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A New Description of the Advertisement Call of Terrestrial Nebulous Treefrog, *Scinax nebulosus* (Spix, 1824) in Brazil: Implications for Interpopulation Variation

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Abstract

The genus *Scinax* encompasses 75 recorded species, making it one of the most abundant within the Hylidae group. *Scinax nebulosus*, a small terrestrial anuran, is distributed throughout northern South America, between Venezuela, Bolívia and northeastern Brazil. This study aimed to characterize the advertisement call of two distinct populations of *Scinax nebulosus* (Spix, 1824) in the state of Pernambuco, Brazil. Fieldwork was conducted at the Dois Irmãos State Park and the Camocim forest. The advertisement call of this species consists of a single multipulsed note, lasting 0.3 seconds, with an inter-note interval of 0.9 seconds and a dominant frequency of 3.3 kHz. Temporal and spectral parameters of the Northeast Brazilian populations differ from those in the Amazon. The wealth of bioacoustics information from various populations plays a crucial role in propelling comprehensive research in anuran bioacoustics, contributing to advancements and a better understanding of this field.

Subject Areas

Biology

Keywords

Anuran, Acoustic Parameters, Advertisement Call, Bioacoustics Diversity, Northeastern Brazil

1. Introduction

Anurans are known for their reproductive gatherings, where males vocalize to attract females and delineate their territories [1]. Advertisement calls are predominantly species-specific and are emitted by males, serving to promote the social and ecological organization of the environment in which these organisms are found [2]. Due to their specificity, advertisement calls have been used as a valuable tool to clarify taxonomic information in various groups [3].

The genus *Scinax* [4], belonging to the family Hylidae, currently comprises 75 species [5], widely distributed in secondary forests, natural habitats, fragmented environments, and urban areas. *Scinax nebulosus* [6] is a small anuran widely distributed in the Southeast Venezuela, extending through the Guianas and the lower Amazon region to Alagoas in northeastern Brazil. It is also found in the Amazonian region of Bolivia.

This study aims to provide a comprehensive description of the advertisement call pattern of *Scinax nebulosus* [6] in northeastern region of Brazil, based on data collected in two Atlantic Forest fragments located in Pernambuco. Additionally, the goal is to contextualize the results in relation to populations found in the Amazon region. This research aims to contribute to the understanding of communication patterns and diversification within the genus *Scinax* to a broader comprehension of the acoustic ecology of the species involved.

2. Materials and Methods

2.1. Study Area

The study was conducted on May 12, 2012, at a temporary pond in the Dois Irmãos State Park (8˚0'36"S/34˚56'59"W) and on October 16, 2016, at a temporary pond on the Mata do Camocim (8˚2'16"S/35˚8'41"W), both areas located in the state of Pernambuco, Brazil (**Figure 1**). The region features a dry summer (As) according to the Köppen-Geiger climate classification [7]. The rainy season occurs in autumn and winter, with annual average precipitation of 1.900 mm and minimum values dropping to less than 100 mm for up to five months [8] [9].

2.2. Acoustic Parameters

Advertisement call recordings were made using a directional Yoga Ht-81 microphone attached to a Tascam DR40 digital recorder (44.1/48/96 kHz, 16/24-bit), positioned at approximately 0.5 meters from the animal between 6:00 PM and 9:00 PM. Mean air temperature and relative humidity were measured with a digital thermohygrometer (temperature: ±1˚C/humidity: ±5% RH (40% - 80%)). Mass and snout vent length (SVL) were also recorded after each recording session.

Acoustic parameter graphs were constructed using the Seewave package [10] in RStudio software. To analyse call duration(s), inter-call interval(s), number of pulses/notes, call rate/minute, minimum frequency, maximum frequency,

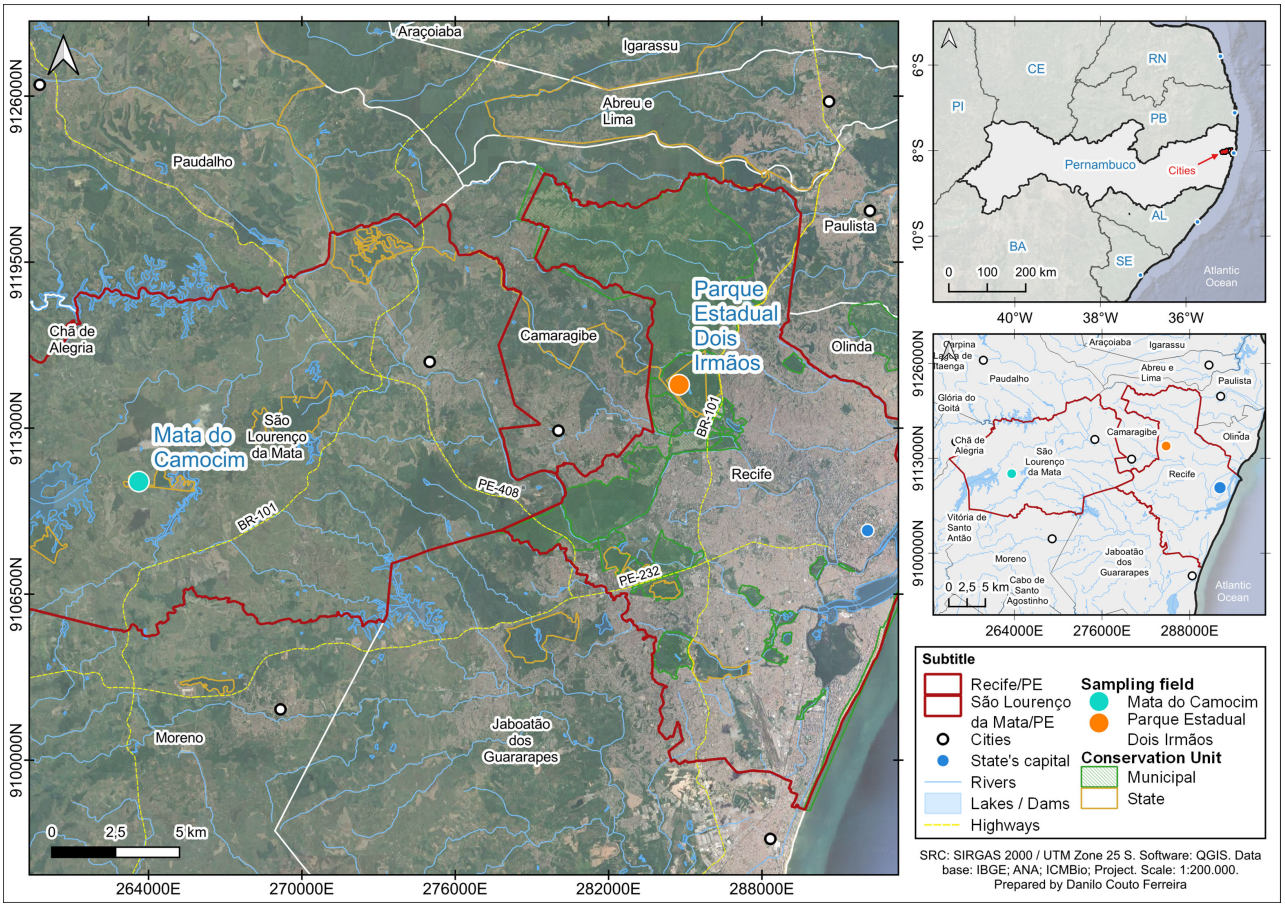

Figure 1. Map depicting the geographical locations of the two study areas within the metropolitan region of Recife where specimens of *Scinax nebulosus* were recorded.

frequency amplitude, and dominant frequency we used Avisoft SASlab Lite 5.2.09 [11]. The acoustics parameters followed the methodology outlined by Köhler *et al.* (2017) [12].

The voucher specimens and call recordings are deposited in the Herpetological and Paleoherpetological Collection Coaxar, belonging to the Herpetological and Paleoherpetological Studies Laboratory of the Universidade Federal Rural de Peranmbuco (CH-UFRPE), and in the MNCK collection, belonging to the Herpetology Laboratory of the Federal Universidade de Campina Grande (LHUFCG). The collection of animals was conducted in compliance with federal and institutional procedures, as per protocol number 55436-1.

3. Results

The study recorded the vocal activity of five *S. nebulosus* males near a temporary pond in the Dois Irmãos State Park, with a snout-vent length of 29.5 ± 1.0 cm (29.4. - 29.5 cm) (**Figure 2**). Additionally, another five males were recorded near a temporary pond in the Camocim Forest, with a snout-vent length of 29.4 ± 1.0 (28.9 - 29.5 cm) cm. In total, six advertisement calls from each male were analyzed, totaling 30 calls from each population, and therefore, a total of 60 adver-

tisement calls were analyzed. The weather conditions during the recordings were different: the average air temperature was 29˚C with a relative humidity of 67% in the Dois Irmãos State Park, while in the Camocim Forest, a temperature of 23˚C and relative humidity of 79% were recorded.

During the observation period, the most prevalent vocalization was the advertisement call. Throughout the observations, the animals did not emit any other distinct types of vocalizations (Table 1). There was no significant difference between the acoustic parameters of the two populations analyzed in the forest fragments of Pernambuco.

The advertisement call is characterized by the presence of a single note, with an average duration of 0.3 ± 0.1 (0.1 - 0.3) seconds, an interval between calls of 0.6 ± 0.3 (0.2 - 2.3) seconds, and a number of pulses of 9 ± 1.0 (7 - 11) pulses. The frequency minimum was 1450 (1200 - 1700) Hz, the frequency maximum was 7560 (5300 - 10,800) Hz, the frequency amplitude was 6110 (3800 - 9300) Hz, and the dominant frequency was 3453 (3233 - 4399) Hz. The repetition rate was 25 ± 0.9 (24 - 26) calls per minute (Figure 3).

Figure 2. Male *Scinax nebulosus* with a snout-vent length (SVL) of 29.5 cm, observed at Dois Irmãos State Park, Pernambuco, northeastern Brazil. Photo credit: Marco Freitas.

Table 1. Acoustic parameters of the advertisement call of two populations of *Scinax nebulosus* of the metropolitan region of Recife, Pernambuco, Brazil. The values are presented as mean, standard deviation, minimum, and maximum.

Acoustic parameters	Advertisement call	
Call	State Park Dois Irmãos	Forest of Camocim
Call duration (s)	0.3 ± 0.1 (0.1 - 0.3)	0.3 ± 0.1 (0.2 - 0.3)
Interval between call (s)	0.9 ± 0.1 (0.7 - 2.3)	0.3 ± 0.1 (0.2 - 0.3)
Number of pulses/calls	0.9 ± 0.1 (7 - 11)	0.9 ± 1.0 (7 - 11)
Frequency minimum (Hz)	1540 (1700 - 1500)	1360 (1500 - 1200)
Frenquency maximum (Hz)	7480 (10,800 - 5300)	7640 (1360 - 1500)
Frequency amplitude (Hz)	5940 (9300 - 3800)	6280 (7500 - 5300)
Dominant frequency (Hz)	3572 (3710 - 3233)	3334 (4399 - 3381)
Repetition rate (call/min)	24.7 ± 0.9 (24 - 26)	24.7 ± 0.9 (24 - 26)

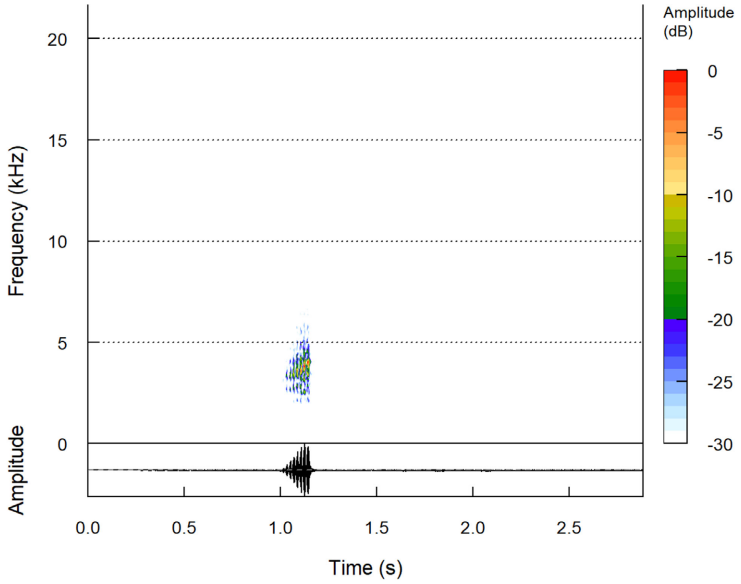

Figure 3. Advertisement call of *Scinax nebulosus*, recorded at Dois Irmãos State Park under conditions of 29˚C temperature and 69% air humidity.

4. Discussion

The investigation of the advertisement calls of the species within the *Scinax* proved to be a crucial step in this study. However, it is important to acknowledge that certain studies did not provide comprehensive data regarding acoustic parameters, resulting in gaps that may guide future analyses and comparisons. This variation in information availability can be attributed, in part, to the absence of complete data in some bibliographic sources.

When comparing the advertisement calls of *S. nebulosus* as documented by Duellman (1972—*Hyla egleri*) [13] with the records from the population in Pernambuco, significant differences in the calls become evident. The previously recorded advertisement call has an average of 58 (55 - 60) pulses, whereas the populations described in this study have an average rate of 9 pulses. Additionally, Duellman (1972) [13] described a call rate per minute (referred to as "note" in his article) of 39.5, which is higher than the 25 calls per minute for the populations recorded in this study. Unfortunately, results for other spectral parameters of the call were not available.

Another relevant reference is the study by Hödl (1977) [14], which provided a detailed description of the calls of a population of *S. nebulosus* from Manaus (*H. egleri*), in the Amazon region of Brazil. This study identified the presence of two distinct types of calls, possibly corresponding to advertisement and territorial calls. It is important to note that Hödl's work revealed spectral and temporal parameters that exceeded the values found in the two populations in Pernambuco. For instance, the recorded dominant frequency was higher (4.5 kHz), and the average call duration was longer (1.5 seconds). Interestingly, the territorial call was not detected in the two populations examined in this study.

According to the detailed results reported by Duellman and Pyles (1983) [15], *S. nebulosus* typically emits a single type of note per call, displaying a repetition rate of 62.3 notes per minute. The average note duration is 0.13 s, while the pulse rate reaches 160 pulses per second. The dominant frequency of these calls varies within the range of 3840 to 4147 Hz. In an additional study, de la Riva *et al.* (1994) [16] provides a description of the advertisement call based on a single note with multiple pulses (0.24 s) and a dominant frequency of 2870 Hz. These values provide a fundamental reference point for understanding the characteristic vocalization patterns of this species.

These findings underscore the complexity of *S. nebulosus* vocalization and highlight significant variations in acoustic aspects among different populations, which may be linked to specific adaptations to each habitat. Intraspecific variation in call advertisement is a relevant aspect in anuran communication. Understanding how acoustic characteristics vary within a species can provide valuable insights into conspecific recognition and discrimination [17]. Several factors can influence call variation, including temperature, humidity, noise, social context [18]. Additionally, ambient temperature and the size of vocalizing males can also play a significant role in shaping acoustic characteristics [19]. The observed variability among individuals and populations in advertisement calls can serve as crucial cues for intraspecific recognition [20]. Temporal characteristics of calls often exhibit greater variability than spectral properties, contributing to individual distinctions [21]. The persistence of intraspecific variation can be maintained when stabilizing selection is weak, resulting in multimodal distributions of traits.

Detailed description of advertisement calls from different populations, such as those found in *S. nebulosus*, plays a fundamental role. By examining vocalization patterns in various locations and contexts, researchers have the opportunity to identify intrapopulation acoustic variations. Each population may adapt its calls to better communicate in specific environments or to interact with local mates and competitors. Therefore, a detailed analysis of differences in temporal and spectral parameters among different populations can reveal crucial insights into the ecology, behavior, and evolution of *S. nebulosus*.

When considering the broader landscape of acoustic biodiversity, the study of vocalization in different populations of the same species enriches our understanding of animal communication strategies and behavioral plasticity. With each new description of advertisement calls, we contribute to the growing body of knowledge about the bioacoustics of anurans and their unique acoustic adaptations, which are shaped by natural selection in diverse environments.

5. Conclusions

The results highlighted significant variations in the acoustic parameters of *S. nebulosus* advertisement calls among different populations. Comparative analyses with previous studies revealed notable differences in vocalization patterns, including duration, frequency, pulse number, and call repetition rate, between

the studied populations and those previously documented. The detailed description of advertisement calls in various populations plays a crucial role in understanding intrapopulation vocalization patterns and the adaptation of these calls to specific environmental conditions. The observed variability in advertisement calls may play a crucial role in intraspecific recognition, providing important clues for individual and population identification.

Furthermore, studying vocalization in different populations of the same species enriches our understanding of animal communication strategies and behavioral plasticity. Each new description of advertisement calls contributes to the growing body of knowledge on the bioacoustics of anurans and their unique acoustic adaptations shaped by natural selection in diverse environments.

It is recommended to conduct samplings across a variety of habitats and geographical regions to obtain a comprehensive understanding of acoustic variation within and among *S. nebulosus* populations. Additionally, long-term monitoring studies are needed to assess temporal trends in vocalization and potential adaptive responses to environmental changes, such as climate variations and anthropogenic pressures. These complementary approaches can provide a more comprehensive understanding of the acoustic ecology of this species and help guide appropriate conservation and management measures.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Toledo, L.F., Martins, I.A., Bruschi, D.P., Passos, M.A., Alexandre, C. and Haddad, C.F. (2015) The Anuran Calling Repertoire in the Light of Social Context. *Acta Ethologica*, **18**, 87-99. https://doi.org/10.1007/s10211-014-0194-4

[2] Giaretta, A.A., Lopes, A.G. and Bang, D.L. (2020) Reassessment of the Advertisement Call of Topotypic *Scinax squalirostris* (Anura: Hylidae), with an Acoustic Evaluation of Its Occurrence in the Serra da Mantiqueira, Southeastern Brazil. *Phyllomedusa*: *Journal of Herpetology*, **19**, 49-61. https://doi.org/10.11606/issn.2316-9079.v19i1p49-61

[3] Guerra, V., Llusia, D., Gambale, P.G., Morais, A.R.D., Marquez, R. and Bastos, R.P. (2018) The Advertisement Calls of Brazilian Anurans: Historical Review, Current Knowledge and Future Directions. *PLOS ONE*, **13**, e0191691. https://doi.org/10.1371/journal.pone.0191691

[4] Wagler, J. (1830) Natürliches System der Amphibien, mit vorangehender Classification der Säugthiere und Vogel: Ein Beitrag zur vergleichenden Zoologie. Stuttgart and Tübingen: J. G. Cotta, München. https://doi.org/10.5962/bhl.title.108661

[5] Frost, D.R. (2024) Amphibian Species of the World: An Online Reference. Version 6.2 (Date of Access). American Museum of Natural History, New York. https://amphibiansoftheworld.amnh.org/index.php

[6] Spix, J.B. (1824) Animalia nova sive Species novae Testudinum et Ranarum quas in itinere per Brasiliam annis MDCCCXVII-MDCCCXX jussu et auspiciis Maximiliani Josephi I. Bavariae Regis. F. S. Hübschmann, München. https://doi.org/10.5962/bhl.title.63182

[7] Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.D.M. and Sparovek, G. (2013) Köppen's Climate Classification Map for Brazil. *Meteorologische zeitschrift*, **22**, 711-728. https://doi.org/10.1127/0941-2948/2013/0507

[8] Condepe (2000) Base de dados do Estado—Climatologia: Descrição dos tipos. Governo do Estado de Pernambuco, Instituto de Planejamento de Pernambuco, Recife.

[9] Neves, R.M.L. (2004) Estudo da Avifauna em quatro fragmentos de Mata Atlântica, Brasil. Ph.D. Thesis, Universidade de São Carlos, São Paulo.

[10] Sueur, J., Aubin, T. and Simonis, C. (2008) Seewave, a Free Modular Tool for Sound Analysis and Synthesis. *Bioacoustics*, **18**, 213-226. https://doi.org/10.1080/09524622.2008.9753600

[11] Elliott, L. (2009) The Frogs and Toads of North America: A Comprehensive Guide to Their Identification, Behavior, and Calls. Houghton Mifflin, Boston.

[12] Köhler, J., Jansen, M., Rodríguez, A., Kok, P.J.R., Toledo, L.F., Emmrich, M., Glaw, F., Haddad, C.F.B., Rödel, M.O. and Vences, M. (2017) The Use of Bioacoustics in Anuran Taxonomy: Theory, Terminology, Methods and Recommendations for Best Practice. *Zootaxa*, **4251**, 1-124. https://doi.org/10.11646/zootaxa.4251.1.1

[13] Duellman, W.E. (1972) South American frogs of the *Hyla rostrata* Group (Amphibia, Anura, Hylidae). *Zoologische Mededelingen*, **47**, 177-192.

[14] Hödl, W. (1977) Call Differences and Calling Site Segregation in Anuran Species from Central Amazonian Floating Meadows. *Oecologia*, **28**, 351-363. https://doi.org/10.1007/BF00345990

[15] Duellman, W.E. and Pyles, R.A. (1983) Acoustic Resource Partitioning in Anuran Communities. *Copeia*, **1983**, 639-649. https://doi.org/10.2307/1444328

[16] de la Riva, I., Márquez, R. and Bosch, J. (1994) Advertisement Calls of Bolivian Species of *Scinax* (Amphibia, anura, Hylidae). *Bijdragen tot de Dierkunde*, **64**, 75-85. https://doi.org/10.1163/26660644-06402002

[17] de Souza, A.O., Oliveira, S.R., Bastos, R.P. and Morais, A.R. (2023) Intraspecific Advertisement Call Variation of *Scinax fuscomarginatus* (Lutz, 1925) from Central Brazil. *Studies on Neotropical Fauna and Environment*, **58**, 476-484. https://doi.org/10.1080/01650521.2021.1978212

[18] Grenat, P.R., Valetti, J.A. and Martino, A.L. (2013) Intra-Specific Variation in Advertisement Call of *Odontophrynus cordobae* (Anura, Cycloramphidae): A Multilevel and Multifactor Analysis. *Amphibia-Reptilia*, **34**, 471-482. https://doi.org/10.1163/15685381-00002902

[19] Rodríguez, A., de la Nuez, D. and Alonso, R. (2010) Intraspecific Variation in the Advertisement Call of the Cloud-Forest Frog *Eleutherodactylus glamyrus* (Anura: Eleutherodactylidae). *Journal of Herpetology*, **44**, 457-466. https://doi.org/10.1670/09-038.1

[20] Gasser, H., Amezquita, A. and Hoedl, W. (2009) Who Is Calling? Intraspecific Call Variation in the Aromobatid Frog *Allobates femoralis*. *Ethology*, **115**, 596-607. https://doi.org/10.1111/j.1439-0310.2009.01639.x

[21] Senthilnathan, A. and Gavrilets, S. (2021) Ecological Consequences of Intraspecific Variation in Coevolutionary Systems. *The American Naturalist*, **197**, 1-17. https://doi.org/10.1086/711886