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ARTICLE

103 butterflies (Papilionoidea) from Ilha Grande and Ilha da Marambaia, Rio de Janeiro, Brazil

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Abstract. Here we show a list of 103 butterflies (Papilionoidea) found at Ilha Grande and Ilha da Marambaia, Rio de Janeiro State, Brazil. To our knowledge, this is the first butterfly inventory conducted in these islands. The species richness, the collecting methods utilized, endemism, and the mimicry rings found in the islands are discussed. Moreover, we emphasize the importance and the utilization of butterflies as suitable models to assess community ecology patterns.

Keywords. Atlantic Forest; Coastal Rain Forest; Inventory; Diversity.

Resumo. 103 borboletas (Papilionoidea) da Ilha Grande e Ilha da Marambaia, Rio de Janeiro, Brasil. Neste artigo apresentamos uma lista com 103 borboletas (Papilionoidea) encontradas na Ilha Grande e Ilha da Marambaia no Estado do Rio de Janeiro, Brasil. Até onde sabemos este é o primeiro inventário de borboletas realizado nestas ilhas. A riqueza de espécies, os métodos de coleta utilizados, endemismos e os anéis miméticos encontrados em ambas as ilhas são discutidos. Além disto, nos enfatizamos a importância e a utilização de borboletas como modelos na investigação de padrões relacionados à ecologia de comunidades.

Palavras-Chave. Floresta Atlântica; Floresta Pluvial Costeira; Inventários; Diversidade.

INTRODUCTION

The Atlantic Forest is by far the richest biome for butterflies and many other animals in the Neotropics (Brown-Jr. & Freitas, 2000; Myers *et al.,* 2000; Lamas, 2004). Unfortunately, it is also the most devastated biome in this large region with less than 12% of its original distribution relatively preserved (Ribeiro *et al.,* 2009). One of the most vulnerable parts of the Atlantic Forest Biome is known as Coastal Rain Forest (Ferri, 1980) that is now restricted to the sides of the Serra do Mar and islands along the Brazilian cost, especially in the Rio de Janeiro State. Ilha Grande (193 km^2) and Ilha da Marambaia (81 km^2) are among the biggest islands of this region (Fig. 1). The former is isolated from the mainland for about 2 km and is covered mostly by dense (47%) and advanced successional stage (43%) of forests (Alho *et al.,* 2002; Oliveira, 2002; Callado *et al.,* 2009). The latter is not a true island as it is connected to mainland by an extension of about 35 km of sandbanks covered by restinga vegetation, but also contains a relatively large portion of primary and secondary Coastal Rain Forest (Pereira *et al.,* 1990; Proença *et al.,* 2013). The forest part of Marambaia belongs to the Brazilian Navy and the restricted access contributed to preserve the vegetation.

A great deal of research has been devoted to the identification and characterization of the flora and fauna of both islands (reviewed in Menezes *et al.,* 2005; INEA, 2010). However, we found no information concerning their butterfly faunas. This led us to publish our list of butterflies (Papilionoidea) observed and collected in these islands almost two decades ago (see below). In addition to general comments on the list and the mimicry rings observed, we reinforce the importance of butterflies as suitable models to assess community ecology patterns.

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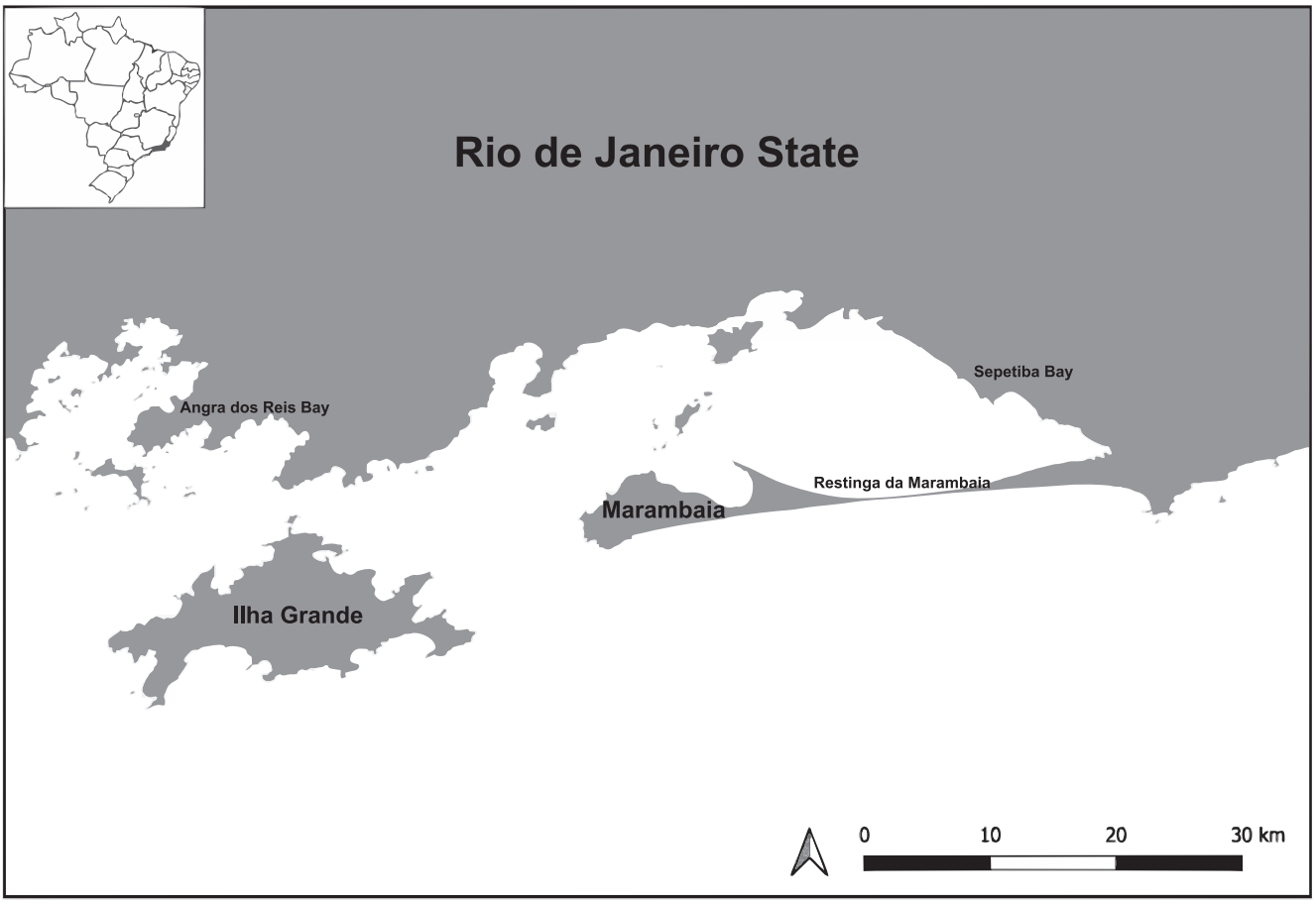

Figure 1. View of Ilha Grande and Ilha da Marambaia, Rio de Janeiro.

MATERIALS AND METHODS

Rather than a traditional inventory, most butterflies in our list were utilized in a variety of behavioral and ecological didactical projects developed in the "ecology field course" of the University of Brasilia. Field courses at Ilha Grande were conducted in April 8-13, 1996; May 1-9, 1999; and June 3-10, 2001. Representative specimens of the butterflies were collected with entomological nets and/or traps containing baits of banana fermented in sugarcane juice in sites relatively close to the Vila do Abraão (23°08′40.5″S; 44°10′12.9″W) on the west side of the island. Field courses at Marambaia were conducted in June 23-29, 2002; May 25-31, 2003; May 9-15, 2004, and May 22-28, 2005. Butterfly collection also involved both methods in sites around the Centro de Adestramento da Ilha da Marambaia (CADIM) (23°04′06″S; 43°57′56″W) on the east side of the island. All butterflies were deposited in the Entomological Collection of the University of Brasília.

RESULTS AND DISCUSSION

A list of 103 butterflies (Papilionoidea) including 60 species found at Ilha Grande and 85 at Ilha da Marambaia is shown in Table 1. Such a difference between islands is due to differences in sampling intensity and, therefore, does not reflect the actual species richness of butterflies in each island. In fact, we do expect that future surveys will reveal many new records of butterflies in both islands. Most butterflies collected were Nymphalidae (n = 73), but representative species of the Papilionidae (n = 3), Pieridae (n = 8), Lycaenidae (n = 3), Riodinidae (n = 2), and Hesperiidae (n = 14) were also found. The large number of Nymphalidae is due to several projects conducted with the Danainae (n = 18) and Heliconiinae (n = 12), two taxa that contain many mimetic butterflies that are easily seen and easily collected with entomological nets (part of them is illustrated in Figs. 2-4), as well as projects involving fruit-feeding butterflies. The latter constitutes a guild of adult butterflies that includes several Nymphalinae (n = 6), Limenitidinae (n = 2), Biblidinae (n = 14), Charaxinae (n = 6) and Satyrinae (n = 15).

Most other taxa remain subsampled. The Pieridae, for instance, is represented by 46 species in continental Rio de Janeiro (Monteiro *et al.,* 2009). Our observations indicate that some of them also occur at Ilha Grande and Ilha da Marambaia. Large and migratory butterflies like *Anteos* Hübner, [1819] and *Phoebis* Hubner, [1819] (Coliadinae) were sighted – but not collected, on many different occasions. The Lycaenidae, with 207 species already found in Rio de Janeiro state (Duarte *et al.,* 2009) and the Riodinidae are groups highly represented in the Atlantic Forest and many new records of both groups are expected to occur in future surveys. In the case of

Table 1. Butterflies (Papilionoidea) found at Ilha Grande and Ilha da Marambaia, Rio de Janeiro State, Brazil and their mimicry rings: BRW (= black, red & white spots); T (= Tiger); CW (= clear wing); BRY (= black, red & yellow bar); OBS (= orange & black stripes). MM = model or Müllerian mimic; BM = Batesian mimic.

TAXA	MIMICRY RINGS	ILHA GRANDE	MARAM-BAIA
PAPILIONIDAE			
Papilioninae			
Troidini			
Battus polydamas polydamas (Linnaeus, 1758)		X	X
Parides tros tros (Fabricius, 1793)		X	
Parides anchises nephalion (Godart, 1819)	BRW – MM	X	X
PIERIDAE			
Dismorphiinae			
Dismorphia amphione astynome (Dalman, 1823)	T – BM	X	X
Coliadinae			
Eurema elathea flavescens (Chavannes, 1850)		X	X
Eurema albula sinoe (Godart, 1819)		X	
Pyrisitia leuce leuce (Boisduval, 1836)			X
Leucidia elvina (Godart, 1819)			X
Phoebis philea philea (Linnaeus, 1763)		X	
Pierinae			
Pierini			
Ascia monuste orseis (Godart, 1819)		X	X
Archonias brassolis tereas (Godart, 1819)	BRW – BM	X	
LYCAENIDAE			
Theclinae			
Eumaeini			
Pseudolycaena marsyas (Linnaeus, 1758)		X	X
Strymon mulucha (Hewitson, 1867)		X	
Panthiades phaleros (Linnaeus, 1767)			X
RIODINIDAE			
Riodininae			
Mesosemiini			
Leucochimona icare matatha (Hewitson, 1873)			X
Nymphidiini			
Nymphidium lisimon (Stoll, 1790)			X
NYMPHALIDAE			
Danainae			
Danaini			
Lycorea halia discreta Haensch, 1909	T – MM	X	X
Danaus gilippus gilippus (Cramer, 1775)			X
Ithomiini			
Aeria olena olena Weymer, 1875			X
Melinaea ethra (Godart, 1819)	T – MM	X	X
Melinaea ludovica paraiya Reakirt, 1866	T – MM	X	X
Mechanitis lysimnia lysimnia (Fabricius, 1793)	T – MM	X	X
Mechanitis polymnia casabranca Haensch, 1905	T – MM	X	X
Hypothyris ninonia daeta (Boisduval, 1836)	T – MM	X	X
Ithomia agnosia zikani R.F. D'Almeida, 1940	CW – MM	X	X
Ithomia drymo Hübner, 1816	CW – MM	X	X
Oleria aquata (Weymer, 1875)		X	X
Episcada striposis Haensch, 1909	CW – MM	X	X
Episcada hymenaea hymenaea (Prittwitz, 1865)	CW – MM	X	
Pteronymia euritea (Cramer, 1780)	CW – MM	X	
Mcclungia cymo salonina (Hewitson, 1855)	CW – MM	X	
Heterosais edessa (Hewitson, [1855])	CW – MM	X	
Pseudoscada acilla acilla (Hewitson, 1867)	CW – MM	X	X
Pseudoscada erruca (Hewitson, 1855)	CW – MM	X	
Heliconiinae			
Acraeini			
Actinote carycina Jordan, 1913	T – MM		X
Actinote parapheles Jordan, 1913	T – MM	X	
Actinote pellenea pellenea Hübner, [1821]	T – MM	X	X
Actinote sp.	T – MM	X	
Heliconiini			
Dryadula phaetusa (Linnaeus, 1758)	OBS – MM	X	X
Dryas iulia alcionea (Cramer, 1779)	OBS – MM	X	X
Dione juno juno (Cramer, 1779)	OBS – MM	X	X
Eueides aliphera aliphera (Godart, 1819)	OBS – MM	X	X
Heliconius erato phyllis (Fabricius, 1775)	BRY – MM	X	X
Heliconius ethilla narcaea (Godart, 1819)	T – MM	X	X
Heliconius numata robigus (Weymer, 1875)	T – MM	X	
Heliconius sara apseudes (Hübner, [1813])		X	X
Limenitidinae			
Limenitidini			
Adelpha cytherea aea (C. Felder & R. Felder, 1867)		X	X
Adelpha plesaure phliassa (Godart, [1824])			X
Biblidinae			
Biblidini			
Biblis hyperia nectanabis (Fruhstorfer, 1909)		X	X
Catonephelini			
Catonephele acontius caeruleus Jenkins, 1985			X
Myscelia orsis (Drury, 1782)		X	X
Ageroniini			
Ectima thecla thecla (Fabricius, 1796)			X
Hamadryas amphinome amphinome (Linnaeus, 1767)			X
Hamadryas februa (Hübner, [1823])		X	X
Hamadryas feronia feronia (Linnaeus, 1758)		X	X
Epiphilini			
Nica flavilla flavilla (Godart, [1824])			X
Eubagini			
Dynamine agacles agacles (Dalman, 1823)			X
Dynamine artemisia artemisia (Fabricius, 1793)		X	X
Dynamine athemon maeon (E. Doubleday, 1849)		X	X
Dynamine postverta postverta (Cramer, 1779)			X
Callicorini			
Haematera pyrame pyrame (Hübner, [1819])			X
Diaethria clymena janeira (C. Felder, 1862)		X	X
Nymphalinae			
Coeini			
Historis odius odius (Fabricius, 1775)			X
Victorinini			
Anartia amathea roeselia (Eschscholtz, 1821)			X
Anartia jatrophae jatrophae (Linnaeus, 1763)		X	X
Melitaeini			
Eresia eunice esora Hewitson, 1857	T – BM	X	
Eresia lansdorfi (Godart, 1819)	BRY – BM	X	X
Tegosa claudina (Eschscholtz, 1821)		X	X
Charaxinae			
Anaeini			
Consul fabius drurii (Butler, 1874)	T – BM	X	X
Hypna clytemnestra ssp.		X	X
Siderone galanthis (Cramer, 1775)			X
Fountainea ryphea phidile (Geyer, 1837)			X
Memphis moruus stheno (Prittwitz, 1865)			X
Preponini			
Archaeoprepona demophon thalpius (Hübner, [1814])		X	X
Satyrinae			
Morphini			
Morpho helenor achillaena (Hübner, [1823])		X	X
Brassolini			
Caligo brasiliensis brasiliensis (C. Felder, 1862)			X

TAXA	MIMICRY RINGS	ILHA GRANDE	MARAM-BAIA
Eryphanis automedon automedon (Cramer, 1775)			X
Opsiphanes invirae amplificatus Stichel, 1904			X
Satyrini			
Chloreuptychia herseis (Godart, [1824])			X
Amiga arnaca arnaca (Fabricius, 1776)			X
Cissia myncea (Cramer, 1780)			X
Cissia phronius (Godart, [1824])			X
Godartiana muscosa (A. Butler, 1870)			X
Hermeuptychia sp. 1			X
Hermeuptychia sp. 2			X
"Paryphthimoides" aff. *sylvina*			X
Pareuptychia ocirrhoe interjecta (R.F. D'Almeida Imeida, 1952)		X	X
Posttaygetis penelea (Cramer, 1777)			X
Taygetis virgilia (Cramer, 1776)			X
HESPERIIDAE			
Eudaminae			
Urbanus proteus proteus (Linnaeus, 1758)			X
Urbanus esmeraldus (A. Butler, 1877)		X	
Urbanus teleus (Hübner, 1821)		X	X
Urbanus procne (Plötz, 1881)			X
Urbanus virescens (Mabille, 1877)		X	
Astraptes fulgerator fulgerator (Walch, 1775)			X
Autochton zarex (Hübner, 1818)			X
Spathilepia clonius (Cramer, 1775)			X
Pyrginae			
Erynnini			
Mylon ander ander Evans, 1953		X	
Pyrgini			
Trina geometrina geometrina (C. Felder& R. Felder, 1867)			X
Pyrgus oileus (Linnaeus, 1767)			X
Hesperiinae			
Calpodini			
Talides riosa Evans, 1955			X
Calpodes ethlius (Stoll, 1782)		X	
Moncini			
Callimormus corades (C. Felder, 1862)			X

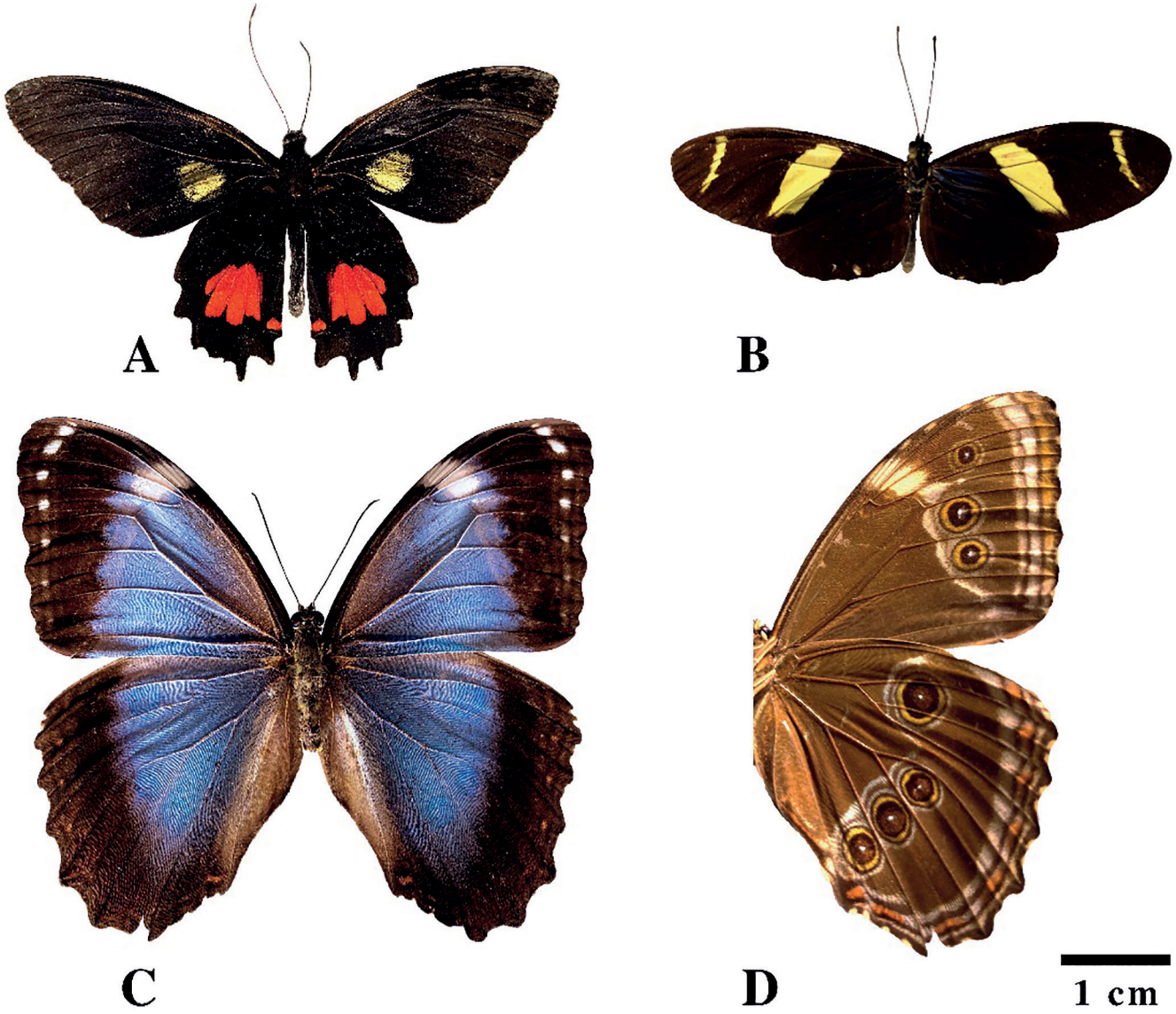

Figure 2. Endemic Atlantic Forest butterflies (A-B) and a local morph (C-D). (A) *Parides tros tros;* (B) *Heliconius sara apseudes;* (C-D) *Morpho helenor achillaena* (dorsal & ventral view). All individuals are males.

Marambaia, the restinga region has never been sampled or visited. Recent observations indicate that restinga habitats usually contain a variety of Riodinidae, Lycaenidae and Hesperiidae species (A.V.L. Freitas *pers. comm.*).

Endemic butterflies

Many butterflies in Table 1 are widespread in Brazil occurring in the Cerrado (Emery *et al.,* 2006; Mielke *et al.,* 2008), the Amazon and other Neotropical regions (Lamas, 2004). However, at least two examples of endemic Atlantic Forest butterflies were found, including *Parides tros tros* (Fabricius, 1793) (Fig. 2A) that is restricted to coastal forests and mountains along the Serra do Mar (Tyler *et al.,* 1994), and *Heliconius sara apseudes* (Hübner, [1813]) (Fig. 2B) that occurs from the Brazilian northeast to the Rio Grande do Sul State (Brown-Jr., 1992; Iserhard *et al.,* 2010). Another example we believe that could constitute a potential case of endemism is the large, eye catching *Morpho helenor achillaena* (Hübner, [1823]) (Fig. 2C). In contrast to other regions where this

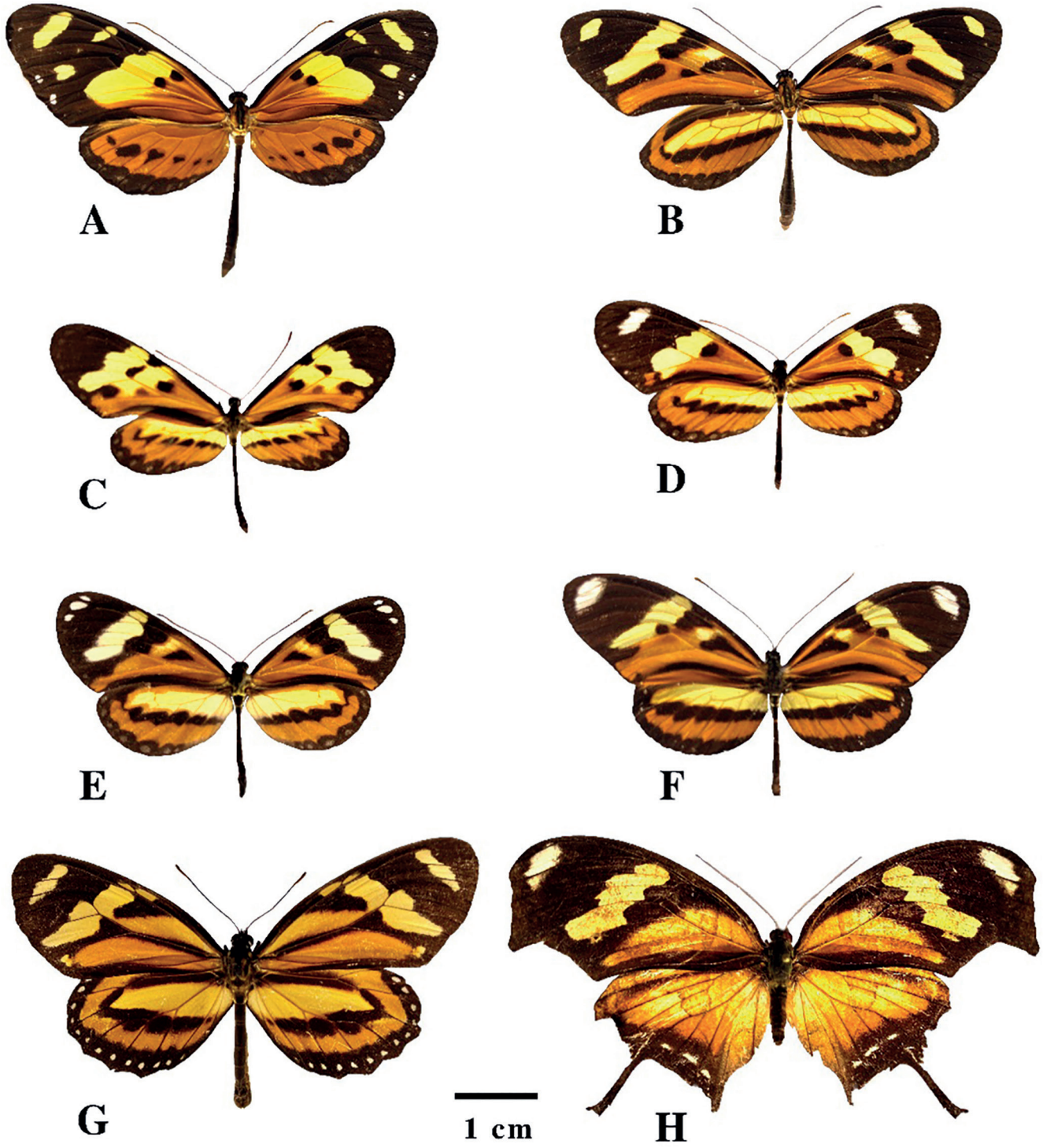

Figure 3. The Tiger mimicry ring (A-H): (A) *Melinaea ludovica paraiya,* male; (B) *Melinaea ethra,* female; (C) *Mechanitis polymnia casabranca,* male; (D) *Mechanitis lysimnia lysimnia,* female; (E) *Hypothyris ninonia daeta,* female; (F) *Heliconius ethilla narcaea,* male; (G) *Lycorea halia discreta,* male; (H) *Consul fabius drurii,* male.

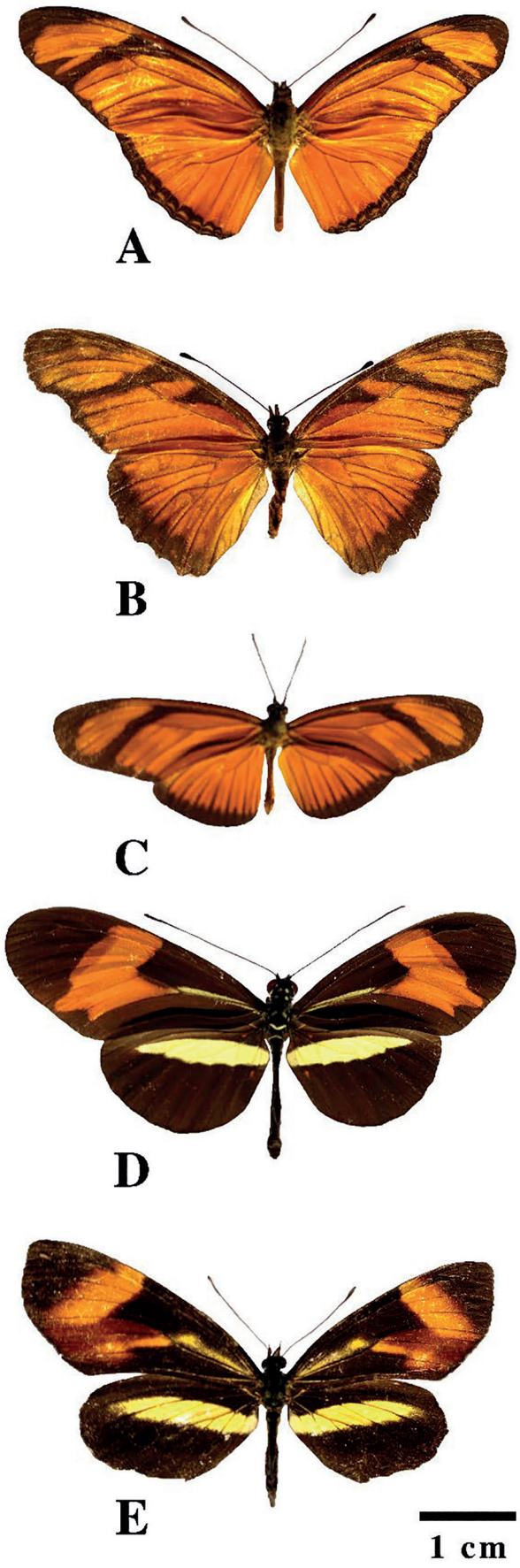

Figure 4. The Orange & Black striped (A-C) and the Black, Red & Yellow mimicry rings (D-E). (A) *Dryas iulia alcionea,* female; (B) *Dione juno juno,* male; (C) *Eueides aliphera aliphera,* male; (D) *Heliconius erato phyllis,* male; (E) *Eresia lansdorfi,* male.

butterfly occurs, most individuals – especially males – show an intense iridescent blue coloration in the medium and, unexpectedly, the inner parts of the upper wings, and also differ in traits on the ventral wing surface (Fig. 2D) like the number of eyespots and other morphological traits usually considered in the systematic of *Morpho* Fabricius, 1807 (Penz *et al.,* 2012). *Melinaea ludovica paraiya* Reakirt, 1866 (Fig. 3A) has been also regarded as an Atlantic Forest butterfly occurring along the Atlantic coastline from Santa Catarina to the Rio de Janeiro (Lamas, 2004). However, recent observations indicate this butterfly reaches the Pernambuco State in northeast Brazil and more rarely also occurs in gallery forests in the cerrado vegetation of Minas Gerais (A.V.L. Freitas, *pers. comm.*). Finally, many other cases of endemism are expected to occur as new surveys and systematic studies are concluded, including the species or subspecies of *Hermeuptychia* sp. 1, *Hermeuptychia* sp. 2, and *"Paryphthimoides"* aff. *sylvina* whose systematic remains poorly understood.

Mimicry rings

Among the butterflies more abundant and easily observed in both islands are several aposematic (*i.e.,* unpalatable and warning colored) and mimetic species that participate in a variety of mimicry rings, *i.e.,* groups of similar looking butterflies usually containing several unpalatable, Müllerian mimics, a phenomenon believed to speed up avoidance learning in predators (Müller, 1879) and one or few palatable, Batesian mimics that mimic the unpalatable species (or models) to deceive predators (Bates, 1862; see Trigo, 2000 for a review of defensive chemicals in Neotropical butterflies).

One of the most common rings partially found in both islands (Table 1) is the "Tiger" mimicry ring that contains several unpalatable Ithomiini, like *Melinaea ludovica paraiya* (Fig. 3A), *Melinaea ethra* (Godart, 1819) (Fig. 3B), *Mechanitis polymnia casabranca* Haensch, 1905 (Fig. 3C), *Mechanitis lysimnia lysimnia* (Fabricius, 1793) (Fig. 3D), and *Hypothyris ninonia daeta* (Boisduval, 1836) (Fig. 3E); two Heliconiini, *Heliconius ethilla narcaea* (Godart, 1819) (Fig. 3F) and *Heliconius numata robigus* Weimer, 1875; one Danaini, *Lycorea halia discreta* Haensch, 1909 (Fig. 3G) and the palatable, not chemically defended *Consul fabius drurii* (Butler, 1874) (Charaxinae; Fig. 3H), *Eresia eunice esora* Hewitson, 1857 (Melitaeini), and *Dismorphia amphione astynome* (Dalman, 1823) (Dismorphinae). Brown-Jr. & Benson (1974) include the *Actinote* Hubner, [1819] species as part of this ring, but we believe they constitute a ring apart.

Another ring containing numerous unpalatable Ithomiini is the "clear wing" mimicry ring that includes several species of *Ithomia* Hübner, 1816, *Episcada* Godman & Salvin, 1880, *Pteronymia* Butler & Druce, 1872, *Mcclungia* Fox, 1940, *Heterosais* Godman & Salvin, 1880, and *Pseudoscada* Godman & Salvin, 1879 (Table 1). These butterflies live mostly in shady habitats inside the forest and the species composition of the ring often changes in different islands and sites.

The "Orange & Black stripes" ring is also common and easily seen in both islands. It is composed by several moderately unpalatable Heliconiini (Pinheiro, 1996) including: *Dryas iulia alcionea* (Cramer, 1779) (Fig. 4A), *Dione juno juno* (Cramer, 1779) (Fig. 4B), *Eueides aliphera aliphera* (Godart, 1819) (Fig. 4C), and *Dryadula phaetusa* (Linnaeus, 1758). These butterflies occur mostly in open and sunny sites.

Other rings like the "Black, Red & Yellow" and the "Black, Red & White" are represented by only one unpalatable model, respectively, *Heliconius erato phyllis* (Fabricius, 1775) (Fig. 4D) and *Parides anchises nephalion* (Godart, 1819), and one Batesian mimic, respectively *Eresia lansdorfi* (Godart, 1819) (Fig. 4E) and *Archonias brassolis tereas* (Godart, 1819). *Heliconius erato phyllis* is by far the most abundant butterfly in both islands. It is easily seen in trails and along the forest border. In the Atlantic region it usually occurs along with the co-mimetic *Heliconius melpomene nanna* Stichel, 1899 and, more rarely, *Heliconius besckei* Ménétriés, 1857, but these butterflies were not found in our surveys.

Other aposematic butterflies like *Heliconius sara apseudes* (Hübner, 1806) (Fig. 1B), *Battus polydamas polydamas* (Linnaeus, 1758), and *Danaus gilippus gilippus* (Cramer, 1775) also participate as models or Müllerian mimics in other Atlantic Forest, Cerrado, and Amazon mimicry rings (see examples in Brown-Jr., 1992), but remain as unique representatives of their rings at Ilha Grande and Ilha da Marambaia. We do expect, however, that widespread species that mimic *Danaus gilippus gilippus* in the "Monarch" mimicry ring like *Danaus erippus* (Cramer, 1775) and *Danaus eresimus plexaure* (Godart, 1819) shall appear in future surveys. Other butterflies, like *Adelpha cytherea aea* (C. Felder & R. Felder, 1867), *Adelpha plesaure phliassa* (Godart, [1824]), *Hypna clytemnestra* ssp., *Archaeoprepona demophon thalpius* (Hübner, [1814]) and several Hesperiidae species are believed to participate in mimicry rings not based on unpalatability, but on their ability to escape predator attacks (reviewed in Pinheiro & Freitas, 2014). Such a possibility, however, has not been fully demonstrated and accepted by many authors.

In contrast to most aposematic Nymphalidae that visit flowers for nectar and, more rarely, pollen feeding (such as *Heliconius;* Brown-Jr., 1992), many other Nymphalidae species feed on sap and rotting fruits. They are often palatable (Pinheiro, 1996, 2007) and show cryptic coloration on both wing sides, *e.g., Hamadryas februa* (Hübner, [1823]), *Hamadryas feronia feronia* (Linnaeus, 1758), and the Satyrinae species, or at least on the underside wings, *e.g., Biblis hyperia nectanabis* (Fruhstorfer, 1909), *Catonephele acontius caeruleus* Jenkins, 1985, *Siderone galanthis* (Cramer, 1775) that render them cryptic at rest, with closed wings. Some of these butterflies also became Batesian mimics, *e.g., Consul fabius drurii* (Butler, 1874) (Fig. 3H). This guild of fruit-feeding butterflies has been utilized in a variety of comparative studies on butterfly communities (*e.g.,* Pinheiro & Ortiz, 1992; DeVries & Walla, 2001; Uehara-Prado *et al.,* 2007), as well as in monitoring programs to evaluate habitat quality over time (reviewed in Santos *et al.,* 2016).

CONCLUSIONS

Ilha Grande and Ilha da Marambaia still preserve important parts of the original Coastal Rain Forest and show a high diversity of butterflies. It is important to emphasize that our 103 butterfly list contains mostly the more abundant and widespread species. We suggest and encourage that future inventories in both islands incorporate other regions and periods of the year that remain uninvestigated. In addition to important and interesting investigations concerning endemism, mimicry and color pattern related phenomena, we suggest that butterflies are also utilized in monitoring programs relative to habitat quality and species diversity. These programs should be applied to both islands, but especially to Ilha Grande that contains a reserve, Parque Estadual da Ilha Grande, created in 1971 (but implemented in 2007), that naturally requires monitoring programs for conservation. In the long term, butterfly inventories should ideally include other small and medium size islands in the Sepetiba and the Angra dos Reis bay to investigate other important community ecology patterns such as species-area relationships and test the supposed equilibrium between colonization and extinction rates of species (MacArtur & Wilson, 1967) that remains virtually untested for most invertebrates.

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