ISSN 1021-0296

REVISTA NICARAGUENSE DE ENTOMOLOGIA

N° 367 Enero 2025

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PUBLICACIÓN DEL MUSEO ENTOMOLÓGICO
LEÓN - - - NICARAGUA

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URL DE LA REVISTA: http://www.bio-nica.info/RevNicaEntomo/RevNicaEntomo.htm

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Joxual J. Araque Pérez[1] & Jaime Navarrete-Rivas[2].

RESUMEN

Este estudio documenta la diversidad de polillas Saturniidae y Sphingidae en los bosques de transición pre-montanos del Cerro Quizaltepe, San Lorenzo, Boaco, Nicaragua, una zona previamente inexplorada. Durante la estación seca, se registraron 70 individuos de 25 especies, siendo *Manduca lefeburii* y *Dysdaemonia boreas* las más abundantes. Los análisis de uso de suelo identificaron amenazas de expansión agrícola, subrayando el valor de conservación de este sitio, que actúa como un refugio para especies de tierras bajas y de montaña. Estos resultados iniciales apuntan a que la temporada de lluvias podría incrementar la diversidad y abundancia de especies, destacando la necesidad de investigaciones estacionales y la relevancia del área como corredor ecológico y refugio para la conservación de especies.

Palabras clave: Diversidad de Lepidoptera, Saturniidae, Sphingidae, bosque premontano, Quizaltepe-Boaco.

DOI: 10.5281/zenodo.14613299

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ABSTRACT

This study documents the diversity of Saturniidae and Sphingidae moths in the transitional premontane forests of Quizaltepe Hill, San Lorenzo, Boaco, Nicaragua, a previously unexplored area. During the dry season, 70 individuals representing 25 species were recorded, with *Manduca lefeburii* and *Dysdaemonia boreas* being the most abundant. Land-use analysis identified threats from agricultural expansion, underscoring the conservation value of this site, which serves as a refuge for both lowland and montane species. These preliminary results suggest that the rainy season could increase species diversity and abundance, highlighting the need for seasonal research and the importance of the area as an ecological corridor and refuge for species conservation.

Palabras clave: Moth diversity, Saturniidae, Sphingidae, premontane forest, Quizaltepe-Boaco.

INTRODUCTION

The group commonly referred to as "Heterocera" encompasses approximately 147,415 species of nocturnal Lepidoptera (Amarillo, 2000), including the Saturniidae family, which is characterized by large-sized moths with an estimated 1,200–1,300 species worldwide (Heppner, 1991), 850 of which are found in the Neotropics (Scoble, 1992). Conversely, the Sphingidae family includes around 1,400 species across 200 genera, with members distributed across most continents (Rothschild & Jordan, 1903; Kitching & Cadiou, 2000).

Research on Saturniidae and Sphingidae remains limited, despite their broad geographic range and relatively well-established taxonomy (Lemaire, 1978, 1980, 1988, 2002). Even less information exists regarding their current status and conservation needs. Santos *et al*. (2015) emphasize their ecological role as prey within food webs, supporting birds, bats, parasitoids, and parasites.

Sphingids are also recognized as essential pollinators, showing seasonal patterns aligned with local flora (Haber & Frankie, 1989). In contrast, adult Saturniids do not feed (Janzen, 1984). Thus, these families serve as valuable bioindicators of ecosystem health (Highland *et al*., 2013), making their study crucial for understanding tropical biodiversity complexity and its preservation (Balvanera *et al*., 2002; Novotny *et al*., 2010).

The primary objective of this research is to document moth species in Quizaltepe Hill, an area previously unexplored in terms of faunal diversity. The site's unique orographic and climatic characteristics offer promising opportunities to identify and potentially discover moth species that are rare or absent in the Boaco department.

As a transitional zone between humid and dry forest ecosystems, Quizaltepe Hill offers a valuable setting for studying the seasonal diversity of moths. Additionally, as one of the few remaining forest remnants in the San Lorenzo area, it may serve as a crucial refuge for numerous species, underscoring its ecological importance for conservation and establishing a solid foundation for future research. The significance of these forest fragments, along with their shape and structure, is essential for preserving areas that serve as habitats for many endangered or at-risk species (Araque, 2023).

MATERIALS AND METHODS

Location of the Study Area

The municipality of San Lorenzo, located in the department of Boaco, Nicaragua, is situated in the Central North region of the country. It is positioned between the coordinates 12°03'40" and 12°47'00" north latitude, and 84°52'20" and 85°59'12" west longitude, located in the southern part of the department. Geographically, it forms part of the sub-basins of the Tecolostote and Malacatoya rivers, which drain their waters into Lake Nicaragua (Cocibolca), within basin 69, according to PREVDA, 2010. Boaco consists of six municipalities: Boaco, San José de los Remates, Teustepe, Santa Lucía, San Lorenzo, and Camoapa.

Figure 1. Aerial view of Quizaltepe Hill, San Lorenzo – Boaco (Nicaragua) (photo © Milton Ñamendy).

The Quizaltepe hill area is located within the municipality of San Lorenzo, Boaco (Figure 1). This region is characterized by a diverse climate that ranges from very humid to semi-arid conditions, contributing to the variability in species abundance and diversity (PREVDA, 2010). The area is classified as a pre-montane zone with dry to semi-humid forest characteristics, as it serves as a transitional region between the drier Pacific side of Nicaragua and the wetter, more humid Caribbean side.

To characterize the area, meteorological data from NASA-Power, were utilized (https://power.larc.nasa.gov/), covering a 21-year period (2001-2022). The data indicate that average temperatures in the area range from 15°C to 26°C. This temperature variation is significantly influenced by trade winds from the Caribbean and Pacific regions of Nicaragua, shaping the microclimatic conditions observed in the study area (Figure 2).

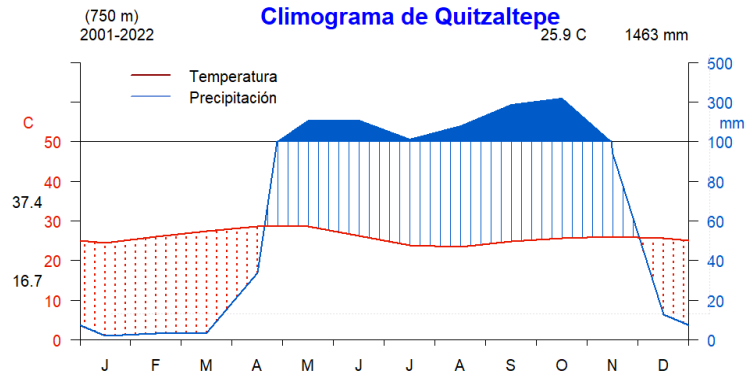


Figure 2. Climograph of Quizaltepe: Temperature and Precipitation Trends (2001-2022) (authors elaboration)

The figure 3, Finca Hilario highlights two distinct life zones according to Holdridge's classification: the Subtropical Moist Forest (Dry), shown in light brown, characterized by moderate humidity and a distinct dry season, and the Tropical Dry Forest (Cool), indicated in blue, which features cooler and drier conditions typically found in elevated tropical areas (Holdridge, 1967).

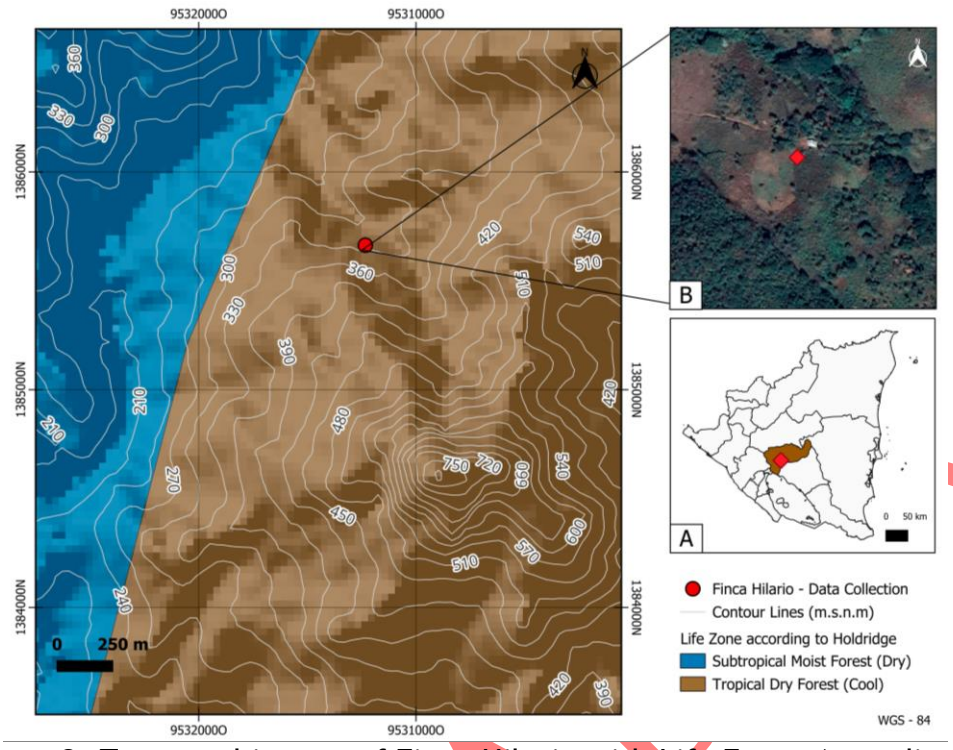


Figure 3. Topographic map of Finca Hilario with Life Zones According to Holdridge Classification. Source: authors elaboration based on WMS data from SIGportal (sica.int).

Maps and Graphs: All maps were created using QGIS software, version 3.28 (Firenze). The DEM/Elevation data were derived from the file n12_w086_1arc_v3 - DEM30M, downloaded from Earth Explorer. Graphs generated from the species collections were produced using R-Studio (R-Core Team, 2024).

Supervised Classification: Satellite images from Planet.com for December 2023, code (L15-0533E-1093N), were downloaded. The raster resolution is 4.7m per pixel. A virtual raster was created in QGIS with bands R:2, G:1, and B:3 to perform supervised classification and generate a land use cover map. The virtual raster (band combination) and the output model were used for classification using Random Forest through the Dzetsaka classification plugin in QGIS (Pollini, 2021).

Specimen capture: Was conducted during the dry season in April and May 2024, with two sampling nights of 6 hours each, totaling 24 hours of sampling effort. Two light traps equipped with a 250W mercury bulb (MED) was used, operating with a power transformer during the 6-hour nightly sessions over a square-shaped white cloth. The trap was set at coordinates 12.34947, -85.61934. Moths were euthanized using ethyl alcohol injected into the thorax with a 3-cc syringe and subsequently stored in labeled paper triangles (Figure 4).

Figure 4. Species capture process: (A) Collection of Lepidoptera at the light trap; (B) Photographic records above the trap; (C) *Eacles imperialis* on the cloth of the light trap; (D) *Dysdaemonia boreas* beneath the light trap.

Identification: Species identification was performed based on references including Maes *et al*. (2001), Chacón & Montero (2007), Tórrez *et al*. (2007), Maes (2007), AGG (2016), and the Online Lepidoptera Catalog (BioNica, 2024). Photographs of the specimens were uploaded to the iNaturalist.org database for dual verification, allowing expert community members to review and correct the scientific names of some species. Photographs were taken with a Canon EOS Rebel T7 camera, a Laowa 100mm lens, and an external flash donated by IdeaWild.org.

RESULTS

A supervised classification was conducted to identify the current land use (Figure 5), aiming to document the area as a baseline due to threats from burning, resulting from agriculture, poor soil management, and agricultural expansion. The geography and climatic conditions make it a special place for conservation with potential for ecotourism. Additionally, being unexplored, it may harbor species that have not been reported in the country.

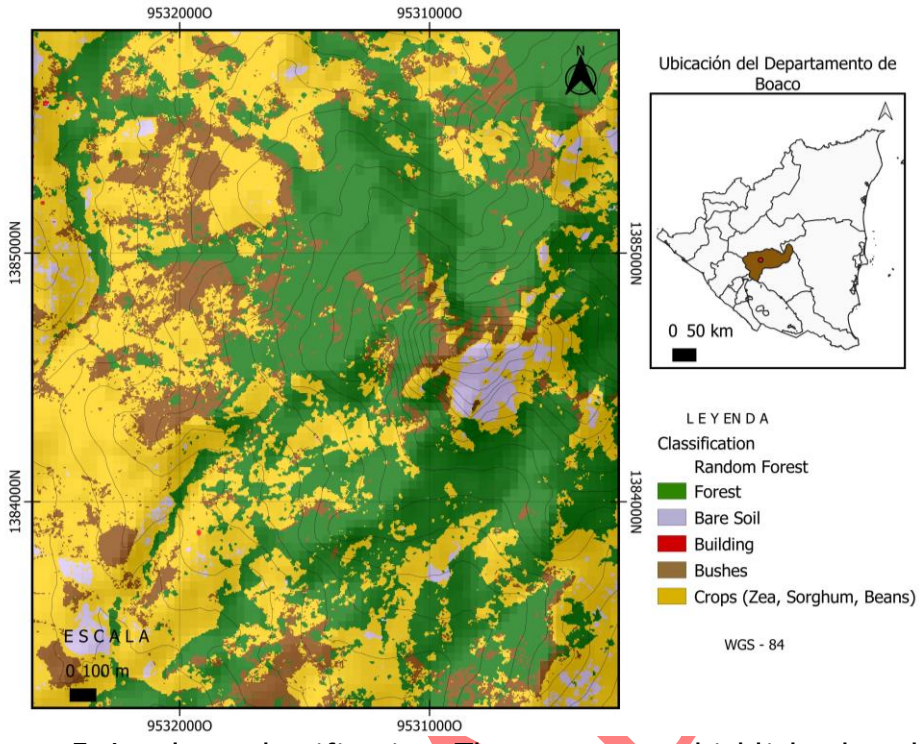


Figure 5. Land use classification. The green areas highlight that the surrounding area of the hill preserves the most vegetation, which could potentially harbor new species records.

A total of 70 individuals and 25 species were captured, demonstrating that ***Manduca lefeburii*** is the most abundant species, with 11 individuals recorded, followed by ***Dysdaemonia boreas*** with 8 individuals. On the other hand, several species, such as ***Caio championi***, ***Cautethia spuria***, *and* ***Erynnyis crameri***, were represented by only one individual (Figure 6).

A segmentation based on altitude differences was included with the aim of establishing a precedent where the altitudinal variable can be used in future studies to identify a greater number of species or new records (Figure 8). Since this area had not been previously explored in terms of its entomological fauna, specifically moths, a photographic catalog was created to document the species captured during the study. Conducted during the dry season, and considering that the conditions of the area (Quizaltepe) favor many species to take refuge or distribute themselves in the region, it is expected that a greater number of individuals and species will be recorded during the rainy season, when climatic conditions are more favorable for insect activity.

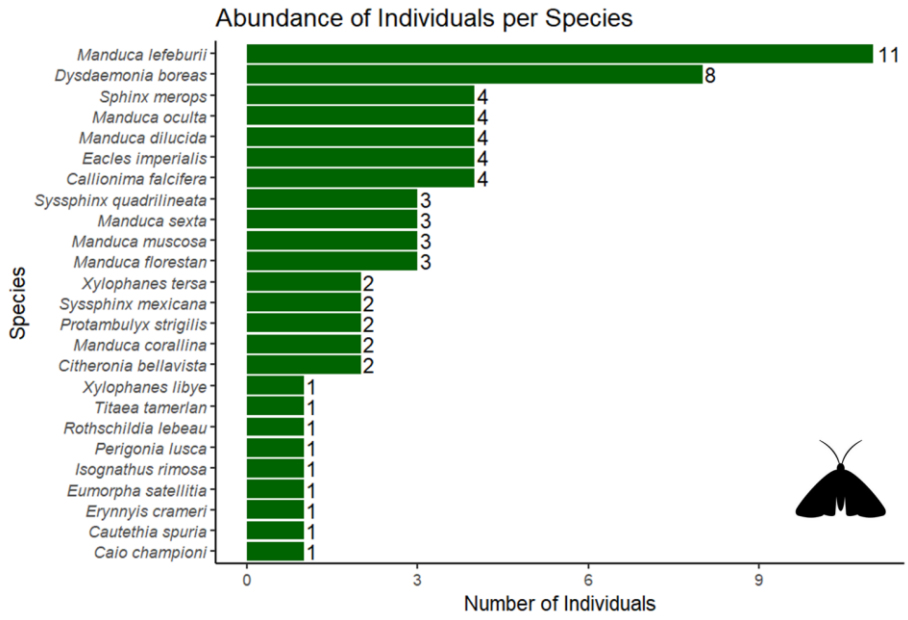


Figure 7. Species captured in the study area indicating the number of individuals captured.

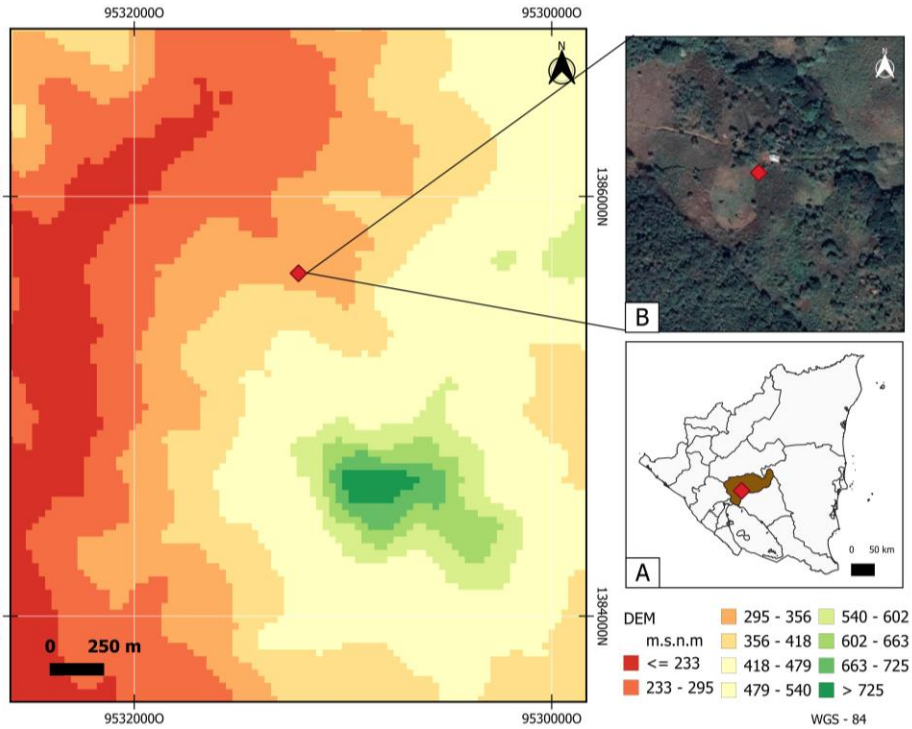
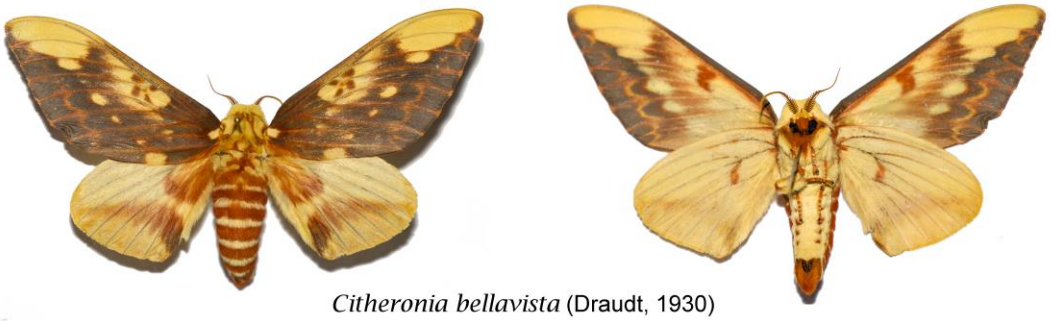


Figure 8. Elevations of the Study Area (DEM): A) Macrolocation of the Department of Boaco, Nicaragua, B) Microlocation showing the red point – Finca Hilario, where species captures were conducted, C) Detailed view of the capture site (authors elaboration).

IDEA WILD



Citheronia bellavista (Draudt, 1930)

Eacles imperialis (Drury, 1773)

Rothschildia lebeau (Guérin-Méneville, 1868)

Titaea tamerlan nobilis (Schaus, 1912)

Caio championi (Druce, 1886)

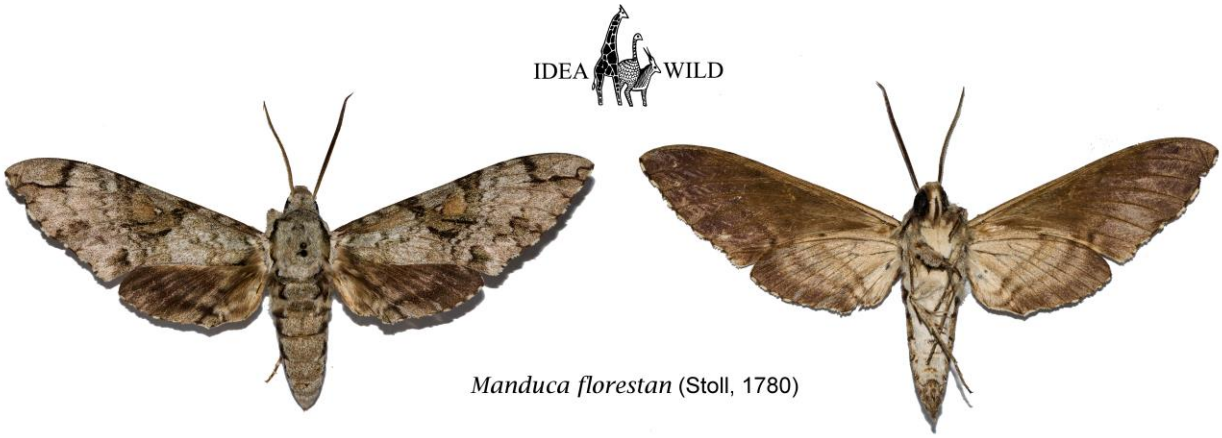
Dysdaemonia boreas (Cramer, 1775)

Callionima falcifera (Gehlen, 1943).

Eumorpha satellitia (Linnaeus, 1771)

Isognathus scyron (Cramer, 1780)

Manduca corallina (Druce, 1883)



Manduca florestan (Stoll, 1780)

Manduca lefeburii (Guérin-Méneville, 1844)

Manduca occulta (Rothschild & Jordan, 1903)

Manduca sp

Protambulyx strigilis (Linnaeus, 1771)

Sphinx merops (Boisduval, 1870)

Xylophanes tersa (Linnaeus, 1771)

Perigonia lusca (Fabricius, 1777)

DISCUSSION

The genera *Callionima*, *Eumorpha*, *Manduca*, and *Protambulyx* are predominantly found in lowland areas, as noted by Sublett *et al.*, 2019. However, captures made on Cerro Quizaltepe during the dry season not only include lowland species but also mountain and humid area species, as detailed in Table 1. This indicates that the area retains a diversity of plant species that support a rich biodiversity, positioning the site as a transition zone. Conservation efforts in this area have allowed it to function as a refuge for many species during the dry season. Furthermore, it is likely that the number of species and individuals will increase during the rainy season. Future research could verify the presence of endemic species from humid forests within this study area.

Table 1. Characterization of some individuals captured, based on the area.

Species	Individuals	Area	Cited
Caio championi	1	LowLand	Sublett *et al.*, 2019
Callionima falcifera	4	Cosmopolita	Ignatov *et al.*, 2011
Erynnyis crameri	1	Hills/Mountain	
Eumorpha satellitia	1	Hills/Mountain	
Isognathus rimosa	1	Cosmopolita	
Manduca corallina	2	LowLand	Sublett *et al.*, 2019
Manduca dilucida	4	LowLand	
Manduca florestan	3	LowLand	
Manduca lefeburii	11	LowLand	
Manduca muscosa	3	LowLand	
Manduca oculta	4	LowLand	
Manduca sexta	3	LowLand	Ignatov *et al.*, 2011
Perigonia lusca	1	Hills/Mountain	
Protambulyx strigilis	2	LowLand	
Xylophanes libye	1	LowLand	
Xylophanes tersa	2	Cosmopolita	

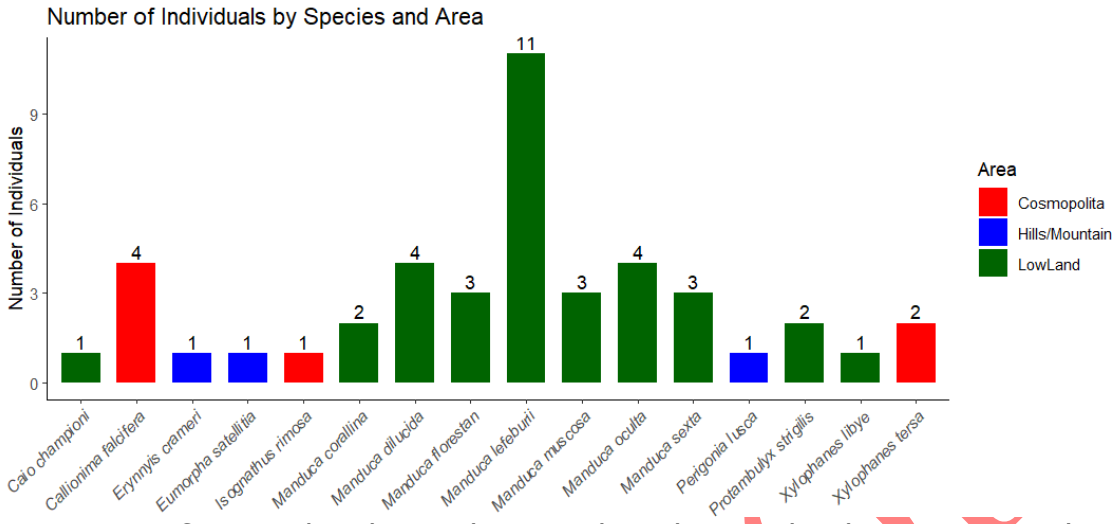


Figure 9. Species distribution by area, based on studies by Ignatov *et al.*, 2011, and Sublett *et al.*, 2019.

Transitional plant communities may provide food sources for both montane and lowland hawkmoths. Beck and Chey (2008) found positive correlations between moth and plant species richness. Suggesting that during the dry season, more humid areas on the hill (Quizaltepe) could harbor species absent from drier zones. Mountains, with their environmental gradients such as temperature and habitat in small areas, facilitate biodiversity studies with high reproducibility and enable pattern comparisons across various habitats and latitudes (Beck and Kitching, 2009; Malhi *et al.*, 2010).

Boggs and Murphy (1997) emphasized the critical influence of weather conditions, particularly temperature and precipitation, on the availability of food resources, which in turn affects species distribution. They pointed out that habitat type significantly determines species presence, while both precipitation and elevation are key factors in shaping community composition. Due to the altitudinal and microclimatic gradient of Cerro Quizaltepe, ranging from 300 to 750 meters above sea level, a greater diversity of species and individual counts may be observed across different seasons.

Additionally, the area's microclimate is further enriched by the presence of four springs, enhancing local biodiversity. This zone serves as a transitional area between dry and humid forests. The preliminary findings, documenting 25 species during the dry season, likely represent just a fraction of the actual moth community structure in the study area.

CONCLUSION

During the investigation, the presence of 25 moth species was recorded, representing only a fraction of the estimated total due to sampling during the dry season. It is suggested that a greater diversity of species could be observed during the rainy season. Additionally, land-use classification maps were generated, providing a foundation for future research. It is essential to consider the influence of altitudinal gradients, as Quizaltepe Hill, with its forest strata and fragments, possesses high ecological value, serving as a refuge for species adapted to both dry and humid climates. These results highlight the need for further studies to better understand the dynamics of moth communities across seasons and to confirm the area's potential for species conservation.

AGRADECIMIENTOS

We extend our deepest gratitude to the team at ***IdeaWild*** (https://ideawild.org) for their generous donation of the camera and lens, which allowed us to photograph the specimens presented in this article, as part of donation Project ID ARAQNICA0923-00.

Additionally, we extend our gratitude to Dr. Jean Michel Maes for his valuable comments and the time dedicated to improving this article. His legacy and dedicated work have been an inspiration to both authors.

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