

Butterflies of Alcatrazes Island, São Paulo State, Brazil (Lepidoptera: Papilionoidea and Hesperioidea)

Ronaldo Bastos Francini* and Renato Rogner Ramos

Universidade Católica de Santos, Laboratório de Biologia da Conservação, Avenida Conselheiro Nébias, 300, CEP 11015-002, Santos, SP, Brazil
* Corresponding author. E-mail: francini@unisantos.br

ABSTRACT: Islands are simplified and isolated ecosystems that have been used to study ecological and evolutionary process. An important study site is the The Alcatrazes Archipelago; its main island is forested and occupied by marine birds and endemic species of terrestrial vertebrates. Records of specie richness are useful to assess the degree of habitat isolation and resilience, both relevant to practical of conservation. The pioneering registers of Lüderwaldt and Fonseca in 1923 cited seven species of butterflies. We found only three of them and found eight and two new occurrences during 1993-1994 and 2011 expeditions, respectively. Alcatrazes island has only 18 species of butterflies known against 538 species of continental coastline. This low richness is derived from hard physical conditions of island, hindering the colonization. The Alcatrazes butterflies have good power of flight dispersal and feed on plants of secondary vegetation near-coastal habitats; its populations and community changed in short time space.

INTRODUCTION

Generally, ecosystems are difficult to handle experimentally due their great complexities, but Islands are simplified microcosms that constitute natural laboratories of the highest quality. They are systems relatively isolated with variations and quantity of species that allow testing ecological and evolutionary theories (MacArthur and Wilson 1967).

Darwin's notes during the Galapagos expedition in 1835 were the first steps that unleash the development of the modern theory of island biogeography, which changed the vision about archipelagos (Darwin 1859).

The Alcatrazes Archipelago comprises 13 Islands, islets, and slabs that are part of the Ecological Station of Tupinambás created in 1987, and now managed by the Chico Mendes Institute for Conservation of Biodiversity (ICMbio 2013). According to Lüderwaldt and Fonseca (1923), the island was inhabited in the past by people, which explored its natural resources and constructed three houses. In addition, more recently, the Brazilian Navy used the archipelago for military training, but these activities ceased at the end of 1990s.

The main island, Alcatrazes, is forested and has the biggest nesting place of marine birds of the south and southeast coast of Brazil (Rezende 1987), and also endemic species of terrestrial vertebrates (Bataus and Reis 2011). The first scientific work about Alcatrazes described new plant species and was published by Edwall (1897) but the first complete description of the island biota was the work of Lüderwaldt and Fonseca (1923) (but see Lüderwaldt 1926; Fonseca 1957) which studied the island during October and November 1920. The physical aspects of the insular environment were described by Wendel (1915) but other published studies focused on plants (Löfgren 1897a, b; 1898; Visnadi and Vital 2001), invertebrates (Leitão 1923; Schubart 1955; Hoffman 1971), and vertebrates (Vanzolini 1950; 1973; Marques *et al.* 2002; Campos *et al.* 2004).

Studies involving records of species richness and taxon cycle in island colonization process are useful in assessing of the relationship between degree of habitat isolation and resilience, a theme relevant to conservation (New and Thornton 1992). Butterflies are appropriate tools for these types of studies, especially with communities of islands, and have been widely used in works such as Krakatau (New *et al.* 1988; Bush and Whittaker 1991; Dennis *et al.* 2012) and the British tidal Isles (Dennis *et al.* 2010).

The coastal area of the São Paulo state (Mongaguá to Bertioga), where Alcatrazes Archipelago is inserted has 538 known butterfly species (Francini *et al.* 2011).

This paper is a contribution to the knowledge of the terrestrial biota of the Alcatrazes Archipelago due the importance of its conservation as the most distant continental island of the littoral of the São Paulo.

MATERIAL AND METHODS

The Alcatrazes Island has an area of 17 km² and is situated (24°06'55.55" S, 45°41'34.51" W) approximately 34 km from the north coast of São Paulo state, Brazil (Campos *et al.* 2004; Figure 1A-B). The main physiognomies found in the Island are the marine rocky shores but it may be considered an inselberg (Porembski 2007; Figure 2A), with strong marine influence and open Atlantic Forest formations, with predominance of Myrtaceae trees and *Syagrus romanzoffiana* (Arecaceae; Figure 2B).

The collections had Sisbio Authorization number 31172-1 (23/09/2011). Voucher specimens from 1992-1994 were deposited in the collection of Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP). The sampling effort encompassed 72 h of field work using entomological nets to capture butterflies along the tracks (Figure 1C) and the island slopes. In the inaccessible sites we used photographic equipment. We also searched actively for possible resources for adults and larval host-plants. The species found were added to historical collection list of Alcatrazes Island published by

Lüderwaldt and Fonseca (1923).

RESULTS

There are 18 butterfly species known from the Alcatrazes Island (Table 1), all of them being common species with wide geographical distribution.

The butterflies were using flowers of *Austroeupeatorium inulaefolium* H.B.K. (Figure 4A), *Chromolaena odorata*, *Emilia sonchifolia*, *Mikania micrantha*, *Mikania cordifolia* (Figure 4B) and *Vernonia scorpioides* (Asteraceae) which are in bloom during the autumn (end of March to June). All of them being considered agricultural weeds (Aranha *et al.* 1982) and possibly remains of the incipient agriculture practiced when the island was occupied, as indicated by the presence of *Ricinus communis* (Euphorbiaceae; Figure 4C).

DISCUSSION

The butterfly assemblage of Alcatrazes Island has low species richness when compared to an equivalent continental area. The data from two consecutive expeditions on April 1993 and 1994 showed only 11 and five active butterfly species, respectively. In the same years, a walking of only four hours along one trail in the Vale do Rio Quilombo, Santos (Figure 1B), showed more than 50 butterfly species (RBF, unpublished data). This reduced richness could be related to the prevalent conditions of the physical environment. Several areas were covered by bare rocks (Figure 2A) and there is no permanent water body. When the clouds are low, the condensed moisture allows the use of liquid water by plants (Figure 2B). This creates an environment that is hot and dry and not adequate for most butterfly species. There is also the spray of salt water

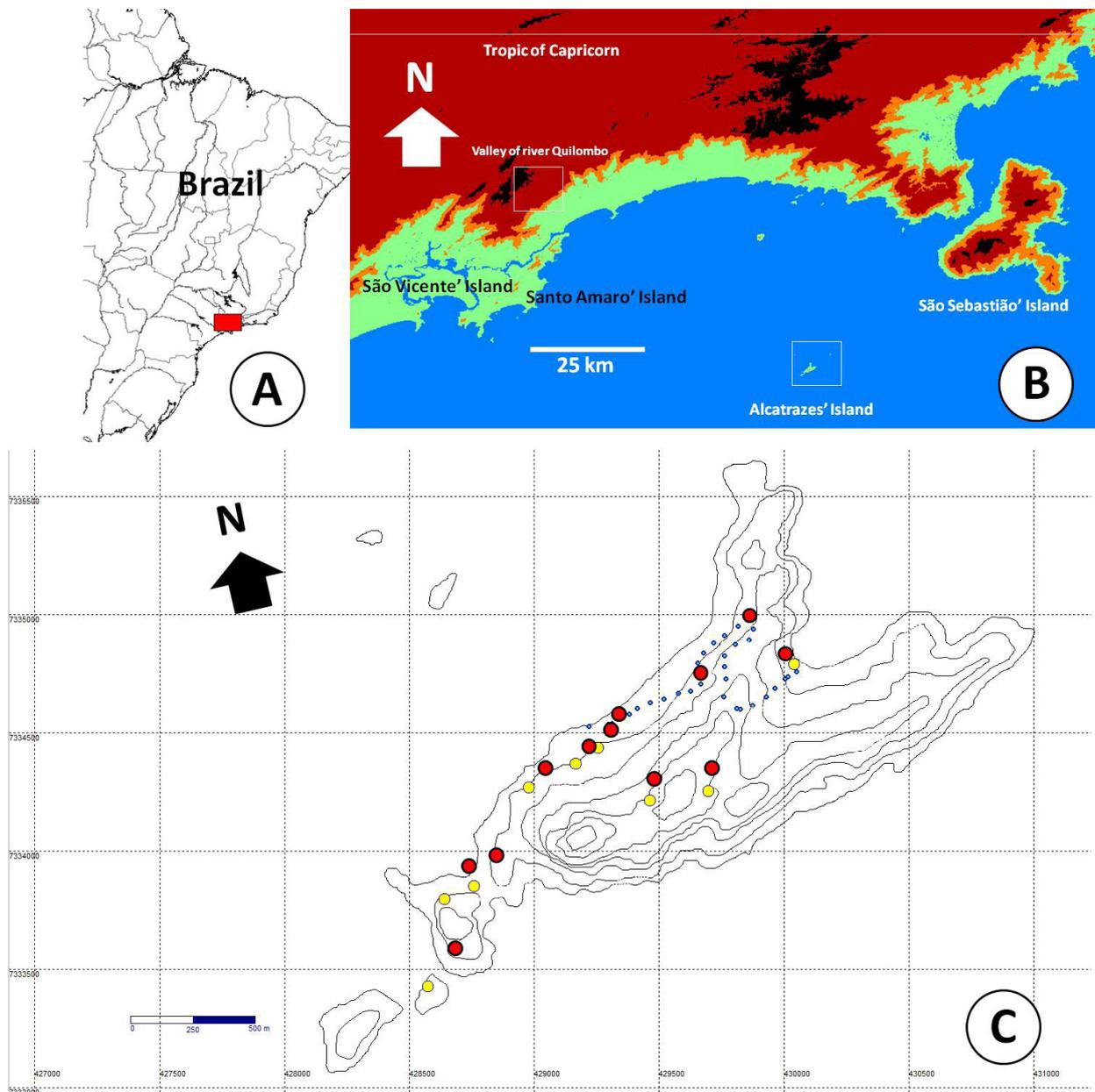


FIGURE 1. Location of the Alcatrazes Island in SE Brazil (A) showing the surrounding coastal area (B) and sampling points in expeditions of 1993, 1994 (yellow circles), and 2011 (red circles).

that, in days of agitated sea, may contribute to increase the water loss by terrestrial organisms. There was no meteorological station in the island but in Moela Island, near to Guarujá. The mean annual rainfall is lower than the interior continental area (Santos 1965). The hot and dry climatic pattern of Alcatrazes was indicated by plates of crystallized salt between rocks near the sea by Lüderwaldt and Fonseca (1923) and also because the area covered by rocks is bigger than the vegetation area. During the dry season, the lack of freshwater bodies in the island is not adequate condition for survival of plants and butterflies, restricting the phenological cycles. The high quantity of nitrates and phosphates accumulated due to sea birds guano, affect the quality and development of flowers and host plants when deposited on leaf or floral surfaces, as seen on *Chromolaena odorata* (Figure 3). In addition, the burnings caused by Navy bombing since 1980s probably

reduced resources and could lead several species to local extinction. Therefore, these effects may cause difficulties in establishment of a butterfly species due to resources restriction for adults and larvae.

Lüderwaldt and Fonseca (1923) cited seven species of butterflies (Lepidoptera: Papilionoidea and Hesperioidea). We found only three of them, but found another eight and two new occurrences during 1993-1994 and 2011 expeditions (Table 1).

One species collected in 1920 (Lüderwaldt and Fonseca 1923) and identified as *Actinote corycina* [sic], probably is *Actinote carycina* Jordan, 1913 and is in fact *Actinote pellenea pellenea*, a common widespread species in Southeast Brazil (Francini and Penz 2006). Its larvae eat leaves of *A. inulaefolium*, *M. micrantha*, and *M. cordifolia* but we never saw exuviae or larval skins in these plants. This may indicate events of colonization and extinction with a turnover of species. Therefore, it seems that butterfly populations are ephemeral in Alcatrazes Island and its assemblage changed in short time space. Small-sized species, such as *Leptotes cassius* and other Lycaenidae are probably brought by the winds, while the bigger species with great flight capacity and migratory potential, such as *Danaus plexippus* and *Phoebis*, can disperse actively, but none presented signs of residence.

However, despite the colonization difficulties, some species may have better competitive ability during this process. Species in which adults use food resources of their larval host plants can have a generation without relying on other plant species in an island with limited resources. In the Alcatrazes there are many palms of *Syagrus romanzoffiana* where the butterflies of species *Brassolis astyra* (Brassolini; Figure 4D) found abundant resource for their larvae. For this reason, they are able to maintain resident populations in the island. Two strong evidences corroborates that this species is resident in the island: 1) one individual collected in October 2011 was a newly emerged indicating its life-cycle was completed on island; 2) The leaves of their host plants, *S. romanzoffiana*, are available during all seasons.

In the same way as butterflies of the Krakatau Island (Thornton 2007), the species of Alcatrazes are very frequent along the continental coastline, with good dispersal and wide distribution, which feed on plants of secondary vegetation near-coastal habitats. Generalist species with high colonization ability and high migration capacity are potentially the first visitors to arrive and colonize. Conversely, specialists with weaker dispersal capacity and lower colonization ability enter later. We did not find forest-dweller butterflies. These are probably less vagile and their host-plants less likely to be present after arrival on the island. Thus, specialists also have a short stay time; they rapidly will become extinct, even if colonization is briefly successful (Dennis *et al.* 2012).

The oscillations of butterfly assemblages of Alcatrazes seem to depend on these dynamics and need more time to recover from the impact of natural and anthropogenic interferences. Therefore, more collection and investigations will be necessary to follow life cycles, turnovers, and colonization process of Alcatrazes' butterflies.

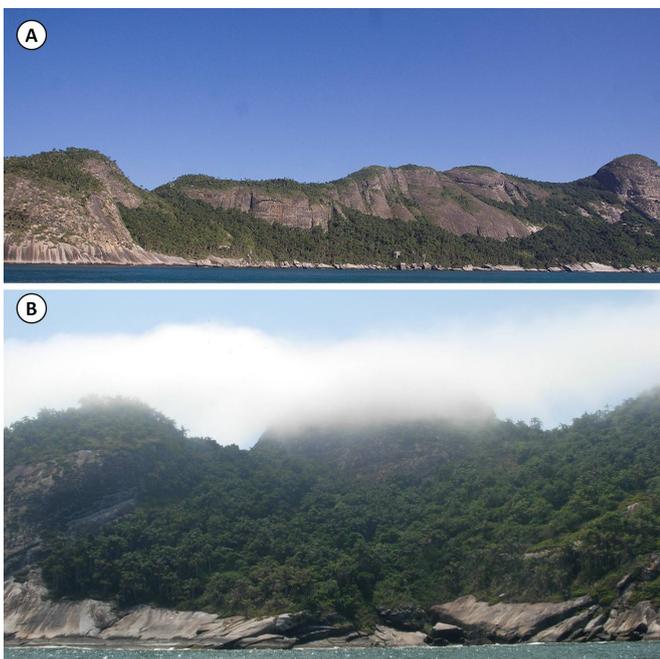


FIGURE 2. (A) Profile of Alcatrazes Island view from north to south, showing the inselberg landscape with marine rocky shores in lower portion and open forest, with predominance of trees of the family Myrtaceae and *Syagrus romanzoffiana*. (B) Low clouds surrounding the island top where dew provides liquid water to Alcatrazes plant community.



FIGURE 3. *Chromolaena odorata* (Asteraceae) showing the effect of salt deposition due to seabird colonies, with high nitrates and phosphates in their droppings.

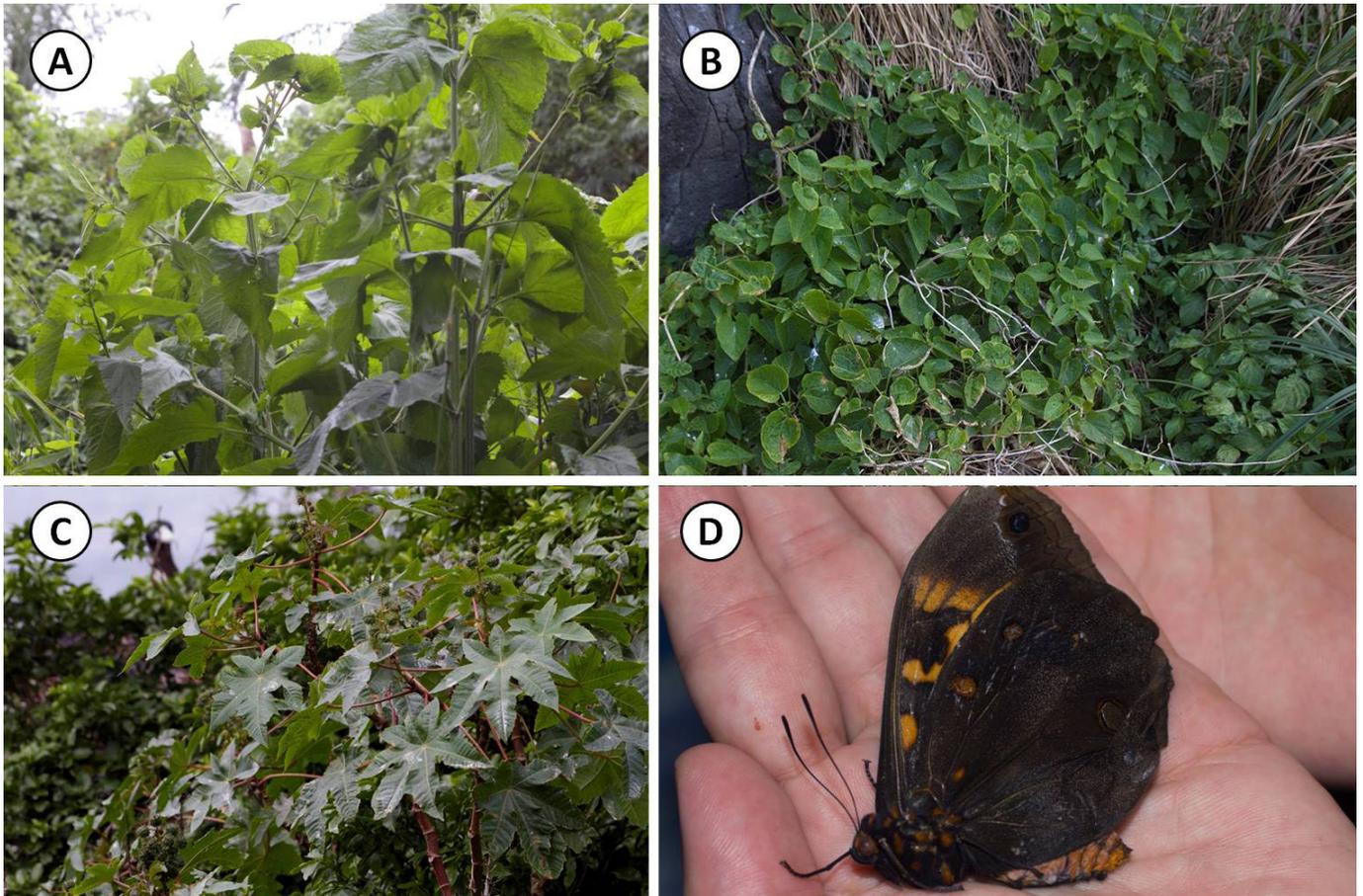


FIGURE 4. (A) *Austroepatorium inulaefolium*, (B) *Mikania cordifolia*, and (C) *Ricinus communis*. (D) The newly emerged imago of *Brassolis astyra* found in the last trip.

TABLE 1. Species of butterflies observed or collected at Alcatrazes Island, SP and the Families of their larval host-plant (FLH-P): Acanthaceae (ACA), Arecaceae (ARE), Apocynaceae (APO), Asteraceae (AST), Cruciferae (CRU), Passifloraceae (PAS), unknown (?). Nomenclature used by Lüderwaldt and Fonseca (1923) (L&F), collectors name and dates of expeditions: Herman Lüderwaldt (HL), Ronaldo Bastos Francini (RBF), Renato Rogner Ramos (RRR); species presence (X). Observations: material not found in the MZUSP. * Possibly a common Brazilian species such as *Hylephilla phileus* or *Polites vibex*.

TAXA	NOMENCLATURE L&F	FLH-P	COLLECTORS AND DATES OF EXPEDITIONS					
			HL 1920	RBF Apr. 93	RBF Feb. 94	RBF Apr. 94	RBF Jun. 94	RBF&RRR Oct. 2011
Hesperiidae								
Hesperiinae sp.	<i>Hesperia</i> sp.*	?	X	-	-	-	-	-
<i>Urbanus proteus proteus</i> (Linnaeus, 1758)	<i>Thimele proteus</i>	LEG	X	X	-	-	-	-
Libytheinae								
<i>Libytheana carinenta</i> (Cramer, 1777)		-	-	-	-	X	-	-
Lycaenidae								
<i>Hemiargus hanno hanno</i> (Stoll, 1790)	<i>Hemiargus hannus</i>	LEG	-	X	-	-	-	-
<i>Leptotes cassius cassius</i> (Cramer, 1775)	<i>Lycaena cassius</i> Cr.	LEG	X	X	-	-	-	X
<i>Thecla</i> sp.	<i>Gargina gargophia</i> (Hew.)	?	X	-	-	-	-	-
Nymphalidae								
<i>Actinote pellenea pellenea</i> (Hübner, [1821])	<i>Actinote corysina</i> [sic] Jord.	AST	X	-	-	-	-	-
<i>Brassolis astyra astyra</i> Godart, [1824]		ARE	-	-	-	-	-	X
<i>Danaus erippus</i> (Cramer, 1775)		APO	-	X	-	-	-	X
<i>Dryas iulia alcionea</i> (Cramer, 1779)	<i>Colaenis julia</i> F.	PAS	X	X	-	X	-	-
<i>Eresia lansdorfi</i> (Godart, 1819)		ACA	-	X	-	-	-	-
<i>Hamadryas februa februa</i> (Hübner, [1823])		?	-	X	-	-	-	-
<i>Morpho helenor achillaena</i> (Hübner, [1823])			-	-	-	X	-	-
Pieridae								
<i>Ascia monuste orseis</i> (Godart, 1819)	<i>Pieris orseis</i> Godt.	CRU	X	-	-	-	-	-
<i>Eurema albula sinoe</i> (Godart, 1819)		?	-	X	-	-	-	-
<i>Phoebis argante argante</i> (Fabricius, 1775)		LEG	-	X	-	X	-	-
<i>Phoebis philea philea</i> (Linnaeus, 1763)		LEG	-	-	-	X	-	-
Riodinidae								
<i>Synargis calyce</i> (C. Felder & R. Felder, 1862)		LEG	-	X	-	-	-	-

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