

## Seasonal Activity of Anuran Species and Their Pattern of Vocalization in Piauí, Brazil

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### ABSTRACT

Although Brazil encompasses one of the highest rates of anuran diversity, the knowledge about the group in the Northern portions of the country is still limited, especially in the State of Piauí, which is geographically located in a remarkable area of Cerrado and Caatinga ecotone. In this study we analyzed the ecology of anurans, seasonality of species, and their seasonal patterns of vocalization in relation to abiotic factors in the southern portion of the State of Piauí. The pattern of activity for each species was established using the function  $y=\text{sen}(\omega x)$  and the main abiotic factor influencing the abundance of species was tested for correlation using Spearman and t test. Nineteen species from six families were observed, and from this total *Dendropsophus nanus*, *Hypsiboas raniceps*, *Scinax ruber*, *Physalaemus cuvieri*, *Leptodactylus vastus* and *Leptodactylus fuscus* were monitored throughout the sampling period. Despite the similarity in species occurrence observed in the present study with others performed in different parts of the country, the remarkable aspects of the study site highlights the need of further researches aiming the increasing of knowledge on the biology of the anuran community from this area.

Keywords: Advertisement Call, Amphibia, Call Activity, Courtship, Brazilian Savannah, Caatinga.

## Atividade sazonal de anfíbios anuros e seus padrões de vocalização no Piauí, Brazil

### RESUMO

O Brasil é um país com uma das maiores diversidades de anfíbios, sendo, entretanto, seu conhecimento incipiente em regiões como o Nordeste, em especial no estado do Piauí que apresenta condição geográfica peculiar em área ecotonal de Cerrado e Caatinga. Avaliamos aqui a anurocenose, sua sazonalidade de espécies e biorritmo de vocalização frente às condições abióticas do sul do Piauí onde o ritmo de atividade por espécie foi estabelecido através da função  $y=\text{sen}(\omega x)$  e o fator abiótico de maior influência na abundância de espécies foi submetido à correlação de Spearman e teste t para correlação. Dezenove espécies de seis famílias foram observadas, sendo que *Dendropsophus nanus*, *Hypsiboas raniceps*, *Scinax ruber*, *Physalaemus cuvieri*, *Leptodactylus vastus* e *Leptodactylus fuscus* estiveram presentes por todo o período amostral. Embora as espécies tenham apresentado padrão de ocorrência similar ao observado em outras regiões do país, a peculiaridade desta região incita a necessidade de mais pesquisas que possam propiciar melhor conhecimento da biologia de sua anurocenose.

Palavras chave: Amphibia, Atividade Reprodutiva, Canto de Advertência, Cerrado, Caatinga.

## INTRODUCTION

Brazil has 988 species of anurans, being acknowledged as the country with greatest amphibian diversity since 2005 (Segalla et al. 2015); 27% of the country's anuran diversity occurs in the State of São Paulo (Rossa-Feres et al. 2011). The Neotropic region is known for the highest rate of species diversity, and Brazil, along with Colombia and Ecuador, are the countries that contribute most to the discovery of new species (Duellman 1988). The knowledge about the extant anuran fauna in the Northern parts of Brazil, especially in the State of Piauí, is still limited, being the majority of the studies focused on the expansion of geographic distribution, such as: *Leptodactylus syphax* Bokermann, 1969 (Andrade et al. 2011); *Leptodactylus mystaceus* Spix, 1924 (Affonso et al. 2011); *Dendropsophus rubicundulus* Reinhardt and Lütken, 1862 (Annunziata et al. 2007); *Sphaenorhynchus lacteus* Daudin, 1800 (Benício et al., 2011); *Rhinella veredas* Brandão, Maciel and Sebben, 2007 (Brandão et al. 2007); *Scinax fuscomarginatus* A. Lutz, 1925 (Leite Jr et al. 2008). Several studies have highlighted the species diversity (Loebmann and Haddad 2010), diversity of amphibians and reptiles in the Caatinga domains, amphibians of the Coastal Zone of Piauí (Loebmann and Mai 2008); amphibians of the dunes of the extreme north of the State of Piauí; and diversity of terrestrial vertebrates in the Estação Ecológica Uruçuí-Una (Zaher 2001). Based on these studies, there is clear need of further studies on the natural history of anurans, with the potential for discovery of new species in the State of Piauí, which is geographically located in the ecotonal zone of Cerrado and Caatinga.

This study aimed at evaluating the relation between the community of anurans of the southern Piauí and local seasonality of species, abiotic factors and periods of vocalization according to species biorhythm which is supposed to decrease the interspecific competition.

## STUDY SITE

The State of Piauí is located in a remarkable geographic position, encompassing in its Southern portions the domains of the Cerrado biome, the Caatinga biome in the Middle West, the Parnaíba River in the Middle East, which divides the state from Maranhão and its domains of palm forest (PLANAP 2006, Correia-Filho 2009). Another remarkable characteristic of the state is the semi-arid and sub-humid climate, named Equatorial

(IBGE 2016), with pluviometric variation ranging from 700 to 1500 mm, and accentuated dry season occurring from April to November, mean temperature of 39°C and relative humidity of 60% (IBGE 2016). Ab'Sáber (2010) described lowland climatic regimen for the State of Piauí with transitional characteristics in the borders with Maranhão, the presence of the biome Caatinga with intermountain and interplanaltic semi-arid valleys in the Middle West, continental tropical “*chapadões*” with Cerrado and gallery forests in the South of the state.

## Sampling Area

The sampling was performed in a temporary pond formed during the rainy season (November to May), located in the municipality of Floriano (06°46' 01" S and 43° 01' 22" W) in southern Piauí.

## Sampling Period and Cycle of Vocalization

Data on the pattern of vocalization of anuran species mating in temporary ponds was collected during the rainy season, between the months of November 2011 and May 2012. The methodology was based on Cardoso and Martins (1987), and species survey was carried out between 16:00 to 24:00 in regular intervals of 30 minutes. The surveys were performed at least four days/month, resulting in 31 sampling-days. The occurrence of species was listed in a binary matrix and classified for presence (1) and absence (0), and interpolated using an equation according to Colwell et al. (2004). The sampling was performed using the animal focal method (Altmann 1974).

## Abiotic Factors

Daily abiotic data was provided by Floriano Meteorological Station, distant 5 km apart from the field site. The station is in accordance with the INMET – *Instituto Nacional de Meteorologia* (National Institute of Meteorology) standards, providing data on pluviosity (mm), atmospheric pressure (hPa), relative humidity (UR%) and temperature (°C) (INMET 2016).

## Sampling Analysis

The pattern of vocalization per species was established using the function ( $y = \text{sen}(\omega x)$ ) (Legendre and Legendre 2003), where a matrix for the function is developed for the interval “x” and the omega constants corresponding

to each species according to time period. The mathematical increment of the function is given by the interpolation of time interval, presence of the species vocalizing and the sampling period (Ruggiero and Lopes 1996).

Abiotic data (relative humidity, atmospheric pressure and pluviosity) were log transformed ( $\text{Log } X+1$ ) for homocedasticity and confrontation of results for days of occurrence of anurans and respective abiotic results.

The abiotic factor identified as the most influential for species abundance was tested using Spearman's Correlation Test and Student's t-Test. Additionally, the species were displayed using a Pareto diagram, with the bars representing the cumulative frequency of occurrence according to month, and the line graph the respective absolute values of rainfall.

### Collection and Deposit of Voucher Material

Authorization SISBIO 28629-1 from 30/06/2011, voucher material deposited in the Coleção de História Natural da Universidade Federal do Piauí – CHNUFPI, Br 343, km 3.5, Meladão, Floriano, Piauí, CEP 64.800-000, Brazil.

## RESULTS AND DISCUSSION

A total of 19 species from five families, were registered during the study (Table 1). The species *Dendropsophus nanus*, *Hypsiboas raniceps*, *Scinax ruber*, *Physalaemus cuvieri*, *Leptodactylus vastus* and *Leptodactylus fuscus* were monitored throughout the sampling period. As shown in Figure 1 the pattern of calling of *P. cuvieri*, *S. ruber* and *H. raniceps* exhibits a modular pattern composed of peaks and troughs. The vocalizations of these species are more frequent from 18:00 to 20:00h. The observed peak of vocalization of *P. cuvieri* does not overlap with those observed for the other two species, which occurred between the 1<sup>st</sup> to the 9<sup>th</sup> and 21<sup>st</sup> and 30<sup>th</sup> day of study. Different from this pattern, *P. cuvieri* showed peaks of vocalization occurring between the 9<sup>th</sup> and 21<sup>st</sup> day of the sampling period. According to our results we suggest that these species module their pattern of vocalization in peaks and troughs, which is probably related to mating activity. Additionally it is possible to infer that there is no competition interference regarding neither vocalization nor space among *S. ruber* and *H. raniceps*. Conversely, our results suggest a competition interference with *P. cuvieri*.

Previously described for the State of Piauí, *P.*

*cuvieri* is an euriectian species – a species which can survive in a wide range of environmental conditions (Loebmann and Haddad 2010). It is distributed across the country (IUCN 2015), with vocalization pattern occurring from 18:00 to 24:00h and peaks observed from 19:00 and 21:00h (Rossa-Feres and Jim 2001, Pedro and Feio 2010, Pombal Jr 2010). In São Miguel Arcanjo, a municipality of the State of São Paulo in the southeast of Brazil, vocalization period occurring from 17:00 to 20:00h was described (Forti 2009). The pattern of vocalization observed in the present study is, therefore, in accordance with the patterns described in the literature for the group, and the starting time of vocalization registered at 16:00 h for some individuals could be explained by the sub-Equatorial location of the State of Piauí.

*Scinax ruber* was first described in Loreto in Peru and is distributed across the Amazon (Duellman and Wiens 1993, IUCN 2015). According to Ab'Sáber (2010) the State of Piauí is characterized as a large ecotonal zone with forests of gallery in its Southern portions, which extends the distribution of this species to the south of Piauí between the coordinates 06° 46' 01" S and 43° 01' 22" W. This range extension has been already noted in cartographic images (IUCN 2015). Regarding the activity period, the species is considered nocturnal occurring mainly from 19:00 to 24:00h (Lima and Cruz 2006), which is corroborated by our findings. *Hypsiboas raniceps* was first described in Paraguay (Cochran 1961) and occurs in most parts of Brazil, except in the south portion such as the states of Paraná, Santa Catarina and Rio Grande do Sul, southeast of the states of Minas Gerais, Espírito Santo and Rio de Janeiro, and, in the Northeast Brazil, the species is present only in the states of Maranhão and Piauí (IUCN 2015), occurring from the littoral to the Caatinga domains (Freitas et al. 2009). According to Guimarães and Bastos (2003) the species starts to vocalize 20 minutes after sunset reaching peak calling activity at 20:00 h, with few males vocalizing before the sunset. This vocal behaviour was also found in the present study, in an ecotonal area with semi-arid equatorial climate, with adverse climate conditions from that study area surveyed by Guimarães and Bastos (2003).

The other three species *Dendropsophus nanus*, *Leptodactylus vastus* and *Leptodactylus fuscus* show conspicuous pattern of vocalization, with *D. nanus* cycle occurring from 18:50 to 20:00 h; *L. vastus* from 19:00 to 20:00 h and *L. fuscus* from 17:30 to 19:00 h. Patterns of vocalization with peaks and troughs were not observed

Table 1. Matrix of species registered during the sampling period.

Species	November	December	January	February	March	April
<b>Bufonidae</b>						
<i>Rhinella schneideri</i> (Werner, 1894)	+	-	-	-	-	-
<b>Hylidae</b>						
<i>Dendropsophus nanus</i> (Boulenger, 1889)	+	+	+	+	+	+
<i>D. rubicundulus</i> (Reinhardt & Lütken, 1862)	-	-	+	-	-	-
<i>Hypsiboas raniceps</i> Cope, 1862	+	+	+	+	+	+
<i>Phyllomedusa nordestina</i> Caramaschi, 2006	-	+	+	-	-	-
<i>Scinax ruber</i> (Laurenti, 1768)	+	+	+	+	+	+
<i>Scinax x-signatus</i> (Spix, 1824)	+	+	+	-	-	-
<b>Leptodactylidae</b>						
<i>Leptodactylus fuscus</i> (Schneider, 1799)	+	+	+	+	+	+
<i>Leptodactylus cf jolyi</i> (Sazima & Bokermann, 1978)	-	+	+	-	-	-
<i>Leptodactylus troglodytes</i> (A. Lutz, 1926)	-	+	+	-	-	-
<i>Leptodactylus vastus</i> A. Lutz, 1930	+	+	+	+	+	+
<i>Physalaemus albifrons</i> (Spix, 1824)	-	-	+	-	-	-
<i>Physalaemus cuvieri</i> Fitzinger, 1826	+	+	+	+	+	+
<i>Physalaemus nattereri</i> (Steindachner, 1863)	+	-	-	-	-	-
<i>Pleurodema diplolister</i> (Peters, 1870)	-	-	+	-	-	-
<i>Pseudopaludicola aff mystacalis</i>	-	-	+	-	-	-
<b>Microhylidae</b>						
<i>Dermatonotus muelleri</i> (Boettger, 1885)	-	-	+	-	-	-
<i>Elachistocleis piauiensis</i> (Caramaschi & Jim, 1983)	+	-	-	-	-	-
<b>Odontophrynidae</b>						
<i>Proceratophrys cristiceps</i> (Müller, 1884)	-	-	+	-	-	-

+ occurrence, - absence

for these species, with slight modulation noticed during the study period.

The distribution of *Dendropsophus nanus* is spread throughout Brazil, being absent only from the coastline (IUCN 2015). Several authors describe the activity pattern of this species that initiates at 17:00 h decreasing until 00:00 h (Martins and Jim 2003, Toledo et al. 2003, Menin et al. 2005, Prado et al. 2005, Queiroz-Filho et al. 2010, Valdujo et al. 2011). In the present study the species shows an increased activity peak from 18:50 to 20:00 h, in accordance with other studies performed in different areas. The difference in the duration of activity reported by our study in comparison to previous findings may be due to the fact that other studies considered only the activity of the overall community where the species is found, whilst we considered the focal species inserted in the whole community. In other words, the divergence found in the present study is related to our method of recording only the vocalization of the focal animal, not the overall population.

*Leptodactylus fuscus* is widespread in Brazil occurring in areas until 1700 m above sea level (IUCN 2015). Regarding the activity patterns of the species in the Central Brazilian Cerrado, it shows peaks occurring between 19:00 to 21:00 h (Brito-de-Carvalho et al. 2008), while in urban lands of Corumbá in the State of Mato Grosso do Sul, the peaks occur from 19:00 to 23:00 h (Ávila and Ferreira 2004), and in the Cerrado of Boa Vista, State of Roraima, the activity occurs from 18:00 to 21:00 h (Martins 1988). The period of activity of the species in this study varied between 17:30 to 19:00 h corresponding to approximately two hours of the high activity followed by a gradual decrease in vocalizations. In the present study we considered the activity period in which the species is more active in relation to the sympatric biocenosis. This approach may have led to the divergences found when compared with the literature cited above.

*Leptodactylus vastus* is a species with distribution restricted to the Brazilian northeast, being first described

in Guaribá, State of Paraíba (Lutz 1930). The species is known to occur in all the states in Northeast of Brazil, along the coast until the Caatinga, except in the extreme south of the states of Maranhão and Piauí (IUCN 2015). Previous studies in the State of Pernambuco showed that the species is more active from 19:00 to 20:00 h (Moraes et al. 2009), while in rainforest fragments of the State of Bahia, Coelho and Oliveira (2010) consider the activity pattern as nocturnal without defining a specific parameter for term of activity. In this study the results corroborates the findings of Moraes et al. (2009), confirming the trajectory of the pattern of vocalization shown in Figure 1.

The other species observed during the survey were noted opportunistically and were probably influenced by

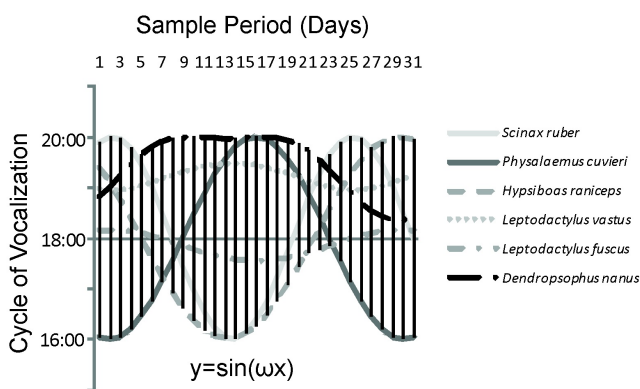


Figure 1. Pattern of vocalization of the species registered during the sampling period. The line charts correspond to the sampling period in “days of occurrence”, while the Y axis shows the time interval (16:00h minimum, 18:00h middle, 20:00h maximum). The curve shows the time of vocalization/species.

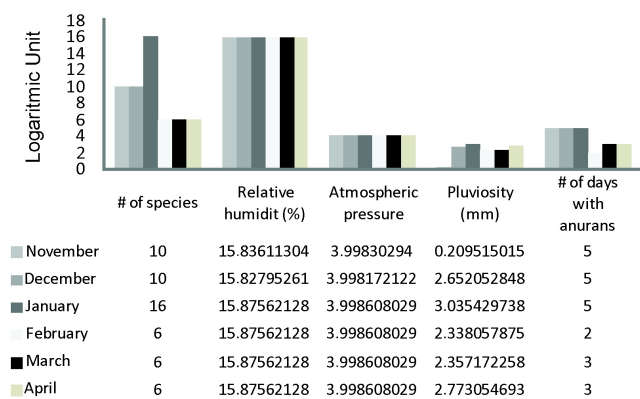


Figure 2. Abiotic factors (Relative humidity, Atmospheric pressure and Pluviosity - Log X+1) number of species and occurrence expressed in absolute values.

the abiotic factors, with pluviosity influencing diversity, since relative humidity and atmospheric pressure did not alter (see Figure 2).

Figure 2 shows the variation of species richness throughout the study period, with a total of 10 species registered in November with 0.20 mm of rainfall, 10 in December with 2.65 mm of rainfall and 16 in January with 3.03 mm of rainfall, whilst during February, March and April the number of species decreases to six, which were the species continuously registered during the sampling period. It was first surmised that increasing in species richness was related to pluviosity, though further analysis showed that the number of species varies only before or after a rainy day, but not during the rainy day *per se*. Figure 3 shows the ascending trend in species accumulation curve for non-rainy days ( $R^2 = 0.83$ ;  $t = 6.20$ ;  $n-1$  GL;  $p = 0.05$ ), while also correlates the number of species with rainy season. The descending curve ( $R^2 = 0.94$ ;  $t = 4.83$ ;  $n-1$  GL;  $p = 0.05$ ) corresponds to the following time intervals: November and December with 45 mm of rainfall and 10 species/month (interval 1); January with 108 mm of rainfall and 16 species (interval 2); February, March and April with 99 mm of rainfall and six species (interval 3).

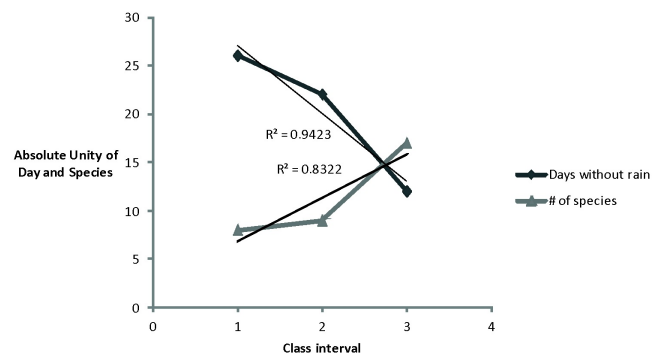


Figure 3. Spearman's Correlation Coefficient for non-rainy days and occurrence of species according to three class intervals (1- November-December; 2-January; 3-February, March-April).

Higher species diversity was registered during November to January, while a decreasing trend in species richness was registered for February, March and April, with the following six species being continuously observed during the sampling period: *Scinax ruber*, *Physalaemus cuvieri*, *Leptodactylus vastus*, *Leptodactylus fuscus*, *Dendropsophus nanus*, and *Hypsiboas raniceps*. The Pareto diagram (Figure 4) shows that species depend on rainfall, though not varying in number during the rainy day. These findings suggest that species

wait for the formation of ponds with suitable environmental conditions in order to perform their adaptive perpetuation, as previously suggested by other authors (Martins 1988, Guimarães and Bastos 2003, Pombal Jr 2010) but so far not registered to occur in the State of Piauí in a semi-arid condition.

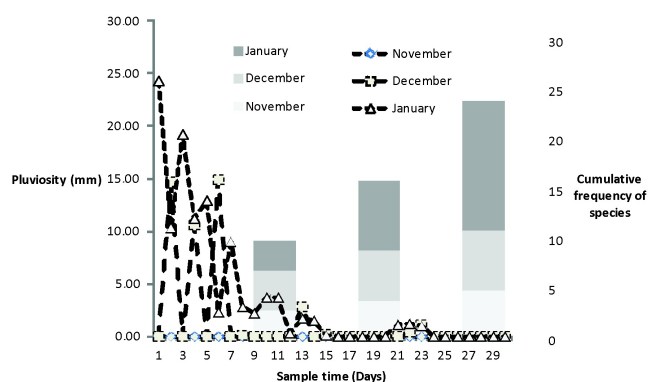


Figure 4. Pareto diagram showing the rainfall frequency and species accumulation frequency for the sampling period with higher species richness.

## CONCLUSIONS

The species evaluated in the present study showed similar period of occurrence as registered in other regions of Brazil. However, specific abiotic features such as low rainfall (700 mm/year) limit the reproductive period of the anurans in the study area when compared with other regions in the country. The peak of activity of these species is not related to rainy days; conversely, it is increased in days preceding or succeeding the rain. Such findings depict the need of further and intensive research in this peculiar ecotonal area to enable better understanding of the reproductive cycle of the anurans of this region.

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## REFERENCES

- Ab'Sáber, A.N. 2010. A Obra de Aziz Nacib Ab'Sáber. Organized by Modenesi-Gauttieri, M.C.; Bartorelli, A.; Mantesso-Neto, V.; dal Ré Carneiro, C.; Lisboa, M.B.A.L. BecaBall Edições Ltda. São Paulo, Brasil. 588 pages.
- Affonso, I.P.; Delariva, R.L. and Navarro, M.P. 2011. Amphibia, nura, Leptodactylidae, *Leptodactylus mystaceus* (Spix, 1824): Distribution extension. Check List 7(2): 198-199.
- Altmann, J. 1974. Observation study of behavior: sampling methods. Behavior 49: 227-267.
- Andrade, E.B.; Guimarães, R.; Leite-Jr, J.M.A. and Leite, J.R.S.A. 2011. Amphibia, Anura, Leptodactylidae, *Leptodactylus syphax* Bokermann, 1969: Distribution extension and geographic distribution map. Check List 7(5): 592-593.
- Annunziata, B.B.; Fontenele, W.M.; Castro, I.S.; Gurgel, R.F. and Nascimento, K.A. 2007. Amphibia, Anura, Hylidae, *Dendropsophus rubicundulus*: Distribution extension. Check List 3(3): 242-243.
- Ávila, R.W. and Ferreira, V.L. 2004. Riqueza e densidade de vocalizações de anuros (Amphibia) em uma área urbana de Corumbá, Mato Grosso do Sul, Brasil. Revista Brasileira de Zoologia 21(4): 887-892.
- Benício, R.A.; Silva, G.R. and Fonseca, M.G. 2011. Amphibia, Anura, Hylidae, *Sphaenorhynchus lacteus* (Daudin, 1800): First record of the genus and species for the state of Piauí, Brazil. Check List 7(2): 196-197.
- Brandão, R.A.; Maciel, N.M. and Sebben, A. 2007. A New Species of *Chaunus* from Central Brazil (Anura; Bufonidae). Journal of Herpetology 41(2): 309-316.
- Brito-de-Carvalho, C.; Freitas, E.B.; Faria, R.G.; Batista, R.C.; Batista, C.C.; Coelho, W.A. and Bocchiglieri, A. 2008. Natural history of *Leptodactylus mystacinus* and *Leptodactylus fuscus* (Anura: Leptodactylidae) in the Cerrado of Central Brazil. Biota Neotropica 8(3): 105-115.
- Cardoso, A.J. and Martins, J.E. 1987. Diversidade de Anuros durante o turno de vocalizações em comunidade neotropical. Papéis Avulsos de Zoologia, 36(23): 279-285.
- Cochran, D.M. 1961. Type specimens of reptiles and amphibians in the U.S. Washington. National Museum. Bulletin 220, Washington D.C. 316 pp.
- Coelho, H.E.A. and Oliveira, R.S. 2010. Anurofauna de um fragmento de Mata Atlântica em Lauro de Freitas – Bahia. Candombá Revista Virtual, 6(1): 52-60.
- Colwell, R.K.; Mao, C.X. and Chang, J. 2004. Interpolating, extrapolating and comparing incidence-based species accumulation curves. Ecology 85(10): 2717-2727.
- Correia-Filho, F.L. 2009. Projeto Borda Sudeste da Bacia Sedimentar do Panaíba: relatório final. Vol. 2. Teresina, Piauí, Brasil. CPRM – Serviço Geológico do Brasil. pages.
- Duellman, W.E. and Wiens, J.J. 1993. Hylid Frogs of the Genus *Scinax* Wagler, 1830, in Amazonian Ecuador and Peru. Oc P Harvard Museum of Natural History 153: 1-57.

- Duellman, W.E. 1988. Patterns of species diversity in anuran amphibians in the American tropics. *Annals of the Missouri Botanical Garden* 75(1): 79-104.
- Forti, L.R. 2009. Temporada reprodutiva, micro-habitat e turno de vocalização de anfíbios anuros em lagoa de Floresta Atlântica, no sudeste do Brasil. *Revista Brasileira de Zoologia* 11(1): 89-98.
- Freitas, M.A.; Silva, T.F.S. and Loebmann, D. 2009. Amphibia, Hylidae, *Sphaenorhynchus pauloalvini* Bokermann, 1973: Distribution extension and rediscovery in nature. *Check List* 5(2): 200-201.
- Guimarães, L.A. and Bastos, R.P. 2003. Vocalizations and acoustic interactions in *Hyla raniceps* (Anura, Hylidae) during the breeding season. *Iheringia* 93(2): 149-158.
- IBGE. 2016. Instituto Brasileiro de Geografia e Estatística. Available at <<http://www.ibge.gov.br>> Accessed on 02.05.2016.
- INMET. 2016. Estação Meteorológica de Observação de Superfície Automática. Available at: <<http://www.inmet.gov.br/portal/index.php?r=estacoes/estacoesAutomaticas>> Accessed on 30.04.2016.
- IUCN. 2015. IUCN Red List of Threatened Species. Version 2015.4. Available at: <[www.iucnredlist.org](http://www.iucnredlist.org)> Accessed on 10.05.2016.
- Legendre, P. and Legendre, L. 2003. *Numerical Ecology*. 2<sup>a</sup> edition. Elsevier Science, Amsterdam. 853 pages.
- Leite-Jr, J.M.A.; Sampaio, J.M.S.; Silva-Leite, R.R.; Toledo, L.F.; Loebmann, D. and Leite, J.R.S.A. 2008. Amphibia, Anura, Hylidae, *Scinax fuscocomarginatus*: Distribution extension. *Check List* 4(4): 475-477.
- Lima, R.N. and Cruz, W.P. 2006. Inventário de Vertebrados Terrestres (Herpetofauna) dos Fragmentos de Vegetação de Cerrados e Ecossistemas Ecotonais do Sul do Piauí. *Anais do I CONNEPI (Proceedings of I Congresso Norte-Nordeste de Pesquisa e Inovação)*.
- Loebmann, D. and Haddad, C.F.B. 2010. Anfíbios e répteis de uma área altamente diversa do domínio Caatinga: composição e implicações para conservação. *Biota Neotropica* 10(3).
- Loebmann, D. and Mai, A.C.G. 2008. Amphibia, Anura, Costal Zone, state of Piauí, Northeastern Brazil. *Check List* 4(2): 161-170.
- Lutz, A. 1930. Segunda memória sobre espécies brasileiras do gênero *Leptodactylus*, incluindo outras aliadas/Second paper on Brazilian and some closely related species of the genus *Leptodactylus*. *Memórias do Instituto Oswaldo Cruz* 23: 1-34.
- Martins, I.A. and Jim, J. 2003. Bioacoustic analysis of advertisement call in *Hyla nana* and *Hyla sanborni* (Anura, Hylidae) in Botucatu, São Paulo, Brazil. *Brazilian Journal of Biology* 63(3): 507-516.
- Martins, M. 1988. Biologia reprodutiva de *Leptodactylus fuscus* em Boa Vista, Roraima (Amphibia: Anura). *Revista Brasileira de Biologia* 48(4): 969-977.
- Menin, M.; Rossa-Feres, D.C. and Giaretta, A.A. 2005. Resource use and coexistence of two syntopic hylid frogs (Anura, Hylidae). *Revista Brasileira de Zoologia* 22(1): 61-72.
- Moraes, D.M.; Manso, T.K.C.; Almeida, V.L.S.; Andrade, V.E. and Moura, G.J.B. 2009. Riqueza e distribuição espaço temporal de anuros em área remanescente de mata atlântica no Estado de Pernambuco. *JEPEX (IX Jornada de Ensino, Pesquisa e Extensão)*. Available at: <[http://www.eventosufrpe.com.br/jepex2009/cd/lista\\_area\\_02.htm](http://www.eventosufrpe.com.br/jepex2009/cd/lista_area_02.htm)> Accessed on 01.4.2016.
- Pedro, V.A.S. and Feio, R.N. 2010. Distribuição espacial e sazonal de anuros em três ambientes na Serra do Ouro Branco, extremo sul da Cadeia do Espinhaço, Minas Gerais, Brasil. *Biotemas* 23(1): 143-154.
- PLANAP. 2006. Plano de Ação para o Desenvolvimento Integrado da Bacia do Parnaíba, Piauí. CODEVASF (Companhia de Desenvolvimento dos Vales do São Francisco e Parnaíba), Brasília.
- Pombal-Jr, J.P. 2010. O espaço acústico em uma taxocenose de anuros (Amphibia) do sudeste do Brasil. *Arquivos do Museu Nacional* 68(1-2): 135-144.
- Prado, C.P.A.; Uetanabaro, M. and Haddad, C.F.B. 2005. Breeding activity patterns, reproductive modes, and habitat use by anurans (Amphibia) in a seasonal environment in the Pantanal, Brazil. *Amphibia-Reptilia* 26: 211-221.
- Queiroz-Filho, R.G.; Mendes-Pinto, T.J. and Fragoso, A.C. 2010. Anurofauna da área do Centro Universitário Nilton Lins, Manaus, Amazonas, Brasil (Amphibia; Anura). *Revista de Biologia e Farmácia* 4(2): 13-21.
- Rossa-Feres, D.C. and Jim, J. 2001. Similaridade do sítio de vocalização em uma comunidade de anfíbios anuros na região noroeste do Estado de São Paulo, Brasil. *Revista Brasileira de Zoologia* 18(2): 439-454.
- Rossa-Feres, D.C.; Sawaya, R.J.; Faivovich, J.; Giovanelli, J.G.R.; Brasileiro, C.A.; Schiesari, L.; Alexandrino, J. and Haddad, C.F.B. 2011. Amphibians of São Paulo State, Brazil: state of art and perspectives. *Biota Neotropica* 11(1a): 47-66.
- Ruggiero, M.A.G. and Lopes, V.L.R. 1996. *Cálculo Numérico, Aspectos Teóricos e Computacionais*. 2<sup>a</sup> ed. Unicamp, São Paulo, Brasil. Pearson. 422 pages.
- Segalla, M.V.; Caramaschi, U.; Cruz, C.A.G.; Grant, T.; Haddad, C.F.B.; Langone, J. and Garcia, P.C.A. 2015. Brazilian amphibians – List of species. Accessible at <http://www.sbherpetologia.org.br>. Sociedade Brasileira de Herpetologia. Accessed on 10.05.2016.
- Toledo, L.F.; Zina, J. and Haddad, C.F.B. 2003. Distribuição Espacial e Temporal de uma Comunidade de Anfíbios Anuros do Município de Rio Claro, São Paulo, Brasil. *Holos Environment* 3(2): 136-149.
- Valdujo, P.H.; Camacho, A.; Recoder, R.S.; Teixeira-Jr, M.; Ghellere, J.M.B.; Mott, T.; Nunes, P.M.S.; Nogueira, C. and Rodrigues, M.T. 2011. Anfíbios da Estação Ecológica Serra Geral do Tocantins, região do Jalapão, Estados do Tocantins e Bahia. *Biota Neotropica* 11(1): 251-262
- Zaher, H.E.D. 2001. Projeto Diversidade de Vertebrados Terrestres da Estação Ecológica de Uruçuí-Una, Piauí (PI): Subsídios para o Plano de Manejo. Curitiba. Fundação O Boticário.

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