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A new two-pored *Amphisbaena* Linnaeus from the endangered Brazilian Cerrado biome (Squamata: Amphisbaenidae)

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Abstract

Amphisbaena carli **sp. nov.** is described from a Cerrado region in the southwestern of the state of Bahia, Brazil. The new species is diagnosable by having: small and separated nasal scales; two pre-cloacal pores separated from each other; 221–242 body annuli; 10–13 caudal annuli; 21–23 dorsal and 21–23 ventral segments to a midbody annulus; and tail without visible autotomic constriction. A proposition of standardization of head scalation nomenclature for amphisbaenids and comments on the current status of the genus *Amphisbaena* are also provided.

Key words: Amphisbaenia, Bahia, Brazil, Head scalation nomenclature, worm lizard

Resumo

Amphisbaena carli **sp. nov.** é descrita de uma região de Cerrado no sudoeste do estado da Bahia, Brasil. A nova espécie é diagnosticada por possuir: escamas nasais pequenas e separadas; dois poros pré-cloacais separados; 221–242 anéis corporais; 10–13 anéis caudais; 21–23 segmentos dorsais e 21–23 segmentos ventrais contados em um anel no meio do corpo; e cauda sem plano de autotomia visível. Uma proposta de padronização da nomenclatura para a escutelação da cabeça de anfisbenídeos e comentários sobre a situação atual do gênero *Amphisbaena* também são apresentados.

Introduction

Amphisbaenians are worm-like Squamata distributed mainly in South America, Caribbean and sub-Saharan Africa but also with a few small genera limited to North America, Northern Africa, Middle East and the Mediterranean region (Vidal *et al.* 2008). Despite being known as a monophyletic group (Lee 1998; Kearney 2003; Kearney & Stuart 2004; Macey *et al*. 2004; Townsend *et al*. 2004), Amphisbaenia has been target of a series of discussions concerning not only the taxonomic status of different genera and species (Gans 1971; Vanzolini 2002; Kearney 2003; Gans 2005; Mott & Vieites 2009), but also the phylogenetic position of the group in relation to other Squamata (Estes *et al*. 1988; Townsend *et al.* 2004; Conrad 2008). Two reasons that may explain this situation are their fossorial habit, which makes sampling a difficult task, and the paucity of researchers working with these taxa (Kearney 2003).

The group comprises six families, the most diverse being Amphisbaenidae with about 175 species

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distributed in 18 genera, of which seven occurred in South America (Gans 2005): *Amphisbaena*, *Anops* Bell, *Aulura* Barbour, *Bronia* Gray, *Cercolophia* Vanzolini, *Leposternon* Wagler and *Mesobaena* Mertens (the first being the most diverse with about 75 species distributed through Central and South Americas).

These genera were traditionally recognized as distinct groups based mostly on morphology and cranial features (Vanzolini 1951; Gans 1971; Kearney 2003), although some authors had already discussed the possibly homoplastic evolution of these characters (Lee 1998; Kearney & Stuart 2004; Mott & Vieites 2009). Based on a molecular analysis, Mott and Vieites (2009) synonymized five of the seven South American genera to *Amphisbaena* (*Mesobaena* was not included in the analysis, and so its generic status was maintained).

During a survey at Jatobá farm, municipality of Jaborandi, a Brazilian Cerrado region in the southwestern of the state of Bahia, two specimens of amphisbaenids were collected representing a new species which is described herein. A third specimen from Cocos (also a municipality from southwestern Bahia) was found at the herpetological collection of Universidade de Brasília (CHUNB), Distrito Federal, Brazil, previously identified as *Bronia brasiliana* Gray. We also provide discussions on the position of the new species within the genus *Amphisbaena* as well as some aspects of the head scalation in amphisbaenids.

Material and methods

Specimens examined are housed in the following collections: Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ), Rio de Janeiro, Brazil; Zoologia Universidade Federal do Rio de Janeiro (ZUFRJ), Rio de Janeiro, Brazil; and Coleção Herpetológica da Universidade de Brasília (CHUNB), Distrito Federal, Brazil. The observed characters are from external morphology and hemipenis. Meristic data follow Gans and Alexander (1962). Measurements were taken with a flexible ruler to the nearest millimeter, except head length and some shield measurements which were taken with a Digimess 300 mm digital caliper to the nearest 0.1 mm. Hemipenis terminology follows Rosenberg (1967) and Thomas and Hedges (2006). Techniques for hemipenis preparation follow Pesantes (1994) and Myers and Cadle (2003).

Head scalation. Nomenclature on head scalation of amphisbaenids has always been a matter of issues due to the absence of marks that clearly identify some key shields on the top of the head (Gans & Alexander 1962; Gans 1971; Vanzolini 1991a). Herein we define a proposition for some shields long confusing in the literature in order to standardize this nomenclature. Despite some disagreements about naming parietals and occipitals shields, the main question about head scalation in amphisbaenids has been the presence or absence of prefrontals, frontals and postfrontals. Two main patterns of head scalation are present: broad nasals meeting each other on the midline or small nasals separated from each other by the rostral. The first condition is by far the most common in south American forms being present in most representatives of the genus *Amphisbaena*, while the second is present in poorly diverse taxa, such as the genus *Mesobaena* and the recently synonymized genera *Aulura*, *Anops*, *Cercolophia* and *Bronia*, the later with two representatives showing this condition: *B. brasiliana* and *B. saxosa* Castro-Mello (Vanzolini 1951; Gans 1971; Castro-Mello 2003; Mott & Vieites 2009). In order to clarify the correlations between the shields, although no proposition of homology is implied, the head scalation proposed and used in the present study is based mainly on Gans and Alexander 1962 (and Vanzolini 1991a for ventral scales nomenclature) with some modifications described as follow (Fig. 1—the numbers correspond to the caption):

According to the present proposition the terms prefrontals and postfrontals are not applied in the head scalation of amphisbaenids; (3) frontals are the paired shields that follow nasals (taxa with nasals meeting each other on the midline—Fig. 1A and B) or may represent the first paired shields on the top of the head (taxa with small nasals separated from each other by the rostral—Fig. 1C and D); (4) parietals are distinct paired shields placed after frontals; (5) occipitals are defined as the most dorsal scales between parietals and first body annulus and may be present arranged in one or more rows (Fig. 1C and D) or absent (Fig. 1A and B); (7) temporals are scale rows between parietals and supralabials or post-supralabials; numbers of temporals may vary (two in Fig. 1C and D against three in Fig. 1A and B); the postocular (*sensu* Gans & Alexander

1962) is here considered a temporal; shields that form the labial comissure are called (8) supralabials (when above the comissure) and (11) infralabials (when under the comissure). A scale positioned above, although after the labial comissure, but that also contacts ventrally an infralabial that does take place under the comissure is also considered a supralabial (the contrary is also true if applied to an infralabial). In some cases, between the last labials and the first body annulus, there is a small scale similar to a supralabial (or to an infralabial) but that does not fit in the definition of labials. Similar cases were already discussed by Gans (1971) and are called post-supralabials or (15) post-infralabials. First body annulus is the first row of segments posterior to the last labials (or post-labials if present) that completely encloses the body.

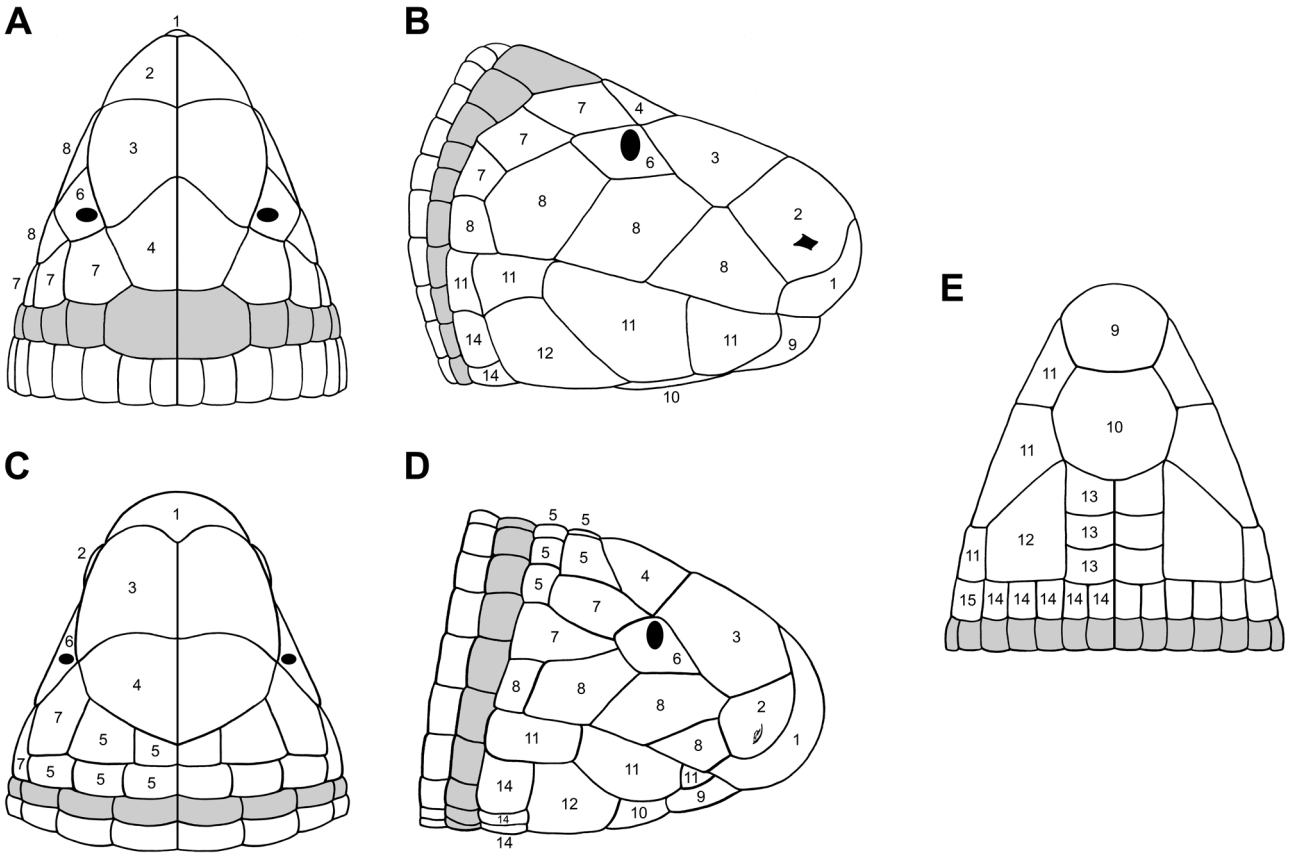

FIGURE 1. Dorsal (A) and lateral (B) schemes of the head scalation pattern with nasals meeting on the midline. Dorsal (C) and lateral (D) schemes of the head scalation pattern with separated nasals. Ventral (E) scheme for both patterns of head scalation: 1—Rostral; 2—Nasal; 3—Frontal; 4—Parietal; 5—Occipital; 6—Ocular; 7—Temporal; 8—Supralabial; 9—Symphysial; 10—Postsymphysial; 11—Infralabial; 12—Lateral genial; 13—Median genial; 14—Postgenial; 15—Postinfralabial. Shaded scales represent the first body annulus. Notice not only the differences between the nasals but also that: occipitals may be present (C and D) or absent (A and B); postlabials may be present (e.g. postinfralabials in E) or absent (B and D); numbers of temporals may vary (two in C and D against three in A and B); median genials may be arranged in one or more rows (e.g. three rows in E).

***Amphisbaena carli* sp. nov.**

Holotype (Fig. 2). Adult male (MNRJ 19256) collected in a recently deforested *Pinus* spp. plantation area at Jatobá farm, 14º01'S / 45º54'W, municipality of Jaborandi, southwestern Bahia, at 10:30 on 11 April 2009 by A. Bocchiglieri.

Paratypes (Fig. 3). Adult male (MNRJ 19257) found road killed between a Cerrado fragment and a *Pinus* spp. plantation area at Jatobá farm, 14º03'S / 45º52'W, on 30 January 2008 by A. Bocchiglieri and A. F. Mendonça.

FIGURE 2. Dorsal view of the body (upper) and lateral view of the head (lower) of the holotype of *Amphisbaena carli* (MNRJ 19256) when found in field at Jatobá farm, Bahia, Brazil.

FIGURE 3. Dorsal (upper) and ventral (lower) views of the body of the paratype of *Amphisbaena carli* (CHUNB 51554) in preservative.

Adult, undetermined sex, (CHUNB 51554) collected in the municipality of Cocos, southwestern Bahia, on 5–6 November 2006 by G. Colli.

Etymology. *Amphisbaena carli* is named after Carl Gans (*in memoriam*), a researcher who contributed immensely to the knowledge of amphisbaenians and whose works were fundamental to the production of this paper.

Diagnosis. *Amphisbaena carli* is diagnosable from all congeners by the following conjunction of characters: (1) small nasals separated from each other by the rostral; (2) two pre-cloacal pores separated from each other by the cloacal shield; (3) 221–242 body annuli; (4) 10–13 caudal annuli; (5) 21–23 dorsal and 21–23 ventral segments to a midbody annulus; (6) tail without visible autotomic constriction.

Comparisons are based on literature data (Gray 1865; Gans 1964; Gans 1971; Vanzolini 1971; Vanzolini 1991b; Vanzolini 1992; Strüssmann e De Carvalho 2001; Vanzolini 2002; Castro-Mello 2003; Hoogmoed *et al.* 2009; Mott & Vieites 2009; Ribeiro *et al.* 2009) and specimens examined (Appendix). In order to make comparisons clear, species were separated by groups reflecting the taxonomy before Mott and Vieites (2009).

Amphisbaena carli is distinguished from *Mesobaena huebneri* Mertens and *M. rhachicephala* Hoogmoed *et al*. by having a rounded rostrum, instead of a keel-shaped rostrum in both species of *Mesobaena*. It also differs from the species of *Amphisbaena* formally placed at the genus *Anops*—*Amphisbaena bilabialata*

(Stimson), *A. kingii* (Bell) and *A. acrobeles* (Ribeiro *et al*.)—by having a rounded snout against a vertically keeled rostrum in the later species. It differs from the species of *Amphisbaena* formally placed at the genus *Aulura*—*Amphisbaena anomala* (Barbour)—by having a rounded snout against a shovel-shaped rostrum in the later species. It differs from the species of *Amphisbaena* formally placed at the genus *Leposternon*—*Amphisbaena infraorbitale* (Berthold), *A. kisteumacheri* (Porto *et al.*), *A. microcephalum* (Wagler), *A. octostegum* (Duméril), *A. polystegum* (Duméril), *A. scutigerum* Hemprich and *A. wuchereri* (Peters)— by having a rounded snout against a shovel-shaped rostrum in the later species. It differs from the species of *Amphisbaena* formally placed at the genus *Cercolophia*—*Amphisbaena absaberi* (Strüssmann & de Carvalho), *A. bahiana* Vanzolini, *A. borellii* Peracca, *A. cuiabana* (Strüssmann & de Carvalho), *A. roberti* Gans and *A. steindachneri* Strauch—by having no keeled tail, present in the later species.

Amphisbaena carli shares with the species of *Amphisbaena* formally placed at the genus *Bronia*—*Amphisbaena bedai* (Vanzolini), *A. brasiliana*, *A. kraoh* (Vanzolini) and *A. saxosa*— the strongly curved rostrum. Besides, it also shares with *A. brasiliana* and *A. saxosa* the nasals separated from each other by the rostral. However, it can be easily distinguished from these four species by having only two pores (against six in *A. kraoh* and four in *A. brasiliana*, *A. bedai* and *A. saxosa*) and 240–242 body annuli (against 213–229 in *A. brasiliana*, 253–272 in *A. saxosa*, 272–284 in *A. bedai*, and 281 in *A. kraoh*). It differs from the two-pored species formally placed at the genus *Amphisbaena*—*A. anaemariae* Vanzolini, *A. brevis* Strüssmann & Mott, *A. crisae* Vanzolini, *A. darwini* Duméril & Bibron, *A. dubia* Müller, *A. heterozonata* Burmeister, *A. hiata* Montero & Céspedez, *A. leeseri* Gans, *A. miringoera* Vanzolini, *A. mitchelli* Procter, *A. neglecta* Dunn & Piatt, *A. silvestrii* Boulenger and *A. trachura* Cope—by having small nasals separated from each other by the rostral (against large nasals touching each other on the midline in the later species). It is further distinguishable from *A. anaemariae*, *A. brevis*, *A. crisae*, *A. darwini*, *A. dubia*, *A. heterozonata*, *A. mitchelli*, *A. neglecta*, *A. silvestrii* and *A. trachura* by having 240–242 body annuli (against less than 231 in the other species). *Amphisbaena carli* can also be distinguished from *A. miringoera* by having 12–13 caudal annuli (against 22–24) and from *A. hiata* and *A. leeseri*, by having no autotomic site (present in those species).

Description of the holotype (Fig. 4). Adult male, snout-vent length (SVL) 264 mm, tail length (TL) 15 mm. Head dorsally triangular and poorly distinct from the neck which is slightly narrower than the rest of the body; rostrum extremely rounded, projecting forward beyond the jaw (prognathous snout); rostral well visible in dorsal view, broader than long and in contact with nasals and frontals; anterior portion very rounded; small posterior projection toward the suture between frontals; laterally rostral forming a concave curve around the anterior portion of nasals, contacting first supralabial; nasals separated by the rostral, not meeting each other on the midline; nasals contacting first supralabial; frontals paired, touching each other on the midline, longer than broad, being the largest shields on the top of the head (2.5 mm long at ventral edge); frontals with postero-lateral projections above the oculars toward the parietals; laterally frontals in a narrow contact with the first and second supralabials; parietals paired, large, touching each other on the midline and with lateral projections towards the oculars; occipitals absent; after parietals follows the first body annulus with the dorsalmost segments nearly square, slightly larger than the rest of the body segments; four supralabials, second and third touching ocular; the first three diagonally oriented and larger than the fourth, which does not participate on the formation of the labial comissure but is herein considered as a supralabial for its position above the third infralabial; two temporals on each side of the head arranged in a single row; upper temporal slightly higher than lower temporal and visible from above; there is an azygous shield at the left upper temporal; lower temporal about twice higher than fourth supralabial to which it is in contact; lower temporal also contacts the third supralabial and a very small portion of the ocular; oculars nearly triangular; eyes visible dorsally and laterally, located at the postero-dorsal portion of the oculars, near the contact with parietals. In ventral view symphysial anvil-shaped, separating first pair of infralabials; postsymphysial wider than long (1.7 / 1.4 mm respectively) and posteriorly rounded, separating the second pair of infralabials; three infralabials, first small, second occupies most of the labial comissure, and third extends to some ventral segments of the first body annulus; four genials in a single row; lateral genials broader than long and median genials longer than broad; eight postgenials, the outermost pair broader than the six inner scales; 240 body annuli; 13 caudal annuli; tail relatively blunt and short, no evidence of autotomy site; four lateral incomplete

annuli between the last body annulus and the first caudal one; lateral sulci well visible, more noticeable after the first third of the body; 21 dorsal and 21 ventral segments (counted at a midbody annulus); dorsal and ventral sulci absent; cloacal shield covered by six segments decreasing in size from the larger medial pair; two well visible pre-cloacal pores separated one from the other; each pore located at a single, small scale next to the two outermost pairs of segments of the cloacal shield. The pore-bearing scales (as well as the cloacal shield) are part of the first incomplete annulus. Dorsal ground color of the head and body creamish white; small dark dots visible at the anterior half of the medial dorsal segments, more noticeable at the posterior half of the body and also at the dorsum of the tail; venter creamish white, immaculate.

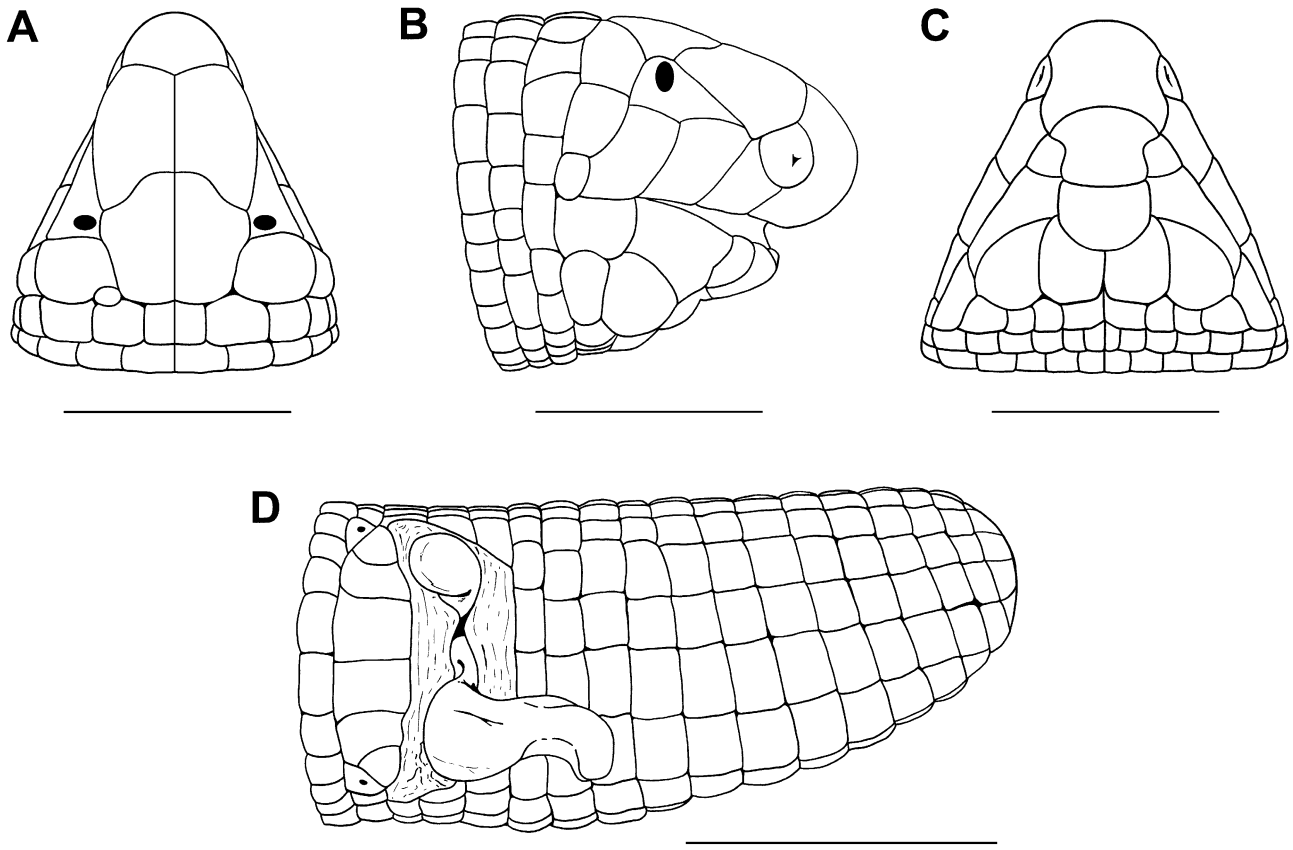

FIGURE 4. Dorsal (A), lateral (B) and ventral (C) views of the head and ventral (D) view of the tail and cloacal region of the holotype of *Amphisbaena carli* (MNRJ 19256). Scale = 1 cm.

Description of the hemipenis (Fig. 5). Bilobed, with no capitulum or ornamentations but with a wrinkled surface. Lobes correspond to about one third of hemipenial body, with simple rounded tips slightly curved towards the asulcate side. Sulcus spermaticus with prominent lips bifurcates at the base of the lobes, each branch following to the tip of a lobe in a centrolineal direction. On the asulcate side a dense semi-circle of inner tissue is well visible by transparency at the branching point of the organ projecting inside both lobes.

Variation. The paratype from Jaborandi (MNRJ 19257; SVL = 171 mm and TL = 10 mm) has 242 body and 12 caudal annuli and 22 dorsal and ventral segments. The paratype from Cocos (CHUNB 51554; SVL = 227 mm and TL = 13 mm) has 221 body and 10 caudal annuli and 23 dorsal and ventral segments. Others characters and color pattern are similar to the holotype for both specimens.

Distribution (Fig. 6). The new species is known from its type locality, Jatobá farm (13º53'S / 45º42'W), municipality of Jaborandi, Bahia state, near the frontier with the state of Goiás. The area corresponds to the Chapadão Ocidental of the São Francisco River at the region called "Gerais". The farm is bounded by two rivers (Arrojado and Veredãozinho) that are part of the São Francisco basin and has a total area of 92,000 ha. In the decade of 1980, the farm started planting *Pinus* spp. and *Eucalyptus* spp., occupiyng 40,000 ha of the total area, the remaining area (52,000 ha) being kept as cerrado (like an open savannah) biological reserves

(Fenger & Sevensson 2004). It is interesting to point out that the holotype was found in a *Pinus* spp. planting area while the paratype from Jaborandi was found road-killed nearby a Cerrado fragment. Nevertheless, both habitats are endangered once they are being deforested since the beginning of 2008 to make room for soy plantation, which at the present time represents the main activity of the farm. Nowadays, the remaining area of cerrado (30,000 ha—22,000 ha less than in the 80´s) are confined to the rivers bounding the farm (gallery forest) and rocky environments, the latter representing an unfavorable habitat for amphisbaenids. *Amphisbaena carli* is also known from Cocos, state of Bahia, a neighboring municipality to Jaborandi, approximately 180 kilometers northeast from Jatobá farm. The specimen of this locality was found in a cerrado area with sandy soil, similar to the environment where specimens from Jatobá farm were collected.

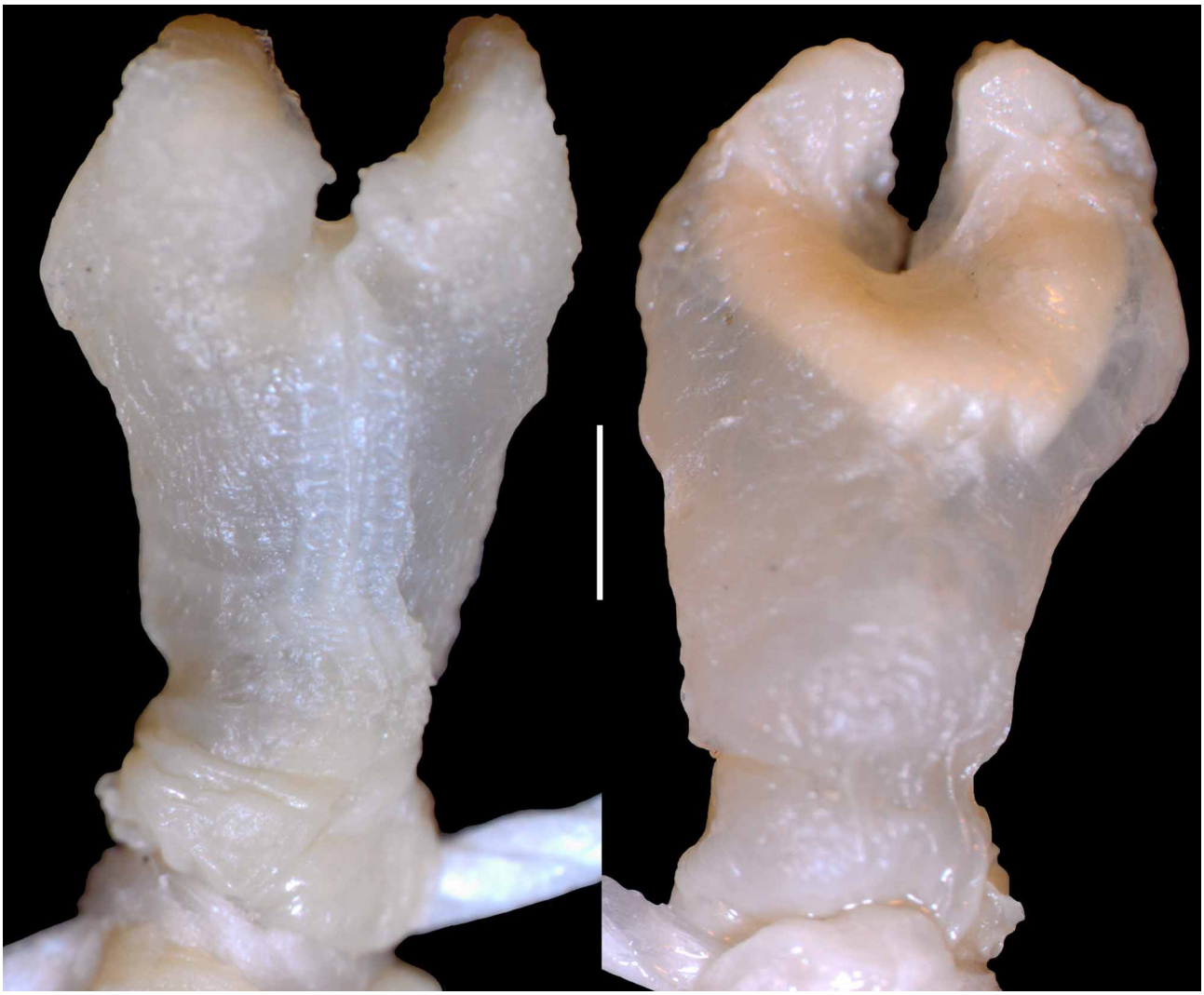

FIGURE 5. Sulcate (left) and asulcate (right) sides of the hemipenis of the holotype of *Amphisbaena carli* (MNRJ 19256). Scale = 1 mm.

Discussion

The new species has several similarities to the genus *Bronia*, sunk into *Amphisbaena* by Mott and Vieites (2009). The first genus had already been synonymized to the later by Strauch (1881) with no further explanations. This status was accepted by Beddard (1905), although Vanzolini (1951) revalidated the genus based on the skull and head scalation of its type species *Bronia brasiliana*. Even though the presence of pore-bearing segments divided by a median hiatus is not a synapomorphy of *Bronia* as explicit by Mott and Vieites (2009), the four species formerly allocated in this genus share with *Amphisbaena carli* some features long

considered as diagnostics, such as the strongly curved and rounded rostrum. Furthermore, the new species shares with *A. brasiliana* and *A. saxosa* the reduced nasals not meeting on the midline. Nevertheless, as Mott and Vieites (2009) clearly states, *A. kraoh* and *A. bedai* were originally placed in *Bronia* despite the fact they lack this last condition. Once almost all genera belonging to the family Amphisbaenidae seem to be based on morphological homoplasies (Mott & Vieites 2009), systematics studies are extremely necessary to reevaluate specific and generic status of these taxa in order to reflect monophyletic groups. We agree with the most conservative taxonomic decision taken by Mott and Vieites (2009), although future studies with different sources of data are necessary to clarify the issue, mainly the status of the genera *Mesobaena* and *Leposternon*, the first not included and the later being recovered as a monophyletic group in their molecular analysis.

The Cerrado region is currently restricted to 20% of its original vegetation cover and is considered a global biodiversity hot spot (Myers *et al.* 2000; Machado *et al.* 2004). *Amphisbaena carli* is known only from a relatively small area and Cerrado fragments in this region are being rapidly replaced by soy plantation. Efforts to enhance the knowledge of this threatened biome and the associated fauna are fundamental to the construction of effective measures to conserve it.

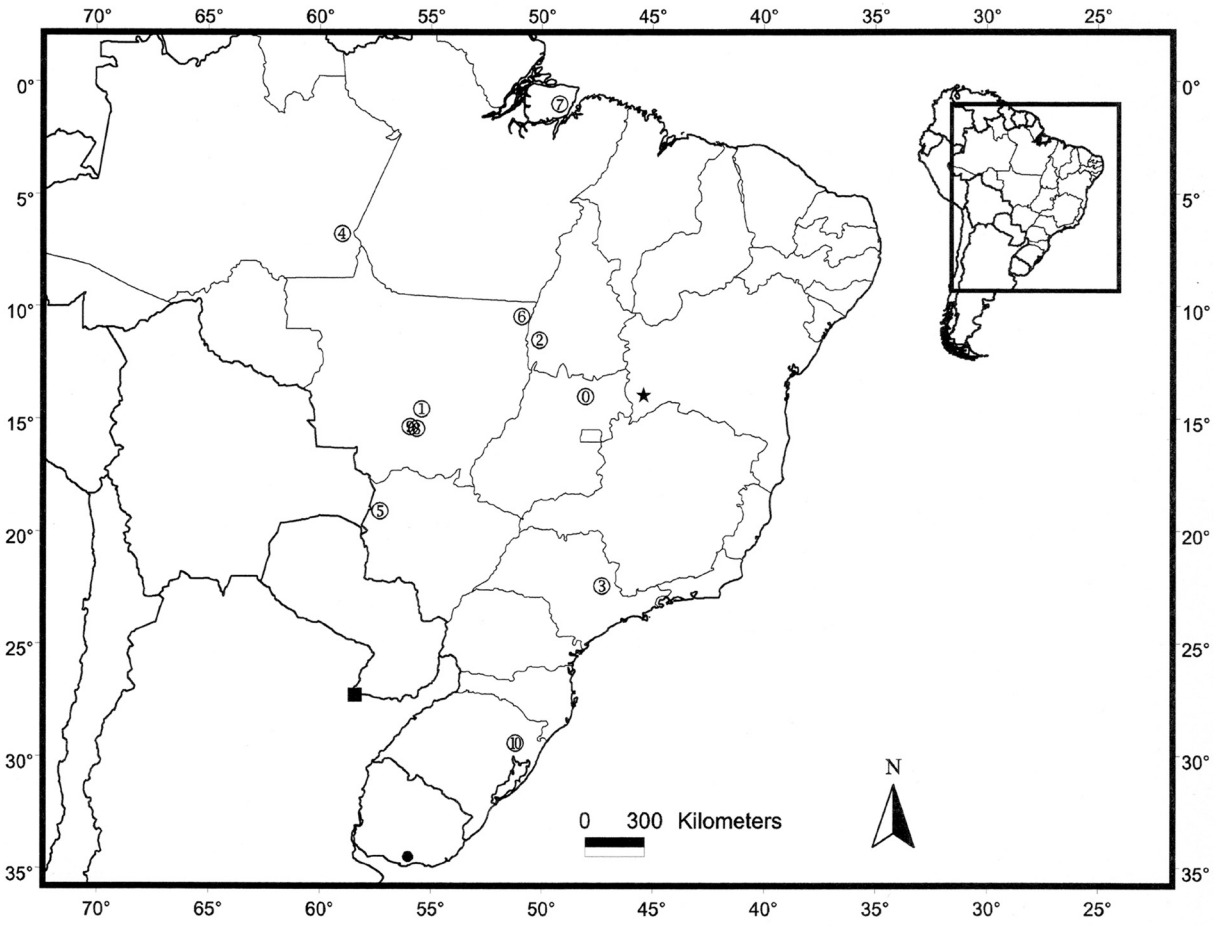

FIGURE 6. Type localities of the two-pored species of *Amphisbaena*: 0—*A. anaemariae*; 1—*A. brevis*; 2—*A. crisae*; 3—*A. dubia*; 4—*A. heterozonata*; 5—*A. leeseri*; 6—*A. miringoera*; 7—*A. mitchelli*; 8—*A. neglecta*; 9—*A. silvestrii*; 10—*A. trachura*; Circle—*A. darwini*; Square—*A. hiata*; Star—*A. carli*.

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Appendix: Specimens examined

Amphisbaena bedai: Brazil: Bahia: Cocos: CHUNB 50193, 51555, 52389.

Amphisbaena brasiliana: Brazil: Mato Grosso: Guarantã do Norte: CHUNB 30685, 30686, 30687, 30688, 30689, 30690, ZUFRJ 1671, 1673, 1674, 1675.

Amphisbaena kraoh: Brazil: Tocantins: Mateiros: CHUNB 30675, 30676.

Amphisbaena saxosa: Brazil: Tocantins: Palmas: CHUNB 24236.