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Seeing the Unseeable

Ultraviolet Reflectance, Aposematism and Mimicry



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Aposematism



Vespa crabo

Aposematism and Mimicry



Vespa crabo



Volucella zonaria

Imperfect Aposematism







Picture credits (LR/TB): 1&3 Leeds Swifts via FB; 2 Vassilis Kosteres via Flickr; 4 AJD; 5 Ian Gillan via FB; 6 Tracy Farrer Flickr; 8 Mike Barron via FB

Imperfect Aposematism & Imperfect Mimicry










Picture credits (LR/TB): 1&3 Leeds Swifts via FB; 2 Vassilis Kosteres via Flickr; 4&7 AJD; 5 Ian Gillan via FB; 6 Tracy Farrer Flickr; 8 Mike Barron via FB

Imperfect Mimicry - Mapping & Modelling

- Biodiversity & Mimicry Lab
  - University of Nottingham, UK
- How perfect does a mimic need to be?

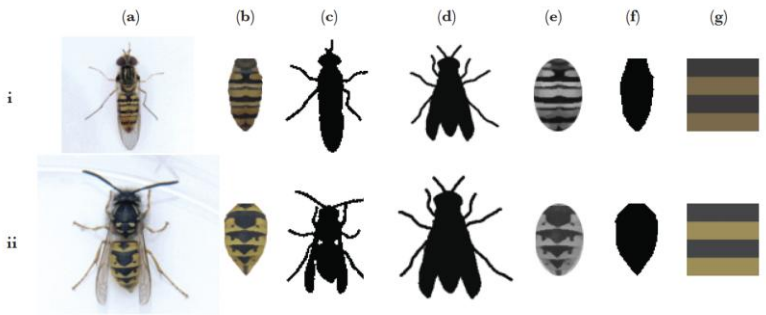


Figure 1
Examples of image types used in the online quiz. These images are shown at the same resolution as they appeared to participants. a) Complete. b) Abdomen. c) Shape. d) Size. e) Abdomen pattern. f) Abdomen shape. g) Abdomen color. i) Images of *Episyrphus balteatus*. ii) Images of *Vespula vulgaris*.

C. H. Taylor, J. Warrin, F. Gilbert and T. Reader: Behavioral Ecology 2016 Vol. 28 Issue 2 Pages 460-470

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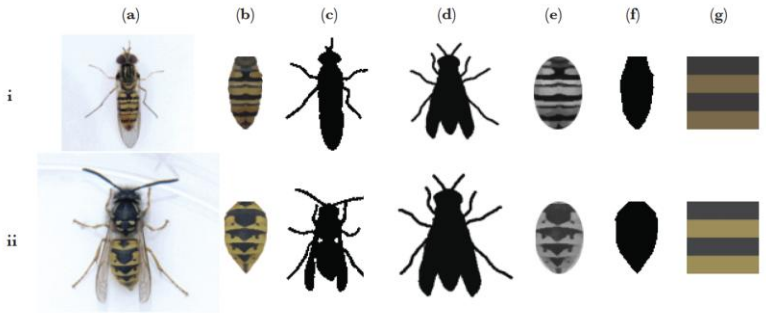


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nature

Article

Mapping the adaptive landscape of Batesian mimicry using 3D-printed stimuli

https://doi.org/10.1038/s41586-025-09216-3
Received: 27 March 2024
Accepted: 29 May 2025
Published online: 2 July 2025
Open access
Check for updates

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In a classic example of adaptation, harmless Batesian mimics gain protection from predators through resemblance to one or more unpalatable models[1,2]. Mimics vary greatly in accuracy, and explaining the persistence of inaccurate mimics is an ongoing challenge for evolutionary biologists[3,4]. Empirical testing of existing hypotheses is constrained by the difficulty of assessing the fitness of phenotypes absent among extant species, leaving large parts of the adaptive landscape unexplored[5]—a problem affecting the study of the evolution of most complex traits. Here, to address this, we created mimetic phenotypes that occupy hypothetical areas of trait space by morphing between 3D images of real insects (flies and wasps), and tested the responses of real predators to high-resolution, full-colour 3D-printed reproductions of these phenotypes. We found that birds have an excellent ability to learn to discriminate among insects on the basis of subtle differences in appearance, but this ability is weaker for pattern and shape than for colour and size traits. We found that mimics gained no special protection from intermediate resemblance to multiple model phenotypes. However, discrimination ability was lower in some invertebrate predators (especially crab spiders and mantises), highlighting that the predator community is key to explaining the apparent inaccuracy of many mimics.

Is Ultraviolet Significant?



Vespula vulgaris

Is Ultraviolet Significant?



Vespula vulgaris

Is Ultraviolet Significant?



Vespula vulgaris



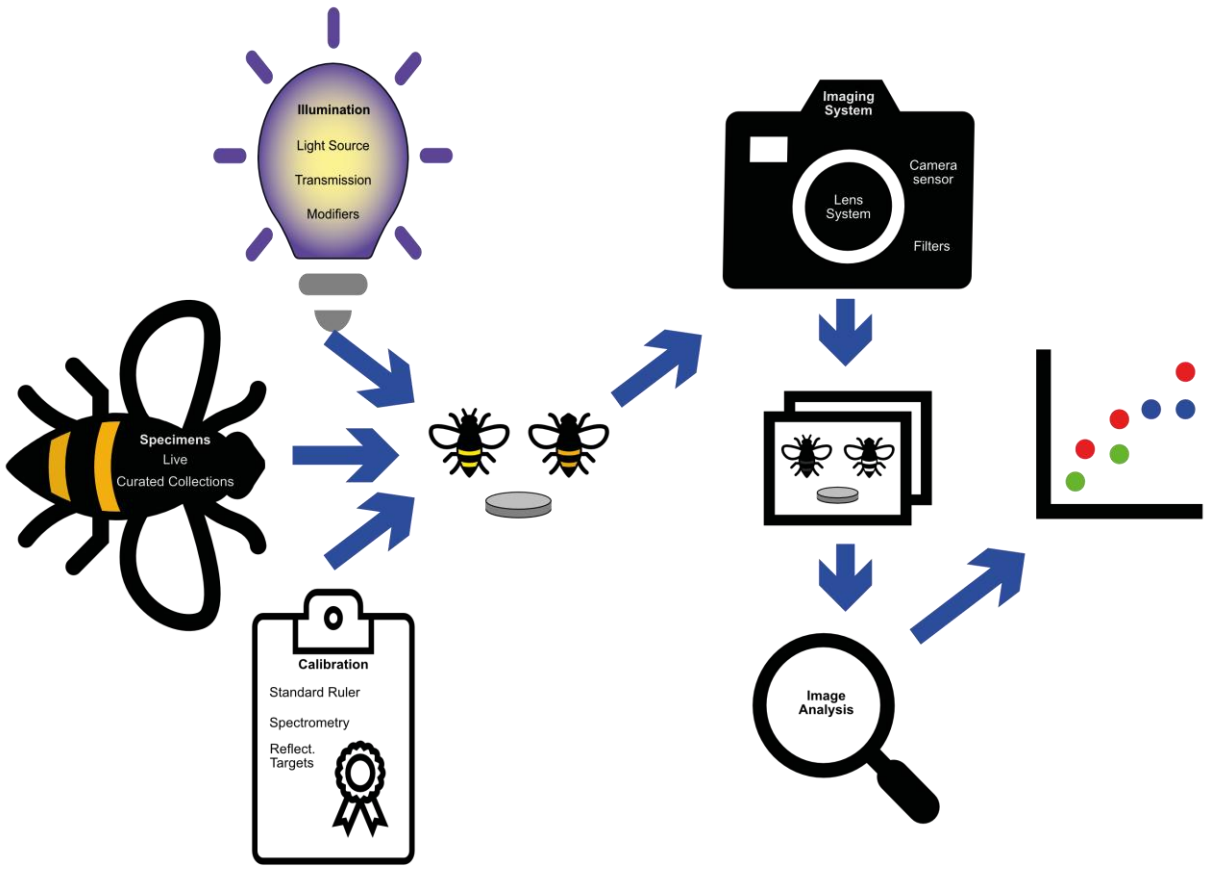
Myathropa florea

Project Outline

- Develop photogrammetric methods to measure insect UV and visible patterns
- Survey wasp-mimicking Syrphids and their putative Hymenopteran models
- Assess how preservation method effects UV and visible patterning
- Investigate UV-induced visible fluorescence
- Use cone-catch and acuity models in the context of aposematism and mimicry



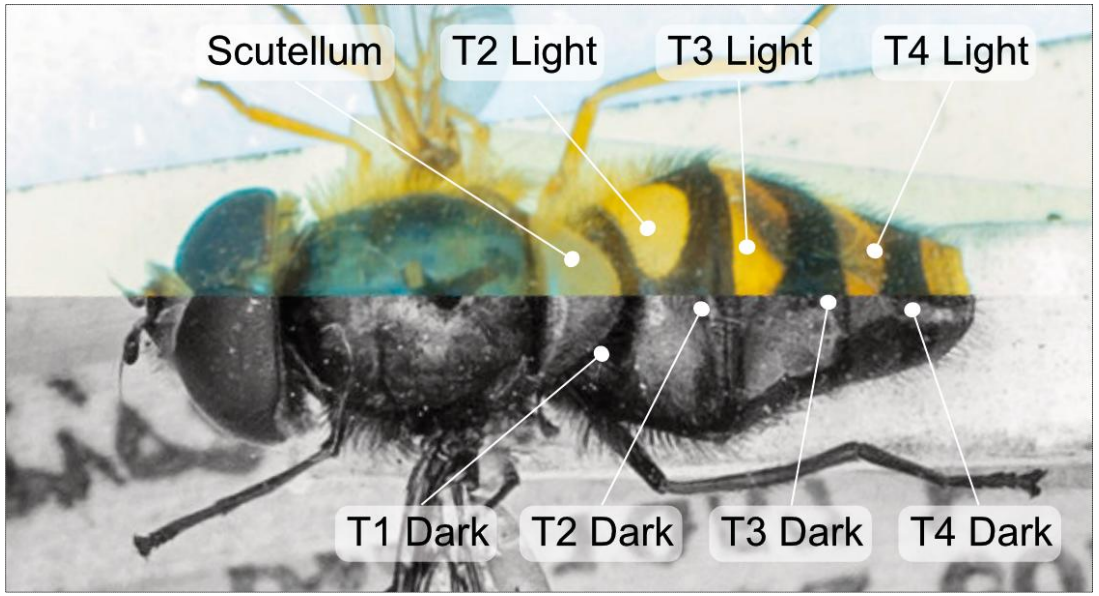
Photogrammetric Data Acquisition – UV & Vis

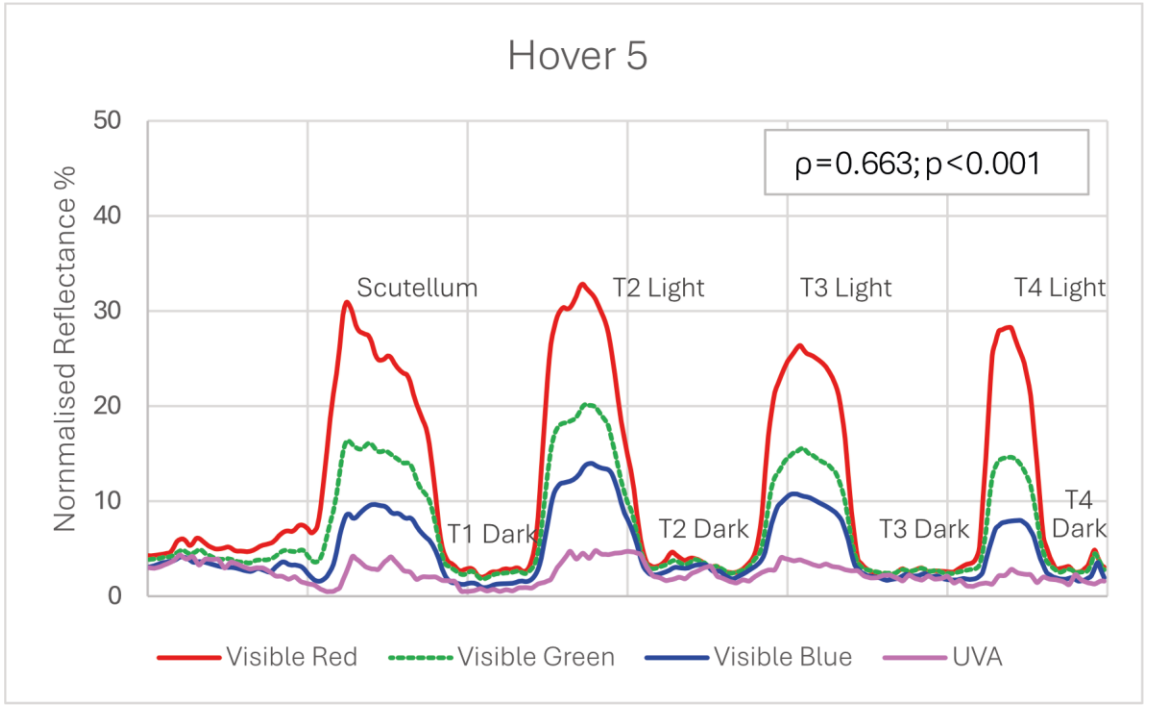




Example Output – *Syrphus ribesii*

British Collection – Oxford University Museum of Natural History

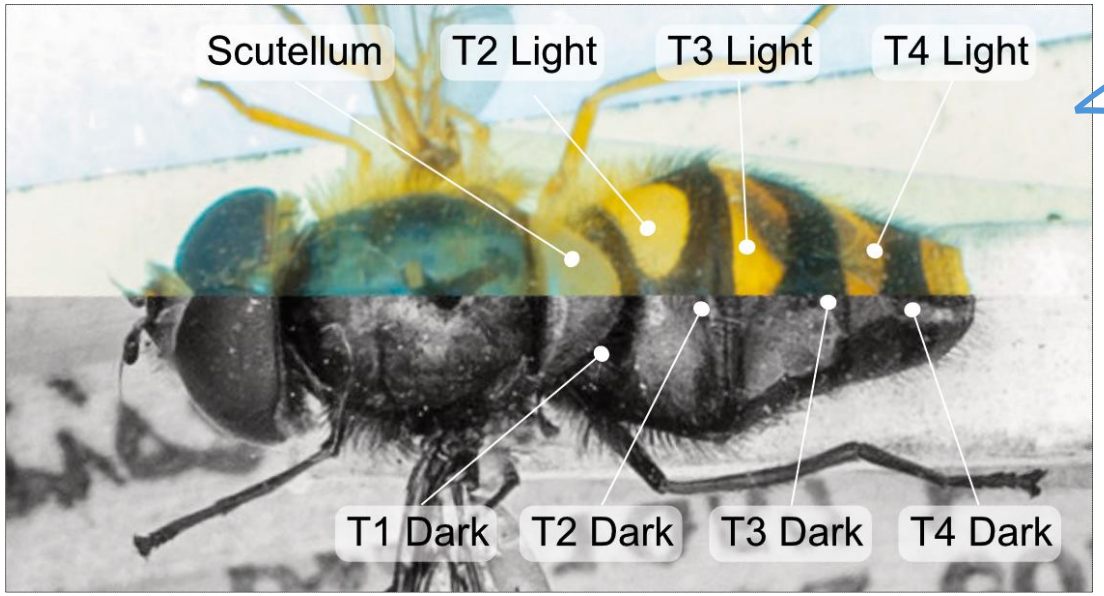


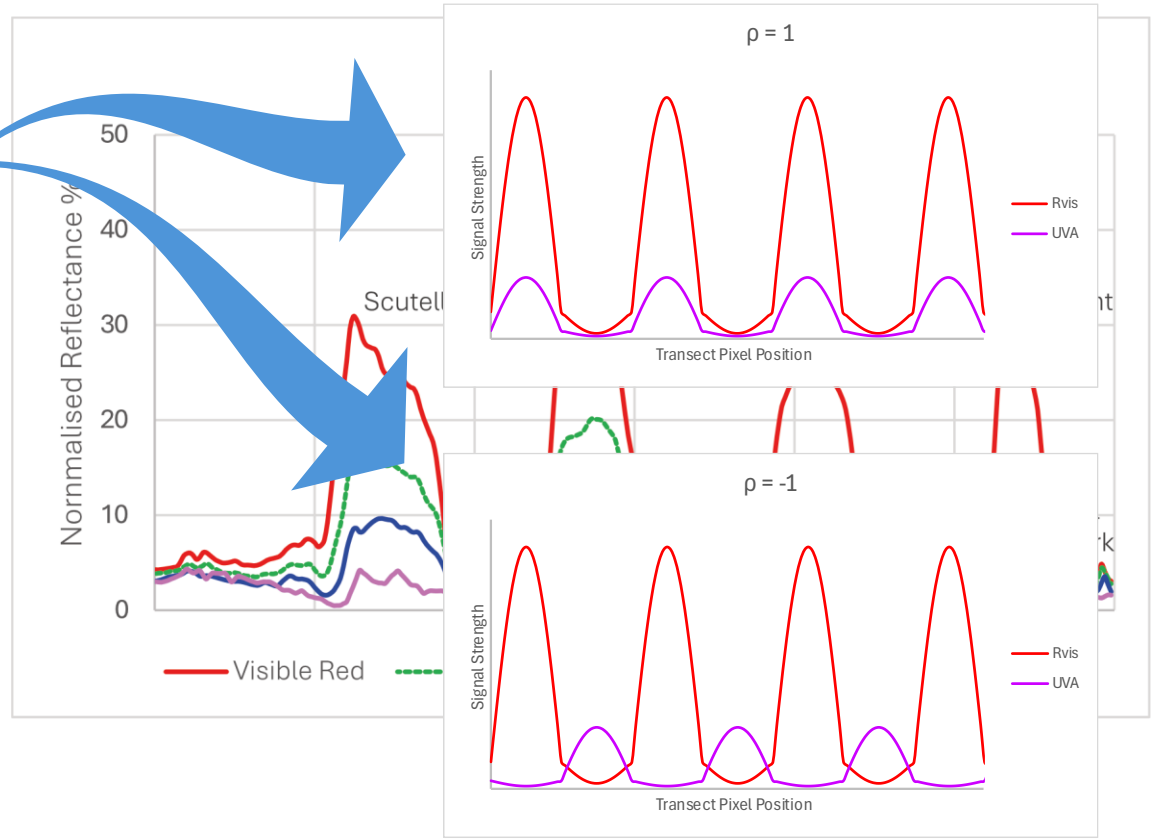


ρ is Spearman's Rank Correlation Coefficient: comparison of Visible Red vs UVA signal

Example Output – *Syrphus ribesii*

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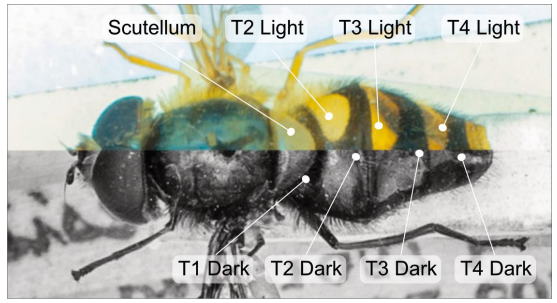


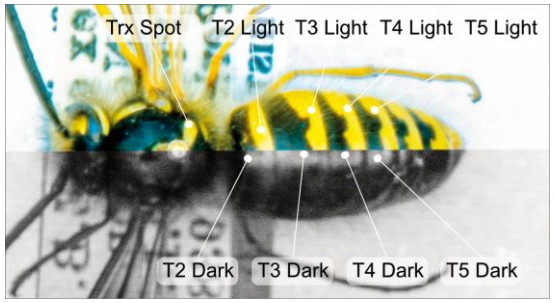


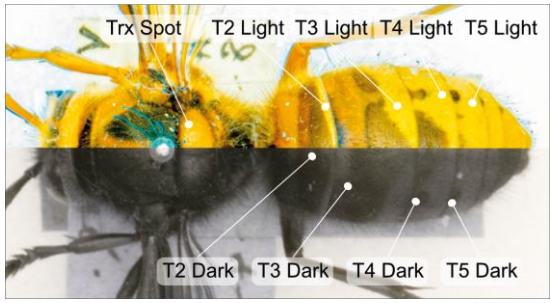
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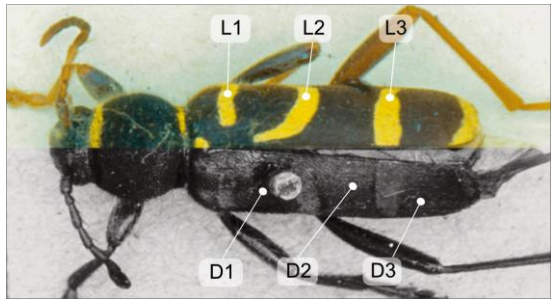
Examples of Other Taxa

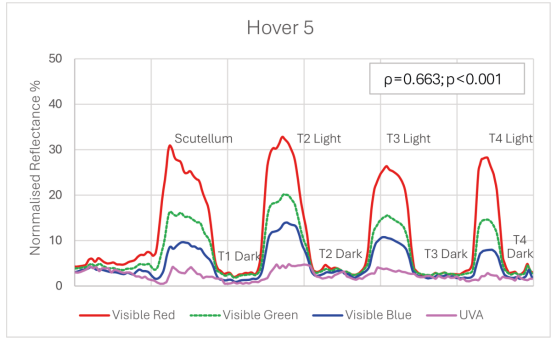
British Collection – Oxford University Museum of Natural History

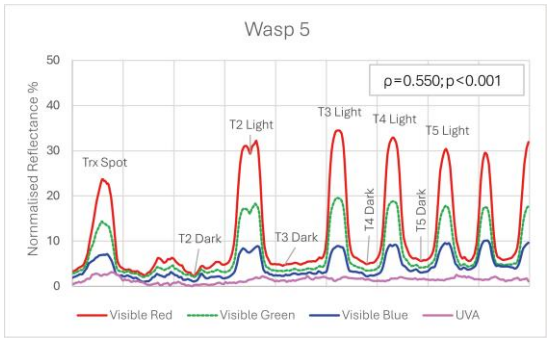


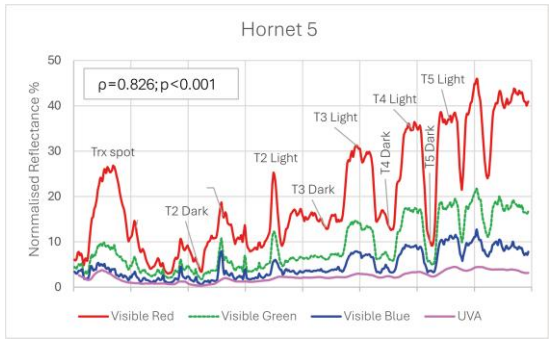


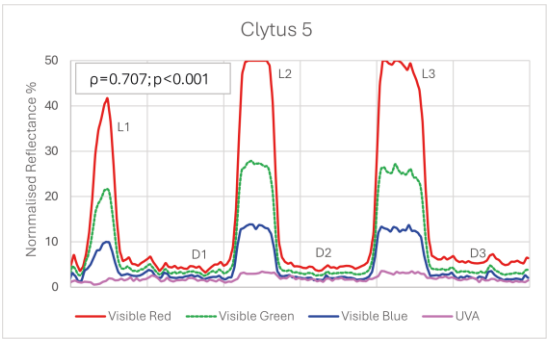












Syrphus ribesii

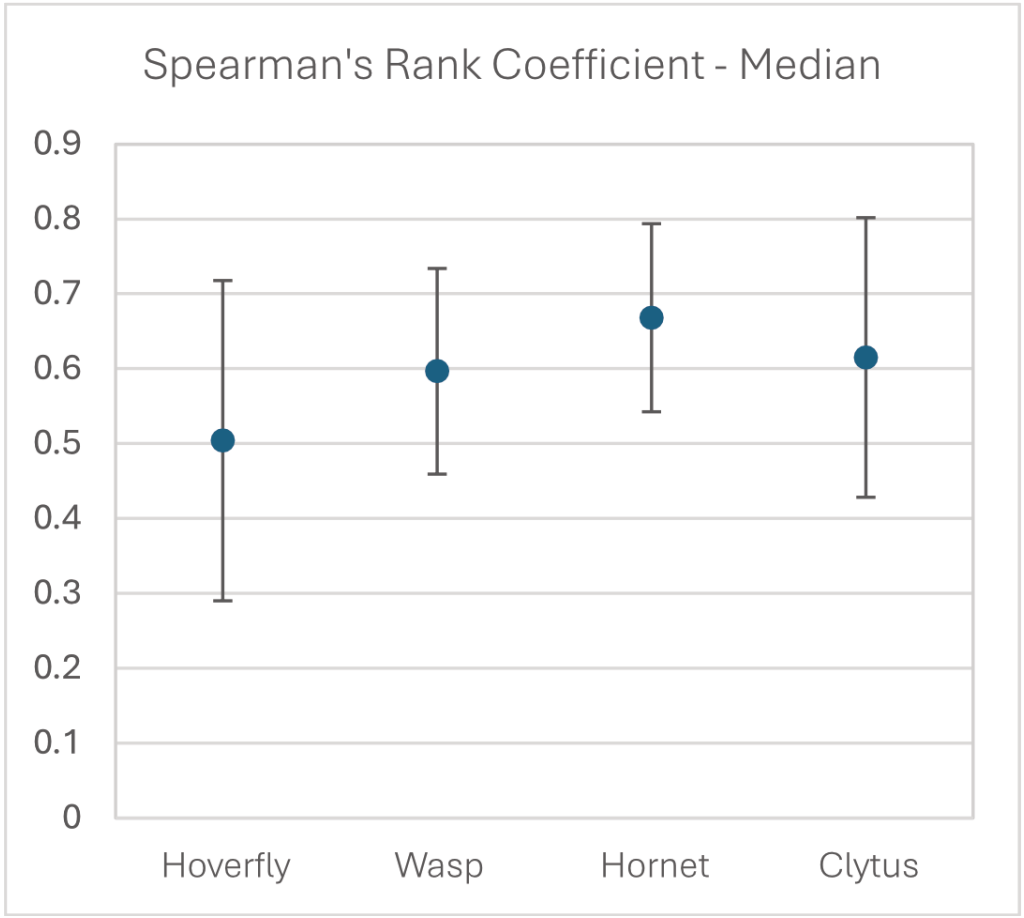
Vespula vulgaris

Vespa crabo

Clytus arietis

ρ is Spearman Rank Coefficient: comparison of Visible Red vs UVA signal

Correlation – UV vs Visible (Red) Signals



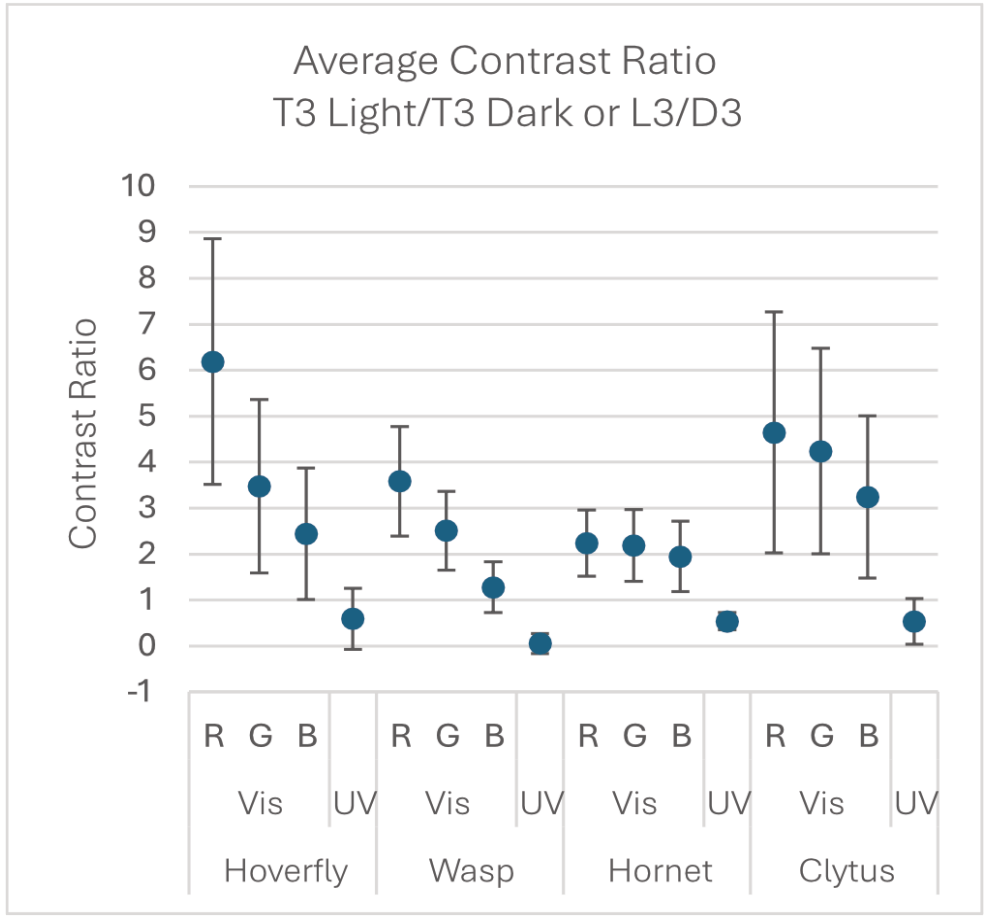
- Spearman's Rank Correlation Coefficient
- In general, positive correlations seen
- UV signal maps to the visible signal
- Probably no cryptic UV patterns

- Noisy data
  - Condition of specimens
  - Imaging and data collection method

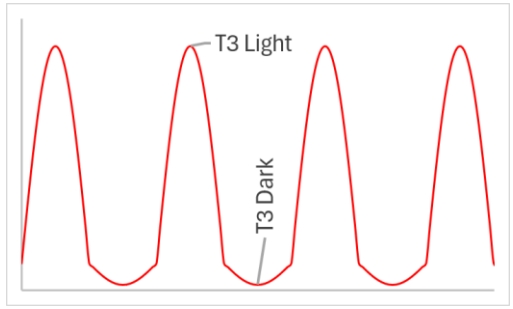
Error bars to one standard deviation

Hoverfly; n=12; Wasp: n= 5; Hornet: n=7; Clytus n=7

Contrast Ratio – Example



- UV contrast is much lower than R&G (yellow components)
- Visible signals low vs expected from live specimens
- Noisy data
  - Condition of specimens
  - Imaging and data collection method



Error bars to one standard deviation

Hoverfly; n=12; Wasp: n= 5; Hornet: n=7; Clytus n=7

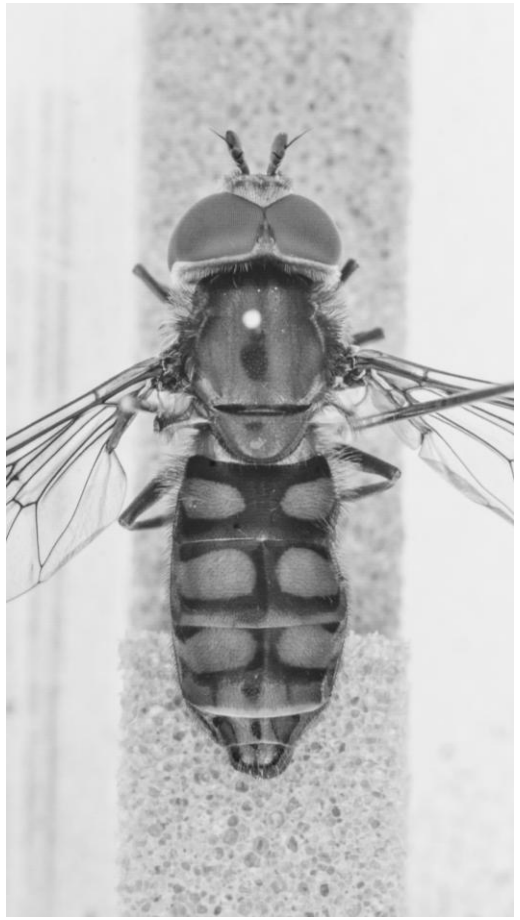
Live… and then Un-alive Specimens

- Commercially available hoverflies
  - biological control of aphids
- Similar life histories
- Available ‘on demand’
- Non-seasonal
- *Eupeodes corollae* obtained



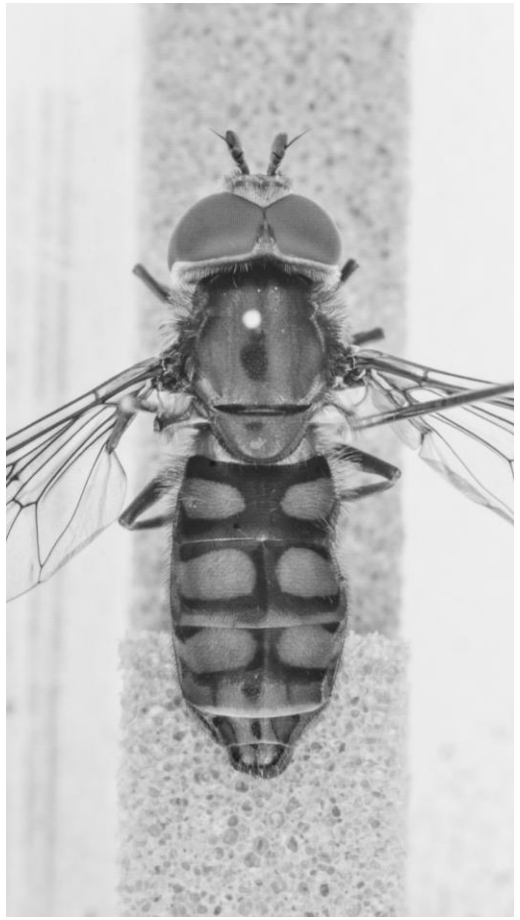
Example – Stabbed…

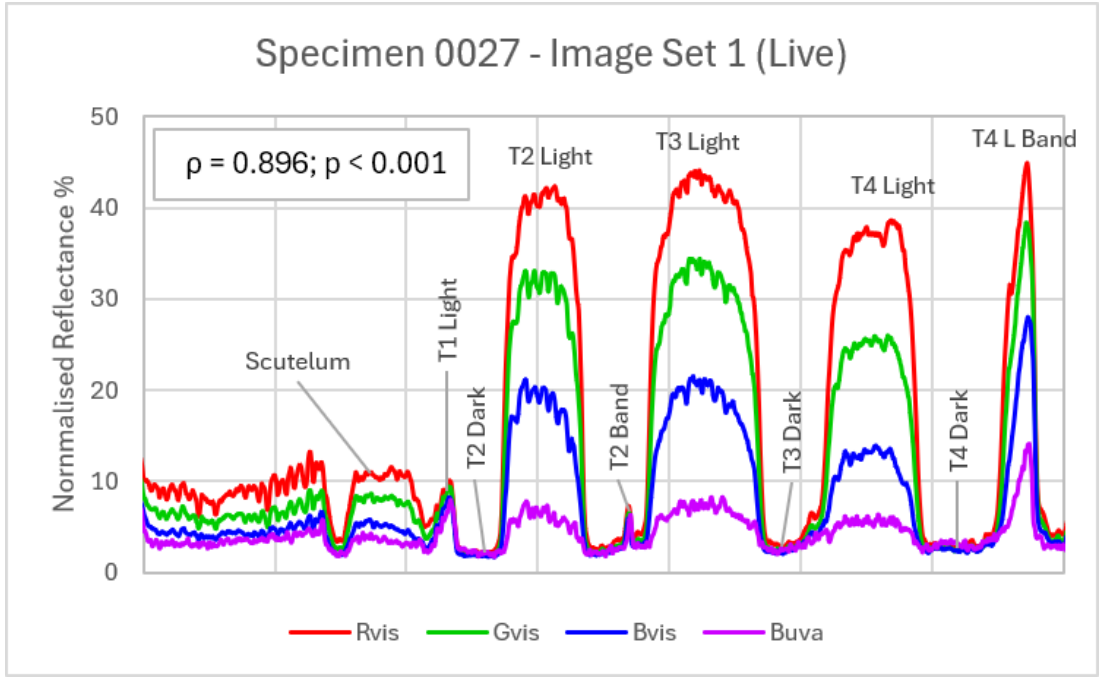




Example – Stabbed…



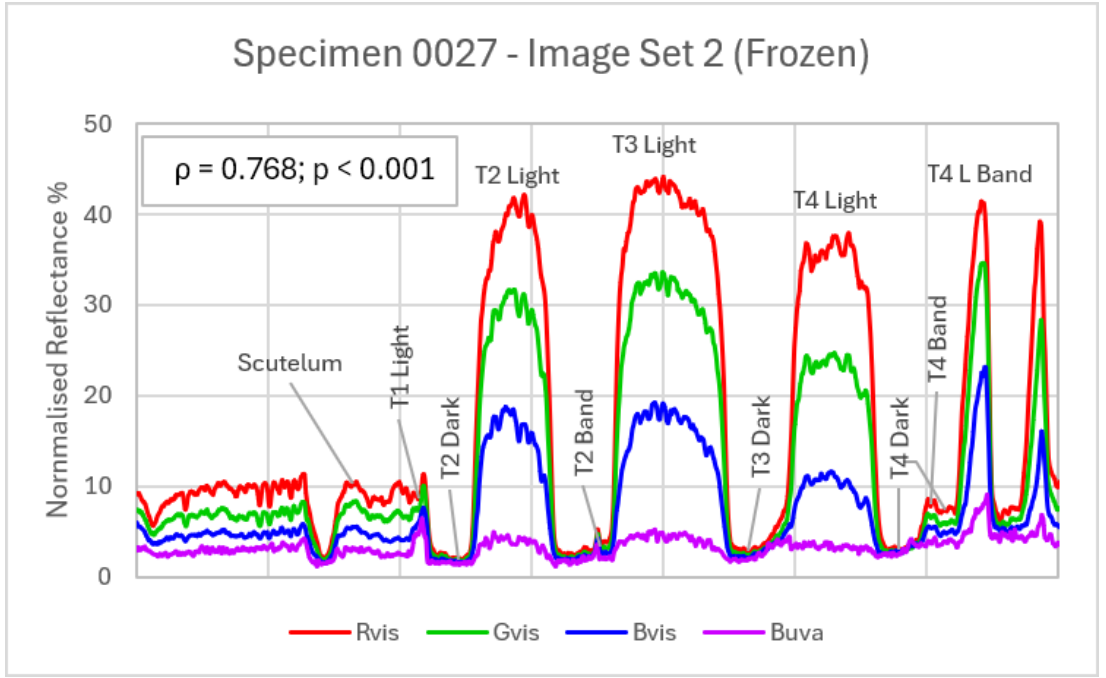




Example – Stabbed, Frozen…

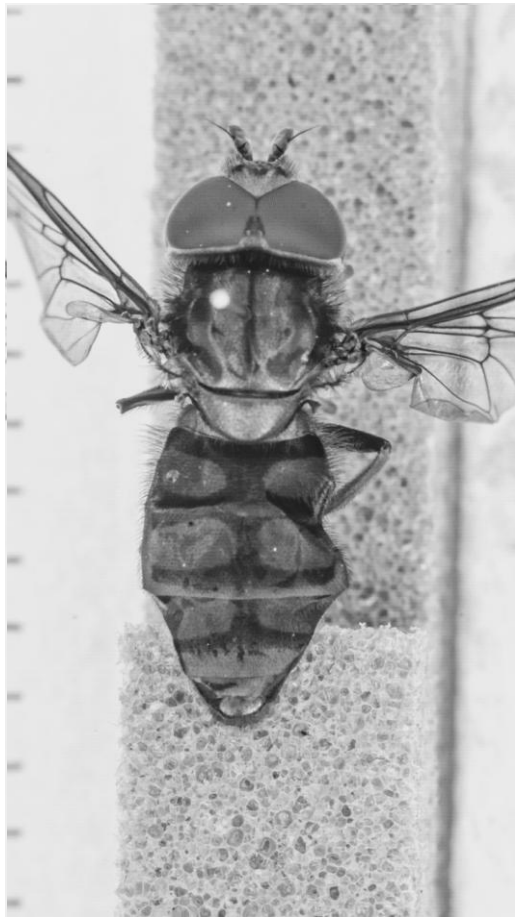


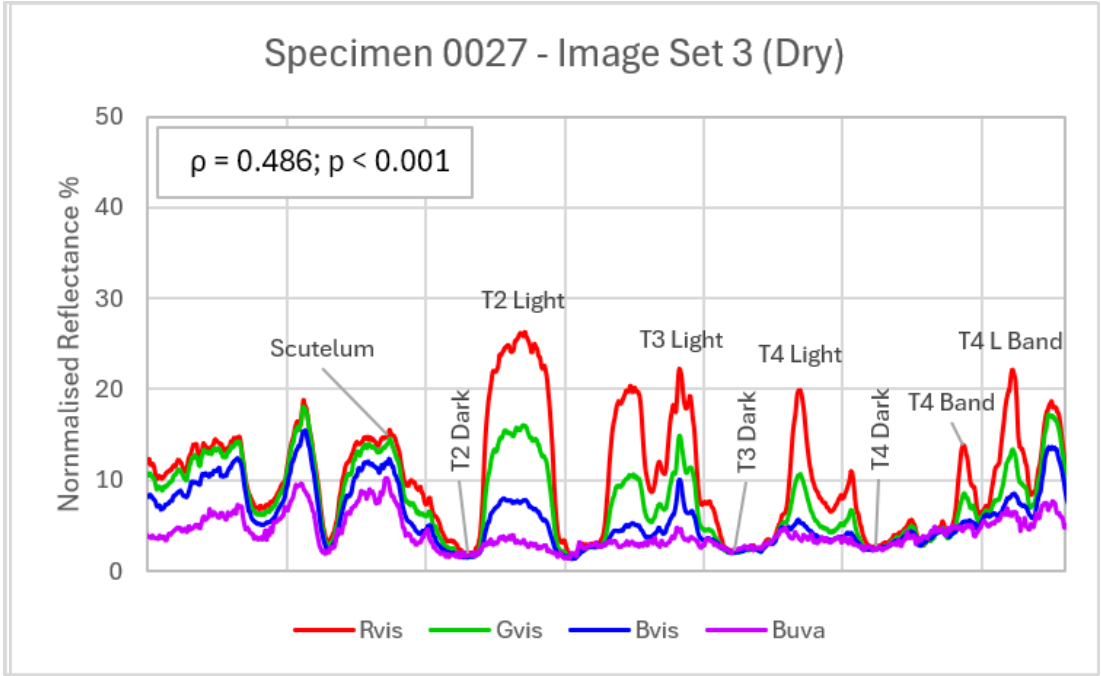




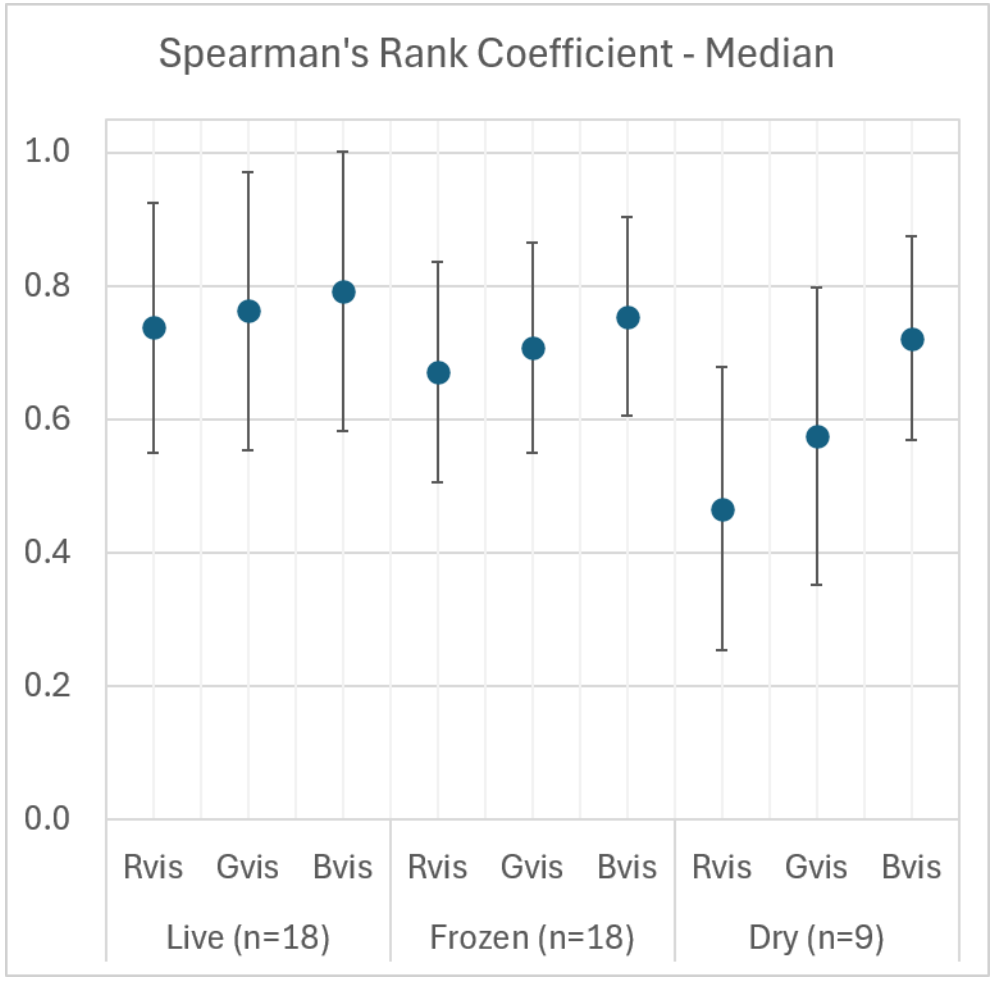
Example – Stabbed, Frozen & Dried







Correlation – UV vs Visible Signals

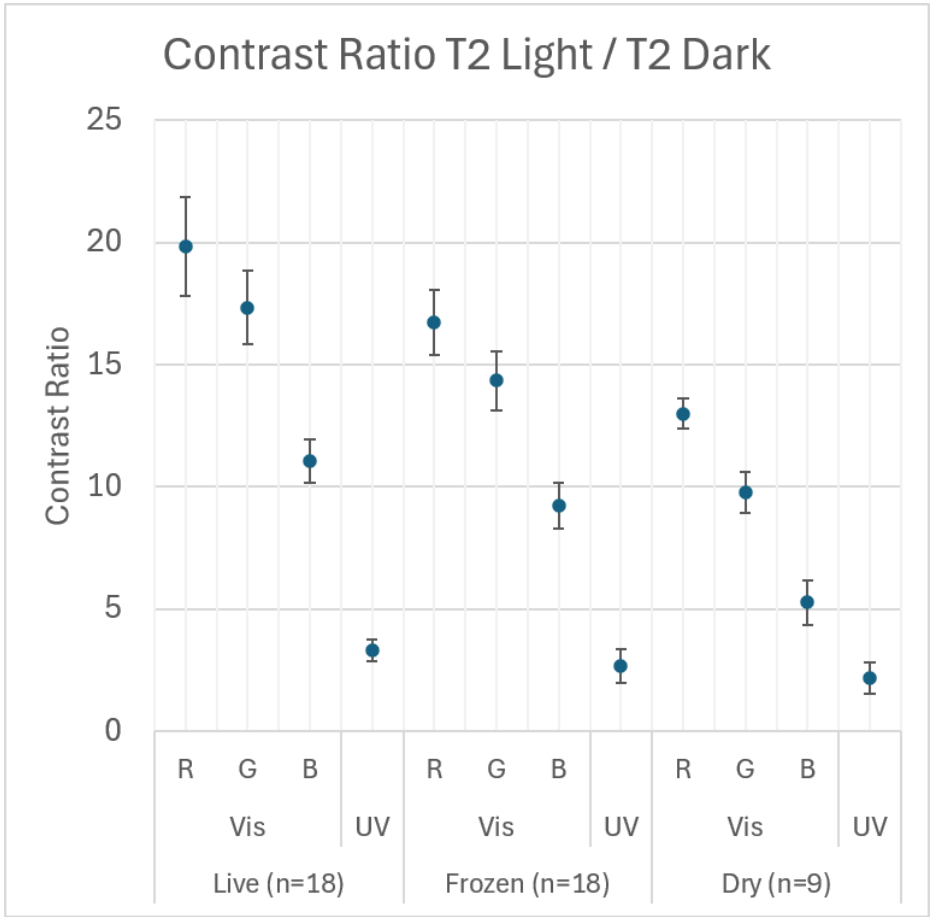


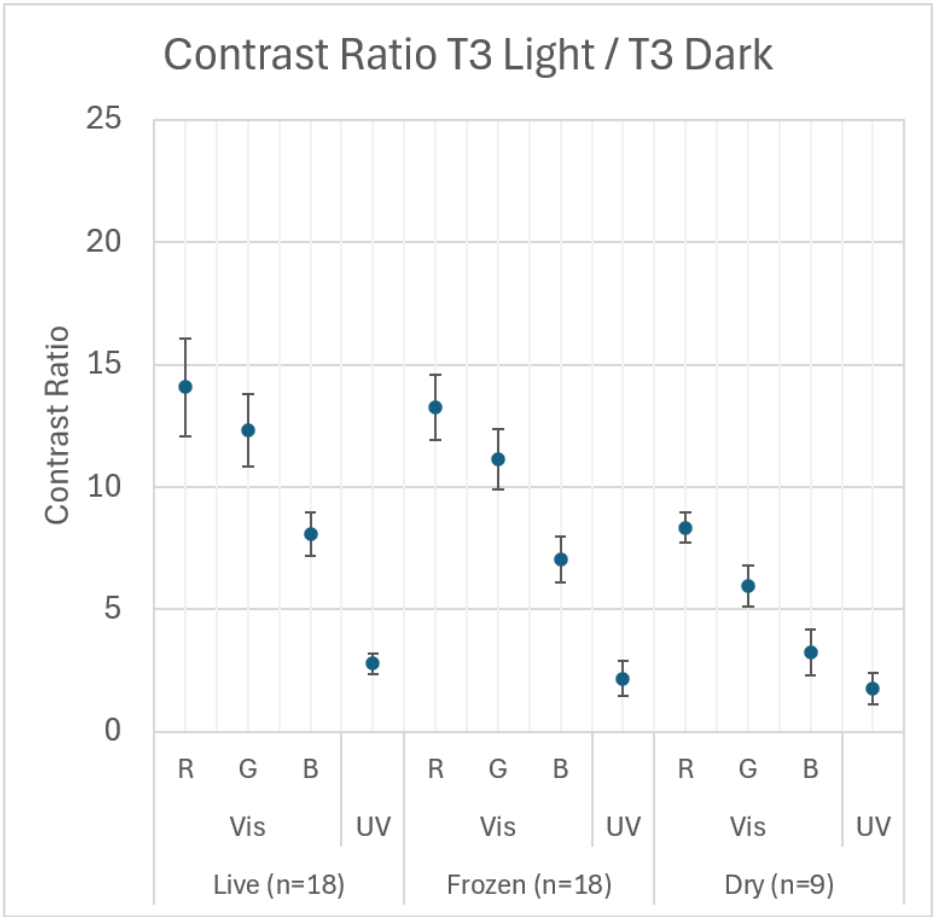
- In general, positive correlations seen
- Suggests UV signal maps to visible signal
- No significant UV only patterns seen

- Biggest change in Red Channel correlation

Error bars to one standard deviation

Contrast Ratios





Next Steps – UV Reflection

- Continue processing *Eupeodes* data
  - Death by water+detergent; freezing; ethanol; ethyl acetate; other
  - Preservation by freezing; ethanol (70%); drying (inc ‘re-hydration’)
- Repeat - other commercial taxa
  - *Episyrphus balteatus*
  - *Sphaerophoria rueppellii*
- Repeat - with wild taxa
  - Syrphids and ‘aposematic models’



Future Work - UV-Induced Fluorescence





Future Work - Predator and Congener Cone-catch & Acuity Models





Acknowledgements

- Dr Tom Reader, Principal Supervisor, University of Nottingham
- Prof Francis Gilbert, Emeritus Professor, University of Nottingham
- Dr Tom Hartman & David McMahon, Supervisors, University of Nottingham
- Dr J Crowther, JMC Scientific Consulting Ltd
- Dr Chris Taylor & Steve Galloway, University of Nottingham
- Dr Zoë Simmons and Louis Lofthouse, Oxford University Museum of Natural History
- Biodiversity & Mimicry Lab, University of Nottingham
- Elsa Haywood, Oxford University
- Natalie Dayer

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Back Up Slides

What is the Message…?



What is the Message and Who Is It For?

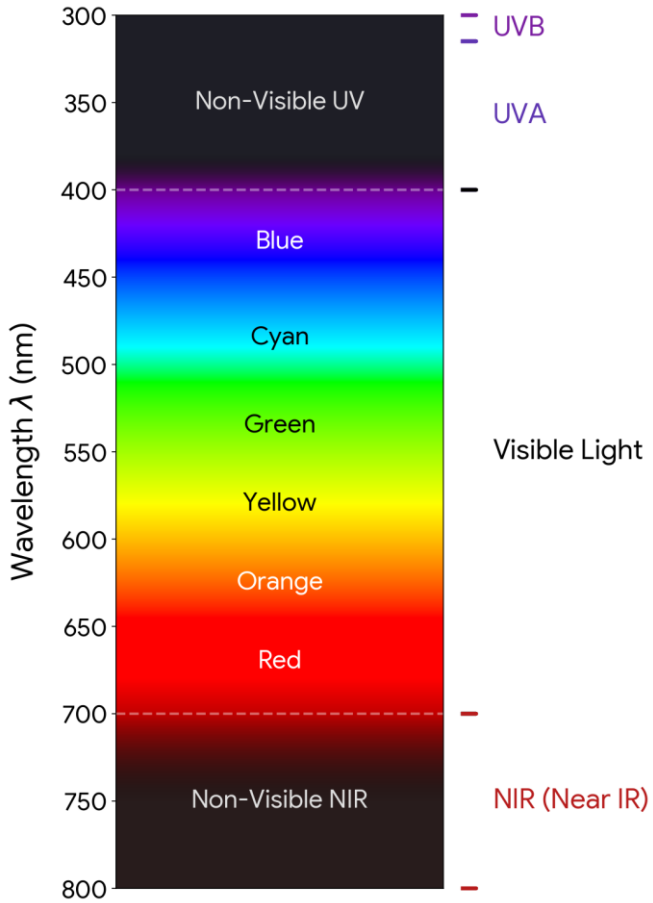


Red, Green, Blue



Green, Blue

Who Is Looking?



Who Is Looking?

