



# Convergence en sympatrie des motifs de couleurs des Papilionidae à l'échelle globale : l'impact des interactions écologiques

Agathe Puissant

*Thèse encadrée par Violaine Llaurens*

# Sympatry





**Vegetation**



**Lighting**



**Predation**

**Convergence**





**Divergence**

**Reproductive  
interference**



**Competition**

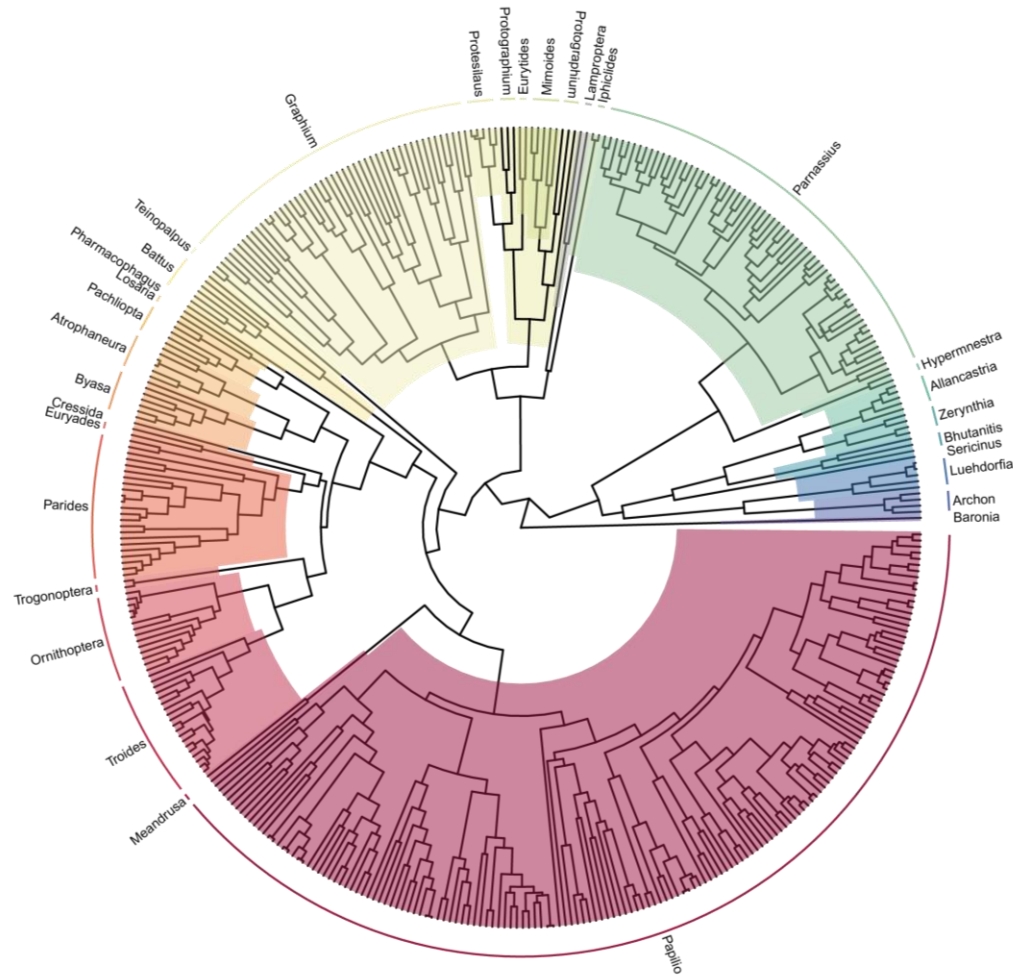
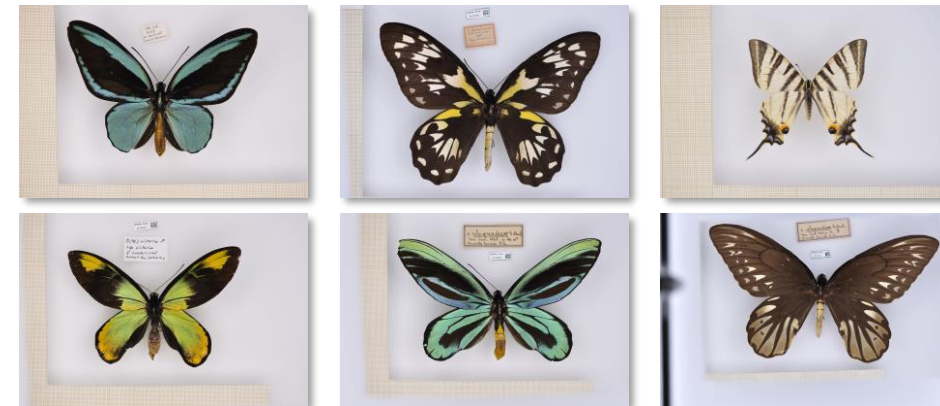
What is the effect of sympatry on phenotypic convergence and divergence on a macroevolutionary scale?

# What is the effect of sympatry on phenotypic convergence and divergence on a macroevolutionary scale?

## *MNHN collections*



- 29 genera
- 267 species
- 1358 specimens

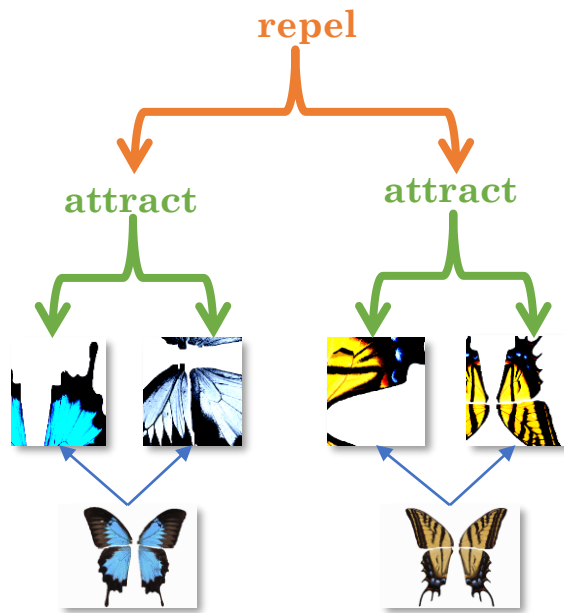


*Allio et. al. (2020)*

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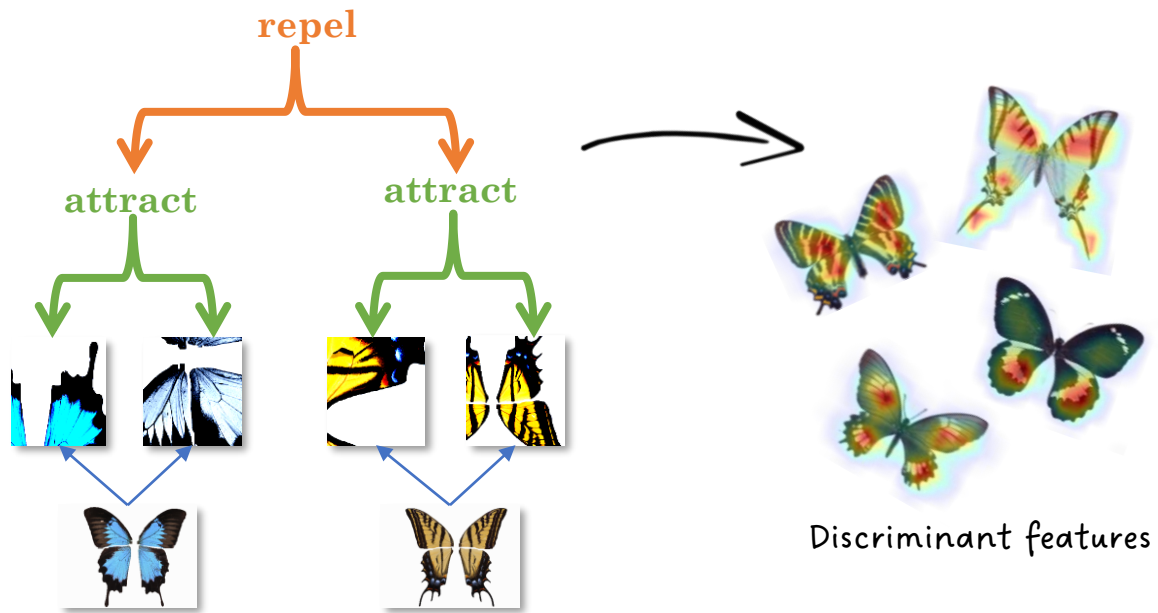
# Quantification of phenotypic variation

Training on image database



# Quantification of phenotypic variation

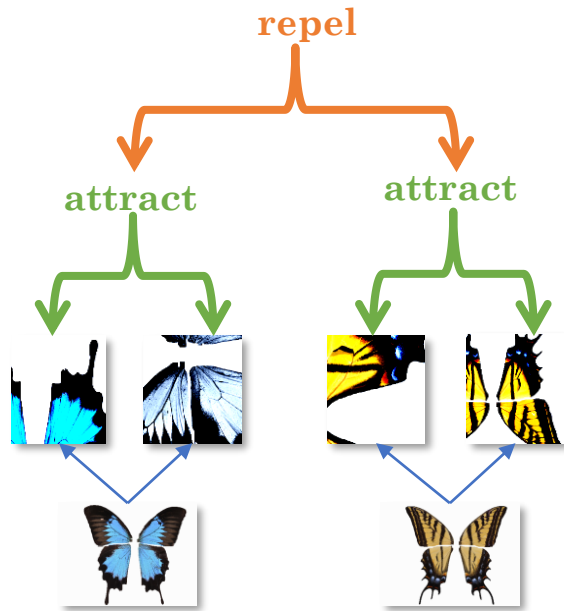
Training on image database





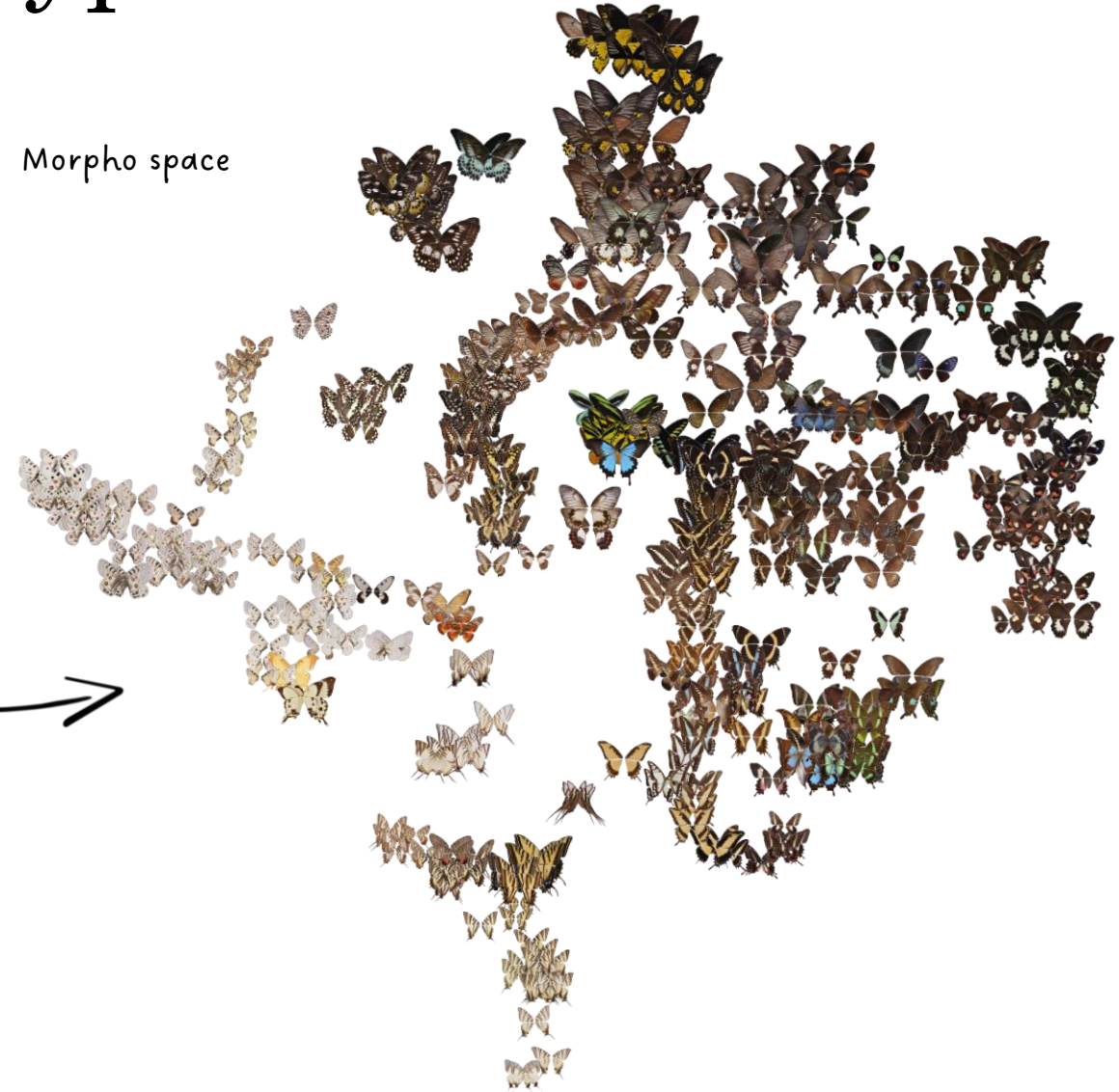
# Quantification of phenotypic variation

Training on image database



Discriminant features

Morpho space



# Phylogenetic Linear Mixed Model

*Phenotypic distance* ~  
*% overlap*\**phylogenetic distance*

# Phylogenetic Linear Mixed Model

*Phenotypic distance* ~  
*% overlap*\**phylogenetic distance* +  
*% overlap*\**phylogenetic distance*<sup>2</sup>

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Acceleration/deceleration of  
phenotypic divergence with  
phylogenetic distance

# Phylogenetic Linear Mixed Model

*Phenotypic distance* ~  
*% overlap*\**phylogenetic distance* +  
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*(Species 1)* + *(Species 2)*

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Species identities as random effect,  
linked with variance-covariance  
phylogenetic matrix

# Phylogenetic Linear Mixed Model

*Phenotypic distance* ~  
*% overlap*\**phylogenetic distance* +  
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**Significant effect of geographic  
overlap and its interaction  
with phylogenetic distance**

# Phylogenetic Linear Mixed Model

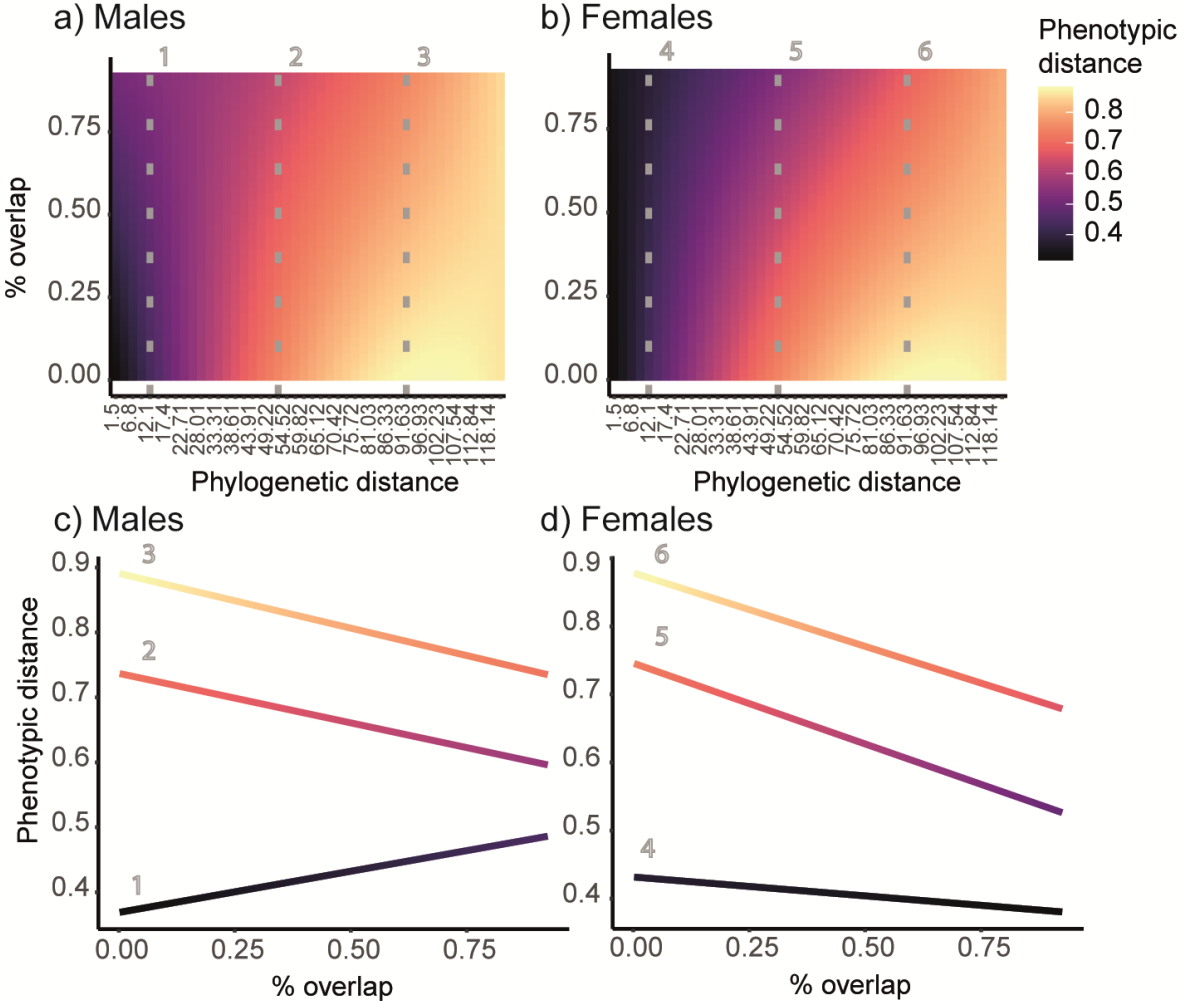
$$\text{Phenotypic distance} \sim$$

$$\% \text{ overlap} * \text{phylogenetic distance} +$$

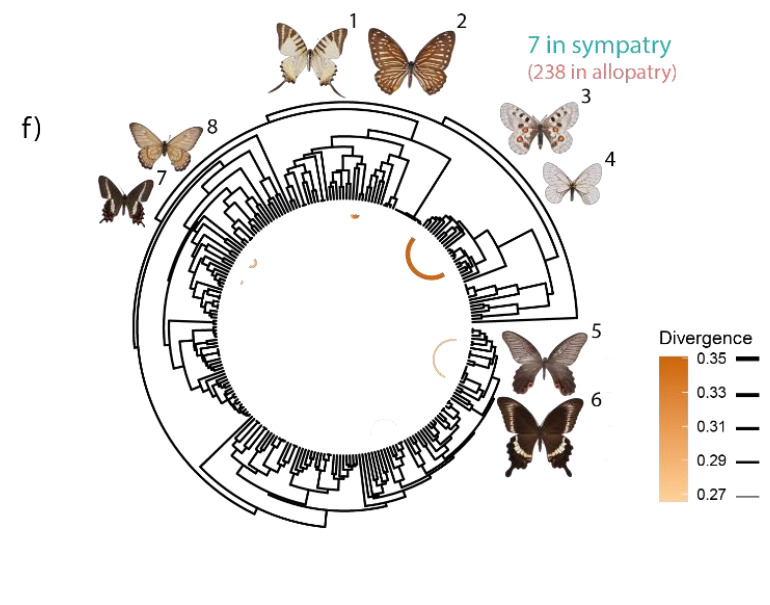
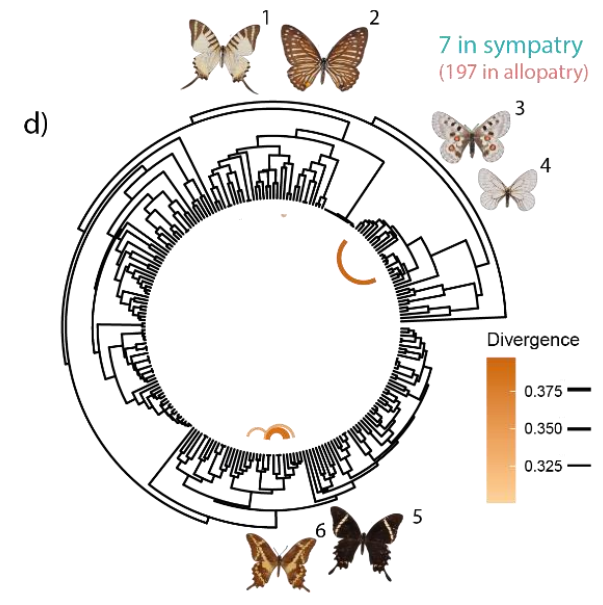
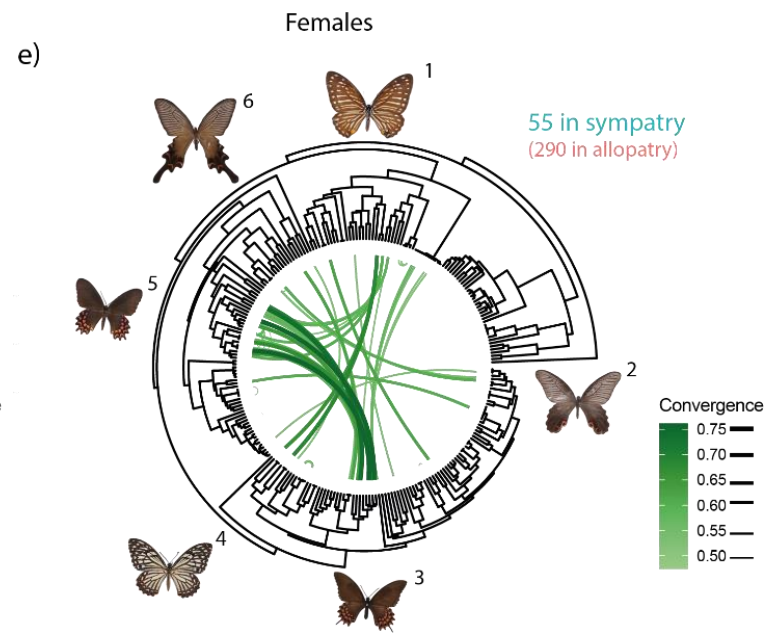
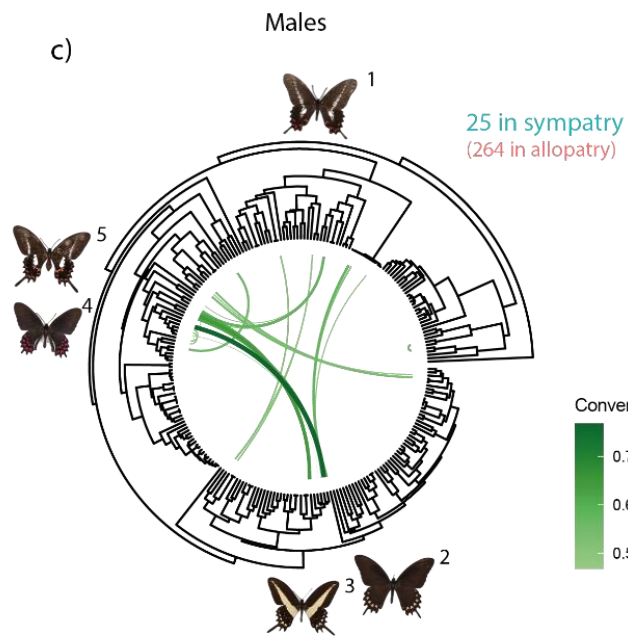
$$\% \text{ overlap} * \text{phylogenetic distance}^2 +$$

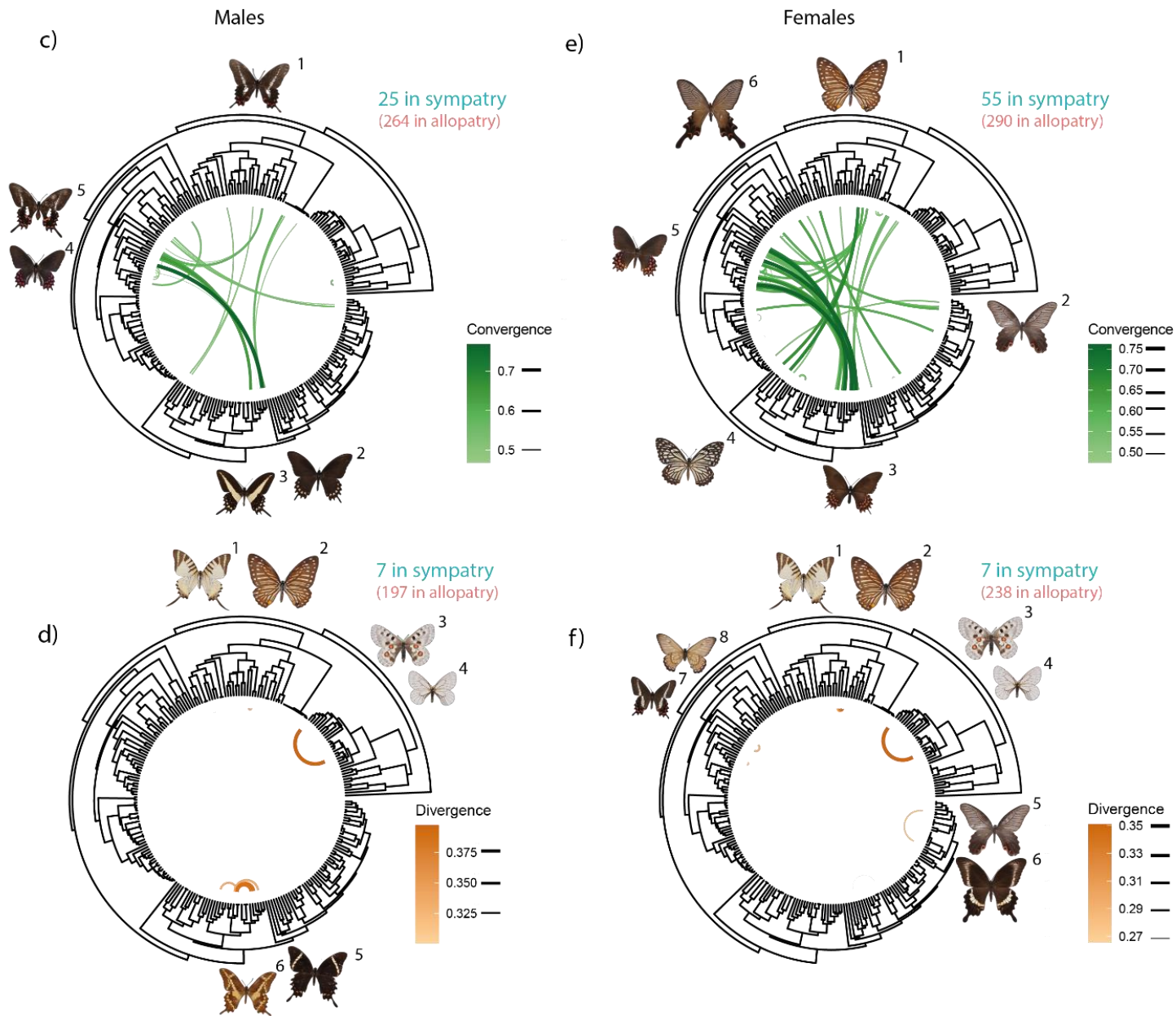
$$(\text{Species 1}) + (\text{Species 2})$$

**Significant effect of geographic overlap and its interaction with phylogenetic distance**

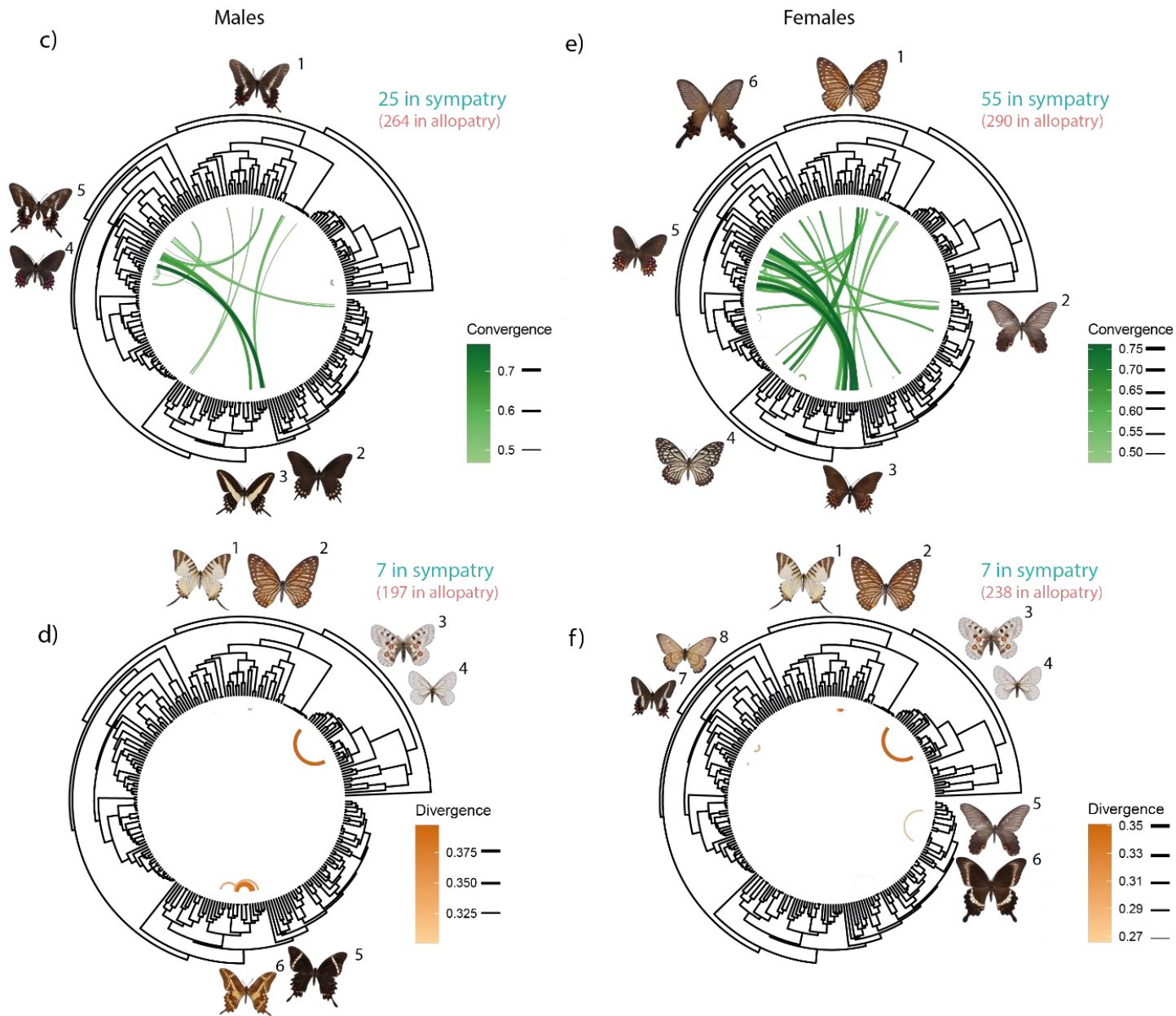






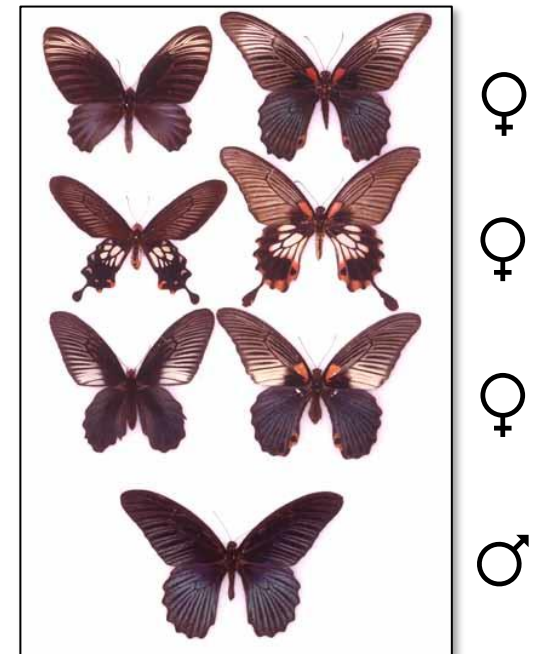


➤ Convergences are more frequent and stronger in sympatry than in allopatry, especially for females.

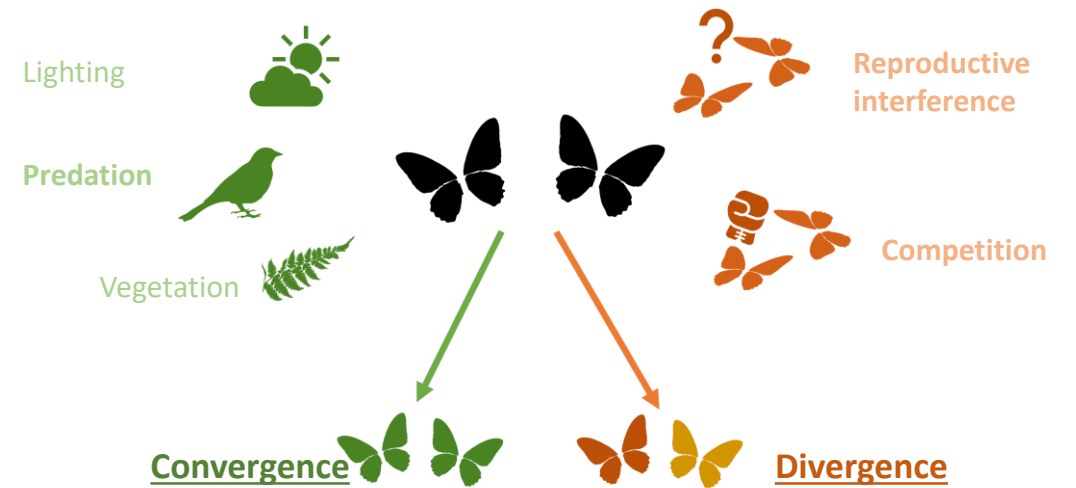


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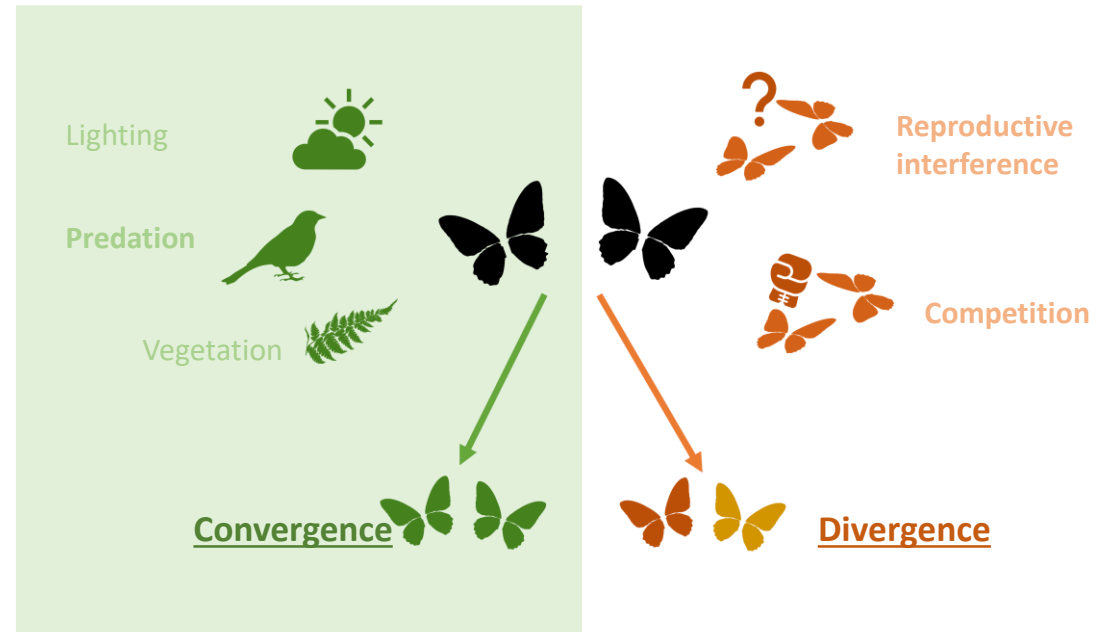
Model P. memnon



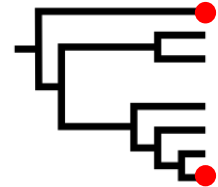
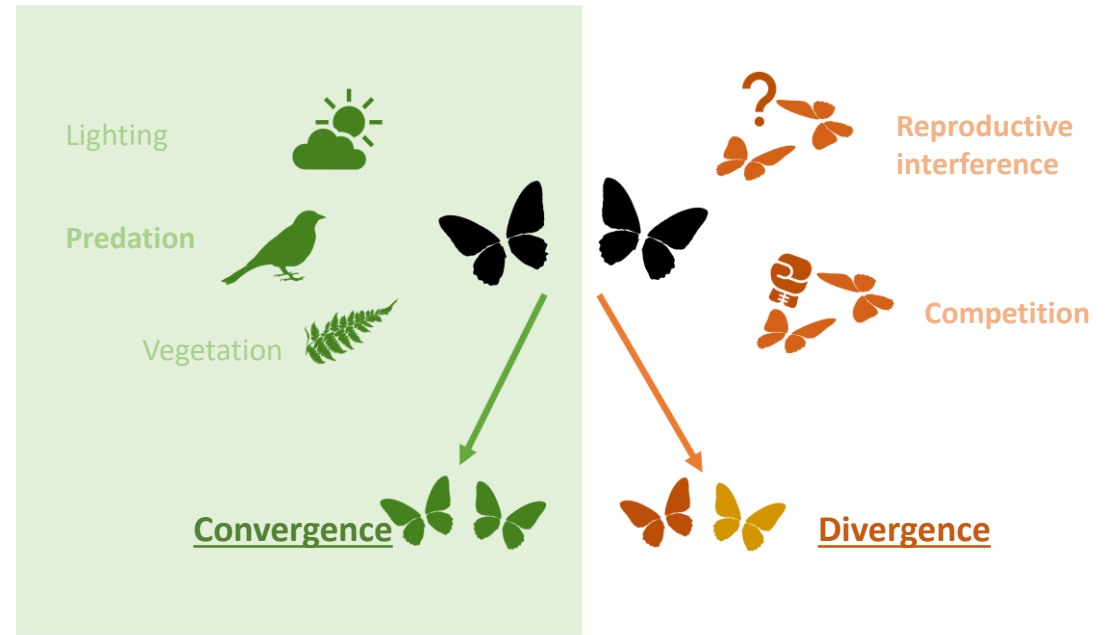
- Overall, we find a signal for phenotypic **convergence** in sympatry
- Convergence signal is stronger for phylogenetically distant species
- For males, we find **divergence** between closely related species



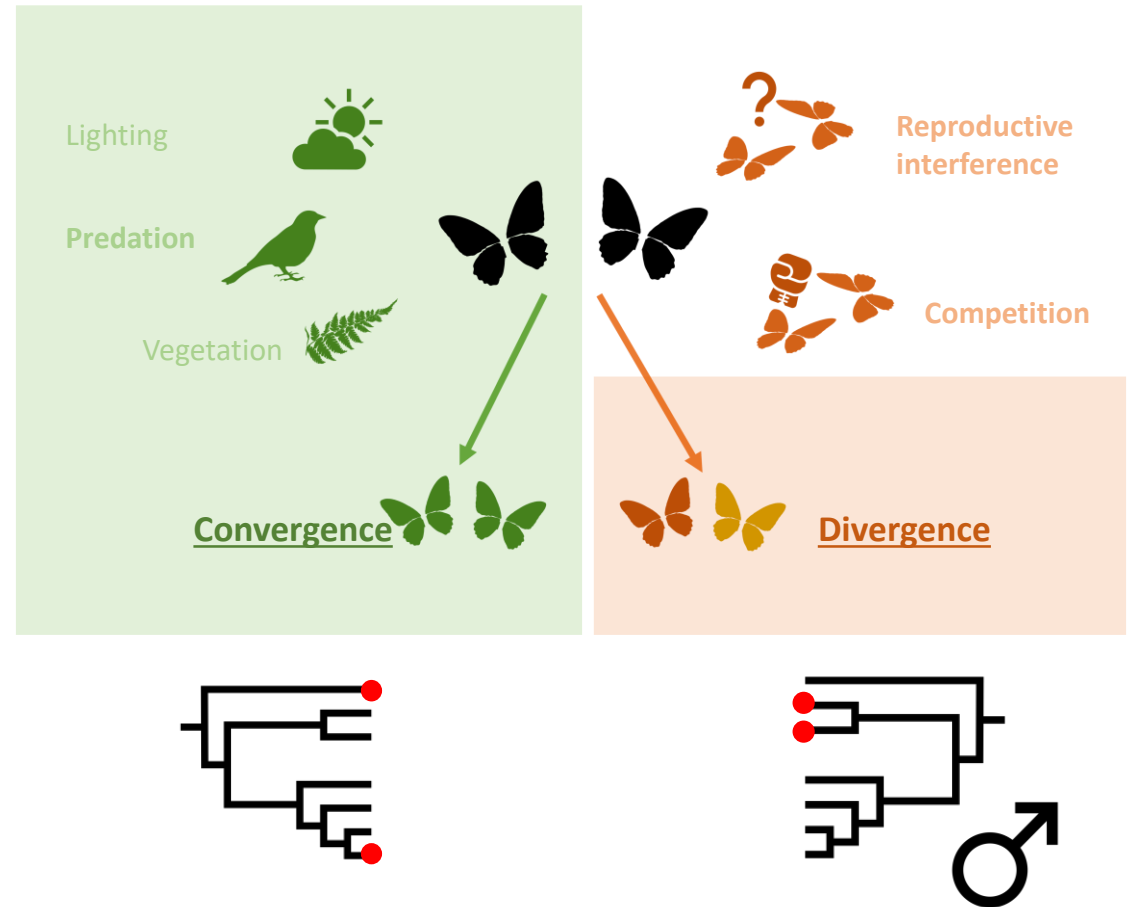
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Visible light



UV





Nonmimetic

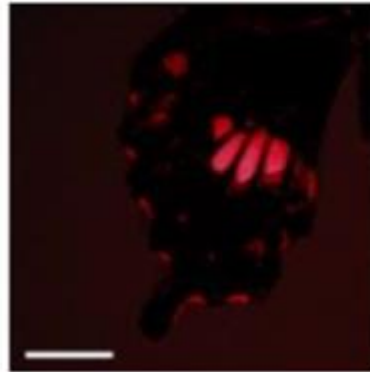
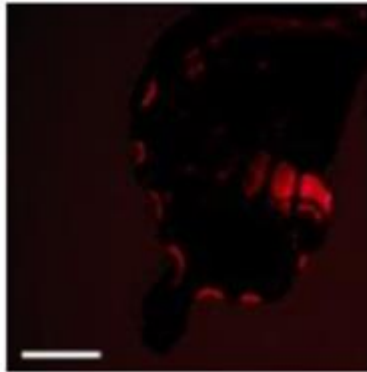
Mimetic

Female

Visible



UV



SCIENCE ADVANCES | RESEARCH ARTICLE

ORGANISMAL BIOLOGY

Genetic switch in UV response of mimicry-related pale-yellow colors in Batesian mimic butterfly, *Papilio polytes*

Shinichi Yoda<sup>1\*</sup>, Kousuke Sakakura<sup>1\*</sup>, Tasuku Kitamura<sup>1\*</sup>, Yūsuke KonDo<sup>1</sup>, Kazuki Sato<sup>2</sup>, Ryosuke Ohnuki<sup>2</sup>, Itsuki Someya<sup>1</sup>, Shinya Komata<sup>1</sup>, Tetsuya Kojima<sup>1</sup>, Shinya Yoshioka<sup>2</sup>, Haruhiko Fujiwara<sup>1†</sup>

In a Batesian mimic butterfly *Papilio polytes*, mimetic females resemble an unpalatable model, *Pachliopta aristolochiae*, but exhibit a different color pattern from nonmimetic females and males. In particular, the pale yellow region on



*Colias eurytheme* ♀



*Colias eurytheme* ♂



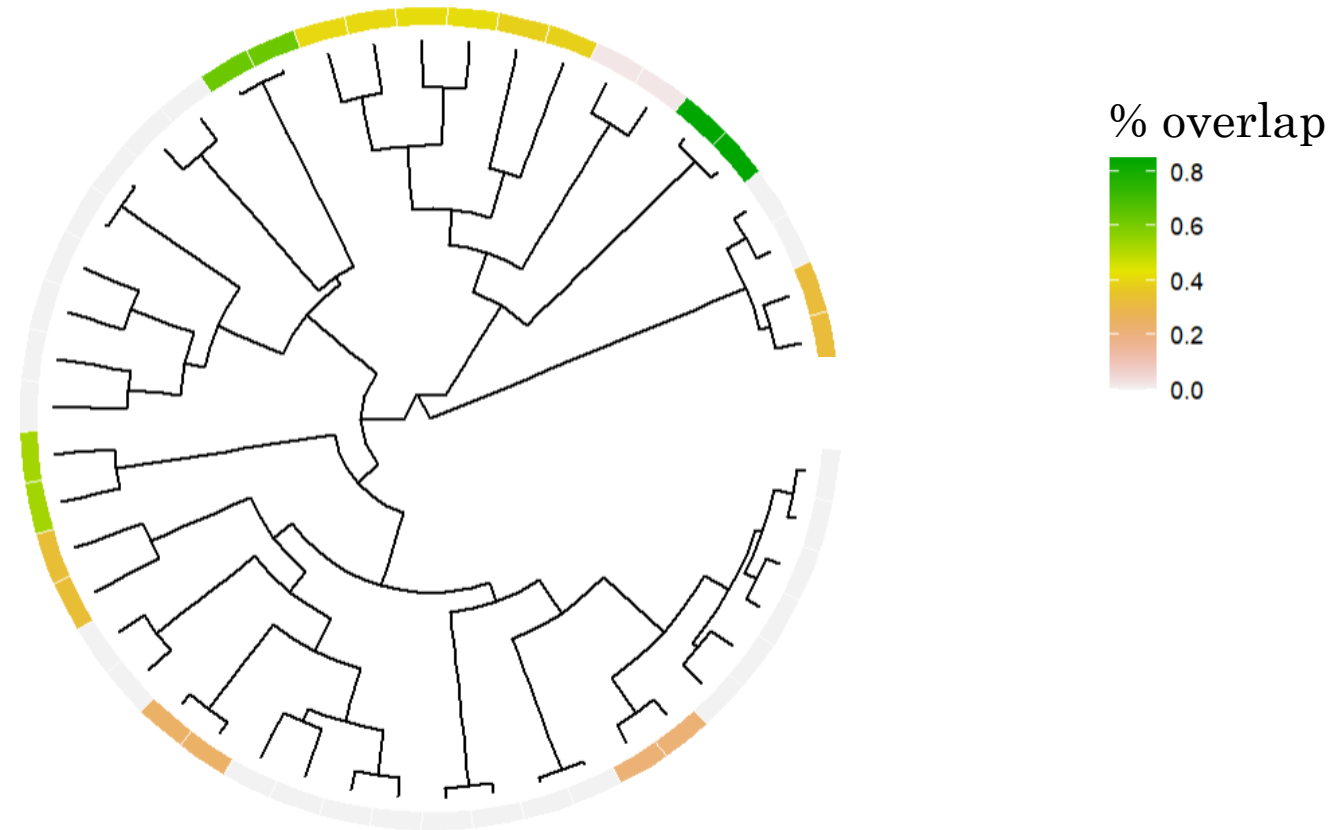
*Colias philodice* ♀



*Colias philodice* ♂

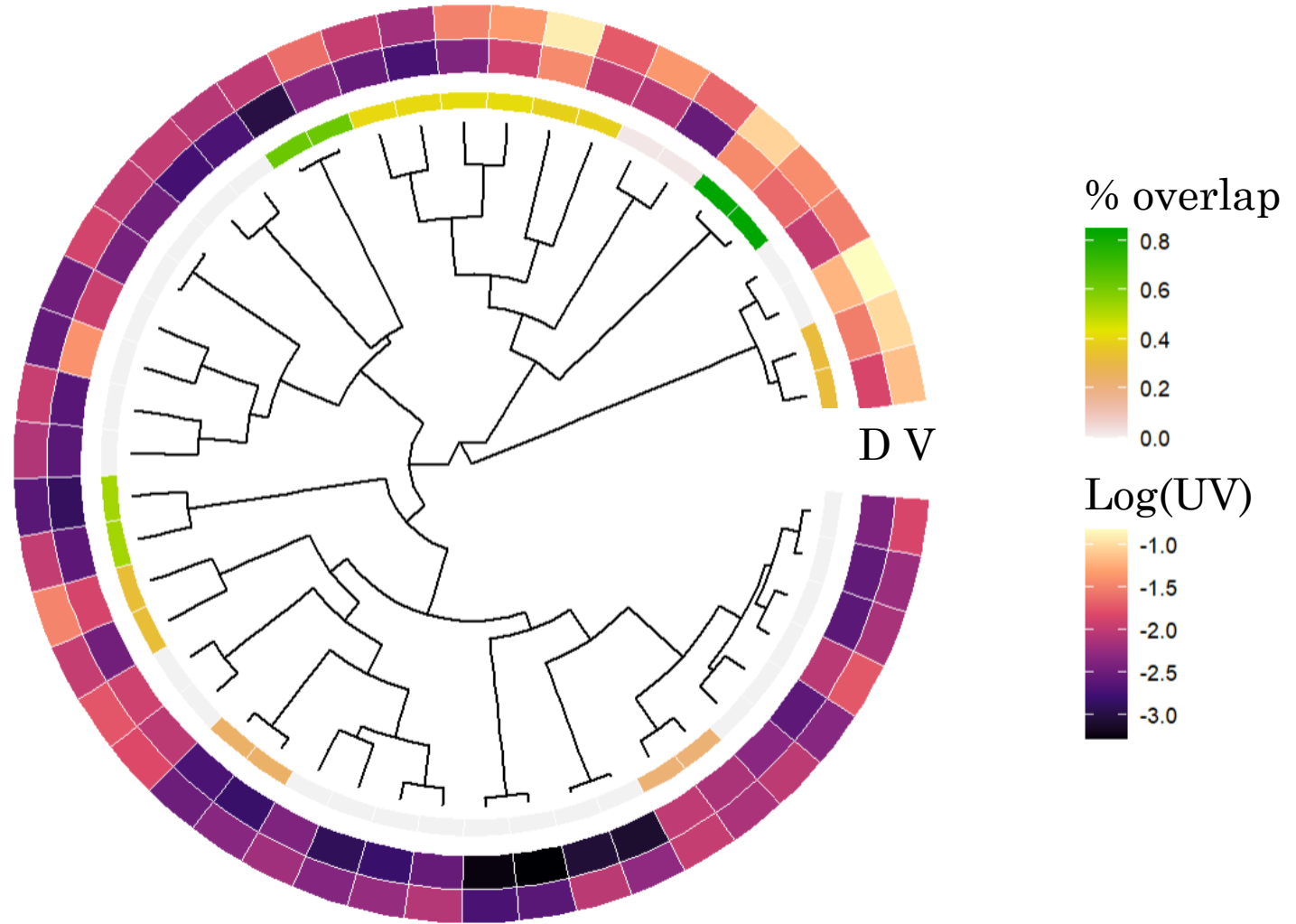
# Are UV patterns more different in sympatry than in allopatry for species that have diverged recently?

- Standardized UV photography of specimens of sister species
- 24 pairs of sister species for which geographic information is available



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UV distance not explained by visible distance



**Species 1**

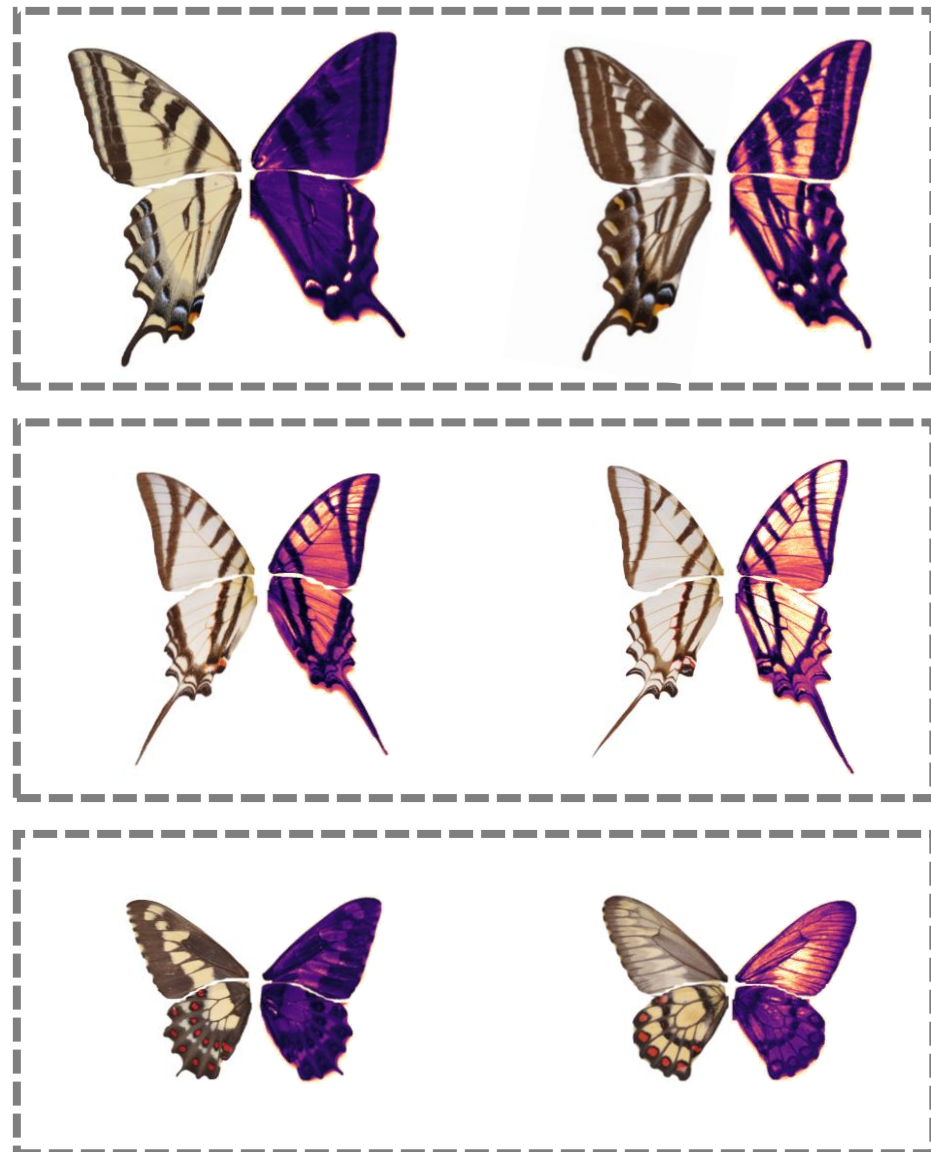
**Species 2**

*Visible*

*UV*

*Visible*

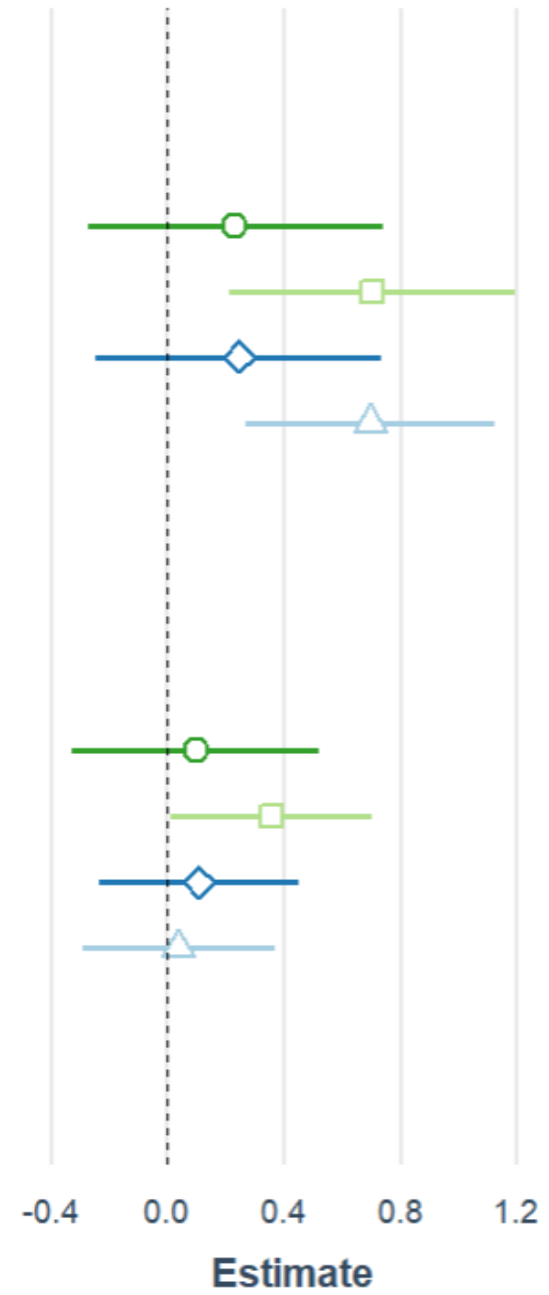
*UV*



*UV distance ~ % overlap + visible light distance*

Visible light distance

% overlap



- Femelles ventral
- Femelles dorsal
- Mâles ventral
- Mâles dorsal

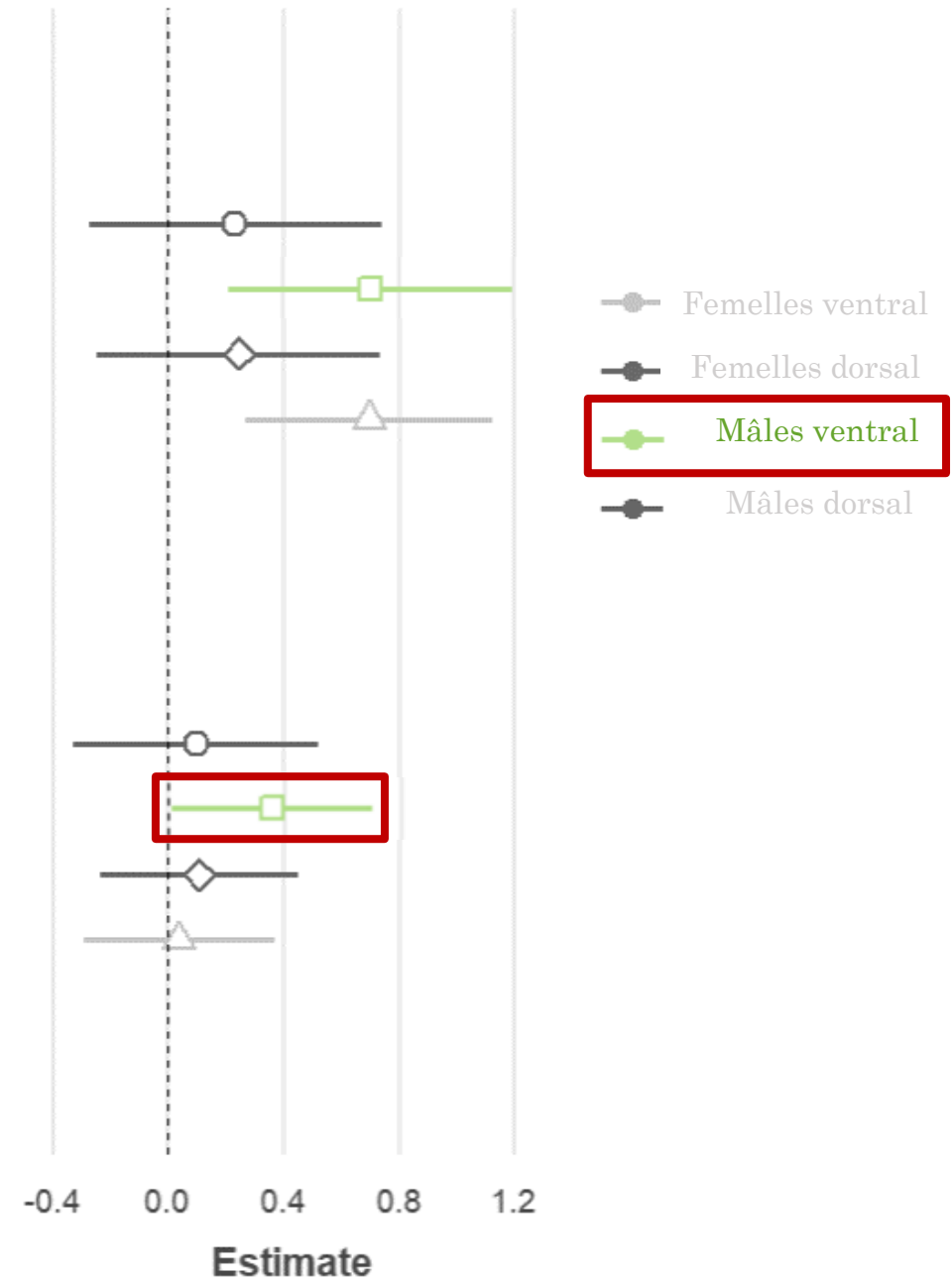
*UV distance ~ % overlap + visible light distance*

**For the ventral side of males :**

- Controlling for distance in the visible, we find a significant effect of % geographic overlap on UV distance.
- Positive relationship: the stronger the sympatry, the more the ventral faces of males diverge in the UV

Visible light distance

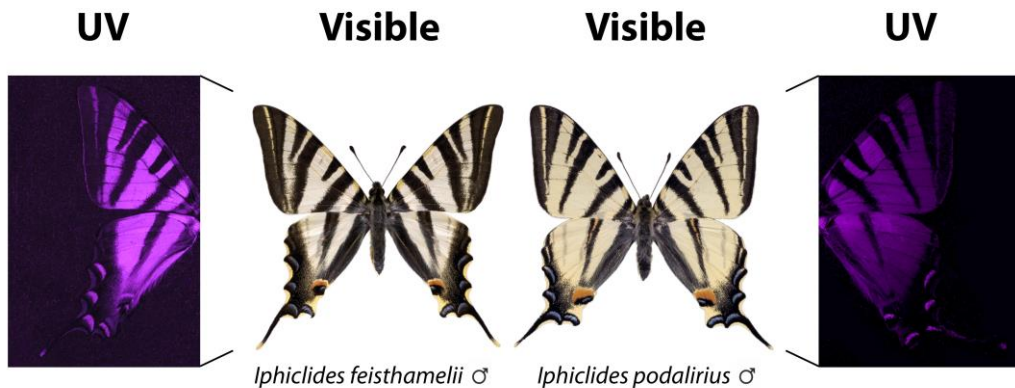
% overlap



*UV distance*  $\sim$  % overlap + *visible light distance*

**For the ventral side of males :**

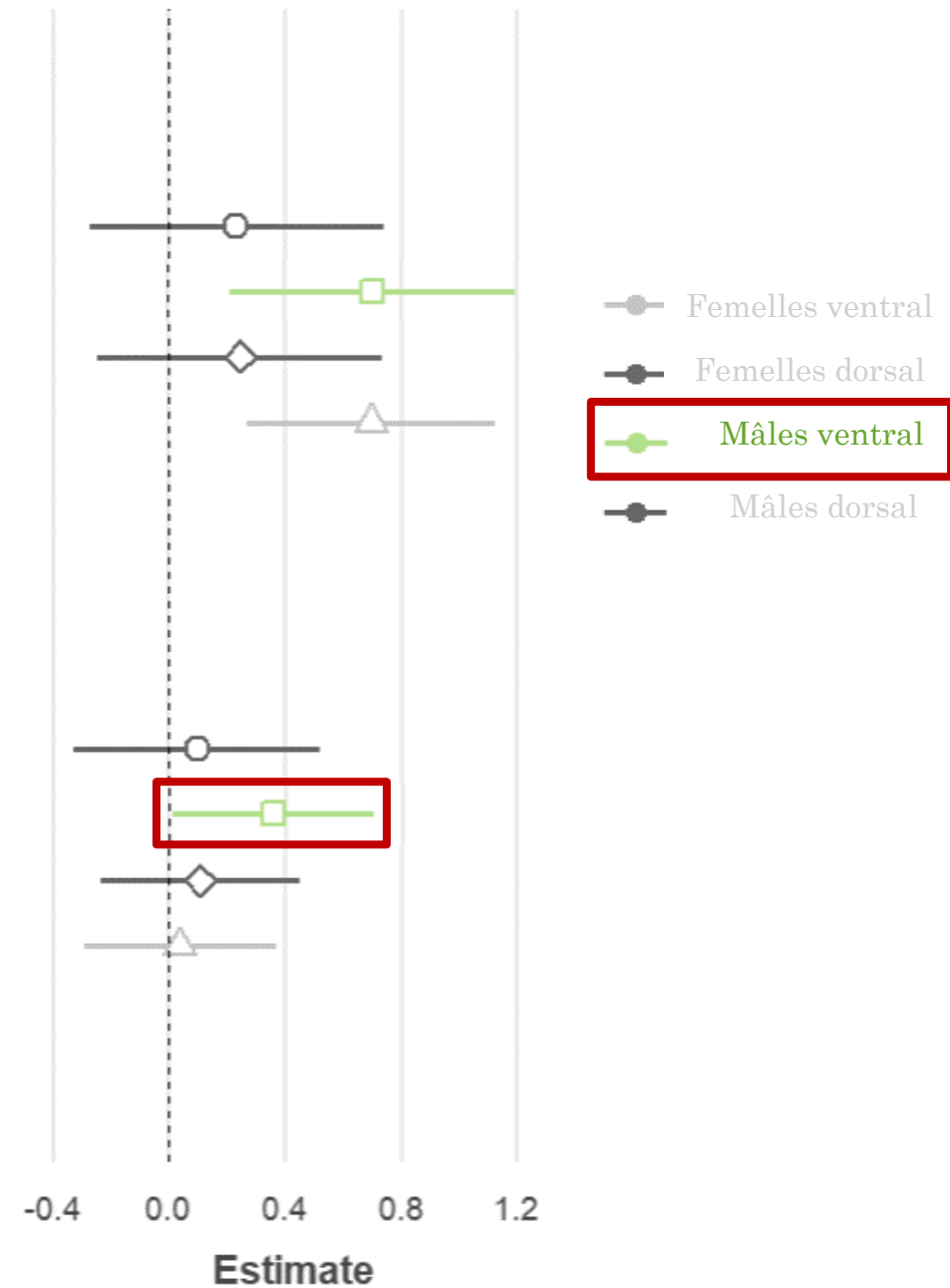
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*Gaunet et. al. (2019)*

Visible light distance

% overlap





Merci de  
votre  
attention !

