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Ramsai Butterfly Conservatory: An effort for the conservation of butterflies adjacent to a tropical forest in West Bengal, India

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Abstract: Recently, major efforts have been seen toward conservation of insects as potential taxa for understanding changing habitats and the survival of many other organisms, including humans. One of the most widely appreciated and studied groups of insects is the butterflies, which has prompted scientists and conservationists to develop unique strategies to conserve these organisms. The creation of habitats with plants preferred by the local butterfly population has given rise to "butterfly gardens", which has become a popular concept throughout the world. We conducted this study in one of the first established butterfly gardens in the vicinity of a forest patch in northern West Bengal, India. We generated a preliminary database of visitor and reared butterfly species, documented early stages of the butterflies, categorized the roles of different plants in the garden and observed butterfly abundance and diversity in the garden. We also briefly discuss the benefits of these butterfly gardens as refuges for butterflies, as an education center which can focus on bottom-up conservation initiatives, and some of the hurdles that are generally faced by these gardens in a sensitive zone such as a forest fringe in a biodiversity-rich country.

Keywords: butterfly; conservatory; forest; population; West Bengal.

INTRODUCTION

During recent decades, natural habitats have been impacted at ever-increasing rates, resulting in a loss of overall biodiversity (Gaston & Fuller, 2008). The continuous need for agricultural land has led to the encroachment of natural habitats such as forests, lakes, and grasslands, resulting in their destruction, fragmentation, and transformation across continents. Such loss of habitats is not only creating additional pressure on the survival of larger animals living in those habitats, but also impacting several smaller species of invertebrates (Sánchez-Bayo & Wyckhuys, 2019; Kehoe *et al.*, 2021), such as insects. The loss of insects from an ecosystem impacts food chains and, in extreme cases, may lead to its collapse (Cardoso *et al.*, 2020; Wagner, 2020). Human intervention is forcing ecological functional shifts in insect groups and reducing natural populations (Larsen *et al.*, 2005; Choudhary & Chishty, 2020; Crespo-Pérez *et al.*, 2020). For example, logging in tropical forests has caused a dramatic decrease in beetles, termites and earthworms, which act as natural decomposers (Ewers *et al.*, 2015). Loss of canopy cover has decreased the abundance and diversity of pollinators, including butterflies, in many tropical forests (Ghazoul, 2002; Dumbrell & Hill, 2005). Fragmentation of habitats is creating small islands where insect populations are experiencing higher competition and selection pressure (Rossetti *et al.*, 2017; Guo *et al.*, 2018).

In addition to the functional importance of butterflies and bees as pollinators, they also play an essential role in trophic interactions and are a major driver of co-evolutionary processes with plants as well as their immediate predators (secondary consumers) (Guimarães *et al.*, 2011; Wagner, 2020; Bartomeus *et al.*, 2021). It has been repeatedly suggested that understanding the abundance and distribution of insects, including butterflies, can be used to measure both the direct effects of anthropogenic activities such as logging (Hill *et al.*, 1995; Hamer *et al.*, 1997, 2003), and also indirect effects such as changes in climate due to global warming (Gérard *et al.*, 2020; Hill *et al.*, 2021).

Addressing declines in pollinator communities in different biogeographical zones demands careful planting of native wild plants along with ornamental plants that may optimize the habitat usage of urban green space. These demands have led to the idea of the creation of 'gardens for pollinators', which are of interest to scientists, conservationists and policymakers. These 'gardens' are a common, yet little studied, process of habitat restoration where land is modified by planting a variety of species that are kept under maintenance. Many studies monitoring insect abundance and richness in urbanized areas have also indicated the importance of urban gardens in preserving the local population of butterflies and bees (Koh & Sodhi, 2004; Levy & Connor, 2004; Di Mauro *et al.*, 2007; Matteson & Langellotto, 2012; Jaturas *et al.*, 2020; Majewska & Altizer, 2020). In recent years, initiatives such as butterfly monitoring schemes that have been actively taken up in various countries have involved members of the public to better understand butterfly communities. These initiatives have also stimulated people to create their own 'backyard butterfly garden' and contribute to the conservation of butterflies (Vickery, 2007).

In a highly populated country such as India, a few notable habitats for butterflies have been established in the last decade in addition to the presence of many protected forest areas (Sondhi, 2021). Gorumara National Park (GNP) in the northern part of state West Bengal is one of the most diverse national parks in terms of habitats. It was declared as the best among the protected areas of India for 2009-10 for its rich biodiversity and strategic location (Bhattacharya *et al.*, 2012). There have been considerable developments recently along the boundary of Gorumara National Park for improving accessibility, including widening roads, which are causing man-animal conflict in the buffer zones. Despite these developmental activities the park still has a tremendous diversity of insects and other taxa (Ghosh, 2012; Raychaudhuri & Saha, 2015; Mishra *et al.*, 2022). More than 300 butterfly species have been recorded in GNP through multiple surveys, making it a year-round butterfly hotspot (Ghatak & Basu Roy, 2013). However, aside from the checklist of the butterfly species present in the area, there is shortage of knowledge on their life history traits and local population dynamics, making it difficult to initiate conservation programs for butterflies.

In 2013, one of the first butterfly gardens (and associated laboratory) in India was established adjacent to GNP. Rearing of butterflies is being carried out in the butterfly conservatory, to help support continuous populations of butterflies in that region, as well as maintain a habitat suitable for butterflies. Most of the plants present in the conservatory can be divided into two broad categories: host plant and nectar plant. Our study in this garden provides baseline knowledge on: i) the existing butterfly diversity, and ii) associations among host plants, nectar plants and the butterfly species in this poorly documented region of West Bengal.

METHODS

Study Site: The butterfly conservatory (26°43'34.464"N, 88°51'17.568"E) is situated in the 'terai' region, defined as the lowland at the foothills of the Himalayas fed by different rivers (Fig. 1). Due to the intensive networks of rivers, these areas tend to have extensive, rich alluvial soil with grasslands and *Shorea robusta* (Dipterocarpaceae) forests dominating the landscape. There are thus many unique forested areas in the West Bengal terai region of India, ranging from mostly moist deciduous mixed forests to sub-tropical wet hill forests. The conservatory is located in a small village known as Ramsai (6.39 km^2), in close proximity to GNP, a protected moist deciduous mixed forest. The village falls in the buffer region where the fauna of forests and rural landscapes converge and interact. Most of the area around the village is either used for tea gardens or left as fallow land to be converted into pastures.

The conservatory was established in December 2013, on a 1.50-acre plot of fallow land which was being converted into a pastures due to grazing pressure from cattle of nearby villages. The butterfly conservatory has a tea garden on one side and the national park on the other. Jaldhaka, a small tributary river of the river Brahmaputra, flows through the eastern boundary of the conservatory. The location experiences three main seasons: hot and humid summer, monsoon (south-west rain as well as north-east rain), and moderately dry and cold winter. The temperature ranges from around 35°C in the summer to below 10°C in the winter, with humidity fluctuating between 50-90%. The presence of such variability in temperature and humidity, along with annual rainfall averaging 7000 mm, creates suitable conditions for high insect diversity.

Butterfly species documentation

Visitor and reared list: Regular documentation of visiting butterfly species in the conservatory was carried out from 2014 to 2021 through random and opportunistic sightings (Table 1). Two people from the local community were trained in handling and identification of butterflies and were assigned to maintain the garden and laboratory. They also regularly searched for early stages of visiting butterfly species to the conservatory and brought the larvae into the laboratory (Fig. 2). Larvae were reared inside ventilated plastic boxes and maintained at the same temperature and humidity as wild conditions. Boxes were cleaned daily and larvae were fed with fresh leaves from their host plant until they pupated. The emerged adults were

Figure 1: a. Location of the Ramsai Butterfly Conservatory between Gorumara National Park and Jaldhaka river **b.** Present condition of the butterfly conservatory.

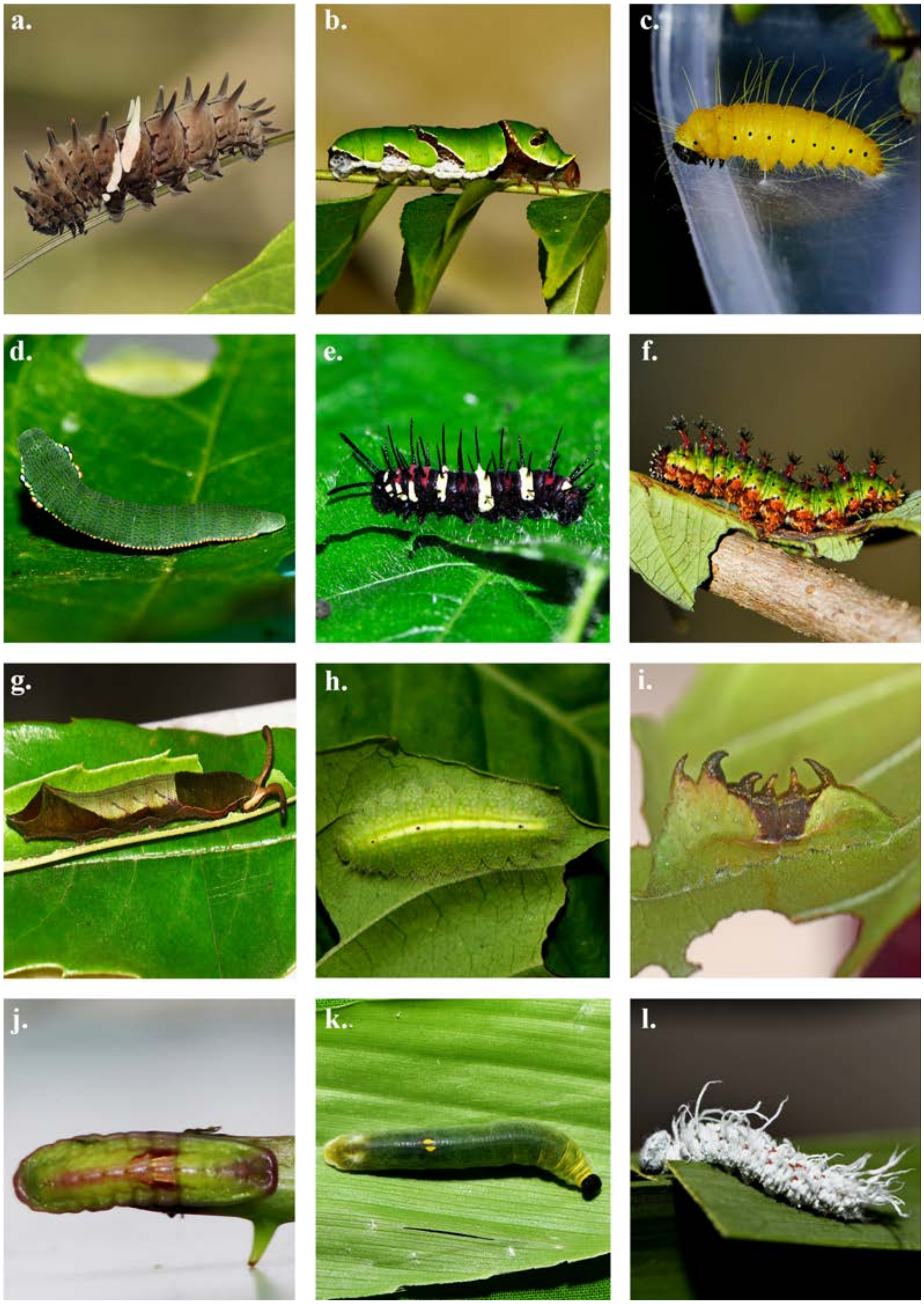

Figure 2: Larval stages of some of the notable butterfly species reared in the conservatory: **a.** *Troides helena* (Papilionidae), **b.** *Papilio polytes* (Papilionidae), **c.** *Delias descombesi* (Pieridae), **d.** *Hebomoia glaucippe* (Pieridae), **e.** *Cethosia cyane* (Nymphalidae), **f.** *Athyma perius* (Nymphalidae), **g.** *Dichorragia nesimachus* (Nymphalidae), **h**. *Zemeros flegyas* (Riodinidae), **i.** *Cheritra freja* (Lycaenidae), **j.** *Loxura atymnus* (Lycaenidae), **k.** *Udaspes folus* (Hesperiidae), **l.** *Gangara thyrsis* (Hesperiidae).

released into the wild after identification and documentation of their rearing history (Table 1).

Plants of the conservatory: Based on prior surveys in adjoining forests and rural areas, and a literature study in the case of the host plants of local butterfly species, saplings of endemic host and nectar plants were acquired and planted in the conservatory (Figs. 3, 4). An association map was created with *ggplot2* in R (v 4.1.2) after pooling data from two sources: i) observing the type of interaction that a butterfly species was displaying with particular plant (ovipositing or feeding) present in the garden; and ii) literature study for previously recorded interactions between butterfly species and plants present in the garden. Among 27 plant species in the garden used for collecting nectar by the butterflies, flowers of *Stachytarpheta* *jamaicensis*, *Hibiscus rosa-sinensis*, *Ixora singaporensis*, *Cuphea hyssopifolia* were observed to be highly preferred by multiple butterfly species from different families throughout the year (Fig. 5) (plant families are provided in Table 2). Most of the nectar plants in the garden form woody shrubs or bushes and are largely perennial, whereas *Cosmos bipinnatus* and *Zinnia elegans* are annual nectar plants. Apart from these specialized nectar plants, some of the tree species in the garden such as *Murraya koenigii*, *Mangifera indica*, *Zizyphus* sp., and *Albizia lebbeck* serve as both host and nectar plants to a group of butterflies (Table 2). A total of 52 plant species known to be used as host plants are present in the garden, ranging from trees such as *Polyalthia longifolia*, *Michelia champaca*, *Cassia fistula*, *Crateva nurvala*, *Trema orientalis*, *Neolamarckia cadamba*, *Sabia limoniacea*, *Zizyphus* sp., and *Bambusa* sp., to woody shrubs such as *Citrus limon*, *Ricinus communis*, *Calotropis gigantea*, and even creepers such as *Aristolochia tagala*, *Passiflora foetida*, and *Wattakaka volubilis* (Table 2). Most species of butterflies show host specificity to one or a few families of plants (Robinson *et al.*, 2001). Several plant species are used by multiple butterfly species as host plants, whereas some plants are specific to single butterfly species (Fig. 6).

Butterfly count: A 'time-constrained count' (Suman *et al.*, 2021) was implemented from 2019 to 2021 to estimate the abundance and richness of butterfly species in the conservatory. The number of butterfly species and their abundances were recorded along a transect covered in 30 min. In this method, the transect length and pace at which it was covered were not constant, but the limiting factor was the time interval. This is a realistic approach to quantify tropical butterfly diversity since typical methods such as Pollard walks do not allow the pace to be varied, for example to identify small lycaenid butterflies present on shrubs or bushes, or to distinguish similar species in flight (Pollard & Yates, 1993; Riva *et al.*, 2020). The time-constrained count was carried out weekly and the entire conservatory was covered in four 30-min intervals starting from 1000 hrs. to 1200 hrs. The weekly raw counts were added for each month to get a monthly estimate of the number of butterfly species and total number of individual butterflies. These counts were then graphically plotted against months to observe changes in the population across the year through *ggplot2* in R (v 4.1.2). For this study, we designated months under four seasons in the following way: a. *Pre-monsoon*: March to May, b. *Monsoon*: June to September, c. *Post-monsoon*: October to November, and d. *Winter*: December to February (Fig. 7).

RESULTS

From 2014 to 2021, as a result of random and opportunistic sightings 124 butterfly species were documented as visitor species to the conservatory across 6 families: Papilionidae, Pieridae, Nymphalidae, Riodinidae, Lycaenidae and Hesperiidae. Nymphalidae (46 species) constituted the bulk of the visitor species, whereas the least number of species was documented from Riodinidae (2 species) (Table 1). Almost half of the visitor butterfly species, i.e. 60 species, were successfully reared in the laboratory during this period (Table 1). Out of the reared species, 21 species belonged to Nymphalidae followed by 12 species from Papiliondae, 10 species from Pieridae, 9 species from Hesperiidae, 6 species from Lycaenidae and only 2 species from Riodinidae.

As a result of the time-constrained count, a total of 15,868 butterfly individuals were observed belonging to 94 species across three years, 2019-2021. The data were collected for a total of 271 hours over the three years. The results were graphically plotted against months to observe the changes in the population across the year. The abundance of butterflies within Papilionidae, Pieridae and Nymphalidae followed a similar trend, where the number of butterflies started to rise at the beginning of pre-monsoon and dropped at the end of the monsoon season (Fig. 7). Except for Lycaenidae, abundance of the other five families reached their minimum during winter. The seasonality was more comprehensible when the number of butterfly species (richness) was considered across the year for all the families (excluding Riodinidae which consisted of only two species) (Fig. 8). Richness for Papilionidae, Pieridae and Nymphalidae showed similar trend to the abundance curves. Richness of Hesperiidae was higher in the monsoon season, whereas Lycaenidae richness reached its maximum during either end of post-monsoon or onset of winter.

DISCUSSION

Fluctuations observed in such a large and diverse population of butterflies is mainly associated with variation in environment rather than any particular demographic changes for a species (Lande *et al.*, 2003). In our case, the geographical location of the conservatory is associated with broad seasonal gradients in temperature, humidity and precipitation throughout the year. The recurrent fall and rise in the butterfly populations observed at the conservatory suggest an adaptive response of different families of butterflies with respect to climate seasonality (Nokelainen *et al.*, 2018; Nylin, 1994). Changes in environmental factors can induce shifts in butterfly populations either directly or indirectly. The direct effect can be seen as some physiological alterations or developmental changes in the early stages of the butterfly, whereas changes in butterfly populations due to morphological or phenological changes in the plants can be an example of an indirect effect of seasons (Kingsolver *et al.*, 2011; Kocsis & Hufnagel, 2011). Even when rearing in a predator-free environment in the laboratory, unfavorable conditions created by low temperature and humidity during winter were seen to reduce larval fitness and changes in larval or pupal duration, causing density-independent mortality in some cases. For example, in our conservatory *Papilio clytia*, *Pachliopta aristolochiae* and *Udaspes folus* were observed to undergo hibernation in the pupal stage during the winter, and the adults emerged in the pre-monsoon season of the following year. However, apparently unfavorable conditions for some species may be favorable for other species, such as in the case of Lycaenidae. Species belonging to this family are small compared to other species and have a considerably shorter lifespan. They have unique adaptive strategies such as larvae synchronizing with the blooming time of winter flowering plants, such as in the case of *Hypolycaena erylus* where larvae feed on flowers of *Ixora singaporensis* (Rubiaceae) (Karmakar *et al.*, 2018). Some

Figure 3: Images of some of the host plants present in the conservatory: **a.** *Strobilanthes callosa*, **b.** *Aristolochia tagala*, **c**. *Carissa carandas*, **d.** *Crateva nurvala*, **e.** *Glochidion zeylanicum*, **f.** *Meliosma rigida*, **g.** *Maesa indica*, **h.** *Melastoma malabathricum*, **i.** *Sabia limoniacea*, **j.** *Millettia pachycarpa*, **k.** *Ichnocarpus frutescens*, **l.** *Wattakaka volubilis*.

species, such as *Chilades lajus*, may be avoiding inter-specific competition with *Papilio polytes* or *Papilio demoleus* by laying eggs on tender leaves of *Citrus medica* after the brief post-monsoon showers when the population of these papilionids start to drop. Thus, population data on holometabolous insects such as butterflies should be accompanied by life history data, which can provide an explanation for abundance fluctuations observed in the wild (Smith, 1926; Walter *et al.*, 2018). Such data enable

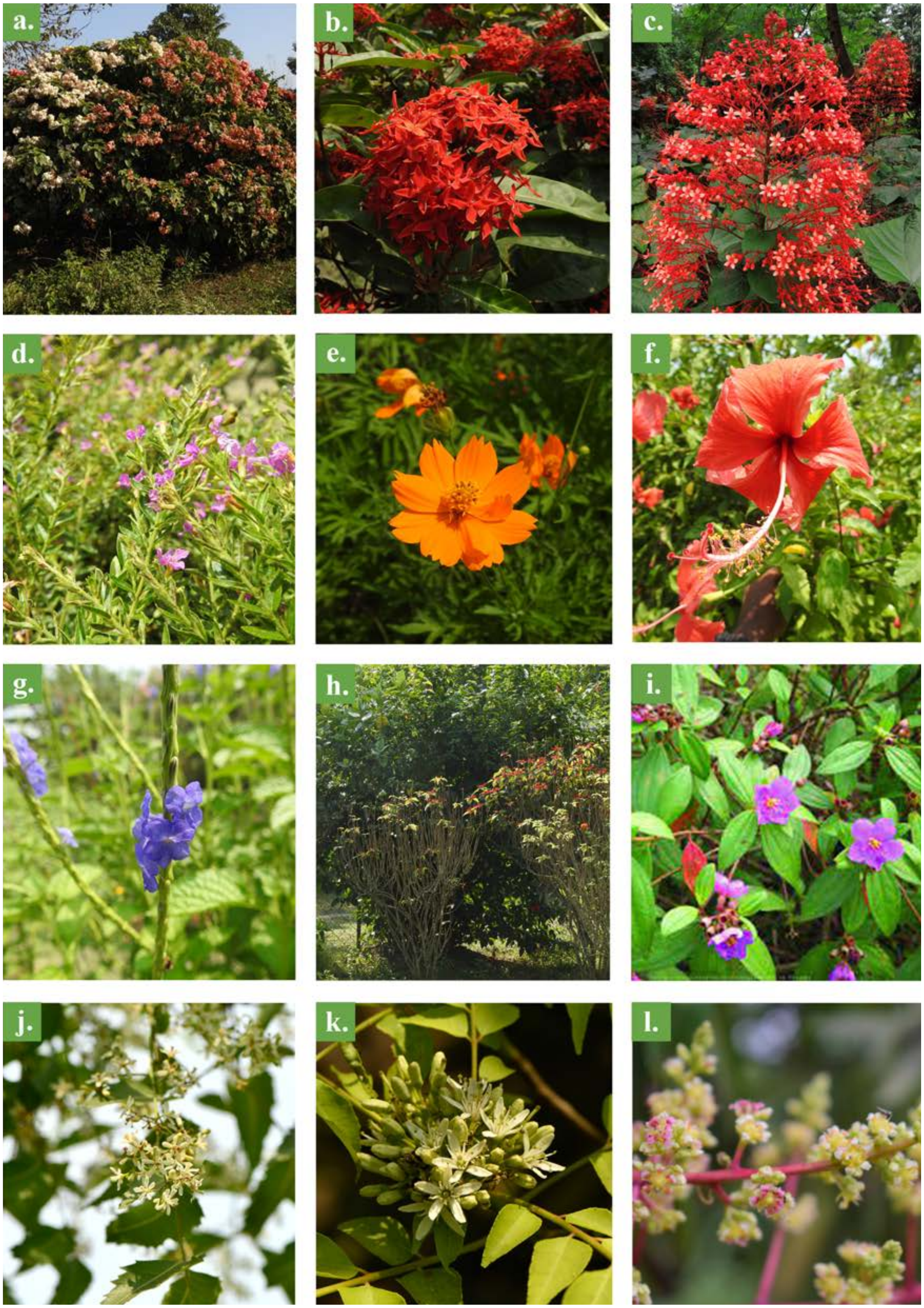

Figure 4: Images of some of the nectar plants present in the conservatory: **a**. *Mussaenda erythrophylla*, **b.** *Ixora singaporensis*, **c.** *Clerodendrum paniculatum*, **d.** *Cuphea hyssopifolia*, **e**. *Cosmos bipinnatus*, **f.** *Hibiscus rosa-sinensis*, **g.** *Stachytarpheta jamaicensis*, **h.** *Euphorbia pulcherrima*, **i.** *Melastoma malabathricum*, **j.** *Azadirachta indica*, **k.** *Murraya koenigii*, **l.** *Mangifera indica*.

studies of intra-specific and inter-specific ecology, and plant-butterfly co-evolution. Population data and life history data serve as the base for many scientific studies in butterflies.

Importance of butterfly conservatory

The presence of 70 species of plants with more than 600 individuals in the small space of the conservatory (1.5 acre) has created a densely packed 'refuge' for butterflies in the vicinity

Figure 5: The association of butterfly species is mapped with its nectar plant based on the observational record in the conservatory. Larger number of butterfly species in a family associating with a plant corresponds to a paler shaded box, whereas fewer associations correspond to a darker shaded box, and no box indicates no association between the butterfly and the plant species. The colour palette used was applied from *distiller* color palette in R (v.4.1.2).

of a forest. Every plant species present inside the perimeter of the conservatory contributes to the growth of the wild butterfly population, either by supporting the early stages (host plants) or the adults (nectar plants) of butterfly species. In addition, the rearing facility in the conservatory has provided an opportunity for the butterflies to sustain their basal population levels in the absence of predation pressures. The butterfly population maintained at the conservatory can act as a supplement to the wild population, which experiences high density-dependent as well as density-independent mortality. However, the rearing process has not been able to eliminate the chances of parasitoid infections, which usually occur either in eggs or early larval

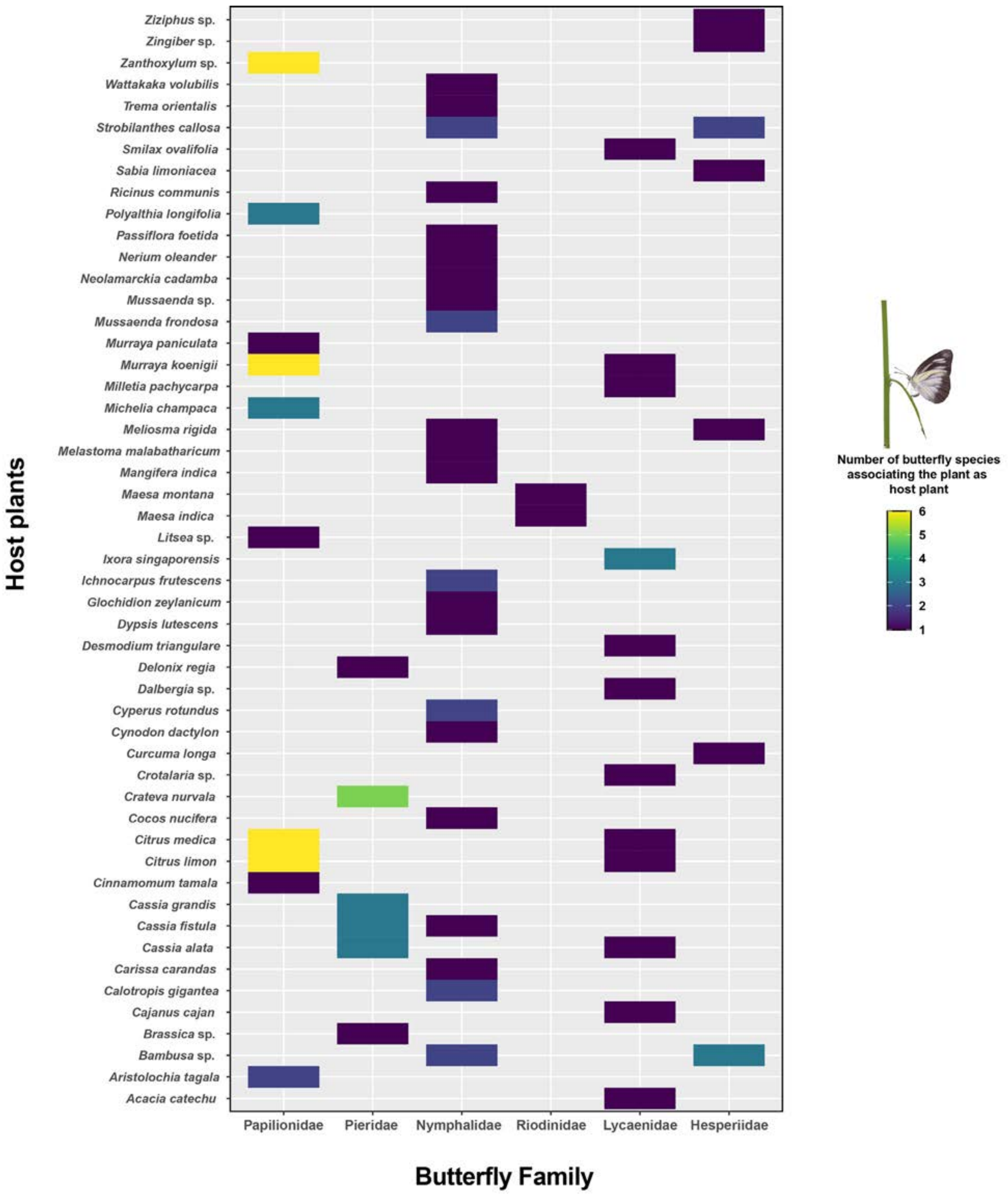

Figure 6: The association of butterfly species is mapped with its host plant based on observations in the conservatory as well as known host plant association information from the literature. Larger number of butterfly species in a family associating with a plant corresponds to a paler shaded box, whereas fewer associations correspond to a darker shaded box, and no box indicates no association between the butterfly and the plant species. The colour palette used was applied from *viridis* color maps package in R (v.4.1.2).

instars before collection from the wild. This fact ensures the stability of the butterfly population, limiting any sharp increase in the population and also conserving the co-evolutionary interactions between host and parasitoids. This stability in the butterfly population can in turn support higher taxa for which it acts as a prey base, thereby stabilizing trophic interactions through a bottom-up approach.

Maintenance of conservatories and its future

Areas adjacent to forest (buffer zones) in India are often used for pastoralism and agriculture (Darro *et al.*, 2020; Upadhyay *et al.*, 2012), or even left as barren wasteland,

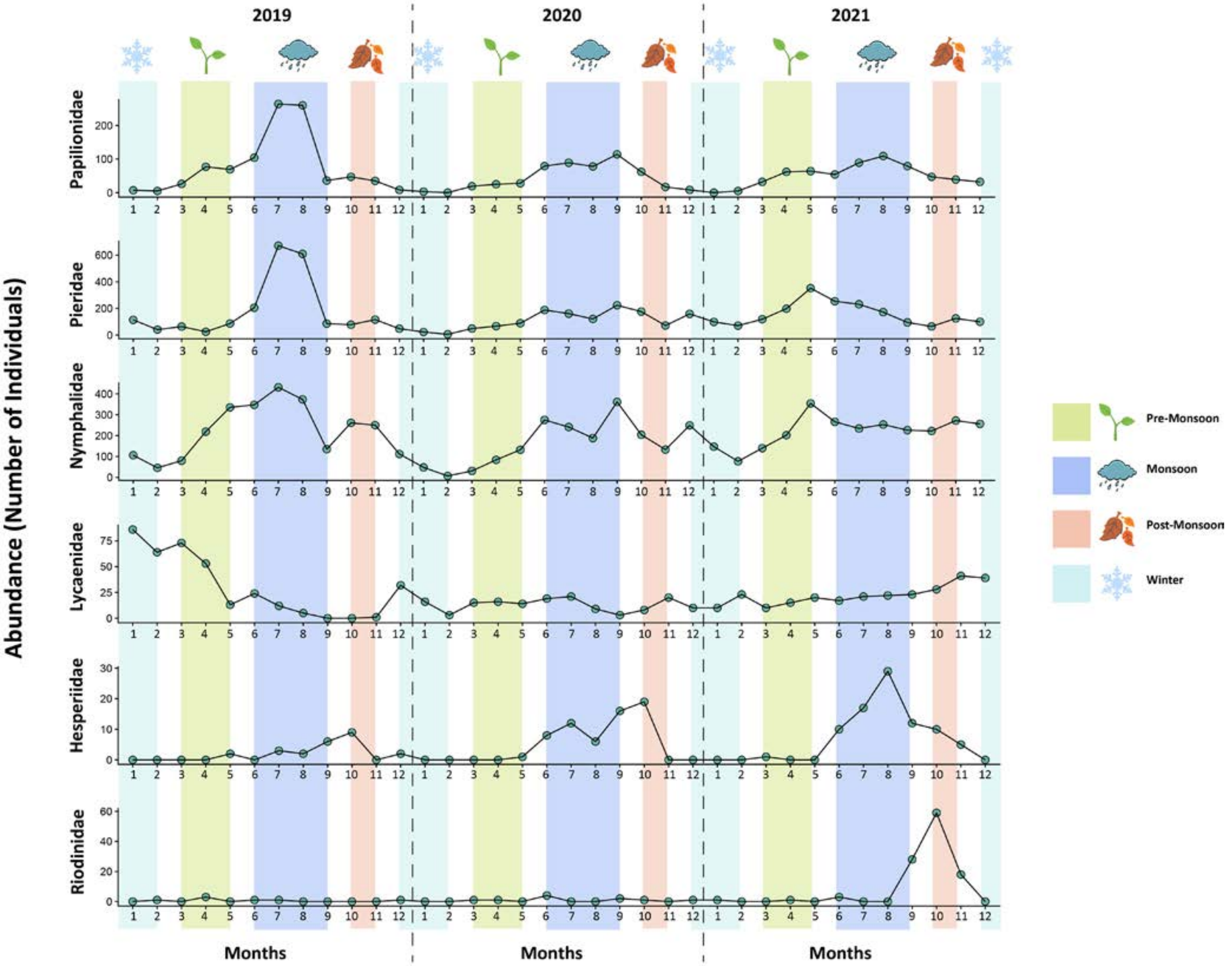

Figure 7: Weekly butterfly counts summed together as monthly counts corresponding to the number of butterfly individuals (abundance) belonging to six families across 3 years. The four seasons are depicted through *light green*: Pre-monsoon, *royal blue*: Monsoon, *brown*: Post-monsoon, and *celeste*: Winter.

which creates pressure on the forest resources (Sharma *et al.*, 2014). Meticulous planning and execution of strategies to establish insect or butterfly conservatories can transform the land into a biodiversity-rich zone (Wu *et al.*, 2014), which can provide a conservation breeding space for common and rare butterflies alike. Thus, maintenance of the larval host plants as well as nectar plants will help to create a biodiversity conservation zone and reduce habitat degradation of the protected areas. Maintenance of an insect conservatory in such sensitive zones requires synchronization of following four factors: administrative permissions, human resources, constant funding sources, and understanding and acceptance of scientific knowledge. In a biodiversity-rich country such as India, the presence of a strict wildlife protection act has ensured the successful conservation of its biodiversity by preventing illegal poaching and trading. In West Bengal, India, many steps have been taken by the Government of West Bengal to initiate conservation of butterflies, such as establishment of Butterfly Gardens for conservation and awareness. The Ramsai Butterfly Conservatory is an example of the aforementioned initiatives. However, it has also created difficulty in performing fundamental research or conservation practices. In order to establish a conservatory in close proximity to a national park requires permission and cooperation from government agencies such as the forest department. Human resources are another important part of maintaining such habitat in a developing country, which is extremely constrained by the availability of funds. All of the above three hurdles can be negated by generating awareness among the public of the significance and seriousness of depleting pollinators from the wild. More initiatives, such as butterfly conservatories, where the public can be engaged and interact directly with species of interest, will help realize conservation goals and broaden appreciation for the need for conservation efforts.

The butterfly population data generated by this conservatory provide a baseline for conducting future studies on a large scale, such as the community level. They will also help understand and extrapolate the effects of changing climatic variables and associated plant phenological changes on the butterfly population across time.

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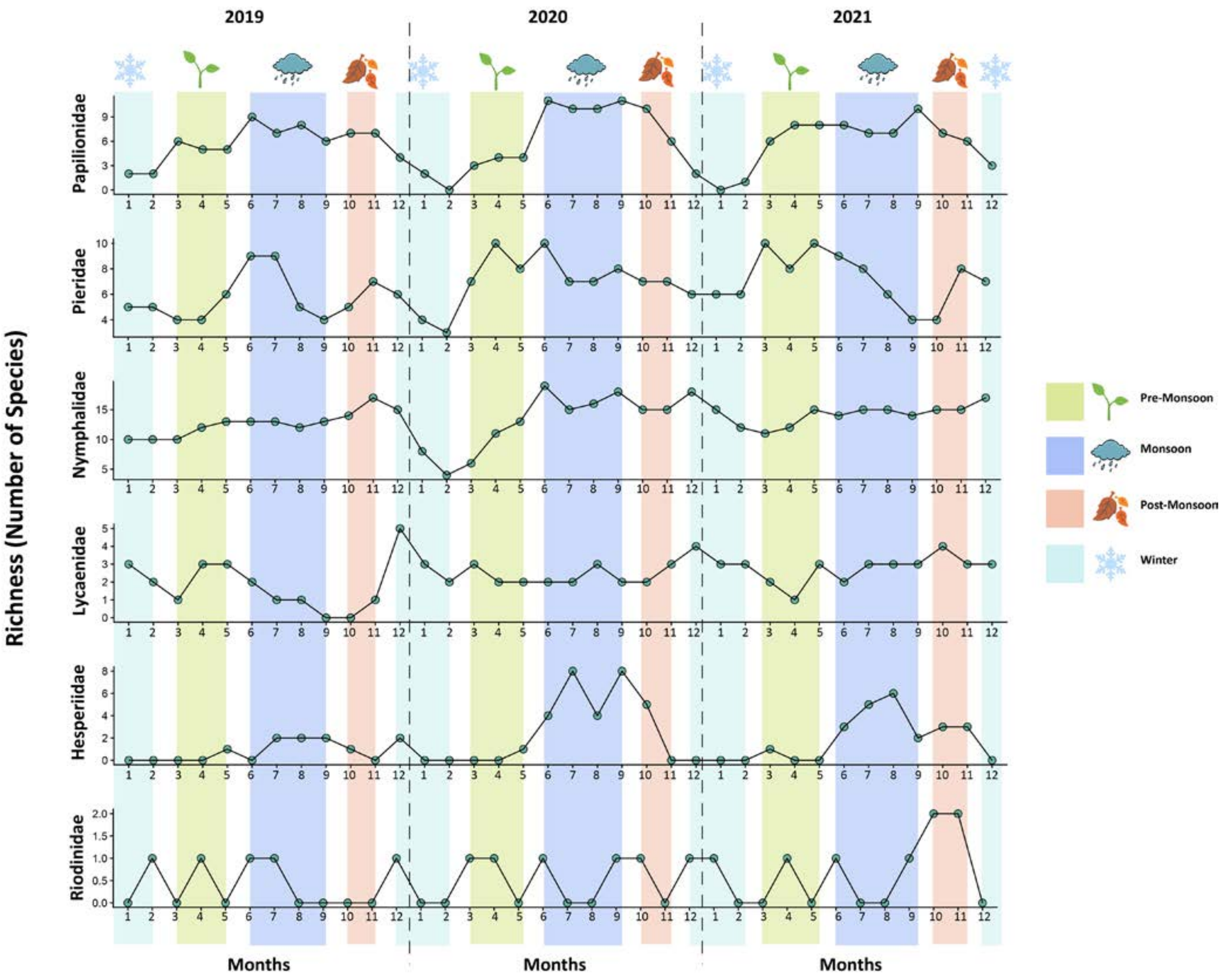

Figure 8: Weekly butterfly counts summed together as monthly counts corresponding to the number of butterfly species (richness) belonging to six families across 3 years. The four seasons are depicted through *light green*: Pre-monsoon, *royal blue*: Monsoon, *brown*: Post-monsoon, and *celeste*: Winter.

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LITERATURE CITED

Bartomeus, I., Saavedra, S., Rohr, R. P., Godoy, O. 2021. Experimental evidence of the importance of multitrophic structure for species persistence. *Proceedings of the National Academy of Sciences of the USA* 118: 12 e2023872118.

Bhattacharya, D., Sarkar, R., Choudhury, B. 2012. Irresponsible ecotourism practices flanking the best national park in India: A multivariate analysis. *SIT Journal of Management* 1: 1-27.

Cardoso, P., Barton, P. S., Birkhofer, K., Chichorro, F., Deacon, C., Fartmann, T., Fukushima, C. S., Gaigher, R., Habel, J. C., Hallmann, C. A., Hill, M. J. 2020. Scientists' warning to humanity on insect extinctions. *Biological Conservation* 242: 108426.

Choudhary, N. L., Chishty, N. 2020. Effect of habitat loss and anthropogenic activities on butterflies survival: A review. *International Journal of Entomology Research* 5: 94-98.

Crespo-Pérez, V., Kazakou, E., Roubik, D. W., Cárdenas, R. E. 2020. The importance of insects on land and in water: a tropical view. *Current Opinion in Insect Science* 40: 31-38.

Darro, H., Swamy, S. L., Thakur, T. K., Mishra, A. 2020. Floristic composition, structure, diversity and conservation strategies for rehabilitation of dry tropical forests in buffer zone of Achanakmaar Amarkantak Biosphere Reserve (AABR), India. *International Journal of Current Microbiology and Applied Sciences* 9: 650-663.

Di Mauro, D., Dietz, T., Rockwood, L. 2007. Determining the effect of urbanization on generalist butterfly species diversity in butterfly gardens. *Urban Ecosystems* 10: 427-439.

Dumbrell, A. J., Hill, J. K. 2005. Impacts of selective logging on canopy and ground assemblages of tropical forest butterflies: Implications for sampling. *Biological Conservation* 125: 123-131.

Ewers, R. M., Boyle, M. J. W., Gleave, R. A., Plowman, N. S., Benedick, S., Bernard, H., Bishop, T. R., Bakhtiar, E. Y., Chey, V. K., Chung, A. Y. C., Davies, R. G., Edwards, D. P., Eggleton, P., Fayle, T. M., Hardwick, S. R., Homathevi, R., Kitching, R. L., Khoo, M. S., Luke, S. H., March, J. J., Nilus, R., Pfeifer, M., Rao, S. V., Sharp, A. C., Snaddon, J. L., Stork, N. E., Struebig, M. J., Wearn, O. R., Yusah, K. M., Turner, E. C. 2015. Logging cuts the functional importance of invertebrates in tropical rainforest. *Nature Communications* 6: 6836.

Gaston, K. J., Fuller, R. A. 2008. Commonness, population depletion and conservation biology. *Trends in Ecology & Evolution* 23: 14-19.

Gérard, M., Vanderplanck, M., Wood, T., Michez, D. 2020. Global warming and plant-pollinator mismatches. *Emerging Topics in Life Sciences* 4: 77-86.

Ghatak, S., Basu Roy, A. 2013. *A Pictorial Guide: Butterflies of Gorumara National Park*. Kolkata, Citadel. 350pp.

Ghazoul, J. 2002. Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand. *Biodiversity and Conservation* 11: 521-541.

Ghosh, S. B. 2012. Biodiversity and Wild Fodder of Gorumara National Park in West Bengal, India. *Journal of Environment and Ecology* 3: 18-35.

Guimarães, P. R., Jordano, P., Thompson, J. N. 2011. Evolution and coevolution in mutualistic networks. *Ecology Letters* 14: 877-885.

Guo, Q., Riitters, K. H., Potter, K. M. 2018. A subcontinental analysis of forest fragmentation effects on insect and disease invasion. *Forests* 9: 744.

Hamer, K. C., Hill, J. K., Benedick, S., Mustaffa, N., Sherratt, T. N., Maryati, M., Chey, V. K. 2003. Ecology of butterflies in natural and selectively logged forests of northern Borneo: the importance of habitat heterogeneity. *Journal of Applied Ecology* 40: 150-162.

Hamer, K. C., Hill, J. K., Lace, L. A., Langan, A. M. 1997. Ecological and biogeographical effects of forest disturbance on tropical butterflies of Sumba, Indonesia. *Journal of Biogeography* 24: 67-75.

Hill, G. M., Kawahara, A. Y., Daniels, J. C., Bateman, C. C., Scheffers, B. R. 2021. Climate change effects on animal ecology: butterflies and moths as a case study. *Biological Reviews* 96: 2113-2126.

Hill, J. K., Hamer, K. C., Lace, L. A., Banham, W. M. T. 1995. Effects of selective logging on tropical forest butterflies on Buru Indonesia. *Journal of Applied Ecology* 32: 754-760.

Jaturas, N., Sing, K. W., Wilson, J. J., Dong, H. 2020. Butterflies in urban parks in the Bangkok Metropolitan Region, Thailand. *Biodiversity Data Journal* 8: e56317.

Karmakar, T., Nitin, R., Sarkar, V., Baidya, S., Mazumder, S., Chandrasekharan, V. K., Das, R., Kumar, G. S. G., Lokhande, S., Veino, J., Veino, L., Veino, R., Mirza, Z., Sanap, R. V., Sarkar, B., Kunte, K. 2018. Early stages and larval host plants of some northeastern Indian butterflies. *Journal of Threatened Taxa* 10: 11780-11799.

Kehoe, R., Frago, E., Sanders, D. 2021. Cascading extinctions as a hidden driver of insect decline. *Ecological Entomology* 46: 743-756.

Kingsolver, J. G., Arthur Woods, H., Buckley, L. B., Potter, K. A., MacLean, H. J., Higgins, J. K. 2011. Complex life cycles and the responses of insects to climate change. *Integrative and Comparative Biology* 51: 719-732.

Kocsis, M., Hufnagel, L. 2011. Impacts of climate change on Lepidoptera species and communities. *Applied Ecology and Environmental Research* 9: 43-72.

Koh, P. L., Sodhi, N. S. 2004. Importance of reserves, fragments, and parks for butterfly conservation in a tropical urban landscape. *Ecological Applications* 14: 1695-1708.

Lande, R., Engen, S., Saether, B. E. 2003. *Stochastic population dynamics in ecology and conservation*. New York, Oxford University Press. 212 pp.

Larsen, T. H., Williams, N. M., Kremen, C. 2005. Extinction order and altered community structure rapidly disrupt ecosystem functioning. *Ecology Letters* 8: 538-547.

Levy, J. M., Connor, E. F. 2004. Are gardens effective in butterfly conservation? A case study with the pipevine swallowtail, *Battus philenor*. *Journal of Insect Conservation* 8: 323-330.

Majewska, A. A., Altizer, S. 2020. Planting gardens to support insect pollinators. *Conservation Biology* 34: 15-25.

Matteson, K. C., Langellotto, G. 2012. Evaluating community gardens as habitat for an urban butterfly. *Cities and the Environment (CATE)* 5: 10.

Mishra, T. K., Gupta, B., Panda, P. K. 2022. *Issues of Biodiversity Conservation and Conflict in Gorumara National Park, West Bengal, India*, pp. 477-500. *In*: M. Sahana, G. Areendran, K. Raj (Eds.), *Conservation, Management and Monitoring of Forest Resources in India*. Cham, Springer.

Nokelainen, O., Van Bergen, E., Ripley, B. S., Brakefield, P. M. 2018. Adaptation of a tropical butterfly to a temperate climate. *Biological Journal of the Linnean Society* 123: 279-289.

Nylin, S. 1994. *Seasonal plasticity and life-cycle adaptations in butterflies*, pp. 41-67. *In*: H. V Danks (Ed.), *Insect Life-Cycle Polymorphism: Theory, Evolution and Ecological Consequences for Seasonality and Diapause Control*. Netherlands, Springer.

Pollard, E., Yates, T. J. 1995. *Monitoring Butterflies for Ecology and Conservation*. Dordrecht, Springer. xiv + 274 pp.

Raychaudhuri, D., Saha, S. 2015. Spiders (Araneae: Arachnida) of Reserve Forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. *World Scientific News* 20: 1-336.

Riva, F., Gentile, G., Bonelli, S., Acorn, J. H., Denes, F. V, Crosby, A. D., Nielsen, S. E. 2020. Of detectability and camouflage: evaluating Pollard Walk rules using a common, cryptic butterfly. *Ecosphere* 11: e03101.

Robinson, G. S., Ackery, P. R., Kitching, I. J., Beccaloni, G. W., Hernández, L. M. 2001. Hostplants of the Moth and Butterfly Caterpillars of the Oriental Region. Kuala Lumpur, Southdene Sdn Bhd, 744 pp.

Rossetti, M. R., Tscharntke, T., Aguilar, R., Batáry, P. 2017. Responses of insect herbivores and herbivory to habitat fragmentation: a hierarchical meta-analysis. *Ecology Letters* 20: 264-272.

Sánchez-Bayo, F., Wyckhuys, K. A. G. 2019. Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation* 232: 8-27.

Sharma, R., Rishi, M. S., Ahluwalia, A. S., Lata, R. 2014. Comparative change in Landuse/Landcover in the buffer zone of Kashlog limestone mines, Darlaghat, Himachal Pradesh, India using Remote Sensing and GIS tools. *International Journal of Remote Sensing & Geoscience* 3: 27-30.

Smith, H. S. 1926. The fundamental importance of life-history data in biological control work. *Journal of Economic Entomology* 19: 708-714.

Sondhi, S. 2021. *Fly on Little Wings: A Guide to India's Butterfly Parks*. www.roundglasssustain.com. Accessed 5 August 2021.

Suman, A., Ravikanthachari, N., Kunte, K. 2021. A comparison between time-constrained counts and line transects as methods to estimate butterfly diversity and monitor populations in tropical habitats. *BioRxiv* 2021: 09.

Upadhyay, S., Sahu, S. K., Panda, G. K., Upadhyay, V. P. 2012. Linkages between Agriculture and Forest: Case Study from three tribal villages located in a Biosphere Reserve of India. *International Journal of Tropical Geology, Geography and Ecology* 36: 39-48.

Vickery, M. 2007. Gardens as an aid to the conservation of some butterfly species. *Science Progress* 90: 223-244.

Wagner, D. L. 2020. Insect declines in the Anthropocene. *Annual Review of Entomology* 65: 457-480.

Walter, J. A., Ives, A. R., Tooker, J. F., Johnson, D. M. 2018. Life history and habitat explain variation among insect pest populations subject to global change. *Ecosphere* 9: e02274.

Wu, R., Long, Y., Malanson, G. P., Garber, P. A., Zhang, S., Li, D., Zhao, P., Wang, L., Duo, H. 2014. Optimized spatial priorities for biodiversity conservation in China: A systematic conservation planning perspective. *PLoS ONE* 9: e103783.

Table 1: List of butterfly species categorized on the basis of their occurrence as 'Reared' or 'Visitor Only' and their respective 'Host Plants' recorded from the conservatory. The list is based on random and opportunistic sightings collected from 2014-2021.

Sl. No.	Family	Scientific Name	Common Name	Status (Visitor Only/Reared)	Host Plant
1	Papilionidae	*Papilio polytes* Linnaeus, 1758	Common Mormon	Reared	*Citrus limon, Zanthoxylum sp., Murraya paniculata, Murraya koenigii, Citrus medica*
2	Papilionidae	*Papilio demoleus* Linnaeus, 1758	Lime Swallowtail	Reared	*Citrus limon, Zanthoxylum sp., Murraya koenigii, Citrus medica*
3	Papilionidae	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay	Reared	*Polyalthia longifolia, Michelia champaca, Cinnamomum tamala*
4	Papilionidae	*Graphium doson* (C. & R. Felder, 1864)	Common Jay	Reared	*Polyalthia longifolia, Michelia champaca, Cinnamomum tamala*
5	Papilionidae	*Papilio clytia* Linnaeus, 1758	Common Mime	Reared	*Cinnamomum tamala, Litsea* sp.
6	Papilionidae	*Pachliopta aristolochiae* (Fabricius, 1775)	Common Rose	Reared	*Aristolochia tagala*
7	Papilionidae	*Papilio helenus* Linnaeus, 1758	Red Helen	Reared	*Citrus medica, Murraya koeniggi, Citrus limon, Zanthoxylum* sp.
8	Papilionidae	*Papilio chaon* Westwood, 1845	Yellow Helen	Reared	*Citrus medica, Murraya koeniggi, Citrus limon, Zanthoxylum* sp.
9	Papilionidae	*Papilio paris* Linnaeus, 1758	Paris Peacock	Visitor Only	
10	Papilionidae	*Papilio protenor* Cramer, [1775]	Spangle	Reared	*Murraya koenigii, Citrus limon*
11	Papilionidae	*Graphium sarpedon* (Linnaeus, 1758)	Common Bluebottle	Reared	*Cinnamomum tamala*
12	Papilionidae	*Papilio agenor* Linnaeus, 1758	Great Mormon	Reared	*Citrus limon, Zanthoxylum sp., Murraya koenigii, Citrus medica*
13	Papilionidae	*Troides helena* (Linnaeus, 1758)	Common Birdwing	Reared	*Aristolochia tagala*
14	Papilionidae	*Graphium antiphates* (Cramer, [1775])	Five-bar Swordtail	Visitor Only	
15	Pieridae	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	Reared	*Cassia grandis, Cassia alata, Delonix regia*
16	Pieridae	*Eurema andersonii* (Moore, 1886)	One-spot Grass Yellow	Reared	*Cassia grandis, Delonix regia*
17	Pieridae	*Eurema blanda* (Boisduval, 1836)	Three-spot Grass Yellow	Visitor Only	
18	Pieridae	*Eurema laeta* (Boisduval, 1836)	Spotless Grass Yellow	Visitor Only	
19	Pieridae	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	Reared	*Cassia grandis, Cassia alata, Cassia fistula*
20	Pieridae	*Catopsilia pomona* (Fabricius, 1775)	Lemon Emigrant	Reared	*Cassia grandis, Cassia alata, Cassia fistula*
21	Pieridae	*Delias eucharis* (Drury, 1773)	Indian Jezebel	Visitor Only	
22	Pieridae	*Delias acalis* (Godart, 1819)	Redbreast Jezebel	Visitor Only	
23	Pieridae	*Delias descombesi* (Boisduval, 1836)	Red-spot Jezebel	Visitor Only	
24	Pieridae	*Pareronia hippia* (Fabricius, 1787)	Indian Wanderer	Visitor Only	
25	Pieridae	*Leptosia nina* (Fabricius, 1793)	Psyche	Visitor Only	
26	Pieridae	*Cepora nerissa* (Fabricius, 1775)	Common Gull	Visitor Only	
27	Pieridae	*Pieris canidia* (Linnaeus, 1768)	Asian Cabbage White	Reared	*Brassica* sp.
28	Pieridae	*Gandaca harina* (Horsfield, [1829])	Tree Yellow	Visitor Only	
29	Pieridae	*Ixias pyrene* (Linnaeus, 1764)	Yellow-orange Tip	Reared	*Crateva nurvala*
30	Pieridae	*Hebomoia glaucippe* (Linnaeus, 1758)	Great-orange Tip	Reared	*Crateva nurvala*
31	Pieridae	*Appias lyncida* (Cramer, [1777])	Chocolate Albatross	Reared	*Crateva nurvala*
32	Pieridae	*Appias olferna* Swinhoe, 1890	Eastern-striped Albatross	Reared	*Crateva nurvala*
33	Pieridae	*Appias albina* (Boisduval, 1836)	Common Albatross	Reared	*Crateva nurvala*
34	Nymphalidae	*Tirumala limniace* (Cramer, [1775])	Blue Tiger	Reared	*Wattakaka volubilis*
35	Nymphalidae	*Tirumala septentrionis* (Butler, 1874)	Dark Blue Tiger	Visitor Only	
36	Nymphalidae	*Danaus genutia* (Cramer, [1779])	Striped Tiger	Visitor Only	
37	Nymphalidae	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	Reared	*Calotropis gigantea*
38	Nymphalidae	*Parantica aglea* (Stoll, [1782])	Glassy Tiger	Reared	Apocynaceae unidentified
39	Nymphalidae	*Parantica melaneus* (Cramer, [1775])	Chocolate Tiger	Visitor Only	
40	Nymphalidae	*Euploea core* (Cramer, [1780])	Common Crow	Reared	*Nerium oleander, Carissa carandas, Ichnocarpus frutescens*
41	Nymphalidae	*Euploea klugii* Moore, [1858]	King Crow	Visitor Only	
42	Nymphalidae	*Euploea radamanthus* (Fabricius, 1793)	Magpie Crow	Visitor Only	
43	Nymphalidae	*Euploea midamus* (Linnaeus, 1758)	Blue-spotted Crow	Visitor Only	
44	Nymphalidae	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy	Visitor Only	
45	Nymphalidae	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy	Reared	*Strobilanthes callosa*
46	Nymphalidae	*Junonia orithya* (Linnaeus, 1758)	Blue Pansy	Visitor Only	
47	Nymphalidae	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy	Reared	*Strobilanthes callosa*
48	Nymphalidae	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy	Visitor Only	
49	Nymphalidae	*Junonia iphita* (Cramer, [1779])	Chocolate Pansy	Visitor Only	
50	Nymphalidae	*Hypolimnas bolina* (Linnaeus, 1758)	Great Eggfly	Visitor Only	
51	Nymphalidae	*Hypolimnas misippus* (Linnaeus, 1764)	Danaid Eggfly	Visitor Only	
52	Nymphalidae	*Acraea terpsicore* (Linnaeus, 1758)	Tawny Coster	Visitor Only	
53	Nymphalidae	*Ariadne merione* (Cramer, [1777])	Common Castor	Reared	*Ricinus communis*
54	Nymphalidae	*Elymnias hypermnestra* (Linnaeus, 1763)	Common Palmfly	Reared	*Cocos nucifera, Dypsis lutescens,*
55	Nymphalidae	*Phalanta phalantha* (Drury, [1773])	Common Leopard	Visitor Only	
56	Nymphalidae	*Moduza procris* (Cramer, [1777])	Commander	Reared	*Neolamarckia cadamba,Mussaenda frondosa, Mussaenda* sp.
57	Nymphalidae	*Neptis hylas* (Linnaeus, 1758)	Common Sailer	Reared	*Trema orientalis*
58	Nymphalidae	*Vanessa cardui* (Linnaeus, 1758)	Painted Lady	Visitor Only	
59	Nymphalidae	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	Visitor Only	
60	Nymphalidae	*Melanitis phedima* (Cramer, [1780])	Dark Evening Brown	Reared	*Cynodon dactylon*
61	Nymphalidae	*Melanitis zitenius* (Herbst, 1796)	Great Evening Brown	Reared	*Cyperus rotundus*

Sl. No.	Family	Scientific Name	Common Name	Status (Visitor Only/Reared)	Host Plant
62	Nymphalidae	*Mycalesis perseus* (Fabricius, 1775)	Common Bushbrown	Visitor Only	
63	Nymphalidae	*Mycalesis mineus* (Linnaeus, 1758)	Dark-branded Bushbrown	Visitor Only	
64	Nymphalidae	*Mycalesis visala* Moore, [1858]	Long-branded Bushbrown	Reared	*Cyperus rotundus*
65	Nymphalidae	*Charaxes bernardus* (Fabricius, 1793)	Tawny Rajah	Visitor Only	
66	Nymphalidae	*Discophora sondaica* Boisduval, 1836	Common Duffer	Reared	*Bambusa sp.*
67	Nymphalidae	*Ypthima huebneri* Kirby, 1871	Common Four-ring	Visitor Only	
68	Nymphalidae	*Ypthima baldus* (Fabricius, 1775)	Common Five-ring	Visitor Only	
69	Nymphalidae	*Cethosia cyane* (Drury, [1773])	Leopard Lacewing	Reared	*Passiflora foetida*
70	Nymphalidae	*Athyma inara* Westwood, 1850	Colour Sergeant	Reared	*Glochidion zeylanicum*
71	Nymphalidae	*Athyma perius* (Linnaeus, 1758)	Common Sergeant	Reared	*Glochidion zeylanicum*
72	Nymphalidae	*Athyma selenophora* (Kollar, [1844])	Staff Sergeant	Reared	*Mussaenda frondosa*
73	Nymphalidae	*Symbrenthia lilaea* (Hewitson, 1864)	Northern Common Jester	Visitor Only	
74	Nymphalidae	*Tanaecia lepidea* (Butler, 1868)	Grey Count	Reared	*Melastoma malabathricum*
75	Nymphalidae	*Euthalia aconthea* (Cramer, [1777])	Baron	Reared	*Mangifera indica*
76	Nymphalidae	*Euthalia lubentina* (Cramer, [1777])	Gaudy Baron	Visitor Only	
77	Nymphalidae	*Dichorragia nesimachus* (Doyère, [1840])	Constable	Reared	*Meliosma rigida*
78	Nymphalidae	*Euripus consimilis* (Westwood, [1851])	Painted Courtesan	Visitor Only	
79	Nymphalidae	*Charaxes bharata* C. & R. Felder, [1867]	Indian Nawab	Visitor Only	
80	Riodinidae	*Zemeros flegyas* (Cramer, [1780])	Punchinello	Reared	*Maesa montana*
81	Riodinidae	*Abisara bifasciata* Moore, 1877	Double-banded Judy	Reared	*Maesa indica*
82	Lycaenidae	*Spalgis epius* (Westwood, [1851])	Apefly	Visitor Only	
83	Lycaenidae	*Surendra quercetorum* (Moore, [1858])	Common Acacia Blue	Reared	*Acacia catechu*
84	Lycaenidae	*Horaga onyx* (Moore, [1858])	Common Onyx	Visitor Only	
85	Lycaenidae	*Loxura atymnus* (Stoll, 1780)	Yamfly	Reared	*Smilax ovalifolia*
86	Lycaenidae	*Hypolycaena erylus* (Godart, [1824])	Common Tit	Visitor Only	
87	Lycaenidae	*Remelana jangala* (Horsfield, [1829])	Chololate Royal	Visitor Only	
88	Lycaenidae	*Rapala manea* (Hewitson, 1863)	Slate Flash	Visitor Only	
89	Lycaenidae	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot	Visitor Only	
90	Lycaenidae	*Heliophorus epicles* (Godart, [1824])	Purple Sapphire	Visitor Only	
91	Lycaenidae	*Catochrysops strabo* (Fabricius, 1793)	Forget-me-not	Reared	*Cajanus cajan*, *Millettia pachycarpa*
92	Lycaenidae	*Chilades lajus* (Stoll, [1780])	Lime Blue	Reared	*Citrus limon*, *Citrus medica*
93	Lycaenidae	*Lampides boeticus* (Linnaeus, 1767)	Pea Blue	Reared	*Crotalaria* sp., *Desmodium triangulare*, *Dalbergia* sp.
94	Lycaenidae	*Zizula hylax* (Fabricius, 1775)	Tiny Grass Blue	Visitor Only	
95	Lycaenidae	*Zizeeria karsandra* (Moore, 1865)	Dark Grass Blue	Visitor Only	
96	Lycaenidae	*Jamides celeno* (Cramer, [1775])	Common Cerulean	Visitor Only	
97	Lycaenidae	*Jamides bochus* (Stoll, [1782])	Dark Cerulean	Visitor Only	
98	Lycaenidae	*Prosotas nora* (C. Felder, 1860)	Common Line Blue	Visitor Only	
99	Lycaenidae	*Cheritra freja* (Fabricius, 1793)	Common Imperial	Reared	*Rosa acicularis*
100	Lycaenidae	*Zeltus amasa* (Hewitson, [1865])	Fluffy Tit	Visitor Only	
101	Lycaenidae	*Curetis* sp.	Sunbeam	Visitor Only	
102	Lycaenidae	*Acytolepis puspa* (Horsfield, [1828])	Common Hedge Blue	Visitor Only	
103	Hesperiidae	*Badamia exclamationis* (Fabricius, 1775)	Brown Awl	Visitor Only	
104	Hesperiidae	*Hasora badra* (Moore, [1858])	Common Awl	Visitor Only	
105	Hesperiidae	*Hyarotis adrastus* (Stoll, [1780])	Tree Flitter	Visitor Only	
106	Hesperiidae	*Matapa aria* (Moore, [1866])	Common Branded Redeye	Reared	*Bambusa* sp.
107	Hesperiidae	*Gangara thyrsis* (Fabricius, 1775)	Giant Redeye	Reared	*Bambusa* sp.
108	Hesperiidae	*Notocrypta paralysos* (Wood-Mason & de Nicéville, 1881)	Common Banded Demon	Reared	*Curcuma longa*
109	Hesperiidae	*Ancistroides nigrita* (Latreille, [1824])	Chocolate Demon	Reared	*Zingiber* sp.
110	Hesperiidae	*Udaspes folus* (Cramer, [1775])	Grass Demon	Reared	*Zingiber* sp.
111	Hesperiidae	*Ampittia dioscorides* (Fabricius, 1793)	Bush Hopper	Visitor Only	
112	Hesperiidae	*Oriens gola* (Moore, 1877)	Common Dartlet	Visitor Only	
113	Hesperiidae	*Choaspes benjaminii* (Guérin-Méneville, 1843)	Common Awlking	Reared	*Sabia limoniacea*
114	Hesperiidae	*Choaspes stigmata* Evans, 1932	Branded Awlking	Reared	*Meliosma rigida*
115	Hesperiidae	*Celaenorrhinus leucocera* (Kollar, [1844])	Common Spotted Flat	Visitor Only	
116	Hesperiidae	*Tagiades japetus* (Stoll, [1781])	Common Snow Flat	Visitor Only	
117	Hesperiidae	*Tagiades litigiosa* Möschler, 1878	Water Snow Flat	Visitor Only	
118	Hesperiidae	*Sarangesa dasahara* (Moore, [1866])	Common Small Flat	Visitor Only	
119	Hesperiidae	*Iambrix salsala* (Moore, [1866])	Chestnut Bob	Visitor Only	
120	Hesperiidae	*Polytremis discreta* (Elwes & Edwards, 1897)	White-fringed Swift	Reared	*Bambusa* sp.
121	Hesperiidae	*Borbo cinnara* (Wallace, 1866)	Rice Swift	Visitor Only	
122	Hesperiidae	*Parnara* sp.	Parnara Swift	Reared	*Bambusa* sp.
123	Hesperiidae	*Telicota bambusae* (Moore, 1878)	Dark Palm-dart	Visitor Only	
124	Hesperiidae	*Pseudocoladenia dan* (Fabricius, 1787)	Fulvous Pied Flat	Visitor Only	

Table 2: List of plants present in the butterfly conservatory categorized as Host and/or Nectar plant based on the behavioral observations of butterflies.

Serial No.	Family	Scientific Name	Host Plant or Nectar Plant
1	Aristolochiaceae	*Aristolochia tagala* Cham., 1832	Host Plant
2	Magnoliaceae	*Magnolia champaca* (L.) Baill. ex Pierre	Host Plant
3	Annonaceae	*Polyalthia longifolia* (Sonn.) Benth. & Hook.f. ex Thwaites	Host Plant
4	Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm.	Host Plant
5	Lauraceae	*Litsea* sp.	Host Plant
6	Smilacaceae	*Smilax ovalifolia* Roxb. ex D.Don	Host Plant
7	Arecaceae	*Cocos nucifera* L.	Host Plant
8	Arecaceae	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.	Host Plant
9	Zingiberaceae	*Zingiber* sp.	Host Plant
10	Zingiberaceae	*Curcuma longa* L.	Host Plant
11	Cyperaceae	*Cyperus rotundus* L.	Nectar Plant, Host Plant
12	Poaceae	*Bambusa* sp.	Host Plant
13	Poaceae	*Cynodon dactylon* (L.) Pers.	Host Plant
14	Sabiaceae	*Meliosma rigida* Siebold & Zucc.	Host Plant
15	Sabiaceae	*Sabia limoniacea* Wall. ex Hook.f. & Thomson	Host Plant
16	Fabaceae	*Crotalaria* sp.	Host Plant
17	Fabaceae	*Cassia grandis* L.f.	Host Plant
18	Fabaceae	*Cassia fistula* L.	Host Plant
19	Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	Host Plant
20	Fabaceae	*Acacia catechu* (L.f.) Willd.	Host Plant
21	Fabaceae	*Albizia lebbeck* (L.) Benth.	Nectar Plant
22	Fabaceae	*Cajanus cajan* (L.) Huth	Host Plant
23	Fabaceae	*Cassia alata* L.	Host Plant
24	Fabaceae	*Desmodium triangulare* (Retz.) Merr.	Host Plant
25	Fabaceae	*Dalbergia* sp.	Host Plant
26	Fabaceae	*Millettia pachycarpa* Benth.	Host Plant
27	Polygonaceae	*Persicaria chinensis* (L.) H.Gross	Nectar Plant
28	Rosaceae	*Rosa acicularis* Lindl.	Host Plant
29	Rhamnaceae	*Ziziphus* sp.	Nectar Plant, Host Plant
30	Cannabaceae	*Trema orientale* (L.) Blume	Host Plant
31	Passifloraceae	*Passiflora foetida* L.	Host Plant
32	Euphorbiaceae	*Croton* sp.	Nectar Plant
33	Euphorbiaceae	*Ricinus communis* L.	Host Plant
34	Euphorbiaceae	*Trevia nudiflora* L.	Nectar Plant
35	Euphorbiaceae	*Euphorbia pulcherrima* Willd. ex Klotzsch	Nectar Plant
36	Phyllanthaceae	*Glochidion zeylanicum* (Gaertn.) A.Juss.	Host Plant
37	Lythraceae	*Cuphea hyssopifolia* Kunth	Nectar Plant
38	Myrtaceae	*Psidium guajava* L.	Nectar Plant
39	Melastomataceae	*Melastoma malabathricum* L.	Nectar Plant, Host Plant
40	Anacardiaceae	*Mangifera indica* L.	Nectar Plant, Host Plant
41	Rutaceae	*Citrus × limon* (L.) Osbeck	Host Plant
42	Rutaceae	*Murraya koenigii* (L.) Spreng.	Nectar Plant, Host Plant
43	Rutaceae	*Murraya paniculata* (L.) Jack	Nectar Plant, Host Plant
44	Rutaceae	*Citrus medica* L.	Nectar Plant, Host Plant
45	Rutaceae	*Zanthoxylum* sp.	Host Plant
46	Meliaceae	*Azadirachta indica* A.Juss.	Nectar Plant
47	Malvaceae	*Hibiscus × rosa-sinensis* L.	Nectar Plant
48	Capparaceae	*Crateva nurvala* Buch.-Ham.	Host Plant
49	Brassicaceae	*Brassica* sp.	Nectar Plant, Host Plant
50	Primulaceae	*Maesa indica* (Roxb.) Sweet	Host Plant
51	Primulaceae	*Maesa montana* A.DC.	Host Plant
52	Rubiaceae	*Mussaenda erythrophylla*	Host Plant
53	Rubiaceae	*Mussaenda frondosa* L.	Host Plant
54	Rubiaceae	*Ixora chinensis* Lam.	Nectar Plant
55	Rubiaceae	*Neolamarckia cadamba* (Roxb.) Bosser	Host Plant
56	Rubiaceae	*Ixora singaporensis* hort.	Nectar Plant, Host Plant
57	Apocynaceae	*Adenium* sp.	Nectar Plant
58	Apocynaceae	*Alstonia scholaris* (L.) R.Br.	Nectar Plant
59	Apocynaceae	*Calotropis gigantea* (L.) W.T.Aiton	Host Plant
60	Apocynaceae	*Carissa carandas* L.	Host Plant
61	Apocynaceae	*Ichnocarpus frutescens* (L.) W.T.Aiton	Host Plant
62	Apocynaceae	*Nerium oleander* L.	Host Plant
63	Apocynaceae	*Wattakaka volubilis* (L.f.) Stapf	Host Plant
64	Acanthaceae	*Strobilanthes callosa* Nees	Host Plant
65	Verbenaceae	*Clerodendrum indicum* (L.) Kuntze	Nectar Plant
66	Verbenaceae	*Clerodendrum paniculatum* L.	Nectar Plant
67	Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl	Nectar Plant
68	Asteraceae	*Tagetes erecta* L.	Nectar Plant
69	Asteraceae	*Cosmos bipinnatus* Cav.	Nectar Plant
70	Asteraceae	*Zinnia elegans* Jacq.	Nectar Plant

Notes on the immature stages and larval host plant of the Nilgiri Tit (*Hypolycaena nilgirica* Moore, [1884]) in the Western Ghats, India

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Abstract: The immature stages of the butterfly Nilgiri Tit *Hypolycaena nilgirica* Moore, [1884] family Lycaenidae, were studied in the foothills of the Nilgiris, Western Ghats, India. The species' life cycle on its newly identified host plant *Eulophia epidendraea* (J.Koenig ex Retz.) C.E.C.Fisch. (Orchidaceae) is reported for the first time in India. The immature stage development, from oviposition to adult eclosion, took approximately 25-32 days. Distribution records of the butterfly species in the region of the type locality are documented and a description of the larval stages is provided. This study provides basic information on the species' life cycle and host plant in India.

Key words: Life cycle; Lycaenidae; Nilgiri Biosphere Reserve; Orchidaceae.

INTRODUCTION

The genus *Hypolycaena* C. & R. Felder, 1862 (Lepidoptera: Lycaenidae) belongs to the subfamily Theclinae and tribe Hypolycaenini, which has 25 species in the Afrotropical region (Stempffer, 1967) and 11 species in the Indo-Malayan Region, with five in India (Kunte, 2015). In south India, the genus is represented by two species, Nilgiri Tit *Hypolycaena nilgirica* Moore, [1884], endemic to Western Ghats (Tamil Nadu and Kerala) and Sri Lanka, and Orchid Tit *Hypolycaena othona* Hewitson, (1865), occurring from southwest India to Malaysia and Indochina (Fiedler, 1992). The species *Hypolycaena nilgirica* was described in 1884 by Moore based on a single male specimen from Coonoor, 1000 feet elevation, Nilgiris, Western Ghats (Moore, 1884-1887; Swinhoe, 1911), and later recorded by several authors from the type locality (Hampson, 1888; Evans, 1932; Wynter-Blyth, 1944, 1945; Larsen, 1987; Jeevith *et al*., 2017). It has since been recorded from Sri Lanka (Ceylon) first reported by Moore (1884-1887) and later Hampson (1888). In India, until the late 1980s, the species was observed only from the foothills of the Nilgiris at Kallar by Wynter-Blyth (1944) and Larsen (1987), with a few records from Palnis (Larsen, 1987). However, since Larsen's observations in the 1980s, many sightings have been registered from different regions of Western Ghats, including the Geddai slopes of Nilgiris District, Aiyannar Falls of Virudhunagar District, Anamalais of Coimbatore District and Kalakkad Mundanthurai Tiger Reserve of Thirunelveli District in Tamil Nadu, Chinnar Wildlife Sanctuary of Idukki district, and Silent Valley National Park of Palakkad District in Kerala (Sadasivan *et al.*, 2023) (Fig. 1). The species has also been recorded from several locations in Sri Lanka (iNaturalist.org). The species is protected under Schedule II of the Indian Wildlife (Protection) Act, 1972 (New, 1993). Some information has been published on the larval food plants of Nilgiri Tit from Sri Lanka (Poorten *et al*., 2013), but in Western Ghats, India, the larval host plant was until now unknown, as reported by Bhakare and Ogale (2018), Jeevith *et al*. (2017), and Nitin *et al*. (2018). Indeed, there are no records of the immature stages or definitive larval host plant records from anywhere India. In this paper, the complete life biology of the Nilgiri Tit from egg to adult, with its feeding habits and larval food plant, is reported for the first time from India.

MATERIALS AND METHODS

The study was carried out through biweekly butterfly surveys in the Kallar Horticulture Garden (11°20'32.39"N, 76°50'21.13"E), in the Nilgiri Foothills of southern Western Ghats (Fig. 1), in the type locality region (Moore, 1884). Records from this region and notes on butterfly behavior are provided in Table 1. Observations were made on multiple visits to Kallar Horticulture Garden from January 2020 to December 2021 to document the ovipositing behavior and early instars of the species. The immature stages were observed *in situ*

Table 1. Observations of Nilgiri Tit in the region of its type locality, Nilgiris, Western Ghats, India.

Location	Month	Habitat	Activity (Encounters)
Kallar, Coonoor slopes, Nilgiri Foothills	July, August, October, November, December and January	Moist deciduous forest and rock slopes	Basking and Ovipositing (1) Puddling (1)
Kolikarai, Kotagiri slopes	January	Semi-evergreen and moist deciduous forest	Basking (1)
Kunjappanai, Kotagiri	September	Semi-evergreen and moist deciduous forest	Puddling (1)
Geddai, Manjoor slopes	November	Moist deciduous forest	Puddling (1)

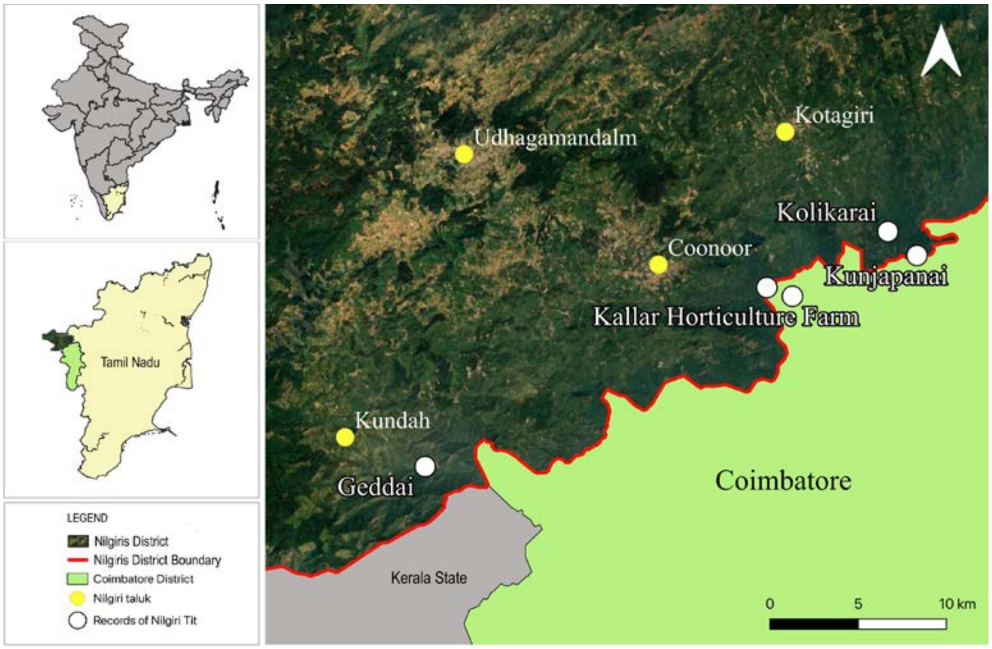

Figure 1. Locations where Niligiri Tit has been recorded in study region.

regularly throughout the life cycle. Identification of instar stage was based on comparison with observations in Poorten *et al*. (2013). Individuals were not marked or enclosed in containers, but the authors visited the field regularly throughout the study period and observations reported here represent best estimates. In particular, there is some doubt about the identity of fourth and fifth instars, since these are similar in size, color, and feeding pattern, and observations are therefore pooled for these instars. The immature stages were photographed using Nikon 90D, 7200, and 7500 DSLRs with Tamron 90mm and Nikkor 100mm macro lenses. The plant species were identified with the help of pertinent literature (Joseph, 1987; Jalal and Jayanthi 2012) and the nomenclature was updated based on POWO (2023). Field observations of the plant were also made, including habit and habitat, inflorescence, phenology status, and distribution of the species, and photographs were taken *in situ*.

RESULTS

Nilgiri Tit *Hypolycaena nilgirica* lays eggs on the inflorescence of the larval host plant *Eulophia epidendraea* (J.Koenig ex Retz.) C.E.C.Fisch. (Orchidaceae), a terrestrial orchid species (Fig. 2). This is the first known record of the butterfly species utilizing this plant as a larval host plant in India. In Sri Lanka, Orchidaceae species including *Malaxis versicolor, Peristylus trimenii, Arundina graminifolia, Spathoglottis plicata, Arachnis flos-aeris*, *Vanda tessellata* and *Vanda testacea* were reported as larval host plants for *H. nilgirica* (Poorten *et al.*, 2013; plant name authorities provided in that paper). Observation of the immature stages of the butterfly in the study area are given in Table 2 and estimates of the duration of each instar are provided in Table 3.

Larval Host Plant

Eulophia epidendraea is a large terrestrial orchid (Fig. 2), with pseudobulbous stems. Leaves grass-like and plaited, and base sheathing has a pseudobulb. Flowers greenish yellow with a white, purple-streaked lip, 2 cm long; flower-cluster-stalk is round, about 45-48 cm long, erect, bearing 9 membranous sterile bracts. Floral bracts ovate, tapering; dorsal petals lanceolate-oblong, apiculate; lateral sepals, obovate-lanceolate, apiculate; petals broadly lanceolate; sepal lip obovate-oblong; lateral lobes of lip small, erect; mid-lobe broadly oblong, rounded, crenulate, recurved; spur short, cylindrical (Joseph, 1987).

Distribution: The plant species is distributed in India, Sri Lanka and Bangladesh (POWO, 2023).

Phenology: October - March (flowering and fruiting).

Habitat and associated species: This terrestrial orchid was found on rocky slopes in humid areas. The species can also be cultivated *ex situ* with suitable climatic conditions (Joseph, 1987). In the study area, *Eulophia epidendraea* was mainly associated with *Cymbopogon flexuosus* (Steud.)., *Chrysopogon nodulibarbis* (Hochst. ex Steud.) Henrard., *Melinis repens* (Willd.) Zizka., (Poaceae), *Urena lobata* L. (Malvaceae), *Tri-*

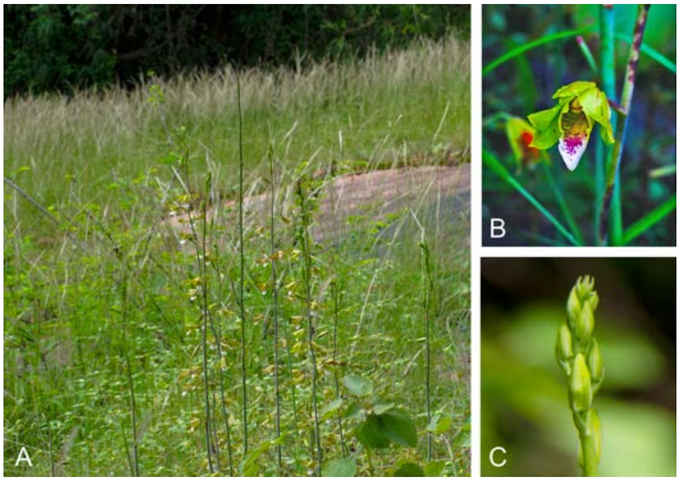

Figure 2. *Eulophia epidendraea* (Orchidaceae) hostplant of Nilgiri Tit *Hypolycaena nilgirica*. **A.** Habitat, **B.** Flower, **C.** Flower bud. © Selvaraj Jeevith.

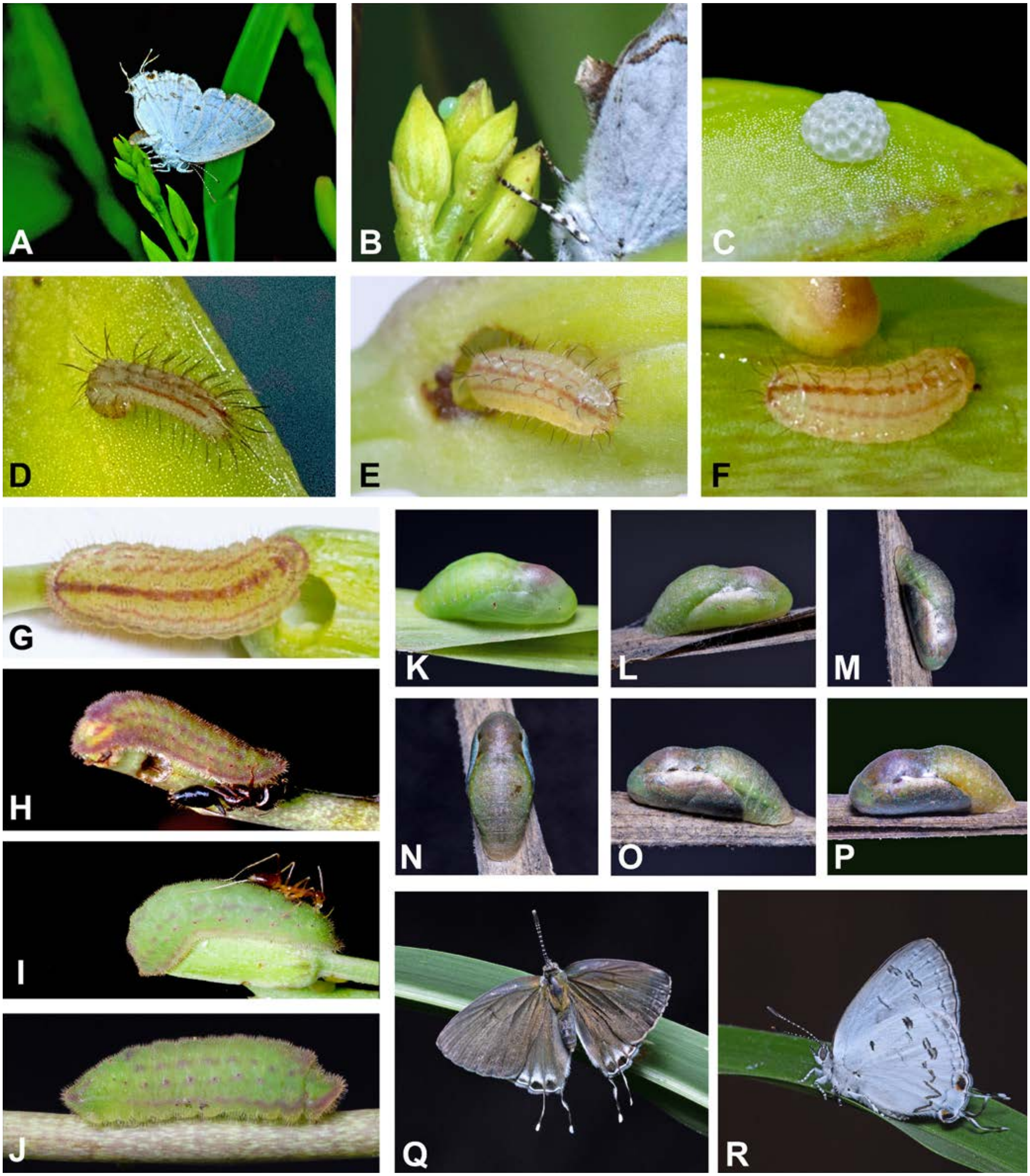

Figure 3. Nilgiri Tit *Hypolycaena nilgirica* early stages. **A & B.** Female ovipositing on *Eulophia epidendraea*; **C.** Egg; **D.** First instar larva; **E.** Second instar larva; **F.** Third instar larva; **G.** Fourth instar larva - pink morph; **H.** Fourth instar larva, with associated ant *Camponotus* sp.; **I.** Fourth instar larva, with associated ant *Anoplolepis gracilipes*.; **J.** Fifth instar larva - green morph; **K.** Newly formed pupa; **L.** Pupa with white curvature marking; **M.** Pupa lateral view; **N.** Pupa ventral view; **O.** Pupa dark morph; **P.** Pupa fully matured; **Q.** Adult freshly eclosed upper wing; **R.** Underwing. © Manoj Sethumadhavan and Felix Nirmal Dev.

dax procumbens L., (Asteraceae), and the tree *Chloroxylon swietenia* (Roxb.) DC. (Rutaceae).

Notes on Immature Stages

Egg: Females laid eggs generally around noon on hot, sunny days. Eggs were laid singly on the flower buds (Fig. 3A), stem or other parts of the inflorescence of the host plant. Eggs were initially translucent green in color (Figs 3B, C), which on hardening turned chalky white, within a few seconds after oviposition. The eggs were hemispherical with chorionic

Table 2. Observations of adults and early stages of Nilgiri Tit in the study area.

Date of Observation	Time (hrs)	Butterfly stages
05, 21, 27 & 28 January 2020	1100 – 1400	Adult
07 June 2020	1000 – 1400	Adult
21, 28 June 2020	1030 – 1400	Adult
15, 17, 27 July 2020	1000 – 1300	Adult
23, 27 September 2020	1100 – 1400	Adult
29 & 30 November 2020	1130 – 1330	Adult (f), eggs, larva (3 & 4 instar), pupa
01 to 06 December 2020	1000 – 1300	Adult
10 to 12 December 2020	1130 – 1330	Adult
14 & 15 December 2020	1100 – 1300	Adult
25 February 2021	1000 – 1200	Adult
26 August 2021	1230 – 1400	Pupa on host plant
12 October 2021	1530 – 1630	Adult, egg, larva on host plant
20 October 2021	1230 – 1330	Adult, egg, larva & pupa on host plant
24 October 2021	1100 – 1330	Adult, egg, larva & pupa on host plant
30 October 2021	1130 – 1330	Adult, egg, larva & pupa on host plant

Table 3. Life biology of Nilgiri Tit *Hypolycaena nilgirica*.

Butterfly stage	No of Days	Remarks
Egg	4 - 5	
1st Instar larva	2 - 3	
2nd Instar larva	2 - 3	
3rd Instar larva	5 - 6	
4th/ 5th Instar larva	2 - 3	Feeding stopped during early 5th instar
Pupal stage	10 - 12	The pupa turns from green to ochreous
Total	25 - 32	

sculpturing of thick, distinct reticulated hexagonal ribs, as is typical for lycaenid ova (Downey & Allyn 1981, 1984). As in other lycaenid species, the eggs were also found on flower buds and the plant stem (Fig. 3B). Empty eggshells and unhatched eggs were observed on the stem and leaf nodes. Most eggs were observed on the terminal and lateral buds. Occasionally, eggs were also seen on the flower petals, but no eggs were observed on the leaves. The eggs took 4 to 5 days to hatch, with no further changes in coloration, and usually hatched during early morning hours.

Larval stages: Two larval morphs were observed, one pink and one green. However, the white morph reported from Sri Lanka (Poorten *et al.*,, 2013) was not observed in our study.

First Instar: The egg shells were not eaten by the larvae and 10 individual hatched egg shells were observed on the inflorescence of the plant. The first instar larva was covered fully with small setae. The larva was translucent yellow with pale red disjointed lines running laterally. As soon as the eggs hatch, the larvae bored into the buds and remained there feeding inside the bud throughout the first instar. Frass pellets were observed on the buds, stem, and nodes; however, it was unclear if the larvae exited the bud to excrete or made holes to excrete from inside the buds. This instar lasted approximately 2 to 3 days (Fig. 3D).

Second Instar: After molting from the first instar, the second instar larva emerged out of the buds. The color became pale green with pale red lines and with fewer hair-like structures. The setae became much more reduced in number, organized linearly, pronounced and distributed along the lateral reddish lines. Once the second instar emerged from the bud, they kept feeding on the outer buds as well as the flower petals. At this stage, the head could be retracted under the sclerotized prothoracic plate and the feeding pattern changed. The larvae started to feed either on the flower buds or plant stem or moved on to feed on fully grown flowers. This instar lasted approximately 2-3 days (Fig. 3E).

Third Instar: At the end of 5-6 days after eclosion, feeding increased considerably. The third instar larva fed on flower petals and on average half the flower was consumed at the end of the first day after molting. By the end of the second day, we estimated that the larva was able to consume approximately 70% of a flower, based on examination of sequential photographs. The length of the larva increased considerably, the hair-like structures were completely replaced with tiny bristles, and the spiracles became visible. This instar lasted for approximately 3-4 days. (Fig. 3F).

Fourth/Fifth Instar: At 9-10 days after eclosion, the larva entered the fourth instar and the feeding became intense, feeding on two complete flowers in two days. The lateral pale red markings disappeared in the mid-section of the larva and remained visible on the dorsal part of the head capsule and posterior sections. The larvae changed color to pale yellow or pale green. The spiracles became more conspicuous. The pale red markings became much duller and the lateral bands clearer both above and below the spiracles. It was difficult to separate the 4th and 5th instars during *in situ* observations and from images, since these instars were similar in size and color, but it is assumed that five instars were present, as reported by Poorten *et al*. (2013). These instars are estimated to have each lasted approximately two days (Figs. 3G-J).

Pupal Stage: The pupa was pale green throughout. On the anterior part of the head, there was a pale red patch. The pupa was attached to the stem at its posterior tip and fastened by a thin silk girdle across the abdomen. Just above the wing cases, the green turned to ashy white with a distinct blackish patch. After 8-9 days the pupa turned ochreous and the coloration of the wings and body developed rapidly (Figs. 3K-P).

Adult: Four observed adults eclosed early in the morning at 0530 to 0630. The expansion and drying of the wings took approximately one hour (Figs. 3Q,R). Overall, we estimate that the immature life stages took approximately 25 to 32 days from oviposition to eclosion.

Arthropod species associated with *Eulophia epidendraea*: Several other species of insect were observed on *E. epidendraea*. Several species of ants including *Camponotus* sp., *Meranoplus bicolor, Anoplolepis gracilipes* and *Crematogaster* sp. were observed on the particular plant on which *H. nilgirica* immatures were feeding, with no predation of larvae of *H. nilgirica* observed. *Anoplolepis gracilipes* were observed feeding on secretions from *H. nilgirica* larvae (Fig. 3I). Author FND observed a wasp species attending and preying on *H. nilgirica* during their pupal stage, and also a parasitic wasp emerging from one pupa.

DISCUSSION

This is the first description of the immature stages of Nilgiri tit from India, and although more intensive studies are needed, it provides additional data to compare and contrast with previous observations of the species (Poorten *et al*., 2013). In our study, the butterfly larva fed on a terrestrial orchid species, but elsewhere in Western Ghats (Kerala), Kalesh (pers. comm.) observed a few epiphytic orchid species as hostplants for *H. nilgirica*, including *Vanda tessellata* (Roxb.) Hook. Ex G.Don and *Aerides ringens* (Lindl.) C.E.C.Fisch. Further study is needed on ant associations, larval forms, and larval host preferences at different elevations. Breeding in captivity for further genetic and morphological study would also be desirable. The larva of Nilgiri Tit has several color morphs (Poorten *et al.*, 2013), with a white form reported in Sri Lanka that was not observed in this study. The presence of such a form in Sri Lanka could be due to larval adaptation to the surroundings, the stem, the inflorescences, or the white flowers of the host plant in that region. Alternatively, it may be that the white form is present in India but was not recorded by us due to the limited sample size. The feeding pattern of *H. nilgirica* generally followed that of *Hypolycaena othona* Hewitson, 1895 as documented in West Malaysia, which was also usually seen feeding by way of tunneling into fleshy tissues of the larval host plant (Fiedler, 1992). Similarly, *H. nilgirica* also avoided feeding on leaves, as in the case of *H. othona*. However, contrary to *H. othona*, *H. nilgirica* was seen feeding on flowers.

Pierce *et al.* (2002) categorized lycaenid-ant association into three categories as obligate, facultative and non-ant associated. Obligate interactions are necessary during at least some portion of the life cycle wherein the immature butterfly is dependent on ants for its survival. Such interactions can be either mutualistic or parasitic and typically involve a single species or genus of ant. By contrast, in facultative associations, the larvae are found only intermittently associated with ants and do not require attendant ants for survival. The association is also non-specific, with more than one genus or subspecies of ants attending the larvae. These associations are mostly mutualistic, although a few species are also predaceous. In the case of *H. nilgirica* in India, the species did not appear to require the attending ant for its survival, based on our regular field observations. We thus follow previous authors in regarding this type of interaction as a moderate facultative relationship (Pierce, 2002; Poorten *et al.*, 2013; Sujitha *et al.*, 2023).

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LITERATURE CITED

Bhakare, M., Ogale, H. 2018. *A Guide to Butterflies of Western Ghats (India). Includes Butterflies of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat States*. Satara, Milind Bhakare. x + 496 pp.

Downey, J. C., Allyn, A. C. 1981. Chorionic sculpturing in eggs of Lycaenidae. Part I. *Bulletin of the Allyn Museum* 61: 1-29.

Downey, J. C., Allyn, A. C. 1984. Chorionic sculpturing in eggs of Lycaenidae. Part II. *Bulletin of the Allyn Museum* 84: 1-44.

Evans, W. H. 1932. *The Identification of Indian Butterflies, 2nd Edition*. Mumbai, Bombay Natural History Society. 221 pp.

Fiedler, K. 1992. Notes on the biology of *Hypolycaena othona* (Lepidoptera: Lycaenidae) in West Malaysia. *Nachrichten des Entomologischen Vereins Apollo* 13: 65-92.

Hampson, G. F. 1888. The butterflies of the Nilgiri District, south India. *The Journal of the Asiatic Society of Bengal* 57: 346-368.

Jalal, J. S., Jayanthi, J. 2012. Endemic orchids of peninsular India: a review. *Journal of Threatened Taxa* 4(15): 3415-3425.

Jeevith, S., Manoj, S., Vinod, S., Nathen, C., Ramesh, O. V. 2017. Validation and documentation of some rare butterflies (Insecta: Lepidoptera) in the Nilgiris, Southern Western Ghats, Tamil Nadu, India. *Journal of Entomology and Zoology Studies* 596: 1311-1315.

Joseph, J. 1987. *Orchids of Nilgiris*. Calcutta, Calcutta Botanical Survey of India. 186 pp.

Kunte, K. 2015. A new species of *Hypolycaena* (Lepidoptera: Lycaenidae) from Arunachal Pradesh, north-eastern India. *The Journal of Research on the Lepidoptera* 48: 21-27.

Larsen, T. B. 1987. The butterflies of the Nilgiri mountains of southern India (Lepidoptera: Rhopalocera). *Journal of the Bombay Natural History Society* 84(1): 26-54; 84(2): 291-316; 84(3): 560-584.

Moore, F. 1884. Descriptions of new Asiatic diurnal Lepidoptera. *Proceedings of the Zoological Society of London* 1883 (4): 521-535; pls. 48-49.

Moore, F. 1884-87. *The Lepidoptera of Ceylon*. Vol. III. London, L. Reeve & Co. 752 pp.

Pierce, N. E., Braby, M. F., Heath. A., Lohman, D. J., John, M., Rand, D. B., Travassos, M. A. 2002. The ecology and evolution of ant association in the Lycaenidae (Lepidoptera). *Annual Review of Entomology* 47: 733-771.

POWO. 2023**.** *Plants of the World Online*. Kew, Royal Botanic Garden. http://www.plantsoftheworldonline.org. Accessed January 2023.

New, T. R. 1993. *Conservation Biology of Lycaenidae*. Part 1. IUCN Species Survival Commission (SSC), WWF, Oman, Sir Peter Scott IUCN/SSC Action Plan Fund, National Wildlife Federation, USA. 173 pp.

Nitin, R., Balakrishnan, V. C., Churi, P. V., Kalesh, S., Prakash, S. Kunte, K. 2018. Larval host plants of the butterflies of the Western Ghats, India. *Journal of Threatened Taxa* 10(4): 11495-11550.

Sadasivan, K., Sujitha, P. C., Augustine, T., Kunhikrishnan, E., Nair, V. P., Murukesh, M. D., Kochunarayanan, B. 2023. Butterflies of Silent Valley National Park and its environs, Western Ghats of Kerala, India. *Journal of Threatened Taxa* 15(2): 22661-22676.

Stempffer, H. 1967. The genera of the African Lycaenidae (Lepidoptera: Rhopalocera). *Bulletin British Museum of Natural History (Entomology)* (Supplement 10): 1-322.

Sujitha, P. C., Sadasivan, K., Nair, V. P., Kripakaran, M., Prasad, G. 2023. Myrmecophily in Lycaenidae butterflies (Rhopalocera, Lepidoptera) of Kerala, Western Ghats, Southern India. *Oriental Insects* 58: 1: 74-99.

Swinhoe, C. 1912. *Lepidoptera Indica IX: Rhopalocera, Family Papilionidae and Family Lycaenidae*. London, Lovell Reeve and Co. Limited. 84 pp.

Van Der Poorten, G., Van Der Poorten, N. 2013. New and revised descriptions of the immature stages of some butterflies in Sri Lanka and their larval food plants (Lepidoptera: Lycaenidae). Part 1: Polyommatinae and Theclinae, in part. *The Journal of Research on the Lepidoptera* 46: 25-49.

Wynter-Blyth, M. A. 1944. The butterflies of the Nilgiris (part II). *Journal of the Bombay Natural History Society* 45(1): 47-60.

Wynter-Blyth, M. A. 1945. Addenda and corrigenda to the butterflies of the Nilgiris' published in Vols. XLIV and XLV of the Journal. *Journal of the Bombay Natural History Society* 45(4): 613-615. 2002.

A new species of *Brevioleria* (Nymphalidae: Danainae: Ithomiini) from northeastern Brazil

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Abstract. A new clearwing butterfly, *Brevioleria maculele* Freitas **sp. nov.**, is described from the Atlantic Forest in northeastern Brazil. This species is not common and has been collected in only two localities in the coastal forests in the state of Bahia.

Key words: Atlantic Forest; Godyridina; *Hypoleria*; Ithomiini; *Mcclungia*; Solanaceae

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INTRODUCTION

Extending for more than 3000 km along the Brazilian coast, the Atlantic Forest domain, including humid forests and associated physiognomies (such as sand forests, dunes, mangroves, high altitude highlands, and other minor physiognomies) is the second largest Neotropical forest (Morellato & Haddad [2001]). After 500 years of European occupation, the Atlantic Forest has mostly been replaced by anthropogenic environments, and now it is restricted to less than 16% of its original cover (Ribeiro *et al.*, 2009). The region also presents a high level of endemism, making the Atlantic Forest one of the global biodiversity hotspots for conservation (Myers *et al.,* 2000).

Despite its broad geographic extent, the Atlantic Forest is far from homogeneous, and it includes subtropical forests with *Araucaria* pine trees (Araucariaceae) in the south, semideciduous forests in the interior, and tropical evergreen forests in the northernmost portion (Oliveira-Filho & Fontes, [2001]). In the coastal region from northern Espírito Santo and south Bahia, the warm and rainy climate all year round has allowed the development of an exuberant, tall forest so similar to rainforest in the Amazon that it received the name of "Hiléia Baiana" (Bahian Hylaea) (Andrade-Lima, 1966; Oliveira-Filho & Fontes, [2001]). This region presents a high level of endemism of plants and animals and also contains several otherwise typically Amazonian taxa, including butterflies (Brown & Freitas, 2000, [2001]; Freitas *et al.,* 2023). The present paper describes a new species of clearwing butterfly (Ithomiini) in the genus *Brevioleria* Lamas, 2004 from the region of the Bahian Hylaea in South Bahia and discusses its systematic position within the subtribe Godyridina (Danainae: Ithomiini).

MATERIALS AND METHODS

Adult Ithomiini specimens from Bahia were studied in three collections in Brazil: **DZUP**: Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Paraná; **ZUEC**: Zoological Collection, Museu de Diversidade Biológica da Universidade Estadual de Campinas, Campinas, São Paulo; **ZUEC-AVLF**: André V. L. Freitas collection, Universidade Estadual de Campinas, Campinas, São Paulo. In addition, photographs of Neotropical butterfly type specimens taken by Gerardo Lamas and available in Warren *et al.* (2023) were reviewed and compared with the new taxon described herein. The taxonomy of the subtribe Godyridina follows Chazot *et al.* (2016).

To determine the phylogenetic position of the new species within Godyridina, total genomic DNA was extracted from the legs of 25 individuals, three of which are of the new species described herein, together with other samples of Godyridina species found in the Atlantic Forest (the collection data and GenBank [Benson *et al.*, 2005] accession codes are shown in Table 1). DNA extractions were kept at 20°C in TE buffer. The barcode region, which is the 5′ extremity of the mitochondrial gene cytochrome oxidase subunit I (COI, ca. 658 bp), was amplified using PCR reactions with the primers LCO (5′GGTCAACAAATCATAAAGATATTGG) and NANCY (5′ CTGGTAAAATTAAAATATA AACTTC) (Folmer *et al.*, 1994; Caterino & Sperling, 1999).

Geneious 10.2.6 was used to evaluate and align sequences (Kearse *et al.*, 2012). The final matrix included 76 specimens of the subtribe Godyridina, including all the individuals listed above, as well as some representatives of the species sampled in the dataset of Chazot *et al.* (2016) and other sequences from GenBank (Benson *et al.* 2005). Two mitochondrial genes, *cytochrome oxidase I* (COI, 1508 bp), *cytochrome oxidase II* (COII, 678 bp), and the nuclear genes *elongation factor 1-alpha* (EF-1a, 1240 bp) and *Tektin* (tekt, 739 bp), were included (only COI was obtained for the new species here described; the nuclear genes could not be amplified due to technical limitations). Maximum likelihood (ML) analyses were conducted using W-IQ-TREE (Trifinopoulos *et al.*, 2016). ModelFinder was used to determine optimal substitution models for each gene codon partition (Kalyaanamoorthy *et al.*, 2017). IQ-TREE started tree reconstruction using the best model scheme discovered, and support for nodes was evaluated with 1000 ultrafast bootstrap (UFBoot2) approximations (Hoang *et al.*, 2017).

Brevioleria maculele Freitas **sp. nov.**
Figs. 1, 2, 4

Diagnosis. Based on wing shape and size, *Brevioleria maculele* **sp. nov.** is most similar to *Brevioleria plisthenes* (d'Almeida, 1958), but lacks the white postdiscal patch extending from the costa to space M_3-CuA_1 on the forewing. The wing pattern is similar to that of small individuals of *Hypoleria alema oreas* Weymer, 1899, but can be distinguished by the presence of light gray apical marginal dashes on the ventral wings. In the male genitalia, the valvae of *B. maculele* **sp. nov.** possess three short distal projections, similar to those of *Brevioleria seba emyra* (Haensch, 1905) (valvae of *B. plisthenes* and *Brevioleria arzalia* (Hewitson, 1876) possess only two projections); however, the two projections at the tip of the valvae are blunt in *B. maculele* **sp. nov.** (these are more pointed in *B. seba emyra*).

Description.

Male (Figs. 1A, B). Antennae entirely black, 13 mm in length, with 44 antennomeres; club with 13 antennomeres, not conspicuously developed. Thorax black with a thin white dorsal line; patagium black. Abdomen black dorsally, white ventrally. Forewing length 22 mm; hindwing length 17 mm (n=1). General wing pattern translucent with borders and veins black: forewing with a short white postdiscal patch; hindwing translucent with dark veins and borders. Ventral wing margins orangish brown, bordered with thin dark brown lines; light gray marginal dashes in apical region of both wings; a single long beige 'hair pencil' on dorsal costal margin, extending from humeral vein to end of discal cell. Discal cell closed. Male genitalia (Fig. 2): saccus and aedeagus very long; aedeagus straight and thin, with an expansion at end; tegumen short, uncus short and pointed, slightly curved ventrally, very thin in dorsal view; valvae symmetrical, subtriangular with three short projections, first lateral, pointed and curved inwards, second and third rounded, of similar size at tip of valvae.

Female (Figs. 1C, D). Very similar to male, with dark brown borders slightly broader. Antennal length 13 mm (n = 4), with 45-46 antennomeres; club with 13 antennomeres. Forewing length 22-24 mm (n = 4); hindwing length 15-16 mm (n = 4).

Type material. Holotype male (Fig. 1A), deposited in ZUEC. Labels on the holotype (4 labels separated by transverse bars): / HOLOTYPUS / Brazil Bahia Camacan RPPN Serra Bonita 17 a 19/08/2009 Eduardo de O. Emery / Holotypus *Brevioleria maculele* Freitas *det*. 2023 / ZUEC LEP 13744 /.

Allotype female (Fig. 1B), deposited in ZUEC. Labels on the allotype (4 labels separated by transverse bars): / ALLOTYPUS / Brazil Bahia Camacan RPPN Serra Bonita 17 a 19/08/2009 Eduardo de O. Emery *leg. /* Allotypus *Brevioleria maculele* Freitas *det*. 2023 / ZUEC LEP 13745 /.

Paratypes (all from Bahia, Brazil). **Camacan.** Reserva Particular do Patrimônio Natural Serra Bonita, 01.III.2015, 600 m 1 female, 200 m 2 females, J. Benetti-Longhini and A. Brower *leg*. DNA Voucher BLU 772, BLU 775, BLU 777 (ZUEC LEP 13746, ZUEC LEP 13747, ZUEC LEP 13748); **Ilhéus**. Fazenda do Alemão, 15°0'1.77"S, 39°8'12.79"W, VI.2000, 120m, 1 female (in bait trap), G. M. Accacio *leg*. (ZUEC LEP 13749).

Etymology. The species is named after the 'maculelê', a folk Afro-Brazilian dance from the state of Bahia, northeastern Brazil. It is treated as a feminine noun in apposition.

Systematic Position and Taxonomy. The molecular phylogenetic analysis (Fig. 4) recovered all former *Hypoleria* Godman & Salvin, 1879 and *Mcclungia* R. Fox, 1940 (*sensu* Meilke & Brown 1979) in a clade with moderate support, divided into three main subclades: 1) the '*Hypoleria* clade', including *Hypoleria alema* (Hewitson, [1857]), *Hypoleria lavinia* (Hewitson, [1855]), and *Hypoleria xenophis* Haensch, 1909; 2) the '*Mcclungia* clade', including *Mcclungia cymo* (Hübner, [1806]), *Hypoleria adasa* (Hewitson, [1855]), *Brevioleria coenina* (Hewitson, 1869), *Hypoleria ocalea* (Doubleday, 1847), *Hypoleria aureliana* (Bates, 1862), *Hypoleria sarepta* (Hewitson, [1852]) and an undescribed species; and 3) the '*Brevioleria* clade', including *Brevioleria seba* (Hewitson,

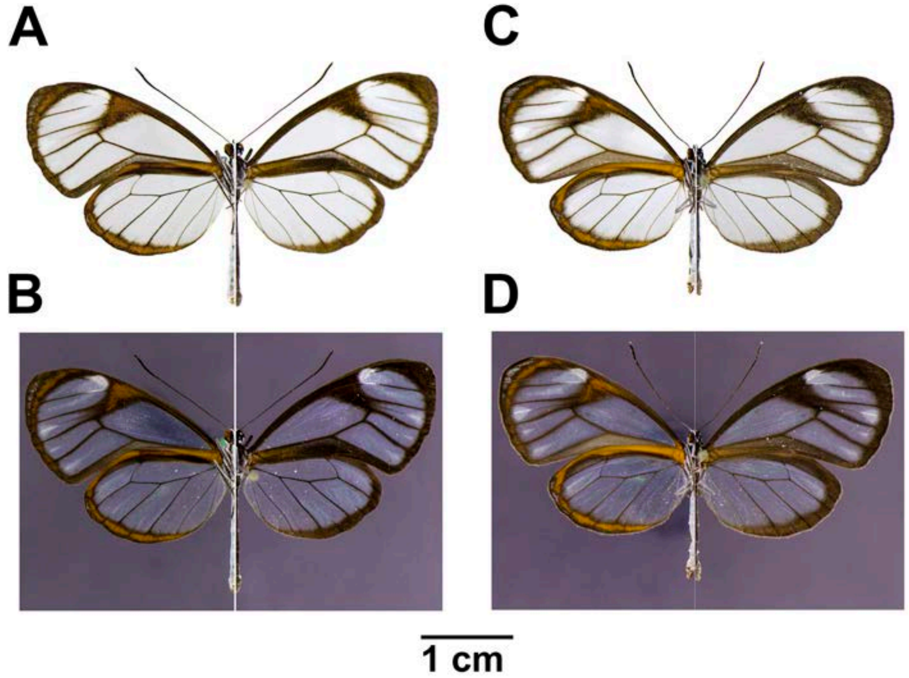

Fig. 1. *Brevioleria maculele* **sp. nov. A, B.** Holotype male, **C, D.** allotype female. Left = ventral; Right = dorsal.

1872), *Brevioleria arzalia, Brevioleria plisthenes, Brevioleria maculele* **sp. nov.** and the genus *Pachacutia* Willmott & Lamas, 2007. The here-described *Brevioleria maculele* **sp. nov.** forms a well-supported clade that is sister to *B. aelia* + *B. arzalia* + *B. plisthenes*, validating its assignment at the species level (Fig. 4). However, the absence of some taxa similar to *B. maculele* **sp. nov.**, such as *Brevioleria aelia jamariensis* (R. F. d'Almeida, 1951), could influence the present decision. The taxonomy of the '*Brevioleria* clade' needs to be clarified based on morphological and molecular evidence, to corroborate the species and subspecies-level classification of *Brevioleria*.

Distribution. The species is known from only two localities in south Bahia, in the municipalities of Camacan and Ilhéus.

Natural history. *Brevioleria maculele* **sp. nov.** has been recorded from the warm rainforests of South Bahia, at elevations from 100 to 800 m in well-preserved forests (Fig. 3A, B). The species is not abundant and easily goes unnoticed among several sympatric transparent co-mimics, in particular *Pseudoscada acilla acilla* (Hewitson, 1867), *P. florula genetyllis* (R.F. d'Almeida, 1922), and *Hypoleria adasa* (Hewitson, [1855]) (Fig. 3G), which are similar in size and wing pattern. In Camacan, up to 11 'blue clearwing' putative co-mimics can

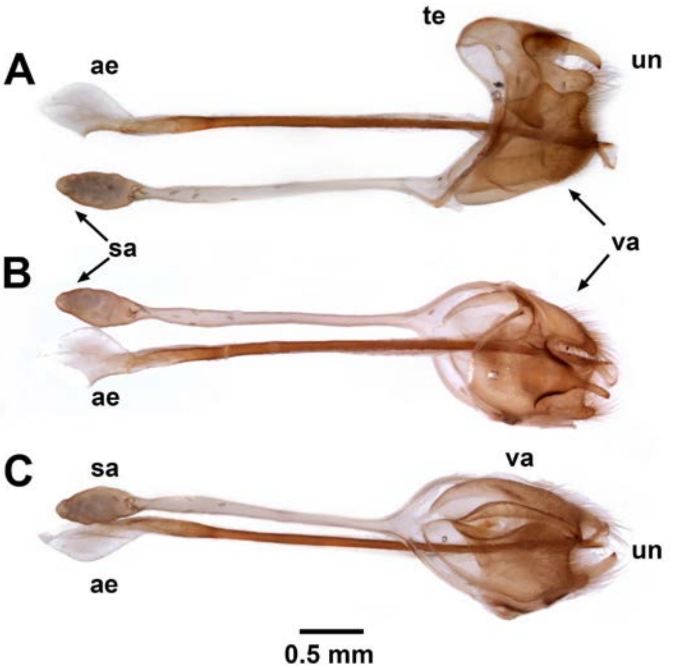

Fig. 2. Male genitalia of *Brevioleria maculele* **sp. nov. A.** lateral view; **B.** dorsal view; **C.** ventral view. ae, aedeagus; sa, saccus; te, tegumen; un, uncus; va, valva.

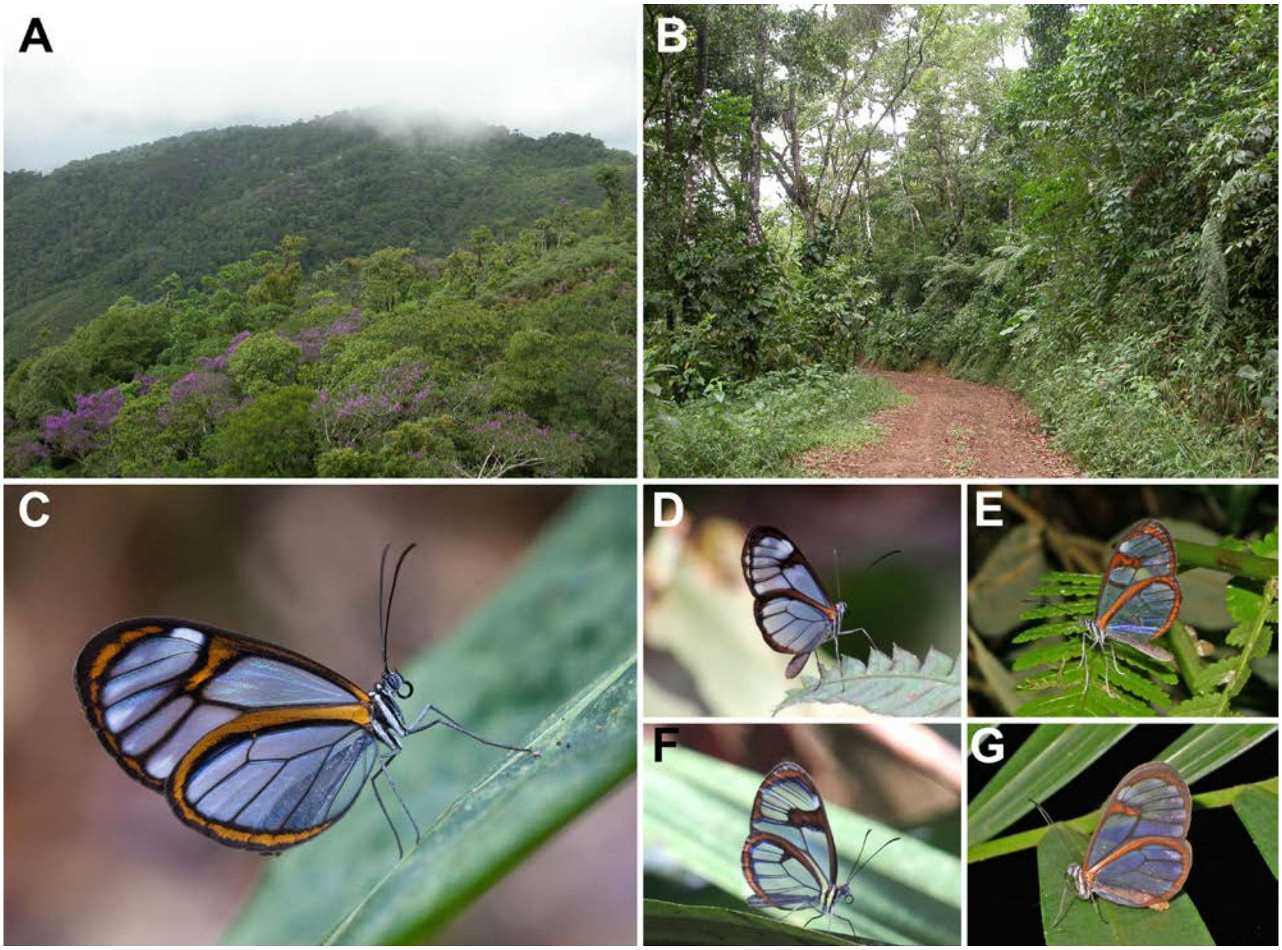

Fig. 3. Habitat of *Brevioleria maculele* **sp. nov.** and its co-mimics at the type locality in Camacan, Bahia, NE Brazil. **A.** General view of the vegetation; **B.** Close view of a dirt road inside the forest; **C.** *Hypoleria alema oreas* (female); **D**. *Hypoleria alema oreas* (male); **E**. *Oleria aquata* (Weymer, 1875) (male); **F**. *Ithomia lichyi* d'Almeida, 1939 (female); **G**. *Hypoleria adasa* (Hewitson, [1855]) (female).

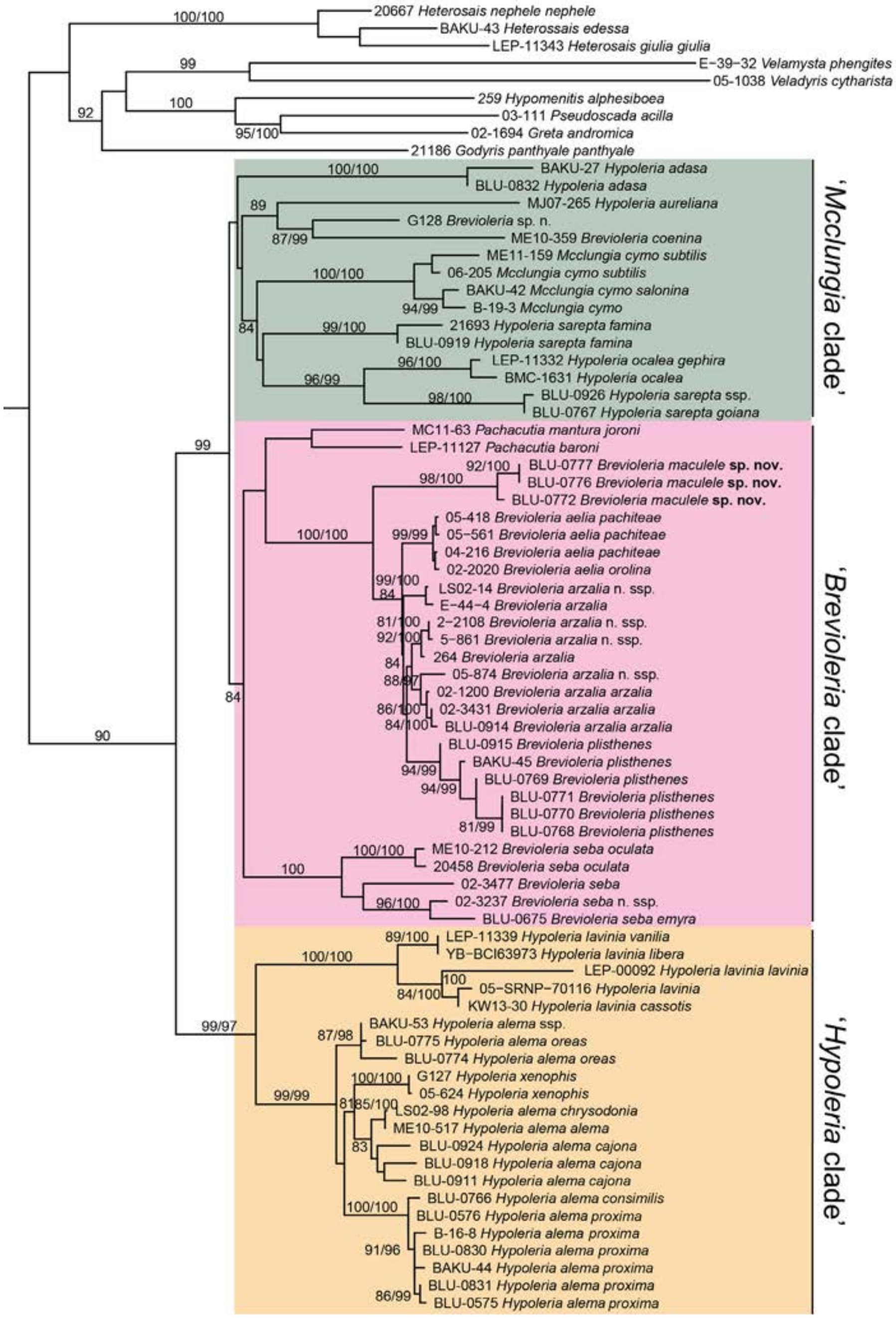

Fig. 4. Phylogenetic relationships of subtribe Godyridina based on four genes and obtained by a maximum likelihood analysis. Three clades are highlighted with shaded rectangles:1) the *'Mcclungia* clade' in green; 2) the '*Brevioleria* clade' in pink; and 3) the '*Hypoleria* clade' in orange. Numbers on branches refer to bootstrap supports when SH-aLRT >= 80% and UFboot2>= 95%.

fly together (see examples in Fig. 3C-G). Adults were mainly observed in the forest interior during the day, flying in clearings and open trails in the early morning. Host plants and early stages are unknown, but based on the known natural history of closely related species of *Brevioleria*, the host plants are almost certainly Solanaceae in the tribe Cestreae.

DISCUSSION

Based on the present results, the phylogeny recovered all taxa formerly assigned to *Hypoleria* (*sensu* Meilke & Brown 1979) forming a clade, a result similar to that obtained by Chazot *et al.* (2016). The main difference was the position of *B. coenina*; in the present study, this species was recovered as sister to *H. aureliana* in the *'Mcclungia* clade', while it was recovered as sister to *Brevioleria seba* as part of the '*Brevioleria* clade' in Chazot *et al.* (2016). The position of *Pachacutia,* making the genus *Brevioleria* paraphyletic, is also similar to that obtained by Chazot *et al.* (2016). The positions of these two taxa should be studied to clarify the limits of the genus *Brevioleria* and its monophyly. Concerning the position of *Brevioleria maculele* **sp. nov.**, the phylogenetic analysis recovered three sequenced individuals in a well-supported, isolated clade, within the '*Brevioleria* clade', validating the current description of the present taxon at the species level (but see comments above concerning *B. aelia jamariensis*). *Brevioleria* is complex and clearly requires a thorough taxonomic revision (Chazot *et al.* 2016: Appendix 1), and the decision to describe this new taxon at the species level is currently the best-supported option.

Even though the Atlantic Forest is one of the best studied domains in Brazil (Carneiro *et al.*, 2008; Shirai *et al.*, 2019), several new butterfly taxa have been recently described from this region. For the tribe Ithomiini, however, the recently described taxa were at the subspecies level, and all of them are well-known and have just been waiting to receive a name (Freitas, 2020; Freitas *et al.*, 2021). In the present case, this is a new species that was never previously collected; the few known individuals come from relatively recent sampling in south Bahia. In fact, no additional specimens were located in museum collections that includes material from the region. Possibly, this absence is related to the fact that *B. maculele* **sp. nov.** is not locally abundant and is easily mistaken for other sympatric and much more common clearwings, as previously mentioned.

Although *B. maculele* **sp. nov.** is known from only two localities, this species is likely to occur in several other areas with similar forests in South Bahia, including some well-preserved reserves such as the Serra das Lontras National Park and the Una Biological Reserve. Also, it would be important to search for additional localities north and south of the known distribution, to understand the real limits of distribution of the species. Finding additional localities for *B. maculele* **sp. nov.** is important not only to better understand its conservation status, but also because these new localities are additional opportunities for the conservation of this species.

Note added in proof: When reviewing butterfly specimens recently collected in South Bahia by Geanne Carla Novais Pereira, the first author identified 31 more specimens of *B. maculele* **sp. nov.** in six new localities in the municipalities of Belmonte, Mascote, and Una (70-170 m). These new findings support the predictions of this paper and provide valuable information about the geographical distribution of this species.

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LITERATURE CITED

Andrade-Lima, D. 1966. *Vegetação*. *In*: Instituto Brasileiro de Geografia e Estatística, *Atlas Nacional do Brasil.* Rio de Janeiro, Conselho Nacional de Geografia.

Benson, D. A., Karsch-Mizrachi, I., Lipman, D. J., Ostell, J., Wheeler, D. L. 2005. GenBank. *Nucleic Acids Research* 33 (Suppl. 1): 34-38.

Brown, K. S. Jr, Freitas, A. V. L. 2000. Diversidade de Lepidoptera em Santa Teresa, Espírito Santo. *Boletim do Museu de Biologia Mello Leitão* (Nova Série) 11/12: 71-116.

Brown, K. S. Jr, Freitas, A. V. L. [2001]. Atlantic Forest butterflies: indicators for landscape conservation. *Biotropica* 32(4b): 934-956.

Carneiro, E., Mielke, O. H. H., Casagrande, M. M. 2008. Inventários de borboletas no Brasil: estado da arte e modelo de áreas prioritárias para pesquisa com vistas à conservação. *Natureza e Conservação* 6(2): 68-90 [also published in English in the same issue, pp. 176-198].

Caterino, M. S., Sperling, F. A. H. 1999. *Papilio* phylogeny based on mitochondrial cytochrome oxidase I and II genes. *Molecular Phylogenetics and Evolution* 11(1): 122-137.

Chazot, N., Willmott, K. R., Condamine, F. L., Silva, D. L. de, Freitas, A. V. L., Lamas, G., Morlon, H., Giraldo, C. E., Jiggins, C. D., Joron, M., Mallet, J., Uribe, S., Elias, M. 2016. Into the Andes: Multiple independent colonizations drive montane diversity in the Neotropical clearwing butterflies Godyridina. *Molecular Ecology* 25(22): 5765-5784.

Folmer, O., Black, M., Hoeh, W., Lutz, R., Vrijenhoek, R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology* 3(5): 294-299.

Freitas, A. V. L. 2020. A new clearwing butterfly from northeastern Brazil (Nymphalidae: Danainae: Ithomiini). *Tropical Lepidoptera Research* 30(1): 28-32.

Freitas, A. V. L., Rosa, A. H. B., Brown, K. S. Jr, Nobre, C. E. B., Melo, D. H. A., Kerpel, S. M. 2021. A new and rare Ithomiini from northeastern Brazil (Lepidoptera: Nymphalidae: Danainae). *Journal of the Lepidopterists' Society* 75(1): 44-48.

Freitas, A. V. L., dos Santos, J. P., Rosa, A. H. B., Melo, D. H. A., Nobre, C. E. B., dos Santos, L. N., Cardoso, M. Z. 2023. *The butterfly fauna of the Northern Atlantic Forest*, pp. 33-46. *In:* Pereira-Filho, G. A., França, F. G. R., Alves, R. R. N., Vasconcellos, A. (Eds.), *Animal Biodiversity and Conservation in Brazil's Northern Atlantic Forest.* Cham, Springer. XIV + 276 pp.

Hoang, D. T., Vinh, L. S., Chernomor, O., Minh, B. Q., von Haeseler, A. 2017. UFBoot2: Improving the Ultrafast Bootstrap Approximation. *Molecular Biology and Evolution* 35(2): 518-522.

Kalyaanamoorthy, S., Minh, B. Q., Wong, T. K. F., von Haeseler, A., Jermiin, L. S. 2017. ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* 14(6): 587-589.

Kearse, M., Moir, R., Wilson, A., Stones-Havas, S., Cheung, M., Sturrock, S., Buxton, S., Cooper, A., Markowitz, S., Duran, C., Thierer, T., Ashton, B., Meintjes, P., Drummond, A. 2012. Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. *Bioinformatics* 28(12): 1647-1649.

Mielke, O. H. H., Brown, K. S. Jr. 1979. *Suplemento ao Catálogo dos Ithomiidae Americanos de R. Ferreira d'Almeida (Lepidoptera) (Nymphalidae: Ithomiinae).* Curitiba, Centro de Recursos Audiovisuais da UFPr. vii + 216 pp.

Morellato, L. P. C., Haddad, C. F. B. [2001]. Introduction: the Brazilian Atlantic Forest. *Biotropica* 32(4b): 786-792.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B., Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853-858.

Oliveira-Filho, A. T., Fontes, M. A. L. [2001]. Patterns of floristic differentiation among Atlantic Forests in southeastern Brazil and the influence of climate. *Biotropica* 32(4b): 793-810.

Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J., Hirota, M. M. 2009. The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142(6): 1141- 1153.

Shirai, L. T., Machado, P. A., Mota, L. L. Rosa, A. H. B., Freitas, A. V. L. 2019. DnB, the Database of nymphalids in Brazil, with a checklist for standardized species lists. *Journal of the Lepidopterists' Society* 73(2): 93-108.

Table 1. Godyridina specimens studied, with voucher code, sampling locality, and GenBank accession numbers for the four genes sequenced.

Genus	Species	subspecies	Voucher	COI	COII	EFIa	Tektin	Locality
Brevioleria	*aelia*	*orolina*	02-2020	HM051677	HM051678			Peru: San Martín, Km 103.1 Tarapoto-Yurimaguas
Brevioleria	*aelia*	*pachiteae*	05-418	KX362076		KX361995	KX362191	Peru: Loreto, Cerro de Mira Culo, PNCAZ
Brevioleria	*aelia*	*pachiteae*	05-561	EU069024	EU069024	EU069117	HM052045	Peru: San Martín, Quebrada Huacanqui
Brevioleria	*aelia*	*pachiteae*	4-216	HM051684	HM051684		HM052040	Peru: Ucayali, IVITA,
Brevioleria	*arzalia*	*loronia*	264	KX362077		KX361948	KX362137	Ecuador: Azuay, Comunidad Shuar Mirador, 70 km E of Macas (Macas to Puyo road)
Brevioleria	*arzalia*	*arzalia*	02_3431	KX362083		KX362001	KX362228	Peru: Cuzco, de Pilcopata a Santa Rosa de Huacaría
Brevioleria	*arzalia*	ssp.	05-874	KX362039		KX361963	KX362138	Peru: San Martín, Caño Negro, Río Biabo, PNCAZ
Brevioleria	*arzalia*	*arzalia*	2-1200	HM051790	HM051790		HM052135	Peru: San Martín, Km 22 Tarapoto - Yurimaguas
Brevioleria	*arzalia*	ssp.	2-2108	HM051788	HM051788		HM052132	Peru: San Martín , Km 7.2 Pongo-Barranquita
Brevioleria	*arzalia*	ssp.	5-861	HM051789	HM051789		HM052133	Peru: San Martín, Laguna del Mundo Perdido
Brevioleria	*arzalia*	*arzalia*	BLU-0914	PP729880				Brazil: Acre, Marechal Thaumaturgo, Reserva Extrativista do Alto Juruá, Lago Ceará
Brevioleria	*arzalia*	*loronia*	E-44-4	DQ157477	DQ157477	DQ177924		Ecuador: Sucumbíos, El Recodo
Brevioleria	*arzalia*	*loronia*	ME-2007 LS02-14	EU068977	EU068977	EU069119		Ecuador: Sucumbíos, Garza Cocha
Brevioleria	*coenina*		ME10-359	JX573755		JX573684		Ecuador: Napo, Cocodrilo
Brevioleria	***maculele***		**BLU-0772**	**PP729871**				**Brazil: Bahia, Camacan, RPPN Serra Bonita**
Brevioleria	***maculele***		**BLU-0776**	**PP729874**				**Brazil: Bahia, Camacan, RPPN Serra Bonita**
Brevioleria	***maculele***		**BLU-0777**	**PP729875**				**Brazil: Bahia, Camacan, RPPN Serra Bonita**
Brevioleria	nsp1		G128	KX362023				Peru: Cuzco, Quebrada Quitacalzón
Brevioleria	*plisthenes*		BAKU-45	EU068771	KX362028	KX361945	KX362132	Brazil: São Paulo, Monte Alegre do Sul
Brevioleria	*plisthenes*		BLU-0768	PP729867				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Brevioleria	*plisthenes*		BLU-0769	PP729868				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Brevioleria	*plisthenes*		BLU-0770	PP729869				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Brevioleria	*plisthenes*		BLU-0771	PP729870				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Brevioleria	*plisthenes*		BLU-0915	PP729881				Brazil: Minas Gerais, Bueno Brandão, Cachoeira Ponte Alta
Brevioleria	*seba*	*oculata*	20458	EU069025	EU069025	EU069120	KX362142	Ecuador: Orellana, Río Añángu
Brevioleria	*seba*	ssp. n1	02_3237	KX362057		KX361996	KX362194	Peru: Cuzco, Palma Real (otro lado del río)
Brevioleria	*seba*		02_3477	KX362065		KX362005	KX362193	Peru: Cuzco, Pilcopata
Brevioleria	*seba*	*emyra*	BLU-0675	PP729864				Brazil: Mato Grosso do Sul, Bonito, Taiguaral
Brevioleria	*seba*	*oculata*	ME10-212	KX362087	KX362087		KX362202	Ecuador: Napo, Mariposa
Godyris	*panthyale*	*panthyale*	21186	JX573765	JX573765	JX573694	KX362248	Ecuador: Zamora-Chinchipe, San Francisco
Greta	*andromica*		02-1694	KX362098	KX362098	KX361969	KX362144	Peru: San Martín, Río Nieva
Heterosais	*edessa*		BAKU-43	KX362031	KX362031	KX361946	KX362133	Brazil: São Paulo, Monte Alegre do Sul
Heterosais	*giulia*	*giulia*	LEP-11343	KX362129			KX362211	Colombia: Antioquia
Heterosais	*nephele*	*nephele*	20667	EU069043	EU069043	EU069148	KX362212	Ecuador: Orellana, Río Añangu
Hypoleria	*adasa*		BAKU-27	KX362075			KX362217	Brazil: São Paulo, Boracéia
Hypoleria	*adasa*		BLU-0832	PP729878				Brazil: São Paulo, São Francisco Xavier
Hypoleria	*alema*	*proxima*	B-16-8	DQ157504	DQ157504	DQ177949		Brazil: São Paulo, Jundiaí, Serra do Japi
Hypoleria	*alema*	*proxima*	BAKU-44	KX362047		KX361953	KX362134	Brazil: São Paulo, Monte Alegre do Sul
Hypoleria	*alema*	ssp.	BAKU-53	KX362060			KX362213	Brazil: Alagoas, Ibateguara, Mata de Coimbra Usina Serra Grande
Hypoleria	*alema*	*proxima*	BLU-0575	PP729862				Brazil: São Paulo, Jundiaí, Serra do Japi
Hypoleria	*alema*	*proxima*	BLU-0576	PP729863				Brazil: São Paulo, Jundiaí, Serra do Japi
Hypoleria	*alema*	*consimilis*	BLU-0766	PP729865				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Hypoleria	*alema*	*oreas*	BLU-0774	PP729872				Brazil: Bahia, Camacan, RPPN Serra Bonita
Hypoleria	*alema*	*oreas*	BLU-0775	PP729873				Brazil: Bahia, Camacan, RPPN Serra Bonita
Hypoleria	*alema*	*proxima*	BLU-0830	PP729876				Brazil: Minas Gerais, Ibirité, PE Serra do Rola Moça
Hypoleria	*alema*	*proxima*	BLU-0831	PP729877				Brazil: São Paulo, São Francisco Xavier
Hypoleria	*alema*	*cajona*	BLU-0911	PP729879				Brazil: Acre, Marechal Thaumaturgo, Reserva Extrativista do Alto Juruá, Pedra Pintada

Table 1, continued. Godyridina specimens studied, with voucher code, sampling locality, and GenBank accession numbers for the four genes sequenced.

Genus	Species	subspecies	Voucher	COI	COII	EFIa	Tektin	Locality
Hypoleria	*alema*	*cajona*	BLU-0918	PP729882				Brazil: Acre, Marechal Thaumaturgo, Reserva Extrativista do Alto Juruá, Foz do Tejo
Hypoleria	*alema*	*cajona*	BLU-0924	PP729884				Brazil: Acre, Marechal Thaumaturgo, Reserva Extrativista do Alto Juruá, Foz do Tejo
Hypoleria	*alema*	*chrysodonia*	LS02-98	EU068985		EU069152		Ecuador: Sucumbíos, Garza Cocha
Hypoleria	*alema*	*alema*	ME10-517	JX573785			KX362200	Ecuador: Napo, Hollín
Hypoleria	*aureliana*		MJ07-265	KF268431		KX361956	KX362189	Peru: San Martín, Shapaja-Chazuta km 5
Hypoleria	*lavinia*		05-SRNP-70116	ON436819				Costa Rica: Área de Conservación Guanacaste
Hypoleria	*lavinia*	*cassotis*	KW13-30	KX362049			KX362243	Panama: Panamá
Hypoleria	*lavinia*	*lavinia*	LEP-00092	KX362120				Ecuador: Manabí, S Santa Lucía, km 20 Jipijapa-Guayaquil rd., Cerro Prieto
Hypoleria	*lavinia*	*vanilia*	LEP-11339	KX362069			KX362214	Colombia: Antioquia
Hypoleria	*lavinia*	*libera*	YB-BCI63973	KP849011				Panama: Panamá, Barro Colorado Is, Armour1
Hypoleria	*ocalea*		BMC-1631	KX362070			KX362218	Colombia: Antioquia, Gómez Plata, Porce
Hypoleria	*ocalea*	*gephira*	LEP-11332	KX362124			KX362242	Colombia: Antioquia
Hypoleria	*sarepta*	*famina*	21693	KX362021		EU069245	KX362190	Ecuador: Sucumbíos, Pañacocha
Hypoleria	*sarepta*	*goiana*	BLU-0767	PP729866				Brazil: Distrito Federal, Brasília, APA Gama Cabeça de Veado
Hypoleria	*sarepta*	*famina*	BLU-0919	PP729883				Brazil: Acre, Marechal Thaumaturgo, Reserva Extrativista do Alto Juruá, Foz do Tejo
Hypoleria	*sarepta*	ssp.	BLU-0926	PP729885				Brazil: Mato Grosso, Colniza, Parque Nacional Igarapés do Juruema
Hypoleria	*xenophis*		05-624	KX362050		KX361952	KX362215	Peru: San Martín, Robashca, Puesto de Control 11, PNCAZ
Hypoleria	*xenophis*		G127	KX362061			KX362216	Peru: San Martín, Yacusisa
Hypomenitis	*alphesiboea*		259	KX362125	KX362125	KX361973	KX362223	
Mcclungia	*cymo*	*subtilis*	06-205	KX362063				Peru: San Martín, Achinamiza, Bajo Río Huallaga
Mcclungia	*cymo*	*salonina*	B-19-3	DQ157512	DQ157512	DQ177958		Brazil: São Paulo, Campinas
Mcclungia	*cymo*	*salonina*	BAKU-42	KX362035	KX362035	KX361947	KX362135	Brazil: São Paulo, Monte Alegre do Sul
Mcclungia	*cymo*	*subtilis*	ME11-159	JX573792		JX573720	KX362136	Ecuador: Zamora-Chinchipe, Quebrada Chorillos
Mechanitis	*polymnia*	*casabranca*	BLU-0001	PP729861				Brazil: São Paulo, Campinas
Pachacutia	*baroni*		LEP-11127	KX362089				Ecuador: Morona-Santiago, km 19 Macas-Nueve de Octubre rd. Río Abanico
Pachacutia	*mantura*	*joroni*	MC11-63	KX362127			KX362197	Peru: San Martín, Sauce, Limoncocha
Pseudoscada	*acilla*	ssp.	03-111	KX362094		KX362003	KX362177	Brazil: Bahia, Camacan, RPPN Serra Bonita
Veladyris	*cytharista*		05-1038	KX362081		KX361991	KX362224	Peru: San Martín, Venceremos + 4 km (Segundo Baden)
Velamysta	*phengites*		E-39-32	DQ157548	DQ157548	DQ177994	KX362222	Ecuador: Sucumbíos, La Bonita

Two new records of clearwing butterfly *Epityches eupompe* (Geyer, 1832) aggregations in Brazilian Atlantic Forest (Nymphalidae, Ithomiini)

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Abstract: A massive aggregation of the clearwing butterfly *Epityches eupompe* (Nymphalidae, Ithomiini) was reported in 2017 at Intervales State Park, São Paulo State, Brazil, with another record at Corupá, Santa Catarina State. In 2023, similar aggregations of this species were observed in two new locations in Brazil: Quilombinho River, Santos, São Paulo State; and Serra da Baitaca State Park, Anhangava, Paraná State. All four observations happened during winter, in Ombrophilous Dense Forest localities of the Serra do Mar mountain range, near streams. The lethargic behavior of the adults and the lack of larval hostplants, signs of herbivory, or other mass emergence evidence, suggest that these aggregations do not reflect areas of growth and reproduction but instead provide climatic protection for adult butterflies. To increase public awareness, we will launch a citizen science campaign to gather knowledge about whether members of the public have seen this phenomenon elsewhere and promote these aggregations as spectacular biological phenomena with ecotourism potential, similar to Monarch butterfly aggregations. We highlight how sustainable tourism can bring people and nature closer together, aiming to benefit both parties.

Key words: ecotourism; ithomiine pocket; microclimatic refugee; Monarch butterfly; Nymphalidae; roosting.

Resumo: Uma agregação em massa da borboleta asa-de-vidro *Epityches eupompe* (Nymphalidae, Ithomiini) foi reportada em 2017 no Parque Estadual Intervales, São Paulo, com outro registro em Corupá, Santa Catarina. Em 2023, agregações semelhantes desta espécie foram observadas em duas novas localidades: Rio Quilombinho, Santos, São Paulo; e Parque Estadual da Serra da Baitaca, Anhangava, Paraná. Todas as quatro observações ocorreram durante o inverno, em localidades de floresta ombrófila densa da Serra do Mar, próximas a riachos. O comportamento letárgico e a falta de plantas hospedeiras, sinais de herbivoria ou outras evidências de emergência em massa sugerem que a agregação não reflete áreas de crescimento e reprodução, mas talvez forneça proteção climática aos adultos. Para aumentar a sensibilização do público, lançaremos uma campanha de ciência cidadã para levantar informações, perguntando se o público viu esse fenômeno em outros locais, promovendo-o como o equivalente ecoturístico à agregação da borboleta monarca. Destacamos como o turismo sustentável pode aproximar pessoas e natureza, para o benefício de ambos.

Palavras chave: bolsão de ithomíneos; borboleta monarca; dormitório; ecoturismo; Nymphalidae; refúgio microclimático.

Adult butterfly aggregations happen in different flavors. For example, multiple species can aggregate for resource exploitation (*e.g.* mud-puddling behavior; Beck *et al*., 1999; Boggs & Dau, 2004), reproduction (*e.g.* hilltopping; Baughman & Murphy, 1988), anti-predator defense (*e.g.* communal roosting; Benson & Emmel, 1973; Brown, 1981; DeVries *et al.*, 1987; Sourakov, 2007; Finkbeiner *et al*., 2012), and dry-season protection (*e.g.* ithomiine pockets; Kitching & Zalucki, 1981; Ivie, 1990; Pinheiro *et al*., 2008; Shirai *et al*., 2017). These aggregations can have various levels of fidelity to the location or to the group of individuals/species, and different sizes, from dozens to hundreds of individuals. More remarkably, single-species aggregations occur sometimes in massive numbers, from thousands to millions of individuals. Among single-species butterfly aggregations with a migratory character, perhaps the most iconic are: 1) the Monarch (*Danaus plexippus* (Linnaeus, 1758)) butterfly aggregation, that confers climatic protection associated with migration (Brower & Calvert, 1985); and 2) the longest known butterfly migration (> 4,000 km in a single generation) by the Painted Lady (*Vanessa cardui* (Linnaeus, 1758)), from Africa to Europe, crossing the Sahara Desert (Talavera & Vila, 2017).

We previously reported massive aggregations of tens of thousands of *Epityches eupompe* (Geyer, 1832) in Brazil, at Intervales State Park, São Paulo State, and near Corupá, Santa Catarina State (Shirai *et al*., 2017). Here, we report two new

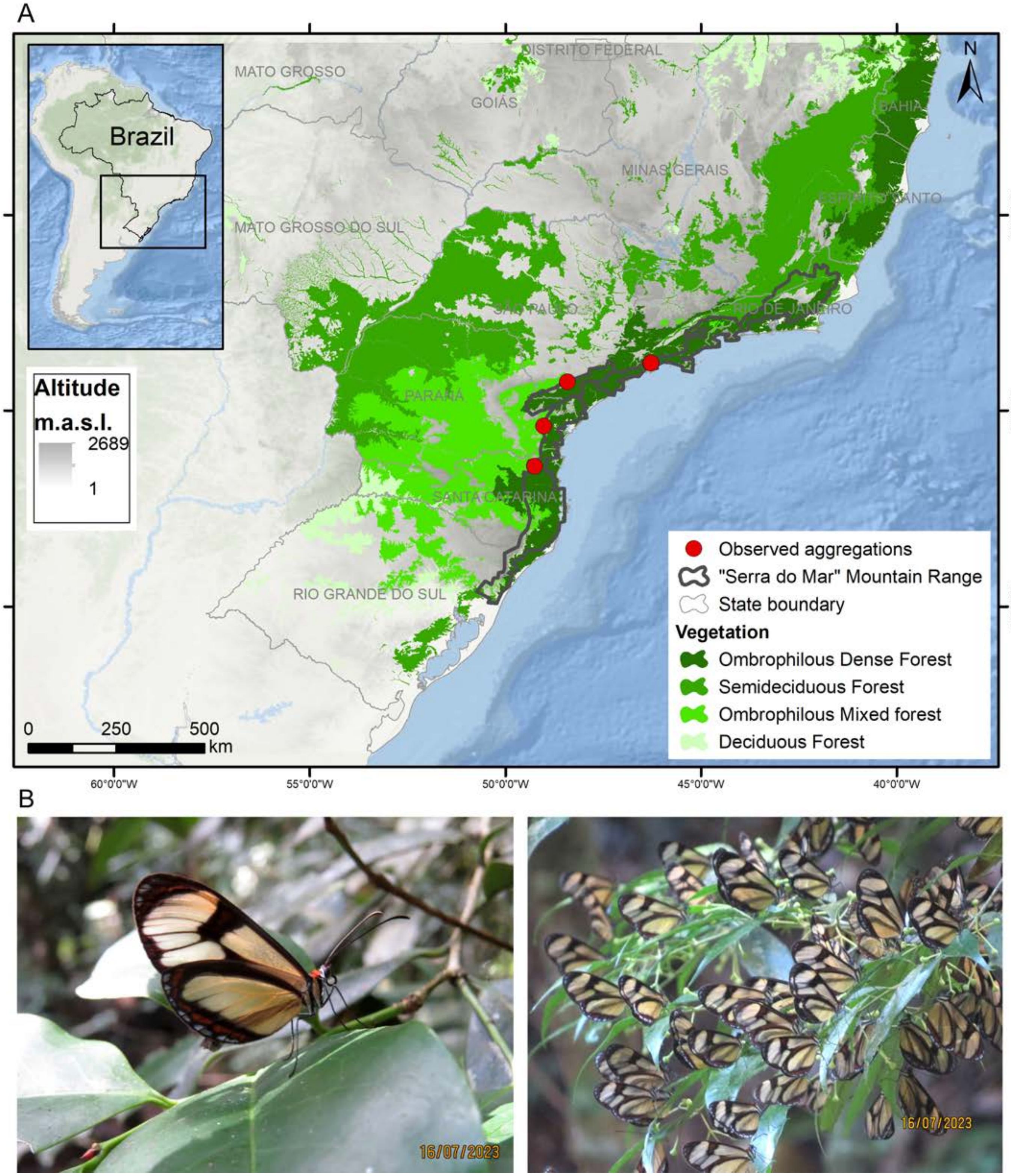

Figure 1. (A) All known *Epityches eupompe* aggregations occur in Ombrophilous Dense Forest at the Serra do Mar mountain range, from upper right to lower left: Quilombinho River, São Paulo; Intervales State Park, São Paulo; Serra da Baitaca State Park, Paraná; and Corupá, Santa Catarina. (B) Butterflies found at Anhangava - images by IS.

localities of *E. eupompe* aggregations, similar in numbers of individuals, both observed in July 2023, at Quilombinho River, Santos, São Paulo State; and Serra da Baitaca State Park, Anhangava, Paraná State (Fig. 1). All four observations happened during winter, near streams, in Ombrophilous Dense Forest (IBGE, 2012) of the largest continuum of Atlantic Forest, at the Serra do Mar mountain range.

The Quilombinho River aggregation was in an isolated trail at around 500 m above sea level, about halfway between the lowlands and the plateau of the Serra do Mar. Trekkers found this aggregation and communicated through the social media account of the AVLF lab (https://instagram.com/labbor_unicamp). According to Köppen's climate classification, the area has a Cfa climate, Humid Subtropical, influenced by the ocean, without a dry season and with a hot and humid summer, and cool to mild winters (Peel *et al*., 2007; Alvares *et al*., 2013). Mean temperatures of the coldest month are 15.3 ºC and of the hottest month are 22.0 ºC, with annual precipitation of 2,863 mm (Hijmans *et al*., 2005; Worldclim, 2020). This slope area is sheltered between two mountain ranges around 1,000 m high, and has Sub-montane Ombrophilous Dense Forest (IBGE, 2012) with many creeks, close to the Quilombo River.

The Anhangava aggregation was found while IS was trekking at the Serra da Baitaca State Park (Fig. 1B). This park has 3,053.21 hectares, with minimum temperature of -5 °C, an annual average of 13.4 ºC and absolute maximum of 30°C (Roderjan & Grodski, 1999), and includes three vegetation types: Cloud Forest, Alto-montane Ombrophilous Dense Forest, and High-altitude Grassland. Similar to the observations at Intervales, butterflies showed a lethargic behavior, hanging in large clusters and resting at several heights from understory to canopy. If disturbed, immense numbers of butterflies took off and flew, rapidly resuming their resting position once the disturbance passed. Also similar to Intervales, the Anhangava aggregation had no evidence of larval hostplants, herbivory or signs of mass larval emergence.

The coastal region of the Brazilian Southeast is very humid, so moist and sheltered areas are apparently needed for these Atlantic Forest butterflies, and probably more so when winters are windy and drier than usual, acting as a microclimatic refugee. As previously stated, these aggregations of tens of thousands of lethargic *E. eupompe* adults are different from typical ithomiine pockets, since *E. eupompe* aggregations are not composed of multiple species, the individuals are more numerous, and there is little activity involved, such as feeding and reproduction (Shirai *et al*. 2017), despite microclimatic protection being important in both. As far as we know, single-species aggregations in Ithomiini only occur in *E. eupompe* (Shirai *et al*., 2017) and *Episcada hymenaea* (Prittwitz, 1865) (Strickman, 1981; Quinteros & Núñez Bustos, 2018), based on the following literature review. We checked every Google Scholar result using the search term "aggregation" added to every ithomiine genus name listed in the "Butterflies of America" (Warren *et al*., 2023), also searching for the subjective synonyms *Placidina* d'Almeida, 1928 and *Aremfoxia* Real, 1971. We performed individual searches for each genus and, in some cases, we added the term "butterfly" for a more specific filter (*e.g*., for *Aeria* Hübner, 1816, *Athesis* E. Doubleday, 1847, and *Olyras* E. Doubleday, 1847). We found evidence for aggregations only in these two species and, while we cannot confirm that they represent the exact same phenomenon, these single-species aggregations are presumably independently derived in these members of two different subtribes.

To address the lack of information about these kinds of butterfly aggregations, we will launch a citizen science campaign via our social media profiles (Instagram: @labbor_unicamp, @leshirai, @israelschneiberg, @renato.rogner, @andre.roc, @juniayoc, @insecnideos), as well as at the two State Parks involved, based on flyers and videos (publicly available at https://www.youtube.com/watch?v=ZYLeJ2ttY4E, https://www.youtube.com/shorts/ypTzkT2YBQE, https://www.youtube.com/shorts/Y9p--n7cBl8). We had previously suggested that the participation of both scientists an d amateurs could help find other localities for *E. eupompe* aggregations (Shirai *et al*., 2017). This idea has led to the present paper, with non-scientists (see Acknowledgments) and a non-butterfly scientist (IS) communicating their observations, obtained while trekking in the forest. By uniting our interests, we agreed to engage with a wider public, aiming to increase public awareness about biological phenomena like this.

Epityches eupompe aggregations have the potential to become a significant ecotourism attraction in the Atlantic Forest, similar to the Mexican Monarch aggregations. The phenomenon is biologically somewhat different, since we do not yet have any evidence that *E. eupompe* aggregations involve migration and overwintering (Shirai *et al*., 2017), and *E. eupompe* aggregations occur over a much broader area than those of the Monarch. We think it is likely that other *E. eupompe* aggregations exist throughout the species range, from Bahia to Rio Grande do Sul States (d'Almeida, 1938; Brown, 1979), so the citizen science campaign focuses on inspiring the public to report aggregations, along with bringing attention to this fascinating phenomenon. In our experience, observers (including non-scientists) who have witnessed this spectacle have reported it to be one of the most beautiful and magical things that they had ever seen. An impact of such magnitude has strong potential to bring humans closer to nature, which is essential to increase biophilia (Wilson, 1984) and bioliteracy (Janzen, 2010), and decrease biophobia (Vanderstock *et al*., 2022) and environmental apathy (Shirai *et al*., 2022).

While we believe that *Epityches* aggregations could become an ecotourism attraction, clearly it is important to minimize negative impacts on the butterflies. We still argue that this phenomenon might be vulnerable to human disturbance, although it is reassuring to see there are more than we previously knew about. The Intervales aggregation is the only one we know that is recurring: it was first observed in 2013, reassessed in 2017 (Shirai *et al*., 2017), and has been followed yearly ever since (Thiago B. Conforti, pers. comm.). We cannot be sure for how long *E. eupompe* will remain in each of the four places we reported, but we strongly encourage that any action towards these aggregations should be careful, respectful, and sustainable.

Intervales and Anhangava are both protected areas, but hiking is the main attraction of Serra da Baitaca State Park, with trails within a forest that lead to the summit climb (elevation 1,420 m). One of the access trails crosses a small seasonal water body, which is the location where IS found the aggregation. Hundreds of people pass through this trail and may have their attention drawn when butterflies are flying. In such an exposed location, it could be important to restrict access to this portion of the trail, but highlight that the phenomenon occurs there, promoting the observation through binoculars or even through cameras. We will attempt to engage with local land-use managers to discuss appropriate plans for the public to access, view, and experience these aggregations without causing unnecessary disturbance at Anhangava. At Intervales, where the trail is more protected, the observation could be done closer to the butterflies but still without unnecessary disturbances, such as provoking their flight. When birds vocalize or branches fall in the forest, the butterflies fly by the hundreds or by the thousands, so we suggest instead to quietly observe it, for as long as it takes. We also encourage spreading images and videos, along with information aiming to share and impress others by the sheer natural beauty of this phenomenon.

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LITERATURE CITED

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M., Sparovek, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711-728.

Baughman, J. F., Murphy, D. D. 1988. What constitutes a hill to a hilltopping butterfly? *American Midland Naturalist* 120(2): 441-443.

Beck, J., Mühlenberg, E., Fiedler, K. 1999. Mud-puddling behavior in tropical butterflies: in search of proteins or minerals? *Oecologia* 119: 140-148.

Benson, W. W., Emmel, T. C. 1973. Demography of gregariously roosting populations of the nymphaline butterfly *Marpesia berania* in Costa Rica. *Ecology* 54: 326-335.

Boggs, C. L., Dau, B. 2004. Resource specialization in puddling Lepidoptera. *Environmental Entomology* 33(4): 1020-1024.

Brower, L. P., Calvert, W. H. 1985. Foraging dynamics of bird predators on overwintering monarch butterflies in Mexico. *Evolution* 39(4): 852-868.

Brown, K. S. 1981. The biology of *Heliconius* and related genera. *Annual Review of Entomology* 26: 427-457.

Brown, K. S. 1979. *Ecologia geográfica e evolução nas florestas neotropicais*. Livre docência thesis. Campinas, Universidade Estadual de Campinas. xxxi + 265 pp.; Appendices: 120 pp.

d'Almeida, R. F. 1938. Estudo sobre tres generos da sub-familia Ithomiinae (Lepid.: Rhop.). *Memórias do Instituto Oswaldo Cruz* 33: 381-399.

deVries, P. J., Schull, J., Greig, N. 1987. Synchronous nocturnal activity and gregarious roosting in the neotropical skipper butterfly *Celaenorrhinus fritzgaertneri* (Lepidoptera: Hesperiidae). *Zoological Journal of the Linnean Society* 89: 89-103.

Finkbeiner, S. D., Briscoe, A. D., Reed, R. D. 2012. The benefit of being a social butterfly: communal roosting deters predation. *Proceedings of the Royal Society B: Biological Sciences* 279(1739): 2769-2776.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., Jarvis, A. 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.

Instituto Brasileiro de Geográfica e Estatística (IBGE). 2012. *Manual Técnico da Vegetação Brasileira*. IBGE, Rio de Janeiro. 275 pp.

Ivie, M. A, Philips, T. K., Johnson, K. A. 1990. High altitude aggregations of *Anetia briarea* Godart on Hispaniola (Nymphalidae: Danainae). *Journal of the Lepidopterists' Society* 44: 209-214.

Kitching, R. L., Zalucki, M. P. 1981. Observations on the ecology of *Euploea core corinna* (Nymphalidae), with special reference to an overwintering population. *Journal of the Lepidopterists Society* 35: 106-119.

Janzen, D. H. 2010. Hope for tropical biodiversity through true bioliteracy. *Biotropica* 42: 540-542.

Peel, M. C., Finlayson, B. L., Mcmahon, T. A. 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth Systems Sciences* 11: 1633-1644.

Pinheiro, C. E. G., Medri, I. M., Salcedo, A. K. M. 2008. Why do ithomiines (Lepidoptera, Nymphalidae) aggregate? Notes on a butterfly pocket in central Brazil. *Revista Brasileira de Entomologia* 52(4): 610-614.

Quinteros, R., Núñez Bustos, E. O. 2018. Una enorme congregación de *Episcada hymenaea* (Lepidoptera: Nymphalidae: Danainae) en las yungas del norte de Salta, Argentina. *Acta Zoológica Lilloana* 62(2): 44-50.

Roderjan, C. V., Grodski, L. 1999. Acompanhamento meteorológico em um ambiente de Floresta Ombrófila Densa Altomontana no morro Anhangava, município de Quatro Barras - PR, no ano de 1993. *Cadernos da Biodiversidade* 2(1): 27-34.

Shirai, L. T., Mota, L. L., Freitas, A. V. L. 2017. Aggregation of *Epityches eupompe* (Nymphalidae: Ithomiini) in southern Brazil. *Tropical Lepidoptera Research* 27(2): 111-114.

Shirai, L. T., Stanton, M. A., D'Angelo, G. B., Conforti, T. B., Freitas, A. V. L., Kato, M. J., Yamaguchi, L. F. 2022. Interaction gardens and butterfly catalogues: a joint strategy to promote capacity development in protected areas and reduce the extinction of experience in cities. *Cities and the Environment* 15(1): 3.

Sourakov, A. 2007. Dominican Republic - notes on evolution of butterflies and of our knowledge about them. *News of Lepidopterists' Society* 49: 46-55.

Strickman, D. 1981. Observation of an aggregation of *Episcada hymenaea* Prittev. (Ithomiidae) in Paraguay. *Journal of the Lepidopterists' Society* 35(2): 158.

Talavera, G., Vila, R. 2017. Discovery of mass migration and breeding of the painted lady butterfly *Vanessa cardui* in the Sub-Sahara: the Europe-Africa migration revisited. *Biological Journal of the Linnean Society* 120(2): 274-285.

Vanderstock, A., Grandi-Nagashiro, C., Kudo, G., Latty, T., Nakamura, S., White, T. E., Soga, M. 2022. For the love of insects: gardening grows positive emotions (biophilia) towards invertebrates. *Journal of Insect Conservation* 26:751-762.

Warren, A. D., Davis, K. J., Stangeland, E. M., Pelham, J. P., Willmott, K. R., Grishin, N. V. 2023. *Illustrated Lists of American Butterflies*. [23-VI-2023] http://www.butterfliesofamerica.com.

Wilson, E. O. 1984. *Biophilia: The human bond with other species*. Harvard University Press, Cambridge. 157p.

WorldClim. 2020. *WorldClim - Global Climate Data. Free climate data for ecological modeling and GIS*. www.worldclim.org.

Interactive maps for visualizing geographic distributions and phenotypes

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Abstract: Museum databasing initiatives have resulted in the release of large amounts of geographic locality data for a wide range of plants and animals. Species lists with images of type specimens are also increasingly available online. For specialists working with a particular group, it would be helpful to connect these phenotypic and geographic data within a single interactive interface that can be easily updated following taxonomic changes or the discovery of new taxa. Here, we present interactive web-maps for *Heliconius* butterflies and allies, together with a portal for downloading the underlying specimen and locality data. The maps and portal can be viewed here: https://heliconius-maps.github.io. The code and software underlying these maps are all open source, and the website is hosted for free by the GitHub servers. It should be straightforward for researchers to adapt our methods to their own taxa of interest.

Keywords: biodiversity informatics; butterflies; *Heliconius*; web-maps

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INTRODUCTION

Since the turn of the century, a number of technological advances have revolutionised biodiversity informatics (Graham *et al.*, 2004). Large databasing initiatives have seen museums digitise metadata from vast numbers of specimens, and many of these datasets are freely available online. At the same time, the use of geographical information systems has become widespread, so that users can download species data and perform spatial analyses that address a broad range of questions in ecology, evolution and conservation. Many websites dedicated to taxonomy and identification have also been developed. For example, https://butterfliesofamerica.com currently comprises 160,500 images of over 8,300 species, including many type specimens. For researchers working on taxonomy and systematics, it would be helpful to visualise these phenotypic and distribution data simultaneously. However, we are not aware of any free and accessible platforms for creating such a resource.

Heliconius butterflies and allies (Nymphalidae: Heliconiini) comprise ~70-80 species (Lamas & Jiggins, 2017). In the past 30 years, research on *Heliconius* has increased enormously and they are the subjects of dozens of papers each year, the majority of which focus on evolutionary biology (Figure 1A). A striking feature of many species is their phenotypic variability. Many species exhibit locally adapted color patterns that mimic other co-occurring species (Merrill *et al.*, 2015). This variation is extreme - some species have as many as 30 geographic subspecies, and 450+ subspecies are currently recognised within the Heliconiini (Lamas & Jiggins, 2017).

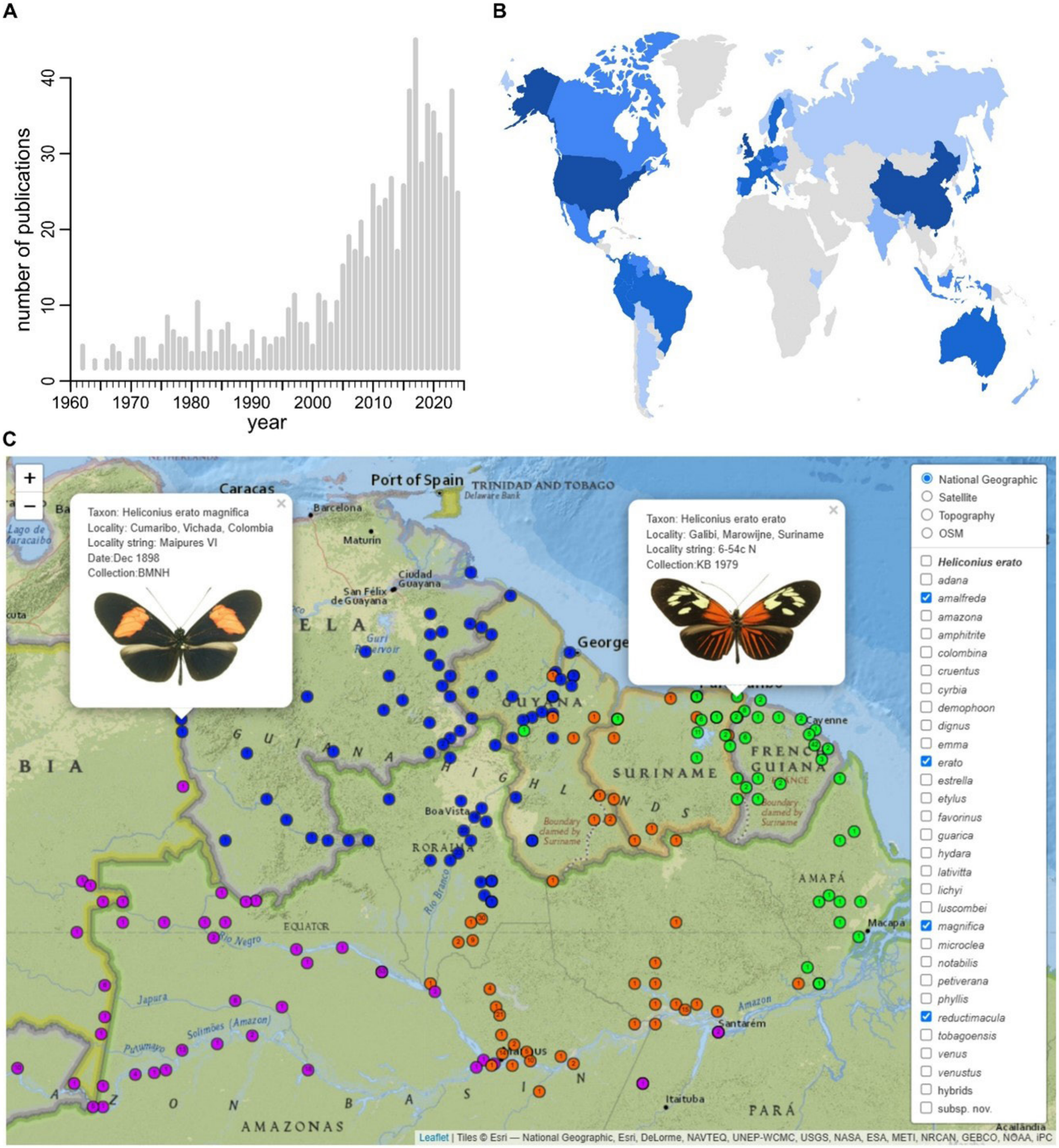
While some excellent taxonomic resources exist for *Heliconius,* they are nonetheless difficult to identify to species due to their mimicry. New molecular data also frequently lead to revisions and the description of new taxa (Rosser *et al*., 2019; Thawornwattana *et al*., 2023). Consequently, online databases of taxonomic and geographic distribution information such as GBIF are often riddled with errors, either due to incorrect museum specimen label data, errors during digitization, or because they have not been updated following nomenclatural or taxonomic changes. A recent paper on *Heliconius* biogeography explicitly avoided using GBIF data, “to ensure the use of data that have been curated by specialists both in terms of georeference and taxonomy” (Rueda-M *et al*., 2021). To address these issues, we developed open-source, interactive web-maps that couple community-validated taxonomy and distribution data with representative images of species and subspecies of *Heliconius* and related genera, together with a portal for downloading the underlying data. These maps are accessed daily by users around the world (Figure 1B). Here we outline the underlying code and website architecture, should others wish to adopt our approach for different taxa.

WEB-MAPS FOR *HELICONIUS*

Maps using museum data

The web-maps comprise point localities corresponding to individual specimens. When a point locality is clicked, a pop-up bubble appears which displays key specimen information, together with an image of a representative phenotype, frequently the type specimen (Figure 1C). The data to be mapped are stored in tabular format in a comma-delimited text file. Fields include, but are not limited to, a unique identifier, genus, species and subspecies identity, collecting locality and decimal coordinates, and the collection source (for example, the Natural History Museum, London). The phenotype is displayed via a field containing a hyperlink to images hosted on either https://butterfliesofamerica.com or Michel Cast's website (https://cliniquevetodax.com/Heliconius). Our museum database was compiled originally by Rosser *et al.* (2012) and we have subsequently incorporated a number of new datasets, for example, from Rosser *et al.* (2021) and the collections at the Museum of Comparative Zoology, Harvard University.

We implement two approaches for mapping species distributions and provide example code and geographic data for replicating each at https://github.com/heliconius-maps/web-map.examples. Firstly, we produced an HTML web map for each



Taxon: Heliconius erato magnifica
Locality: Cumaribo, Vichada, Colombia
Locality string: Maipures VI
Date:Dec 1898
Collection:BMNH

Taxon: Heliconius erato erato
Locality: Galibi, Marowijne, Suriname
Locality string: 6-54c N
Collection:KB 1979

Figure 1. a) number of papers published per year which included *Heliconius* in the title, abstract or keywords (Web of Science, accessed 15th September 2024). **b)** Users from 47 countries have accessed the https://heliconius-maps.github.io homepage since it was put online in October 2021. Countries are shaded by number of users; USA has contributed the most users to date (n=704), followed by China (n=405). **c)** Example interactive web map for *Heliconius erato* subspecies.

species using the R package `leaflet` (Cheng, *et al.*, 2022). This package allows users to create and customize interactive maps via the `Leaflet` JavaScript library and the `htmlwidgets` R library. When viewing maps at broader scales, specimens from the same locality are clustered and represented by a single marker, which displays the number of underlying points. The scale at which markers are clustered is determined using a parameter (`maxClusterRadius`). A legend allows users to select which taxa and base map to display. The point localities for each taxon are assigned a unique color automatically and different taxa can be plotted simultaneously for comparison. A variety of different base maps showing satellite imagery, topography etc. can be easily added from sources such as ESRI and OpenStreetMap. Once a suitable template has been decided on, a map for each species in the dataset can be generated automatically using the batch script provided. The resulting maps can be explored here https://heliconius-maps.github.io.

Secondly, we created a `Shiny` interactive web application (Chang *et al.*, 2021). In brief, `Shiny` applications comprise a user interface object (UI) and a server function. A `shinyApp` function creates `shinyApp` objects from an explicit UI/server pair. The `shinyApp` also uses `Leaflet` to map species and subspecies distributions (the server function). However, the user selects species and subspecies by using a drop-down dashboard (the UI). Thus, there is a single HTML webpage for all species. For diverse taxa with hundreds of species, this might be a more tractable approach than mapping each species separately. We also provide options to filter the data by country and department, allowing species lists for a region to be quickly generated. The dashboard also provides a convenient portal for the user to download datasets for their own purposes, and we include a button to allow this. The `shinyApp` can be accessed and used here: https://heliconius-maps.github.io/Download.

Maps using citizen science data

Our core dataset was derived from museum databasing initiatives and comprises specimen metadata. Specimens were identified by the authors, or by the other specialists listed in the acknowledgments. We do not have photographs of each specimen available to us, but in any case, *Heliconius* phenotypes are highly variable, due to polymorphism and/or hybridisation. We therefore provide an image of the type or a specimen we consider canonical for the species/subspecies. Given our primary objective of providing a practical guide to facilitate identification, we feel this is more useful than a specimen by specimen documentation of variation.

Nonetheless, it would be straightforward for the pop-ups to display a photograph of the specimen corresponding to each geographical record. To illustrate this, we added an additional section of the website, which includes 187,414 observations downloaded from the citizen science initiative iNaturalist (last accessed: 15th September 2024, filtered to verifiable, research grade, wild observations). When these observations are clicked on, the pop-ups display the default image from the iNaturalist observation (https://heliconius-maps.github.io/iNaturalist). In addition, the user can quickly access the iNaturalist observation by clicking on a link. As well as providing a vast amount of additional data, these maps also provide a convenient way to check iNaturalist records for errors, for example, by looking for clear geographic outliers.

DISCUSSION

Research on Heliconiini has contributed significantly to our understanding of biodiversity, in fields ranging from evolutionary developmental biology to neotropical biogeography (Merrill *et al.*, 2015). Prior to widespread digitization of museum collections, the most comprehensive geographical reference for *Heliconius* butterflies was Keith S. Brown's 1979 "Livre Docência" (habilitation degree) for the University of Campinas in São Paulo, Brazil. Brown's 296-page monograph was a monumental achievement and the definitive reference manual for *Heliconius* field workers for decades. In 2012, we compiled a database of 58,000 records for species in the Heliconiini tribe (Rosser *et al.*, 2012). We made species maps and data available 1) as static images in an appendix to Rosser *et al.*, (2012) and 2) through Google Fusion Tables, which was a free web service provided by Google for data visualisation and sharing. Despite some limitations, Fusion Tables provided a reasonable solution for making data available for mapping and downloading. However, the service was discontinued in December 2019, leaving few alternatives. Those that did exist were commercial ventures and prohibitively expensive.

The interactive web-maps and data portal described here present an alternative and accessible solution for mapping species distributions. We stress that these are not intended to be competitors to GBIF and similar global data sources. Rather, they fill a different niche with three primary advantages. First, unlike GBIF or other global biodiversity databases, every specimen was examined and identified by specialists using the latest agreed taxonomy (Heliconius Genome Consortium, 2012; Lamas & Jiggins, 2017). Second, the underlying software is all free and open source, and the code and maps are easy to replicate and customize. Thirdly, the data and website can be quickly updated. In our particular implementation, the georeferenced specimen data are held in three differently formatted files, consisting of (1) the first author's personal database, (2) our community-validated museum database, and (3) the data downloaded from iNaturalist. These can be continually curated to a high standard by eliminating errors and employing the latest taxonomy, and new data can be added over time. To update the website, we simply run a custom R script to combine the three databases into a single comma-delimited file. We then run two further scripts that generate the `Leaflet` webmaps and the `shinyApp`. These can then be posted online within a matter of minutes. Researchers should be able to easily adapt our methods to any organisms with available geographic and phenotypic data. Our hope is that they find them as useful as we do.

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LITERATURE CITED

Brown, K. S. Jr. 1979. *Ecologia Geográfica e Evolução nas Florestas Neotropicais*. Tese apresentada à Universidade Estadual de Campinas como parte das exigências de um Concurso de Livre Docência, area de Ecologia, Campinas, Brazil.

Chang, W., Cheng, J., Allaire, J., Sievert, C., Schloerke, B., Xie, Y., Allen, J., McPherson, J., Dipert, A., Borges, B. 2021. shiny: Web Application Framework for R. R package version 1.7.1. https://CRAN.R-project.org/package=shiny.

Cheng, J., Karambelkar, B., Xie, Y. 2022. Leaflet: Create Interactive Web Maps with the JavaScript 'Leaflet' Library. R package version 2.1.1. https://CRAN.R-project.org/package=leaflet.

Graham, C. H., Ferrier, S., Huettman, F., Moritz, C., Peterson, A. T. 2004. New developments in museum-based informatics and applications in biodiversity analysis. *Trends in Ecology & Evolution* 19: 497-503.

***Heliconius* Genome Consortium**. 2012. Butterfly genome reveals promiscuous exchange of mimicry adaptations among species. *Nature* 487: 94-98.

Lamas, G., Jiggins, C. D. 2017. *Taxonomic List*, pp. 214-244. *In*: Jiggins, C. D. (Ed.), *The Ecology and Evolution of* Heliconius *Butterflies*. New York, Oxford University Press.

Merrill, R. M., Dasmahapatra, K. K., Davey, J. W., Dell'Aglio, D. D., Hanly, J. J., Huber, B., Jiggins, C. D., Joron, M., Kozak, K. M., Llaurens, V., Martin, S. H., Montgomery, S. H., Morris, J., Nadeau, N. J., Pinharanda, A. L., Rosser, N., Thompson, M. J., Vanjari, S., Wallbank, R. W. R., Yu, Q. 2015. The diversification of *Heliconius* butterflies: what have we learned in 150 years? J*ournal of Evolutionary Biology* 28: 1417-1438.

Rosser, N., Freitas, A. V. L., Huertas, B., Joron, M., Lamas, G., Mérot, C., Simpson, F., Willmott, K. R., Mallet, J., Dasmahapatra, K. K. 2019. Cryptic speciation associated with geographic and ecological divergence in two Amazonian *Heliconius* butterflies. *Zoological Journal of the Linnean Society* 186: 233-249.

Rosser, N., Phillimore, A. B., Huertas, B., Willmott, K. R., Mallet, J. 2012. Testing historical explanations for gradients in species richness in heliconiine butterflies of tropical America. *Biological Journal of the Linnean Society* 105: 479-497.

Rosser, N., Shirai, L. T., Dasmahapatra, K. K., Mallet, J., Freitas, A. V. L. 2021. The Amazon river is a suture zone for a polyphyletic group of co-mimetic heliconiine butterflies. *Ecography* 44: 177-187.

Rueda-M, N., Salgado-Roa, F. C., Gantiva-Q, C. H., Pardo-Díaz, C., Salazar, C. 2021. Environmental drivers of diversification and hybridization in neotropical butterflies. *Frontiers in Ecology and Evolution* 9.

Thawornwattana, Y., Seixas, F. A., Yang, Z., Mallet, J. 2023. Major patterns in the introgression history of *Heliconius* butterflies. *eLife* 12.

A review of the Jamaican webworm moths (Yponomeutoidea; Attevidae)

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Abstract: In his 2009 review of New World *Atteva* Walker, Becker lists five species of Attevinae (= Attevidae), from Jamaica: *Atteva pustulella* (Fabricius), *A. aurea* (Fitch), *A. siderea* (Walsingham), *A. sidereoides* Becker, and *A. fulviguttata* (Zeller). There has been no recent collection of *A. pustulella* and *A. siderea* and their presence on the island needs reconfirming. *Atteva fulvigutta* has also not been found, but a similar species which is present is now recognized as *A. glaucopidella* Guenée, 1879, **status revalidated**, this name formerly being treated as synonymous with *A. fulvigutta* (Becker, 2009).

Key words: Day flying; endemic species; Jamaica; microlepidoptera; New World.

INTRODUCTION

Becker (2009) noted that of some 50 pantropical species in the genus *Atteva*, just fifteen are found in the New World. Becker (2009) also noted that the genitalia are very similar throughout the genus and are often unreliable for identification, but that wing color patterns are distinct and these characters, together with geographical distribution, can facilitate identification of species.

At the time of initiation of this present study, five species of the colorful, mostly day-flying moths in the genus *Atteva* had been listed from Jamaica, as summarized by Becker (2009) in his review of the New World Attevinae, now recognized as Attevidae (van Nieukerken *et al*., 2011). Of these, *A. fulviguttata* (Zeller, 1873), which was attributed to Jamaica (Walsingham 1892; Becker, 2009), is not present in the island, and this name has been incorrectly assigned to a different Jamaican species. The presence of *A. pustulella* (Fabricius, 1787) in Jamaica is also questionable, as a result of recent DNA studies reported by Dan Janzen to Becker (Becker, 2009, p. 350).

The diagnostic color patterns of each forewing for the Jamaican species are illustrated. When available, photographs of pinned and living specimens are also provided to aid identification.

MATERIALS AND METHODS

Species within this genus are not commonly observed in Jamaica. The specimens reported were observed by chance sightings during the day while visiting flowers or resting on shrubs, or at night when attracted by light sources. The adults were only occasionally present during repeated visits to the same locations. Surveys have not been completed, so the island-wide distribution of each species is not yet fully known. This is a project that can now be undertaken and expanded using this publication as a guide.

Adults were photographed in the field during the day using a Nikon D850 camera with an AF-S VR Micro-NIKKOR 105mm f/2.8G IF-ED lens, and at night using the same equipment with the addition of a Nikon Speedlight SB-800 Electronic Flash. Voucher specimens were photographed using a Sony Cyber-shot 20.4 megapixels with 30X optical zoom to permit more detailed examination of color patterns.

Adults were collected from light sources at night using either a Honda Ex350 generator with 110/350VA output, ballast and regulator, and 125W clear bulb; or 110/120V AC mains supply to BioQuip #2819 Rain Shield and #2818S Poly Skirt lantern with E23 Clear 275W, mercury vapor (MV) 120V, self-ballasted bulb, or with use of a #2804 AC/DC black light. These lights were placed in front of a large white collection sheet.

Collection at night was more recently conducted using a LepiLED Maxi Switch moth trap, backed by a collecting sheet. The light emitted by the eight Nichia Power LEDs contained in the LepiLED Maxi Switch directly corresponds to the three sensitivity peaks of most nocturnal insects (UV, blue and green in the electromagnetic spectrum). Since nocturnal insects respond most strongly to UV radiation, four of the LEDs emit at the UV sensitivity peak at 365 nm. Power at 5V was provided to the lamp by a rechargeable power bank battery with 26 Ah (=26,000 m Ah) and QC 3.0 output USB power pack. Typically, this gave power for around 2.5 hours. A larger Jackery Power Station 518 Wh/500 w was also used, with just 12% energy depletion for the entire night.

Full generic and species synonymies given by Becker (2009) are not repeated here. Brief species descriptions are provided in order of year of discovery, which do not necessarily reflect any phylogenetic relationships. Wing measurements are provisional as statistical samples have not yet been examined, but these initial measurements do provide a guide to size differences between species.

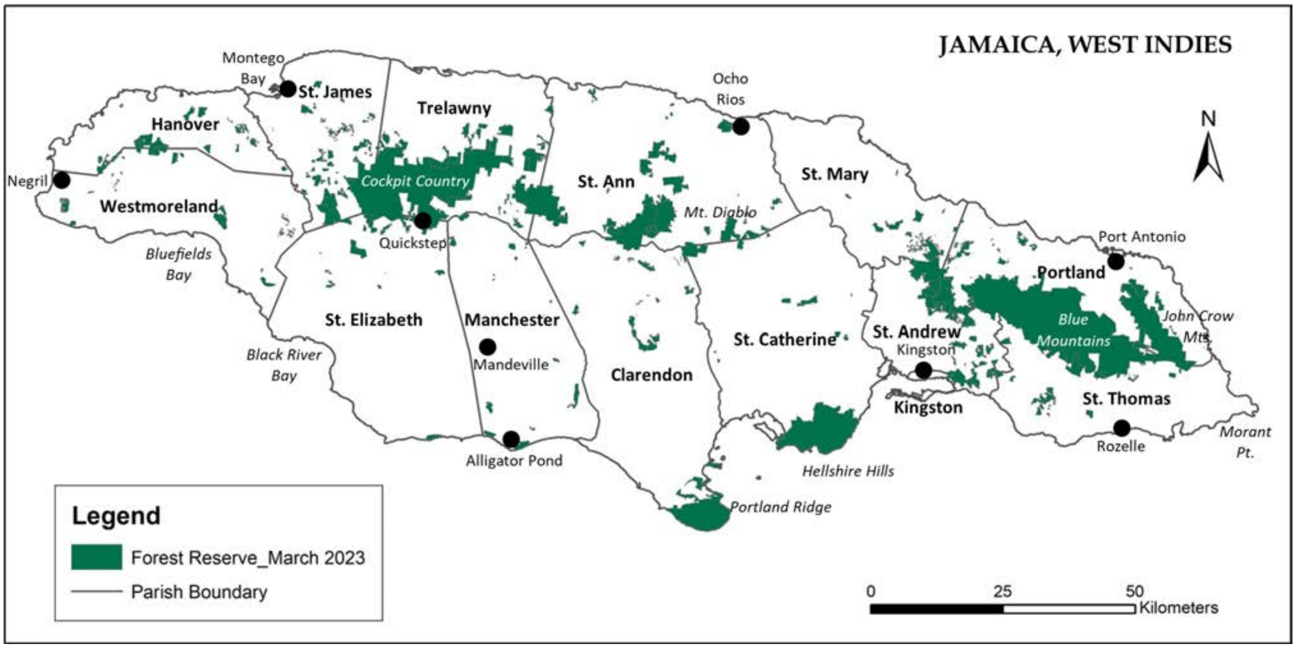

Figure 1. Map of Jamaica showing parishes and forest reserves.

The location of Jamaican parishes mentioned and forest reserves are shown on the map (Fig. 1). Collection of specimens was made possible by the granting of permit # 18/27 issued by the National Environmental Protection Agency (NEPA), Kingston, Jamaica. The following collection abbreviations are used: **CMNH**: Carnegie Museum of Natural History, Pittsburgh, USA; **CNC**: Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Canada; **NEPA**: National Environment Protection Agency, Kingston, Jamaica; **NHM, Copenhagen**: Natural History Museum, University of Copenhagen, Denmark; **NHMUK**: Natural History Museum, London [formerly BM(NH)], UK; **PWD**: Public Works Department, Kingston, Jamaica; **USNM**: United States National Museum, Washington, D.C., USA; **UWI**: University of the West Indies, Jamaica.

Superfamily Yponomeutoidea
Family Attevidae Mosher, 1916
Genus *Atteva* Walker, 1854: 526

Type species: *Atteva niveigutta* Walker, 1854: 526.
Type locality: Bangladesh. Becker (2009) notes that the type species is an Indo-Australian species and that if the New World species prove not to be congeneric with the species of that region, the name *Oeta* Grote, 1865, would be the oldest valid generic name to apply to the New World Attevidae.

Atteva pustulella (Fabricius, 1787)
(Fig. 2)

Type locality: Illustrated by Stoll (1871: 164) from a specimen collected in Surinam.
Type deposition: Undetermined. A neotype was designated from Costa Rica by Wilson *et al*., (2010) and deposited at the USNM.

Figure 2. *Atteva pustulella*, Trinidad, West Indies.

Distribution: Found from Uruguay and Argentina northwards to Costa Rica and in the Antilles, including Dominica, Martinique, Hispaniola, and reported from Jamaica (Becker, 2009; Wilson *et al*., 2010).

Brief description of the adult

Size: Approximately 12 mm overall length; forewing length approximately 10 mm.

Differentiated from next species, *A. aurea* (Fitch), by bolder black wing markings surrounding white wing spots and with orange areas reduced.

Male and female, similar. dorsal head white, marked with a mid-dorsal black spot; antennae black, with an off-white section four fifths of distance from base to tip. Prothoracic segment white with a transverse black dorsal bar connecting to a median black spot immediately to posterior; meso-thoracic and meta-thoracic segments orange; abdomen dark brown, approaching black. Tegulae orange; dorsal forewings orange, with four series of white compound spots edged with bold black borders, also reducing extent of orange ground color. Dorsal hindwing, opaque variably off-white or tinged with gray, with darker gray border, expressed more boldly at apex.

Discussion: No specimens from Jamaica have been found in this present survey, although surveys are incomplete. There are specimens identified as this species from Jamaica at the USNM, but the presence of this insect on the island needs reconfirming.

Jamaican records are few, and Becker (2009) notes that there is no clear evidence to separate *Atteva pustulella* Fabricius and *Atteva aurea* and that the genitalia exhibit no differences. However, DNA barcoding (Wilson *et al*., 2010) indicated that the population from Costa Rica south to Argentina and Uruguay should be regarded as *A. pustulella*, and those from northern Costa Rica north to Canada, including those from Jamaica, should be regarded as *A. aurea*. If both species are present in Jamaica this would suggest that both *A. pustulella* and *A. aurea* were present on the proto-island of Jamaica as it split off from Central America during the Miocene. Alternatively, there would need to have been two separate invasions to account for the presence of both *A. pustulella* and *A. aurea* on Jamaica. It has also been postulated that the original island of Jamaica submerged and that the present island of Jamaica has only been emergent from the sea during the last twelve million years (Porter *et al*., 1982). If so, this would also require separate invasions for each species.

A reported larval food plant for *A. pustulella* in Costa Rica is *Simarouba amara* Aubl. (Simaroubaceae), a rainforest species (Wilson *et al*., 2010). This is the same species of *Simarouba* found in Jamaica, here known as *Simarouba glauca* DC., which is "common in woodlands on limestone" from sea level up to 610 m (Adams, 1972; Carnevali Fernández-Concha *et al.,* 2010).

Atteva aurea (Fitch, 1856)
(Figs. 3, 4)

Type locality: Savannah, Georgia, USA.
Type deposition: Original Fitch specimens not found (Becker, 2009). Neotype from Florida designated by Wilson *et al*. (2010), deposited in the CNC.

Distribution: This species occurs from Costa Rica north to the southern United States, including southern California, northeast to Nova Scotia and southeastern Canada; also, on the islands of Cuba and Jamaica (Becker, 2009; Wilson *et al*., 2010).

Brief description of the adult

Size: Approximately 12-13 mm overall length; forewing length 9-10.5 mm (n= 5).

The wings of *A. aurea* exhibit a similar pattern of colors to those of *A. pustulella*, but with the black wing markings narrow or reduced and with more extensive areas of orange. Variations are illustrated by Wilson *et al*. (2010).

Male and female similar. Dorsal head black, but almost obscured by three pairs of white spots. Antennae black, but with an off-white section, four fifths of distance from base to tip. Dorsal prothorax with median paired black anterior spots merging into two white spots, extending into two small black spots with tapered white posterior dashes; mesothoracic segment light orange; metathorax gray-black. Legs black with white bands. Dorsal abdomen gray to brownish-gray. Tegulae light orange; dorsal forewing light orange with four series of white conjoined spots, each edged narrowly in black. Hindwings opaque, light gray with darker gray margin. Lateral and ventral thorax dark gray with white spots. Ventral abdomen gray with dull white spots on each segment.

Discussion: DNA barcoding of specimens in Costa Rica determined that *A. pustulella* and *A. aurea* should be recognized as distinct (Wilson *et al*., 2010). The status of the Jamaican populations should be further investigated as it is not certain that *A. pustulella* occurs on the island.

Figure 3. *Atteva aurea*, Portland Ridge, Clarendon Parish, 22 May 2023.

Figure 4. *Atteva aurea*, Rozelle, St. Thomas Parish.

Figure 5. *Atteva aurea* distribution map.

Atteva aurea is found primarily in lowland dry limestone scrub subject to seasonal rains, for example in coastal St. Thomas and St. Andrew parishes, and at the dry limestone habitat of Portland Ridge, Clarendon Parish, and is the most frequently seen species of *Atteva* in Jamaica. Specimens have also been recorded from more mesic locations in the parishes of St. Ann, Trelawny, and St. James (Fig. 5). *Atteva aurea* has been reared on *Simarouba glauca* DC., in Mexico (Becker, 2009), from both *S. glauca* and *S. amara* Aubl., in Costa Rica (Wilson *et al*., 2010), and in Honduras (Passoa *et al*., 2022). *Simarouba amara* and *S. glauca* are now regarded as being synonymous (Carnevali Fernández-Concha *et al*., 2010), so both *A. pustulella* and *A. aurea* utilize the same species of *Simarouba* as a larval foodplant.

Atteva glaucopidella Guenée, 1879, **status revalidated**
(Figs. 6, 7, 8)

Type locality: Jamaica.
Type deposition: NHMUK.

Distribution: Jamaica. Endemic.

Brief description of the adult

Size: Overall length approximately 11.5-12 mm; forewing length approximately 9-10 mm (n= 2).

Female dorsal head, eyes, palps and antennae, black. Prothorax with a median inverted 'Y-shaped' black marking abutting head; remainder of thoracic segments burnt-orange. Legs black with narrow white bands. Wings black with a deep blue-indigo sheen. Three large, irregularly shaped orange spots arranged along each wing - basal, postbasal, and subtornal, with an extensive scattering of small white spots of different sizes on dark portions of each wing. Distal end of wing fringed with gray scales. Hindwing dark gray trending to black toward apex and outer margins; lighter median, almost opaque, including cell. Male and female similar.

Discussion: Becker (2009: 352) treated the populations of *Atteva fulviguttata* (Zeller, 1873) on Jamaica and Hispaniola as the same species, accepting the decision by Walsingham (1892: 17) to synonymize *A. glaucopidella* (Guenée 1879: 289), described from Jamaica, with *A. fulviguttata* Zeller, described from Hispaniola in 1873.

Becker (2009) stated: "This species (*A. fulviguttata*) resembles (*Atteva*) *gemmata* (Cuba) and *intermedia* (Antigua); differing from both by lacking the white dots on forewings and terga," then continues, "the species is known only from Jamaica and Hispaniola." The illustration examined by Becker was from the NHMUK and is shown as Fig. 11 in Becker's review. This specimen, from the Dominican Republic collected in 1992, exhibits four orange spots and very minimal white spotting on the black forewing with just four tiny white spots visible, and is a specimen of *A. fulvigutta*.

However, the color patterns on specimens from Hispaniola and Jamaica differ, suggesting that Walsingham's decision to synonymize *A. fulvigutta* and *A. glaucopidella* should be reevaluated. Becker (2009: 349) referencing the genus *Atteva,* states, "The combination of color pattern with geographical distribution enables easy recognition of the species, whereas characters of the genitalia are very similar throughout the genus so are unreliable for determination." In agreeing with this observation, we consider that Jamaican and Hispaniolan specimens are separate species with the Jamaican species being *Atteva glaucopidella* as originally described by Guenée (1879: 289).

The most significant differences between the Hispaniolan *A. fulviguttata* and Jamaican *A. glaucopidella* are the number, size, and distribution of white and orange spots on the forewings. On each forewing of *A. fulviguttata* there is a narrow orange spot toward the wing base, a large median orange spot, followed by a small orange submarginal spot, and then a fourth medium-sized sub-tornal orange spot. In *A. glaucopidella* (Fig. 8) there are three large orange spots of approximately equal size found basally, postbasally, and subtornally across the wing, along with more extensive white speckling (Fig. 6). There are no obvious similarities between Jamaican specimens of *A. glaucopidella*


Figure 6. *Atteva glaucopidella,* north of Quickstep into Trelawny Parish, 26 October 2019.


Figure 7. *Atteva glaucopidella*, female, Marshall's Pen, near Mandeville, Manchester Parish, 24 June 2022.


Figure 8. *Atteva glaucopidella*, showing right forewing detail from figure 7.


Figure 9. *Atteva glaucopidella* distribution map.

and *A. gemmata* Grote, or *A. intermedia* Becker as suggested by Becker (2009). These are smaller insects with more extensive orange markings and white spotting on the forewings.

Atteva glaucopidella is found in mesic lowland broadleaf forest north of Quickstep into Trelawny Parish, and seasonally mesic upland broadleaf forest near Mandeville, Manchester Parish, in west central Jamaica (Fig. 9). Additional surveys are required to determine the complete distribution in the island.

Atteva siderea (Walsingham, 1892)

Type locality: San Domingo, Dominican Republic.
Type deposition: NHMUK.

Distribution: Series of this species were collected in the Dominican Republic between 1973 and 2004 (Becker, 2009). There are also two male specimens at the CMNH with labels stating "Jamaica" with no further information (K. Keegan, pers. comm.).

Brief description of the adult

Size: Overall length estimated to be approximately 11 mm; forewing length 9 mm.

Male dorsal head white; thoracic segments black with fine white spots; dorsal abdomen black, with five pairs of paired white spots and two terminal pale bands. Tegula orange; dorsal forewing black with numerous small white spots and four orange markings - a basal orange dash; a round spot near hind margin just beyond cell; an orange dash posterior of cell; and a submarginal orange marking crossing wing beginning just below anterior margin and meeting hind margin.

Discussion: In the Dominican Republic this species has been found in both arid thorn scrub and within "weedy regrowth with coffee, cacao" (Becker, 2009). Although there are no recent records of this species from Jamaica, this genus has not been the focus of any recent investigations or systematic surveys of suitable habitats in which this species might be found. We therefore consider *A. siderea* as being possibly present until proven otherwise. However, there is no information on where in Jamaica the specimens were collected, and it is possible that the CMNH specimens from "Jamaica" are mislabeled.

Atteva sidereoides Becker, 2009
(Fig. 10)

Type locality: Runaway Bay Caves, St. Ann Parish.
Type deposition: USNM.

Distribution: Jamaica. Endemic. So far known only from the type collected near the Runaway Bay Caves, St. Ann Parish, and a male specimen closely resembling this species collected in dry limestone forest at Portland Ridge, Clarendon Parish (17°44'22"N, 77°09'27"W) (Fig. 11).

This species was first recognized and described by Becker (2009) from a male specimen collected by D. & M. Davis in 1973 and deposited at the USNM.

Brief description of the adult

Size: Overall length 10 mm; forewing length 8 mm (n=2). The female has not yet been collected or described.

Figure 10. *Atteva sidereoides*, Portland Ridge, Clarendon Parish, 18 February 2023.

Male dorsal head white; palps and antennae black. Prothorax with a pair of black spots; mesothorax white, with a large median black marking; metathorax with a small median black spot. Dorsal abdomen black. Forewing black with a pair of orange bars near wing base and a larger orange bar near end of cell and numerous fine white spots and markings on distal quarter of wing. Dorsal hindwings opaque, edged with gray scales, densest toward apex.

Portland Ridge specimen (Fig. 10): head white with a small median mid-dorsal black spot; palpi black with one white segmental band; antennae black, 5.7 mm in length; two median and two lateral black spots at base of each tegula on mesothorax; metathorax with a triangular median black spot; legs black with fine white banding, but ventrally displaying white more extensively; forecoxae of forelegs each have an orange ventral spot; dorsal abdomen blue-black; ventral abdomen black with six anterior segments marked with a white segmental band, each expanded mid-ventrally; claspers edged with white. Dorsal forewing bluish black with a diffuse white basal bar, a pair of joined basal orange spots, another elongated orange discal spot, with an additional orange spot near hind margin below orange spot at end of cell; a diffuse white postdiscal dash in addition to extensive white subapical to apical markings on distal third of wing matching distribution of white markings present on type. Dorsal hindwing opaque with gray margins, densest gray toward apex. Ventral forewing and hindwing black with a few minute white marginal spots.

Discussion: While there are some small differences between the two specimens, these insects are very small and some features can be difficult to discern after pinning. Additional specimens or molecular investigations are required to confirm whether or not these are the same or separate species.

The type specimen was found in dry limestone forest habitat at an elevation of approximately 15 m on Jamaica's north coast. The Portland Ridge specimen was also found in dry limestone forest on the south coast at an elevation of 157 m (Fig. 11). Both specimens were found in arid habitats receiving

Figure 11. *Atteva sidereoides* distribution map.

less than 125 mm rainfall per month for nine months of the year and between 125-250 mm per month between October and December (Nancoo *et al*., 1963).

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LITERATURE CITED

Adams, C. D. 1972. *Flowering plants of Jamaica. With contributions by Proctor, G. R., Read R. W.* Mona, University of the West Indies. 848 pp.

Becker, V. O. 2009. A review of the New World *Atteva* (Walker) moths (Yponomeutidae, Attevinae). *Revista Brasileira de Entomologia* 53(3): 349-355.

Carnevali, Fernández-Concha, G., Tapia-Muñoz, J. L., Duno de Stefano, R., Ramírez-Morillo, I. M. 2010. *Flora ilustrada de la Peninsula de Yucatán. Listado Floristico.* Mérida, Centro de Investigación Científica de Yucatán. 1-326.

Fabricius, J. C. 1787. *Mantissa Insectorum*. Copenhagen, Proft. 382 pp.

Fitch, A. 1856. Third report on the noxious and other insects of the State of New York. *Transactions of the New York State Agricultural Society* 16: 315-490.

Grote, A. R. 1865. Notes on the Bombycidae of Cuba. *Proceedings of the Entomological Society of Philadelphia* 5: 227-255.

Guenée, A. 1879. Études sur les Yponomeutides. *Annales de la Société Entomologique de France* 48: 281-290.

Nancoo M., Rogers, O. B., Saunders, L. E. 1963. *The Rainfall of Jamaica; data 1870-1960 prepared by the Meteorological Office, Palisadoes, and sponsored by the Scientific Research Council, Jamaica*. London, The Whitefriars Press Ltd. 13 pp.

van Nieukerken, E. J., Kaila, L., Kitching, I. J., Kristensen, N. P., Lees, D. C., Minet, J., Mitter, C., Mutanen, M., Regier, J. C., Simonsen, T. J., Walberg, N., Yen, S-H, Zahiria, R., Adamski, D., Baixeras, J., Bartsch, D., Bengtsson, B., Brown, J.W., Bucheli, S. R., Davis, D. R., De Prins, J., Epstein, M. E., Gentili-Poole, P., Gielis, C., Hättenschwiler, P., Hausmann, A., Holloway, J. D., Kallies, A., Karsholt, O., Kawahara, A. Y., Koster, S. (J.C.), Kozlov, M. V., Lafontaine J. D., Lamas, G., Landry, J-F, lee, S., Nuss, M., Park, K-T., Penz, C., Rota, J., Schintimeister, A., Schmidt, B. C., Sohn, J-C., Solis, M. A., Tarmann, G. M., Warren, A. D., Weller, S., Yakovlev, R. V., Zolotuhin, V. V., Zwick, A. 2011. Order Lepidoptera Linnaeus, 1758, pp. 212-221. *In*: Zhang, Z.-Q. (Ed.), Animal biodiversity: an outline of higher classification and survey of taxonomic richness.. *Zootaxa* 3148: 1-237.

Passoa, S., Young, J., Van Den Berghe, E. 2022. Hosts, morphological notes, distribution records, and systematics of three common Honduran moths, *Atteva aurea* (Attevidae), *Mesophleps adustipennis* (Gelechiidae), and *Hyblea puera* (Hyblaeidae). *Journal of the Lepidopterists' Society* 76(4): 268-278.

Porter, A. R. D., Jackson, T. A., Robinson, E. 1982. *Minerals and Rocks of Jamaica*. Kingston, Jamaica Publishing House. 174 pp.

Stoll, C. 1781. {Lepidoptera}, pp. 91-164. *In*: Cramer, P.. *De Uitlandsche Kapellen* III. Amsterdam, J. S. Baalde. 252 pp.

Walker, F. 1854. *List of the specimens of lepidopterous insects in the collection of the British Museum, Part II. Catalogue of Lepidoptera Heterocera. British Museum (Natural History), Department of Zoology, by order of the Trustees.* London, Edward Newman. pp. 279-581.

Walsingham, Lord [T. de Grey]. 1892. On the micro-lepidoptera of the West Indies. *Proceedings of the Zoological Society of London* 1891: 492-548.

Wilson, J. J., Landry, J-F., Janzen, D., Hallwachs, W., Nazari, V., Hajibabaei, M., Hebert, P. 2010. Identity of the ailanthus webworm moth (Lepidoptera, Yponomeutidae), a complex of two species: evidence from DNA barcoding, morphology and ecology. *ZooKeys* 46: 41-60.

Zeller, P. C. 1873. Beiträge zur Kenntniss der nordamericanischen Nachtfalter, besonders der Microlepidopteren. *Verhandlungen der Kaiserlich-Königlichen zoologisch-botanischen Gesellschaft in Wien* 23: 201-334.

A new montane *Stalachtis* Hübner species from the Cordillera del Cóndor in southeastern Ecuador (Lepidoptera: Riodinidae: Nymphidiini)

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Abstract: A new riodinid species in the *Stalachtis calliope* (Linnaeus) group (Nymphidiini: Stalachtina), *S. radfordi* **n. sp.**, is described from elevations between 1100 and 2000 m in the Cordillera del Cóndor and its immediate environs in southeastern Ecuador.

Key words: cloud forest; endemism; Neotropics; species description; taxonomy; tepuis.

INTRODUCTION

The remote Cordillera del Cóndor is one of the longest and tallest of the discontinuous chain of sub-Andean ranges that lie between the Andes and the lowland Amazon basin. It extends about 150 km along the border between Ecuador (southern Morona-Santiago and Zamora-Chinchipe) and Peru (Amazonas), and reaches elevations of nearly 3000 m. The geology of the main Andean chain is primarily volcanic and metamorphic, whereas that of the Cordillera del Cóndor and other sub-Andean ranges is primarily sedimentary, consisting of limestones and sandstones, giving the Cóndor range its distinctive flat-topped tepuis (Neill, 2005). Not only is the geology and landscape of the Cordillera del Cóndor similar to that of the older tepuis-laced Guiana shield region of northeastern South America, but a phytogeographic link has also now been discovered, with at least 10 plant genera found to be endemic to the two distant regions (Ulloa & Neill, 2006). The cessation of intermittent but long-running military hostilities between Ecuador and Peru in 1995 finally opened up the Cordillera del Cóndor to biological exploration, and preliminary assessments have found the region to be very biodiverse, with a high incidence of undescribed endemic species in groups ranging from plants to amphibians (e.g., Schulenberg & Awbrey, 1997; Neill, 2005; Ron *et al*., 2018).

Several new endemic butterfly taxa in the Pieridae and Satyrinae have also been discovered and described from the Cordillera del Cóndor (Lamas, 1997; Pyrcz *et al*., 2006, in prep.; Radford & Willmott, 2013). This paper describes a new riodinid species in the genus *Stalachtis* Hübner, 1818 (Nymphidiini: Stalachtina), from the Ecuadorian side of the Cóndor range, that was collected by a Cambridge University Lepidoptera Expedition in 2010 led by James Radford (see Radford *et al*., 2012). *Stalachtis* is an essentially South American genus of large aposematic species. All but one of the nine described species are confined to lowland habitats and are well represented in collections, having been described in the eighteenth and early nineteenth centuries. The other, *S. halloweeni*, was recently described from a montane tepui in western Guyana (Hall, 2006), and has subsequently been found to occur on two montane tepuis in neighboring eastern Venezuela (Costa *et al*., 2019). The new *Stalachtis* described here represents a second, unrelated, montane species for the genus that resembles and seems to replace the widespread Amazonian species, *Stalachtis calliope* (Linnaeus, 1758) (Fig. 1), at higher elevations.

MATERIALS AND METHODS

Morphology was studied using standard techniques, with the dissection methods used following those outlined in Hall (2018). The terminology for male genital structures follows Klots (1956), Eliot (1973), and Harvey (1987), and the nomenclature for venation follows Comstock & Needham (1898), with cells named for the vein above. *Stalachtis* material was studied in the 27 personally visited institutional and private collections listed in Hall (2018), and the known type specimens were examined for all available names.

SPECIES DESCRIPTION

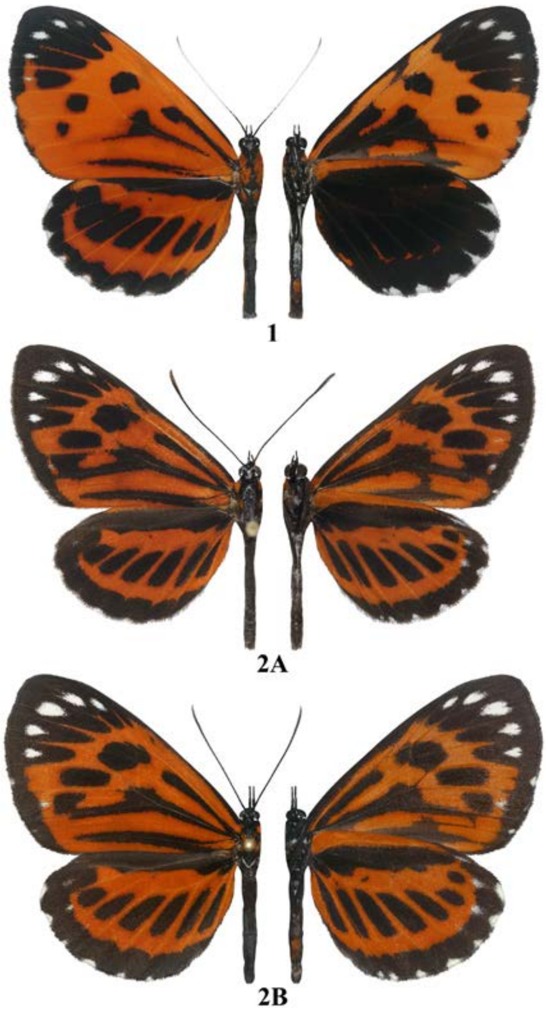
Stalachtis radfordi Hall & Willmott, new species
(Figs. 2-5)

Description: MALE: Forewing length HT 27 mm. *Wings:* see Fig. 2A. *Head:* Eyes dark brown and bare with white marginal scaling; frons black with a white lateral band medially and an isolated white lateral spot dorsally below base of antennae; labial palpi black with very sparse white scaling ventrally and a white patch at outer base of segment two, segments two and three very elongate; antennal length approximately 45% of forewing length, segments black with a narrow nudum section along inner margin, clubs black with a broad inner nudum band and an orange-brown tip. *Body:* Dorsal surface of thorax black with orange lateral scaling in anterior two thirds, a narrow white V-shaped mark posteriorly, and a predominantly orange tegula, ventral surface black with white ventrolateral spots and an orange anterolateral patch at base of forewing; dorsal surface of abdomen black, ventral surface black with a narrow white ventral band in anterior two thirds that becomes orange in anterior third and a narrow white lateral band; foreleg black with a white stripe along inner margin of coxa, mid- and hindlegs black. *Genitalia:* see Fig. 3; upper posterior valve process slightly inwardly curved in ventral view with long setae present along basal half of dorsal margin, lower posterior valve process outwardly directed at an approximately 30° angle in ventral view with long setae present around posterior tip; transtilla continuously sclerotized dorsally between bases of upper posterior valve processes with a narrow hooded process extending ventroposteriorly above aedeagus and between rounded inner valve processes; ductus ejaculatorius enters aedeagus anteriorly, vesica exits aedeagus ventrally; narrow tuft of long, posteriorly directed brown setae around outer margin of genital capsule; eighth abdominal tergite approximately rectangular, sternite approximately rectangular with a slightly narrowed and concave posterior margin. FEMALE: Forewing length PTs 28-30 mm. *Wings:* see Fig. 2B. *Head:* Differs from male by having slightly more elongate second and third palpal segments, and a slightly larger nudum section on antennal segments. *Body:* Differs from male by having an abdomen with more prominent orange ventral scaling and an additional narrow orange sublateral band between two white bands. *Genitalia:* see Fig. 4; expanded medial section of ductus bursae heavily sclerotized, narrowed posterior section weakly sclerotized, ductus seminalis membranous; sclerotized ostium bursae dorsally curves anteriorly into an invaginated pouch below papillae anales that is membranous ventrally and weakly sclerotized dorsally (perhaps forming a protected resting place for extremely long male genital falces during copulation); papillae anales proportionately small and roundly rectangular; very broad semicircular tuft of long, posteriorly directed brown setae around posterior margin of eighth tergite.

Types: HOLOTYPE male: ECUADOR: *Zamora-Chinchipe*, Cóndor Mirador camp, top of Quimi road, Cordillera del Cóndor, 3°38'29"S 78°23'35"W, 2000 m, 20-28 Aug 2010 (J. Radford, E. Hartley, K. Buckland, and S. Padrón *leg.*) (to be deposited in Instituto Nacional de Biodiversidad, Quito, Ecuador [INABIO]).

PARATYPES: ECUADOR: *Zamora-Chinchipe*, same data as HT: 1 female (INABIO); 1 female (McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, FL, USA); 1 female (JPWH collection, Washington, DC, USA).

Etymology: This species is named after James T. Radford, who led the very successful 2010 Cambridge University Lepidoptera Expedition (CULEPEX) to Ecuador's Cordillera del Cóndor, where he and his expedition members discovered this species and collected the type series.



Figs. 1-2. *Stalachtis* adults (dorsal surface on left, ventral surface on right) (1.2 x life size). **1**. *S. calliope* (Linnaeus) male, Río Nangaritza, Zamora-Chinchipe, E. Ecuador (1050 m). **2A**. *S. radfordi* Hall & Willmott **n. sp.,** HT male, Cóndor Mirador, Zamora-Chinchipe, E. Ecuador (2000 m). **2B**. *S. radfordi* PT female, Cóndor Mirador, Zamora-Chinchipe, E. Ecuador (2000 m).

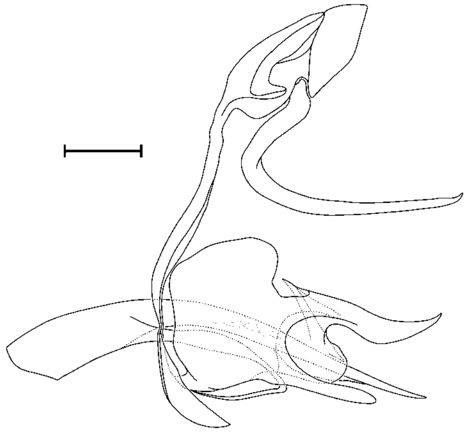


Fig. 3. Male genitalia in lateral view of *S. radfordi* **n. sp.** HT. Scale bar = 0.5 mm.

Systematic Placement: The genus *Stalachtis* can be characterized by its members having hindwing veins Rs and M_1 stalked rather than arising separately from the discal cell end, a tuft of long setae around the posterior margin of abdominal segment eight in males and, to a greater extent, females, and extremely long and weakly bent male genital falces (Bates, 1868; Stichel, 1910-11; Harvey, 1987; Hall, 2006), all characters possessed by the new species *S. radfordi*. Hall (2006) proposed three species groups for *Stalachtis* based on wing pattern and male genitalia, the *phlegia* group for *S. phlegia* (Cramer, 1779) and *S. susanna* (Fabricius, 1787) (recently returned to species status by Magaldi *et al.* (2021)); the *calliope* group for *S. calliope* (Linnaeus, 1758), *S. eugenia* (Cramer, 1777) (recently returned to species status by Gallard & Fernandez (2015)), and *S. magdalena* Westwood, 1851; and the *euterpe* group for *S. halloweeni* Hall, 2006, *S. euterpe* (Linnaeus, 1758), *S. phaedusa* (Hübner, [1813]), and *S. lineata* (Guérin-Méneville, [1844]). *Stalachtis radfordi* can be placed in the *calliope* group based on possessing a band of white submarginal spots on the forewing, an entirely checkered black and white hindwing fringe (both characters shared with the *phlegia* group), parallel orange bands across the hindwing, a pair of large, rounded, inner male genital valve processes with a narrow and elongate transtilla process extending ventroposteriorly between them and across the top of the aedeagus (a genital character complex shared with the

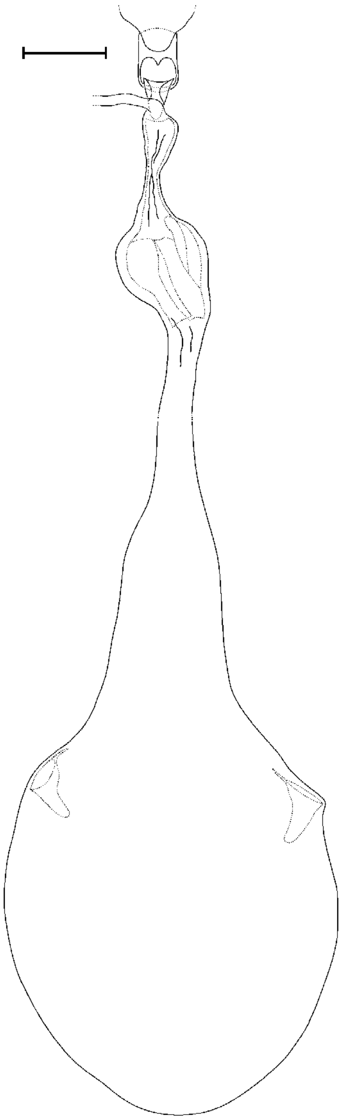


Fig. 4. Female genitalia in dorsal view of *S. radfordi* **n. sp.** PT. Scale bar = 0.5 mm.

euterpe group), and an upper male genital valve process that is broadest medially (instead of basally in the *phlegia* group and distally in the *euterpe* group).

Diagnosis: Within the *Stalachtis calliope* group, *S. calliope* is widespread throughout Amazonia, whereas the other two described species have more restricted ranges, with *S. eugenia* apparently confined to the lower Amazon of Brazil and the Guianas, and *S. magdalena* to the small Transandean area between eastern Panama and central Colombia. The montane *S. radfordi* is most similar to the apparently elevationally parapatric *S. calliope* (Fig. 1), but both sexes of *S. radfordi* can rapidly be distinguished from those of all other *calliope* group species by having black instead of cream and black antennae, a possible symplesiomorphy shared with *phlegia* and *euterpe* group species. In *S. magdalena*, the antennae are black with cream clubs, and in *S. calliope* and *S. eugenia* the antennae are black in the basal third and cream in the distal two thirds. Both sexes of *S. radfordi* additionally differ from those of *S. calliope* by having less prominent orange scaling on the ventral surface of the abdomen, with an entirely brown instead of at least partially orange tuft of long setae around the tip of the eighth abdominal segment, darker and more even toned orange-brown instead of orange (males) to orange-yellow (females) wing patterning, slightly more horizontally elongate dark postdiscal spots on the forewing, a broader and more even black margin in the forewing tornus, larger white submarginal spots in the forewing apex, an additional faint white submarginal spot in cell Cu_1 on the dorsal and/or ventral forewing, and additional white submarginal spots in the apex of the dorsal and/or ventral hindwing. The male of *S. radfordi* additionally has a slightly narrower and more pointed wing shape than the male of *S. calliope*. The genitalia of the *calliope* group are rather homogeneous, and the male and female genitalia of *S. radfordi* do not significantly differ from those of *S. calliope*. In addition to all of the wing pattern differences listed above between *S. radfordi* and *S. calliope*, both sexes of *S. eugenia* can additionally be consistently distinguished from those of *S. radfordi* (and *S. calliope*) by having a more proximally positioned dark postdiscal spot in forewing cell Cu_1, and a relatively smooth and straight instead of rayed distal margin to the orange patch in the forewing apex (Gallard & Fernandez, 2015). *Stalachtis magdalena* is the most distinctive member of the group, with paler orange wing patterning that is reduced to absent distal to the dark postdiscal band on the forewing, and a complete band of enlarged white submarginal spots on the forewing.

Wing pattern variation in the examined specimens of *S. radfordi* is minimal, and limited to whether or not the dark postdiscal spot in forewing cell Cu_1 is connected to the dark scaling proximally along vein Cu_1, and faint white submarginal spots are visible dorsally as well as ventrally in forewing cell Cu_1 and the hindwing apex.

Biology: This species is known to inhabit montane forest from about 1100 to 2000 m. The type locality at 2000 m is a ridge of stunted elfin forest that forms the border between Ecuador and Peru. At the time that the type series was collected in 2010, a military border encampment at the base of the ridge served as an access point, with a road extending from Quimi (750 m), off the Gualaquiza-Zamora road, up to the camp (1750 m) at the top of the Cordillera del Cóndor. However, the most recent visit by the authors to the area in 2021 revealed large-scale open copper and gold mining activities that had severely degraded the environment at lower elevations (conducted by Ecuacorriente S.A., a company owned by a Chinese conglomerate; see Henderson (2014) for more details). The military camp was found to have been abandoned some years before, and, as a consequence, the road up to it had become badly eroded and was impassable. Both sexes of *S. radfordi* were encountered flying up and over the ridge at about 2 m above the ground during the mid to late afternoon, predominantly from the Peruvian side of the ridge whence the wind was blowing (J. Radford, pers. comm.). A female of *S. radfordi* was also photographed by Andrew Neild atop a low leaf (see Fig. 5) at about 1100 m along the Río Bombuscaro, just to the south of Zamora, located about 60 km away from the type locality in the adjacent main Andean chain. Despite many years of searching for *S. radfordi* in the Cordillera del Cóndor region, we have never encountered this rare and/or localized species, and it is not present in any of

Fig. 5. A female of *S. radfordi* **n. sp.** from Río Bombuscaro, near Zamora, Zamora-Chinchipe, E. Ecuador (1100 m) (photo by A. Neild).

the institutional or private collections that we have examined (e.g., see list in Hall (2018)). *Stalachtis radfordi* seems to occur at elevations above those occupied by the closely related, widespread lowland Amazonian *S. calliope*, which we have also recorded in Zamora-Chinchipe province, along the Río Nangaritza at 1050 m (see Fig. 1). Although *Stalachtis* is one of the most well-known groups of aposematic mimetic riodinids (e.g., Seitz, 1916-20; d'Abrera, 1994; Hall, 2006; Magaldi *et al.*, 2021), there are no sympatric butterflies or moths closely resembling *S. radfordi* at montane elevations in the Cordillera del Cóndor region.

Distribution: *Stalachtis radfordi* has only been found at two localities in Zamora-Chinchipe province in southeastern Ecuador, but its presence at the Ecuador-Peru border indicates that it also occurs in the very remote Peruvian section of the Cordillera del Cóndor (Amazonas). The lack of known specimens from elsewhere in southern Ecuador and northern Peru, despite relatively intensive recent collecting, suggests that the species may be endemic to the broader Cordillera del Cóndor region.

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LITERATURE CITED

Bates, H. W. 1868. A catalogue of Erycinidae, a family of diurnal Lepidoptera. *Journal of the Linnean Society of London (Zoology)* 9(39-40): 373-459.

Comstock, J. H., Needham, J. G. 1898. The wings of insects. Chapter III. The specialization of wings by reduction. *American Naturalist* 32: 231-257.

Costa, M., Viloria, A. L., Attal, S., Neild, A. F. E., Fratello, S., Benmesbah, M. 2019. Lepidoptera del Pantepui. Parte VIII. Nuevos Nymphalidae (Charaxinae y Satyrinae) y Riodinidae (Riodininae). *Anartia* 29: 20-48.

d'Abrera, B. 1994. *Butterflies of the Neotropical Region, Part VI. Riodinidae.* Victoria, Hill House. 6: 880-1096.

Eliot, J. N. 1973. The higher classification of the Lycaenidae (Lepidoptera): A tentative arrangement. *Bulletin of the British Museum of Natural History (Entomology)* 28: 373-506.

Gallard, J.-Y., Fernandez, S. 2015. *Stalachtis calliope* (Linné, 1758): Deux espèces confondues en Guyane française et au Surinam (Lepidoptera, Riodinidae). *Bulletin de la Société Entomologique de France* 120(3): 335-340.

Hall, J. P. W. 2006. A remarkable new riodinid species, *Stalachtis halloweeni* (Riodinidae: Stalachtini), from Mount Ayanganna, Guyana. *Journal of the Lepidopterists' Society* 60(3): 138-142.

Hall, J. P. W. 2018. *A Monograph of the Nymphidiina (Lepidoptera: Riodinidae: Nymphidiini): Phylogeny, Taxonomy, Biology, and Biogeography*. Washington, The Entomological Society of Washington. 990 pp.

Harvey, D. J. 1987. *The Higher Classification of the Riodinidae (Lepidoptera).* Ph.D. Thesis. Austin, University of Texas.

Henderson, L. 2014. *Beggars Sitting on a Sack of Gold? Local Stakeholder Perceptions of Large-Scale Mining in Ecuador.* Masters Thesis. Gainesville, University of Florida.

Klots, A. B. 1956. *Lepidoptera*, pp. 97-110. *In*: Tuxen, S. L. (Ed.), *Taxonomists' Glossary of Genitalia in Insects.* Copenhagen, Munksgaard.

Lamas, G. 1997. Lepidoptera of the Cordillera del Cóndor, pp. 80-93. *In:* Schulenberg, T. S., Awbrey, K. (Eds.), *The Cordillera del Cóndor Region of Ecuador and Perú: A Biological Assessment.* RAP Working Papers 7. Washington, Conservation International.

Magaldi, L. M., Kaminski, L. A., Seraphim, N., Azeredo-Espin, A. M., Silva-Brandão, K. L., Freitas, A. V. L. 2021. Hidden in the wing dots: Disentangling mimetic sister species of butterflies (Riodinidae: *Stalachtis*) with an integrative approach. *Zoologischer Anzeiger* 294: 92-99.

Neill, D. A. 2005. Cordillera del Cóndor: Botanical treasures between the Andes and the Amazon. *Plant Talk* 41: 17-21.

Pyrcz, T. W., Willmott, K. W., Hall, J. P. W., Viloria, A. L. 2006. A review of the genus *Manerebia* Staudinger (Lepidoptera: Nymphalidae: Satyrinae) in the northern Andes. *Journal of Research on the Lepidoptera* 39: 37-79.

Radford, J. T., Hartley, E., Buckland, K., Padrón, P. S. 2012. *Investigating the Butterfly Diversity of the Tercera Cordillera. The Cambridge University Lepidoptera Expedition to Ecuador 2010: Final Report*. Cambridge, CULEPEX.

Radford, J. T., Willmott, K. W. 2013. A distinctive new subspecies of *Catasticta poujadei* from the Cordillera del Cóndor in eastern Ecuador (Lepidoptera: Pieridae: Pierinae). *Tropical Lepidoptera Research* 23(2): 86-91.

Ron, S. R., Caminer, M. A., Varela-Jaramillo, A., Almeida-Reinoso, D. 2018. A new treefrog from Cordillera del Cóndor with comments on the biogeographic affinity between Cordillera del Cóndor and the Guianan Tepuis (Anura, Hylidae, *Hyloscirtus*). *Zookeys* 809: 97-124.

Schulenberg, T. S., Awbrey, K. (Eds.). 1997. *The Cordillera del Cóndor Region of Ecuador and Perú: A Biological Assessment.* RAP Working Papers 7. Washington, Conservation International.

Seitz, A. 1916-20. 8. Familie Erycinidae, pp. 617-738. *In*: Seitz, A. (Ed.), *Die Gross-Schmetterlinge der Erde.* Volume 5. Stuttgart, A. Kernen.

Stichel, H. F. E. J. 1910-11. *Lepidoptera Rhopalocera. Fam. Riodinidae. Allgemeines. Subfam. Riodininae*, pp. 1-452. *In*: Wytsman, J. (Ed.), *Genera Insectorum*. Volume 112. Brussels, J. Wytsman.

Ulloa, C., Neill, D. A. 2006. *Phainantha shuariorum* (Melastomataceae), una especie nueva de la Cordillera del Cóndor, Ecuador, disyunta de un género guyanés. *Novon* 16: 281-285.

Immature stages of *Rhinthon bajula* (Schaus, 1902) (Hesperiidae: Hesperiinae)

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Abstract: The immature stages of the skipper butterfly *Rhinthon bajula* (Schaus, 1902) are described. The larval host plant in nature is *Canna paniculata* Ruiz & Pav. (Cannaceae). The egg is hemispherical and translucent lime green. To the naked eye, the body of the larva is smooth in all studied instars. The last instar has a plump body and is peppermint-green in color, with dorsal region whitish cream, patterned with several small circular markings. The head is dark brown with a pair of frontal white stripes. The pupa is elongated, without spines, with a long proboscis sheath, as long as the body, and is attached to the leaf by two silk girdles, one at the cremaster and the other at the thoracic region. The relationship between larval body shape and host plant use in Hesperiidae is discussed.

Key words: Atlantic Forest; Cannaceae; Hesperiini; Moncina; skipper.

Resumo: São descritos os estágios imaturos do hesperíideo *Rhinthon bajula* (Schaus, 1902). A planta hospedeira larval na natureza é o caité-do-brejo *Canna paniculata* Ruiz & Pav. (Cannaceae). O ovo é hemisférico, amarelo limão translúcido. A olho nu, o corpo da larva é liso em todos os instares. O último instar possui corpo rechonchudo e verde claro, a região dorsal é mais opaca esbranquiçada com diversas marcas circulares pequenas. A cabeça é marrom escura com um par de faixas brancas frontais. A pupa é alongada, sem espinhos, com a espirotromba com o comprimento do corpo, sendo atada à folha por dois cordões de seda, um no cremáster e outro passando pela região torácica. As relações entre a forma do corpo da larva e o uso de plantas em Hesperiidae são discutidas.

Palavras chave: Cannaceae, diabinha, Hesperiini, Mata Atlântica, Moncina.

INTRODUCTION

Skippers (Lepidoptera: Hesperiidae) comprise one of the most diverse groups of butterflies, with more than 4000 described species, with the center of diversity in the Neotropical region. Besides the remarkable diversity of the family, it is also notable for many aspects concerning its natural history being poorly studied. Moss (1949) was a pioneer in recording host plants and early stages of skippers from Pará, Brazil. Other studies describing detailed aspects of immature biology of Neotropical skippers have been published recently (Burns & Janzen, 1999, 2001; Cock, 2003, 2006, 2008, 2009; Greeney & Warren, 2003, 2004, 2009a,b; Bächtold *et al*., 2012, 2017; Moraes *et al*., 2012; Lepesqueur *et al*., 2017; Freitas, 2018, 2020; Duerr *et al.*, 2022), but considering the richness of the family, knowledge of their early stages remains extremely scarce.

The genus *Rhinthon* Godman, 1900 belongs to the most species-rich subfamily, Hesperiinae, as part of the subtribe Moncina (Hesperiini) (Zhang *et al.*, 2022). The genus comprises seven recognized species distributed throughout the Neotropics (Mielke, 2005; Zhang *et al.*, 2022, 2023), with two species occurring in the Atlantic Forest, namely *Rhinthon bajula* (Schaus, 1902) and *Rhinthon andricus* (Mabille, 1895). *Rhinthon bajula* is not commonly observed and little is known about its behavior and bionomics. In a recent study based on molecular evidence, the genus *Rhinthon* was recovered as sister to *Cynea* Evans, 1955, and this clade is sister to a large clade composed of several genera, including *Tigasis* Godman, 1900, *Paracarystus* Godman, 1900, *Niconiades* Hübner, [1821], *Vettius* Godman, 1901 and *Thoon* Godman, 1900, among others (Zhang *et al.*, 2022).

Although the subtribe Moncina includes about 100 genera and more than 700 species, host plants and immature stages are known for only a tiny portion of the species in this subtribe. Therefore, this study contributes to filling this gap by describing the immature stages of *R. bajula* and providing general information about its natural history and behavior in constructing larval shelters.

MATERIALS AND METHODS

Adults and immatures of *Rhinthon bajula* were studied in the Serra de Mato Grosso, Saquarema municipality, Rio de Janeiro, Brazil (50 m), in November - December, 2023. All descriptions were made based on a sample of five eggs and two larvae obtained in nature. The region is covered by lowland

Atlantic Forest in the plains and submontane Atlantic Forest on the slopes of the nearby mountains. Eggs were obtained in the field and larvae were reared on potted plants of *Canna paniculata* Ruiz & Pav. (Cannaceae) by the first author. Young plants were collected in nature and planted in a sandy substrate in 1-liter plastic vases, which were kept inside a house. This method eliminates the necessity of relocating larvae due to either a shortage or drying of host plants. However, data on intermediate instars were lost during the rearing process and reliable information is available for the first and the two last instars (it is presumed that there are five instars based on data of other related taxa). Data were recorded on morphology and development time for all stages. Dry head capsules and pupal cases were retained in glass vials. Voucher specimens of the immature stages and reared adults were deposited in the Zoological Collection of the Museu de Diversidade Biológica da Unicamp (ZUEC), Universidade Estadual de Campinas, Campinas, São Paulo, Brazil. Taxonomy is based on Mielke (2005), updated to reflect the latest changes suggested by Zhang *et al.* (2022).

RESULTS

Egg. Hemispherical, translucent lime green, diameter about 1.3 mm. A tiny black sub-central spot appears three days after oviposition, where head capsule starts to develop. Duration 5-6 days (n = 5).

First instar. Body completely smooth, tegument whitish translucent; after feeding, body becomes greenish; head capsule black and trapezoidal. Head and body tegument smooth, without scoli or projections; a black prothoracic plate dorsally on T1. Legs and prolegs pale.

Penultimate instar. Body completely smooth, tegument pale green translucent; head dark brown, trapezoidal, with a pair of rounded bumps on vertex. Legs and prolegs pale. Maximum body length 26 mm (n = 7).

Last instar. Body plump, abruptly decreasing in diameter in thoracic segments towards head, completely smooth, peppermint-green, translucent, dorsal region whitish cream, patterned with several small circular markings; head similar to previous instar but elongated, dark brown with a pair of frontal white stripes running from ocellar region to tip of bumps on vertex. Legs and prolegs pale. Head capsule width: 2.53-2.83 mm (mean = 2.722 mm, SD = 0.1018, n = 7), head capsule height 3.51-3.67 mm (mean = 3.625 mm, SD = 0.07933, n = 7); maximum body length 50 mm.

Pupa. General shape elongated, without spines; proboscis sheath same length as body. Attached to leaf by two silk girdles, one at cremaster and other at thoracic region. Inner shelter and pupa are covered by a white waxy dust. General color brown. Length: 25-28 mm (n = 7).

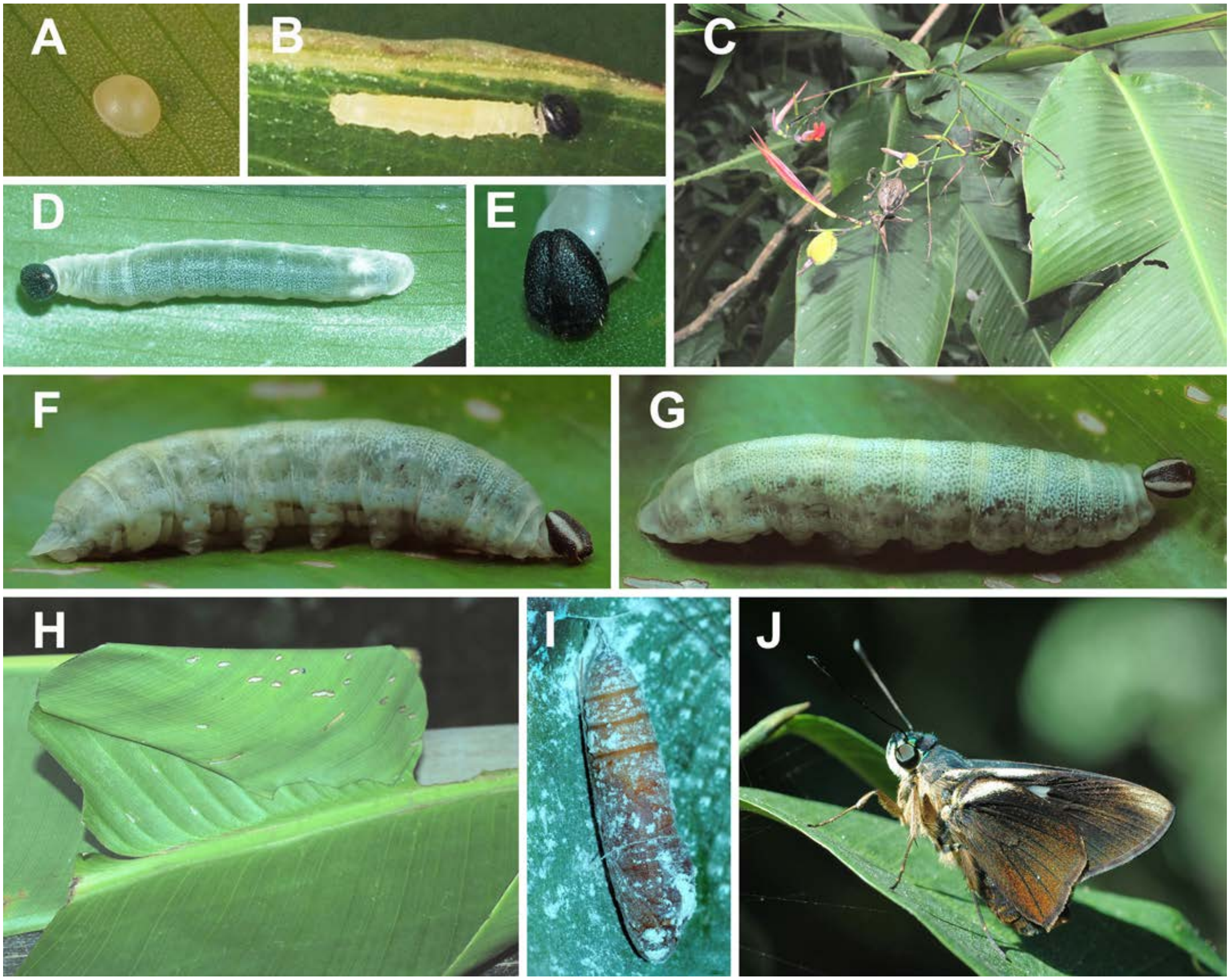

Figure 1. Life stages of *Rhinthon bajula* on *Canna paniculata* in Saquarema, Rio de Janeiro, Brazil. **A**. dorsolateral view of egg; **B**. early first instar, lateral; **C**. general view of the hostplant with flowers and fruits; **D, E**. penultimate instar, dorsal and frontal view of head; **F, G**. last instar, lateral and dorsal view, respectively; **H**. last instar shelter; **I**. pupa in lateral view; **J**. reared adult.

Behavior. Observations on oviposition were based on two separate females on two different days: egg-laying was observed around noon on plants located on the edge of a shaded trail inside the forest. The host plant in nature was identified as *Canna paniculata* Ruiz & Pav. (Cannaceae) (Fig. 1C). Although the host plant was locally common, ovipositions were observed on small plants (1-2 m tall). Female butterflies were observed flying near a group of larger plants, after which they landed on the lower leaves of the smaller plants. These females would take off again and land on the underside of the same leaf, where they laid a single egg. The egg was found to be laid around the middle point between the central vein and the leaf costa. In one instance, an isolated plant was found with a leaf containing two freshly hatched larvae and two eggs. Eggs were always laid on the underside of the leaves. After hatching, larvae ate the eggshell and moved near the leaf margin, aligning parallel to the edge where they started to eat and construct their shelter.

Shelter construction. In the first instar, the larvae positioned themselves parallel to the leaf margin and created a triangular indentation by making a transverse cut in the leaf. Then, they rolled the leaf edge using 4 to 6 silk stitches, folding the leaf and creating a small tunnel. Finally, the larvae hid under a leaf canopy that they made, remaining concealed (shelter Type 6, Group II of Greeney & Jones, 2003 and Type 4 of Greeney, 2009). The larva gradually ate the cut edge of the leaf, creating a triangular shape as it moved towards the central vein. At the same time, it attached silk to the leaf and folded it progressively. As the larva grew larger and passed through the instars, the eating process expanded the original triangular-shaped cut as it migrated down one side of the central vein along the leaf and toward the tip of the leaf. The canopy expanded as it kept accompanying the growing larva development. This methodical eating style resulted in a distinct triangular indentation that deepened as it approached the central vein. Once it reached the vein, the larva shifted its eating direction parallel to the vein and moved toward the leaf tip. In the final instar, the larva sometimes moved onto a fresh leaf and once there, the larva frequently cut halfway through the central vein at the new leaf stalk. This caused the leaf to droop down and slowly wilt over time. After the larva finished eating, it sealed both ends of the folded leaf and began to excrete a white powdery substance. After a few days, typically 2-3, the larva stopped feeding and started to pupate within the hanging and withering leaf shelter.

DISCUSSION

As previously stated, the most recent molecular phylogeny of Hesperiidae recovered *Rhinthon bajula* as a member of the subtribe Moncina, sister to *Rhinthon molion* (Godman, 1901), and the genus *Rhinthon* as sister to *Cynea* (Zhang *et al*., 2022). In fact, the immature stages of both genera are very similar, consistent with this relationship. For example, the head capsule with a pair of white stripes, the plump body abruptly decreasing in diameter towards the head, and the dorsal pattern of the last instar of *R. bajula*, are very similar to those of *Rhinthon cubana* (Herrich-Schäffer, 1865), *Rhinthon osca* (Plötz, 1882), *Rhinthon molion*, *Cynea irma* (Möschler, 1879) and also to *Cynea cannae* (Herrich-Schäffer, 1869) (Moss, 1949; Cock, 2006; Burns *et al*., 2010; Álvarez *et al*., 2020; Orlandin *et al*., 2020). The pupae of both genera are also similar, with a very long proboscis, without cephalic projections, and with the production of white waxy dust (Cock, 2006; Burns *et al*., 2010; Suênia-Bastos *et al*., 2024). Compared to other genera of Moncina in the clade sister to *Rhinthon* + *Cynea* (see Introduction section and Zhang *et al*., 2022), a similar plump body shape abruptly decreasing in diameter towards the head was reported only in *Vettius phyllus* (Cramer, 1777) and *Lychnuchus ponka* Evans, 1955 (Cock, 2006; Duerr *et al*., 2022); in *Niconiades xanthaphes* Hübner, [1821], however, the larval body shape is elongated and slim, just slightly wider than the head (Cock, 2003).

It is worth noting that all plump bodies of the above listed species are associated with the use of host plants with large and soft leaves in the families Cannaceae, Heliconiaceae, Marantaceae and Zingiberaceae, a pattern previously reported for other species of Hesperiidae (Freitas, 2018, 2020). The only species using a Poaceae, *Lychnuchus ponka*, feeds on species of *Pariana* Aubl. (Poaceae: Bambusoideae: Olyreae), a plant with large and soft leaflets compared to other bamboo species (Duerr *et al*., 2022). Curiously, *N. xanthapes*, with a slim and elongated larval body, uses *Olyra latifolia* L. (Poaceae: Bambusoideae: Olyreae), a plant with large leaflets (very similar to species of *Pariana*) (Cock, 2003).

Previous studies with Hesperiidae suggested that plump body shapes are linked to larvae feeding on plants with large and soft leaves, a pattern reported in the subtribes Thymelicina and Pericharina (see Freitas, 2018, 2020). The present study found the same pattern in a different subtribe (Moncina), reinforcing the hypothesis that leaf traits could be a key factor explaining body shape in larvae of Hesperiidae. So, we strongly encourage the descriptions of immature stages of Hesperiidae so that these data could be used in future studies mapping the evolution of body shape and host plant use in this butterfly group.

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LITERATURE CITED

Álvarez, Y., Corso, A. J., Acosta, A. 2020. Nuevos registros y observaciones sobre la historia natural de *Rhinthon cubana* (Lepidoptera; Hesperiidae: Hesperiinae) en Cuba. *Revista cubana de Ciencias biológicas* 8(1): 1-5.

Bächtold, A., Del-Claro, K., Kaminski, L. A., Freitas, A. V. L., Oliveira, P. S. 2012. Natural history of an ant-plant-butterfly interaction in a Neotropical savanna. *Journal of Natural History* 46 (15/16): 943-954.

Bächtold, A., Kaminski, L. A., Magaldi, L. M., Oliveira, P. S., Del-Claro, K., Janzen, D. H., Burns, J. M., Grishin, N., Hajibabaei, M., Hallwachs, W., Freitas, A. V. L. 2017. Integrative data helps the assessment of a butterfly within the *Udranomia kikkawai* species complex (Lepidoptera:

Hesperiidae): Immature stages, natural history, and molecular evidence. *Zoologischer Anzeiger* 266: 169-176.

Burns, J. M., Janzen, D. H. 1999. *Drephalys*: division of this showy Neotropical genus, plus a new species and the immatures and food plants of two species from Costa Rican dry forest (Hesperiidae: Pyrginae). *Journal of the Lepidopterists' Society* 53(3): 77-89.

Burns, J. M., Janzen, D. H. 2001. Biodiversity of pyrrhopygine skipper butterflies (Hesperiidae) in the Area de Conservación de Guanacaste, Costa Rica. *Journal of the Lepidopterists' Society* 55(1): 15-43.

Burns, J. M., Janzen, D. H., Hallwachs, W., Hajibabaei, M., Hebert, P. D. N. 2010. Genitalia, DNA barcodes, larval facies and foodplants place the mimetic species *Neoxeniades molion* in *Rhinthon* (Hesperiidae: Hesperiinae). *Journal of the Lepidopterists' Society* 64(2): 69-78.

Cock, M. J. W. 2003. The skipper butterflies (Hesperiidae) of Trinidad. Part 11, Hesperiinae, Genera group O. *Living World* 2003: 14-48.

Cock, M. J. W. 2006. The skipper butterflies (Hesperiidae) of Trinidad. Part 14, Hesperiinae, genera group L. *Living World* 2006: 8-26.

Cock, M. J. W. 2008. Observations on the biology of *Pyrrhopyge amyclas amyclas* (Cramer) and *Mysoria barcastus alta* Evans (Lepidoptera: Hesperiidae) in Trinidad, West Indies. *Living World* 2008: 43-48.

Cock, M. J. W. 2009. The skipper butterflies (Hesperiidae) of Trinidad. Part 16, Hesperiinae, Genera Group J, *Vettius - Naevolus*. *Living World* 2009: 11-31.

Duerr, N., Corahua-Espinoza, T., Baine, Q., Tejeira, R., Ccahuana, R., Espinoza M. M. Del C., Perlett, E., Cervantes-Martínez, J. N., Santillana, A. L., See, J., Soto-Quispe, Y. S., Wood, H., Arteaga, Z. E., Gallice, G. 2022. Immature stages, new host plant records and shelter structures of *Troyus phyllides* (Röber, 1925) and *Thoon ponka* Evans, 1955 in the Peruvian Amazon (Lepidoptera: Hesperiidae: Hesperiinae: Hesperiini). *Zootaxa* 5200(4): 372-390.

Freitas, A. V. L. 2018. Immature stages of the Neotropical skipper *Lychnuchoides ozias ozias* (Hewitson, 1878) (Lepidoptera: Hesperiidae). *Tropical Lepidoptera Research* 28(1): 25-28.

Freitas, A. V. L. 2020. Immature stages of the Neotropical skipper *Saliana longirostris* (Sepp, [1840]) (Lepidoptera: Hesperiidae). *Tropical Lepidoptera Research* 30(2): 81-85.

Greeney, H. F. 2009. A revised classification scheme for larval hesperiid shelters, with comments on shelter diversity in the Pyrginae. *Journal of Research on the Lepidoptera* 41: 53-59.

Greeney, H. F., Warren, A. D. 2003. Notes on the life history of *Eantis thraso* (Hesperiidae: Pyrginae) in Ecuador. *Journal of the Lepidopterists' Society* 57(1): 43-46.

Greeney, H. F., Warren, A. D. 2004. The life history of *Noctuana haematospila* (Hesperiidae: Pyrginae) in Ecuador. *Journal of the Lepidopterists' Society* 59(1): 6-9.

Greeney, H. F., Warren, A. D. 2009a. The life history and shelter building behavior of *Vettius coryna coryna* Hewitson, 1866 in eastern Ecuador (Lepidoptera: Hesperiidae: Hesperiinae). *Journal of Insect Science* 9(32): 1-9.

Greeney, H. F., Warren, A. D. 2009b. The immature stages and shelter building behavior of *Falga jeconia ombra* in eastern Ecuador (Lepidoptera: Hesperiidae: Hesperiinae). *Journal of Insect Science* 9 (33): 1-10.

Lepesqueur, C., Neis, M., Silva, N. A. P., Pereira, T., Rodrigues, H. P. A., Trindade, T., Diniz, I. R. 2017. *Elbella luteizona* (Mabille, 1877) (Lepidoptera, Hesperiidae: Pyrginae) in Brazilian Cerrado: larval morphology, diet, and shelter architecture. *Revista Brasileira de Entomologia* 61(4): 282-289.

Mielke, O. H. H. 2005. *Catalogue of the American Hesperioidea: Hesperiidae (Lepidoptera).* Curitiba, Sociedade Brasileira de Zoologia. 1: xiii + 125 pp.; 2: [ii] + 127-410; 3: [ii] + 411-771; 4: [ii] + 773-1055; 5: [ii] + 1057-1383; 6: [ii] + 1385-1536. Version: June 9, 2023.

Moraes, A. R., Greeney, H. F., Oliveira, P. S., Barbosa, E. P., Freitas, A. V. L. 2012. Morphology and behavior of the early stages of the skipper, *Urbanus esmeraldus*, on *Urera baccifera*, an ant-visited host plant. *Journal of Insect Science* 12(52): 1-18.

Moss, A. M. 1949. Biological notes on some "Hesperiidae" of Para and the Amazon (Lep. Rhop.). *Acta Zoologica Lilloana* 7: 27-80.

Orlandin, E., Piovesan, M., Carneiro, E. 2020. *Borboletas do Meio-Oeste de Santa Catarina: História Natural e Guia de Identificação*. Joaçaba, Authors. 398 pp.

Suênia-Bastos, A., Cajé, S., Duarte-de-Melo, J., Lima, I. M. de M., Mielke, O. H. H. 2024. Bioecological aspects of *Cynea* (*Cynea*) *diluta* (Herrich-Schäffer, 1869) (Lepidoptera: Hesperiidae: Hesperiinae). Revista Chilena de Entomología 50 (1): 63-74.

Zhang, J., Cong, Q., Shen, J., Grishin, N. V. 2022. Taxonomic changes suggested by the genomic analysis of Hesperiidae (Lepidoptera). *Insecta Mundi* 921: 1-135.

Zhang, J., Cong, Q., Shen, J., Song, L., Opler, P.A., Grishin, N.V. 2023. Additional taxonomic refinements suggested by genomic analysis of butterflies. *The Taxonomic Report of the International Lepidoptera Survey* 11: 1-25.

A new species of *Choranthus* Scudder (Lepidoptera: Hesperiidae: Hesperiinae) from northeastern Cuba

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Abstract: We describe a new species of the genus *Choranthus* Scudder from northeastern Cuba based on morphological and molecular evidence. *Choranthus serranorum* **sp. n.** is the closest relative of *C. richmondi* from the Bahamas. We discuss the implications of its discovery for the evolution of the genus on the islands. Given the apparent restricted distribution of *C. serranorum* **sp. n.**, we recommend a more comprehensive study of its biology.

Key words: Bahamas; COI barcodes; host plant; immature stages; islands; skippers.

Resumen: Describimos una nueva especie del género *Choranthus* Scudder del noreste de Cuba utilizando evidencia morfológica y molecular. *Choranthus serranorum* **sp. n.** es el pariente más cercano de *C. richmondi* de las Bahamas. Discutimos las implicaciones de su descubrimiento en la evolución del género en las islas. Dada la aparente distribución restringida de *C. serranorum* **sp. n.**, recomendamos un estudio más completo de su biología.

Palabras clave: Bahamas; COI código de barras; estadios inmaduros; islas; planta hospedera; saltadoras.

INTRODUCTION

The members of the genus *Choranthus* Scudder, 1872 constitute the second largest endemic butterfly radiation in the Greater Antilles. Among the Greater Antillean endemic butterfly genera, only *Calisto* Hübner, 1823 surpasses *Choranthus*, which now comprises 13 species after the addition of the taxa previously included in *Asbolis* Mabille, 1904 and *Pyrrhocalles* Mabille, 1904 (Zhang *et al.*, 2022, 2023). Most species of *Choranthus* are single island endemics except for two species found in both Cuba and the Bahamas, *C. radians* (Lucas, 1857) and *C. orientis* (Skinner, 1920), and a third inhabiting also South Florida besides those territories, *C. capucinus* (Lucas, 1857).

Many groups of the Greater Antillean biota, including butterflies, are species-poor when compared with the nearby continental areas. On the other hand, butterflies are among the best-studied invertebrates within the archipelago. The combination of these two facts makes the discovery of new butterfly species something that is very rare nowadays. The only exception is the highly diverse genus *Calisto*, with a large number of species recently described after the advent of molecular studies (Núñez *et al.*, 2012, 2013, 2017, 2019; Perez-Asso *et al.*, 2016). The most recent Hesperiidae species discovered from the islands is *Vettius turneri* (Warren & Turland), described from Jamaica (Turland *et al.*, 2012). There have been many skipper species recently added to the Greater Antillean fauna (Zhang *et al.*, 2022, 2023; Núñez *et al.*, 2023), but these only involve taxa already described and now reinstated as species.

Miller (1965) reviewed *Choranthus*, type *C. radians*, and described a new Bahamian species, *C. richmondi* Miller, 1965. This author also removed *magdalia* (Lucas, 1857) and *batesi* (Bell, 1935), included in *Choranthus* by Evans (1955), and provided characters to distinguish *Choranthus* and its closely related genera, species-groups within the genus, and a species identification key. *Choranthus maria* Minno, 1990 from Hispaniola is the most recently described species of the genus (Minno, 1990). In May 2012, a brown, almost unmarked skipper was collected while constantly flying around a large distinctive tussock grass, *Uniola virgata* (Poir.) Griseb, Poaceae, at a coastal area at the eastern outskirts of Baracoa in northeastern Cuba. Examination of the genitalia placed the individual, a female, in the genus *Choranthus*. Its external morphology suggested it did not belong to any of the known species of the genus, something later corroborated by its COI barcode. However, additional

Table 1. *Choranthus* specimens analyzed in this work and the GenBank accession numbers of their COI barcode sequences.

Species	Voucher ID	Country	Accession
Racta racta	USNM:ENT:01586942	Peru	MW982100
Corticea corticea	MACN-Bar-Lep-ct 07905	Argentina	MZ335908
Synapte salenus	04-SRNP-22704	Costa Rica	DQ293341
Anthoptus insignis	11-SRNP-30617	Costa Rica	JQ526654
Flaccilla aecas	09-SRNP-68379	Costa Rica	HM887287
Choranthus antiqua	NW153-20	Dominican Republic	KY019877
Choranthus antiqua	LEP-61253	Dominican Republic	ON436422
Choranthus borincona	WI-JAG-625	Puerto Rico	JN273492
Choranthus borincona	WI-JAG-626	Puerto Rico	JN273493
Choranthus borincona	WI-JAG-627	Puerto Rico	JN273494
Choranthus borincona	WI-JAG-628	Puerto Rico	JN273495
Choranthus capucinus	10BBLEP-01360	USA	HQ583465
Choranthus capucinus	10BBLEP-01375	USA	HQ583480
Choranthus capucinus	10BBLEP-01389	USA	HQ583494
Choranthus capucinus	WI-JAG-679	Cuba	JN273524
Choranthus capucinus	WI-JAG-680	Cuba	JN273525
Choranthus capucinus	UK88		MF555484
Choranthus capucinus	BC ZSM Lep 92906	Cuba	OP587074
Choranthus haitensis	WI-JAG-1060	Dominican Republic	OP586871
Choranthus haitensis	WI-JAG-1173	Dominican Republic	OP586891
Choranthus haitensis	WI-JAG-1171	Dominican Republic	OP586958
Choranthus haitensis	WI-JAG-1172	Dominican Republic	OP586992
Choranthus haitensis	WI-JAG-1059	Dominican Republic	OP586996
Choranthus haitensis	WI-JAG-1057	Dominican Republic	OP586789
Choranthus jamaicensis	BC ZSM Lep 91584	Jamaica	OP587167
Choranthus melissa	WI-JAG-1175	Dominican Republic	OP586825
Choranthus melissa	WI-JAG-1062	Dominican Republic	OP586861
Choranthus melissa	WI-JAG-1061	Dominican Republic	OP586948
Choranthus melissa	WI-JAG-1174	Dominican Republic	OP586986
Choranthus melissa	WI-JAG-1058	Dominican Republic	OP586820
Choranthus orientis	JL-003	Cuba	OP587178
Choranthus radians	RNA-1-175	Cuba	MT672355
Choranthus radians	BC ZSM Lep 92890	Cuba	OP587033
Choranthus radians	JL-043	Cuba	OR145292
Choranthus richmondi	LEP-39741	Bahamas	OP558879
Choranthus richmondi	LEP-65168	Bahamas	PQ150044
Choranthus vitellius	WI-JAG-622	Puerto Rico	JN273489
Choranthus vitellius	WI-JAG-623	Puerto Rico	JN273490
Choranthus vitellius	WI-JAG-624	Puerto Rico	JN273491
Choranthus serranorum	RNA-1-036	Cuba	OR145296
Choranthus serranorum	Y01	Cuba	OR145293
Choranthus serranorum	Y02	Cuba	OR145294
Choranthus serranorum	Y03	Cuba	OR145295

visits to the locality were not possible until November 2021 and July 2022 when more specimens of both sexes were collected. Both males and females resemble the Bahamian *C. richmondi* but are distinctly darker. During a fourth visit in December 2022, a female was observed while ovipositing on *Uniola* and five larvae were collected on the grass. The morphological study of adults and larvae and barcodes led us to distinguish them as members of an unnamed species of *Choranthus* that we described in the present work.

MATERIALS AND METHODS

We obtained COI barcodes following protocols of the Canadian Centre for DNA Barcoding (CCDB, 2013). We cleaned and aligned newly obtained barcode sequences using BioEdit 7.2.6.1 (Hall, 1999). We gathered barcode sequences of ten of the 13 known species of *Choranthus* published by Sahoo *et al.* (2016), Kawahara *et al.* (2023), and Nuñez *et al.* (2023) (Table 1). We submitted newly produced sequences to GenBank (Table 1). Zhang *et al.* (2022, 2023) analyzed the genomes of all these species plus the Jamaican endemic *C. lilliae* Bell, 1931; unfortunately, these data are not publicly available.

We estimated the simple p-distance among the available barcodes of *Choranthus* species using MEGA 11 (Tamura *et al.*, 2021). We inferred a COI gene tree under the maximum likelihood criterion using IQ-TREE 2.2.0 (Minh *et al.*, 2020). The software searched the best-fitting models for the three-codon positions using ModelFinder (Kalyaanamoorthy *et al.*, 2017), which was the GTR model in all cases.

We revised *Choranthus* specimens deposited at the McGuire Center for Lepidoptera (Gainesville), the Zoologische Staatssammlung München (Munich), the Victor Gonzalez Research Collection (currently deposited at Museum of Comparative Zoology, Harvard), the Douglas M. Fernández Research Collection (Camagüey, Cuba), and the Museo Nacional de Historia Natural (MNHN), the Museo Felipe Poey (MFP), and the Instituto de Ecología y Sistemática (CZACC) collections, all in Havana, Cuba. We revised original descriptions, the key, illustrations and diagnoses provided by Miller (1965) for each species of the genus, as well as the detailed descriptions and illustrations by Miller *et al.* (2015). In addition, we examined images of specimens and type specimens

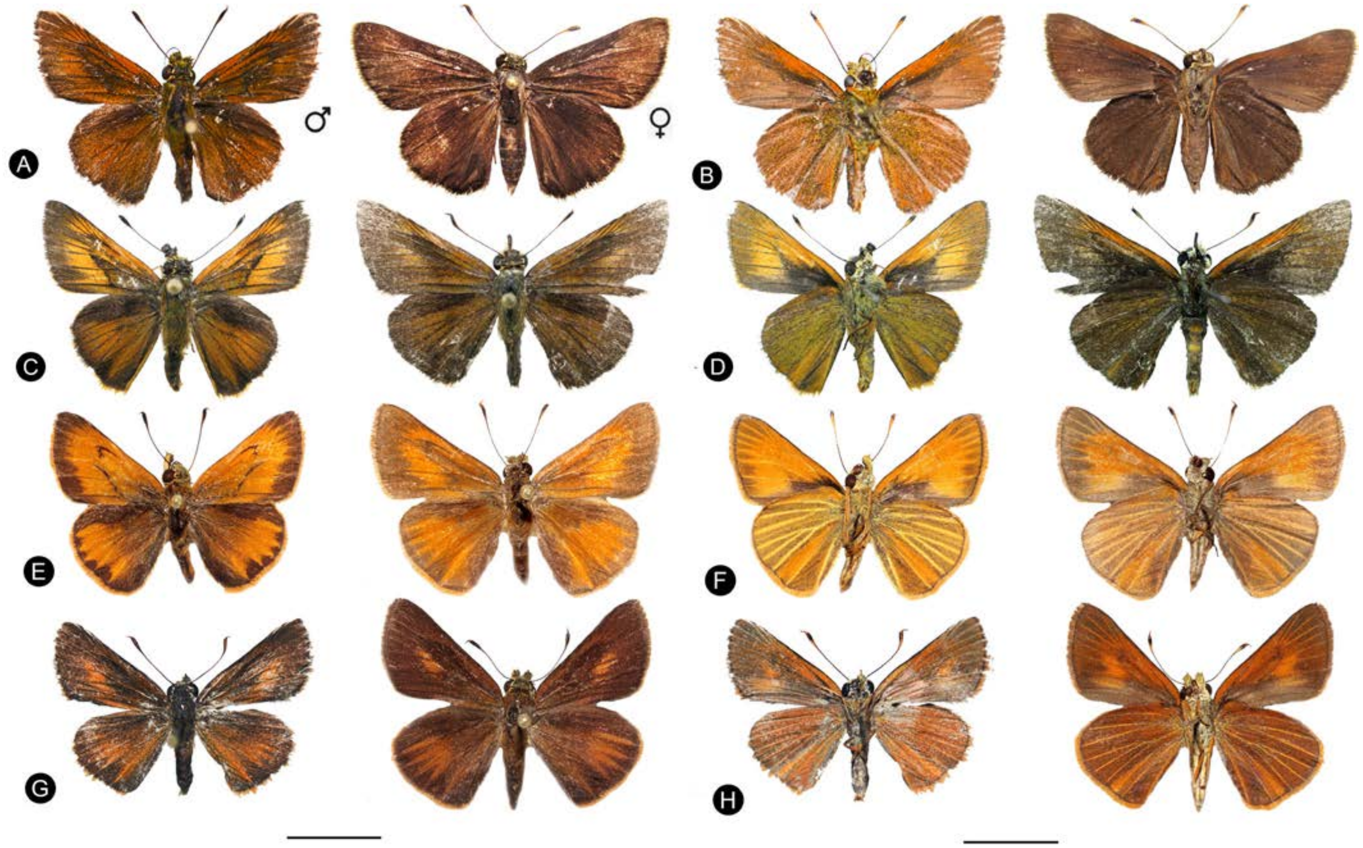

Figure 1. Facies of *Choranthus serranorum* **sp. n.** from Cuba and its closest congeners. *Choranthus serranorum* **sp. n.**: **A**, dorsal view, left- holotype male, Cuba, Y001; right- paratype female, Cuba, BC ZSM Lep 91551. **B**, ventral view: same specimens as in A. *Choranthus richmondi*: **C**, dorsal view, left- male, Bahamas; right- female, Bahamas. **D**, ventral view: same specimens as in C. *Choranthus radians*: **E**, dorsal view, left- male, Cuba; right- female, Cuba. **F**, ventral view: same specimens as in E. *Choranthus radians* "form *ammonia*": **G**, dorsal view, left- male, Cuba; right- female, Cuba. **H**, ventral view: same specimens as in G.

of several *Choranthus* species available at the Butterflies of America website (http://butterfliesofamerica.com/) and the MCZ Database (https://mczbase.mcz.harvard.edu/).

We dissected the genitalia by soaking the abdomens in hot 10% potassium hydroxide until cleaned and then washed them in a 30% alcohol solution with a few drops of acetic acid. We dehydrated the structures in an alcoholic series and mounted them on slides using Euparal or preserved them in glycerol in vials. We photographed the dissected structures using an Olympus E-m10 camera mounted on an Olympus BH2 stereo microscope or an Olympus DP23 digital camera on an Olympus SZX10 microscope. Adult and genitalia photos were all processed with Adobe Photoshop CS2 ® software. Genitalia terminology follows Klots (1970). We use the following abbreviations: FW- forewing, HW- hindwing, L- length, V- ventral surface, D- dorsal surface.

RESULTS

Choranthus serranorum Álvarez & Núñez, sp. n.

(Figs. 1-7)

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Diagnosis. The color pattern of most members of the genus *Choranthus* consist of a brown background with orange patches on both wings that vary in tone and size in each species. Only *C. capucinus* and the females of *C. richmondi* and *C. serranorum* **sp. n.** exhibit a predominantly brown color. In addition, a few individuals of *C. radians* (referred to as form *ammonia* by some authors) exhibit a distinctly darker pattern with smaller dark orange areas instead of larger yellowish orange areas; both color forms still have orange on the HW veins, a diagnostic feature of the species.

Choranthus serranorum **sp. n.** (Figs. 1A-B, 5A-B) most resembles the Bahamian *C. richmondi* (Figs. 1C-D), from which males are distinguished by a darker overall color, broader discal cell stigma in the DFW, and the VFW coloration: *C. richmondi* has a triangular black basal patch and a fulvous discal patch, both of which are reduced in *C. serranorum* **sp. n.**. The males of *C. richmondi* seem to be larger whereas females are similar in size, FW length: males 15-15.4 mm in *C. richmondi* vs 13.4-13.5 in *C. serranorum* **sp. n.**, females 16-16.1 vs 15-16.1 mm, respectively. Their genitalia are very similar (see Miller *et al.*, 2015) and differ mainly in the broader termination of the cucullus and longer juxta in *richmondi*, and the more squared lobes of the uncus of *C. serranorum* **sp. n.** The overall male structure is heavier in *C. serranorum* (Fig. 2). Females of the latter are uniformly brown dorsally, and have a ventral pattern similar to *C. richmondi* but are darker and lack the basal black patch (Figs 1A-D). In the genitalia, the falcate tips of the papillae anales in female *C. serranorum* **sp. n.** separate them

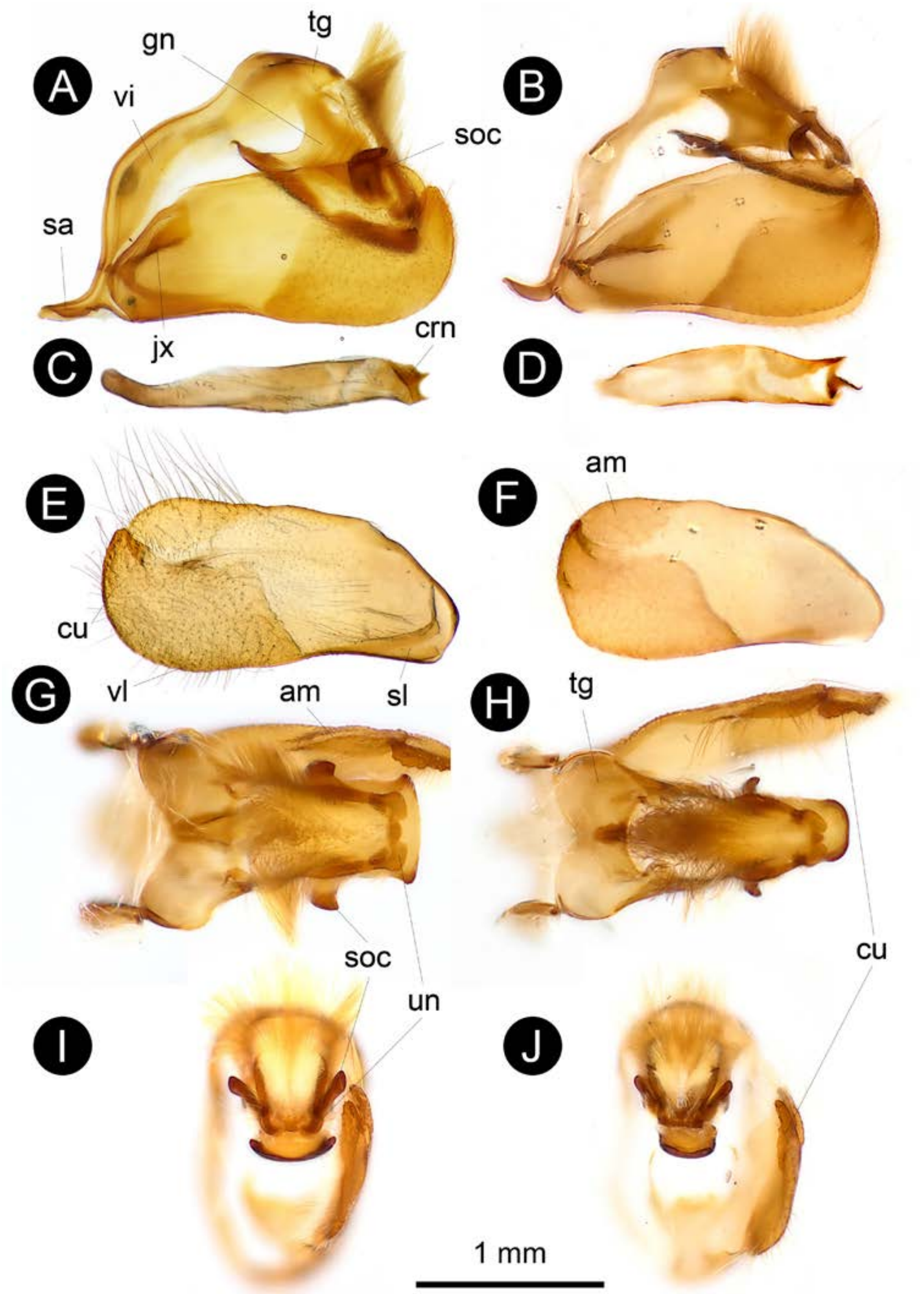

Figure 2. Male genitalia of *Choranthus serranorum* **sp. n.**, left column, and *C. radians*, right column. A, B, main body in lateral view, left valva removed. C, D (posterior tip broken), aedeagus in lateral view. E, F, left valva in lateral view. G, H, main body in dorsal view. I, J, main body in posterior view. Abbreviations: gn- gnathos, vi- vinculum, soc- socii, jx- juxta, tg- tegumen, un- uncus, sa- saccus, sl- sacculus, vl- valvula, cu- cucullus, am- ampulla, crn- cornutus.

from *C. richmondi*, as well as the more elongated lamella antevaginalis (Fig. 3) when comparing with the illustrations by Miller *et al.* (2015).

From sympatric *C. radians*, *C. serranorum* **sp. n.** can be easily separated by the average larger size of females (FW length: 15-16.1 mm vs 14.3-15 mm), the darker coloration in both sexes and the absence of the marked veins in the VHW (Figs. 1A-B, E-F). From the somewhat similar form *ammonia* of *C. radians* (Figs. 1G-H), males differ by having a greater extension of fulvous scales and a broader discal cell stigma in the DFW, while females are browner. Regarding to the genital structures, males possess larger valvae, shorter juxtas, broader gnathos and shorter but broader uncus + tegumen than *C. radians* (Fig. 2). Females are readily separated by the falcate tips of the papillae anales and wider separation of the arms of the lamella postvaginalis in *C. serranorum* **sp. n.** (Fig. 3). The two other Cuban *Choranthus* species, *C. capucinus* and *C. orientis*, are much larger and colored differently, with females of the first

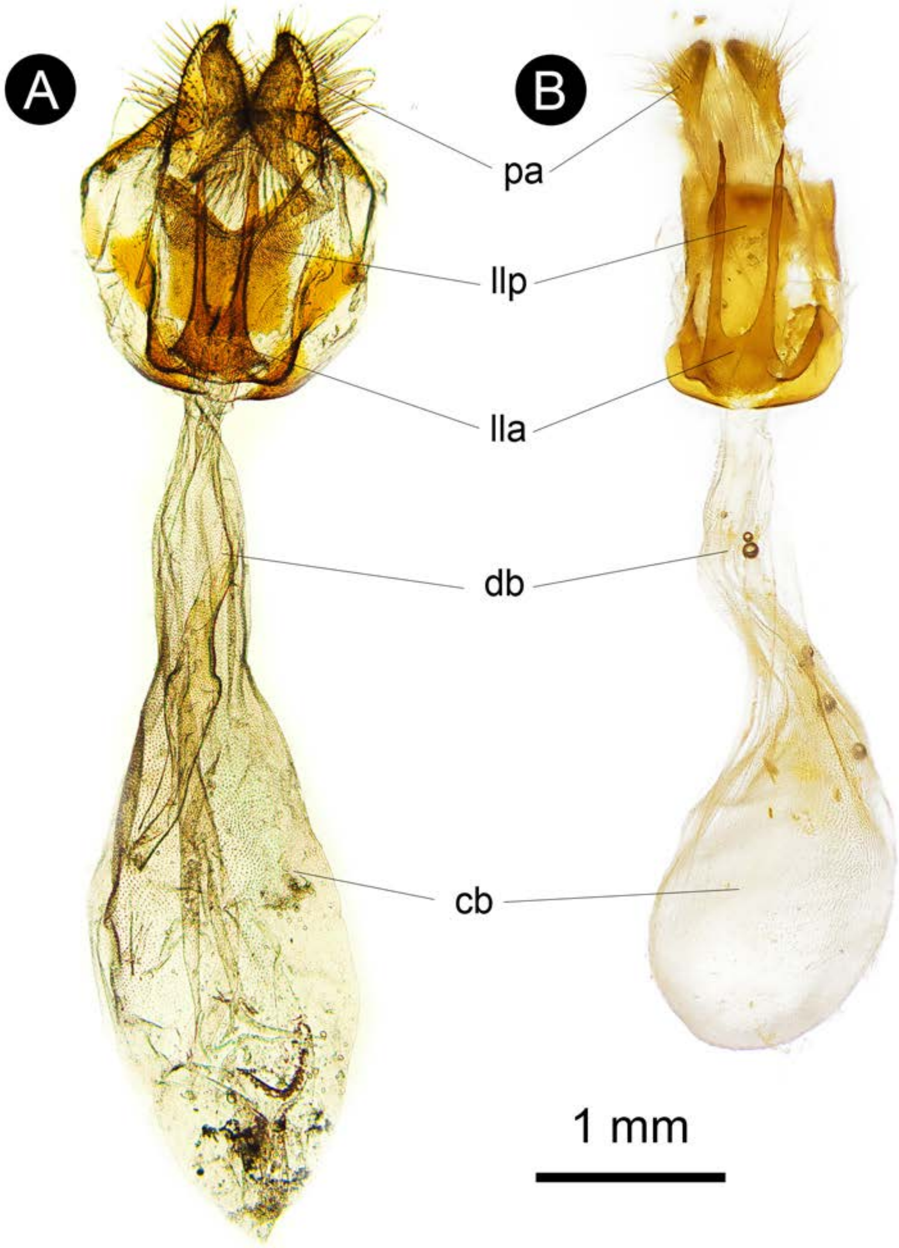

Figure 3. Female genitalia of *Choranthus serranorum* **sp. n.**, A, and *C. radians*, B, in ventral view. Abbreviations: pa- papillae anales, lla- lamella antevaginalis, llp- lamella postvaginalis, db- ductus bursae, cb- courpus bursae.

bearing a pair of post median pale yellow spots that are absent in *C. serranorum* **n. sp.** There are also differences among the last instar larvae of all *Choranthus* species inhabiting Cuba, something that we discuss in the immature stages section.

Outside *Choranthus*, the females of *C. serranorum* **n. sp.** resemble superficially these of *Euphyes singularis* (Herrich-Schäffer, 1865), another skipper found in the Nipe-Sagua-Baracoa Mountains. They have a similar fulvous overall coloration and are slightly larger. The small hyaline spots on the DFW discal cell of *E. singularis* females can be easily overlooked in the field.

Description. Male. FWL 13.4-13.5 mm (*n* = 4). Body fuscous brown, with green overall tinge, mostly on head; eye ring buff; antennae dark brown, club brown with basal and apical thirds fulvous brown. DFW bright fuscous brown, with fulvous scales extending uniformly from base to postdiscal area, with scattered fulvous scales penetrating submarginal area, mostly between apex and Cu_1; submarginal area dark brown, darker near anal angle; veins darkened fuscous brown, with base of radial veins at discal cell and M_2 thickened; a broad, dark brown stigma extending diagonally through discal cell from Cu_1 to 2A (Fig. 1A). DHW dark fuscous brown, with fulvous scales extending uniformly from M_1 to 3A; anal angle, inner margin, outer margin from Cu_2 to 2A, and from costa to M_1, dark brown, with scattered basal fulvous scales near costa; veins darkened fuscous brown, not as dark as in DFW (Fig. 1A). VFW pale brown, with bright fulvous scales extending along costa from base to apex, continued in an arch of scattered fulvous scales from discal cell towards anal angle (Fig. 2B); basal patch of black scales extending from R_1 to 2A. VFW

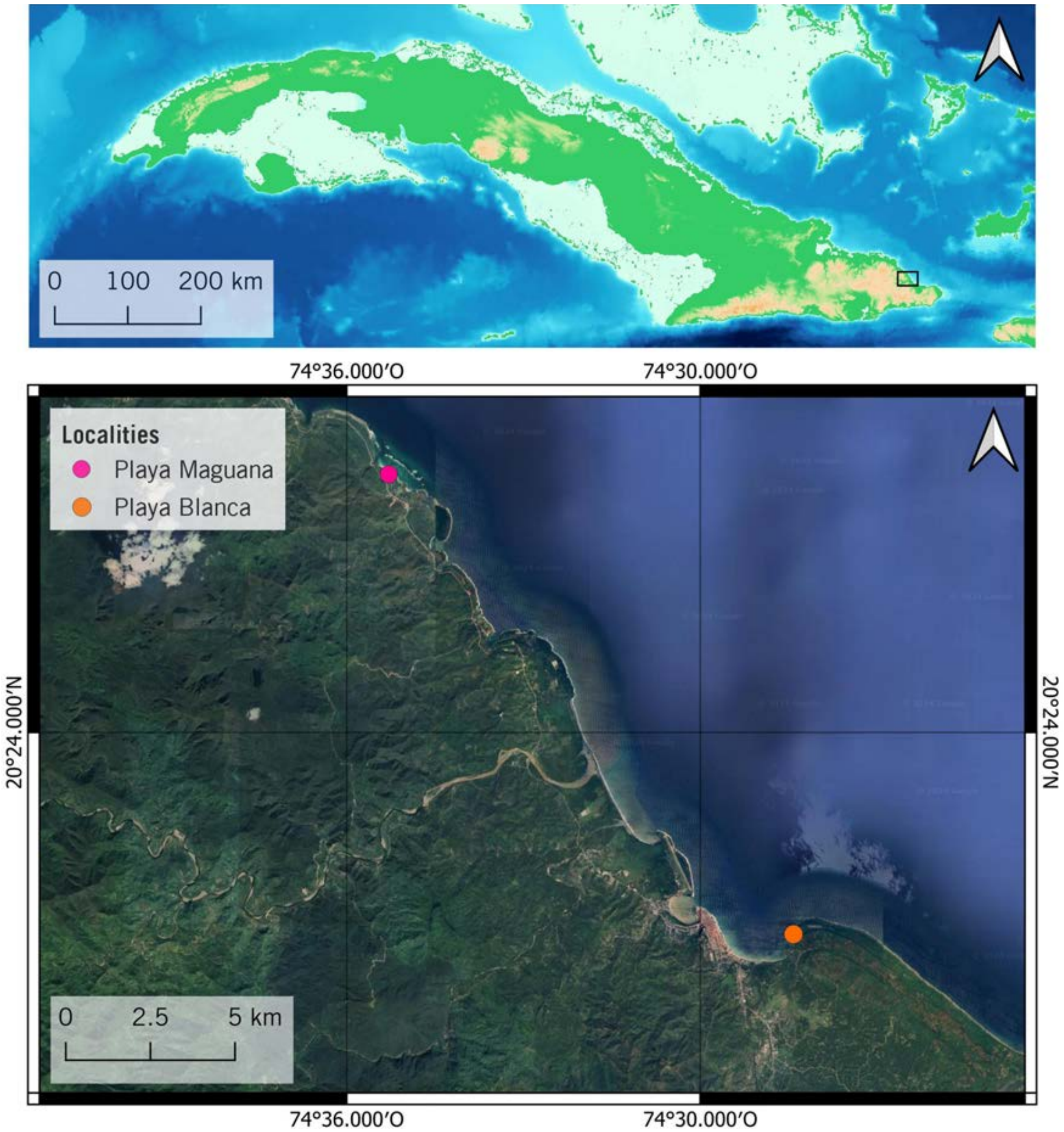

Figure 4. Distribution of *Choranthus serranorum* **sp. n.** in northeastern Cuba. Map generated with QGis 3.26.

pale brown with olivaceous tinge; scattered fulvous scales all over wing, denser at base, from 2A to inner margin and at anal angle (Figs. 1B, 5A). Genitalia (Fig. 2) with highly sclerotized, erect socii, rectangular in shape but curved towards margins; uncus posteriorly subquadrate with short blunt prongs at sides; gnathos prominent, rectangular in shape and ending in a distinctive claw-shaped protuberance and with short blunt lateral prongs at posterior end; saccus shortened and ovoid; valvae wide, thinner near base, with sparse long setae which are denser and larger on tegumen, sacculus reduced, ampulla slightly expanded dorsally, rounded, and separated by a narrow cleft from finely denticulated blunt projection of cucullus, all other parts smooth; juxta short, slightly sclerotized, posterior margin rectangular in shape; aedeagus long and with sclerotized, curved cornutus.

Female. FWL 15-16.1 mm (*n* = 3). Body brown, with green overall tinge, mostly on head; eye ring buff; antennae dark brown, club brown with basal and apical thirds fulvous brown. Dorsal surface uniformly dark brown in both wings, lighter in FW discal cell and with fuscous tinge along costa from base to R_2 (Fig. 1A). Ventral surface similar to male but darker and with fulvous scales much diffuse (Figs. 1B, 5B). Genitalia (Fig. 3) with papillae analis internally falcate near tip, covered by numerous long, thin setae. Lamella antevaginalis fork-shaped and highly sclerotized, outer region basally concave in each side and extending in a small protuberance. Lamella postvaginalis lightly sclerotized, bifurcating in two wide arms towards papillae analis. Ductus bursae opaque, membranous, covered with folds extending into corpus bursae, being both covered in fine spicules even into folds.

Type material. Holotype (Fig. 1A-B) - ♂, CUBA, Guantánamo, Baracoa, Playa Blanca, 20º 34’ N, 74º 47’ W, 5m, 22/XI/2021, Col. A. Serrano, DNA voucher Y001. Deposited in Institute of Ecology and Systematic’s Collection (CZACC, No. 7.519255). **Paratypes** - 3♂, 3♀. Of these, 1♂ and 1♀ with same data as for holotype, DNA vouchers Y002 and Y003. 1♂ and 1♀ with same data as for holotype, except 5/VII/2022, DNA vouchers Y044 and Y045 (not sequenced). 1♂ with same data for holotype, except 3/V/2024. 1♀ with same data as for holotype, except 26/V/2012, Col. R. Núñez, DNA voucher RNA-1-036. Paratypes deposited in the Yosiel Álvarez Collection (YAC, no. YAC-0094, YAC-0095 and YAC-0542), the Institute of Ecology and Systematic’s Collection (CZACC, no. 7.519191, 7.519192 and 7.518996) and the Museum Koenig.

Etymology. We name the species after Adrián Serrano, collector of part of the type series, and his family, especially his late grandfather José “Papi” Serrano. Without their support it would have been impossible to complete this work.

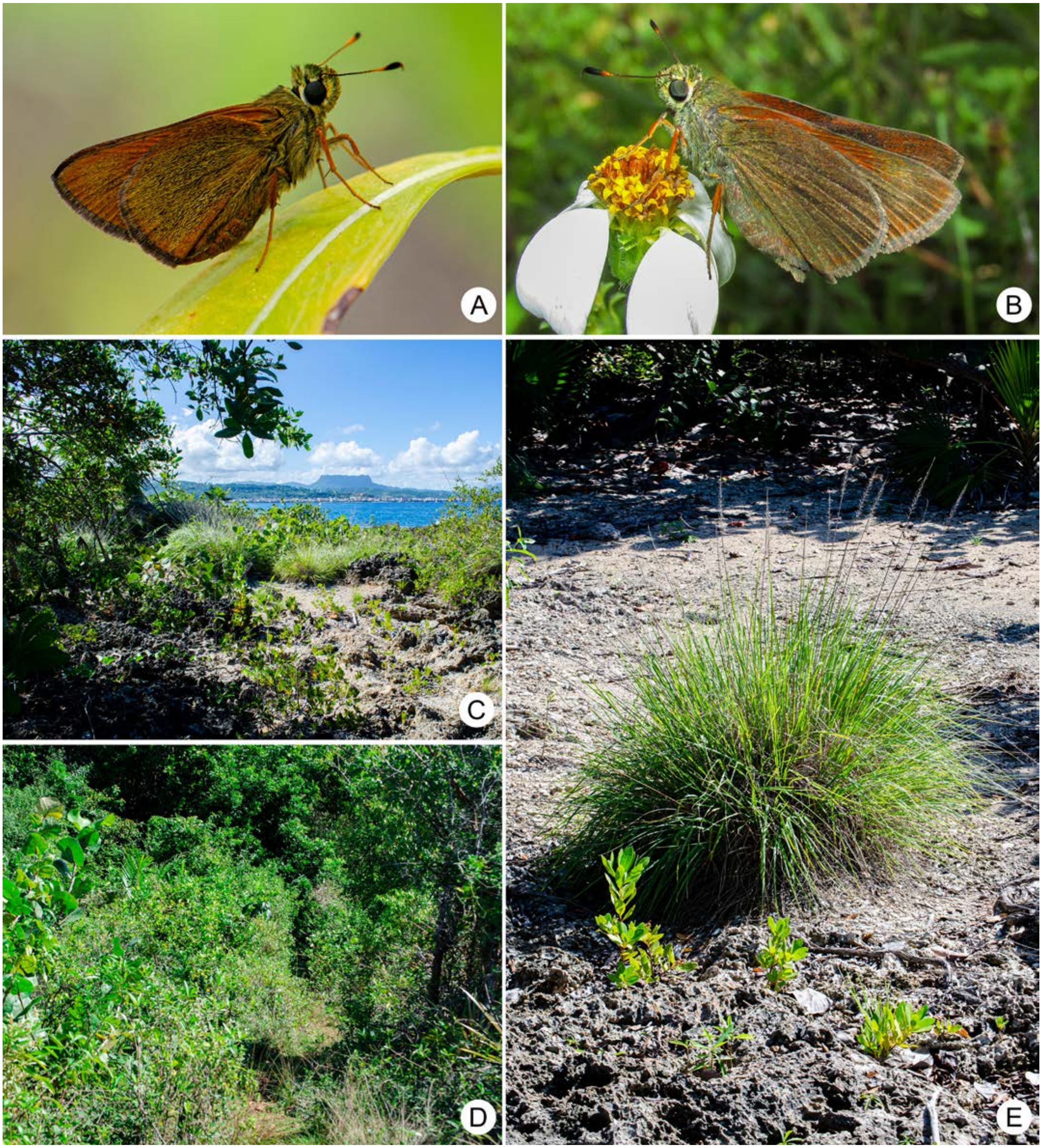

Figure 5. Live specimens of *Choranthus serranorum* **sp. n.**, and its habitat and host plant *Uniola virgata*. A, male from Playa Blanca, Baracoa. B, female from Playa Maguana, Baracoa. C-D, coastal scrub near Playa Blanca, Baracoa. E, *Uniola virgata* (Poir.) Griseb host plant of *Choranthus serranorum*.

Distribution. Known only from two localities near Baracoa city: Playa Blanca, in the western tip of Yara-Majayara Natural Park, 2 km east of Baracoa city, and from Playa Maguana, 16 km west of Baracoa city, Guantánamo province, in eastern Cuba (Fig. 4). Probably also present throughout Baracoa's coastline where the same habitat exists.

Habitat. Low coastal shrubland (Fig. 5C) and associated vegetation along karstic and sandy coastline (Fig. 5D). The tussock grass *Uniola virgata* (Poir.) Griseb is abundant in the area, mostly in the sandy coastline (Fig. 5E).

Biology. The butterfly is frequent, although never abundant, in its very restricted habitat. We found it up to 20 m inland,

Figure 6. Shelters and final instar larvae of *Choranthus serranorum* **sp. n.**. A, B, shelters. C, larva head capsule. D, larva in dorsal view. E, larva in lateral view.

but mostly a few meters from the seashore, where it flies swiftly amongst clearings of thick scrub (Fig. 5D). In this well-preserved habitat, observations suggest that it flies apparently year-round, accompanied by all three other Cuban *Choranthus* and many other butterflies, including endemics such as *Anartia chrysopelea* Hübner, [1831], *Kricogonia cabrerai* Ramsden, 1920, *Parides gundlachianus* (Felder & Felder, 1864), *Phoebis avellaneda* (Herrich-Schäffer, 1865) and *Proteides maysi* (Lucas, 1857). Nectaring was observed on *Lantana involucrata* L., Verbenaceae. Ovipositing behavior was also registered on a young plant of *U. virgata* a few meters from the coast, but the egg was not obtained.

Figure 7. Last instar larvae of the four Cuban *Choranthus* species. A, *C. serranorum* **sp. n.** B, *C. radians*. C, *C. capucinus*. D, *C. orientis*.

Immature stages. Larvae of *C. serranorum* **sp. n.** were collected on *U. virgata*. Larvae build shelters on young leaves of the host plant, cutting the leaf a few centimeters from the apex and folding the margins with silk strands, forming an apical cylinder where they hide, head down, during daytime (Fig. 6A-B). The five collected larvae belonged to different stages, but their coloration was identical, so we only provide the description of the final instar (n = 2).

The maximum width of the head capsule is 3 mm. The ground color is light tan. On each side of the epicranium, from vertex to most of the length of the adfrontal area towards the gena, there are two brown vertical stripes, which are yellowish edged along their inner margin (Figs. 6C-D). Frons with a vertical brown line in the center. Running laterally from ocular area to vertex is a brown stripe (Fig. 6C). Occiput edged with brown.

The ground color of the body is light green, yellowish green between segments, finely dotted with dark green, and with a mid-dorsal line such color (Figs. 6D-E). The prothoracic shield is a narrow black band. There is a conspicuous black irregular line on each side of the anal plate. Prior to pupation the larva develops wax glands in small patches behind each of the abdominal prolegs. The length of mature last instar larva is 38 mm.

The head color pattern of *C. serranorum* larva readily distinguishes it from *C. radians*, as the latter has a paler brown head capsule, the vertical stripes on face are darker brown to black, and there is no brown line in the center of frons (Fig. 7B). The brown line around the margin can be either present or absent in individuals. In frontal view, the head of *C. radians* is rather squarish (see also Dethier, 1939, Plate IX, Fig. 9) rather than rounded as in *C. serranorum*. The larvae of the other two *Choranthus* species inhabiting Cuba, *C. capucinus* and *C. orientis*, besides their larger size, possess pale orange head capsules with different patterned anal shields and black spiracles in the case of the first (Figs. 7C-D).

Table 2. Interspecific simple p-distance among *Choranthus* species. Maximum intraspecific p-distance is shown in the diagonal.

	antiqua (n=1)	*borincona* (n=4)	*capucinus* (n=7)	*haitensis* (n=6)	*jamaicensis* (n=1)	*melissa* (n=5)	*orientis* (n=1)	*radians* (n=3)	*richmondi* (n=2)	*serranorum* (n=4)	*vitellius* (n=3)
antiqua	-										
borincona	6.49	0.00									
capucinus	5.66	6.57	0.16								
haitensis	6.22	7.78	6.23	0.47							
jamaicensis	5.62	7.03	6.27	7.03	-						
melissa	6.27	6.92	7.14	5.39	7.16	0.16					
orientis	2.28	6.68	5.36	6.67	5.78	6.24	-				
radians	5.11	6.36	4.94	5.79	6.46	6.52	5.58	0.99			
richmondi	6.04	7.56	6.44	4.59	6.22	4.90	5.86	5.63	0.17		
serranorum	5.73	7.12	6.97	5.56	7.09	6.09	5.92	6.06	2.58	0.17	
vitellius	6.13	7.95	6.32	2.50	7.65	5.80	6.59	6.31	5.15	6.54	0.15

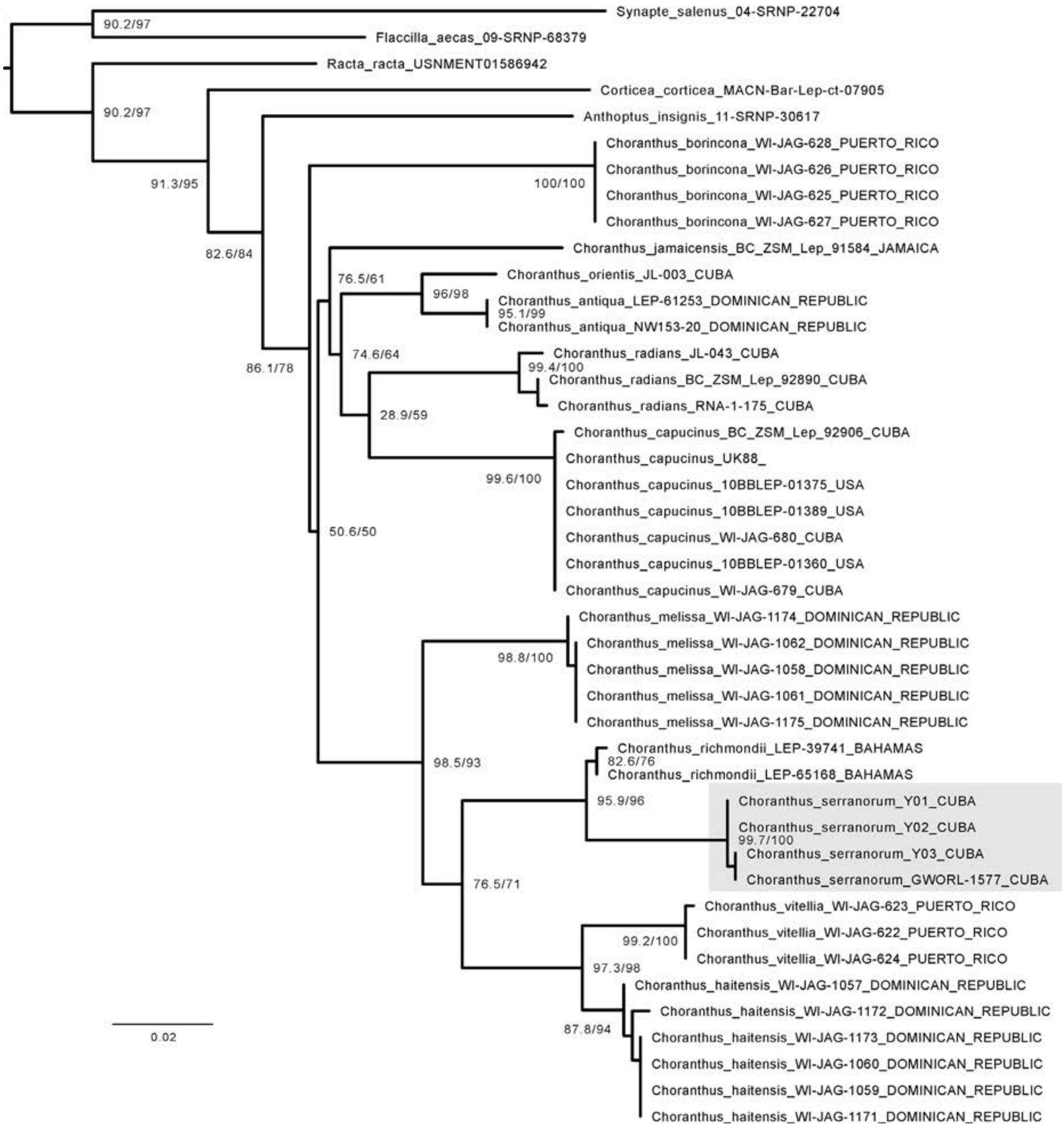

Figure 8. Maximum likelihood tree obtained in IQTREE2 with the available COI barcodes of *Choranthus* species. Numbers at nodes represent ultrafast bootstrap and the SH-aLRT branch test values. The pale gray box highlights the position of *Choranthus serranorum* **sp. n.**

COI barcodes. The minimum simple p-distance between COI barcodes of *C. serranorum* and other *Choranthus* is 2.58% to *C. richmondi* (Table 2). This value is similar to the minimum distance between *C. orientis* and *C. antiqua*, 2.28%, and between *C. haitensis* and *C. vitellius*, 2.5%. The maximum distance between conspecific individuals of *C. serranorum* and *C. richmondi* is 0.17% (Table 2).

Phylogenetic position of *Choranthus serranorum* sp. n. Our maximum likelihood anlaysis with COI barcodes places the new species as sister to Bahamian *C. richmondi* with strong support (Fig. 8). They belong into a clade together with *C. melissa* and *C. haitensis* from Hispaniola and *C. vitellius* from Puerto Rico. Support varies across nodes of our tree from strong to weak.

DISCUSSION

Although we did not perform a formal biogeographical analysis of *Choranthus*, the clade in our tree containing *C. serranorum* **sp. n.** matches the topology of the trees of Zhang *et al.* (2022, 2023) based on genomic data. Yet, there are some discrepancies with the topology recovered in the aforementioned works, such as the placement of *C. radians*. Apparently, COI barcodes do not contain enough information to recover all relationships and several nodes of our tree have a weak support. The evolutionary relationships within *Choranthus* point toward a history of dispersal events followed by speciation in allopatry for many *Choranthus* species. Several species pairs inhabit different islands or archipelagos: *C. vitellius* (Puerto Rico)-*C.*

haitensis (Hispaniola), *C. antiqua* (Hispaniola)-*C. orientis* (Cuba-Bahamas), and *C. richmondi* (Bahamas)-*C. serranorum* **n. sp.** (Cuba). Given the relatively recent origin of most Bahamian islands, 1 MYA or less (Iturralde-Vinent, 2006), the ancestors of present populations likely reached these islands from Cuba in recent times.

The discovery of another species of the genus *Choranthus* is noteworthy but not entirely unexpected. The type locality of *C. serranorum* **n. sp.** lies at the foot of the Nipe Sagua Baracoa massif, a region with an old and complex geological history (Iturralde-Vinent, 2006) that likely has played a major role in the evolution of a wide range of habitats, harboring today a biodiversity among the largest in the West Indies (Pullaiah, 2018). The northeastern coast of Cuba is also the closest point to some of the Bahamian islands, something reflected in the similarity of their faunas, including butterflies. There are several species shared exclusively between Cuba and the Bahamas, with examples such as *Euphyes cornelius* (Latreille, [1824]), *Telegonus xagua* (Lucas, 1857), *Burca braco* (Herrich-Schäffer, 1865), *B. concolor* (Herrich-Schäffer, 1865), *Choranthus orientis, C. radians, Dianesia carteri* (Holland, 1902), *Lucinia sida* Hübner, [1823], *Marpesia eleuchea* Hübner, 1818, and *Parachoranthus magdalia,* among others (Smith *et al.*, 1994; Miller *et al.*, 2015; Zhang *et al.*, 2022, 2023; Núñez *et al.*, 2023). The first records of some of these taxa from Cuba or the Bahamas date only from few decades ago (Knowles, 1995; Cock, 1998; Rozicki & Knowles, 2011) suggesting the need for more fieldwork across both archipelagos but also the likelihood of the extinction, dispersal, and recolonization events at the islands.

Multiple factors may have caused *Choranthus serranorum* to be overlooked until now. One of them is its resemblance, at least at first sight in the field, to other Cuban Hesperiinae, such as *C. radians* in the case of the male and *E. singularis* in the case of the female. Another factor might be the marginality of its coastal habitat compared to other better-sampled Cuban areas, which are mainly located up in the mountains. Despite the latter, a few coastal areas across the Cuban archipelago have been relatively well sampled with no records of this skipper (Hernández *et al*., 1994; Núñez & Barro-Cañamero, 2003; Núñez, 2009).

What limits the distribution of *Choranthus serranorum* remains unclear. Its habitat and host plant, *Uniola virgata*, are present not only across the Cuban archipelago but also along the West Indies (Yates, 1966). The actual distribution of *C. serranorum* might be larger, with the species at least present in nearby coastal areas. The lack of records might be the result of a sampling bias and its resemblance to other species in the field, as commented above. We encourage others to look for this species around Baracoa to try to unveil the actual extent of its distribution towards a future assessment of the status of its populations.

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LITERATURE CITED

CCDB. 2013. The Canadian Centre for DNA Barcoding (CCDB). Available at: http://www.ccdb.ca/resources.php

Cock, M. J. W. 1998. Two species of Hesperiidae recently established on New Providence. *Bahamas Journal of Science* 5(3): 12-15.

Dethier, V. G. 1939. Metamorphoses of Cuban Hesperiinae. Psyche (Cambridge) 46(4): 147-155.

Evans, W. H. 1955. A catalogue of the American Hesperiidae indicating the classification and nomenclature adopted in the British Museum (Natural History). Part IV. Hesperiinae and Megathyminae. London, British Museum (Natural History). v + 499 pp., pls. 54-88.

Hall, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleid Acids Symposyum Series* 41:95-98.

Hernández, L. R., Smith, D. S., Davies, N., Aceres-Mallea, A. 1994. The butterflies and vegetational zones of Guanahacabibes National Park, Cuba. *Bulletin of the Allyn Museum* 139: 1-19.

Iturralde-Vinent, M. 2006. Meso-Cenozoic Caribbean Paleogeography: Implications for the Historical Biogeography of the Region. *International Geology Review* 48: 791-827.

Kalyaanamoorthy, S., Minh, B., Wong, T., von Haeseler, A., & Jermiin, L. S. 2017. ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* 14: 587-589.

Kawahara, A. Y., Storer, C., Carvalho, A. P. S. *et al.*, 2023. A global phylogeny of butterflies reveals their evolutionary history, ancestral hosts and biogeographic origins. *Nature Ecology & Evolution* 7: 903-913.

Klots, A. B. 1970. *Lepidoptera*, pp. 115-130. *In*: Tuxen, S. L. (Ed.), *Taxonomist's Glossary of Genitalia in Insects*. 2nd ed. Copenhagen, Munksgaard.

Knowles, D. O. 1995. First records of *Parachoranthus magdalia* (Hesperiidae) from the Bahamas, and the extension of the Bahamian range of *Battus devilliers* (Papilionidae). *Journal of the Lepidopterists' Society* 49(1): 91-94.

Miller, L. D. 1965. A review of the West Indian *Choranthus*. *Journal of Research on the Lepidoptera* 4(4): 259-274.

Miller, J. Y., Matthews, D. L., Simon, M. J., Rozycki, R. M. 2015. Review and comments on the current status of *Choranthus richmondi* L. Miller (Lepidoptera: Hesperiidae) in the Bahamas. *Insecta Mundi* 414: 1-9.

Minh, B. Q., Schmidt, H. A., Chernomor, O., Schrempf, D., Woodhams, M. D., von Haeseler, A., Lanfear, R. IQ-TREE 2: New models and efficient methods for phylogenetic inference in the genomic era. *Molecular Biology & Evolution* 37(5): 1530-1534.

Minno, M. C. 1990. A new species of *Choranthus* from Hispaniola (Lepidoptera: Hesperiidae). *Tropical Lepidoptera* 1(2): 55-58.

Núñez, R. 2009. Adiciones a la fauna de lepidópteros de la reserva ecológica Siboney-Juticí, Santiago de Cuba, Cuba (Insecta: Lepidoptera). *Revista Biología* 21(1-2): 70-78.

Núñez, R. Barro-Cañamero, A. 2003. Composición y estructura de dos comunidades de mariposas (Lepidoptera: Papilionoidea) en Boca de

Canasí, La Habana, Cuba. *Revista Biología* 17(1): 8- 17.

Núñez, R., Barro-Canamero, A., Minno, M. C., Fernández, D. M., Hausmann, A. 2019. The *herophile* species group of *Calisto* (Lepidoptera : Nymphalidae : Satyrinae), new taxa and historical biogeography. *Invertebrate Systematics* 33: 644-660.

Núñez, R., Genaro, J. A., Miller, J. Y., Barro-Cañamero, A., Álvarez, Y., Fernández, D. M., Minno, M. C., Turner, T., Vaughan, T., Wahlberg, N., Pérez-Asso, A. R., Hausmann, A. 2023. DNA barcodes of the Greater Antillean butterflies (Lepidoptera: Papilionoidea) suggest a richer, more isolated fauna and higher endemism. *Biological Journal of the Linnean Society* 140(3): 447-458.

Núñez, R., Matos-Maravi, P. F., Wahlberg, N. 2013. New *Calisto* species from Cuba, with insights on the relationships of Cuban and Bahamian taxa (Lepidoptera, Nymphalidae, Satyrinae). *Zootaxa* 3669(4): 503-521.

Núñez, R., Oliva, E., Matos, P. F., Wahlberg, N. 2012. Cuban *Calisto* (Lepidoptera, Nymphalidae, Satyrinae), a review based on morphological and DNA data. *ZooKeys* 165: 57- 105.

Núñez, R., Pérez-Asso, A. R., Genaro, J. A., Hausmann, A. 2017. A new species of the *hysius* species-group of *Calisto* Hübner (Lepidoptera, Nymphalidae, Satyrinae) and insights into the status of different populations currently attributed to *C. grannus* Bates. *Zootaxa* 4317: 1-44.

Pérez-Asso, A. R., Núñez, R., Genaro, J. A. 2016. Morphology and COI barcodes reveal four new species in the *lycieus* group of *Calisto* (Lepidoptera, Nymphalidae, Satyrinae). *Zootaxa* 4170(3): 401-450.

Pullaiah, T. (Ed.). 2018. *Global Biodiversity: Volume 4: Selected Countries in the Americas and Australia (1st ed.).* Apple Academic Press.

Rozicki, R., Knowles, D. O. 2011. Some new records of butterflies from Great Inagua, Bahamas. *New of the Lepidopterists' Society* 53(4): 104.

Sahoo, R. K., Warren, A. D., Wahlberg, N., Brower, A. V. Z., Lukhtanov, V. A., Kodandaramaiah, U. 2016. Ten genes and two topologies: an exploration of higher relationships in skipper butterflies (Hesperiidae). *PeerJ* 4:e2653.

Smith, D. S., Miller, L. D., Miller, J. Y. 1994. *The Butterflies of the West Indies and South Florida.* New York, Oxford University Press. 256 pp.

Steinhauser, S. R., Miller, J. Y., Grishin, N. V. 2017. Review of the West Indian *Astraptes xagua* (Lucas) complex (Hesperiidae: Eudaminae) with the description of a new subspecies from the Bahamas. *Journal of Research on the Lepidoptera* 49: 81-90.

Tamura, K., Stecher, G., Kumar, S. 2021. MEGA11: Molecular Evolutionary Genetics Analysis version 11. *Molecular Biology and Evolution* 38: 3022-3027.

Turland, V. A., Warren, A. D., Lewis, D. S. A. 2012. A new genus and species of Moncini from Jamaica, West Indies (Lepidoptera, Hesperiidae, Hesperiinae). *Tropical Lepidoptera Research* 22(2): 66-73.

Yates, H. O. 1966. Revision of Grasses Traditionally Referred to *Uniola*, I. *Uniola* and *Leptochloöpsis*. *The Southwestern Naturalist* 11(3): 372-394.

Zhang, J., Cong, Q., Shen, J., Song, L., Grishin, N. V. 2022. Taxonomic changes suggested by the genomic analysis of Hesperiidae (Lepidoptera). *Insecta Mundi* 921: 1-135.

Zhang, J., Cong, Q., Shen, J., Song, L., Opler, P. A., Grishin, N. V. 2023. Additional taxonomic refinements suggested by genomic analysis of butterflies. *Taxonomic Report of the International Lepidoptera Survey* 11(1): 1-25.

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