Hidden in Plain Sight: Multi-Purpose Defensive Coloration in *Papilio polyxenes*

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Background Information

- Anti-predator mechanisms can take the form of defensive coloration. Examples of defensive coloration include crypsis, aposematism, mimicry, and intimidation [1].
- The efficacy of defensive coloration is dependent on the distance the prey is being viewed at and the visual acuity of the perceiving predator [2].
- Some species of animals demonstrate more than one form of defensive coloration. This is beneficial in the scenario that one form of defensive coloration proves ineffective.
- The black swallowtail butterfly's (*Papilio polyxenes*) larvae demonstrates aposematic coloration, disruptive camouflage, and polyphenism.
- Previous studies on the black swallowtail caterpillar have not focused on how relevant predator visual systems impact the efficacy of defensive coloration.

Research Goals

1. Demonstrate how caterpillar patterns are viewed and utilized within relevant visual systems.
2. Examine the polyphenism and pattern elements of the black swallowtail caterpillar and their usage as defensive coloration.

Results

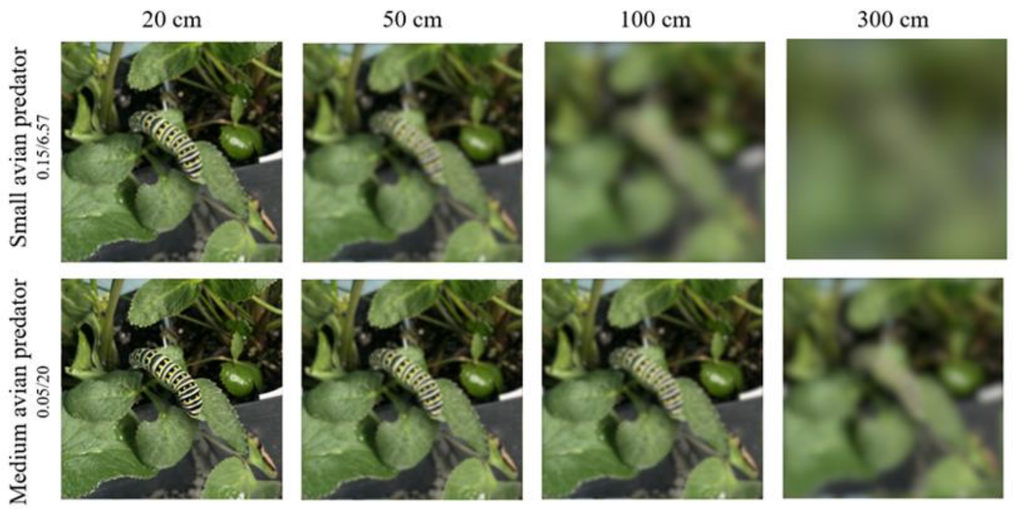

Figure 1. A caterpillar as viewed from three distances by a small and medium avian predator. For the small avian predator, the bands and circles begin to degrade at 50 cm, and the caterpillar pattern elements are completely indistinct from 100 cm away. The medium avian predator does not become indistinct until around 300 cm away. Row labels show the visual acuity of the avian predator in degrees/cycles per degree.

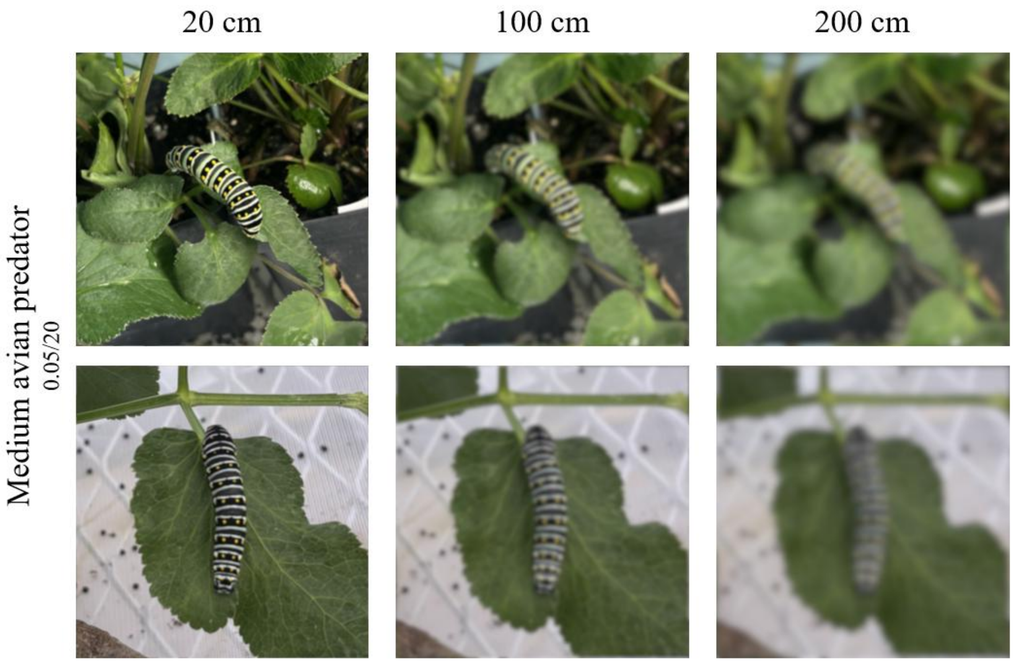

Figure 2. Differences between the phenotypes of the black swallowtail caterpillar. When analysis was run via AcuityView, both black and green phenotypes' patterns degraded at the same distances, though the degraded appearances remained distinct in coloration.

Literature Cited: [1] Caro & Allen, 2017, [2] Caves et al., 2018, [3] Caves & Johnsen, 2017

Methods

This experiment was done in two parts:

1. Caterpillar photos were run through AcuityView, an R package [3], to simulate how the photo would appear given a specific visual acuity and at certain distances.
2. Photos of caterpillars were taken from top and side views. Then the images were imported into ImageJ, where several pattern and color measurements were taken for each photo.

Results (cont.)

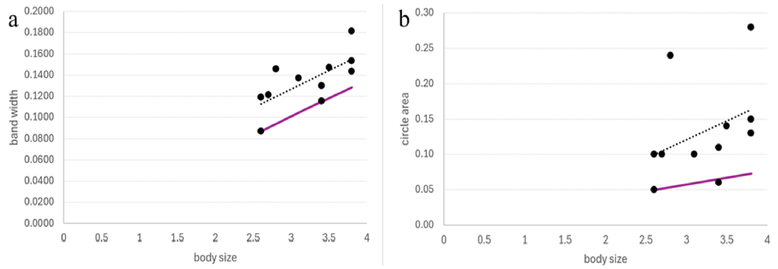

Figure 3. Effects of body size on the pattern of the black swallowtail caterpillar. Purple lines demonstrate expected results if pattern was scaling with size, while black dotted lines indicate actual slope of data. Body size has a significant impact on band width ($n = 11$, $p < 0.05$), while body size has no significant impact on the average area of the circles ($n = 11$, $p > 0.05$).

Conclusions

- No difference was found between coloration percentage of the two phenotypes, and phenotype did not have an impact on how avian predators viewed the caterpillars.
- The phenotypic differences are a result of seasonal polyphenism where the black phenotype serves to achieve optimal crypsis when surrounding flora is less vibrant, and vice versa for the green phenotype.
- Pattern elements generally had no significant differences between the top and side views, potentially due to the small size and simplistic body plan of the caterpillars.
- Pattern elements did not scale consistently with body size.
- The caterpillar's camouflage appears to be relatively effective when viewed by selected avian predators.
- The bands on the caterpillar assist in disruptive camouflage, while the yellow spots are both aposematic and add to the disruptive camouflage.

Acknowledgements

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