

Reptiles (Squamata) in Atlantic forest in Southern Brazil

Adrielle Karlokoski Cunha de OLIVEIRA^{1,*} and Igor Soares de OLIVEIRA²

1. Programa de Pós-Graduação em Zoologia, Departamento de Zoologia, Universidade Federal do Paraná, Rua Cel. Francisco Heráclito dos Santos, 210, Jardim das Américas, CEP 81531-970, Curitiba, Paraná, Brasil.

2. Programa de Pós-Graduação em Ecologia, Instituto de Biologia, Universidade Estadual de Campinas, Avenida Bertrand Russel, s/n, Cidade Universitária Zeferino Vaz, Barão Geraldo, CEP 13083-865, Campinas, São Paulo, Brasil

* Corresponding author, A.K.C. de Oliveira, E-mail: adrikoliveira@gmail.com

Received: 24. December 2013 / Accepted: 12. February 2014 / Available online: 20. February 2014 / Printed: June 2014

Abstract. Brazilian Atlantic forest is a biodiversity hotspot, currently threatened for several factors as deforestation and fragmentation. Nevertheless, basic information on species composition for some regions remains poorly known. Thus, our aim was to assess reptile species richness in a protected area in the Southern Atlantic forest. Herein we present a list of reptiles (Squamata) in the Colônia Castelhanos, a small settlement in the Atlantic forest of the state of Paraná, Southern Brazil, for which local species composition is poorly known. We compiled a species list by using primary (species gathered by the authors) and secondary (species housed in the museum and stomach contents) data. We recorded 21 reptile species distributed in 10 families: Amphisbaenidae (one species), Leiosauridae (one species), Gekkonidae (one species), Diploglossidae (one species), Teiidae (one species), Gymnophthalmidae (two species), Colubridae (four species), Dipsadidae (eight species), Elapidae (one species), and Viperidae (one species). The snake *Echinanthera cyanopleura* was confirmed only by stomach content. We also provide seven new records for the locality. Based on species composition, Colônia Castelhanos apparently is a well-preserved locality, with few disturbed areas. Nonetheless, the number of species may increase with further surveys and the use of additional sampling methods.

Key words: diversity, herpetology, Squamata, biodiversity hotspot, Brazil.

Introduction

The Brazilian Atlantic forest was one of the largest rainforests in South America, highly diverse in environmental conditions, covering approximately 150 million ha in the past, which can be explained, in part, by its latitudinal and longitudinal attributes (Ribeiro et al. 2009, Ribeiro et al. 2011). Longitudinally the decrease of rainfall away from coast provides distinctive forest compositions, whereas latitudinally, the tropical forest gradually changes into a subtropical forest from north to south (Ribeiro et al. 2009). Nowadays, the Atlantic forest is a biodiversity hotspot with a number of threatened and endemic species. Historical and ongoing deforestation has led to a dramatic decrease of this relevant habitat, with currently less than 12% of its original cover range remaining (Ribeiro et al. 2009, Ribeiro et al. 2011).

Among several vertebrates in the Atlantic forest, reptiles are an important group for conservation purposes with 12 species classified as threatened (ICMBio 2013). Even though there are more than 720 reptile species in Brazil (Bérnils & Costa 2012), new species are being described regularly (e.g., Rodrigues et al. 2007, Centeno et al. 2010), which increases the importance of this group in biodiversity conservation strategies. In contrast, even in regions with a strong tradition to gather knowledge on herpetological aspects in Brazil (e.g., southeastern), there is still a lack of species distribution information based on species inventories (Zaher et al. 2011). Furthermore, species lists are the first step for species conservation and may help in monitoring fauna, especially in protected areas, and provide valuable information to understand diversity patterns (Silva-Soares et al. 2011, Zaher et al. 2011).

In this context, the knowledge on reptiles of the state of Paraná, in Southern Brazil is still scarce, with few published works focused on local species compositions (e.g. Bernardes & Machado 2002, Ribas & Monteiro-Filho 2002). On the other hand, Paraná possesses one of the largest Atlantic forest remnants still protected (Ribeiro et al. 2009). Thus, the main

goal of this work is to provide additional information on the composition of squamate reptiles in a remnant of Atlantic forest in the state of Paraná by presenting a list of reptile species based on field work and collection data.

Materials and Methods

Study site

Field activities were conducted around the Colônia Castelhanos (25°47'41" S, 48°54'43" W), a small settlement of a few houses surrounded by Atlantic forest, located in a protected area (Área de Proteção Ambiental de Guaratuba) (APA-G), in the municipality of São José dos Pinhais, in the east of the state of Paraná. APA-G is a mosaic area, with about 200.000 ha, covering Parque Nacional Saint-Hilaire/Lange, with nearly 25.000 ha, Parque Estadual do Boguaçu, with a slightly over 6.000 ha, and numerous farms and small properties where agricultural activities are permitted. Although APA-G is a large area, this work was conducted in two small farms with about 6 km², outside the parks, in the eastern part of the large area (Fig. 1). The site was selected owing to logistic reasons (e.g., access facilities, area for camping) and also because these two farms were the only ones where we were allowed to work by the owners.

The original landscape corresponds to diverse and dense vegetation, forests with canopies at about 35 m height (Roderjan et al. 2002). Although there are large well preserved areas, including pristine vegetation, there are also several agricultural modified patches, especially banana plantations and pastures. Sampling was conducted in both, forested and disturbed areas (Fig. 2). Environments are composed of pristine forests, pastures, wetlands, streams, and paths, including their ecotones. Forested areas are rich in palm groves (*Euterpe edulis*), rivers and streams with riparian vegetation.

Data collection

For the species list composition of this study, we used primary and secondary data. Primary data were collected from our fieldwork activities and secondary data included records from reptile collection of the Museu de História Natural "Capão da Imbuia" (MHNCI) at the municipality of Curitiba, Paraná, Brazil. Additionally, we also analyzed the stomach content of ophiophagous taxa collected during fieldwork to complement our data for difficulty to detect species eventually not recorded in the field or MHNCI collection (e.g., secre-

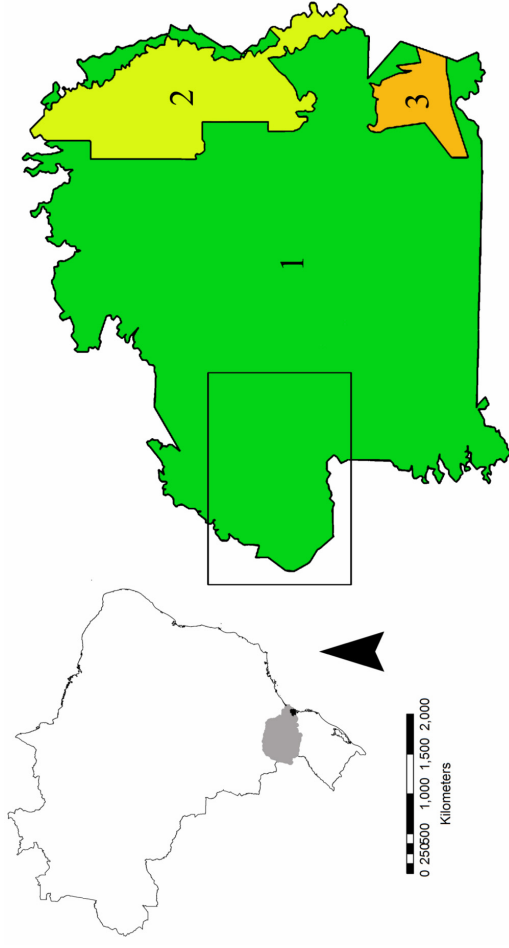


Figure 1. Geographic position of APA-G (details in the text), and location of Colônia Castelhanos (black rectangle) within state of Paraná, Southern Brazil; 2: Parque Nacional Saint-Hilaire/Lange; 3: Parque Estadual do Bogaçu; red circle: area approximately covered by field survey.

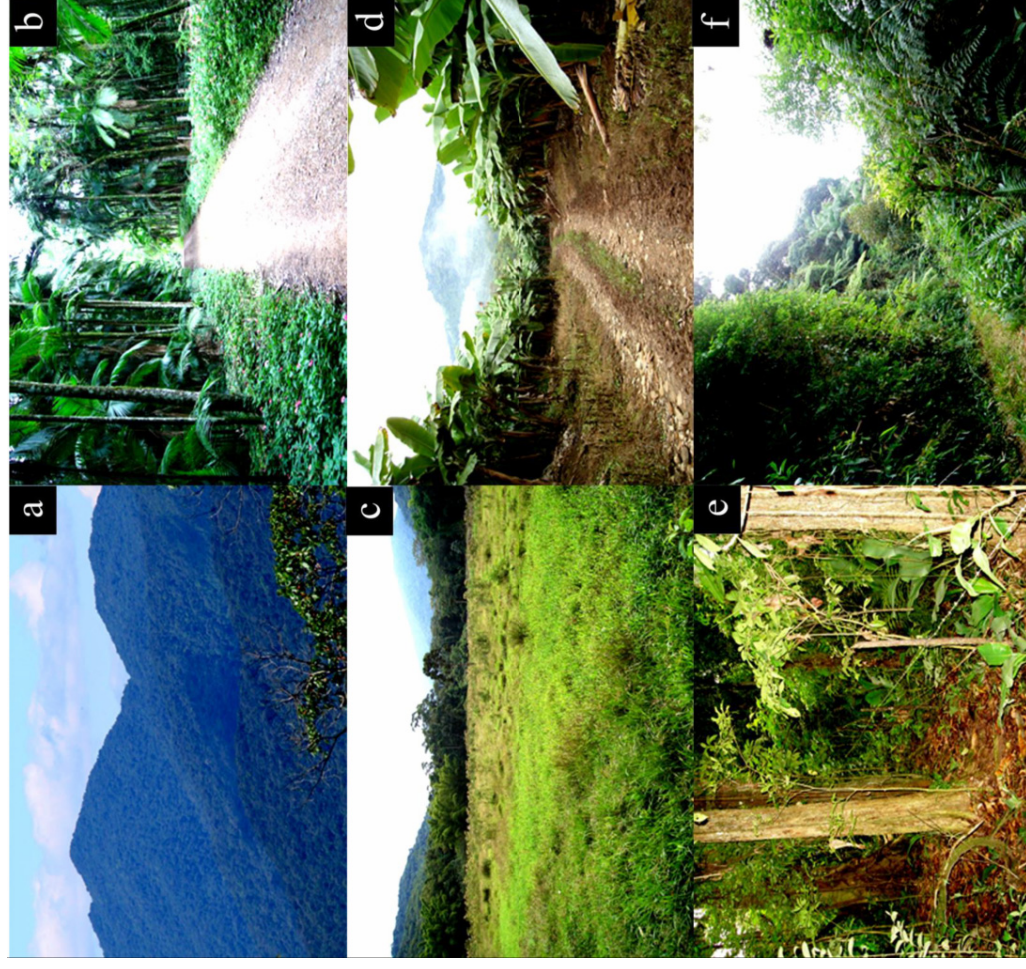


Figure 2. Different types of environments surveyed at Colônia Castelhanos: a: general view of Atlantic forest in APA-G; b: trails through palm trees; c: pastures; d: banana plantations; e: riparian vegetation; and f: forested area.

Table 1. Reptile (Squamata) species from Colônia Castelhanos, municipality of São José dos Pinhais, state of Paraná, Southern Brazil; Data source numbers definitions: 1: primary data collected from fieldwork activities; 2: secondary data obtained from MHNCI (see text for details); 3: records obtained from stomach contents of collected specimens; Types of habitats: FO: forest; HH: human habitations; BP: banana plantation; PA: pasture; NA: information not available.

Taxa	Data Source	Habitat
Amphisbaenidae Gray, 1825		
<i>Leposternon microcephalum</i> (Wagler, 1824)	2	NA
Leiosauridae Frost, Etheridge, Janies & Titus, 2001		
<i>Enyalius iheringii</i> Boulenger, 1885	1	FO
Gekkonidae Gray, 1825		
<i>Hemidactylus mabouia</i> (Moreau de Jonnés, 1818)	1	HH
Diploglossidae Cope, 1864		
<i>Ophiodes striatus</i> (Spix, 1825)	1	NA
Teiidae Merrem, 1820		
<i>Salvator merianae</i> (Duméril & Bibron, 1839)	1,2	FO/HH
Gymnophthalmidae Merrem, 1820		
<i>Colobodactylus taunayi</i> (Amaral, 1933)	1	FO
<i>Placosoma glabellum</i> (Peters, 1870)	2	NA
Colubridae Opper, 1811		
<i>Chironius bicarinatus</i> (Wied, 1820)	1	FO
<i>Chironius exoletus</i> (Linnaeus, 1758)	2	NA
<i>Chironius foveatus</i> Bailey, 1955	2	NA
<i>Spilotes pullatus</i> (Linnaeus, 1758)	1	FO/BP
Dipsadidae Bonaparte, 1838		
<i>Dipsas albifrons</i> (Sauvage, 1884)	2	NA
<i>Echianthera cyanopleura</i> (Cope, 1885)	3	NA
<i>Erythrolamprus aesculapii</i> (Linnaeus, 1766)	1,2	FO/HH/PA
<i>Erythrolamprus miliaris</i> (Linnaeus, 1758)	1,2	FO/PA
<i>Oxyrhopus clathratus</i> Duméril, Bibron & Duméril, 1854	1,2	FO
<i>Sibynomorphus neuwiedi</i> (Ihering, 1911)	2	NA
<i>Tropidodryas serra</i> (Schlegel, 1837)	2	NA
<i>Xenodon neuwiedii</i> Günther, 1863	1,2	FO
Elapidae Boie, 1827		
<i>Micrurus corallinus</i> (Merrem, 1820)	1,2	FO
Viperidae Laurenti, 1768		
<i>Bothrops jararaca</i> (Wied, 1824)	1,2	FO/BP

tive fossorial species). Consultation of this collection also helped to correctly identify the species. In order to standardize scientific names, we follow the list of species provided by Sociedade Brasileira de Herpetologia (Bérnils & Costa 2012).

Fieldwork was carried out during three to four days a month by small teams (two or three people) from May 2006 to April 2007. We used active search method, visual encounters, road driving by car, and incidental encounters. Samples were conducted in diurnal and nocturnal periods (from morning to noon and from late afternoon to night), totalizing a sample effort of 443 hours. For each day in the field we walked a trail of approximately 4.5 km, and we also performed searches by road driving, covering a route with slightly more than 20 km. Specimens occasionally found dead or killed by local inhabitants were also collected and accounted (under licences ICMBIO, 13529-1; IAP, 21/06; CEP/PUCPR 123/06). Voucher specimens were deposited in the MHNCI.

Data analyzes

To evaluate the efficiency of collection effort we constructed a species accumulation curve, using the free software EstimateS 9.1 (Colwell 2013), with 5.000 randomizations. Observed species richness was compared to a theoretical accumulation curve generated by the use of the Bootstrap estimator. This analysis considers only the species recorded during field activities.

Results

Considering both methods combined, i.e. field samples and data from MHNCI collection, we recorded a total of 21 species of squamate reptiles organized in 10 families and 18 genera (Table 1, Fig. 3). Seven taxa were exclusively registered in the scientific collection and seven others were recorded only by field samples. Family Dipsadidae presented the highest richness with eight species, followed by Colubridae with three species, Gymnophthalmidae with two taxa and Amphisbaenidae, Leiosauridae, Gekkonidae, Diploglossidae, Teiidae, Elapidae and Viperidae, with one taxon each.

Considering only the species recorded during field samples the species accumulation curve did not show saturation (plateau) of finding new species after 12 field sampling tours (Fig. 4). However, the number of newly registered taxa clearly tended to diminish towards the final sampling tours. The active search method provided a total of 13 species, with six species being recorded only in forested habitats, five in forested and disturbed areas, and one only in an anthropogenic site. The analysis of stomach contents provided the record of one species (*Echianthera cyanopleura*), previously not registered by other methods.

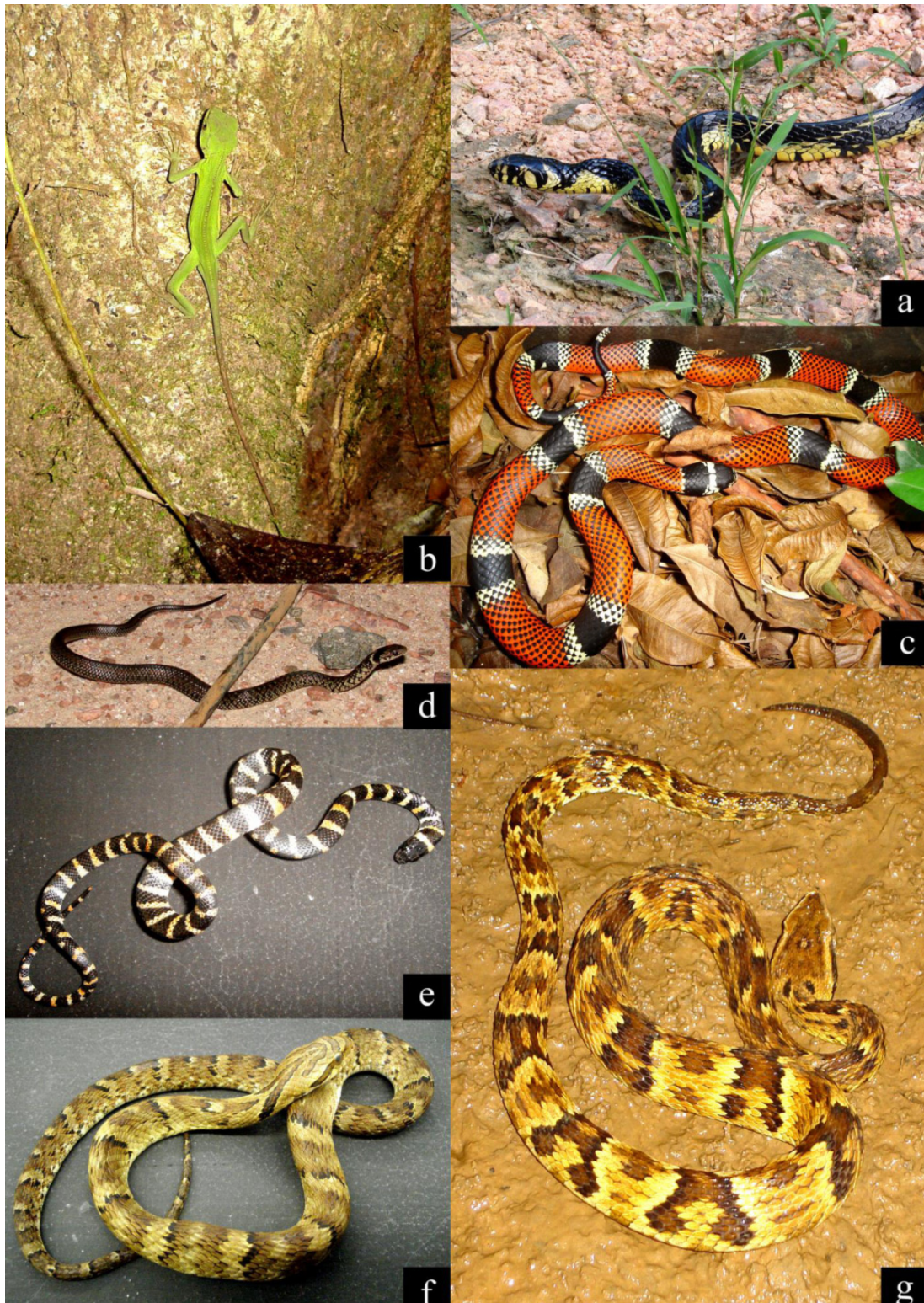


Figure 3. Some reptile species from Colônia Castelhanos: a: *Spilotes pullatus*; b: *Enyalius iheringii*; c: *Erythrolamprus aesculapii*; d: *Erythrolamprus miliaris*; e: *Oxyrhopus clathratus*; f: *Xenodon newwiedii*; g: *Bothrops jararaca*.

Generally, few individuals were recorded by active searches for most species. Regardless, the pit viper *Bothrops jararaca* was the most commonly found ($n = 21$), representing more than 45% of the total sample ($n = 46$), followed by *Erythrolamprus aesculapii* ($n = 5$), *E. miliaris* and *Enyalius iheringii* ($n = 3$); *Spilotes pullatus*, *Xenodon newwiedii*, *Micrurus corallinus*, *Ophiodes striatus* and *Salvator merianae* ($n = 2$); and

Chironius bicarinatus, *Oxyrhopus clathratus*, and the lizards *Colobodactylus taunayi* and *Hemidactylus mabouia* ($n = 1$).

Discussion

According to Bérnils et al. (2004) the number of reptile spe-

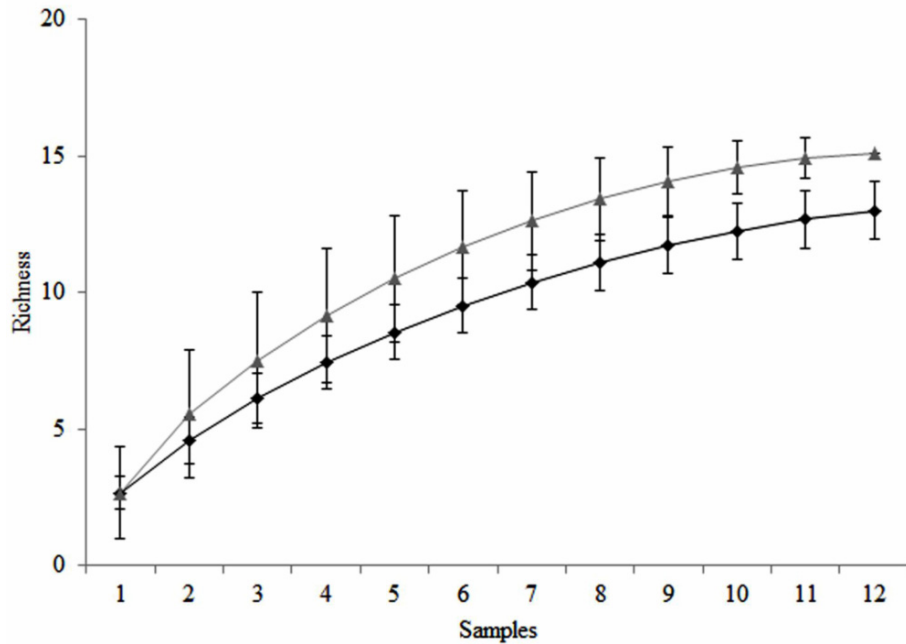


Figure 4. Species accumulation curve for the sampled reptile species in Colônia Castelhanos (black diamonds and line) and theoretical curve using Bootstrap estimator (gray triangles and line) and respective confidence intervals for 12 samples (active search).

cies in the state of Paraná consists of about 154 taxa. Thus, our study recorded approximately 14% of the known species richness for the state. However, comparing to other studies conducted in different localities in the Atlantic forest domain (e.g., Condez et al. 2009, Araujo et al. 2010, Forlani et al. 2010), Colônia Castelhanos seems to present low richness. In fact, features inherent to the location hampered searching far into the forest and there were several natural barriers difficult to overcome (e.g. large rivers, cliffs). For instance, the larger pristine area that we have access was on a top of a hill and samplings were restricted to a narrow trail. This is a common pattern in Atlantic forest resulted of its historical occupation, where the remnants of preserved forest remain in hills and mountains because the difficulty of access (Câmara 2005, Ribeiro et al 2009). Another possible explanation for the low richness observed in field samplings in Colônia Castelhanos may be the notorious difficulty to search cryptic and rare taxa (Lang 1992). The encounter of cryptic species demand not only field experience but also the use of traps (e.g., pitfall traps, funnel traps). For instance, the record of fossorial species in Colônia Castelhanos is likely to be hindered because we did not use pitfall traps. Thus, the methods used to survey Colônia Castelhanos were limited and probably local species composition is underestimated. Furthermore, areas intensively studied (e.g., greater number of days devoted to field samples and teams with more people) and the use of different methods combined usually provide more accurate inventories (e.g., Cicchi et al. 2009, Forlani et al. 2010). In general, the presumed species richness is correlated to sampling efforts, i.e. the higher the number of records, the greater the chances for new species records (Melo et al. 2003). Therefore, even though active searches usually provide a good estimates of local species richness (Cicchi et al. 2009, Araujo et al. 2010), it is likely that further field sampling and the use of additional methods covering a

greater area may increase the number of reptile species for Colônia Castelhanos.

In regard to the significant high relative frequency presented by *B. jararaca*, individuals were most commonly recorded in disturbed habitats and forest edges than in forested sites. One possible explanation is that *B. jararaca* usually inhabits forested and open areas (Marques et al. 2004) and is widely distributed through Atlantic forest (Forlani et al. 2010), which may favor its encounter. Additionally, human settlements (houses, stalls and crops) usually harbor several rodent species, the principal food resource for *B. jararaca* (Marques et al. 2004). Thus, based on the high frequency of *B. jararaca*, one can think that Colônia Castelhanos is a severely disturbed site. However, as we discussed above, several factors may favor the encounter of *B. jararaca* and, in this case, the relative frequency is biased and cannot be considered a good measure to infer on the preservation of Colônia Castelhanos. In addition, the record of some exclusively forest species as *E. iheringii* (Forlani et al. 2010, Rautemberg & Laps 2010) and *C. taunayi* (Vanzolini & Ramos 1977, Bernardo et al. 2011), may provide clues about the real conservation state of the locality. Nevertheless, the degree of preservation in Colônia Castelhanos remains inconclusive and further studies are needed to clarify this issue.

Nonetheless, although the general impression is that reptile species richness recorded in Colônia Castelhanos is low, we emphasize that this is likely to be increased with further field work, especially by the use of additional sampling methods and the coverage of a greater area. This is shown by the species accumulation curve, which did not reach an asymptotic form. Additionally, studies developed with other vertebrates, such as anurans, show high local richness at Colônia Castelhanos (e.g., Cunha et al. 2010), as well as the observed presence of some endemic and threatened birds (e.g., *Aburria jacutinga*, *Onychorhynchus swainsoni*), which

may indicate that Colônia Castelhanos is in fact a well preserved area. Nevertheless, our work increased the current knowledge of the local reptile assemblage with seven new records for Colônia Castelhanos, which were not previously registered in the MHNCI collection.

Acknowledgements. We are grateful to Julio Cesar de Moura-Leite for allowing access the MHNCI herpetology session and for help in the identification process. We also thank the family Grassmann, Manoela W. Cardoso, Rafael Costa, Kelly Mafra, and Thalissa Mendes for help in the field work. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

- Araujo, C.O., Condez, T.H., Bovo, R.P., Centeno, F.C., Luiz, A.M. (2010): Amphibians and reptiles of the Parque Estadual Turístico do Alto Ribeira (PETAR), SP: an Atlantic forest remnant of Southern Brazil. *Biota Neotropica* 10(4): 157-174.
- Bernarde, P.S., Machado, R.A. (2002). Fauna reptiliana da bacia do rio Tibagi. pp. 291-296. In: Medri, M.E., Bianchini, E., Shibata, O.A., Pimenta, J.A. (eds), A bacia do rio Tibagi. Câmara Brasileira do Livro, São Paulo, Brazil.
- Bernardo, P.H., Junqueira, A.F.B., Martins, I.A. (2011): A new geographic distribution record of the rare lizard *Colobodactylus dalcyanus* Vanzolini and Ramos, 1977 (Squamata, Gymnophthalmidae, Heterodactylini). *Herpetology Notes* 4: 327-329.
- Bérnils, R.S., Moura-Leite, J.C., Morato, S.A.A. (2004). Répteis. pp. 499-535. In: Mikich, S.B., Bérnils, R.S. (eds), Livro vermelho da fauna ameaçada no estado do Paraná. Instituto Ambiental do Paraná, Curitiba, Brazil.
- Bérnils, R.S., Costa, H.C. (2012): Brazilian reptiles: List of species. Version 2012.1. Available at <<http://www.sbherpetologia.org.br/>>. Sociedade Brasileira de Herpetologia. Downloaded on November 6th 2013.
- Câmara, I. G. (2005). Breve história da conservação da Mata Atlântica. pp. 31-42. In: Galindo-Leal, C., Câmara I.G. (eds), Mata Atlântica: biodiversidade, ameaças e perspectivas. Conservação Internacional, Belo Horizonte, Brazil.
- Centeno, F.C., Sawaya, R.J., Germano, V.J. (2010): A new species of *Liotyphlops* (Serpentes: Anomalepididae) from the Atlantic coastal forest in southeastern Brazil. *Herpetologica* 66(1): 86-91.
- Cicchi, P.J.P., Serafim, H., Sena, M.A., Centeno, F.C., Jim, J. (2009): Herpetofauna em uma área de floresta Atlântica na ilha Anchieta, município de Ubatuba, sudeste do Brasil. *Biota Neotropica* 9(2): 201-212.
- Colwell, R.K. (2013): EstimateS: Statistical estimation of species richness and shared species from samples. Version 9. User's Guide and application published at: <<http://purl.oclc.org/estimates>>.
- Condez, T.H., Sawaya, R.J., Dixo, M. (2009): Herpetofauna dos remanescentes de Mata Atlântica na região de Tapiraí e Piedade, SP, sudeste do Brasil. *Biota Neotropica* 9(1): 157-185.
- Cunha, A.K., Oliveira, I.S., Hartmann, M.T. (2010): Anurofauna da Colônia Castelhanos, na Área de Proteção Ambiental de Guaratuba, Serra do Mar paranaense, Brasil. *Biotemas* 23(2): 123-134.
- Forlani, M.C., Bernardo, P.H., Haddad, C.F.B., Zaher, H. (2010): Herpetofauna do Parque Estadual Carlos Botelho, São Paulo, Brasil. *Biota Neotropica* 10(3): 265-309.
- ICMBio (2013): Instituto Chico Mendes de Conservação da Biodiversidade. Accessed at November 6th 2013. Available at <<http://www.icmbio.gov.br>>
- Lang, M. (1992): A review of techniques for marking snakes. *Smithsonian Herpetological Information Service* 90: 1-19.
- Marques, O.A.V., Eterovic, A., Sazima, I. (2004): Snakes of the Brazilian Atlantic forest. An illustrated field guide for the Serra do Mar range. 2nd edition. Editora Holos, São Paulo.
- Melo, A.S., Pereira, R.A.S., Santos, A.J., Shepherd, G.J., Machado, G., Medeiros, H.F., Sawaya, R.J. (2003): Comparing species richness among assemblages using sample units: Why not use extrapolation methods to standardize different sample sizes? *Oikos* 101(2): 398-410.
- Rautenberg, R., Laps, R.R. (2010): Natural history of the lizard *Enyalius iheringii* (Squamata, Leiosauridae) in southern Brazilian Atlantic Forest. *Iheringia Série Zoologia* 100(4): 287-290.
- Ribas, E.R., Monteiro-Filho, E.L.A. (2002): Distribuição e habitat das tartarugas de água-doce (Testudines, Chelidae) do estado do Paraná, Brasil. *Biociências* 10(2): 15-32.
- Ribeiro, M.C., Martensen, A.C., Metzger, J.P., Tabarelli, M., Scarano, F., Fortin, M.J. (2011): The Brazilian Atlantic forest: a shrinking biodiversity hotspot. pp. 405-434. In: Zechos, F.E., Habel J.C. (eds), *Biodiversity hotspots. Distribution and protection of conservation priority areas*. Springer-Verlag Berlin Heidelberg.
- 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: 1141-1153.
- Roderjan, C.V., Galvão, F., Kuniyoshi, Y.S., Hatschbach, G.G. (2002): As unidades fitogeográficas do estado do Paraná, Brasil. *Revista e Ambiente* 24: 78-118.
- Rodrigues, M.T., Pellegrino, K.C.M., Dixo, M., Verdade, V.K., Pava, D., Argolo, A.J.S., Sites Jr, J.W. (2007): A new genus of microteiid lizard from the Atlantic forests of state of Bahia, Brazil, with a new generic name for *Colobosaura mentalis*, and a discussion of relationships among the Heterodactylini (Squamata, Gymnophthalmidae). *American Museum Novitates* 3565: 1-27.
- Silva-Soares, T., Ferreira, R.B., Salles, R.O.L., Rocha, C.F.D. (2011): Continental, insular and coastal marine reptiles form the municipality of Vitória, state of Espírito Santo, Southeastern Brazil. *Check List* 7(3): 290-298.
- Vanzolini, P.E., Ramos, A.M.M. (1977): A new species of *Colobodactylus*, with notes on the distribution of a group of stranded microteiid lizards (Sauria, Teiidae). *Papéis Avulsos de Zoologia* 31(3): 19-47.
- Zaher, H., Barbo, F.E., Martinez, P.S., Nogueira, C., Rodrigues, M.T., Sawaya, R.J. (2011): Répteis do estado de São Paulo: conhecimento atual e perspectivas. *Biota Neotropica* 11(1): 67-81.