Too Cool for Camouflage?: The Effects of Dive-Related Thermal Loss on Body Coloration in a Semi-Aquatic Lizard

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Introduction

- Rapid body color change is well documented in animals, and can be affected by many factors, including stress, ambient temperature, light, or substrate type.[1]

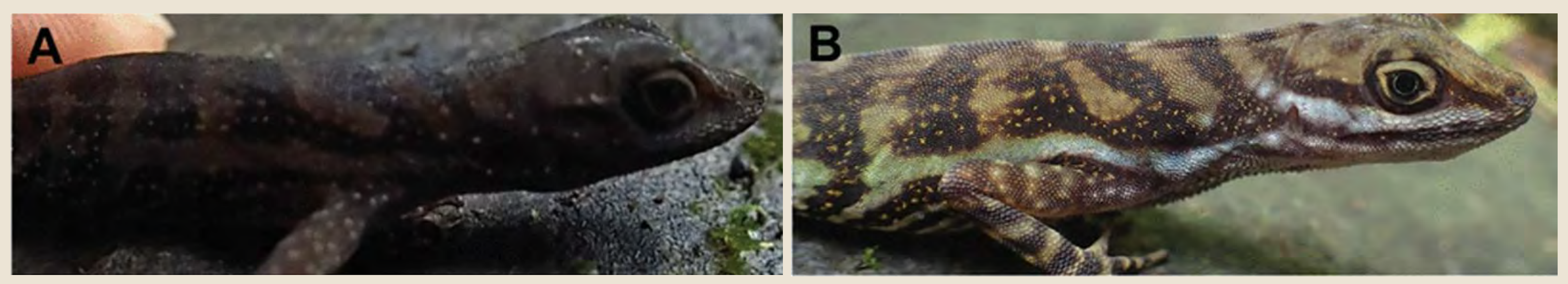
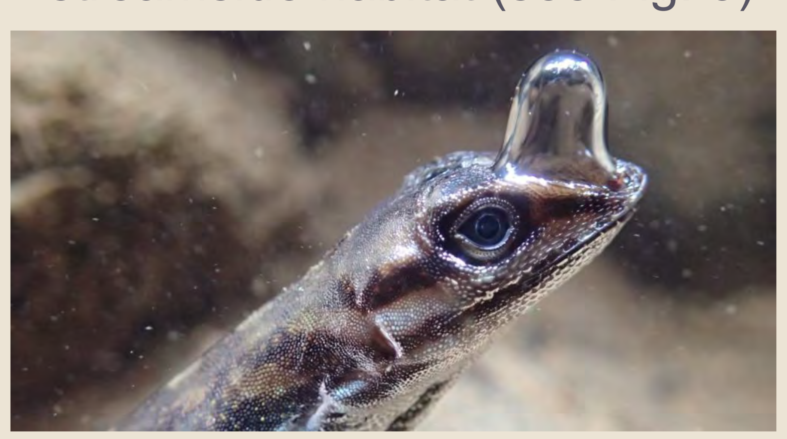


Fig. 1: Example of the color change capacities of *Anolis aquaticus*, Used with permission from Wuthrich et al. 2022

- *Anolis aquaticus* is one species that undergoes rapid body color change, switching between dark browns and lighter browns and green (see Fig. 1)
- This can serve many different functions—like thermo-regulation[1] and, in *A. aquaticus*, it provides camouflage[2] (see Fig. 2) in its streamside habitat (see Fig. 3)



When fleeting from predators, *A. aquaticus* can dive underwater for up to 20 minutes which causes them to lose several degrees of body heat (see Fig. 2).[3]

Fig. 2: *Anolis aquaticus* will dive underwater to flee from predators

- ***A. aquaticus* is a species that doesn't like to bask for warmth, so how does it recover warmth?**

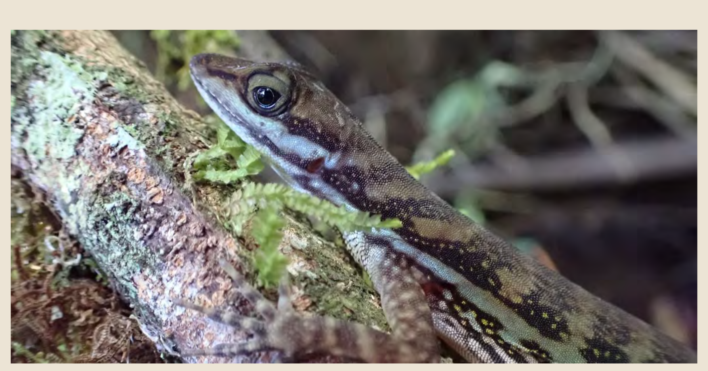


Fig. 3. *A. aquaticus* perched on a branch

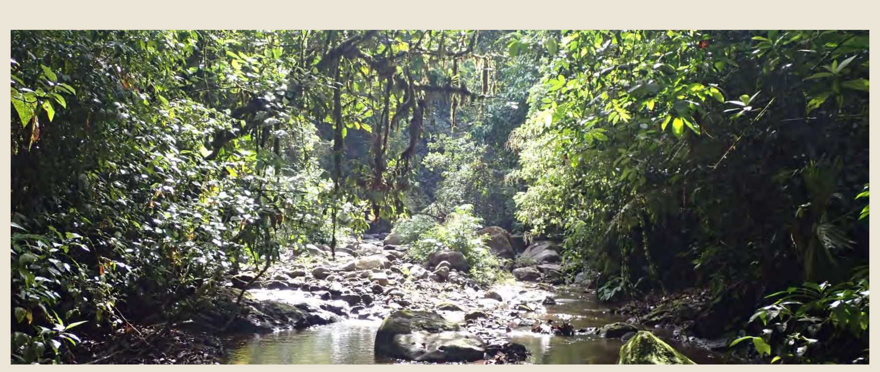


Fig. 4 Field sampling site, Coto Brus, Costa Rica

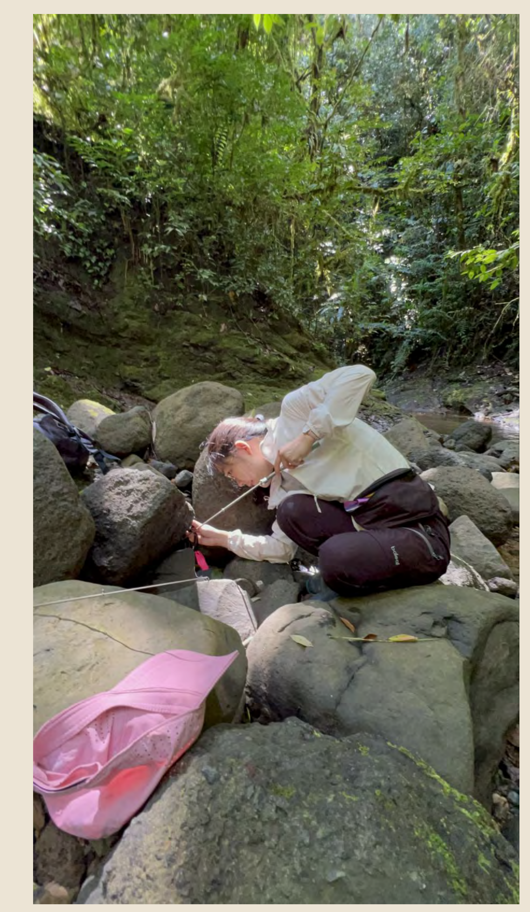
- Darker colors allow for greater heat absorption, and other species, like chameleons have been found to use color change for thermoregulation, turning darker when faced with colder body temperatures.[4]

Hypothesis

- Color change is influenced by body temperature.
- Cooler temperatures will darken body coloration in *A. aquaticus*.

Photography Methods

- **Field:** Photos were taken immediately after capture (n=44), along with body surface temperature and substrate temperature
- **Lab:** Lizards were randomly assigned to control (room temperature, 23C, n=30) or experimental (cool, 18C, n=30) groups.
- Photographs were taken before and after treatments.
- Standard photography methodology were used, including consistent lighting conditions with a color standard.[5]



Visual Modelling

- Visual models were created from lizard body color photos to quantify color and amount of camouflage using the QCPA and the MICA toolbox in ImageJ[5] (see Fig. 5)

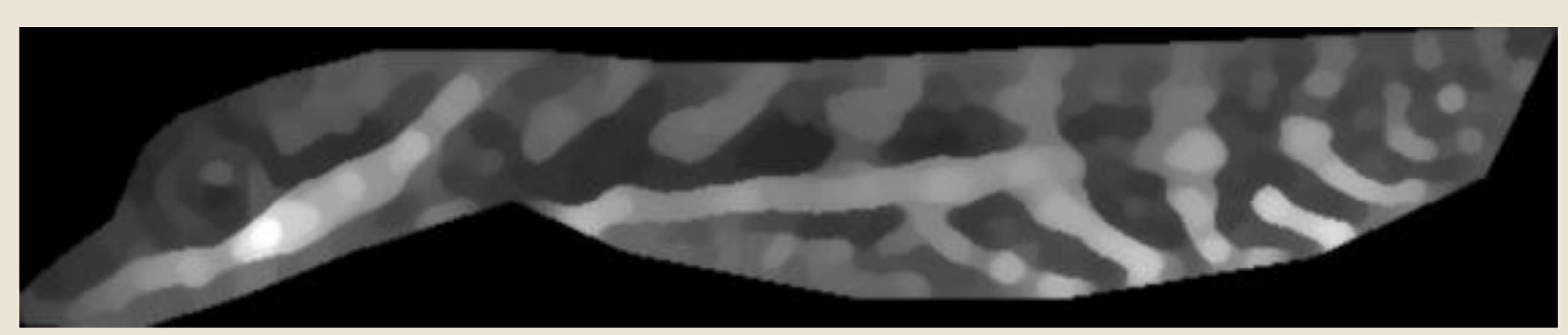


Fig 5. Example image after noise reduction and edge reconstruction, corrected for an avian visual system. Only one visual channel "slice" shown. Pixels are compared to their neighbors, ranked on similarity, and then smoothed more with its similar neighbors than different neighbors.

- **Field:** We used linear models to test how sex, body size, and body temperature affected color variables (see Table 1).
- **Lab:** We used linear mixed models[6] to test how treatment, sex, body size, and period (before/after treatment) affected color variables, with ID as a random effect (see Table 2).

References

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Field Study

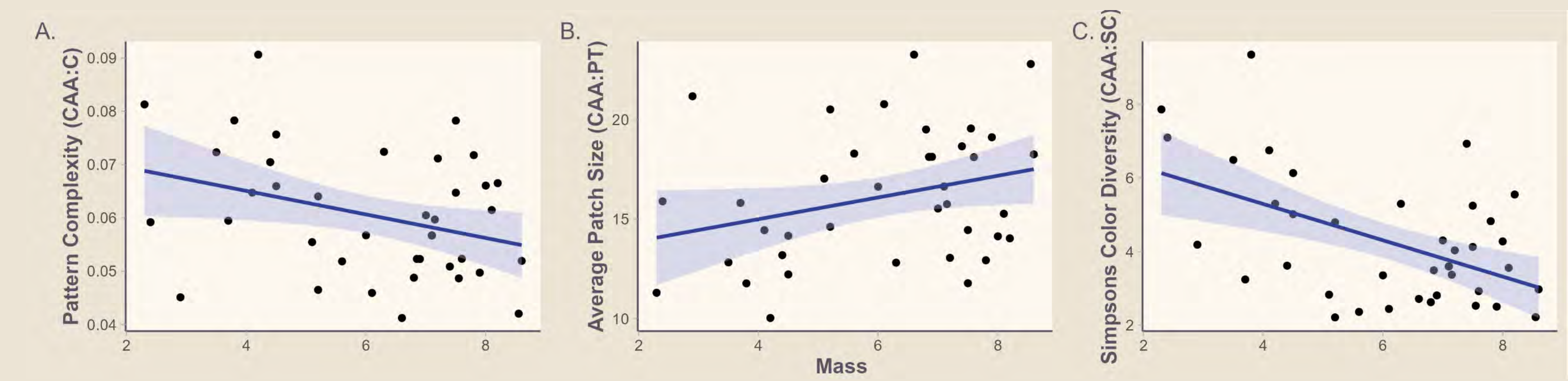

Fig. 5: Effect of mass on 3 color variables for field trials

- Lizards appear to get darker with increasing mass.
- Larger lizards tend to take longer to warm up because of lower thermal inertia, so they may be darker to help absorb more heat

	Sex		Mass		Temperature	
Variable	F-Statistic	P-Value	F-Statistic	P-Value	F-Statistic	P-Value
CAA.C	1.001	0.324	5.233	0.028	0.055	0.816
CAA.PT	0.92	0.344	4.229	0.047	0.384	0.539
CAA.SC	1.456	0.235	14.461	0.001	0.435	0.514

Table 1. Effect of various predictor variables on 3 color variables used as responses in linear mixed models.

Lab Study

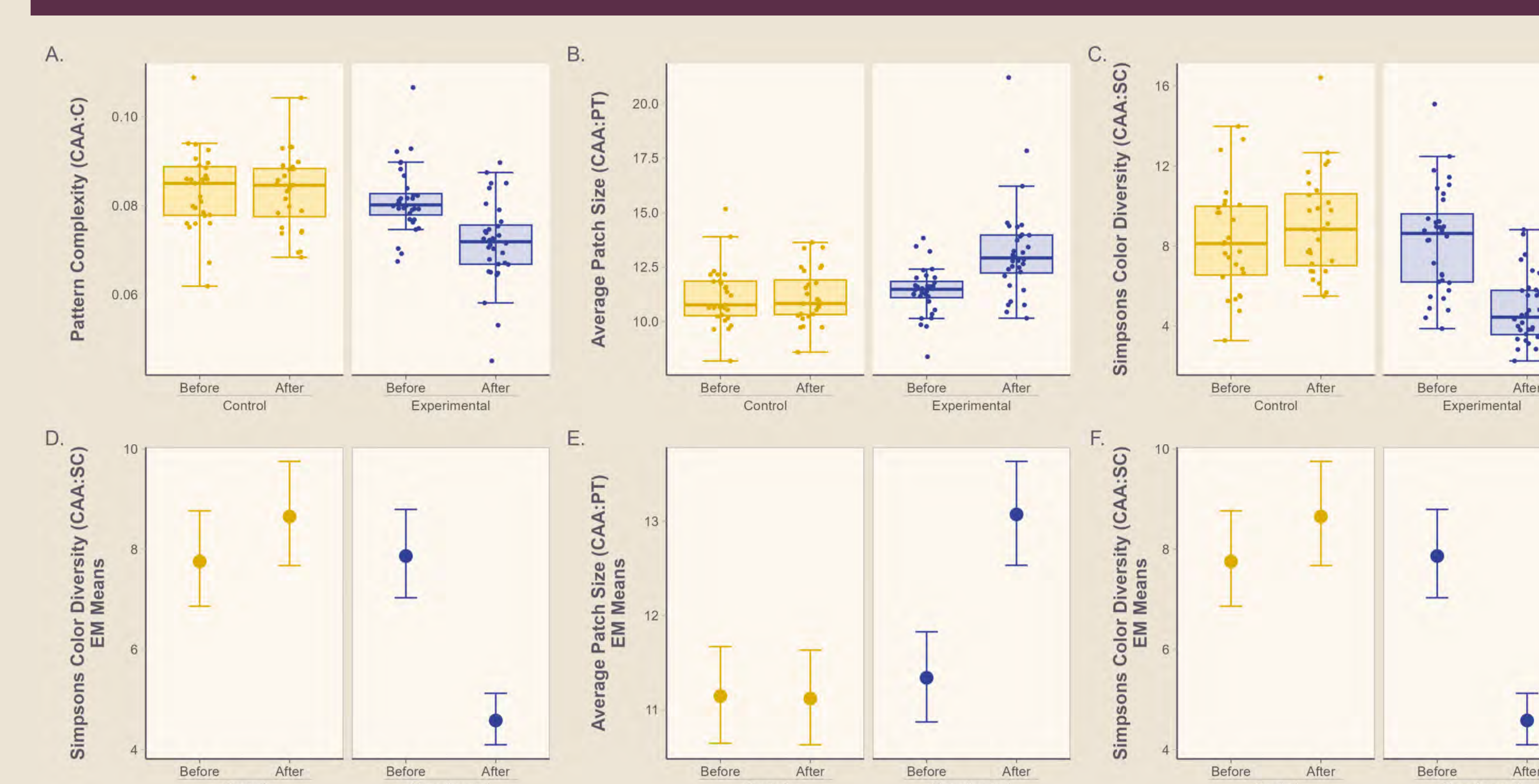

Fig. 6: Cold (blue), or control (yellow) treatment on 3 color variables

- Lizards are darker after losing body heat to 'simulated dives'
- They may turn darker in order to warm up faster at the cost of being more conspicuous.

Variable	x^2	P-Value	Cohen's D	Relative Size
CAA:C	16.910	<0.001	-1.070	High
CAA:PT	17.911	<0.001	1.101	High
CAA:SC	39.505	<0.001	-1.624	High

Table 2. Effect of treatment (cold or control temperature) on 3 color variables used as responses in linear mixed models.