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Island-mainland variation in bees: Applying geometric morphometrics to wing venation in one species

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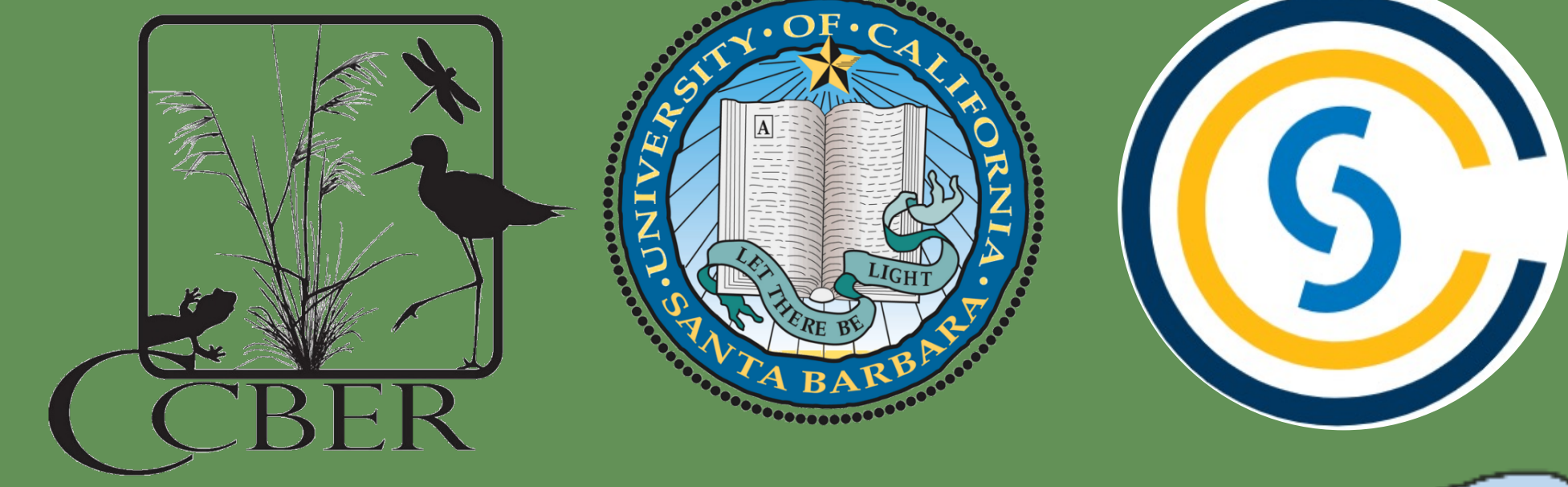
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Supplemental Material

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Island-mainland variation in bees: Applying geometric morphometrics to wing venation in one species

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UC SANTA BARBARA
Undergraduate Research
& Creative Activities

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Introduction and Question

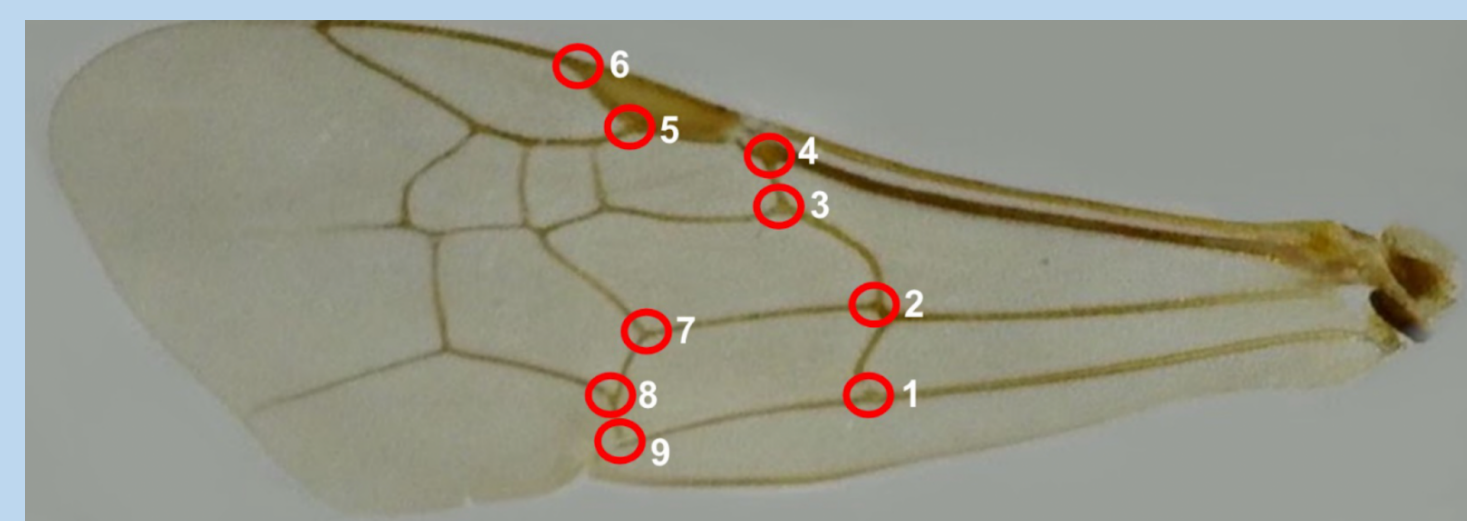
- Island/mainland populations of a single species can vary in phenotype
- Santa Cruz Island off the coast of California and mainland Santa Barbara, California have many like bee species¹ (Hymenoptera: Anthophila) which are geographically separated by 32 km of Pacific Ocean
- One abundant species is the small sweat bee *Halictus tripartitus* (Hymenoptera: Halictidae)
- Are wing venation patterns significantly different between island and mainland *Halictus tripartitus* bees?**



H. tripartitus wing

Methods

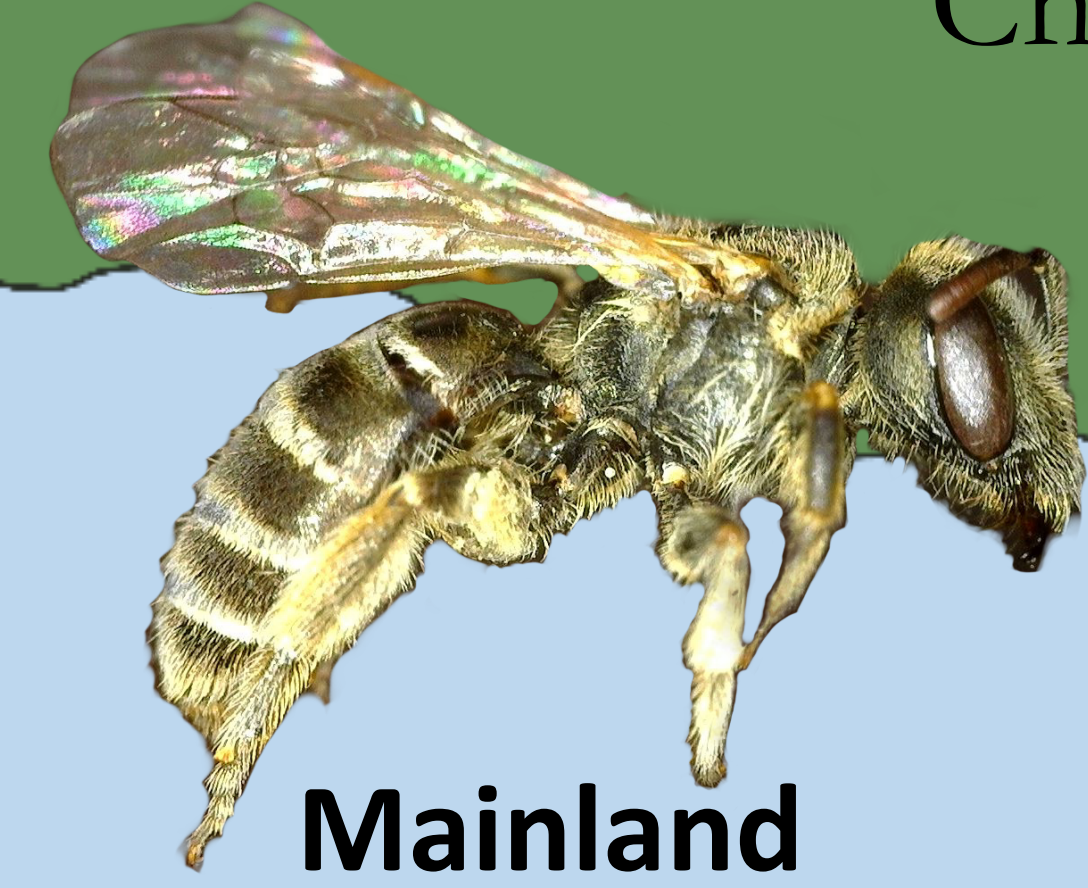
500 specimens were obtained from natural history collections² and new collections³. Forewings were removed, slide-mounted, imaged, and landmarked with the TPS software suite⁴ for 9 homologous landmarks.



Landmarked *H. tripartitus* wing

We aligned landmark coordinates with a Generalized Procrustes Analysis using R package 'geomorph'⁵. We tested for difference between island and mainland populations with an analysis of similarity (ANOSIM) using R package 'vegan'⁶. We visualized the output of a Principal Component Analysis of wing landmark patterns onto a biplot using R package 'ggbiplot'⁷.

For comparison, we duplicated landmark coordinate data and randomly-assigned each bee a population group. We analyzed this random data with the above methods.

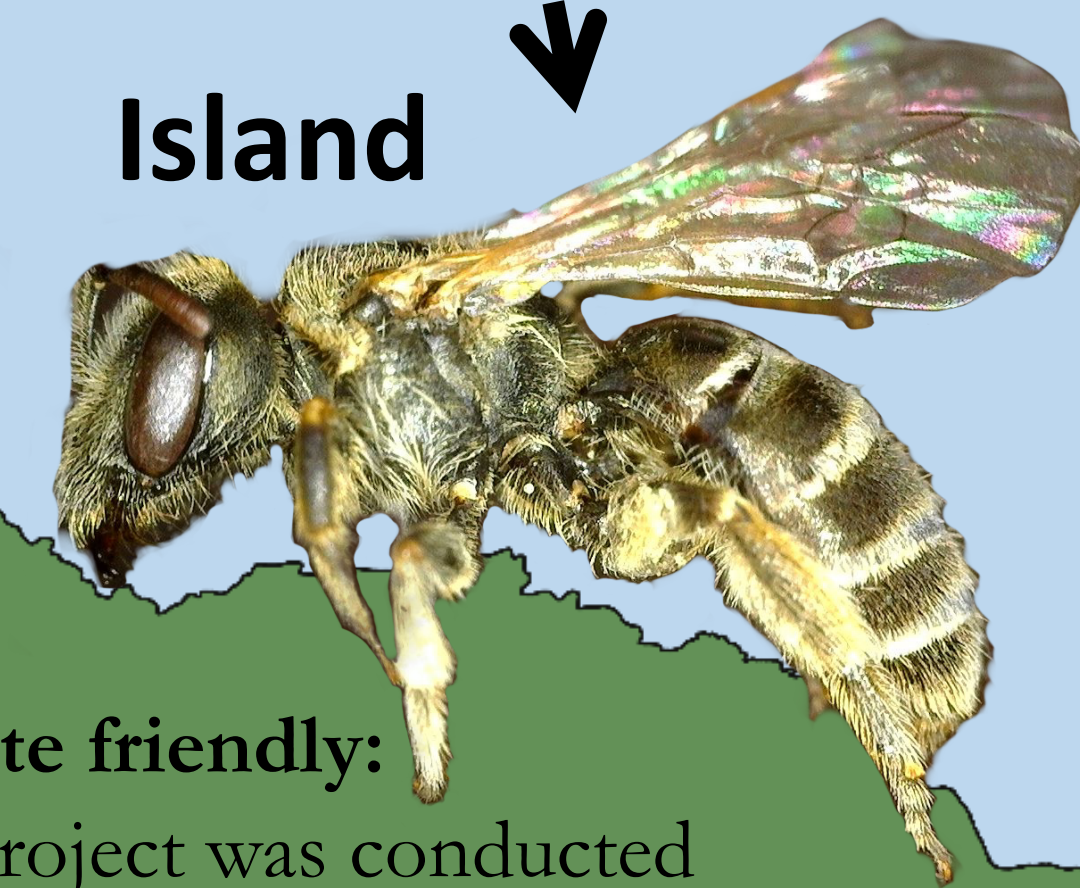


Mainland

Different wings?

32 km

Island

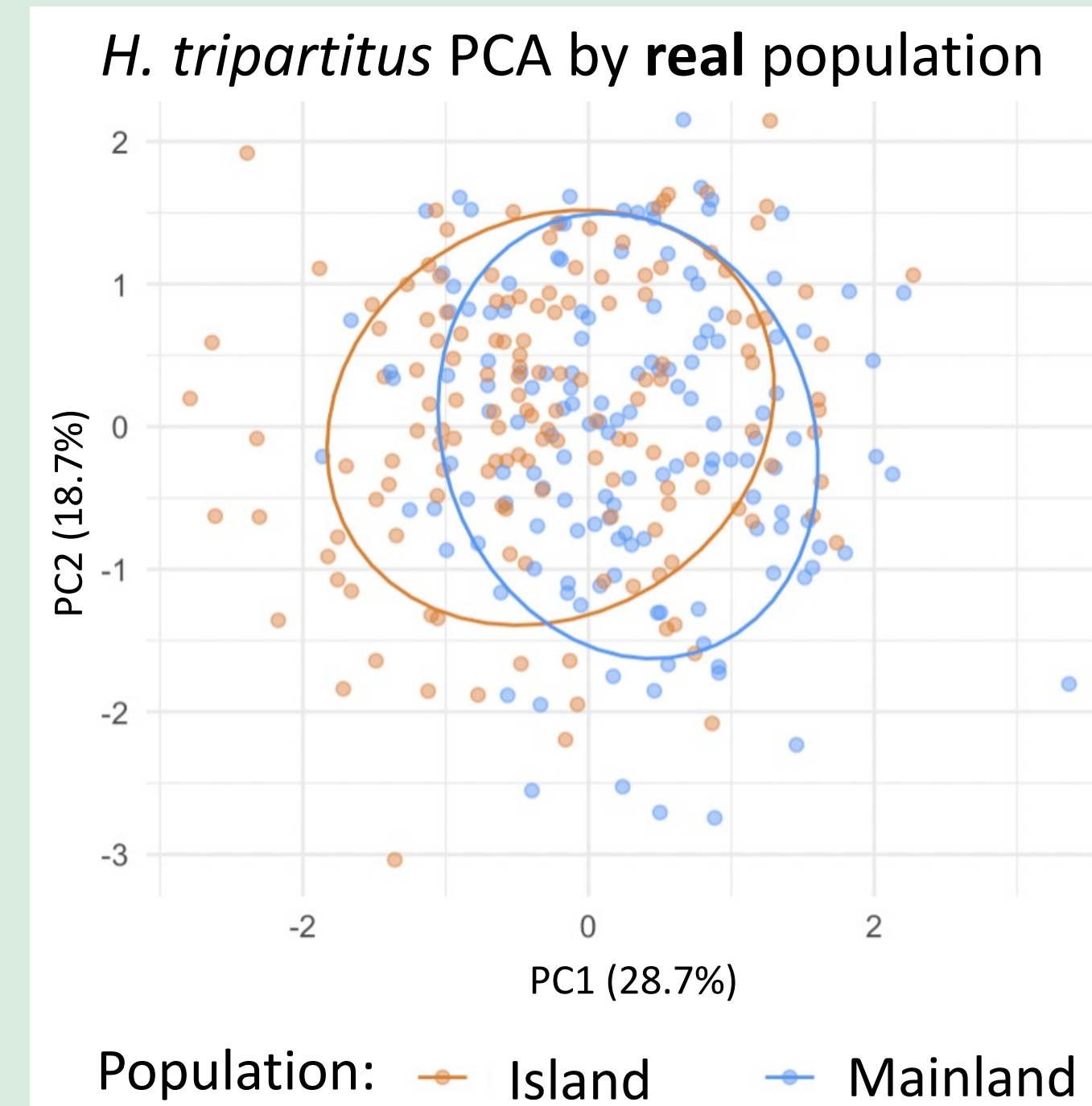


Remote friendly:
This project was conducted entirely remotely and with inexpensive equipment during the COVID-19 pandemic.

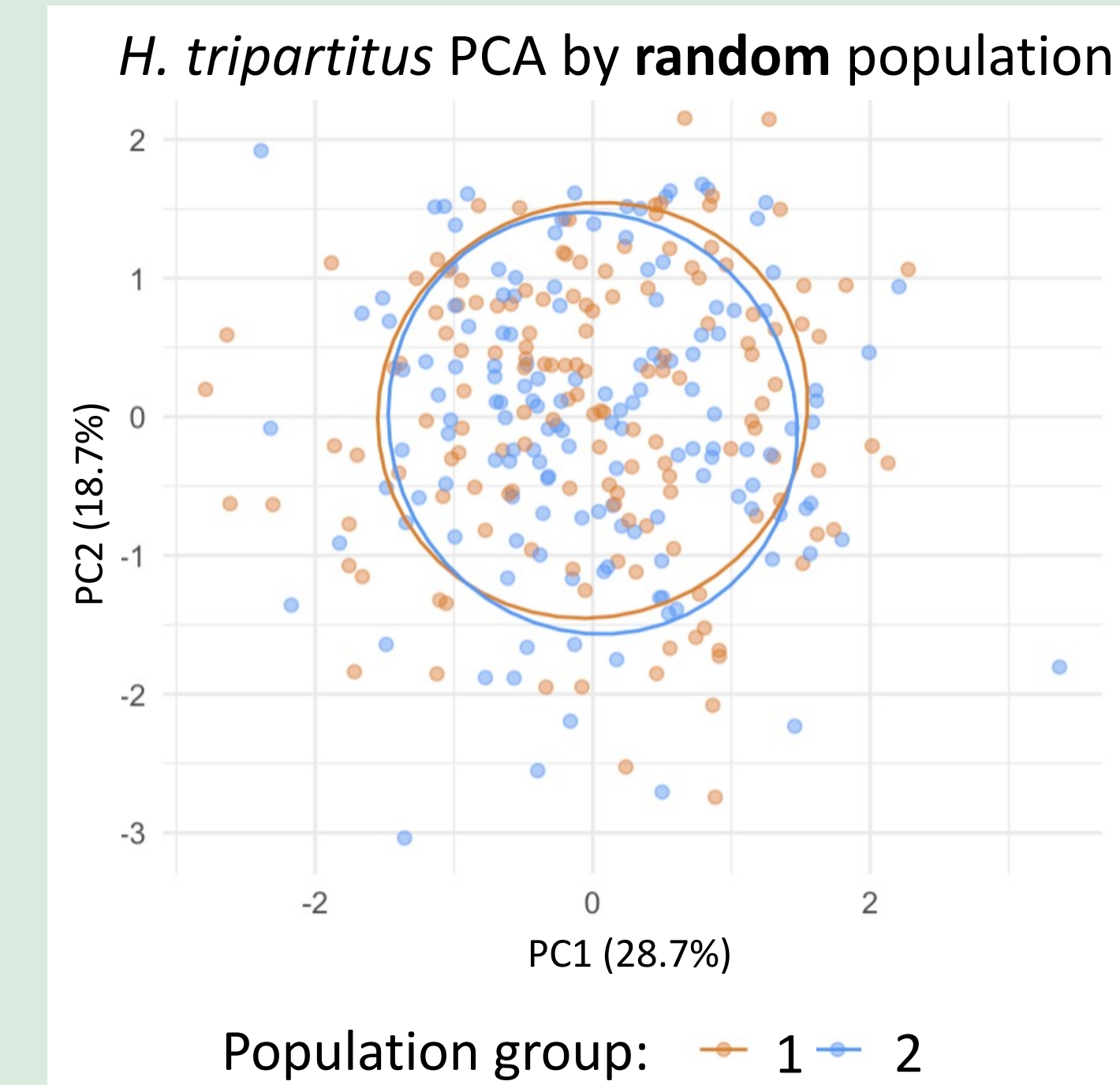
Results

ANOSIM results with 999 permutations show a significant difference between island and mainland populations ($p < 0.05$), but with a low R statistic ($R = 0.102$), indicating a weak difference.

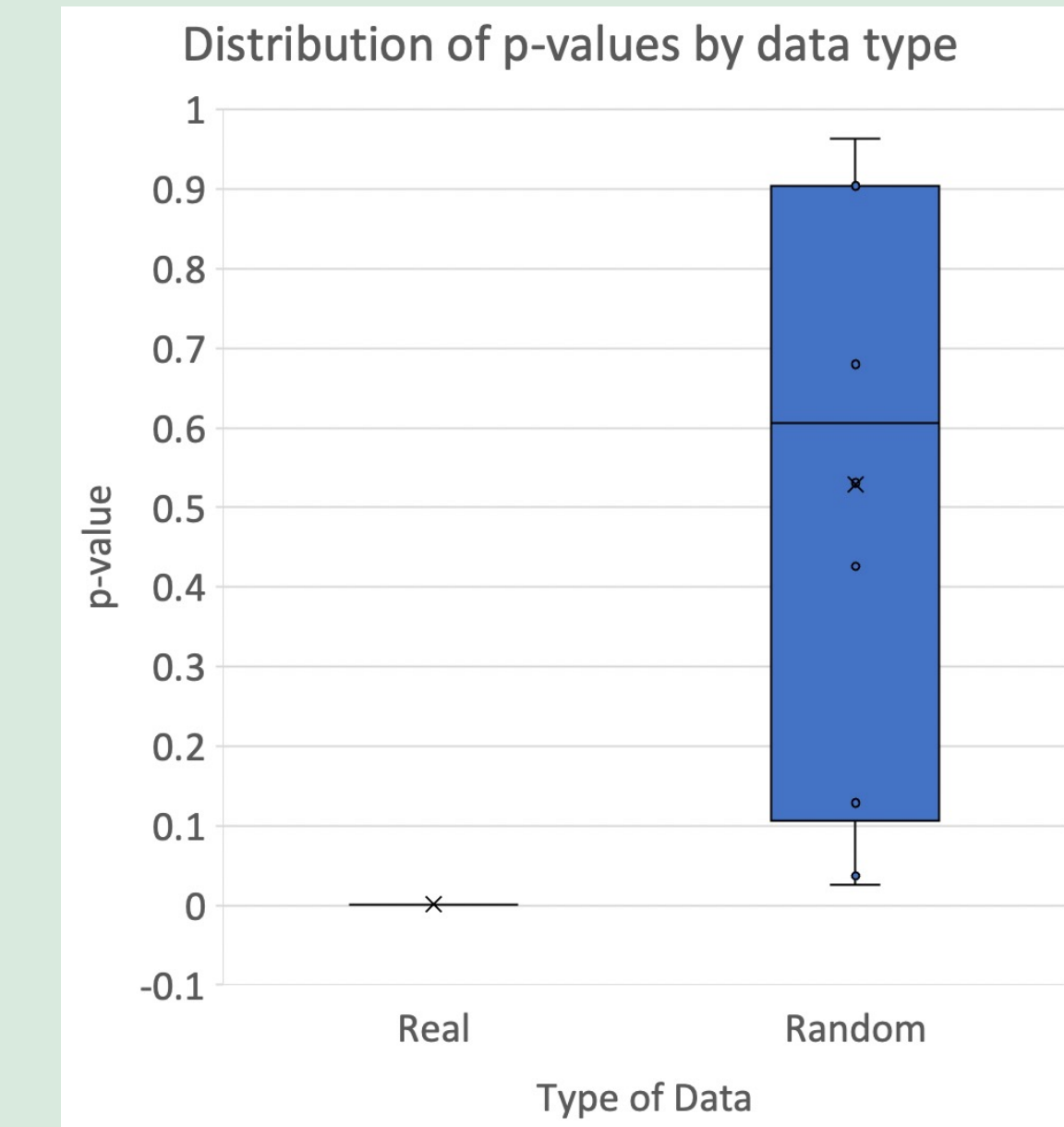
ANOSIM results from the randomly-assigned population data do not show a significant difference between the two populations ($p > 0.05$), and a lower R statistic (average $R = 0.001$) from 10 trials with 999 permutations each.



Biplot of *Halictus tripartitus* specimens by location, with mainland wings in blue and island wings in tan.



Biplot of randomly-assigned population data. Repeated trials yielded similar-looking plots.



Distribution of p-values by real data (left) and random data (right). Only 2 of 10 random trials yielded significant p-values ($p < 0.05$), and random trial p-values have a standard deviation of 0.363.

Discussion

The results of the ANOSIM test show that wing venation patterns are significantly different between island and mainland *H. tripartitus* bees ($p < 0.05$). The R statistic is low, closer to 0 than 1, indicating a weak difference between the two groups. These results are stronger than the randomly-assigned population data, which was not statistically significant ($p > 0.05$) and had a lower R statistic. In 6 of 10 cases, the R statistic was

negative, indicating that dissimilarities within groups was greater than between groups.

The biplot visualizations show a difference between the two groups of island and mainland specimens, with island specimens tending towards the left and mainland tending towards the right, even with considerable overlap in the middle. These results are also supported by the randomly-assigned data, which showed much more overlap.

Literature

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Acknowledgements

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