Applying geometric morphometrics to assess morphological divergence in bees

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Introduction

Bees & Biodiversity

Why study bees?

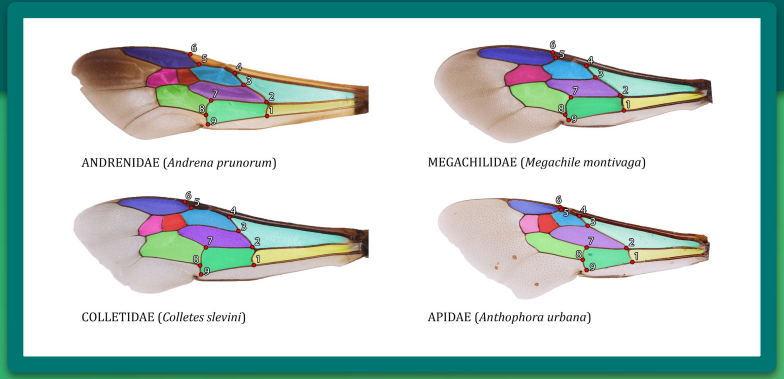
- Bees are **ecologically significant** as plant **pollinators**
- Bees are **highly diverse**
  - 20,000 species globally
  - 100 species in Santa Barbara
- Native bee species are **in decline**

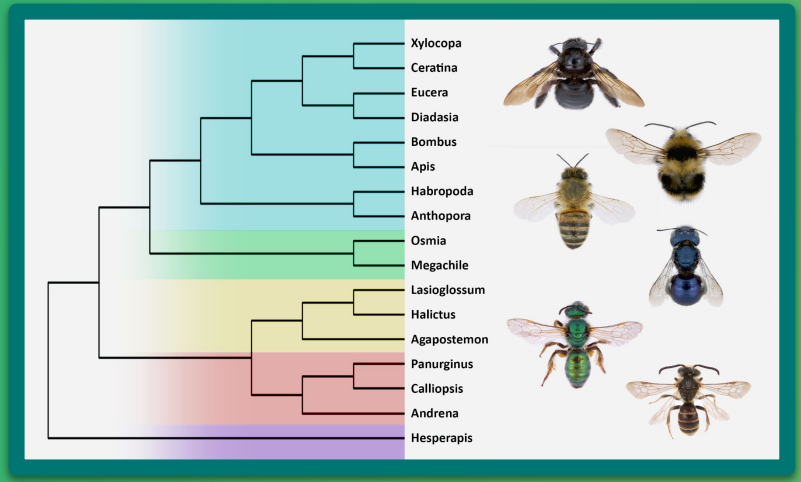
Wings & Classification

Why study bee wings?

- Classification is important for assessing **biodiversity**
  - Bee identification is **difficult**!
- **Wing venation** is crucial for classifying and identifying bees
- Bee wings are relatively **conserved**

Hypothesis: Divergence in wing morphology aligns with evolutionary family tree



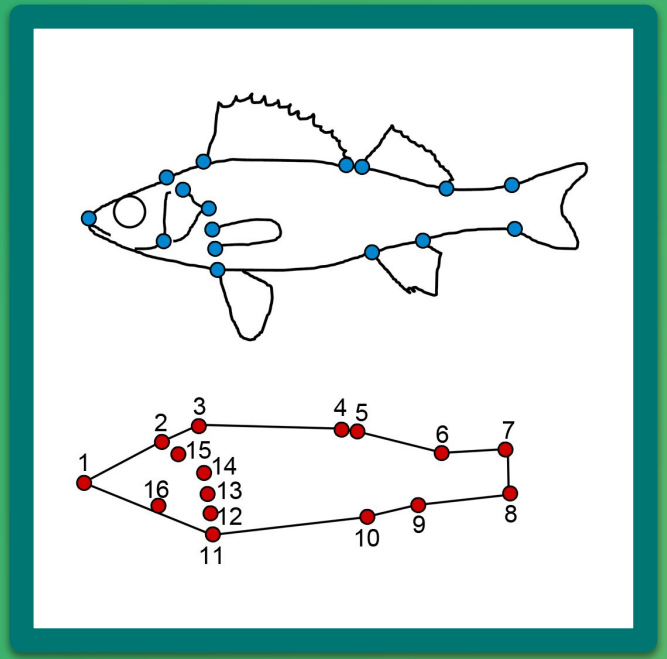


Methods

Geometric Morphometrics

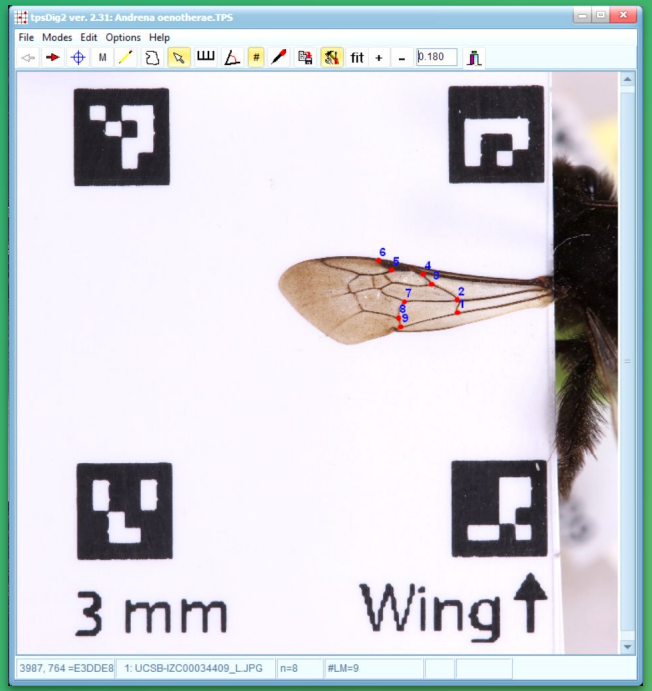
What is Geometric Morphometrics?

- **Geometric Morphometrics (GM)** is a statistical method for shape analysis
- **Landmarks** are plotted on key features
- Relative positioning of landmarks is **compared** across different specimens



Imaging

Landmarking

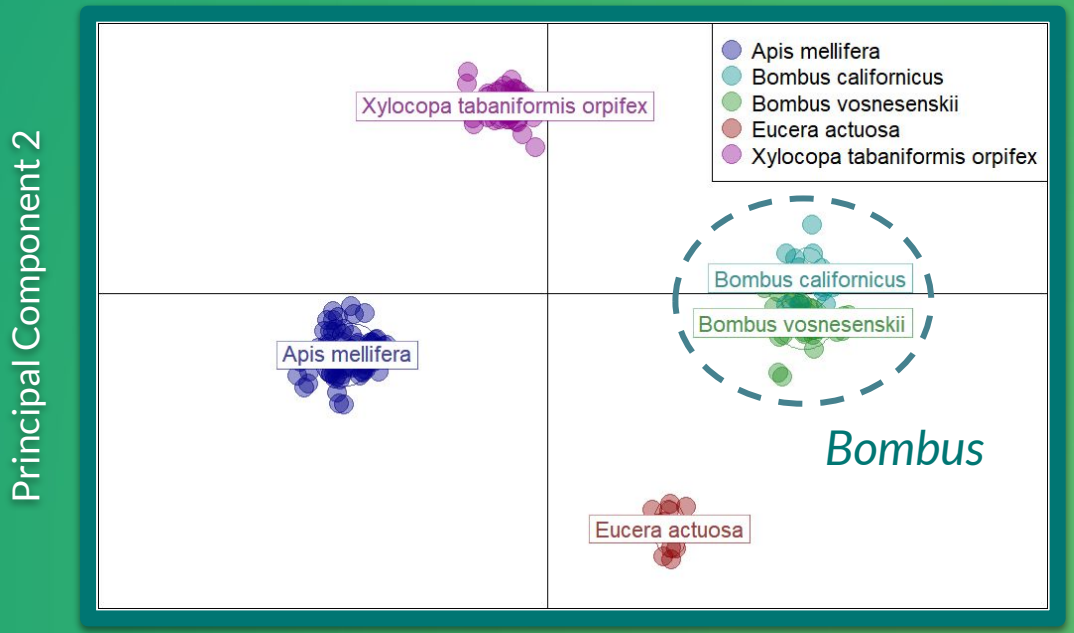


Results

Discriminant Analysis of Principal Components

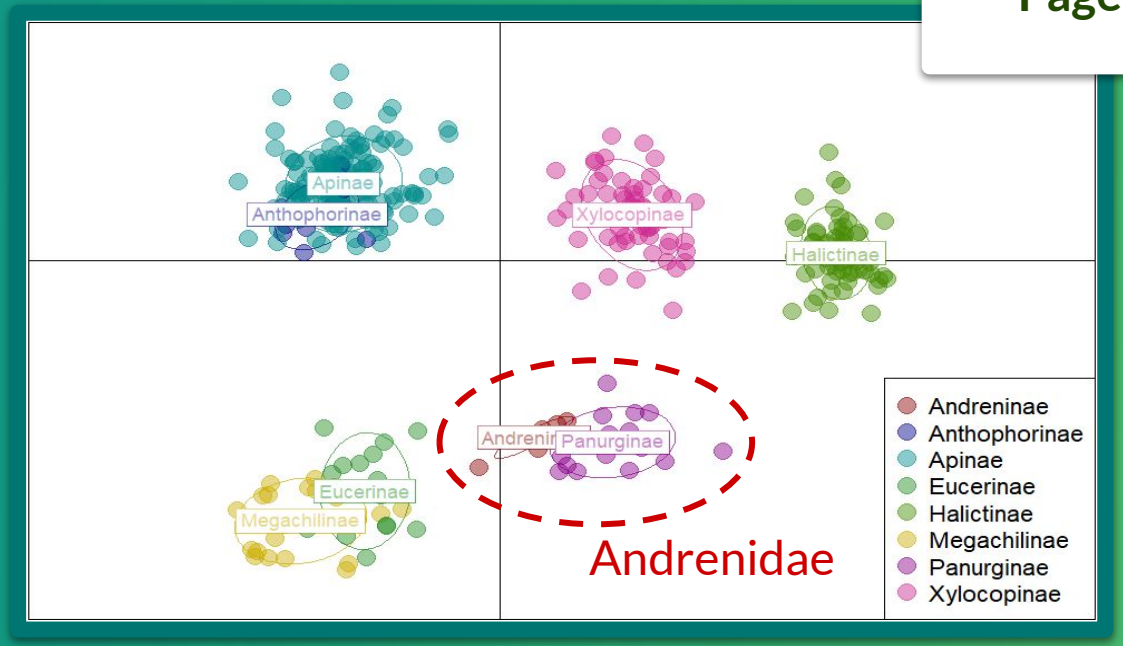
- 5 species from Apidae family
- **Clear discrimination** between species clusters
- Spatial distance consistent with **phylogenetic distance**

Species-Level DAPC



DAPC + Phylogenetic Signal

Subfamily-Level DAPC

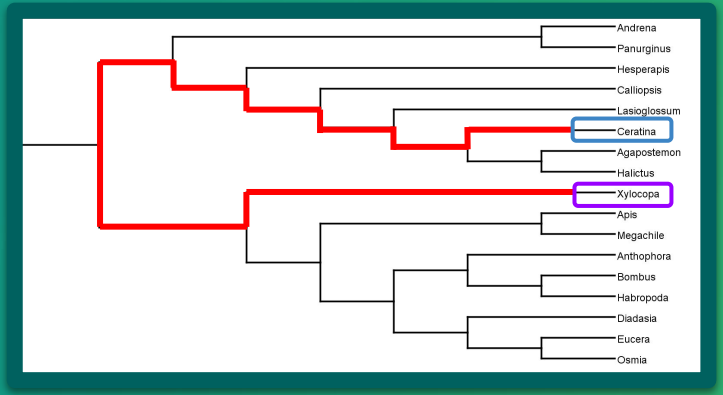


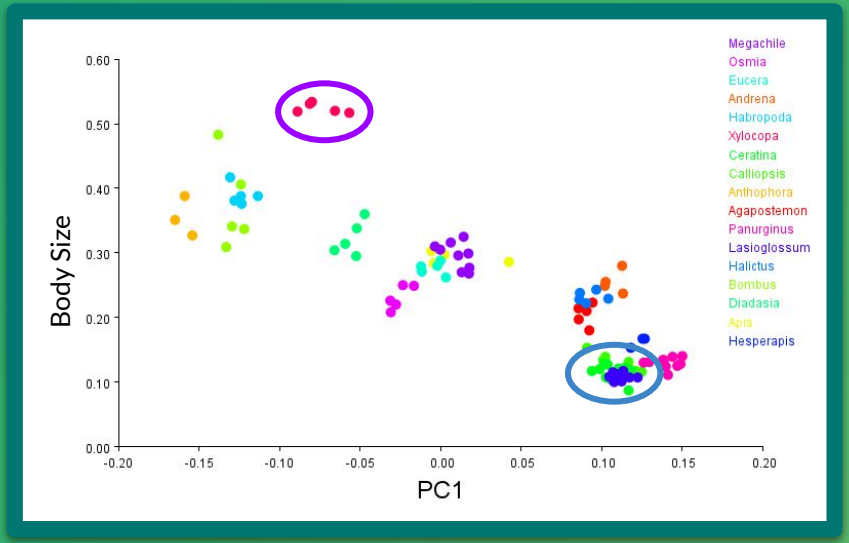
Pagel's λ = 0.999

- Sort samples into clusters at **higher taxonomic levels**
- Wing morphology consistently distinguishes different taxa
- **Phylogenetic Signal** supports results

Phylogenetic Inference + Allometry

Inferred Phylogenetic Tree





- **Phylogenetic tree inference** based on wing morphology recovers much of the known family tree with exceptions
  - ***Xylocopa*** and ***Ceratina***
- **Allometry** may explain discrepancy
  - Morphology and size

Predicted = 74.61%

P-value < 0.0001

Discussion & Future

Discussion

What does this mean?

- **Wing morphology** alone discriminates taxa and reflects evolutionary relationships
  - Extreme size differences may confound results
- **Geometric morphometrics** can be applied for bee identification, phylogenetic inference, and more

Field Imaging - Santa Cruz Island

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