



BIOMETRIC ANALYSIS AND ESTIMATION OF THE AFRICANIZATION DEGREE OF *Apis mellifera* L. (HYMENOPTERA: APIDAE) FROM TWO COLOMBIAN ISLAND ZONES

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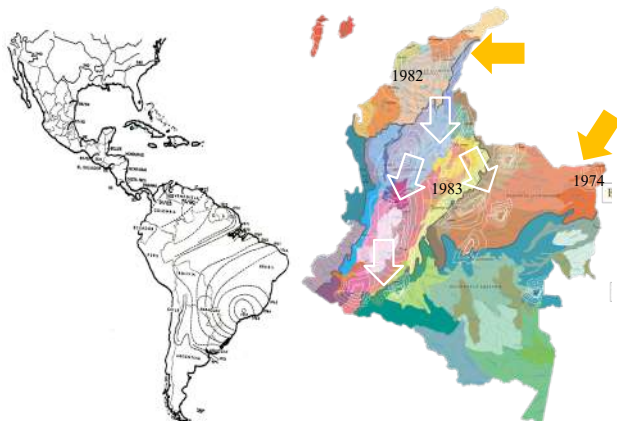
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REMARKS

The morphometrics of *Apis mellifera* (L.) are essential for the study of races or subspecies and their hybrids, enabling their classification and identification. Morphometry has been key to documenting the Africanization process since the 1970s. Studies in Argentina, Colombia, Brazil, Mexico, and the Caribbean confirm morphometrics as a reliable tool alongside genetic markers. Morphometry can be influenced by environment (nutrition, climate). Genetic markers (mtDNA, microsatellites, SNPs) provide more robust ancestry confirmation. Best practice: combine morphometrics + molecular analysis for bee population studies.



This study aims to characterize wild honey bee colonies on Múcura and San Andrés Islands using morphometric and discriminant analyses, with the objective of evaluating the dispersion and introgression of Africanized bees in the San Bernardo Archipelago and San Andrés. **Múcura Island** (9°39'N – 75°52'W), part of the San Bernardo Archipelago in the Colombian Caribbean, covers about 1.5 km² and lies 35 km from Tolu and 80 km from Cartagena. The island harbors diverse ecosystems, including remnants of tropical dry forest, introduced coconut and beach palms, coastal mangroves, seagrass meadows, and coral reefs that support high marine biodiversity. **San Andrés Island** (12°34'N – 81°42'W), part of the Colombian archipelago of San Andrés, Providencia, and Santa Catalina, lies 619 km northwest of mainland Colombia and 150 km east of Nicaragua. With a hot, humid climate (~80 °F) and annual rainfall of ~1,950 mm, the island hosts tropical dry forest, mangroves, seagrass beds, biodiverse coral reefs, and coconut palms.

MATERIALS AND METHODS

Adult worker bees were collected or removed from brood chamber combs and preserved in 70% ethanol for subsequent analysis. From each sampled colony, 6 to 10 specimens were dissected. The morphometric variables analyzed included forewing length (Laa) and width (aL), hindwing length (Lp), femur length (Fm), tibia length (Tb), the cubital index (Ic). The dissected specimens were properly mounted for subsequent image analysis using ImageJ 1.47v (National Institutes of Health, USA).

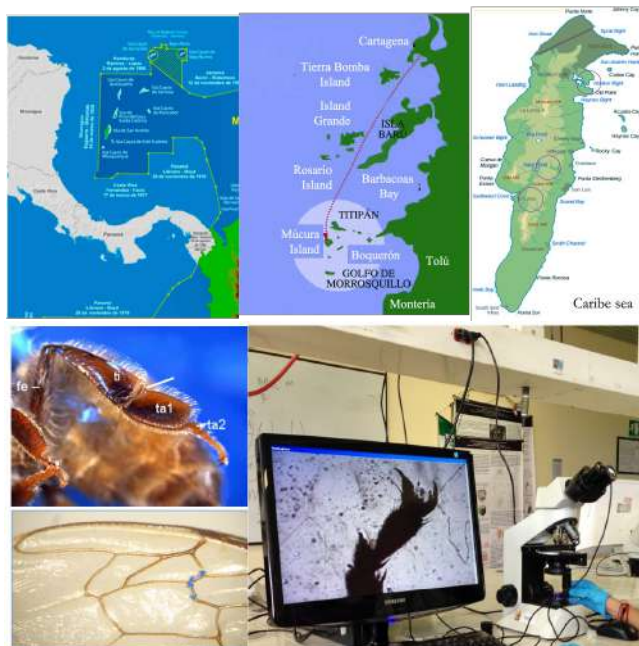


Discriminant factor (FDM) used to differentiate Africanized and European honey bees:

$$FDM = \sum (a \cdot b) - 46.5884$$

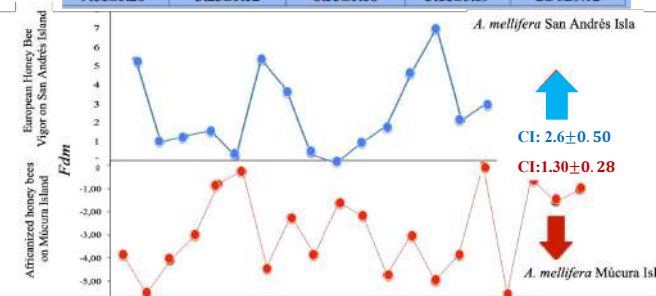
RESULTS

San Andrés is part of an overseas archipelago, while Múcura Island is influenced by the continental mainland.



In the bees from these areas, the continental proximity of Múcura Island is reflected in the Africanization process, whereas San Andrés does not show evidence of this phenomenon. The honey bee colonies from San Andrés exhibited forewing lengths ranging from 9.95 to 9.08 mm, values comparable to those reported for bees from San Cosme, Argentina [comparative study]. In contrast, colonies from Múcura Island showed shorter ranges of 8.06–8.77 mm, clustering morphologically with Africanized bees (Ruttner, 8.66 ± 0.16 mm). Therefore, the bees of San Andrés display morphometric traits consistent with European lineages.

L _a mm	L _{aa} mm	L _{ap} mm	L _{tb} mm	L _{fm} mm
9.61±0.20	3.25±0.12	6.55±0.16	3.11±0.19	2.36±0.12



L _a mm	L _{aa} mm	L _{ap} mm	L _{tb} mm	L _{fm} mm
8.43±0.26	3.11 ± 0.14	4.25±0.30	3.00±0.14	2.30±0.14

On San Andrés Island, beekeeping with European honey bees, *A. mellifera ligustica*, has been actively promoted. The island has been declared a Genetic Reserve for *Apis mellifera ligustica*, emphasizing its importance in the conservation and genetic improvement of this species. Implementing selective breeding processes of European honey bees in areas with continental influence is not recommended due to the pronounced effect of introgression from Africanized bees.

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Morphometric assessments of bees have proven to be valuable in classification processes in animal systematics, facilitating the identification of hybrids and pure races. With the ongoing Africanization process in the Americas, it has become necessary to investigate the expansive effect and the degree of introgression that this process implies. In this study, the nature of wild colonies established on the island zones of Múcura Island in the San Bernardo Archipelago and San Andrés Island was analyzed through biometric and discriminant analysis. Samples of *Apis mellifera* were collected from the study areas, and anatomical variables such as forewing length (La), hindwing length (Lp), femur (Fm), tibia (Tb), and cubital index (Ic) were evaluated to estimate the introgression of Africanized bees in the study area. The discriminant analysis of the evaluated populations revealed values indicating a dominance of Africanized bees in the San Bernardo population (FDm -2.50), positioning them as descendants of hybridization events, introgression, and the expansion of Africanization from the continental side to overseas territories in the Colombian Caribbean. Meanwhile, the San Andrés bee population exhibited characteristics typical of bees bred and maintained in a special genetic reserve zone, with forewing length values ranging from 9.10 to 9.95 mm, similar to those observed in bees from San Cosme, Argentina. In contrast, bees from Múcura Island displayed ranges of 8.06–8.77 mm, which are characteristic of Africanized bees (Ruttner, 8.66 ± 0.16 mm), with FDm values between 1.5 and 7.0. These bees are part of the Seaflower Business Challenge genetic reserve, recognized for their productivity in continental areas of Central America.