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In the Eyes of the Beholder: Rapid Body Color Change Provides Facultative Crypsis in a Lizard

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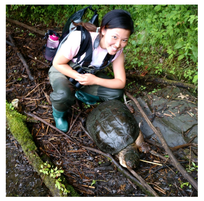

In the Eyes of the Beholder: Rapid Body Color Change Provides Facultative Crypsis in a Lizard

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Introduction

- Many animals use body coloration to avoid predation via camouflage[1]
- However, whether whole-body rapid color change provides camouflage with respect to predators' visual systems in variable environments is largely unknown
- The water anole (*Anolis aquaticus*) is a small, color-changing lizard (Fig 1) that occupies a range of microhabitat substrates, from rock crevices, walls, and mossy banks[2,3]
- Does whole-body color change provide water anoles with camouflage against avian predators?
  - Color matching
  - Pattern matching
  - Disruptive coloration

Figure 1. A) Water anole immediately after capture from a rock crevice and B) 2 minutes later.

Methods

- Water anoles were captured in the field and were then tethered to one of three treatment types (Fig 2)
- Each lizard and corresponding substrate were photographed after 60 minutes of tethering
- Visual models using avian color vision and acuity were created using the Mica Toolbox[4,5] in ImageJ (Fig 3)
- We calculated color (Fig 4) and pattern overlap between each lizard and its substrate. We also quantified edge disruption (how coloration breaks up an outline against a substrate)
- Linear mixed effects models were used to determine the relationships between color change on different substrate treatments

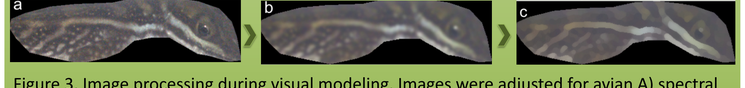

Figure 3. Image processing during visual modeling. Images were adjusted for avian A) spectral sensitivities, B) acuity at a distance of 0.75 m, and C) reconstruction of sharp edges.

Results

- Color matching is greater on solid exposed and unexposed substrates than on heterogeneous and exposed substrates

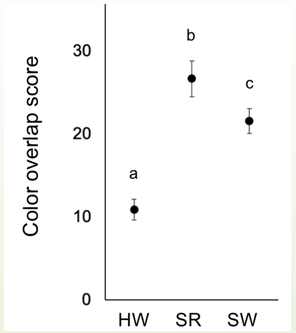

Figure 5. Color overlap score for each treatment type (heterogeneous wall (HW), solid colored refugia (SR), and solid colored wall (SW)). Bars indicate standard error.

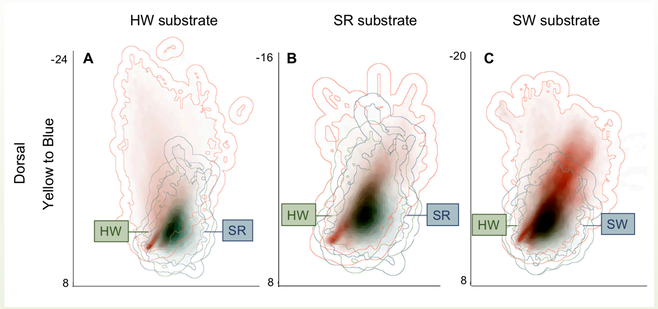

Figure 4. Color maps depicting total color overlap between lizards and substrate. (Heterogeneous wall (HW), solid colored refugia (SR), and solid colored wall (SW)). Red cloud indicates average colors in each treatment type, with blue and green clouds indicating average color of matched and mismatched lizards.

Figure 2. Examples of substrate types used in each treatment and corresponding lizard color change. A) heterogenous exposed wall (mossy boulder) B) solid colored, unexposed substrate (rock crevice) C) solid colored, exposed substrate (riverbank wall).

- Edge disruption is greater on exposed substrates, regardless of substrate color
- Pattern matching did not differ among treatments

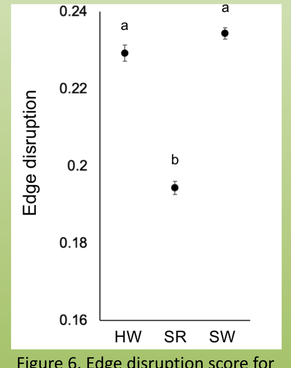

Figure 6. Edge disruption score for each treatment type. Bars indicate standard error. Lowercase letters indicates significant differences at p= 0.05.

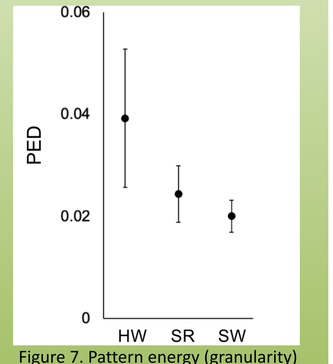

Figure 7. Pattern energy (granularity) differences between lizards and substrates. Bars indicate standard error. Pattern energy refers to the most prevalent pattern markings based on measured pattern size.

Acknowledgements

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Discussion

- Water anoles use color change to flexibly alter their camouflage among their varied microhabitats:
  - Color matching on solid-colored substrates (Fig 5)
  - Disruptive coloration on exposed substrates (Fig 6)
  - No evidence of pattern matching as camouflage (Fig 7)
- Water anoles may utilize color change to optimize both antipredator adaptations and social signaling
- Disruptive coloration may be a more important aspect in exposed substrates where color matching may not be sufficient camouflage

Conclusions

- Overall, rapid body color change reduces conspicuity of water anoles to avian predators; this is unusual in lizards
- Some aspects of color change in water anoles may also play roles in social signaling and thermoregulation, which has yet to be explored
- Whole-body, ecologically relevant visual models can be used to give a more comprehensive picture of the ways in which color change is used in camouflage across taxa

References

1. Stevens, M., and S. Merilaita. 2011. Animal camouflage: Mechanisms and function. Animal Camouflage: Mechanisms and Function.
2. Savage, J. M. 2005. The amphibians and reptiles of Costa Rica: A herpetofauna between two continents, between two seas. University of Chicago Press, Chicago.
3. Márquez B., C., L. R. Márquez R., S. Rea P., and J. Márquez R. 2009. Demografía de la población de *Anolis aquaticus* (Sauria Polychrotidae) de la quebrada La Palma, Puriscal, Costa Rica. Revista Ecuatoriana de Medicina y Ciencias Biológicas 30:62–77.
4. van den Berg, C. P., J. Troscianko, J. A. Endler, N. J. Marshall, and K. L. Cheney. 2020. Quantitative Colour Pattern Analysis (QCPA): A comprehensive framework for the analysis of colour patterns in nature. Methods in Ecology and Evolution 11:316–332.
5. Troscianko, J., and M. Stevens. 2015. Image calibration and analysis toolbox - a free software suite for objectively measuring reflectance, colour and pattern. Methods in Ecology and Evolution 6:1320–1331.

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