

ON THE PRESENCE OF *EUNECTES MURINUS* (SQUAMATA, SERPENTES) FROM THE LATE PLEISTOCENE OF NORTHERN BRAZIL

ANNIE SCHMALTZ HSIU

Departamento de Biologia, FFCLRP, USP, Av. Bandeirantes 3900, Ribeirão Preto, SP, Brazil. anniehsiou@ffclrp.usp.br

GISELE R. WINCK

Departamento de Ecologia, Instituto de Biologia Roberto de Alcântara Gomes, Rua São Francisco Xavier 524, 20550-013, Rio de Janeiro, RJ, Brazil. gwinck@yahoo.com.br

BLAINE W. SCHUBERT

Don Sundquist Center of Excellence in Paleontology and Department of Geosciences, East Tennessee State University, Box 70636, 37614-1709, Johnson City, TN, USA. schubert@etsu.edu

LEONARDO ÁVILLA

Departamento de Zoologia, UNIRIO, Av. Pasteur 458, sala 501, 22290-240, Rio de Janeiro, RJ, Brazil. leonardo.avilla@gmail.com

ABSTRACT – Brazilian late Pleistocene snakes have an extensive fossil record and are recognized for southern, northeastern and northern regions of this country. This fossil record is represented by the families Boidae, ‘Colubridae’, Viperidae and Elapidae. Here is presented the first record for *Eunectes* Wagler for the late Pleistocene of the Brazilian northern region. The material described is a single incomplete dorsal vertebra, and although it shares several vertebral features with most Boidae taxa, it can be distinguished from all other boids because is a robust and wide vertebra with a slightly depressed neural arch, relatively thick and robust zygosphenes with a prominent median tubercle. The taxonomic allocation to *E. murinus* (Linnaeus) is based on the exceptionally large size of the vertebra. The discovery of *E. murinus* in the late Pleistocene of Tocantins State indicates the presence of a large body of water in a region that has previously been interpreted as relatively arid during this time.

Key words: Serpentes, *Eunectes*, late Pleistocene, Tocantins State, Northern Brazil.

RESUMO – As serpentes do Pleistoceno final do Brasil exibem um amplo registro fóssil, sendo reconhecidas para as regiões sudeste, nordeste e norte do país. Esta diversidade é representada pelas famílias Boidae, ‘Colubridae’, Viperidae e Elapidae. Neste trabalho, é apresentado o primeiro registro de *Eunectes* Wagler para Pleistoceno final da Região Norte do Brasil. O material consiste de uma única vértebra dorsal incompleta e, embora compartilhe muitos caracteres com os demais representantes da família Boidae, distingue-se de todos eles por exibir uma vértebra robusta e larga, arco neural ligeiramente deprimido, zigósfene robusta e moderadamente espessa, com um proeminente tubérculo mediano. A atribuição taxonômica a *E. murinus* (Linnaeus) refere-se ao grande tamanho da vértebra do espécime aqui descrito. A descoberta de *E. murinus* para o Pleistoceno final do Estado de Tocantins indica a presença de grandes corpos d’água em uma região que foi previamente interpretada como relativamente úmida durante esse momento.

Palavras-chave: Serpentes, *Eunectes*, Pleistoceno final, Tocantins, norte do Brasil.

INTRODUCTION

The Brazilian late Pleistocene record of snakes has been documented in the southeast and northeast regions, with several taxa correlated to the current Brazilian snake fauna, and mostly represented by the families Boidae, ‘Colubridae’, Viperidae, and Elapidae (Camolez & Zaher, 2010; Hsiou & Albino, 2009, 2010; Hsiou *et al.*, 2012). Among the fossil remains, several specimens are attributed to the well-supported Neotropical boid clade (Burbrink, 2005; Noonan & Chippindale, 2006),

represented by four extant South American genera: *Epicrates* Wagler, 1830, *Corallus* Daudin, 1803, *Boa* Linnaeus, 1758, and *Eunectes* Wagler, 1830 (see Camolez & Zaher, 2010; Hsiou *et al.*, 2012). However, there is only a single record of snake for the late Pleistocene of the Brazilian Northern region, a viperid from southwestern Brazilian Amazonia (Hsiou & Albino, 2011).

In the present work we report the first record of *Eunectes* for Tocantins, northern Brazil. This large specimen is attributed to *E. murinus* Linnaeus, 1758, and provides improved insight into late Pleistocene paleoecology for the region.

LOCATION AND GEOLOGICAL SETTING

The material comes from a limestone cave, the Gruta do Urso, ($12^{\circ}35'0.08''\text{S}$, $46^{\circ}30'58.39''\text{W}$) in the municipality of Aurora do Tocantins, State of Tocantins, Brazil (Figure 1A). The specimen was found in a thick sediment level that fills the corridor of the cave (Figure 1B). The age of the deposit is inferred based on representative taxa, such as *Propraopus grandis* Ameghino, 1881. Both of these taxa were found at the same level as the anaconda specimen, and also have the same color and preservation. Therefore, the deposit is interpreted to be of late Pleistocene age. The other taxa found are living species recorded during the Pleistocene as well; therefore, not suitable for determining a more specific age (e.g. *Panthera onca* Linnaeus, 1758).

The limestone of the Aurora do Tocantins region is part of the Speleological Province of the Bambuí Group, where the largest number of caves in Brazil has been found (Zampaulo & Ferreira, 2009). However, the area is still lacking geological studies. Online notes of CPRM (Companhia de Pesquisa de Recursos Minerais) about the geology of the municipality of Aurora do Tocantins report carbonate deposits of the Bambuí Group, which is Neoproterozoic in age (CPRM, 2006). The lower portion is represented by the Sete Lagoas Formation, which is composed of thick deposits of pelites, limestone and dolomites bearing stromatolites. The Sete Lagoas Formation is covered by siltstone and laminated siltstones of the Serra de Santa Helena Formation. These carbonate rocks are superimposed by dark calcarenites and marls, with organic

material from the Lagoa do Jacaré Formation. Superimposed on the Bambuí Group are Cretaceous sediments of the Urucua Formation. The fossil bearing level is composed of laminated reddish-grey (5YR5/2) loess-like sediment.

MATERIAL AND METHODS

The vertebra is partially covered by a concretion of calcium carbonate and due to the fragility of the specimen, it was not possible to prepare it more appropriately. It is housed at the UNIRIO (Rio de Janeiro, State of Rio de Janeiro, Brazil) fossil vertebrate collection. It comprises an almost complete mid-trunk vertebra (UNIRIO-NM 0001). Data were obtained on extant bovid skeletons to compare and analyze the material (see Appendix). Osteological nomenclature and measurements follow Auffenberg (1963), Rage (1984), LaDuke (1991a,b), and Lee & Scanlon (2002). The description is based on the previous studies of Hsiou & Albino (2009, 2010). Systematic arrangement is based on Noonan & Chippindale (2006). Measurements are expressed in millimeters. **Vertebral measurements.** **cl**, centrum length; **coh**, condyle height; **cow**, condyle width; **cth**, cotyle height; **ctw**, cotyle width; **naw**, neural arch width at interzygapophyseal ridge; **pr-pr**, distance between prezygapophyses; **pr-po**, distance between pre- and postzygapophyses of the same side; **prl**, prezygapophysis length; **prw**, prezygapophysis width; **zh**, zygosphenes height; **zw**, zygosphenes width.

Institutional abbreviations. **IB**, Instituto Butantan, São Paulo; **MCN.D**, Didactic Collection of Herpetology,

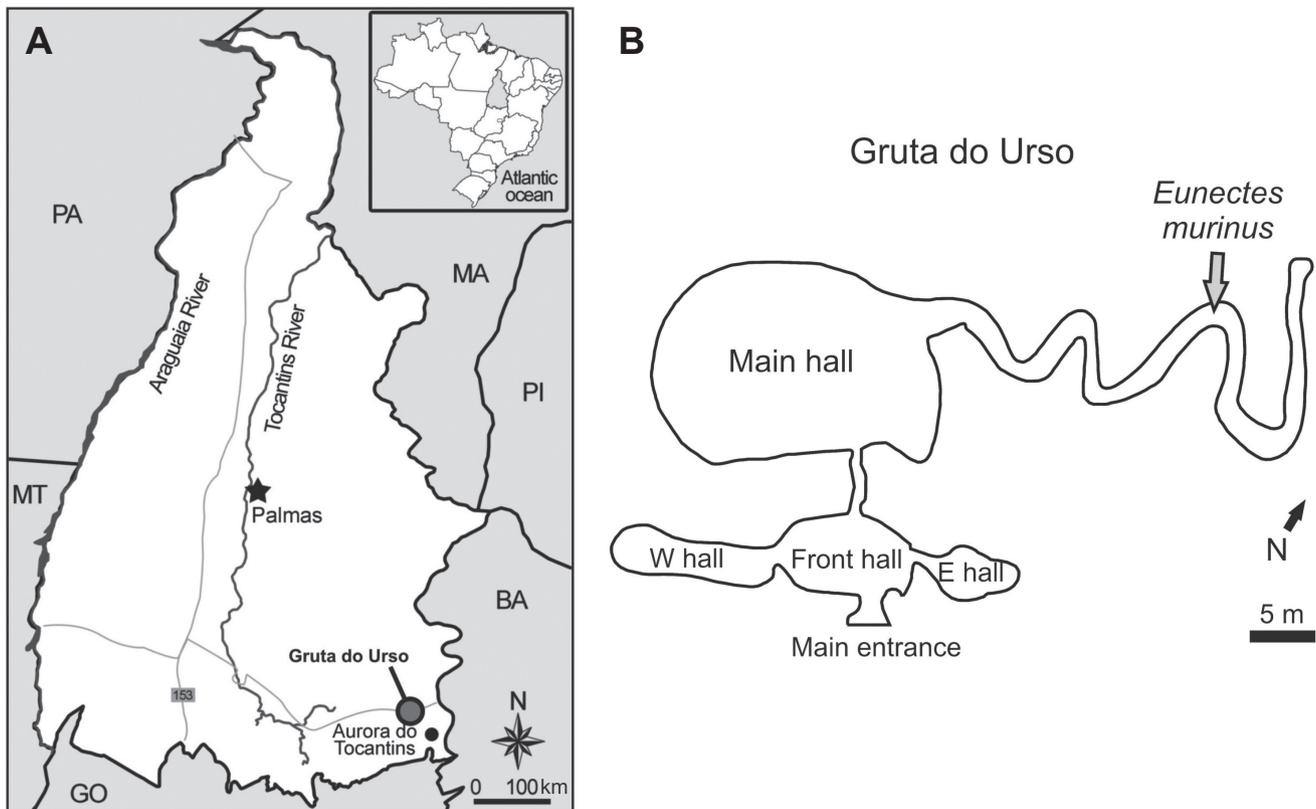


Figure 1. Location of Gruta do Urso and the *Eunectes murinus* specimen reported here. **A**, State of Tocantins, northern Brazil, showing its capital Palmas and its major rivers: Araguaia and Tocantins. The black circle denotes the municipality of Aurora do Tocantins, where Gruta do Urso is located (grey circle). **B**, Schematic diagram of the Gruta do Urso, and the specific site where the snake vertebra was found.

Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre; **MZUSP**, Museu de Zoologia, Universidade de São Paulo, São Paulo; **UNIRIO-NM**, Collection of non-mammals fossils, Laboratório de Mastozoologia, Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro.

SYSTEMATIC DESCRIPTION

Suborder SERPENTES Linnaeus, 1758
 Infraorder ALETHINOPHIDIA Nopcsa, 1923
 Microorder MACROSTOMATA Müller, 1831
 Superfamily BOOIDEA Gray, 1825
 Family BOIDAE Gray, 1825

Eunectes Wagler, 1830

Type species. *Eunectes murinus* (Linnaeus, 1758).

Eunectes murinus (Linnaeus, 1758)
 (Figuras 2A-D)

Referred specimen. One almost complete midtrunk vertebra (UNIRIO-NM 0001).

Locality and age. Gruta do Urso, Municipality of Aurora do Tocantins, southern State of Tocantins, northern Brazil. Late Pleistocene.

Description. The specimen is almost complete, and only lacks the right prezygapophysis, right paradiapophysis, and neural spine. Parts of the vertebra are covered in a concretion that varies in color from orange to tan. The lighter tan concretion is more like calcified sediment while the orange is a coating of what appears to be calcium carbonate with small crystals exposed. There is concretion within the cotyle and neural canal. The vertebra is large, wide, high and shortened, with the vertebral centrum shorter than the neural arch width ($cl < naw$). In anterior view, a wide and robust zygosphene is much wider than the cotyle ($zw > ctw$) and shows a slightly elevated dorsal edge in the middle. Only the left prezygapophysis is preserved; it is weakly inclined above the horizontal plane, with a small prezygapophyseal process that projects a little beyond the articular facets of the prezygapophyses. The neural canal is triangular. The cotyle is nearly circular ($ctw \sim cth$), and there are no paracotylar foramina on either side of the cotyle. Only the right paradiapophysis is preserved and it surpasses the ventral margin of the cotyle. It is robust and lateroventrally oriented. The dia- and parapophysial surfaces are well separated; the diapophyses are convex

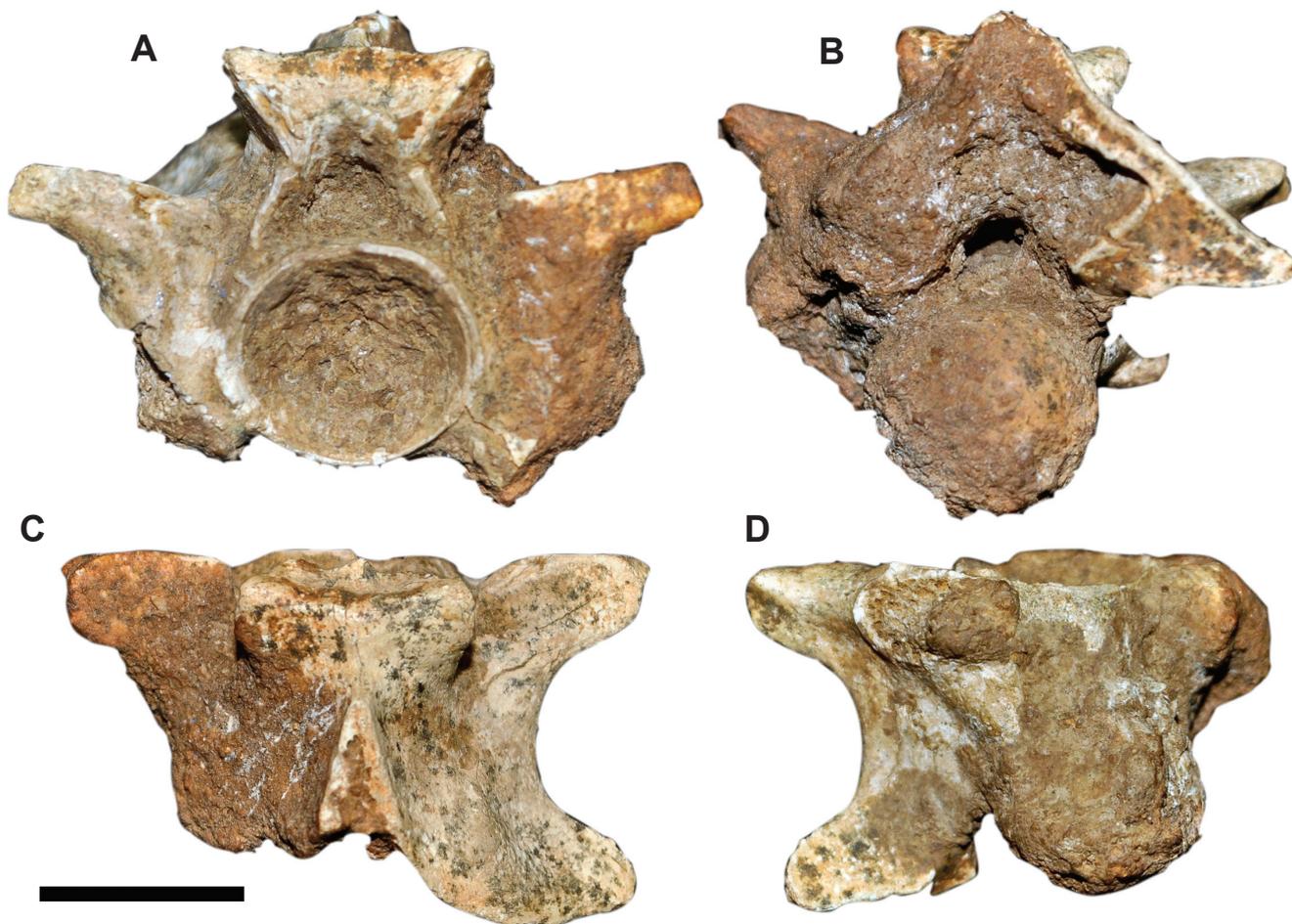


Figure 2. *Eunectes murinus* from the Gruta do Urso cave, State of Tocantins, Northern Brazil. Midtrunk vertebrae, UNIRIO-NM 0001 in (A) anterior, (B) posterior, (C) dorsal, and (D) ventral views. Scale bar = 10 mm.

and prominent, while the parapophysis is rather concave. In posterior view, although part of the neural arch roof is broken on the left side, it is slightly depressed. The posterior surface is covered in a thin layer of calcium carbonate, which partly obscures the zygantrum. The right postzygapophysis is slightly inclined dorsally. The condyle is nearly circular. In dorsal view, the neural arch is wider than it is long ($pr-pr > pr-po$). The articular facet of the prezygapophyses is broad and anterolaterally oriented. The anterior edge of the zygosphene is concave and shows a median tubercle projecting anteriorly and located above the roof of the neural canal. The interzygapophyseal ridge is curved and short. Although the neural spine is broken, it is apparently sharp anteriorly and wide posteriorly. In lateral view, the centrum is short, showing a well-defined haemal keel that reaches the precondylar constriction. In ventral view, the vertebral centrum is short and triangular. The haemal keel is well defined along the midline of the ventral surface of the centrum. It originates from the ventral edge of the cotyle.

Measurements. Cl, 25.31; nch, 7.82; ncw, 3.73; coh, 13.20; cow, 13.97; cth, 11.49; ctw, 12.15; naw, 23.75; pr-pr, 37.26; pr-po, 23.64; prl, 11.30; prw, 7.27; zh, 7.12; zw, 14.95.

Remarks. The specimen UNIRIO-NM 0001 is assigned to the genus *Eunectes* on the basis of the following features: large size, slightly depressed neural arch, robust and moderately thick zygosphene with a prominent median tubercle (Hsiou & Albino, 2009). Moreover, the taxonomic assignment of the specimen described above to Boidae is based on the following combination of vertebral characters shared with the genera of extant Neotropical boines: robust, high, short and wide vertebrae; although incomplete, the neural spine is apparently well developed; relatively thick zygosphene; low inclination of the articular facet of the prezygapophysis (less than 15°); short prezygapophyseal process; vertebral centrum short; marked precondylar constriction; haemal keel well developed in the mid-trunk vertebrae instead of a hypapophysis (Rage, 2001; Lee & Scanlon, 2002; Szyndlar & Rage, 2003; Albino & Carlini, 2008).



Figure 3. Current geographic distribution of the snake *Eunectes murinus* in South America (in gray). **1**, *Eunectes murinus*, late Pleistocene, Gruta do Urso cave, State of Tocantins; **2**, *Eunectes* sp., Quaternary, found in the Buraco do Japonês cave, State of Mato Grosso do Sul, at the municipality of Bonito; **3**, *Eunectes murinus*, Quaternary, found in Lapa dos Brejões cave, State of Bahia, at the municipality of Morro do Chapéu. Records 2 and 3 were assigned by Camolez & Zaher (2010).

DISCUSSION

Fossils of the genus *Eunectes* have been reported from the Miocene of Colombia, Venezuela, and Brazil (Hoffstetter & Rage, 1977; Hecht & LaDuke, 1997; Hsiou & Albino, 2009, 2010), and also from the late Pleistocene of Bahia and Mato Grosso do Sul states (Camolez & Zaher, 2010). From those, only the record from the late Pleistocene of Bahia and the one presented here could be attributed to *E. murinus*, because of their unique larger size (mainly based on the proportions of the vertebrae, *i.e.* cl, pr-pr, and pr-po). According to Camolez & Zaher (2010) there are no differences in the dorsal vertebrae of *Eunectes* species; however, subtle differences could be observed in the postcloacal vertebrae.

The extant *Eunectes murinus* is a typical Neotropical taxon, occurring between latitudes of 10°N and approximately 30°S. This species can be found from very humid to dry climates, but always in association with aquatic environments, occurring in the lowlands of South America east of the Andes, from the island of Trinidad, the Orinoco River Basin, Amazon, Guianas, and the upper courses of the basins of the rivers Paraguay, Paraná and São Francisco, with the southernmost distribution in northeastern Paraguay (Henderson *et al.*, 1995; Waller *et al.*, 1995). Hence, the record of an *E. murinus* fossil in the Gruta do Urso indicates that the environment around this cave included a large body of water, like a river, lake, or flooded savanna during the late Pleistocene. In addition, the aquatic component is further represented by fragments of caimans (Crocodylia, Alligatoridae), mainly isolated osteoderms, in association with the *E. murinus* fossil.

According to Cione & Tonni (1999, 2005) this region of South America was open and dry during the late Pleistocene. Two species associated with the *Eunectes murinus* fossil from Gruta do Urso cave, *Catagonus stenocephalus* (Lund in Reinhardt, 1880) and *Propaopus grandis* Ameghino, 1881, may also suggest an open and dry environment for the region during the late Pleistocene. The inferred dry climate interpretation is quite different from the current humid Cerrado where the caves of the region of Aurora do Tocantins occur. Thus, if the late Pleistocene arid interpretation is correct, the climate has changed dramatically to a more humid environment during the Holocene. Such a change may have had a dramatic impact on some inferred xerophytic species (*e.g.* *C. stenocephalus* and *P. grandis*), and could have contributed to their extinction. In contrast, it is possible that such a climatic change would have a positive impact on *E. murinus* populations due to increased aquatic environments coinciding with higher humidity.

CONCLUSIONS

An exceptionally large snake vertebra was collected in late Pleistocene sediments from the Gruta do Urso cave in northern Brazil. The vertebral morphology and proportions of the vertebra permitted identification of this specimen as *Eunectes murinus*. This is the first record of *E. murinus* for

the late Pleistocene of Northern Brazil, and the occurrence indicates the presence of a large body of water, like a river, lake, or flooded savanna. Previous interpretations of this region during the late Pleistocene suggest an arid environment, but the occurrence of *E. murinus* confirms a significant aquatic component as well.

ACKNOWLEDGMENTS

The expeditions to Aurora do Tocantins and the curatorial procedures of the collected material were financially supported by the CNPq in two projects: (i) the MCT/CNPq n° 32/2010 - Fortalecimento da Paleontologia Nacional/Edital 32/2010 - Faixa B, process n° 401812/2010-3; and (ii) Apoio a Projetos de Pesquisa/Chamada MCTI/CNPq N° 23/2011 - Apoio Técnico para Fortalecimento da Paleontologia Nacional, process n° 552975/2011-7. ASH wishes to thank the financial support provided by FAPESP (process n°. 2011/14080-0) and BWS thanks the Office of Research and Sponsored Programs at East Tennessee State University for travel funding. The CNPq also provided a Postdoctoral Fellowship grant to GRW (process n° 150855/2012-5).

REFERENCES

- Ameghino, F. 1881. La antigüedad del hombre en el Plata. París-Buenos Aires, Masson-Igon Hermanos, 557 p.
- Albino, A.M. & Carlini, A.A. 2008. First record of *Boa constrictor* (Serpentes, Boidae) in the Quaternary of South America. *Journal of Herpetology*, **42**:82-88. doi:10.1670/07-124R1.1
- Auffenberg, W. 1963. The fossil snakes of Florida. *Tulane Studies in Zoology*, **10**:131-216.
- Burbrink, F.T. 2005. Inferring the phylogenetic position of *Boa constrictor* among the Boinae. *Molecular Phylogenetics and Evolution*, **34**:167-180. doi:10.1016/j.ympev.2004.08.017
- Camolez, T. & Zaher, H. 2010. Levantamento, identificação e descrição da fauna de Squamata do Quaternário brasileiro (Lepidosauria). *Arquivos de Zoologia, Museu de Zoologia da Universidade de São Paulo*, **41**:1-96.
- Cione, A.L. & Tonni, E.P. 1999. Biostratigraphy and chronological scale of upper-most Cenozoic in the Pampean area. *Quaternary of South America and Antarctic Peninsula*, **12**:22-51.
- Cione, A.L. & Tonni, E.P. 2005. Bioestratigrafía basada en mamíferos del Cenozoico superior de la provincia de Buenos Aires, Argentina. In: R.E. De Barrio; R.O. Etcheverry; M.F. Caballé & E. Llambias (eds.) *Geología y Recursos Minerales de la Provincia de Buenos Aires*, p. 183-200 (Relatorio 9).
- CPRM. 2006. Rochas carbonáticas do Grupo Bambuí na região Nordeste do Estado de Goiás. <http://www.cprm.gov.br/publique/cgi/cgilua.exe/sys/start.htm?infoid=261&sid=32/> (accessed 5 december 2010).
- Gray, J.E. 1825. A synopsis of the genera of Reptilia and Amphibia. *Annals of Philosophy*, **10**:193-217.
- Hecht, M.K. & LaDuke, T.C. 1997. Limbless tetrapods. In: R.F. Kay; R.H. Madden; R.L. Cifelli & J.J. Flynn (eds.) *Vertebrate Paleontology in the Neotropics – The Miocene Fauna of La Venta*, Smithsonian Institution Press, p. 95-99.
- Henderson, R.W.; Waller, T.; Micucci, P.; Puerto, G. & Bourgeois, R.W. 1995. Ecological correlates and patterns in the distribution of Neotropical Boines (Serpentes: Boidae): a preliminary assessment. *Herpetological Natural History*, **3**:15-27.
- Hoffstetter, R. & Rage, J.C. 1977. Le gisement de vertébrés miocènes de La Venta (Colombie) et sa faune de serpents. *Annales de Paléontologie (Vertébrés)*, **63**:161-190.

- Hsiou, A.S. & Albino, A.M. 2009. Presence of the genus *Eunectes* (Serpentes, Boidae) in the Neogene of southwestern Amazonia, Brazil. *Journal of Herpetology*, **43**:612-619. doi:10.1670/08-295.1
- Hsiou, A.S. & Albino, A.M. 2010. New snake remains from the Miocene of northern South America. *Herpetological Journal*, **20**:249-259.
- Hsiou, A.S. & Albino, A.M. 2011. First record of Viperidae snakes from the Pleistocene of southwestern Brazilian Amazonia. *Alcheringa*, **35**:389-395. doi:10.1016/j.ympv.2006.03.010
- Hsiou, A.S.; Oliveira, P.V.; Ximenes, C.L. & Viana, M.S.S. 2012. Lizards and snakes (Lepidosauria, Squamata) from the Late Quaternary of the State of Ceará in northeastern Brazil. *Journal of Cave and Karst Studies*, **74**:262-270. doi:10.1016/j.ympv.2006.03.010
- LaDuke, T.C. 1991a. *Morphometric variability of the precaudal vertebrae of *Thamnophis sirtalis sirtalis* (Serpentes: Colubridae), and implications for the interpretation of the fossil record*. University of New York, PhD thesis, 235 p.
- LaDuke, T.C. 1991b. The fossil snakes of Pit 91, Rancho La Brea, California. *Contributions in Science*, **424**:1-28.
- Lee, M.S.Y. & Scanlon, J.D. 2002. Snake phylogeny based on osteology, soft anatomy and ecology. *Biological Reviews*, **77**:333-401. doi:10.1017/S1464793102005924
- Müller, J. 1831. Beiträge zur Anatomie und Naturgeschichte der Amphibien. *Zeitschrift für Zoologie*, **4**:190-275.
- Noonan, B.P. & Chippindale, P.T. 2006. Dispersal and vicariance: the complex evolutionary history of boid snakes. *Molecular Phylogenetics and Evolution*, **40**: 347-358. doi:10.1016/j.ympv.2006.03.010
- Nopcsa, F. 1923. *Eidolosaurus* und *Pachyophis*, Zwei neue Neocom-Reptilien. *Palaeontographica*, **55**:97-154.
- Rage, J.C. 1984. *Serpentes, Part II*. Stuttgart and New York, Gustav Fischer Verlag, 80 p.
- Rage, J.C. 2001. Fossil snakes from the Paleocene of São José de Itaboraí, Brazil. Part II. Boidae. *Palaeovertebrata*, **30**:111-150.
- Szyndlar, Z. & Rage, J.C. 2003. *Non-erycine Booidea from the Oligocene and Miocene of Europe*. Kraków, Institute of Systematics and Evolution of Animals, Polish Academy of Science, 109 p.
- Waller, T.; Micucci, P.A. & Palumbo, E.B. 1995. *Distribución y conservación de la Familia Boidae en el Paraguay*. Traffic Sudamérica para la Secretaria CITES, 53 p. (Informe final).
- Zampaulo, R.A. & Ferreira, R.L. 2009. Terrestrial cave invertebrate diversity in nine caves in the municipality of Aurora do Tocantins (TO). In: CONGRESSO BRASILEIRO DE ESPELEOLOGIA, 30, 2009. *Resumos expandidos*, Montes Claros, p. 267-274.

Received in August, 2012; accepted in March, 2013.

Appendix.

Comparative material examined in this study:

Boa constrictor constrictor, MCN.D. 335,343,344,347,351; *Corallus hortulanus*, MCN-PV.DR. 0001; *Epicrates cenchria*, MCN-PV.DR. 0002; *Epicrates crassus*, MCN-PV.DR. 0003; *Eunectes murinus*, MCN.D. 306-316-319-342.