# Identification and evolutionary relationships of genes linked to colour vision in *Sirex noctilio*

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## Introduction

The panel of colours an insect can see is very large and species specific. The ability of an eye to see different colours is dependent on the efficiency of absorption of specific wavelengths by a protein called opsin (Fig 1). Visual opsins can be differentiated by the wavelengths they can absorb; commonly UV, short (purple/blue) or long (green, orange, red) wavelengths, as well as the order of insect they originate from. As a first attempt to evaluate which colours (i.e., wavelengths) *S. noctilio* can see, the *S. noctilio* genome was searched for visual opsin genes and these were mapped onto a phylogenetic tree of all known insect visual opsins.

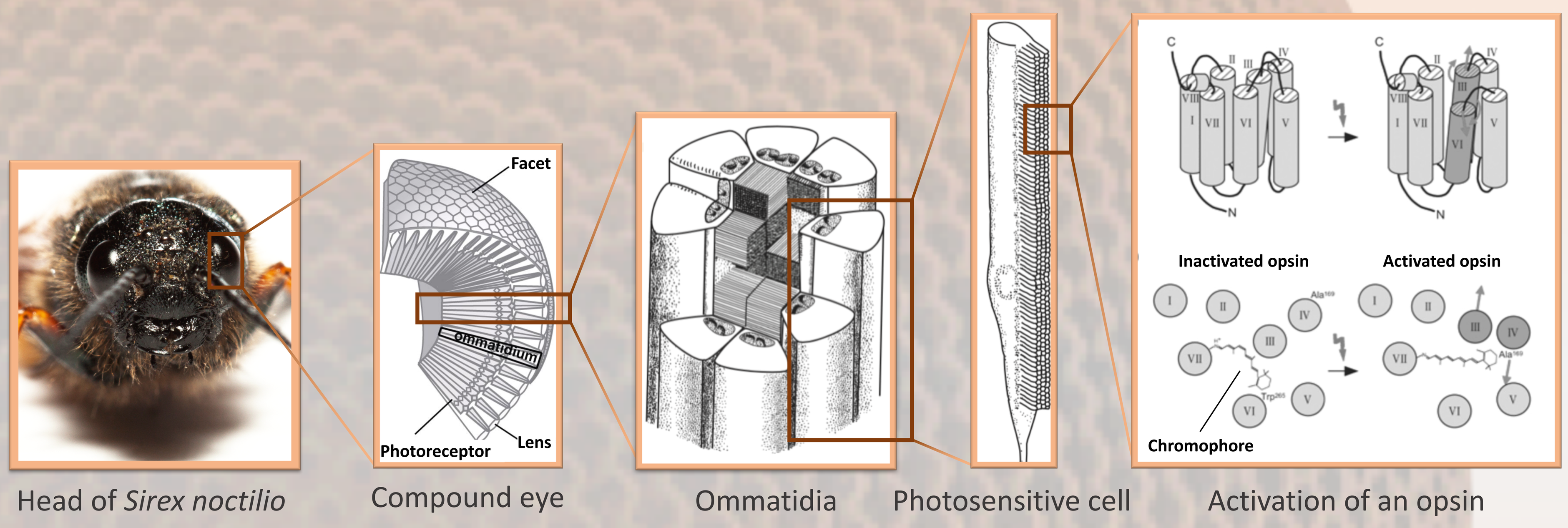


Fig 1: Mechanism of vision in insects. Light is oriented via the lens through the photosensitive cells. The coupled opsin and chromophore is able to absorb a photon in a specific wavelength range depending on the structure of the opsin.

## Materials and Methods

Potential visual opsin genes in *S. noctilio* were identified by blasting with closely related species' visual opsin genes, that absorb UV, long (green to red) and short (blue) wavelenghts (UV, LW and SW, respectively). DNA sequences were compared to data in NCBI and OrthoDB and computed in a gene predictor (Augustus). Genome annotation of *S. noctilio* genes was performed in Appollo. Protein sequences were then manually curated and aligned with MEGA 7.0.20. IQ tree was used to construct the phylogenetic tree. The LG + I + G4 + F model was determined to be the most probable substitution model for all three alignments. To find the most likely topology, 1000 ultrafast bootstrap and SH-aLRT tests were computed.

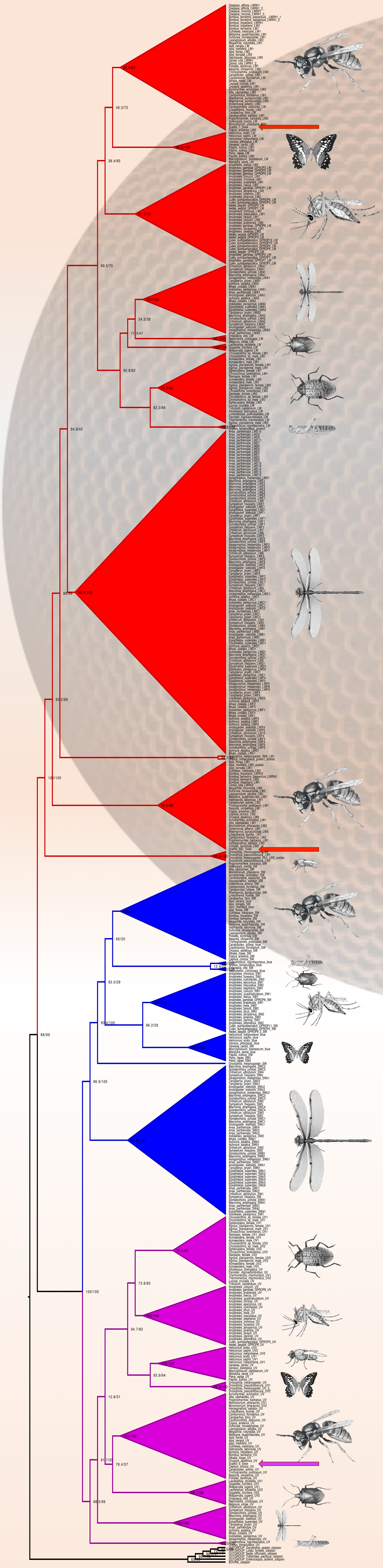

Fig 2: Phylogenetic tree of 538 opsin gene sequences from 107 insects and 6 outgroup species based on the single best maximum likelihood tree. The different colours represent the different wavelengths absorbed by the different kinds of opsins (red: LW, blue: SW, purple: UV).

## Results and Discussion

- The three types of opsins are clearly separated phylogenetically (Fig 2): SW and UV opsins share a more recent common ancestor, while the LW opsin diverged earlier. Additionally, insect orders are well separated within each of the main clades of the three types of opsins. Both of these results are supported by other studies (Lord et al. 2016). We also confirmed that in the Hymenoptera the LW type is divided into two groups (Spaethe et al. 2004).
- We found three potential visual opsins within the *Sirex* genome. When they are placed in the phylogenetic tree, two of them group with the two types of LW opsins of the Hymenoptera, and one with the UV opsins of the Hymenoptera.

## Conclusions

The three visual opsin genes found in *S. noctilio* might be correleted with the ecology of the woodwasp:

- Obvious sexual dimorphism exists in *S. noctilio*, males have a large band of orange colouration on their abdomen and females do not. The two groups of LW opsins identified in *S. noctilio* may be involved in recognition of this orange colouration and discrimination between male and female conspecifics.
- The UV opsin is likely involved in the strong phototaxis (attraction to sunlight) reported in *S. noctilio* post-emergence.

Ultimately we hope that an improved understanding of the visual ecology of *S. noctilio* will facilitate the optimization of survey and detection tools for use in integrated pest management programs.

## Acknowledgements

I would like to thank Alisa Postma, Robert Waterhouse, Katrin Fritza and Josephine Queffelec for their help with genome annotation, sequence alignment and advice on this study; and Amanda Adlam for her corrections.


Fig 3: Sexual dimorphism in *S. noctilio*. The male (bottom right) has an orange and black abdomen, and the female (top left) has a full black abdomen.

## References

Lord, Nathan P., Rebecca L. Plimpton, Camilla R. Sharkey, Anton Suvorov, Jonathan P. Lelito, Barry M. Willardson, and Seth M. Bybee. "A Cure for the Blues: Opsin Duplication and Subfunctionalization for Short-Wavelength Sensitivity in Jewel Beetles (Coleoptera: Buprestidae)." *BMC Evolutionary Biology* 16, no. 1 (December 2016). doi:10.1186/s12862-016-0674-4.

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