



Biota Neotropica
ISSN: 1676-0611
cjoly@unicamp.br
Instituto Virtual da Biodiversidade
Brasil

de França, Rafaela Cândido; de Souza Germano, Carlos Eduardo; Rodrigues França, Frederico
Gustavo
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State, Northeast Brazil
Biota Neotropica, vol. 12, núm. 3, septiembre, 2012, pp. 183-195
Instituto Virtual da Biodiversidade
Campinas, Brasil

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Composition of a snake assemblage inhabiting an urbanized area in the Atlantic Forest of Paraíba State, Northeast Brazil

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FRANÇA, R.C., GERMANO, C.E.S. & FRANÇA, F.G.R. **Composition of a snake assemblage inhabiting an urbanized area in the Atlantic Forest of Paraíba State, Northeast Brazil.** *Biota Neotrop.* 12(3): <http://www.biotaneotropica.org.br/v12n3/en/abstract?inventory+bn00612032012>

Abstract: The Atlantic Forest of Brazil is one of the most biologically diverse regions in the world, but also one of the most highly threatened, with only around six percent of its original cover remaining. Despite the increase in the number of studies on the ecology of Brazilian snakes during the last two decades, there are still very few works on snake assemblages in the Northeast region and almost nothing about snakes inhabiting urbanized areas in Atlantic Forest domain. Herein we describe the snake assemblage from the urban area of Rio Tinto city in Paraíba State, Northeast Brazil. We present data on composition, distribution and some natural history. Also, we compare the snake diversity of the urban area with the diversity in two nearby natural patches. We recorded 161 individuals of 25 species in 16 genera from the urban area of Rio Tinto and the most common species were *Helicops angulatus*, *Bothrops leucurus*, *Epicrates assisi*, and *Philodryas patagoniensis*. Most snake species were non-venomous, but some venomous snakes were abundant in the urban area and people must be cautious when dealing with these. Rarefaction curves did not reach stability and new species should be added to the Rio Tinto snake list in future studies.

Keywords: snakes, Paraíba, urban herpetology, anthropogenic areas.

FRANÇA, R.C., GERMANO, C.E.S. & FRANÇA, F.G.R. **Composição de uma taxocenose de serpentes em uma área urbana na Mata Atlântica da Paraíba, Nordeste do Brasil.** *Biota Neotrop.* 12(3): <http://www.biotaneotropica.org.br/v12n3/pt/abstract?inventory+bn00612032012>

Resumo: A Mata Atlântica é uma das ecorregiões mundiais que apresenta maior diversidade, entretanto é também uma das mais ameaçadas com apenas seis por cento de sua cobertura vegetal original preservada. Apesar do aumento no número de trabalhos sobre ecologia de serpentes brasileiras durante as últimas duas décadas, ainda são poucos os estudos sobre as taxocenoses de serpentes da região Nordeste do Brasil e praticamente nada está publicado sobre serpentes encontradas em áreas urbanas na Mata Atlântica nordestina. Este trabalho apresenta uma descrição da taxocenose de serpentes da área urbana de Rio Tinto, cidade localizada no litoral norte da Paraíba. O trabalho focou a composição, distribuição e alguns aspectos da história natural das espécies de serpentes. Além disso, a diversidade de serpentes encontrada na área urbana foi comparada à de outras taxocenoses de serpentes presentes em unidades de conservação nas proximidades de Rio Tinto. Foram registradas 161 serpentes de 25 espécies e 16 gêneros para a área urbana de Rio Tinto, sendo as espécies mais comuns *Helicops angulatus*, *Bothrops leucurus*, *Epicrates assisi* e *Philodryas patagoniensis*. A maioria das espécies não são venenosas, entretanto, algumas serpentes venenosas apresentaram grande abundância e a população local deve ser cuidadosa ao lidar com estas serpentes. As curvas de rarefação não atingiram a assíntota e novas espécies devem ser registradas para Rio Tinto em estudos futuros.

Palavras-chave: serpentes, Paraíba, herpetologia urbana, áreas antrópicas.

Introduction

The Atlantic Forest of Brazil has been suffering from intense deforestation and fragmentation since the time of European colonization (~1500 a.D.). Even though less than six percent of the original vegetation remains, the Atlantic Forest still harbors high levels of biodiversity with more than 8,000 endemic species of vascular plants, amphibians, reptiles, birds and mammals (Myers et al. 2000). In Northeast Brazil, the Atlantic Forest is critically threatened with only around 0.3 percent of its original extent remaining (Galindo-Leal & Câmara 2003). The high biodiversity and pervasive threat of loss of Northeast Atlantic Forest underscore the urgency to increase our knowledge of this ecoregion and the species occurring in it in order to better understand important ecological processes and develop effective conservation plans (Hirota, 2005).

Studies on ecological communities must consider the deterministic and historical processes that are involved in community assembly, succession and structure (Ricklefs & Schuller 1993, Morin 1999, Webb et al. 2002). Studies on assemblages of phylogenetically related species have provided great insight into how co-distributed and ecologically similar species respond to biotic and abiotic factors (Ricklefs & Miller 1999). Snakes have been considered to be an interesting model in population and community ecology because despite their morphological constraints, they are associated to high levels of plasticity (Shine & Bonnet 2000, Mullin & Seigel 2009). Studies on Neotropical snake assemblages have found high species richness and diversity, and that structure is largely influenced by phylogenetically conserved ecological traits (Zanella & Cechin 2006, França et al. 2008, Colston et al. 2010).

In Brazil, most studies on snake assemblages have been conducted in preserved natural areas (Marques & Sazima 2004, Rocha et al. 2008, Rocha & Prudente 2010) with few works attempting to describe snakes assemblages in urban areas (Brites & Bauab 1988, Carvalho & Nogueira 1998). In fact, worldwide, studies of snakes in urban areas have been limited (Pattishall & Cundall 2008). Information on snakes inhabiting urban areas are essential to the environmental education of the local people, to help medical practitioners with venomous and mildly venomous snakes, and to understand how different snake species deal with human contact, roads, fragmentation, pollution and unnatural and novel food resources (Brites & Bauab 1988, Pattishall & Cundall 2008, Shepard et al. 2008a, Mullin & Seigel 2009).

The number of studies on the ecology of Brazilian snakes has increased considerably during the last two decades (Martins & Oliveira 1998, Sawaya et al. 2008, Hartmann et al. 2009). Nevertheless, there are still few studies of snake assemblages in the Northeast region and most of the ones that have been done were from the Caatinga biome (Vitt & Vangilder 1983, Costa 2006, Loebmann & Haddad 2010). In Atlantic Forest the two most comprehensive works were conducted in preserved patches in Alagoas (Freire 2001) and Paraíba (Pereira Filho & Montingelli 2011), and present the survey results and ecological characteristics of snake species in both areas.

The aim of this study is to describe the snake assemblage from the urban area of Rio Tinto city in Paraíba State, Northeast Brazil. The city is located in the Atlantic Forest ecoregion and preserved patches are located nearby (e.g., Reserva Biológica Guaribas and Indigenous reserves). Herein, we provide information on diversity and natural history of the snake species collected within the urbanized area and compare the diversity found there with the snake diversity in two nearby natural areas.

Materials and Methods

Study area. – The study was conducted in the city of Rio Tinto (06° 48' 10" S and 35° 04' 51" W) located on the north coast of

Paraíba State in Northeast Brazil and within the Atlantic Forest biome (Figure 1). Rio Tinto covers approximately 466 km², with average altitude around 10 m a.s.l. The climate is wet Tropical or non-arid (Aw in Koppen classification), with a rainy season between February and October, a dry season between November and January, and average annual precipitation 1,634 mm (Beltrão et al. 2005).

Since 1918, the city of Rio Tinto has experienced intense urbanization due the establishment of a cotton textile factory (Rosa 2010). The Rio Tinto factory was founded by a family of entrepreneurs from Sweden, the Lundgrens, and reached its industrial peak in the 1940 s, employing over 10,000 workers and comprising around 6,000 workers' homes. The Lundgren's company safeguarded production and facilitated the building of improvements and infrastructure in the city: houses, schools, hospitals, theater, clubs, and even a church and private militia (Rosa 2011). Due to severe economic crisis starting in the 1960 s, the factory was gradually closed down, depriving the city from its principal source of income. Today, Rio Tinto has 23,800 habitants and a university campus was built in the area of the former factory.

The protected area called Reserva Biológica Guaribas (REBIO) is situated near Rio Tinto (Figure 1). This park is fragmented in three patches (called SEMAs I, II and III: from Secretaria Estadual do Meio Ambiente) of 616 ha, 3,378 ha, and 327 ha in size. Two patches (SEMA I and II) are located in Mamanguape municipality, around 10 km from Rio Tinto, and contain principally savanna-like habitats called "Tabuleiros" (Oliveira-Filho & Carvalho 1993); the third patch (SEMA III) is located adjacent to Rio Tinto and is characterized by forested habitat termed "Floresta Estacional Semidecidual" (Brasil 1981). Herein we compare the snake diversity of the urban area in Rio Tinto with the diversity in two natural patches within REBIO: SEMA II and SEMA III.

Data Collection. – We sampled snakes in the urban area of Rio Tinto between March 2010 and July 2011 using the following methods: incidental encounters, visual search, and local collectors (for details of each method see Sawaya et al. 2008). Visual surveys were conducted four times each month by two or three researchers looking for snakes in roads, rivers and forest patches along the urban area of Rio Tinto. Incidental encounters and local collectors were fortuitous methods with snakes being collected by chance. We did not encourage local people to kill snakes, but they usually kill all snakes they encounter so we simply asked them to save the snakes they kill and recorded some basic information about the location and time. In addition to the above methods, our surveys in REBIO Guaribas also employed 60 L pitfall traps with drift fences (100 buckets in each patch), road survey and time-constrained searches (409 hours of search). For road survey method we examined two roads (BR 101 and PB 071) adjacent to REBIO by car, once a week, looking for snakes (totaling 2200 km traveled during the work). Almost all snakes encountered were collected (SISBIO licenses 22940-1 and 22940-2), preserved in 10% formalin and deposited in Coleção Herpetológica da Universidade Federal da Paraíba (Appendix 1). Some individuals of the most common species were released after we marked them by clipping ventral scales to identify them as previously captured. For each individual, we recorded information on location (with GPS), time, habitat use and microhabitat, and morphology.

We constructed species accumulation curves for snakes in the urban area of Rio Tinto and the two patches in REBIO Guaribas using the individual-based rarefaction method (with the nonparametric Mao Tau estimator) to evaluate the relationship between collection effort and species saturation in the assemblage (Gotelli & Colwell 2001, Colwell et al. 2004). The function of richness (Mao Tau) was calculated as the accumulation function of species throughout the number of individuals collected. Due to differences in sampling

Snakes of Rio Tinto PB, Northeast Brazil

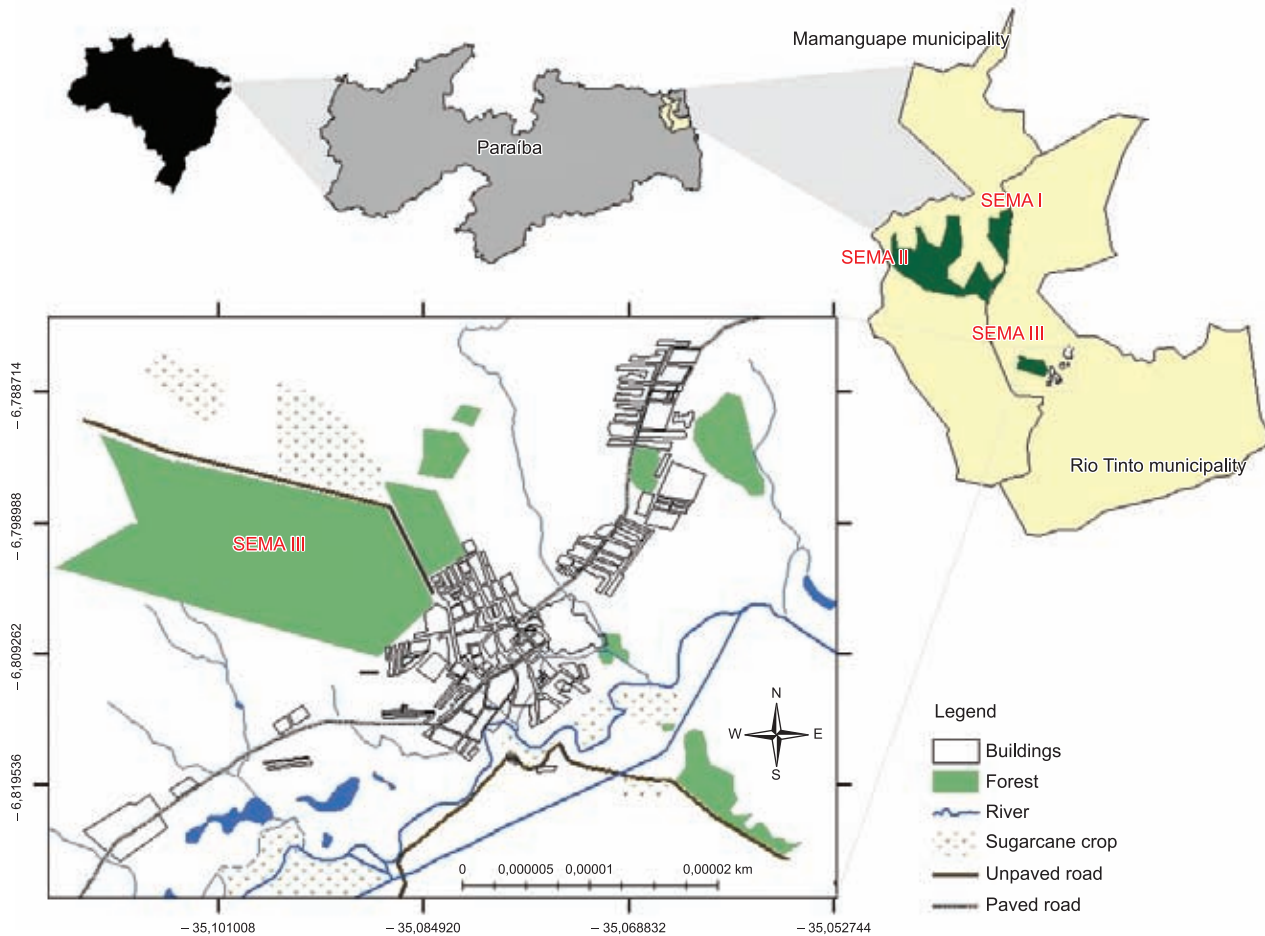


Figure 1. Study area showing the north coast of Paraíba State with Rio Tinto and Mamanguape municipalities and underscoring the urban area of Rio Tinto and the three patches of the Reserva Biológica Guaribas.

methods between three areas, the individual-based rarefaction method is most appropriate to evaluate the richness differences (Gotelli & Colwell 2001). The species rarefaction curves were made without replacement using 1000 randomizations. In addition, we used species richness estimators (with nonparametric incidence-based estimators: Bootstrap, Chao 2, ICE, Jackknife 1 and 2, and abundance-based data: ACE and Chao 1) to determine the expected richness of snakes in each area (Colwell & Coddington 1994, Colwell 2009). The species rarefaction and richness estimators were performed with EstimateS 8.2.0 software (Colwell 2009).

Results and Discussion

We recorded 161 individuals of 25 species in 16 genera from five families (Boidae, Colubridae, Dipsadidae, Elapidae, and Viperidae) from the urban area of Rio Tinto (Table 1, Figure 4 to 7). The most common species were *Helicops angulatus*, *Bothrops leucurus*, *Epicrates assisi* and *Philodryas patagoniensis*. Additional captures of snakes in the protected areas near the urban area increased the total number of species for the region. A total of 14 species were recorded for SEMA III and 35 species for SEMA II of REBIO Guaribas. The most common species for SEMA III were *Bothrops leucurus*, *Imantodes cenchoa*, *Typhlops paucisquamus* and *Typhlops brongersmianus*, and for SEMA II were *Typhlops paucisquamus* and *Typhlops brongersmianus*. Overall for the region, we registered 415 snakes of 45 species in 32 genera from six families

(Table 1). The number of specimens captured in each method was 170 snakes in pitfall traps, 38 snakes found during road surveys, 52 specimens captured during visual searches, 93 snakes donated by local collectors, and 62 snakes were found by incidental encounters.

The species *Helicops angulatus* (N = 26), *Liophis almadensis* (N = 2), *Liophis taeniogaster* (N = 4) and *Leptophis ahaetulla* (N = 7) were found only in the urban area. In addition, *Liophis taeniogaster* was the first record for the species in Paraíba State (França & Bezerra 2010). The species *Bothrops neuwiedi* was previously registered for Rio Tinto based on one specimen (França et al. 2012). However, this specimen was reexamined and it was correctly identified as a juvenile *Bothrops leucurus* with anomalous color pattern (verified by Thaís B. Guedes).

Most snake species found in the urban area of Rio Tinto were non-venomous. However, some venomous snakes were abundant and local people must be cautious when dealing with these: *Micrurus aff. ibiboboca* (N = 18), *Micrurus lemniscatus* (N = 6), and *Bothrops leucurus* (N = 22). Two of the coral snakes we documented were found indoors, one in a house and one inside the local market, and several vipers were captured under debris and logs near habitations. In addition, four other species of snakes that can cause harm to local people were commonly found in the urban area. These are the three *Philodryas* mildly venomous *P. patagoniensis* (N = 14), *P. nattereri* (N = 4) and *P. olfersii* (N = 3), and a large rainbow boa *Epicrates assisi* (N = 14) (Cardoso et al. 2003, Santos et al. 2005, Costa et al. 2010).

Table 1. List of snake species recorded in the three areas of north coast of Paraíba State.

Family/species	UA	Sema II	Sema III
Boidae			
<i>Boa constrictor</i> (Linnaeus, 1758)	0	3	0
<i>Epicrates assisi</i> (Machado, 1945)	14	7	0
Colubridae			
<i>Chironius exoletus</i> (Linnaeus, 1758)	0	2	0
<i>Chironius flavolineatus</i> (Boettger, 1885)	4	1	0
<i>Drymoluber dichrous</i> (Peters, 1863)	1	4	1
<i>Drymarchon corais</i> (Boie, 1827)	0	1	0
<i>Leptophis ahaetulla</i> (Linnaeus, 1758)	7	0	0
<i>Oxybelis aeneus</i> (Wagler, 1824)	1	1	0
<i>Pseustes sulphureus</i> (Wagler, 1824)	0	3	0
<i>Spilotes pullatus</i> (Linnaeus, 1758)	1	2	1
<i>Tantilla melanocephala</i> (Linnaeus, 1758)	0	25	7
Dipsadidae			
<i>Apostolepis cearensis</i> (Gomes, 1915)	2	5	2
<i>Apostolepis</i> cf. <i>longicaudata</i>	0	0	1
<i>Boiruna sertaneja</i> (Zaher, 1996)	0	2	0
<i>Helicops angulatus</i> (Linnaeus, 1758)	26	0	0
<i>Imantodes cenchoa</i> (Linnaeus, 1758)	0	0	8
<i>Liophis almadensis</i> (Wagler, 1824)	2	0	1
<i>Liophis poecilogyrus</i> (Wied, 1825)	5	1	0
<i>Liophis taeniogaster</i> (Jan, 1863)	4	0	0
<i>Lygophis dilepis</i> (Cope, 1862)	5	1	0
<i>Oxyrhopus guibei</i> (Hoge & Romano, 1978)	0	1	0
<i>Oxyrhopus petola</i> (Linnaeus, 1758)	2	2	0
<i>Oxyrhopus trigeminus</i> (Duméril, Bibron & Duméril, 1854)	2	17	0
<i>Philodryas nattereri</i> (Steindachner, 1870)	4	4	0
<i>Philodryas olfersii</i> (Lichtenstein, 1823)	3	4	0
<i>Philodryas patagoniensis</i> (Girard, 1858)	14	1	0
<i>Phimophis guerini</i> (Duméril, Bibron & Duméril, 1854)	0	1	0
<i>Pseudoboa nigra</i> (Duméril, Bibron & Duméril, 1854)	6	1	1
<i>Psomophis joberti</i> (Sauvage, 1884)	3	0	0
<i>Sibon nebulata</i> (Linnaeus, 1758)	1	4	1
<i>Sibynomorphus mikanii</i> (Schlegel, 1837)	6	4	0
<i>Sibynomorphus</i> cf. <i>neuwiedi</i>	0	2	0
<i>Siphlophis compressus</i> (Daudin, 1803)	0	3	0
<i>Taeniophallus affinis</i> (Günther, 1858)	0	1	1
<i>Taeniophallus occipitalis</i> (Jan, 1863)	0	7	0
<i>Thamnodynastes pallidus</i> (Linnaeus, 1758)	0	2	0
<i>Xenodon merremii</i> (Wagler, 1824)	2	6	0
Elapidae			
<i>Micrurus</i> aff. <i>ibiboboca</i>	15	10	4
<i>Micrurus lemniscatus</i> (Linnaeus, 1758)	9	5	0
Typhlopidae			
<i>Typhlops brongersmianus</i> (Vanzolini, 1976)	0	29	7
<i>Typhlops paucisquamus</i> (Dixon & Hendricks, 1979)	0	38	12
Viperidae			
<i>Bothrops leucurus</i> (Wagler, 1824)	22	2	10
Total of species	25	35	14
Total of specimens	161	202	55

Areas are: UA = Urban Area of Rio Tinto and Reserva Biológica Guaribas Sema II and Sema III.

Understanding the diversity and life-history traits of venomous snakes is imperative to prevent accidents that may have tragic consequences for both humans and snakes (Cardoso et al. 2003). Most snake bites in Paraíba State are attributed to *Bothrops* (46%), *Crotalus* (10%) and *Micrurus* (1.7%) (Albuquerque et al. 2005) with Rio Tinto being the city with the second highest number of snake bites from *Bothrops* in the state (Albuquerque et al. 2004). However, even these records may be an underestimate because patients were unable to identify the snake species or genus in at least 30% of cases (Albuquerque et al. 2005). In addition, approximately 13% of snake bites were attributed to mildly venomous snakes, mainly *Philodryas nattereri* and *Philodryas olfersii* (Albuquerque et al. 2005). There also appears to be a relationship between snake activity patterns and incidences of snakebite as evidenced by the corresponding peaks in snake encounters (Figure 2) and accidents in the state during the rainy season (Albuquerque et al. 2005).

None of the individual-based rarefaction curves (Mao Tau) reached stability (Figure 3) and the species richness estimators for all three areas produced estimates greater than the observed richness (Table 2), indicating a higher number of species for the locality. Nevertheless, the estimators showed that the expected richness is not substantially greater than the observed richness. Estimates varied between 28.24 ± 1.73 and 31.97 ± 2.20 for the urban area, between 43.82 ± 6.31 and 51.93 ± 1.09 for the REBIO Guariba's SEMA II, and

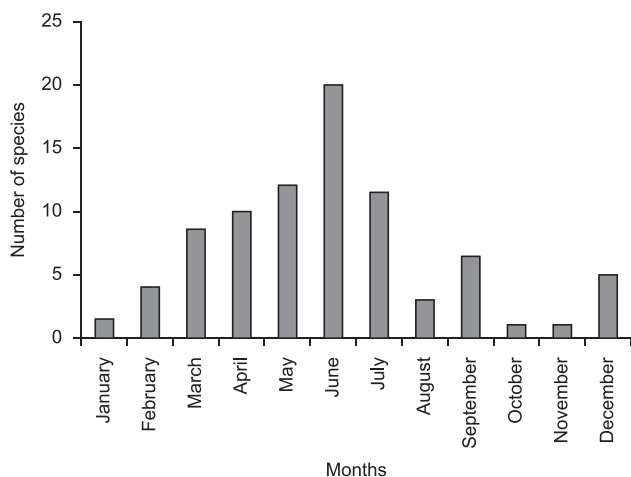


Figure 2. Seasonal encounter rate of snake species in urban area of Rio Tinto.

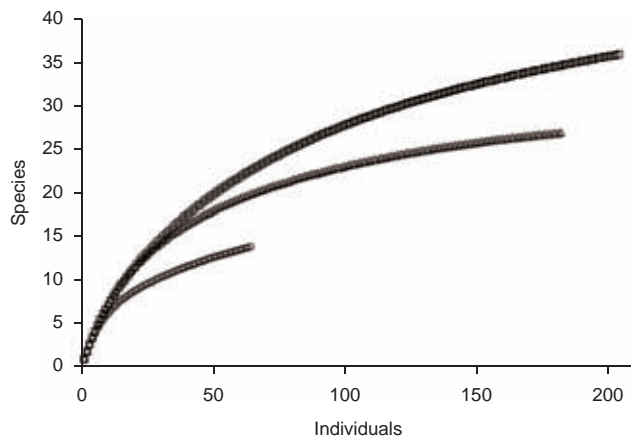


Figure 3. Species rarefaction curves for Rio Tinto (Triangle) and REBIO's Sema II (Square) and Sema III (Circle).

between 18.17 ± 4.88 and 20.91 ± 1.31 for the SEMA III (Table 2). Approximately 35% of the regional species pool (the sum of species observed in three areas) was not found in the urban area of Rio Tinto. The species absent include large snakes such as *Boa constrictor*, *Drymarchon corais*, and *Pseustes sulphureus*. These snakes are rare in the region and appear only in 'tabuleiro' of SEMA II. Other species absent from the urban area include small fossorial/cryptozoic snakes such as *Typhlops paucisquamus*, *Ty. brongersmianus*, *Apostolepis cf. longicaudata*, *Taeniophallus affinis*, and *Ta. occipitalis*. These species are commonly collected by pitfall traps and the use of traps in urban area in future studies would likely increase the number of species for this area.

Habitat variation in the region appears to have a large influence on the distribution of snake species. The two preserved areas of Reserva Biológica Guaribas are contrasting (savanna versus forest) and consequently, we only find species such as *Pseustes sulphureus* and *Siphlophis compressus* in SEMA II, and species such as *Apostolepis cf. longicaudata* and *Imantodes cenchoa* in SEMA III. In the urban area, we primarily find only those snake species that can survive coexisting with humans. Only five snake species were recorded in all three areas: *Drymoluber dichrous*, *Apostolepis cearensis*, *Micrurus aff. ibiboboca*, *Sibon nebulata* and *Bothrops leucurus*.

Natural History of Species. – Below we present information of morphology, habitat use and activity of all snake species found in the urban area of Rio Tinto. We also include data on diet, habitat and habits from the published literature. We use the recent paper of Grazziotin et al. (2012) to support the taxonomy of snake species and families. We also use "Liophis" rather than "Erythrolamprus" because in Grazziotin et al. (2012) the authors comment "Erythrolamprus arrangement of 50 species may be challenged after a more densely sampled analysis".

1. Species accounts

BOIDAE

Epicrates assisi – A large terrestrial species (average SVL = 671.92 mm; range 359 to 1270 mm; N = 15). We found one individual dead on a paved road and five more specimens were killed by local people. Another nine individuals were collected alive and active at night. Most (N = 11) were recorded between March and June. This species eats mammals, birds and lizards (Vitt & Vangilder 1983).

COLUBRIDAE

Chironius flavolineatus – A semi-arboreal species of moderate size (average SVL = 655.25 mm; range 573 to 929 mm; N = 4). Only one individual was found alive, active during the day. Three other individuals were killed by local people. This species primarily eats hylid frogs (Dixon et al. 1993).

Leptophis ahaetulla – An arboreal species of moderate size (average SVL = 590.33 mm; range 545 to 650 mm; N = 7). Two individuals

Table 2. Richness estimators of snake assemblages in the urban area of Rio Tinto and the two patches of Reserva Biológica Guaribas, PB.

Richness estimators	Urban Area	Sema II	Sema III
Observed richness	25	35	14
Ace	30.31 ± 0.44	44.93 ± 0.74	19.75 ± 1.15
Jackknife 1	31.97 ± 2.20	46.95 ± 3.22	18.92 ± 2.13
Jackknife 2	30.03 ± 0.93	51.93 ± 1.09	20.91 ± 1.31
Chao 1	28.25 ± 1.73	43.86 ± 6.34	18.17 ± 4.88
Chao 2	28.24 ± 1.73	43.82 ± 6.31	18.17 ± 4.88



Figure 4. Some snake species recorded in the urban area of Rio Tinto, State of Paraíba. a) *Epicrates assisi*; b) *Chironius flavolineatus*; c) *Leptophis ahaetulla*; d) *Oxybelis aeneus*; e) *Drymoluber dichrous* – juvenile; f) *Drymoluber dichrous* – adult; g) *Apostolepis cearensis*; h) *Helicops angulatus* (Photos by F.G.R. França).

were collected active in trees during the day. Five other individuals were killed by local people, all during the day. This species was found only during the rainy season in February (N = 2) and April-June (N = 5) and eats mainly amphibians (Vitt & Vangilder 1983, Albuquerque et al. 2007).

Drymoluber dichrous – A terrestrial moderate-sized species (SVL = 650 mm; N = 1). The only female found was in an urban area and was active at noon. Other specimens were found inside preserved areas all during the day. This species eats amphibians (Bernarde & Abe 2010).

Snakes of Rio Tinto PB, Northeast Brazil



Figure 5. Some snake species recorded in the urban area of Rio Tinto, State of Paraíba. a) *Liophis almadensis*; b) *Lygophis dilepis*; c) *Liophis taeniogaster* - adult; d) *Liophis taeniogaster* - juvenile; e) *Liophis poecilogyrus* - juvenile; f) *Liophis poecilogyrus* - adult; g) *Oxyrhopus petola*; h) *Oxyrhopus trigeminus* (Photos by F.G.R. França except G - Photo by G.A. Pereira Filho).

Oxybelis aeneus - An arboreal moderate-sized species (SVL = 650 mm; N = 1). Only one male was found in an urban area and was killed by local people during the daylight hours. It eats primarily lizards (França & Araújo 2007).

Spilotes pullatus - A large semi-arboreal species. One individual was found active in the morning in front of a school that is located near the Sema III, however, we did not manage to collect it. This species eats mammals and birds (Vitt & Vangilder 1983).



Figure 6. Some snake species recorded in the urban area of Rio Tinto, State of Paraíba. a) *Philodryas nattereri*; b) *Philodryas olfersii*; c) *Philodryas patagoniensis*; d) *Oxyrhopus petola*; e) *Pseudoboa nigra* – juvenile; f) *Pseudoboa nigra* – adult; g) *Psomophis joberti*; h) *Sibon nebulata* (Photos by F.G.R. França).

DIPSADIDAE

Apostolepis cearensis – A fossorial small-sized species (average SVL = 235 mm; range 225 to 245 mm; N = 2). Only two individuals were found in urban area, one active on the surface at night and the other inactive under coverboards on the University campus during the day.

Helicops angulatus – An aquatic moderate-sized species (average SVL = 413.92 mm; range 240 to 606 mm; N = 26). This was the most common species in the urban area and was common in the ‘Porta d’água’ river that crosses through the city. Most individuals were collected inside the river but two were found active on a road after a flood. This species eats fish and anurans (Ford & Ford 2002).

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Figure 7. Some snake species recorded in the urban area of Rio Tinto, State of Paraíba. a) *Sibynomorphus mikanii*; b) *Xenodon merremii*; c) *Micrurus aff. ibiboboca*; d) *Micrurus lemniscatus*; e) *Bothrops leucurus* – adult; f) *Bothrops leucurus* - juvenile (Photos by F.G.R. França).

Liophis almadensis – A terrestrial moderate-sized species (average SVL = 315 mm; range 240 to 390 mm; N = 2). Only two individuals were found in the urban area, one active in the afternoon on the grass of the University campus and the other inactive under litter near Rebio's SEMA III at night. This species eats amphibians (França et al. 2008).

Liophis poecilogyrus – A terrestrial species of moderate size (average SVL = 348.75 mm; range 165 to 380 mm; N = 5). Three of the individuals encountered were active during the day, two near a stream and one on a paved surface. Another two specimens were killed by local people. This species exhibits color pattern variation with juveniles having dark bands along all the body and adults being all grey, brown or yellow. This species eats amphibians (Vitt & Vangilder 1983).

Liophis taeniogaster – A terrestrial species of moderate size (average SVL = 330 mm; range 150 to 510 mm; N = 4). One individual was recorded active off a road in the morning (França & Bezerra 2010), another one was active in the morning near the river. Two individu-

als were found in the river in syntopy with *Helicops angulatus*. This species eats amphibians (Marques et al. 2001).

Lygophis dilepis – A terrestrial species of moderate size (average SVL = 319 mm; range 155 to 482 mm; N = 5). All individuals encountered were active during the day on either unpaved or paved roads. This species was found from February to September and eats amphibians (Vitt & Vangilder 1983).

Oxyrhopus petola – A terrestrial species of moderate size (average SVL = 673 mm; range 440 to 835 mm; N = 2). This species was frequently found in forested areas and only two individuals were found in the urban area. One was active at night close to a forest patch and the other was killed by local people at night. This species exhibits color pattern variation with juveniles having conspicuous red and black bands along all the body and adults being dark. This species eats lizards, small mammals and birds (Cunha & Nascimento 1978).

Oxyrhopus trigeminus – A terrestrial species of moderate size (average SVL = 633 mm; range 230 to 403 mm; N = 2). This species was frequently found in Rebio's SEMA II but it was rare in the urban area of Rio Tinto. The two individuals from the urban area were active during the day: one was found on litter preying upon a lizard (*Tropidurus torquatus*), and the other was on grass. This species eats lizards and small mammals (França et al. 2008).

Philodryas nattereri – A large-sized terrestrial (or semi-arboreal) species (average SVL = 763.50 mm; range 405 to 1030 mm; N = 4). Three individuals were killed by local people and one was found active in the morning on the roof of a house. This species has a generalized diet, which includes mammals, birds, lizards and amphibians (Vitt & Vangilder 1983)

Philodryas olfersii – A semi-arboreal species of moderate size (average SVL = 532 mm; range 450 to 650 mm; N = 3). Two individuals had been killed by local people and another one was active in the morning on grass. This species eats anurans, small mammals, lizards and birds (Hartmann & Marques 2005, Leite et al. 2009).

Philodryas patagoniensis – A terrestrial species of moderate size (average SVL = 315 mm; range 215 to 902 mm; N = 14). This species was frequently found in the urban area and was rare in protected areas of REBIO (N = 1). All individuals were found active on the ground during the day (N = 7). One was found dead on the road at noon and another one was dead on the edge of a river eating a *Leptodactylus* frog. Five other individuals had been killed by local people. This species has a generalized diet, which includes mammals, birds, lizards and amphibians (Hartmann & Marques 2005) and was found from March to November.

Pseudoboa nigra – A terrestrial species of moderate to large size (average SVL = 622 mm; range 300 to 1010 mm; N = 6). Two juveniles (with red dorsal coloration) were found active on the ground at night. Four adult individuals (with all black coloration) had been killed by local people. This species eats lizards (Vitt & Vangilder 1983).

Psomophis joberti – A terrestrial species of moderate size (average SVL = 269 mm; range 222 to 301 mm; N = 3). This species was found only in urban area of Rio Tinto. One individual was active on grass during the day and two individuals had been killed by local people during the day.

Sibon nebulata – An arboreal species of small to moderate size (SVL = 530 mm; N = 1). Only one female was found active in the top of a tree. This species eats snails (Duellman, 2005).

Sibynomorphus mikanii – A terrestrial snake of small to moderate size (average SVL = 306 mm; range 190 to 360 mm; N = 6). Three individuals were found inactive on the ground (N = 2) and grass (N = 1) during the day. Three other individuals had been killed by local people. This species eats snails (Laporta-Ferreira et al. 1986).

Xenodon merremii – A terrestrial species of moderate size (average SVL = 604 mm; range 408 to 800 mm; N = 2). Two females were found active in the urban area, one on an unpaved road and the other on grass. One of these laid 20 eggs on July 18. This species eats primarily bufonid and leptodactylid frogs (Vitt & Vangilder 1983).

ELAPIDAE

Micrurus aff. ibiboboca – A cryptozoic species of moderate size (average SVL = 585.58 mm; range 270 to 945 mm; N = 18). This species was frequently found in the urban area with individuals encountered

active during both day and night. This species was found throughout the year and eats amphisbaenians and snakes (Roze 1996).

Micrurus lemniscatus – A cryptozoic species of moderate size (average SVL = 373.25 mm; range 45 to 705 mm; N = 6). Two individuals were found active, one during the day and one at night. Three other individuals had been killed by local people. This species eats amphisbaenians, snakes and eels (Roze 1996).

VIPERIDAE

Bothrops leucurus – A large terrestrial species (average SVL = 597.33 mm; range 224 to 1100 mm; N = 22). This species was frequently found in the urban area and in preserved forest patches. Six individuals were found inactive during the day on the University Campus. Individuals were found resting under trash, coverboards and logs. Despite this species being considered nocturnal, individuals (N = 8) were found active in the morning, in the evening, and at night. This species eats frogs (juveniles) and small mammals (adults) (Campbell & Lamar 2004).

Final Comments

Despite snakes being relatively difficult to find due to their rarity and secretive habits (Sawaya et al. 2008), the urban area of Rio Tinto harbors high snake diversity and represents an important region for the study and conservation of snakes associated with the Atlantic Forest of Northeast Brazil. The study of urban snakes can contribute much to our understanding of the ecology of species that may be threatened by urbanization and development and can aid in efforts to educate local people on how to deal with venomous and mildly venomous species. The number of snakebites in Rio Tinto is high and two of the most venomous snakes in the city, *Bothrops leucurus* and *Micrurus aff. ibiboboca*, were abundant and widespread, found inside houses, yards, and even the local market. In addition, one other snakes (*Micrurus lemniscatus*) and some rear-fanged dipsadids are potentially hazardous to people.

Almost all snakes living in urban areas are “endangered” for several reasons. First, snakes are often killed whenever encountered by humans, which are seldom capable of discriminating between venomous and non-venomous species (Greene 1997, Mullin & Seigel 2009). Even plain gray or brown snakes, such as *Liophis poecilogyris* or *Philodryas patagoniensis*, are considered by local people to be extremely dangerous. Almost all species documented in this study included at least one individual that had been killed by local people in Rio Tinto. Second, snakes must frequently cross roads in urban areas and are easy targets for drivers (Bonnet et al. 1999, Shepard et al. 2008b). Third, snakes in urban areas are subject to higher levels of parasitic infection and predation by exotic cats, dogs and chicken (Greene 1997). Finally, habitat modification, loss, and fragmentation in urban areas can reduce food resources, reproduction sites, and gene flow, leading to local extinctions (Shepard et al. 2008b).

Urban ecosystems are increasing throughout the world, and urban ecology is attracting growing research interest (McKinney 2002). The study of snakes that inhabiting urbanized areas can better evidence the relationships of mutual threats between snakes (in special venomous snakes) and humans (Puorto et al. 1991). The knowledge of composition and abundance of snake species found in anthropogenic areas is essential but first step to understand these relationships. Further studies focusing on differences in ecology and behavior of species that occur in natural and urbanized areas, and the differences of distribution into the city must be conducted to evaluate the risks and benefits of snakes living in urban areas.

Acknowledgements

The authors are grateful to Marina Pinheiro Kluppel and ICMbio for collection permits in the Rio Tinto region, Don Shepard for help with the English, and valuable comments and suggestions on manuscript. FGRF thank the financial support from the CNPq (Universal grant 474250/2010-5). RCF and CESG thank the CNPq for PIBIC undergraduate grant.

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Received 04/12/2011

Revised 14/07/2012

Accepted 17/07/2012

Appendix

Appendix 1. Snake species collected at the urban area of Rio Tinto, state of Paraíba, Brazil and housed in the Coleção Herpetológica da Universidade Federal da Paraíba (CHUFPB).

Boidae: *Epicrates assisi* (RT 0001, 0084, 0225, 0277, 0281, 0322, 0342-0345, 0429, 0455, 0464, 0589, 0600); Colubridae: *Chironius flavolineatus* (RT 0462, 0489, 0510, 0644); *Leptophis ahaetulla* (RT 0379, 0405, 0537, 0572, 0578); *Drymoluber dichrous* (RT 0362); *Oxybelis aeneus* (RT 0436); *Spilotes pullatus* (RT 0507); Dipsadidae: *Apostolepis cearensis* (RT 0596); *Helicops angulatus* (RT 0354, 0361, 0363-0371, 0384-0388, 0394-0395, 0408, 0410, 0417, 0433-0435, 0448, 0458-0459, 0492, 0517); *Liophis almadensis* (RT 0176, 0351); *Liophis poecilogyrus* (RT 0082, 0125, 0202, 0233, 0272, 0333, 0427, 0452, 0547, 0550, 0560, 0607); *Liophis taeniogaster* (RT 0015, 0115, 0430-0431, 0515); *Lygophis dilepis* (RT 0036, 0163, 0306, 0352-0353); *Oxyrhopus petola* (RT 0355, 0456); *Oxyrhopus trigeminus* (RT 0222, 0442); *Philodryas nattereri* (RT 0170, 0181, 0393, 0416); *Philodryas olfersii* (RT 0046, 0078, 0533); *Philodryas patagoniensis* (RT 0017-0018, 0034, 0037-0038, 0047, 0056-0057, 0095, 0142, 0144-0145, 0359, 0383, 0390); *Pseudoboa nigra* (RT 0110, 0237, 0245, 0271, 0331, 0461, 0481); *Psomophis joberti* (RT 0092, 0171, 0389); *Sibon nebulata* (RT 0319); *Sibynomorphus mikanii* (RT 0030, 0049, 0079, 0147, 0149, 0422); *Xenodon merremii* (RT 0111, 0453); Elapidae: *Micrurus aff. Ibiboboca* (RT 0060-0067, 0071, 0076, 0089, 0100, 0112, 0133, 0165, 0169, 0210, 0247-0248, 0260, 0310, 0325, 0347, 0357, 0375, 0401, 0406, 0418); *Micrurus lemniscatus* (RT 0113, 0155, 0279, 0360, 0402, 0491); Viperidae: *Bothrops leucurus* (RT 0009, 0054-0055, 0083, 0091, 0118, 0208, 0263, 0278, 0287, 0321, 0382, 0420, 0428, 0443-0446, 0454, 0457, 0475, 0477).