

Notes on the conservation status, geographic distribution and ecology of *Bothrops muriciensis* Ferrarezzi & Freire, 2001 (Serpentes, Viperidae)

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Abstract. The Atlantic forest of Brazil is one of the most biodiverse regions in the world. However, in the last centuries this biome has suffered unparalleled fragmentation and degradation of its forest cover, with only 8% of its original area remaining. The region of Murici, in the state of Alagoas, Brazil, houses some of the largest forest fragments of Atlantic forest and is one of the regions within the biome with more threatened and endemic taxa. One of this is *Bothrops muriciensis*, a snake species previously only known from the three records used to describe it. We present six new records for *Bothrops muriciensis* along with additional information and inferences on the species geographic distribution and natural history. Lastly we use the new information to assess the species according to the IUCN Redlist criteria and suggest that the species should be placed in the Critically Endangered category under criteria IUCN Redlist criteria B2ab(iii). The effective management of this species will require further data on its ecology, geographic distribution and population dynamics but its survival will more likely depend on an effective protection of the Murici Ecological Station, the only locality where *Bothrops muriciensis* has so far been recorded.

Key words: Atlantic forest, Brazil, *Bothrops muriciensis*, Lancehead, Murici, Viperidae.

Introduction

The Atlantic forest of Brazil is one of the 25 major "hotspots" for global biodiversity, with one of the largest number of endemic species of any region in the world, but less than 8% of its original coverage remaining (Myers et al. 2000). Within the Atlantic forest, the area north of the river São Francisco, constitutes the Pernambuco Center of Endemism (PCE), which encompasses the coastal forests of the states of Alagoas, Pernambuco, Paraíba and Rio Grande do Norte (Cardoso & Tabarelli 2000).

The PCE constitutes the most degraded, less protected and less known of five centers of endemism for the Atlantic Forest (Coimbra-Filho & Câmara 1996, Silva & Tabarelli 2001, Tabarelli et al. 2006a, b) with only 2% of the original forest cover remaining (Silva & Tabarelli 2001). This is of much concern for biodiversity conservation, given the hundreds of endemic birds (e.g. Teixeira 1987, Silva et al. 2002), reptiles (Freire et al. 2010, Passos et al. 2010), amphibians (e.g. Peixoto et al. 2003, Carnaval & Peixoto 2004), insects (e.g. Nemésio

2010, Faria & Melo 2011) and plants (e.g. Tabarelli et al. 2006a, b, Siqueira Filho et al. 2007) that have been, and continue to be, described for this region.

The region of Murici, state of Alagoas, is one of the key areas of the PCE, encompassing some of its largest forest remnants (Tabarelli et al. 2006a). Altitude varies from 150 to 600 metres a.s.l. with forest cover currently restricted largely to the higher elevations and surrounded by a matrix of sugar cane fields or pastures (Oliveira & Pôrto 2007). One of the key areas for the PCE, is the Murici Ecological Station (MES), created in May 2001 (Menezes et al. 2004) (Fig.1). The MES covers 61.16 km², being a full protection area with no resource extraction allowed. The MES is buffered by the Murici Environmental Protection Area (MEAP), created in 1997 to ensure the sustainable use of natural resources in the region (Fig.1). The MEAP covers 1161 km² and includes the largest remnant area of Atlantic forest in Northeast Brazil (Menezes et al. 2004). The importance of the Murici region is most easily illustrated through well studied taxa, like birds, with the region supporting

more threatened taxa than any other in the American continent (Wege & Long 1995, Tabarelli et al. 2006a). This importance was formally recognized in 2004 when eight national and international conservation NGOs including Conservation International, The Nature Conservancy, Birdlife International and WWF-Brasil, signed the "pact of Murici", which acknowledged the critical importance of conserving the Atlantic Forest of Northeast Brazil (Tabarelli et al. 2006a).

Although efforts to conserve and study the herpetofauna of Brazil's Atlantic forest have in the last decades gained momentum, there are still large gaps in our knowledge (Martins & Molina 2008). This is reflected in the large number of recently described species, in the large number of species for which only a handful of specimens have ever been seen, and in the number of species classified as Data Deficient (Martins & Molina 2008). One of the few species that fulfills all three of the previous criteria is the snake *Bothrops muriciensis* Freire & Ferrarezzi, 2001, recently described for the region of Murici, state of Alagoas, Brazil, and for which no additional studies or observations have ever been published.

In Brazil there are eight snake species from the genus *Bothrops* (Bérnils 2011), all of which have most recently been assigned, using phylogenetic, morphological and ecological criteria, to the *Bothrops atrox* group (Fenwick et al. 2009). The group contains species with varied geographic distributions: *Bothrops brazili* Hoge, 1954, and *Bothrops jararacussu* Lacerda, 1884, are widely distributed across the Amazon (Cunha & Nascimento 1993) and the Atlantic forest (Argôlo 2009) respectively, while *Bothrops pirajai* Amaral, 1923 and *Bothrops muriciensis* are restricted to the Atlantic forest of northeast Brazil (Fig. 2).

The objective of this work was to collect information about the ecology and geographic distribution of *Bothrops muriciensis*. This will in turn be instrumental in understanding the conservation status of the species, currently listed as Data Deficient in the Brazilian Fauna Red List (Martins & Molina 2008).

Material and methods

A research expedition was conducted between the 5th and 12th of March 2010 in the Bananeiras estate (09° 18'S, 35° 57'W, 550 m a.s.l.), municipality of Murici, State of Alagoas, Brazil. The estate has a total area of 19.25 km², having the expedition covered approximately one of the

11.8 km² that lie within the boundaries of the MES. The team, composed of four people, conducted 12 hours of active search for eight days, totaling 384 manhours of survey effort (SISBIO/ICMBio-1160-1). Folidose features were also documented in all specimens found and compared against those described by Ferrarezi & Freire (2001). To complement the records found in the field we also used our professional networks to find other records of this species where photographic proof of species identity was available.

Results

Two juvenile individuals of *B. muriciensis* were found during the survey, one with 240 mm and the other with 310 mm of length. Both were found close to forest streams. The survey also found single individuals of *Dipsas sazimai*, *Dipsas neivai*, *Pseustes sulphureus*, *Oxyrhopus guibei* and *Philodryas olfersii*, and two individuals of both *Dendrophidion atlantica* and *Siphlophis compressus*.

A search through the professional networks of the authors yielded four further records of *B. muriciensis*, all also from the Bananeiras estate, Murici, state of Alagoas, Brazil. The oldest record was a juvenile found at a forest clearing on top on a hill, on December 2005 (C. da Cruz, pers.comm, 2011) (Fig. 3). The next record concerned an adult female found basking on a forest clearing (F. Tavares, pers. comm. 2009) (Fig. 3). Two other adult individuals one male another female were documented, close to a forest stream and on a forest slope respectively (L. Araújo, pers. comm. 2010) (Fig. 3).

Discussion

Ten years have passed since Ferrarezi & Freire (2001) described *B. muriciensis*, in a publication that until now also presented the only known records of the species. The present work triples the number of available records, from three to nine. This number, although undeniably low, can probably be best explained by the low population density of the species and its restriction to the forest leaf litter, traits known from other *Bothrops* species restricted to the Atlantic forest biome (Cunha & Nascimento 1993, Campbell & Lamar 2004, Freitas 2008). This is further attested given the regional survey effort already put into place by the authors and other researchers (e.g. Freire 2001).

The current knowledge about the natural history of *B. muriciensis* is at best scarce, however the

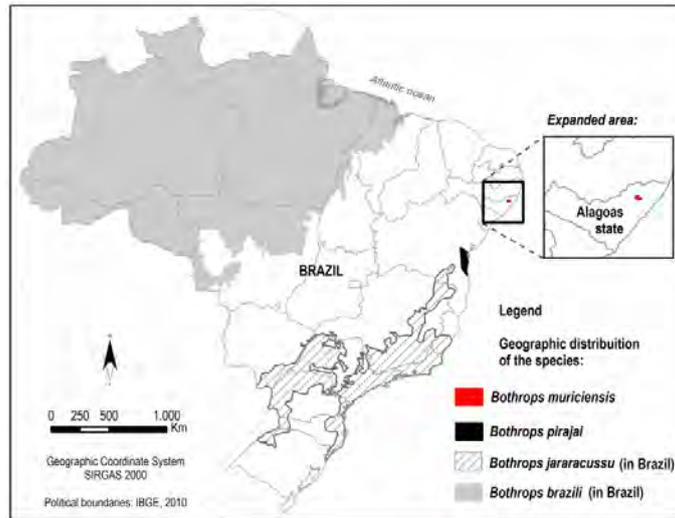


Figure 1. Map of the Murici region, showing the location of the Bananeiras estate, the Murici Ecological station and of the Murici Environmental Protection Area.

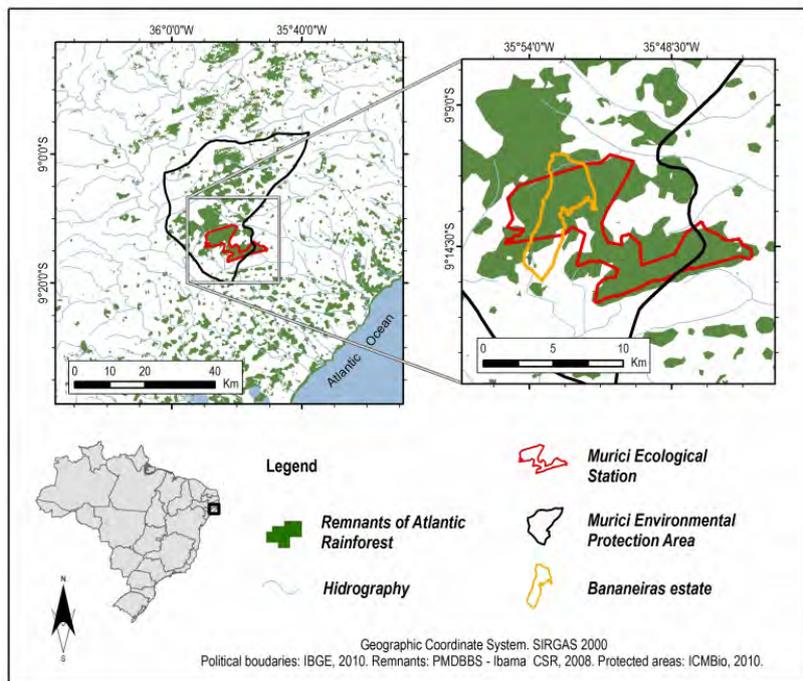


Figure 2. Distribution map of the species *Bothrops muriciensis*; *Bothrops pirajai*; *Bothrops brazili* (in Brazil) and *Bothrops jararacussu* (in Brazil).

new records allow us to make some limited inferences. In terms of habitat use the species seems to be terrestrial, a common trait in its genus (Martins et al. 2002), and to be limited to the Atlantic

forest above 400 meters altitude. This last characteristic might however be influenced by the higher degradation and fragmentation of the forest cover at lower altitudes in the region of Murici.



Figure 3. A- Juvenile, found on the 07/03/2010, 21h51, moving through the leaf litter close to a stream; B- Juvenile, found on the 07/03/2010, moving through the leaf litter close to a stream (Photos by M. Freitas); C- Juvenile, found on the 27/12/2005, at night, on the leaf litter close to a stream (Photo by D. Filho); D- Adult female, found on the 24/11/2009, 10h23, basking on a forest clearing (Photo by F. Tavares); E- Adult male, found on the 28/11/2010, 12h26, close to a forest stream; F- Adult female found on the 29/11/2010, 12h25, on the slope of a forest hill (Photos by L. Araújo).

In terms of diet, the white tail tip found in the juveniles of *B. muriciensis* is likely to be an indicator of caudal luring to attract prey, a behavior described for many species of *Bothrops* (e.g. Sazima 1991, Freitas 2008) and frequently associated with feeding on ectothermic prey, especially anurans (Sazima 1991, Martins & Gordo 1993). This hypothesis is reinforced by the fact that both juvenile individuals recorded in this study were found close to forest streams. We hypothesize thus that this species diet relies on anurans as a juvenile, going then through an ontogenic shift in prey type as its body size increases to become a generalist

predator, as is common in other *Bothrops* species (Sazima 1991, Martins & Gordo 1993). Further surveys of this poorly know species are much needed as to provide insights into its population densities, ecology and distribution, an unfortunately common situation in megadiverse countries such as Brazil (Freitas et al. 2011, Freitas et al. 2012).

Conservation status

The lack of information about the ecology and population dynamics of *B. muriciensis* has hampered the evaluation of the conservation status of

the species, explaining the current Data Deficient (DD) status (Rodrigues 2005). However we believe that the information brought to light by the present study, although limited, can provide enough information to assign a conservation status to the species.

Given the lack of basic data on population monitoring and ecology for this species, only criteria on geographic distribution can currently be used to assign a conservation status to *B. muriciensis*. Nonetheless, given the lack of detailed GPS coordinates for the species records found thus far, we can only rely on broader habitat mapping using GIS tools to establish an approximate species area of occurrence.

All existing records of *B. muriciensis* come from within the 15,29 km² forested fraction of the Bananeiros estate, of which 11,80 km² are part of the MES. This would put the known area of occurrence of the species very close to the 10km² threshold used to fulfill criteria B2 for the category of Critically Endangered (IUCN 2010). Considering that this prediction assumes the unrealistically optimistic point of view that all available habitat will be occupied by the species and using the precautionary principle, we believe that this category is the most appropriate for the species.

To this we have to add the fact that the species is only known from a single locality and the severely fragmented nature of the CPE Forest (Ranta et al. 1998, Cardoso & Tabarelli 2000, Tabarelli et al. 2006b) in general and the MES in particular (Oliveira & Pôrto 2007). The situation in the region is thought to be so critical that one third of the tree species are thought to be threatened due to the loss of large seed dispersers (Cardoso & Tabarelli 2000). Moreover, the area of available habitat has also suffered an important decrease with 5% forest fragments disappearing between 1989 and 2000, and another 11.4 % being reduced by more than a third (A. Amarante, unpublished data in Tabarelli & Roda 2005). This destruction is ongoing even within the MES, a full protection area (Silveira et al. 2003). As such, and considering the available information, we believe the species should be classified as Critically Endangered under IUCN criteria B2ab(iii) (IUCN 2010). This is in line with the recommendations of Martins (2005), and follows from the classification of *Bothrops pirajai*, currently classified as Vulnerable A1c. This is a phylogenetically related and neighboring species which while suffering from many of the same threats of *B. muriciensis* and having itself a restricted distribution,

has a much wider distribution than *B. muriciensis* (Fig 2).

In this light the future priorities for this species should be a more systematic survey of other forested areas in the Murici region as to allow for a better estimate of the species area of occurrence. It should nonetheless be noted that even if the species occupied the entire 344,45 km² of forested area of the MAEP, which includes not only the MES but also all surrounding large forest fragments, it would still fulfill the B2 criteria for the Endangered category. As such, it seems clear that keeping the species as DD is not appropriate.

Since the biggest threat to the species existence is habitat destruction, a common situation among forest snakes given their inability to adapt to open habitats (Rodrigues 2005, Martins & Molina 2008), the conservation of *B. muriciensis* is inevitably linked with an adequate protection of the MES and a sustainable management of the MAEP. Currently the MES, although designated as a full protection area, continues to suffer from fragmentation and loss of forest cover, mostly due to the failure of the government to compensate the farmers established in the area (Tabarelli & Roda 2005). Overturning this situation in the short term will be surely the key test for the "Pact of Murici"; and its success or failure might dictate the fate of an important number of species found nowhere else in the world.

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