCUSSION

All 15 moths successfully escaped from the web. The retention time of moths on the web spanned from 0.04 seconds to 3.76 seconds, averaging 0.78 ± 1.09 seconds. Moths left a larger area of scales on the web than they damaged. The average area of damage by the moths on the web was $1.29 \times 10^{-4} \pm 1.60 \times 10^{-4}$ m^2, and the average area of scales left on the web was $1.14 \times 10^{-2} \pm 4.40 \times 10^{-2}$ m^2.

Figure 5. Photo sequence of a collision of a moth as it hits a spider web. The blue arrow tracks the moth. The yellow circle shows the area of damage and the scales shed by the moth

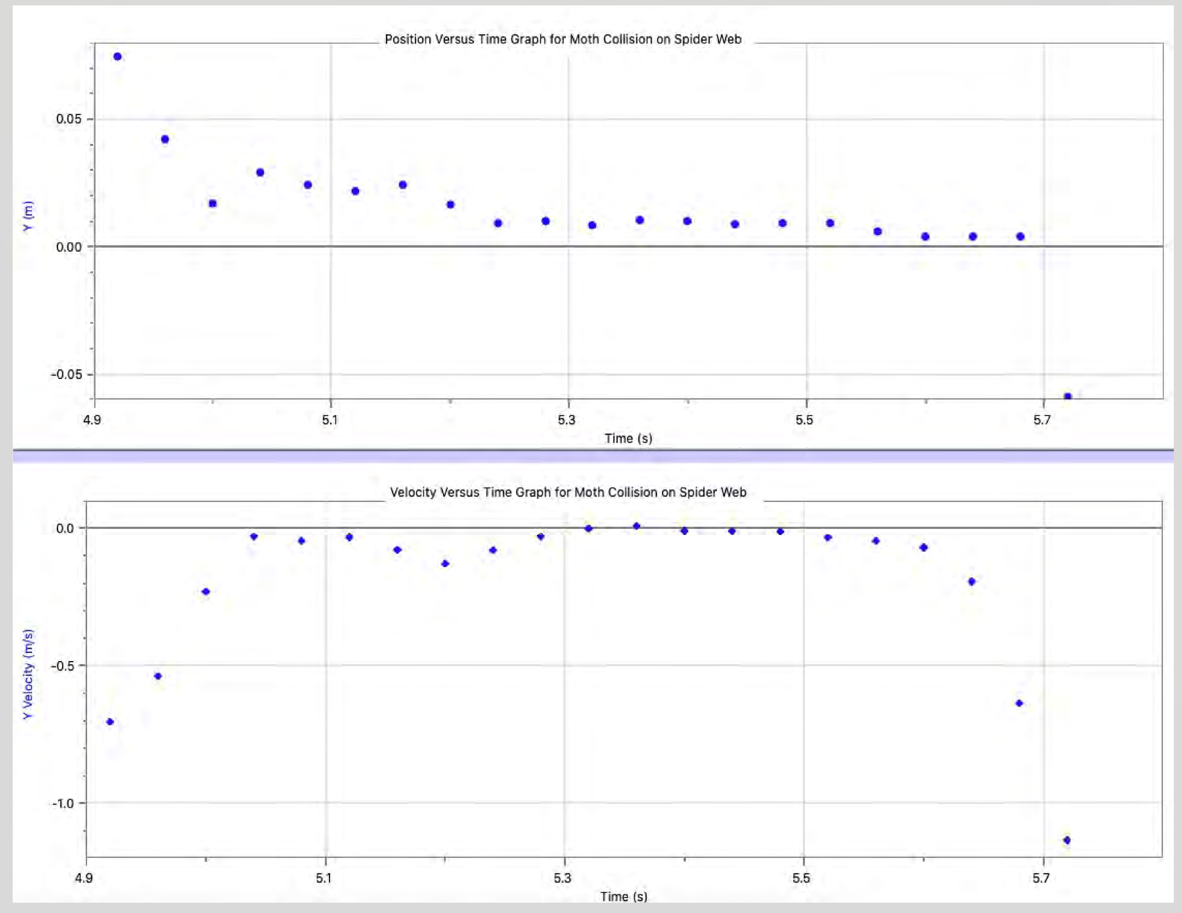

Figure 6. Moth position versus time and moth velocity versus time graph from Logger pro

CONCLUSION

These data suggest the evolutionary significance of spiders as a selection pressure on moths. As glue droplets are unable to overcome the scale shedding defense mechanism in traditional orb-webs. However, we acknowledge there is still more to know about moth spider interactions. When scales are dropped, they are not regenerated. If a moth were to hit a web with the part of its body that was scaleless, it might be more likely to become stuck. Another factor is the response time of the spider as retention time allows the prey to be caught by the spider. Although we did not witness this in the field, it is still possible. Moth spider interaction has many more avenues we'd like to analyze.

Figure 7. Scales left by a moth on spider web capture threads

RELATED LITERATURE

1. Diaz, Candido, et al. "The Moth Specialist Spider Cyrtarachne Akirani Uses Prey Scales to Increase Adhesion." Journal of The Royal Society Interface, vol. 17, no. 162, 2020, p. 20190792., doi:10.1098/rsif.2019.0792.

2. Fuller, Billy W. "Predation by Calleida Decora (F.) (Coleoptera: Carabidae) on Velvetbean Caterpillar (Lepidoptera: Noctuidae) in Soybean." Journal of Economic Entomology, vol. 81, no. 1, 1988, pp. 127–129., doi:10.1093/jee/81.1.127.

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