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Survey of Visual Opsin Evolution Across Caddisflies (Insecta: Trichoptera)

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Survey of Visual Opsin Evolution Across Caddisflies (Insecta: Trichoptera)

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Adult caddisfly illustrations showing diversity in color patterns[4].

Introduction

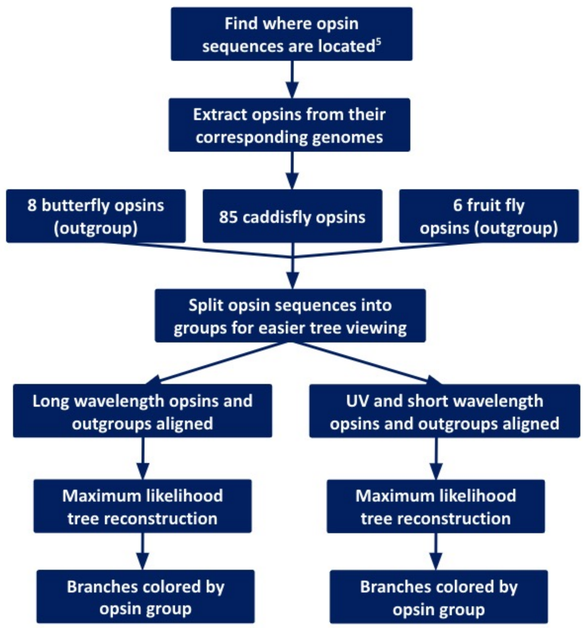
Caddisflies are a highly diverse order of aquatic insects. As eggs, larvae, and pupae, they occupy freshwater habitats, while as adults, they are generally aerial and terrestrial[1]. Such varied environments call for a flexible and complex visual system. Visual systems are controlled by light-sensing molecules called opsins, which are categorized by the wavelength of light they are most sensitive to[2]. In insects, these categories are:

- Long wavelength (LW)
- Short wavelength (SW)
- Ultraviolet wavelength (UV)

Adaptive duplication of opsin genes is the primary mechanism of evolution that allows for greater visual capacity[3]. While opsins have been well studied in some insect groups, such as dragonflies, opsins in caddisflies have never been sampled. To gain an understanding of opsin evolution in caddisflies, we analyze the occurrence and phylogenetic relationships of visual opsins in 22 trichopteran genomes.

Methods

Opsin Gene Tree Reconstruction



Opsin Counts and Species Phylogeny

- The number of copies of opsins in each species were calculated and plotted. Genomes are ordered according to the species phylogeny underneath.
- Species phylogenetic tree was constructed using previously aligned single-copy orthologs[6].

Results

Long Wavelength Opsin Gene Tree

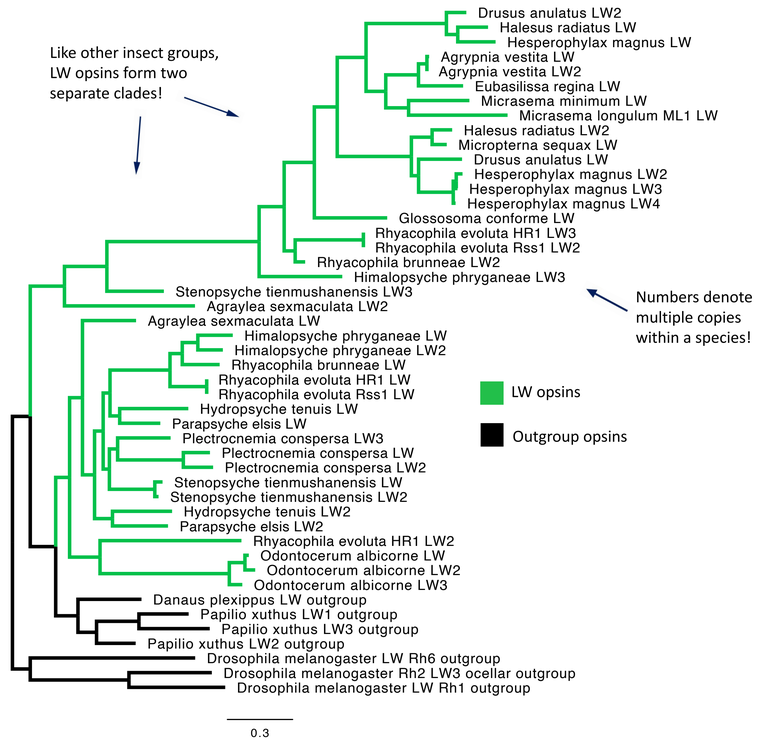


Figure 1: Caddisfly LW opsin phylogeny. Maximum likelihood tree from DNA sequences found in this study along with six outgroup sequences.

Opsin Counts by Species

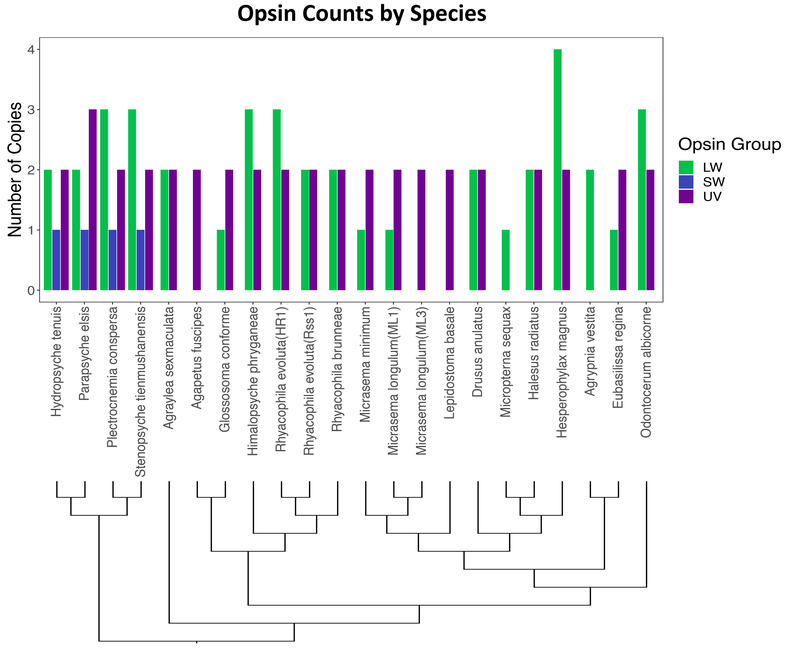


Figure 3: Number of opsins in each caddisfly genome. Bars are colors according to opsin type. Species are ordered by phylogeny created from single-copy orthologs.

UV and Short Wavelength Opsin Gene Tree

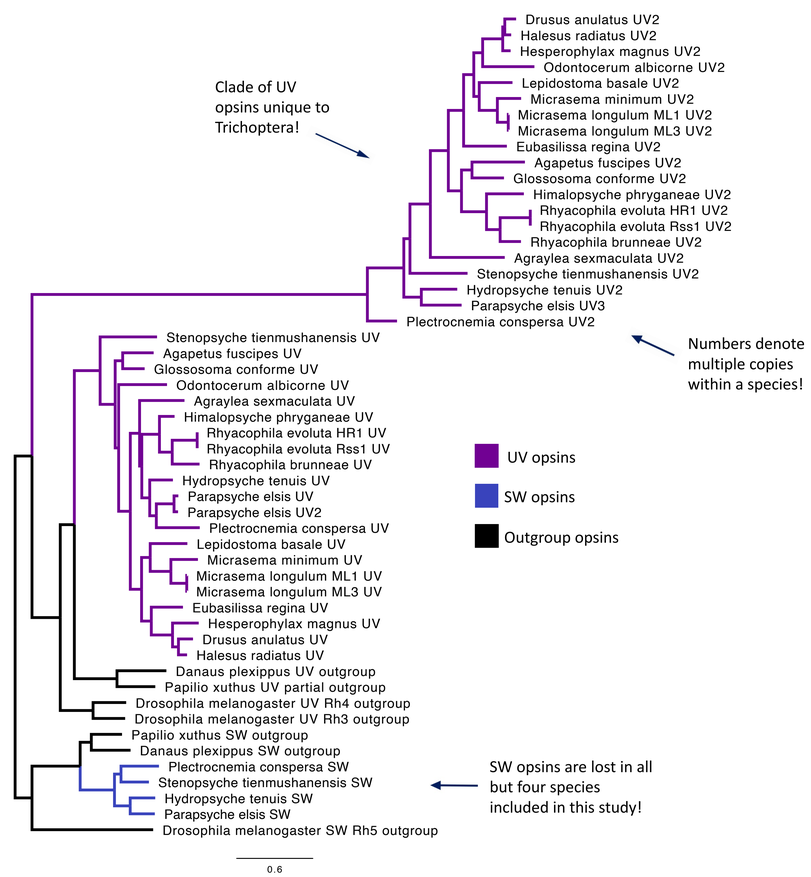


Figure 2: Caddisfly UV and SW opsin phylogeny. Maximum likelihood tree from DNA sequences found in this study along with seven outgroup sequences.

Conclusion

- Caddisflies possess a diverse repertoire of opsins including a clade of UV opsins not found in any other insect group thus far.
- Life history strategies and light environments have been found to heavily influence opsin evolution in other insect groups[2] and likely play a role in caddisfly opsin evolution as well.
- We suspect that because caddisflies are crepuscular, the additional copies of UV opsins could have evolved to aid in flying in low light. In addition, the expansion of UV opsins might serve to overcome the loss of SW opsins in many caddisfly lineages. However, future research is necessary to provide greater insight into the drivers of opsin diversity in caddisflies.

References: 1. Morse et al. (2019). *Insects, 10(5), 125.* **2.** Sondhi et al. (2020). *Commun Biol 4, 177.* **3.** Suvorov et al. (2017). *Molecular Ecology, 26(5), 1306–1322.* **4.** Holzenthal et al. (2007). *Zootaxa, 1668*, 639–698. **5.** Guignard et al. (2022). *BMC Ecology and Evolution, 22.* **6.** Heckenhauer et al. (2021). *Cold Spring Harbor Laboratory.*