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Identification of honey bee populations from the azores: insights from wing geometric morphometrics

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The geometric morphometrics of the wings has been an important method for the identification and evaluation of honey bee diversity patterns around the world. Honey bee populations of the Macaronesian archipelagos of Canaries and Madeira have been intensively surveyed for diversity using a variety of genetic markers. In contrast, honey bee populations inhabiting the Azorean archipelago have been largely undersampled. To fill this gap, we sampled 473 colonies from across the Azores and assessed diversity patterns using a geometric morphometrics approach. A total of 5 forewings were collected per colony, mounted in a slide and photographed with a stereomicroscope. Additionally, the forewings representing 711 colonies of *A. m. iberiensis*, 11 *A. m. ligustica*, 15 *A. m. carnica* and 12 *A. m. caucasia* were used as reference samples. To extract shape information, 19 anatomical landmarks were plotted across the veins' intersections in the wing structures of all individuals. The analyses of wing shape were performed in MorphoJ using the Procrustes superimposition method. Shape differences were investigated through multivariate statistical analysis and Mahalanobis and Procrustes distances were used to construct a dendrogram of the morphological proximity. Results revealed the power of landmark-based methods to discriminate different honey bee populations from the Azores, and also to distinguish them from the subspecies of the reference collection. The wing geometric morphometrics patterns showed that while, overall, populations from the Azores exhibited a closer relationship with *A. m. iberiensis*, some populations, especially those from the islands of Graciosa, but also Terceira and Pico tended to cluster closer to *A. m. ligustica*, *A. m. carnica*. Several non-mutually exclusive factors can contribute to the observed wing patterns such as the recent human-mediated introductions of subspecies from Eastern Europe, and the founder effect resulting from honey bee introductions in historical times. Moreover, the particular insular environment and the barrier to gene flow due to geographical isolation possibly shaped the diversity patterns currently observed in the Azores.

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Integrative approach apply to three Belgian species (*Thoracobombus*) involving DNA sequences and male marking secretions

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Recent betterment in taxonomy consider multiple operational criteria. The integrative taxonomy provides a methodological framework merging these multisource approaches. Bumblebees are considered as a complex group where their classification remain one of the most difficult. Here, we investigate the taxonomic statuses inside a monophyletic group including six taxa (*B. inexpectatus*, *B. mlokosievitzii*, *B. ruderarius*, *B. sylvarum*, *B. velox* and *B. veteranus*) in the most diverse subgenus of bumblebees: *Thoracobombus*. We used an integrative approach based on mitochondrial and nuclear genetic makers and eco-chemical traits commonly used in bumblebee taxonomy. For all species, our genetic analyses demonstrate and confirm clear differentiation in our genetic analyses and species-specificity in the eco-chemical traits. However, based on their unique haplotypes and CLGS differentiation, we conserve the subspecific status of *B. ruderarius simulatilis* and *B. sylvarum daghestanicus* from the east of Turkey and Iran.

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