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Description of sounds emitted by the fossorial snake *Amerotyphlops reticulatus* (Squamata, Typhlopidae) in the Amazon

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ABSTRACT

When threatened, snakes are capable of producing defensive sounds emitted at a frequency above 1,500 Hz. However, their auditory sensitivity is lower (between 200 and 450 Hz). Here, we describe sounds recorded for the first time in the fossorial snake *Amerotyphlops reticulatus*. Two individuals were observed in mating behaviour in the southern Amazon. During handling, the female repeatedly emitted sounds with a dominant frequency of 10,459 Hz and an amplitude ranging from 7,240 to 12,856 Hz, while the male exhibited only the same head and mouth movements. It is known that snakes use sounds for defensive communication, and there is no evidence of acoustic communication between them. However, the sound emission from the female and the reported male behaviour highlight the need for more in-depth investigations into the auditory and neural systems of the group.

KEYWORDS: acoustic communication, defensive sounds, reptiles, spectrogram, whistles

Descrição dos sons emitidos pela serpente fossorial *Amerotyphlops reticulatus* (Squamata: Typhlopidae) na Amazônia

RESUMO

Quando ameaçadas, as serpentes são capazes de produzir sons defensivos emitidos em uma frequência acima de 1,500 Hz. No entanto, sua sensibilidade auditiva é mais baixa (entre 200 e 450 Hz). Aqui descrevemos, pela primeira vez, a gravação de sons da serpente fossorial *Amerotyphlops reticulatus*. Dois indivíduos foram observados em comportamento de acasalamento no sul da Amazônia. Durante o manuseio, a fêmea emitiu repetidamente sons com uma frequência dominante de 10,459 Hz e uma amplitude variando de 7,240 a 12,856 Hz, enquanto o macho exibiu apenas os mesmos movimentos da cabeça e da boca. Sabe-se que as serpentes usam sons para comunicação defensiva e não há evidências de comunicação acústica entre elas. No entanto, a emissão de som pela fêmea e o comportamento relatado do macho destacam a necessidade de investigações mais aprofundadas sobre os sistemas auditivo e neural do grupo.

PALAVRAS-CHAVE: assobios, comunicação acústica, espectrograma, répteis, sons defensivos

Acoustic communication plays an essential role in survival, primarily in defense, territory protection, and reproduction (Russell and Bauer 2020). In non-avian reptiles, sound production is documented for crocodilians, and chelonians (Ferrara et al. 2012; Colafrancesco and Gridi-Papp 2016), while within the Squamata order (snakes, lizards and amphisbaenians), this behaviour is rare (Jorgewich-Cohen et al. 2022), with exceptions for the Gekkota and Phyllodactylidae groups (Brillet and Paillette 1991; Manley 2002; Russell et al. 2014).

Snakes are sensitive to sounds and vibrations propagated through the air and the ground (Hartline 1971; Zdenek et al. 2023). They are also capable of producing a variety of defensive sounds, such as scale abrasion (i.e., sliding of one body segment over the adjacent segment) (Young 2003), cloacal popping (synchronised contractions of the cloacal musculature) (Young et al. 1999), and tail vibration (friction of specialised scales against each other) (Colafrancesco and Gridi-Papp 2016). In addition, snakes can produce defensive sounds involving exhalation and/or inhalation through the

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anterior respiratory tract (Young et al. 1999), known as hissing and wheezing (Young 2003). Furthermore, some snakes have specialised anatomical structures in the respiratory tract that acoustically influence airflow, such as the presence of a tracheal diverticulum responsible for the growl in *Ophiophagus hannah* Cantor 1836 and *Gonyosoma oxycephalum* Boie 1827 (see Young 1991, 1992), and 'vocal cords' responsible for the roar in *Pituophis melanoleucus* Daudin 1803 (Young et al. 1995).

In general, the sounds emitted by snakes have a frequency above 1,500 Hz (Young 2003), with rare exceptions (*O. hannah* – 600 Hz, Young 1991; *P. melanoleucus* – 500 Hz, Young et al. 1995). However, it is currently known that the auditory sensitivity of snakes to vibrations propagated through the air and the ground occurs at a frequency of approximately 200–450 Hz (Hartline 1971; Young 2003; Young and Aguiar 2002; Zdenek et al. 2023), with greater sensitivity to frequencies around 300 Hz (Friedel et al. 2008). Thus, there is an acoustic disparity in that snakes are not sensitive to the sounds they produce themselves (Young 2003), which reinforces the production of these sounds as defense mechanisms (Young et al. 1999).

Here we describe sounds recorded for the first time in an individual of a fossorial snake widely distributed in northern Brazil, *Amerotyphlops reticulatus* Linnaeus 1758 (Family Typhlopidae), during daytime field activities on 30 October 2023, in a secondary forest (10°3'59.40"S, 59° 8'52.44"W; 347 m above sea level) in the municipality of Aripuanã, state of Mato Grosso, in the southwestern Amazon of Brazil. The individuals were identified as *A. reticulatus* by the following sets of characteristics, following Dixon and Hendricks (1979): 20-20-18 rows of dorsal scales; 234 middorsal scales between the rostral and caudal spine; 11 subcaudals; reduction in scale rows 20 (20) – 187/194 (18) – 234; 1 postocular, 2 parietal, 4 supralabial, 9 rows of dark brown-pigmented dorsal scales, the remainder yellowish; white snout and white tail ring.

While reviewing pitfall traps with drift fences installed in the region, we observed the presence of two individuals of the species *A. reticulatus* in mating behaviour within one of the traps (Figure 1a). After mating, the individuals were removed manually from the trap. During handling, the snakes began to make lateral movements with their heads and open their mouths (Figure 1b). At this point, we observed that one of the individuals, identified as female, started to emit repeatedly a short, shrill, and high-pitched sound, while the other individual, identified as male, did not produce any audible sound, although it exhibited the same behaviour of lateral head movements and mouth opening. Audiovisual recordings of the behaviour were made with an iPhone SE in video mode and are available at https://youtu.be/rqOOorI4Jxw. Only after the recordings, both individuals were photographed, sexed and measured to a total length of 45 cm (female) and 32 cm (male). Subsequently, both individuals were released near the capture site.

To describe the call, we converted the original audio (MPEG-4 format [.mov]) to WAVE format (.wav) using the online converter cloudconvert (https://cloudconvert.com/mp4-to-wav). We used the power spectrum tool with 20 dB peak amplitude thresholds to discern the sound of interest (emitted by the snake) from background noise. We descriptively analysed temporal parameters (call duration and

Figure 1. Two individuals of *Amerotyphlops reticulatus* (Squamata: Typhlopidae) recorded in this study. **A** – Detail of mating behaviour; **B** – Individuals while being handled. Female (on the right side) performing lateral head movements and repeatedly emitting short, shrill, and high-pitched sounds, while the male (on the left side) exhibited the same lateral head and mouth movements without emitting audible sounds (see video link indicated in the text).

the interval between calls), spectral parameters (maximum, minimum and dominant frequencies) and structural parameters (number of harmonics and frequency range of harmonics). All acoustic analyses were performed using Raven Pro 1.6 software (academic licence to M.P.). We created graphs representing spectrograms and oscillograms of the analysed sounds, using the Seewave package in RStudio 3.3.0+ (R Core Team 2023; version 2023.12.1+402), with a fast Fourier transform (FFT), a window of 512 points, a minimum amplitude of -50 dB and a frequency resolution of 20 kHz.

The recording lasted 2.40 minutes. It comprised three sequences of the female's vocalisations interspersed with periods without audible sounds. We analysed a total of 27 vocalisations (Figure 2). On average, the vocalisations had a duration of 0.21 seconds (0.15–0.32 second), with an average interval of 3.12 seconds (1.38–6.01 seconds) between them. The vocalisations had an average fundamental frequency of 8,231 Hz (7,321–9,043 Hz) and a dominant frequency of 10,459 Hz (9,474–10,938 Hz), with frequency amplitudes ranging from 7,240 to 12,856 Hz. The vocalizations did not present a fixed structure regarding the position of the frequencies, in some vocalizations the fundamental frequency is lower than the dominant frequency (Figure 3, vocalizations 1 and 2), while in other vocalizations the fundamental and dominant frequencies presented similar values (Figure 3, vocalization 3).

Research on the auditory capability of snakes and their relationship with produced sounds revealed intriguing facets about the sensitivity of these animals to vibrations and sounds (Zdenek et al. 2023). Several studies have debunked the conventional idea that snakes are deaf or only sensitive to terrestrial vibrations (Hartline 1971; Young 2003; Christensen et al. 2012; Russell and Bauer 2020; Møller et al. 2021; Fernandes et al. 2023; Perez-Martinez and Vallejos 2023). Despite an increasing body of knowledge regarding sound production in snakes, to date, there is no evidence of acoustic communication among them (Young 2003). Snakes respond to sounds propagated through the air (Young and Aguiar 2002) and certain species possess vocal cords (Young et al. 1995), demonstrating the existence of anatomical structures responsible for the emission and reception of these sounds. However, our understanding of the vibratory mechanics of snake ears, neural control, and auditory sensitivity remains incomplete (Young 2003).

So far, the vocal production in snakes has been linked to defensive behaviour (Young et al. 1995, 1999; Young and Aguiar 2002; Christensen et al. 2012), with no information regarding the association of these sounds with other behaviours, such as communication between males and females. Acoustic communication is one of the main attributes associated with the reproductive success of groups that carry out their activities nocturnally, because during the night other commonly used signals, such as vibrant colouration, are generally imperceptible (Endler 1992; Chen and Wiens 2020). Thus, the emission of sounds by the female *A. reticulatus*, shortly after the mating behaviour, leads us to consider that the existence of acoustic communication between males and females could be advantageous in some way, such as helping to locate fossorial organisms. However, the stress caused by handling snakes can also be responsible

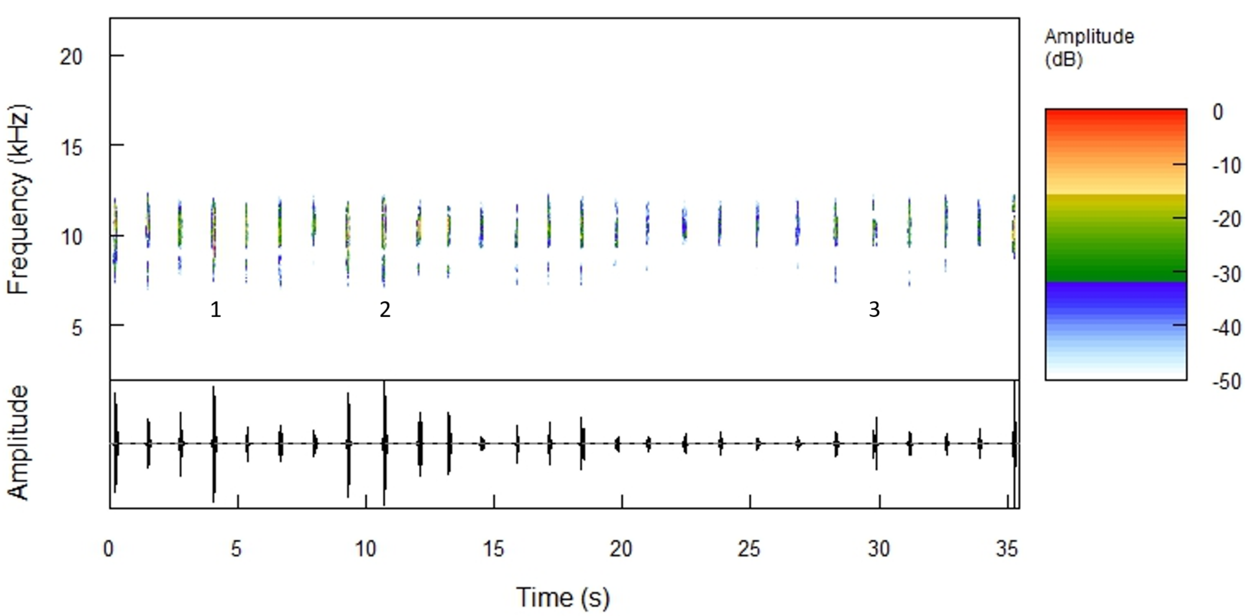

Figure 2. Spectrogram (frequency over time) and oscillogram (amplitude over time) of 27 sounds emitted by an adult female of the fossorial snake *Amerotyphlops reticulatus* (Squamata: Typhlopidae) in the southwestern Amazon, Brazil.

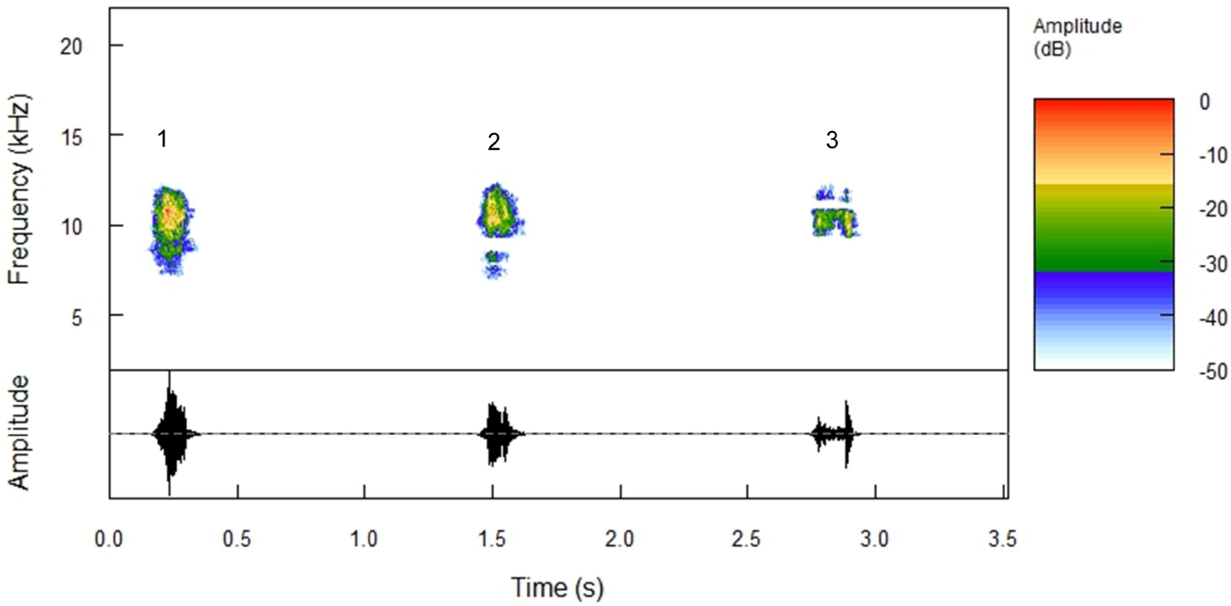

Figure 3. Spectrogram (frequency over time) and oscillogram (amplitude over time) of three sounds emitted by an adult female of the fossorial snake *Amerotyphlops reticulatus* (Squamata: Typhlopidae) in the southwestern Amazon, Brazil. Numbers 1, 2 and 3 represent three examples of vocalizations observed among 27 vocalizations analysed.

for the emission of sounds, which reinforces vocal emission as a defensive behaviour.

The production of high-pitched sounds in association with head movements and mouth opening during sound production, as observed in here, have also been documented in other snakes of the Typhlopidae family (Waite 1929 cited in Schwaner et al. 1985; Perez-Martinez and Vallejos 2023). Thus, they seem to be more common than previously thought for this group. Zdenek et al. (2023) suggest that the consistency of certain defensive behaviours in snakes may be associated with a response to certain stimuli, such as predation pressure. To improve the discussion on this subject, it is necessary to understand the auditory capability of Scolecophidians, as only basal groups have been studied so far (Colubridae, Dipsidae, and Viperidae) (Young 2003; Fernandes et al. 2023; Zdenek et al. 2023). Additionally, further investigation using recording equipment with more refined technology could capture some sound emission from male *A. reticulatus*. Our report points to the importance of studies on sound production in fossorial snakes, with emphasis on their auditory and neural systems, in order to improve our understanding of the sound ecology, communication patterns and behaviour in this group.

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REFERENCES

Brillet, C.; Paillette, M. 1991. Acoustic signals of the nocturnal lizard Gekko Gecko: Analysis of the 'long complex sequence'. *Bioacoustics* 3: 33–44.

Chen, Z.; Wiens, J.J. 2020. The origins of acoustic communication in vertebrates. *Nature Communications* 11: 369. doi:10.1038/s41467-020-14356-3.

Christensen, C.B.; Christensen-Dalsgaard, J.; Brandt, C.; Madsen, P.T. 2012. Hearing with an atympanic ear: good vibration and poor sound-pressure detection in the royal python, *Python regius. Journal of Experimental Biology* 215: 331–342.

Colafrancesco, K.C.; Gridi-Papp, M. 2016. Vocal sound production and acoustic communication in amphibians and reptiles. In: Suthers, R.A.; Fitch, W.T.; Fay, R. R.; Popper, A.N. (Eds.). *Vertebrate Sound Production and Acoustic Communication*, Springer, Cham. p.51–82.

Dixon, J.R.; Hendricks, F.S. 1979. The wormsnakes (family Typhlopidae) of the Neotropics, exclusive of the Antilles. *Zoologische Verhandelingen* 173: 3–39.

Endler, J.A. 1992. Signals and the direction of evolution. *American Naturalist* 139: 125–153.

Fernandes, I.Y.; Koch, E.D.; Mônico, A.T. 2023. First record of a snake call in South America: the unusual sound of an ornate snail-eater *Dipsas catesbyi*. *Acta Amazonica* 53: 243–245.

Ferrara, C.R.; Vogt, R.C.; Sousa-Lima, R.S. 2012. Turtle vocalizations as the first evidence of posthatching parental care in chelonians. *Journal of Comparative Psychology* 127: 24–32

Friedel, P.; Young, B.A.; Hemmen, L.V. 2008. Auditory localization of ground-borne vibrations in snakes. *Physical Review Letters* 100: 048701.

Hartline, P.H. 1971. Physiological basis for detection of sound and vibration in snakes. *Journal of Experimental Biology* 54: 349–371.

Jorgewich-Cohen, G.; Townsend, S.W.; Padovese, L.R.; Klein, N.; Praschag, P.; Ferrara, C.R. 2022. Common evolutionary origin of acoustic communication in choanate vertebrates. *Nature Communications* 13: 6089. doi:10.1038/s41467-022-33741-8.

Manley, G.A. 2002. Evolution of structure and function of the hearing organ of lizards. *Journal of Neurobiology* 53: 202–211.

Møller, A.P.; Gil, D.; Liang, W. 2021. Snake-like calls in breeding tits. *Current Zoology* 67: 1-7. doi:10.1093/cz/zoab001.

Perez-Martinez, C.A; Vallejos, J.G. 2023. Squeaks in the dark: vocalisations in the Claw-snouted Blind Snake, *Anilios unguirostris* (Peters, 1867). *Herpetology Notes* 16: 885–887.

R Core Team. 2023. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. (https://www.R-project.org/). Accessed on 11 Dec 2023.

Russell, A.P.; Bauer, A.M. 2020. Vocalization by extant nonavian reptiles: a synthetic overview of phonation and the vocal apparatus. *Anatomical Record* 304: 1478–1528.

Russell, A.P.; Hood, H.A.; Bauer, A.M. 2014. Laryngotracheal and cervical muscular anatomy in the genus *Uroplatus* (Gekkota: Gekkonidae) in relation to distress call emission. *African Journal of Herpetology* 63: 127–151.

Schwaner, T.D.; Miller, B.; Tyler, M.J. 1985. Reptiles and amphibians. In: Twidale, C.R.; Tyler, M.J.; Davies, M. (Eds.). *Natural History of the Eyre Peninsula*, Royal Society of South Australia, Adelaide. p.159–168.

Young, B.A. 1991. Morphological basis of "growling" in the king snake, *Ophiophagus hannah. Journal of Experimental Zoology* 260: 275–287.

Young, B.A. 1992. Tracheal diverticula in snakes: possible functions and evolution. *Journal of Zoology* 227: 567–583.

Young, B.A. 2003. Snake bioacoustics: toward a richer understanding of the behavioral ecology of snakes. *Quarterly Review of Biology* 78: 303–325.

Young, B.A.; Aguiar, A. 2002. Response of western diamondback rattlesnakes *Crotalus atrox* to airborne sounds. *Journal of Experimental Biology* 205: 3087–3092.

Young, B.A.; Nejman, N.; Meltzer, K.; Marvin, J. 1999. The mechanics of sound production in the puff adder *Bitis arietans* (Serpentes: Viperidae) and the information content of the snake hiss. *Journal of Experimental Biology* 202: 2281–2289.

Young, B.A.; Sheft, S.; Yost, W. 1995. Sound production in *Pituophis melanoleucus* (Serpentes: Colubridae) with the first description of a vocal cord snakes. *Journal of Experimental Zoology* 273: 472–481.

Zdenek, C.N.; Staples, T.; Hay, C.; Bourke, L.N.; Candusso, D. 2023. Sound garden: how snakes respond to airborne and groundborne sounds. *PLoS One 18*: e0281285

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DATA AVAILABILITY: The data supporting the findings of this study are available on the YouTube platform (link in the text).

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