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Geographic distribution, population densities, and issues on conservation of whiptail lizards in *restinga* habitats along the eastern coast of Brazil

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Abstract. We investigated the current geographic distribution of species of *Ameivula* and *Contomastix* along the Brazilian coast. We also estimated population sizes and conservation status of species from both genera and recorded potential sources of habitat degradation. Fieldwork was carried out in 12 areas of *restinga* (coastal sandy plain) from northeastern (Rio Grande do Norte) to southern Brazil (Santa Catarina), along approximately 4,000 km of coast. We used straight-line transects to estimate population densities. The data indicated that the ranges of species do not overlap. Only the distribution of *A. ocellifera* overlapped to some degree with *A. abaetensis*. In general, *restingas* with intermediate and high levels of degradation had the lowest population densities. We suggest some management strategies for the conservation of coastal species of *Ameivula*.

Key words: *Cnemidophorus*, geographic distribution, lizard conservation, population densities, *restinga* habitat.

Introduction

Cnemidophorus Wagler, 1830 (Teiidae) was until recently considered to have a wide distribution, occurring from the United States to Argentina (Wright 1993). However, Reeder et al. (2002) transferred the species occurring from the United States to northern Costa Rica to the genus *Aspidoscelis* Fitzinger, 1843. The South American species (comprising the former *lemniscatus* group of Wright, 1993) remained in a paraphyletic genus *Cnemidophorus*, pending more studies with a wider sampling within this group (Reeder et al. 2002).

Recently, Harvey et al. (2012) carried out a review of morphological traits of the family Teiidae and proposed a new taxonomic arrangement. According to these authors, the "*lemniscatus* complex" and *Cnemidophorus* from Caribbean form a cohesive genus, with the southern species comprising three unrelated new groups. Thus, currently the distribution of species among the four teiid genera in Brazil is as follows: *Ameiva* (2 spp.), *Ameivula* (10 spp.), *Cnemidophorus* (2 spp.), and *Contomastix* (2 spp.).

One *Contomastix* (*C. lacertoides*) and four *Ameivula* species (*A. ocellifera, A. abaetensis, A. nativo,* and *A. littoralis*) occur in the *restingas* (coastal sand-dune plain) along the Brazilian coast. Three of them are endemic to *restinga* habitats (*A. nativo, A. littoralis,* and *A. abaetensis*) and were assigned as "vulnerable" in the Brazilian Red List (Martins & Molina 2008) due to intense anthropogenic disturbance on *restingas*.

There are some autoecological studies on *Ameivula* populations in *restingas* along the Brazilian coast, but they are concentrated mainly in the States of Rio de Janeiro, Espírito Santo, and Bahia (e.g., Bergallo & Rocha 1994, Ribas et al. 1995, Menezes et al. 2000, 2004a, 2004b, 2006, 2011, Teixeira-Filho et al. 2003, Dias & Rocha 2004, 2007, Peloso et al. 2008, Rocha et al. 2009, Menezes & Rocha 2011) with only one study on the ecology of *Contomastix* (Ariani et al. 2011). Currently, information about the conservation status and population densities of species of *Ameivula* and *Contomastix* in *restingas* is lacking. Additionally, knowledge about the geographic distribution of each species along *restingas* of the eastern Brazilian coast is incipient (e.g., Rocha et al. 1999, Vrcibradic et al. 2002, Dias & Rocha 2005). Here, we investigated the occurrence and geographic distribution of *Ameivula* and *Contomastix* species occurring along the eastern Brazilian coast. We also estimated (i) population sizes for each species, (ii) the potential sources of habitat disturbance, and (iii) the conservation status of the corresponding populations in each area.

Material and methods

Study areas

Fieldwork was carried out in 12 areas of *restinga* from Genipabu, Rio Grande do Norte, northeastern Brazil to Florianópolis, Santa Catarina, southern Brazil (Fig. 1).

These areas comprise approximately 4,000 km of coast. *Restingas* are sandy ridges located between the sea and the mountains of the Brazilian eastern seashore. This type of habitat originated in the Quaternary due to successive marine regressions and transgressions throughout the Holocene and Pleistocene (Muehe 1983, Perrin 1984, Suguio & Tessler 1984).

Sampling Methods and Analysis

Surveys were conducted during the rainy season (October-May) along three years (2004-2006, depending on the area). We established straight-line transects in different days during the peak of activity of species to estimate lizard population densities (from 09:00 to 13:00 h; Menezes et al. 2000, Hatano et al. 2001, Dias & Rocha 2007). Since the area and structure of each *restinga* varied considerably, the number of transects was unequal, but the total distance walked in each area was approximately 2,050 m. The observer walked at a slow and constant pace along the transect, recording all *Ameivula* and *Contomastix* individuals sighted within 5 m to each side of the observer. The total sampled area at each locality was about 2.1 ha (2,050 m x 10 m). A standardized index of population density was estimated by dividing the total number of lizards recorded at a particular area by the total sampled area (ha) in transects (expressed as ind/ha). We considered up to five individuals/ha as "low" density, from five to ten individuals/ha as "intermediate" and more than 10 individuals/ha as "high" density.

Additionally, we recorded the following sources of disturbance: 1) vegetation removal for road building; 2) trampling on vegetation to gain access to the beach; 3) house building; 4) traffic of motorized vehicles on sand-dune vegetation; 5) vegetation removal for volleyball or football sand courts; 6) vegetation removal for the establishment of trade kiosks; 7) burning of the vegetation; 8) vegetation removal for construction of sidewalks; 9) trail opening; 10) removal of useful or ornamental plant species; 11) garbage dumping on vegetation; 12) large-scale sand removal; 13) establishment of agricultural cultures; 14) parking lots; 15) hunting; 16) presence of grazing animals (e.g., cows, horses, and goats).

We attributed a value to each of these sources of disturbance to estimate the degree of habitat degradation (see Rocha et al. 2003), as follows: 0 if no disturbance was recorded; 1 if there were some disturbance but it was comparatively lower in relation to other *restingas*; 2 for intermediate disturbance, and 3 when disturbance was comparatively higher. The final degree of disturbance was equal to the sum of attributed values to each source of degradation and used to represent the relative degree of conservation of each *restinga*. We considered as "low" habitat degradation environments with index of disturbance under 10, "intermediate" from 11 to 20, and "high" with index above 20.

The approximate geographical distributions of the five lizard species were obtained by evaluating the occurrence of each species in the *restingas,* supplemented with field data, an extensive bibliographical revision, and by consulting the HerpNET database (www.herpnet.org).

These data were used to map the distribution *Ameivula* and *Contomastix* species occurring along the Brazilian coast. This procedure allowed us to identify areas where species occurred in sympatry. Maps were made using the program ArcGIS 9.2 (ESRI 2006). Based on our results, we suggest some management and conservation proposals for the endemic and threatened species of *Ameivula* listed in the Brazilian Red List (Martins & Molina 2008).

Results

The most widespread species along the 4,000 km of *restinga* in the Brazilian coast was *Ameivula ocellifera*, while the distribution of *Contomastix lacertoides* and *A. littoralis* was more restricted (Fig. 1, Table 1). *Contomastix lacertoides* was recorded in only one *restinga* in the state of Santa Catarina (Fig. 1, Table 1). *Ameivula littoralis,* endemic to the state of Rio de Janeiro, was recorded in only four *restingas*, and the known limits of its geographic distribution along the coast comprehended about 250 km (Fig. 1, Table 1).

The southern limit distribution of *Ameivula ocellifera* and *A. abaetensis* was recorded as the restinga of Abaeté in Salvador (Bahia). These two species have been recorded to occur sympatrically in some restinga habitats northwards to Aracaju (Sergipe), which is the northern known limit of distribution of *A. abaetensis*. *A. ocellifera* and *A. abaetensis* occur sympatrically in some restingas. *Ameivula ocellifera* was also recorded along the coast of Brazil northwards to Fortaleza (Ceará). This species is distributed discontinuously along approximately 1,300 km along the northwestern cost of Brazil (Fig. 1, Table 1).

Ameivula nativo occured in some *restingas* in the states of Espírito Santo and Bahia (Fig. 1, Table 1), with a scattered distribution along approximately 870 km throughout the coast. The three coastal *Ameivula* species threatened with extinction (*A. littoralis, A. nativo* and *A. abaetensis*) are endemic to *restinga* and apparently have a narrow geographic distribution, without overlapping ranges along the coast (Fig. 1).

The densities of lizard populations varied among the *restinga* (Table 2). The densities of the threatened species (*A. littoralis, A. abaetensis*, and *A. nativo*) were generally lower in *restingas* with higher or intermediate levels of disturbance (Table 2).

Our habitat disturbance index indicated that *restingas* varied in the intensity of impact (Table 2). The areas with the highest degrees of disturbance

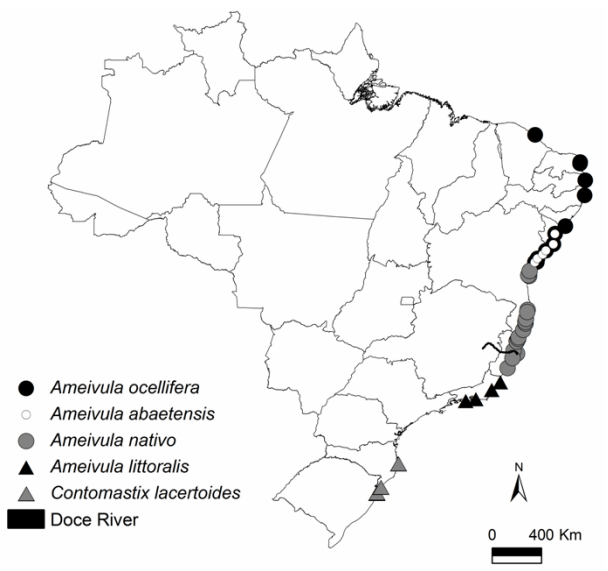

Figure 1. Distribution of *Ameivula* and *Contomastix* species occurring in the *restingas* along the eastern coast of Brazil.

were Piaçabuçu (Alagoas), Maraú (Bahia), and Guarajuba (Bahia). The highest conservation level was found at the *restingas* in Jurubatiba (Rio de Janeiro) and Joaquina (Santa Catarina).

The main sources of degradation were: (1) vegetation removal for road building, (2) house building, (3) vegetation trampling to open access to the beach, (4) traffic of motor vehicles on dune vegetation, and (5) trail opening.

Discussion

The geographic ranges of *Ameivula* species did not overlap along the Brazilian coast. Only the distribution of the widely distributed species *A. ocellifera* (Cabrera 2012), which occurs in four countries, overlapped with *A. abaetensis* in five *restingas* along the coast. *Contomastix lacertoides* occurred in allopatry with the species of the genus *Ameivula*, being recorded only in the southern coast. This species supposedly occupied coastal areas by expanding its distribution from areas farther inland in the state of Rio Grande do Sul, and in Uruguay and Argentina (Lema 1994). We did not find any record of species of *Contomastix* or *Ameivula* from the *restinga* of Joaquina in Santa Catarina up to the *restinga* of Marambaia, in Rio de Janeiro. A similar disjunction occurs with lizards of the genus *Liolaemus*, a genus without representatives along this portion of the coast. *Liolaemus occipitalis* occurs in the *restinga* of Joaquina and *L. lutzae* occurs in the *restinga* of Marambaia (Vanzolini & Ab'Saber 1968, Rocha et al. 2009). The disjunct distribution of Cnemidophorines and *Liolaemus* might have been influenced by the narrow width of the *restinga* along this portion of the Brazilian coast.

Ameivula nativo occurs in the *restingas* of the coast of Espírito Santo up to the southern portion of Bahia, whereas in the *restingas* of Salvador (Bahia) to Sergipe *A. ocellifera* and *A. abaetensis* occur (though the distribution of *A. ocellifera* extends northwards along the coast). An interesting biogeographic aspect is that the same distributional pattern occurs with lizards of the genus *Tropidurus*. *Tropidurus torquatus* occurs in the *restingas* south of Salvador. *Tropidurus hygomi* and *T. hispidus* occur from Salvador northwards (Rodrigues 1987, 1988). At the moment, it is not possible to identify biogeographic and/or ecological factors responsible for the distributional patterns of these two genera. Information on the fauna and historical processes are currently available for only few Brazilian *restingas* (Lacerda et al. 1984).

Until recently, the southern distribution limit of *A. nativo* has been considered to be at the northern margin of the Rio Doce river, which apparently constitutes an important barrier for the distribution of a number of animal species (Rocha 2000, Rocha et al. 2003). However, recent records of *A. nativo* in the *restinga* of Setiba, south of the Rio Doce (Peloso et al. 2008, present study) suggest that this river may not represent a barrier for this species.

Ameivula nativo, A. littoralis, and *A. abaetensis*

Table 1. Geographic distribution of the five lizards living in *restinga* along the eastern coast of Brazil. Brazilian states codes are: RS – Rio Grande do Sul, SC – Santa Catarina, RJ – Rio de Janeiro, ES – Espírito Santo, BA – Bahia, SE – Sergipe, AL – Alagoas, PB – Paraíba, RN – Rio Grande do Norte, CE – Ceará. * MBML = Museu de Biologia Prof. Mello Leitão.

Species	Locality	Coordinates	Source
C. lacertoides	Atlântida, RS	29º 47′ S; 50º 01′ W	Lema 1994
	Capão da Canoa, RS	29º 44′ S; 50º 00′ W	Lema 1994
	Torres, RS	29º 20′ S; 49º 43′ W	Lema 1994
	Joaquina, Florianópolis, SC	27º 35′ S; 48º 35′ W	Present study
A. littoralis	Marambaia, Mangaratiba, RJ	23° 03′ S; 43° 33′ W	Carvalho et al. 2007
	Barra de Maricá, Maricá, RJ	22º 57′ S; 42º 50′ W	Rocha et al. 2000, Present study
	Jurubatiba, Carapebus, RJ	22º 17′ S; 41º 41′ W	Rocha et al. 2000, Present study
	Grussaí, São João da Barra, RJ	21º 44′ S; 41º 02′ W	Present study
A. nativo	Setiba, Guarapari, ES	20º 34′ S; 40º 27′ W	Present study
	Santa Cruz, Aracruz, ES	19º 57′ S; 40º 09′ W	MBML*
	Aracruz, ES	19º 50′ S; 40º 06′ W	MBML*
	Comboios, Linhares, ES	19º 42′ S; 39º 57′ W	Present study
	Nativo do Paraju, Linhares, ES	19º 18′ S; 40º 19′ W	Rocha et al. 1997
	Ponta Sul, São Mateus, ES	18º 42′ S; 39º 51′ W	MBML*
	Guriri, São Mateus, ES	18º 41′ S; 39º 45′ W	Teixeira 2001, Present study
	Conceição da Barra, ES	18º 35′ S; 39º 43′ W	Rocha et al. 1999
	Itaúnas, ES	18º 24′S; 39º 43′ W	Rocha et al. 1999
	Nova Viçosa, BA	17º 89′ S; 39º 37′ W	Rocha et al. 1999
	Guaratiba, Prado, BA	17º 25′ S; 39º 12′ W	Rocha et al. 1999, Present study
	Prado, BA	17º 18′ S; 39º 13′ W	Rocha et al. 1999, Present study
	Cumuruxatiba, Prado, BA	17º 05′ S; 39º 10′ W	Rocha et al. 1999
	Arraial D'Ajuda, Porto Seguro, BA	16º 26′S; 39º 03′ W	Rocha et al. 1999
	Trancoso, Trancoso, BA	16º 31' S;39º 05' W	Dias & Rocha 2005
	Boipeba, Cairú, BA	13º 58′ S; 38º 56′ W	Dias & Rocha 2005
	Ilha Grande, Camamu, BA	13º 56′ S; 39º 06′ W	Vrcibradic et al. 2002
	Península de Maraú, Maraú, BA	13º 36′ S; 38º 54′ W	Present study
A. abaetensis	Abaeté, Salvador, BA	12º 55′ S; 38º 42′ W	Dias et al. 2002
	Camaçari, Guarajuba, BA	12º 38' S; 38º 04' W	Dias & Rocha 2005, Present study
	Porto Sauípe, Mata de São João, BA	12º 31′S; 38º 17′ W	Dias et al. 2002
	Baxio, Esplanada, BA	12º 07' S; 37º 42' W	Dias et al. 2002
	Costa Azul, BA	11º 40' S; 37º 29' W	Dias & Rocha 2005
	Barra dos Coqueiros, Aracajú, SE	10º 54′ S; 37º 02′ W	C. M. Carvalho, pers. comm.
A. ocellifera	Itapoan, Salvador, BA	12º 57′ S; 38º 18′ W	HerpNet
	Abaeté, Salvador, BA	12º 55′ S; 38º 42′ W	Dias et al. 2002
	Camaçari, Guarajuba, BA	12º 38' S; 38º 04' W	Dias & Rocha 2005, Present study
	Baixio, Esplanada, BA	12º 07' S; 37º 42' W	Dias et al. 2002
	Costa Azul, BA	11º 40' S; 37º 29' W	Dias & Rocha 2005
	Barra dos Coqueiros, Aracajú, SE	10º 54′ S; 37º 02′ W	Present study
	Pontal do Peba, Piaçabuçu, AL	10º 21′ S; 36º 18′ W	Freire 1996, Present study
	Boa viagem, PE	08º 04′ S; 34º 55′ W	HerpNet
	Praia de Ponta de Campina, Cabedelo, PB	07º 01′ S; 34º 50′ W	Freire 1996
	Dunas de Natal, Natal, RN	05º 47′ S; 35º 10′ W	Freire 1996
	Genipabu, RN	05º 43′ S; 35º 13′ W	Present study
	Fortaleza, CE	03º 45′ S; 38º 31′ W	Feltrim 1999
	Mucuripe, Fortaleza, CE	03º 39′ S; 38º 37′ W	HerpNet

are currently threatened with extinction in the IUCN Red List (IUCN 2012) and in the Brazilian Red List (Machado 2008). These three coastal species have restrict and non-overlapping ranges. It is likely that this pattern of occurrence reflects relatively recent speciation events from one common ancestor. In fact, one of the species (*A. nativo*) is parthenogenetic (e.g., Rocha et al. 1997, Menezes et al. 2004a) and its evolution can be tied to hybridization processes from two parental species

Table 2. Index of degradation and estimated density of *Ameivula* and *Contomastix* populations in the *restingas* along the Brazilian coast.

Species	City	Index of degradation	Density (ind/ha)
C. lacertoides	Joaquina, SC	Intermediate (11)	Low (2.9)
A. littoralis	Maricá, RJ	Intermediate (13)	High (34.6)
	Jurubatiba, RJ	Low (4)	High (13.2)
	Grussaí, RJ	Intermediate (21)	Low (1.0)
A. nativo	Setiba, ES	Intermediate (17)	Low (0.5)
	Comboios, ES	High (20)	Low (3.4)
	Guriri, ES	Intermediate (12)	Intermediate (5.8)
	Maraú, BA	High (27)	Low (1.0)
A. abaetensis	Guarajuba, BA	High (24)	Low (0.5)
A. ocellifera	Guarajuba, BA	High (24)	Intermediate (6.8)
	Praia do Porto, SE	Low (10)	High (26.8)
	Piaçabuçu, AL	High (33)	High (15.6)
	Genipabu, RN	Intermediate (16)	Low (1.9)

that occur in *restingas* (potentially *A. ocellifera* and *A. abaetensis*; Dias et al. 2002).

In general, the *restingas* with intermediate and high levels of degradation had the lowest population densities of *Ameivula* and *Contomastix* species. The exception was Piaçabuçu (Alagoas), this area had the highest degree of degradation and a relatively high density of *A. ocellifera*. Currently, this species is the most widely distributed of this genus in Brazil, occurring in different types of habitats, such as caatinga, Cerrado, *restingas*, and "campos rupestres" (high-altitude grassland; Mesquita & Colli 2003, Menezes et al. 2011, Sales et al. 2012). The adaptation to different environments possibly favors its occurrence in environments with different disturbance levels.

Population density varied among and within species of *Ameivula* . Some studies (e.g., Pianka 1970, 1986) suggest that the density of lizards may be regulated by the local availability of arthropods. However, others (e.g., Magnusson et al. 1986, Vitt & Carvalho 1992) demonstrated that habitat structure (relative proportion of shrubs and soil type) influences significantly population density of lizards (Cosentino et al. 2013). These results indicate that populations must be sensitive to microgeographical differences (Magnusson et al. 1986). Though studies on lizard population density are still scarce in Brazil, several factors may influence population density such as prey availability in the environment, the local thermal environment, presence of predators, sex ratio, availability of potential shelters and safe places for nidification (e.g., Magnusson & Silva 1993). However, it seems that the level of disturbance may also consistently affect population sizes.

Recent studies have shown that the *restingas* have been degraded and suppressed at an increasing rate by human action (Rocha & Bergallo 1992, Rocha et al. 2003, 2005). Habitat alterations have negatively affected *restinga* lizards (Rocha & Bergallo 1992, Rocha et al 2003, Dias & Rocha 2005, Rocha et al. 2009). A recent study evaluating density and conservation status of *Liolaemus lutzae*'s populations showed that population densities were negatively related to the level of human disturbances along the species range (Rocha et al. 2009). Population size of *L. lutzae* was strictly related to the corresponding local disturbances level in the *restingas* (Rocha et al. 2009). The same seems to be the case of populations of endangered species of *Ameivula* occurring in *restingas* along the eastern Brazilian coast. *Ameivula* lizards require specific environmental temperatures to attain the high metabolic rates necessary for maintaining a high body temperature and to keep up with the energetic demands of active foraging (e.g., Teixeira-Filho et al. 1995, 2003, Menezes et al. 2000, Mesquita & Colli 2003). Changes in these conditions can contribute to their decline or even local extinction (Dias & Rocha 2005). Additionally, since these lizards are active foragers, they need a wide home range for their daily activities (e.g., Cooper 1990, Etheridge & Wit 1993). Thus, conservation plans to their habitats need to consider their ecophysiological requirements.

Considering *restinga* degradation and conservation status of *Ameivula* populations, the main strategies for the conservation of these coastal lizards should be: (1) creation of more nature reserves, (2) implementation of recovery programs of disturbed *restingas*, (3) law enforcement, (4)

promotion of educational programs directed to local people, (5) establishment of monitoring programs to periodically evaluate population sizes, and (6) examination of land use in and around *restingas* to identify current pressures.

Suggestions of Priority Areas for Conservation of Threatened Ameivula Species.

We suggest some areas that potentially would be of higher protection value for the endangered species.

Ameivula abaetensis do not occur in any protected area. We recommend that the *restinga* of Guarajuba (Camaçari, Bahia) should be a priority area for conservation, since it constitutes one of the few areas where two species of *Ameivula* occur simpatrically: *A. abaetensis* and *A. ocellifera.*

Ameivula nativo occur in only three protected areas, all in the Espírito Santo. We recommend as priority areas for conservation: (1) *Restinga* of Maraú (Bahia), which has a high reptile species richness including, besides *A. nativo*, the endemic viperid snake *Bothrops pirajai* (Dias & Rocha 2005), (2) the remnants of restinga near the cliffs in the northern portion of Prado (Bahia) that, though of relative small size, still harbors populations of *A. nativo*, and (3) the *restinga* of Guriri (Espírito Santo) in which *A. nativo* presented the highest population density among studied areas (Rocha et al. 2003).

Ameivula littoralis occur only in the Protected Area of *Restinga* of Jurubatiba National Park in the northern coast of Rio de Janeiro. The population of Marambaia is protected to some degree due to the administration by the Brazilian army, though it is not a Protected Area. The conservation of this species must be prioritized at the *restingas* of Maricá and Grussaí in Rio de Janeiro, which are two less protected areas out of the four in which this species occurs. It is important that the public authorities of each city map all remnants of *restinga* inside their political and geographical limits in order to protect those with good conservation status, even the small ones. If the state and city authorities do not take effective actions to reverse this situation, the lack of protection of most of the remnants can result in mid-term disappearance of large portions of this habitat and species that depend on it.

Considering the increasing rates of degradation of the *restinga* (Rocha et al. 2003, 2005), we believe that these species will be effectively protected from extinction only by establishing new Protected Areas. The lack of information on the ecology of these threatened species and the destruction rates of these habitats demonstrate that more studies are needed.

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