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A New Worm Lizard Species (Squamata: Amphisbaenidae: *Amphisbaena*) with Non-autotomic Tail, from Northeastern Brazil

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ABSTRACT.—We describe a new species of *Amphisbaena* from the Caatinga of northeastern Brazil. The new taxon is identified mainly by having 216–239 body annuli, 13–17 caudal annuli without autotomic site, 4–8 (usually six) precloacal pores without a median hiatus, 18–24 dorsal and 18–24 ventral segments at a midbody annulus, 4 supralabials, 3 infralabials, and postmalar row present. The continued discovery of new amphisbaenians from Caatinga highlights the insufficient current knowledge regarding the diversity of this group in this semiarid region.

RESUMO.—Nós descrevemos uma nova espécie de *Amphisbaena* da Caatinga no nordeste do Brasil. O novo táxon é identificado principalmente por possuir 216–239 anéis corporais; 13–17 anéis caudais sem ponto de autotomia; 4–8 (geralmente seis) poros pré-cloacais sem hiato medial; 18–24 segmentos dorsais e 18–24 segmentos ventrais em um anel do meio do corpo; 4 supralabiais; 3 infralabiais; fileira pós-malar presente. A contínua descoberta de novas anfisbênias na Caatinga destaca o conhecimento ainda insuficiente que temos sobre a diversidade deste grupo nesta região semiárida.

Brazil has the greatest Amphisbaenia species richness (Costa and Bérnils, 2018; Uetz and Hošek, 2018), and new discoveries continue to be made every year (Almeida et al., 2018; Oliveira et al., 2018; Ribeiro et al., 2018a,b, 2019). However, gaps in the knowledge of worm lizard diversity in Brazil (Colli et al., 2016) not only impair the understanding of the dimensions of Brazilian biodiversity but also hamper appropriate conservation measures (Böhm et al., 2013). Collection in localities not previously sampled, or still understudied, is one important action in the search for new or poorly known species (Colli et al., 2016). However, funding cuts to the sciences by the Brazilian government (Gibney, 2015; Angelo, 2016, 2019; Fernandes et al., 2017) are imposing serious threats to critical areas of research, including taxonomy and systematics.

While funding for science in Brazil declines, the conversion of native areas continues—mostly to croplands, pastures, and power plants—paradoxically contributing to the discovery of new species. Environmental impact assessments, wildlife rescues during vegetation removal, and wildlife monitoring are literally digging up new species of worm lizards from different Brazilian regions (Teixeira et al., 2014; Costa et al., 2015; Ribeiro et al., 2016, 2019; Oliveira et al., 2018). Unfortunately, scientific advances that co-occur with development are costly because critical habitat is being lost.

In the semiarid Caatinga of northeastern Brazil, wind farms are spreading rapidly in a trade-off between development and environmental stewardship (Fonseca et al., 2018). During the construction of a wind farm in Campo Formoso, state of Bahia, a new worm lizard taxon was discovered and later described by us (Ribeiro et al., 2018a). Here, we describe another new worm lizard species from the same region.

MATERIALS AND METHODS

Environmental analysts collected 31 specimens of an undescribed species in a wildlife rescue during the construction of a wind farm in the semiarid region of the state of Bahia, Brazil, although the authors did not participate in specimen collection. Collectors fixed the specimens in formalin and subsequently preserved them in 70% ethanol at the herpetological collection of Museu de Fauna da Caatinga (MFCH), located at the Centro de Conservação e Manejo de Fauna da Caatinga, Universidade Federal do Vale do São Francisco, municipality of Petrolina, state of Pernambuco.

Scale counts and nomenclature follow Gans and Alexander (1962). We measured the snout–vent length (SVL) and tail length (TL) to the nearest 1.0 mm by using a ruler and the head length (HL) and width (HW) to the nearest 0.1 mm by using a digital caliper. Color descriptions are based on preserved specimens. We determined the sex of specimens by making a small incision at the base of tail to confirm the presence of hemipenes, or by direct examination of the gonads after a small incision in the venter. One specimen (MFCH 4670; 187 mm SVL) could not be sexed. We based comparisons with other species on specimens previously examined by us (Costa et al., 2018a,b, 2019; Ribeiro et al., 2018a), newly examined specimens (Appendix 1), and on literature (Gans, 1964; Gans and Diefenbach, 1972; Gans and Mathers, 1977; Vanzolini, 2002; Dal Vechio et al., 2016).

We tested sexual dimorphism for a group of meristic variables (the number of body annuli, caudal annuli, and total midbody segments), and a group of morphometric variables: SVL, TL, HL, and HW. To remove the effects of size from the last three variables, we used their ratios with SVL included as a covariate in the analyses. For meristic variables, we used all available specimens of known sex ($N = 30$; 12 females and 18 males), whereas for morphometric variables we used only adult specimens ($N = 26$; 10 females and 16 males). To avoid damaging all specimens during the determination of sexual

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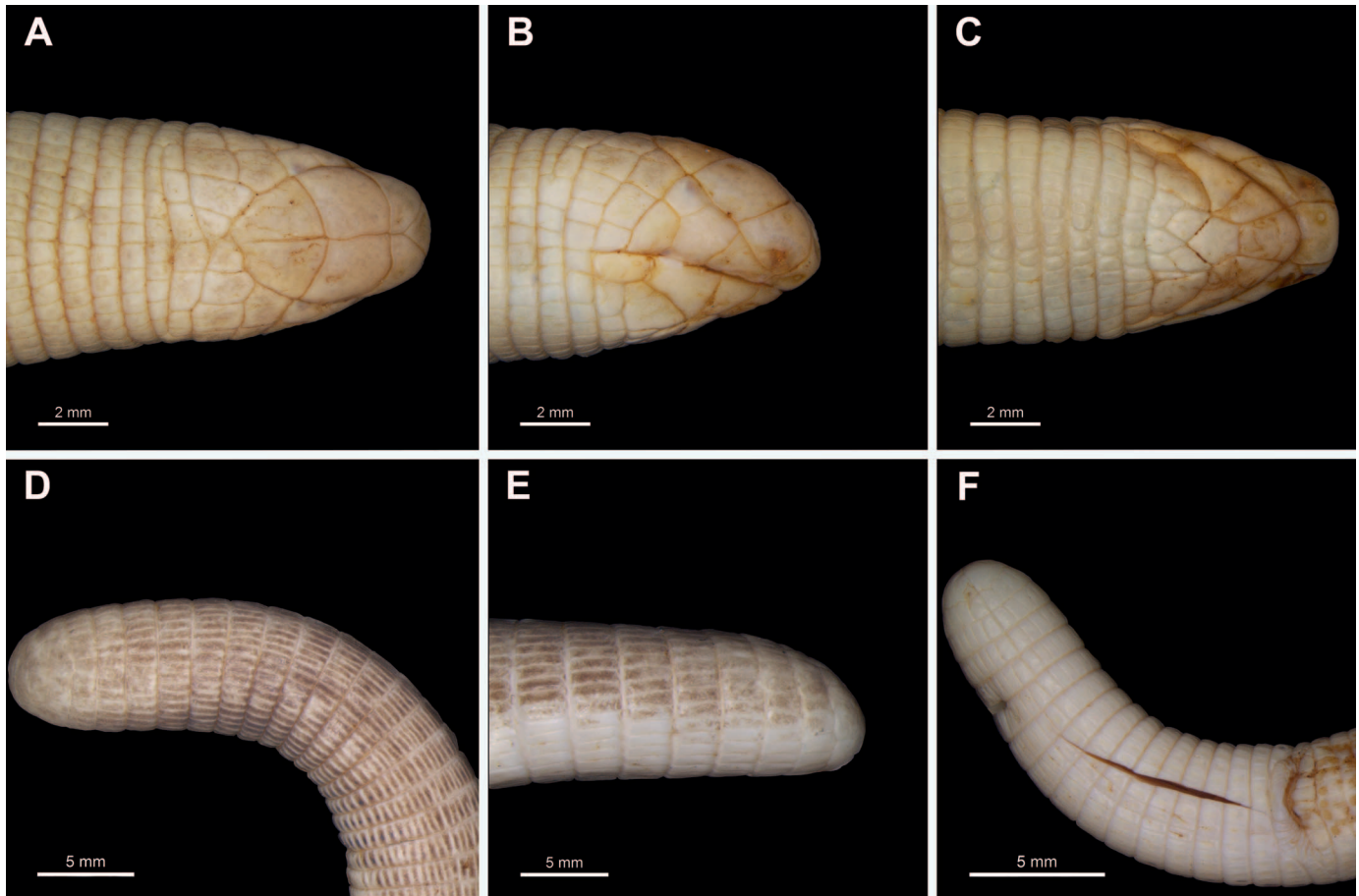


FIG. 1. Holotype of *Amphisbaena acangaoba* sp. nov. (MFCH 4654). Dorsal (A), lateral (B), and ventral (C) views of the head; dorsal (D), lateral (E), and ventral (F) views of the tail.

maturity when we examined the gonads, we used data of a sympatric species of similar size, *A. vermicularis*, as surrogate, considering males >180 mm and females >220 mm SVL as adults (Santos, 2013). We assessed normality of values through the Shapiro-Wilk test, and for sexual dimorphism we used the Student's *t*-test for data with normal distribution and Mann-Whitney *U*-test for data with non-normal distribution. All statistical analyses were conducted using Past 3.3 software (Hammer et al., 2001).

RESULTS

Amphisbaena acangaoba sp. nov. Ribeiro, Gomides, and Costa (Zoobank ID: lsid:zoobank.org:act:46F18AAA-1020-4FB1-84C4-534A4FB8510A)

(Figs. 1–3; Tables 1–3)

Holotype.—Adult male, MFCH 4654, from the area of Complexo Eólico Campo Largo (10.4725°S, 41.4593°W, datum WGS 84, 1,061 m above sea level), municipality of Umburanas, state of Bahia, Brazil. The specimen was collected on 13 June 2017 by Adrien Bessane.

Paratypes.—Five specimens, MFCH 4652, 4653, 4669, 4670, and 4671, from the type locality; 25 specimens, MFCH 4467, 4479, 4481, 4482, 4486, 4487, 4492, 4495, 4649, 4650, 4651, 4655–4658, 4660–4668, and 4749, from Complexo Eólico Campo Largo, municipality of Sento Sé, state of Bahia (Tables 1 and 2). The coordinates of each collection site are presented in Appendix 1.

Definition.—A species of *Amphisbaena* identified by the following combination of characters: 1) head round, highly domed from rostral to frontal shields, with a prognathous snout terminating in a horizontal edge in dorsal and ventral views; 2) suture lengths: frontal > prefrontal > nasal; 3) preloacal pores, 4–8 (usually six), without median hiatus; 4) body annuli, 216–239; 5) lateral annuli, 2–4; 6) caudal annuli, 13–17; 7) caudal autotomy, absent; 8) tail tip slightly dorsally depressed; 9) dorsal segments, 18–24, and ventral segments, 18–24 at a midbody annulus (38–48 total segments); 10) supralabials, 4; 11) infralabials, 3; 12) parietals variable in size and shape; 13) postoculars, 1 or 2; 14) temporals, 1 or 2; 15) postgenials in 1 or 2 rows; 16) postmalar row present; 17) lateral sulcus present, dorsal and ventral sulci absent; 18) color (in preservative) brown with cream narrow to wide segment sutures on dorsum (sometimes giving a reticulate appearance), becoming paler toward venter, which is immaculate cream after the first to fourth segment below the lateral sulcus; tail brown dorsally and cream ventrally.

Diagnosis.—The combination of a round head, 4–8 preloacal pores, 216–239 body annuli, 18–24 dorsal and 18–24 ventral segments at a midbody annulus, distinguishes *A. acangaoba* sp. nov. from other South American amphisbaenians, except *A. angustifrons*, *A. borelli*, *A. brasiliana*, *A. fuliginosa*, *A. leucocephala*, *A. mertensii*, *A. plumbea*, *A. pretrei*, *A. spurrelli*, and *A. vermicularis*. *Amphisbaena borelli*, *A. fuliginosa*, *A. leucocephala*, *A. pretrei*, and *A. spurrelli*, however, present three supralabials (four in *A. acangaoba* sp. nov.). The number of caudal annuli (13–17) further distinguishes *A. acangaoba* sp. nov. from *A. fuliginosa*

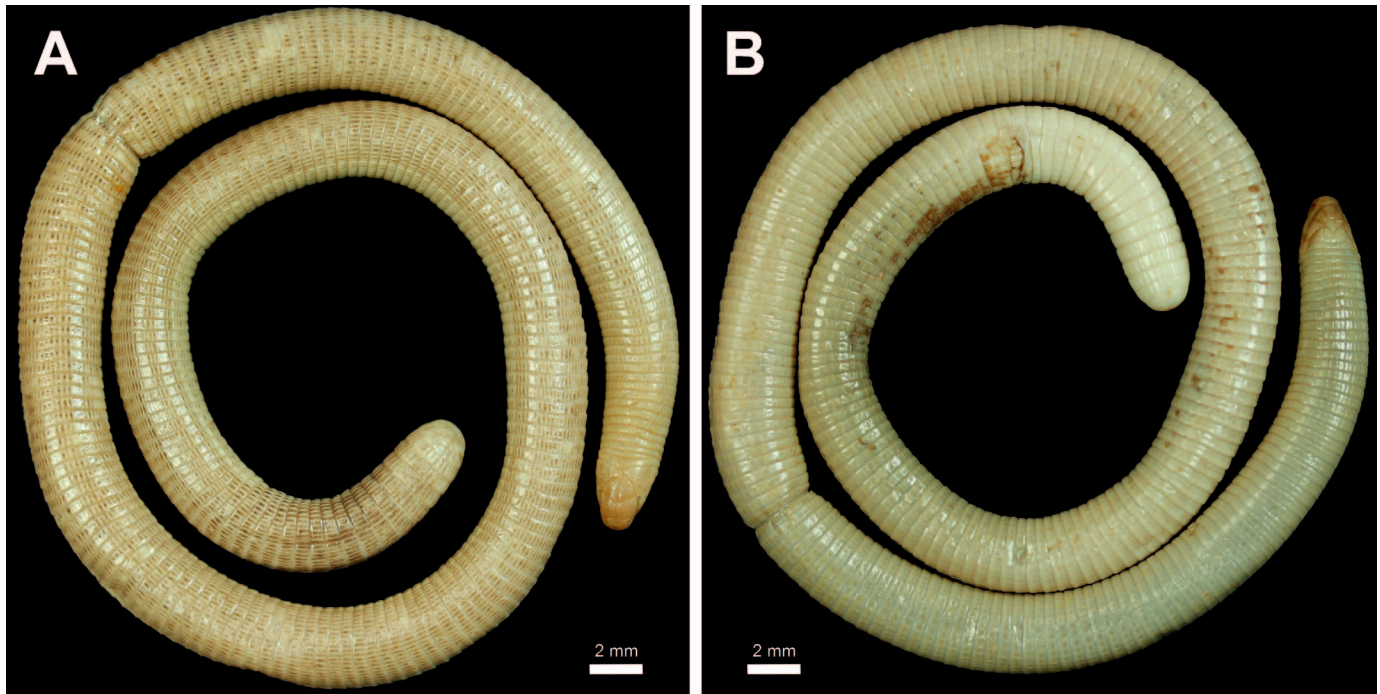


FIG. 2. Holotype of *Amphisbaena acangaoba* sp. nov. (MFCH 4654). Body in dorsal (A) and ventral (B) views.

TABLE 1. Summary of meristic data of specimens of *Amphisbaena acangaoba* sp. nov. All specimens have four supralabials and three infralabials. When counts differ from both sides, they are indicated as left/right.

Specimen	Sex ^a	Character ^b													
		BA	LA	CA	DS	VS	PO	TE	PG	PM	SHA	PP	PRC	POC	
MFCH 4467	M	235	2	17	24	24	2/1	2/3	2+5	13	14	6	6	16	
MFCH 4479	F	229	3	16	20	22	1	1	2+3	11	11	7	8	18	
MFCH 4481	F	229	2	15	20	24	2	1	2+5	11	5	7	8	14	
MFCH 4482	M	239	3	16	20	22	1	1/2	2+5	12	8	6	8	14	
MFCH 4486	M	232	3	16	20	22	1	1	2+3	11	10	6	7	15	
MFCH 4487	F	236	2	15	22	22	1/2	1	2+4	10	12	6	8	15	
MFCH 4492	F	235	2	15	20	24	2	1	3+5	11	12	6	8	15	
MFCH 4495	M	228	2	13	22	20	1	1/2	2+3	11	4	6	8	14	
MFCH 4649	M	234	3	16	18	20	1/2	1	3+2	10	7	6	6	14	
MFCH 4650	F	235	2	15	18	22	1	1/2	2+4	11	7	6	10	14	
MFCH 4651	F	231	4	15	18	22	1	1	2+4	11	9	6	6	13	
MFCH 4652	M	234	2	16	20	24	1	1	3+0	11	7	6	8	14	
MFCH 4653	M	236	3	15	20	24	2	1	2+4	10	3	6	6	14	
MFCH 4654 ^c	M	230	2	15	22	24	1	1	2+5	11	9	6	8	16	
MFCH 4655	M	219	2	14	20	20	2/1	1	4+0	11	3	5	8	14	
MFCH 4656	F	234	3	15	18	22	2	1	2+5	11	0	6	7	15	
MFCH 4657	M	222	2	13	23	20	1	1	3+4	12	3	5	7	15	
MFCH 4658	F	237	3	15	18	22	2	1	2+5	11	12	6	8	14	
MFCH 4660	M	234	2	14	18	23	1	1	2+5	11	3	6	8	16	
MFCH 4661	M	224	2	15	22	20	2/1	1	5+0	11	4	6	6	14	
MFCH 4662	M	230	2	16	20	20	1	1	2+5	13	10	6	9	13	
MFCH 4663	F	216	2	13	20	18	2/1	1	2+2	10	5	4	6	14	
MFCH 4664	F	237	3	15	18	22	2	1	1+3	9	8	6	8	16	
MFCH 4665	M	236	2	16	19	21	1	1	4+0	8	8	6	6	14	
MFCH 4666	M	230	2	14	22	24	2	1	2+3	11	9	6	8	15	
MFCH 4667	M	233	3	15	18	22	2/1	1	3+0	11	8	8	6	14	
MFCH 4668	M	238	3	16	20	24	2	1	2+5	11	8	6	7	18	
MFCH 4669	F	236	3	16	20	24	1	1	2+5	11	0	6	9	16	
MFCH 4670	?	235	2	16	20	24	2/1	1	2+4	11	2	6	8	14	
MFCH 4671	M	236	3	15	18	22	1	1	2+5	11	4	6	6	14	
MFCH 4749	F	234	3	14	20	20	1	1	2+3	9	8	4	6	14	

^a F = female; M = male; ? = undetermined.

^b BA = body annuli; LA = lateral annuli; CA = caudal annuli; DS = dorsal segments at midbody; VS = ventral segments at midbody; PO = postoculars; TE = temporals; PG = postgenials (first + second row); PM = postmalars; SHA = segments in the dorsal half annuli (between first and second complete body annuli); PP = prelocoanal pores; PRC = prelocoanal segments; POC = postlocoanal segments.

^c Holotype.

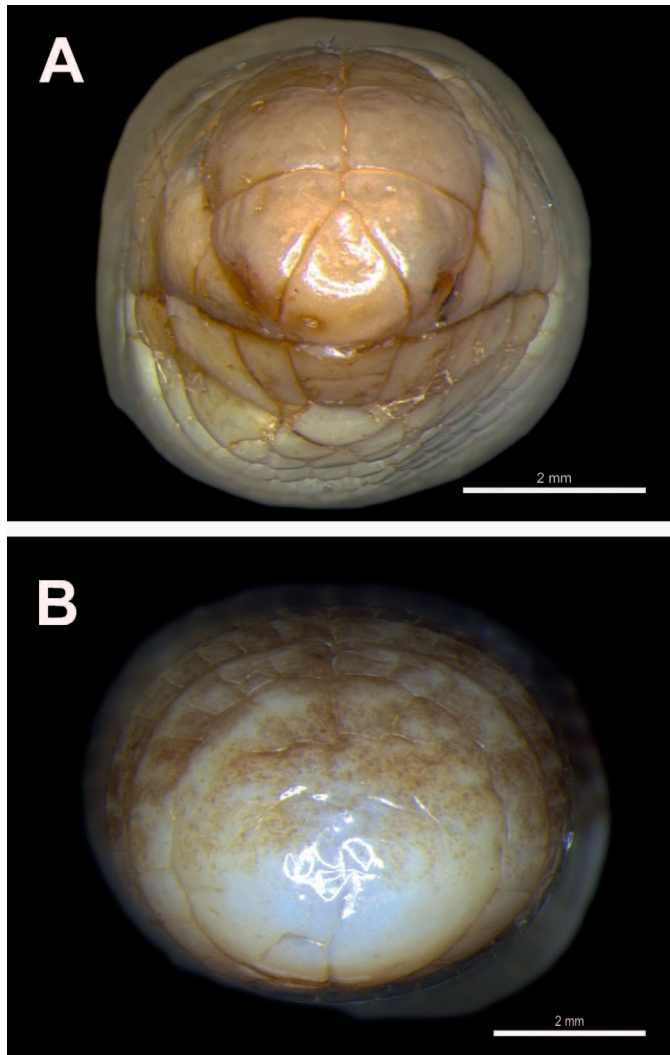


FIG. 3. Holotype of *Amphisbaena acangaoba* sp. nov. (MFCH 4654). Head in anterior view (A) and the tip of the tail in posterior view (B).

(20–30), *A. leucocephala* (25–29), *A. mertensii* (25–32), *A. pretrei* (21–26), *A. spurrelli* (18–20), and *A. vermicularis* (25–35). *Amphisbaena angustifrons* and *A. brasiliiana* share with *A. acangaoba* sp. nov. the absence of autotomic caudal annuli, although having a rounded tail tip (slightly dorsally compressed in *A. acangaoba* sp. nov.). *Amphisbaena acangaoba* sp. nov. further differs from *A. angustifrons*, *A. fuliginosa*, *A. leucocephala*, *A. mertensii*, *A. pretrei*, *A. spurrelli*, and *A. vermicularis* by the head highly domed (not highly domed in those species). Finally, the precloacal pores sequentially arranged distinguish *A. acangaoba* sp. nov. from *A. brasiliiana* (pores interrupted by non-pore-bearing segments).

Description of the Holotype.—An adult male specimen, SVL 290 mm; caudal length 26.4 mm; head short (7.9 mm, 2.7% of SVL), rounded, highly domed from rostral to frontals, not distinct from the neck; body slenderness proportion (SVL/HW), 52.1; rostrum projecting beyond the jaw, with a blunt horizontal tip in dorsal and ventral views. Rostral triangular in dorsal view, clearly visible, in contact with nasals and first supralabial; in ventral view it is rectangular, although concave posteriorly. Nasal single, trapezoidal in lateral view and triangular in dorsal view; middorsal suture 0.4 mm (4.8% of head length), in broad contact with rostral anteriorly, and with first supralabials and prefrontals posteriorly. Nasals in narrow contact with second supralabials

with nostrils in the inferior portion of nasals. Prefrontals paired, parallelogram shaped, middorsal suture 1.7 mm (21.5% of head length), in contact with nasals anteriorly, second supralabials inferiorly, ocular and frontals posteriorly. Frontals paired, triangular, middorsal suture, 2.6 mm (32.9% of head length), in contact with oculars and postoculars inferiorly, prefrontals anteriorly, parietals and an adjacent segment of first body annulus posteriorly. Parietals small and somewhat triangular, middorsal suture 0.5 mm (6.3% of head length), in contact with frontals anteriorly, adjacent segment of first body annulus inferiorly, and second body annulus posteriorly. Ocular diamond shaped, in contact with second and third supralabials below, with the prefrontal anteriorly, with the frontal above, and with the postocular posteriorly. Eye visible. Temporal diamond shaped, contacting third supralabial anteriorly, postocular dorsally, fourth supralabial inferiorly, and first body annulus posteriorly. Supralabials four, the first triangular is as long as high, contacting rostral anteriorly, nasal dorso-anteriorly, and second supralabial posteriorly. Second, supralabial pentagonal, higher than long, in contact with nasal anteriorly, contacting prefrontal dorsally, ocular posterodorsally, and third supralabial posteriorly. Third supralabial pentagonal, higher than long, as high as second supralabial, contacting it anteriorly, the fourth supralabial and temporal posteriorly, ocular and postocular dorsally; fourth supralabial smallest, rectangular, contacting third supralabial anteriorly, temporal dorsally, the first body annulus posteriorly, and third infralabial inferiorly. Mental shield wedge shaped, convex anteriorly, contacting postmental posteriorly and first infralabials laterally. Postmental pentagonal, contacting mental anteriorly, first infralabial laterally, and postgenials posteriorly. Postgenials in two rows, the first with two scales, followed by the second with five scales. Postgenials of the first row and the first postgenial of both sides of the second row in contact with malars laterally. Postgenials of the first row also in short contact with first infralabial. Postgenials of the second row in contact with some postmalars posteriorly. Postmalar row with 11 scales. Three infralabials, first triangular and smaller than second. Second infralabial trapezoidal, largest; third infralabial rectangular, smallest. First infralabial contacting mental and postmental laterally, and second infralabial and postgenials posteriorly; second infralabial contacting third infralabial and malar posteriorly; third infralabial in contact with second infralabial anteriorly, malar and first scale of postmalar row laterally, and the first body annulus posteriorly. First body annulus dorsally includes a row of 12 segments posterior to the fourth supralabial, parietals included; ventrally it includes a row of 18 segments posterior to postmalars. Dorsally, the second body annulus is divided, forming a dorsal half annulus with nine segments.

Body annuli 230; 22 dorsal and 24 ventral rectangular segments. There are no dorsal or ventral sulci, but a lateral sulcus is visible from the 50th body annulus to the cloacal region. Precloacal pores six, round, medium sized, half the size of the rectangular pore-bearing segments; these segments are adjacent to each other, each with one pore posteriorly. Precloacal segments 8, postcloacal segments 16; lateral annuli 2, caudal annuli 15, with no autotomic site; tail round in cross section, the tip slightly depressed dorsally.

Coloration in Preservative.—Head cream. Dorsum pale brown; some dorsal segments are brown with cream intersegmental sutures, whereas other segments are cream with a brown central spot. Ventral segments are uniform cream colored, except for the two first segments below the lateral sulcus, which are pale brown, similar to dorsum. Color in life unknown.

TABLE 2. Summary of morphometric data (in mm) of specimens of *Amphisbaena acangaoba* sp. nov. with SVL, TL, HL (from the tip of the snout to the second body annulus).

Specimen	Sex ^a	Morphometric data (mm) ^b									
		SVL	TL	HL	HW	NSL	PFSL	FSL	PSL	HL/SVL	SVL/HW
MFCH 4467	M	194.0	19.0	6.3	4.0	0.4	1.4	2.1	0.3	3.2	48.4
MFCH 4479	F	246.0	23.8	6.7	5.4	0.4	1.7	2.4	0.3	2.7	46.0
MFCH 4481	F	246.0	24.4	6.9	4.4	0.6	1.7	2.2	0.4	2.8	55.5
MFCH 4482	M	186.0	19.4	6.0	3.8	0.5	1.5	2.1	0.2	3.2	49.6
MFCH 4486	M	274.0	27.6	7.8	5.6	0.3	1.6	2.7	0.5	2.8	48.9
MFCH 4487	F	241.0	22.4	6.6	4.6	0.3	1.5	2.4	0.4	2.7	52.6
MFCH 4492	F	250.0	20.3	7.0	4.3	0.3	1.7	2.2	0.2	2.8	57.6
MFCH 4495	M	232.0	18.4	7.8	5.3	0.7	1.4	2.4	0.3	3.4	43.9
MFCH 4649	M	220.0	20.4	7.1	5.1	0.2	1.8	2.1	0.2	3.2	43.0
MFCH 4650	F	245.0	21.0	6.8	4.6	0.2	1.5	2.3	0.0	2.8	53.1
MFCH 4651	F	231.0	20.9	6.8	4.6	0.4	1.6	2.3	0.4	2.9	50.7
MFCH 4652	M	252.0	25.5	7.5	5.6	0.4	1.8	2.7	0.0	3.0	44.8
MFCH 4653	M	185.0	17.5	6.1	4.0	0.3	1.4	2.1	0.3	3.3	46.6
MFCH 4654 ^c	M	290.0	26.4	7.9	5.6	0.4	1.7	2.6	0.5	2.7	52.1
MFCH 4655	M	212.0	17.2	7.5	5.2	0.7	1.6	2.7	0.5	3.5	41.0
MFCH 4656	F	232.0	21.4	6.6	4.4	0.2	1.4	2.4	0.2	2.8	52.7
MFCH 4657	M	241.0	20.2	8.4	5.8	0.9	2.0	2.9	0.1	3.5	41.6
MFCH 4658	F	258.0	20.3	6.4	4.4	0.2	1.6	2.3	0.2	2.5	59.2
MFCH 4660	M	248.0	20.2	7.2	5.2	0.5	1.7	2.5	0.2	2.9	47.7
MFCH 4661	M	226.0	20.5	7.9	5.7	0.9	1.8	2.5	0.3	3.5	39.4
MFCH 4662	M	216.0	19.4	6.9	4.5	0.4	1.6	2.3	0.3	3.2	48.4
MFCH 4663	F	172.0	16.0	6.0	4.1	0.5	1.3	2.2	0.4	3.5	42.2
MFCH 4664	F	194.0	19.0	6.1	3.8	0.0 ^d	1.6	2.0	0.2	3.1	51.1
MFCH 4665	M	252.0	24.6	7.8	5.0	0.4	1.7	2.8	0.4	3.1	50.2
MFCH 4666	M	222.0	18.9	7.4	4.9	0.5	1.4	2.5	0.5	3.3	45.4
MFCH 4667	M	247.0	23.8	7.4	5.6	0.5	1.5	2.3	0.3	3.0	44.4
MFCH 4668	M	236.0	22.1	7.1	4.7	0.4	1.7	2.5	0.3	3.0	50.4
MFCH 4669	F	222.0	20.6	6.5	4.2	0.2	1.6	2.4	0.6	2.9	53.1
MFCH 4670	?	187.0	16.6	6.1	3.7	0.5	1.4	2.2	0.3	3.3	50.7
MFCH 4671	M	217.0	20.1	7.0	4.6	0.1	1.6	2.1	0.0	3.2	47.5
MFCH 4749	F	237.0	18.5	6.9	4.5	0.4	1.3	2.3	0.3	2.9	52.5

^a F = female; M = male; ? = undetermined.

^b NSL = nasal suture length; PFSL = prefrontal suture length; FSL = frontal suture length; PSL = parietal suture length.

^c Holotype.

^d Nasals separated by rostral.

Variation.—Nasals are completely separated by rostral in MFCH 4664. In MFCH 4467, the left postocular and the right temporal are divided in two smaller scales. In MFCH 4481, MFCH 4492, MFCH 4653, MFCH 4656, MFCH 4658, MFCH 4664, MFCH 4666, and MFCH 4668 there is a small upper postocular on each side. The right temporal is divided in two smaller scales in MFCH 4482, MFCH 4495, and MFCH 4650. There are two right postoculars in MFCH 4487, MFCH 4649, and two left postoculars in MFCH 4655, MFCH 4661, MFCH 4663, MFCH 4667, and MFCH 4670. The size and shape of parietals vary in the sample. There is only one row of postgenials in MFCH 4652, MFCH 4655, MFCH 4661, MFCH 4665, and MFCH 4667, whereas all other specimens have two rows. Although the number of dorsal and ventral midbody segments vary from 18 to 24, the modal values are 20 dorsal ($N = 14$; 45%) and 22 ventral

($N = 11$; 35%) midbody segments. Preloacal pores vary between four and eight, although most specimens ($N = 24$; 77%) have six pores. Most specimens ($N = 29$; 93%) have a half dorsal annulus between the first and second complete body annuli. The number of segments of the half dorsal annulus varies from 4 to 14. A summary of variation in meristic characters is shown in Table 1 and variation in morphometry in Table 2.

In color pattern, most specimens have a pale brown dorsum with broad cream intersegmental sutures; MFCH 4479, MFCH 4481, MFCH 4492, MFCH 4658, MFCH 4660, MFCH 4668, MFCH 4670, and MFCH 4671 have a dark brown dorsum with narrow cream intersegmental sutures. The venter is uniformly cream, but the first to fourth segments below the lateral sulcus are the same color as the dorsum.

TABLE 3. Variation of a set of morphological characters (mean \pm SD) in males and females of *Amphisbaena acangaoba* sp. nov.

Character ^a	Female	Male
BA	216–237 (232.4 \pm 5.9)	219–239 (231.7 \pm 5.5)
CA	13–16 (14.9 \pm 0.8)	13–17 (15.1 \pm 1.1)
MS	38–44 (41.3 \pm 2.1)	38–48 (42.3 \pm 2.6)
SVL	222–258 mm (240.8 \pm 10.5)	194–290 mm (236.2 \pm 24.3)
TL	18.5–24.4 mm (21.4 \pm 1.7)	17.2–27.6 mm (21.5 \pm 3.1)
HL ^b	6.4–7.0 mm (6.7 \pm 0.2)	6.3– 8.4 mm (7.4 \pm 0.5)
HW ^b	4.2–5.3 mm (4.5 \pm 0.3)	4.0–5.8 mm (5.1 \pm 0.5)

^a BA = body annuli; CA = caudal annuli; MS = segments at a midbody annulus (dorsals + ventrals).

^b Sexually dimorphic characters.

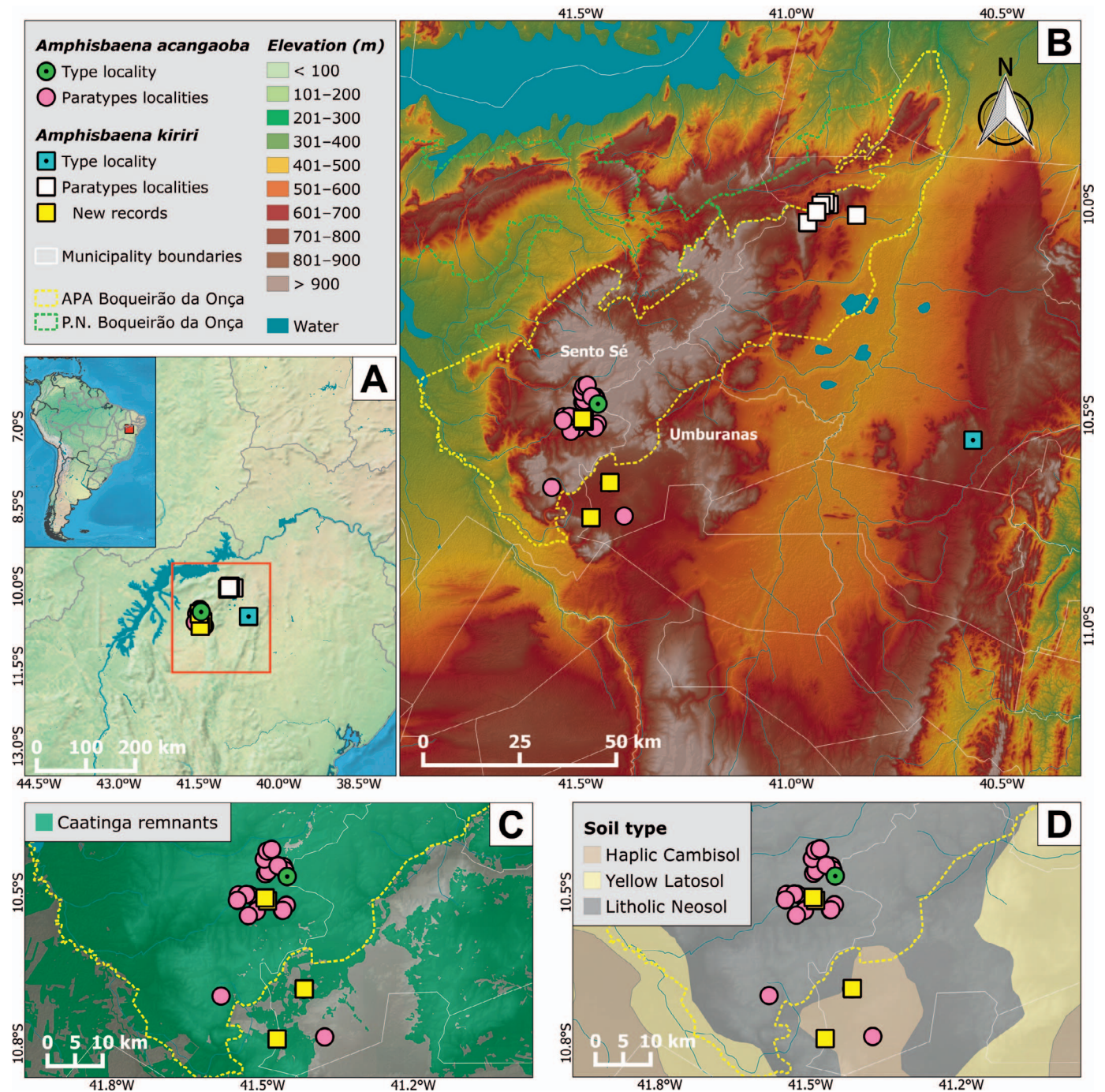


FIG. 4. Geographic distribution map of *Amphisbaena acangaoba* sp. nov. Locality records of *A. acangaoba* and the sympatric *A. kiriri* (A); magnification detailing the elevation gradient of the region where *A. acangaoba* and *A. kiriri* were found (B); remnants of the Caatinga ecoregion/biome (MMA/IBAMA, 2011) (C); soil classification (Santos et al., 2018) in the study region (D). APA = Área de Proteção Ambiental (Environmental Protection Area); P.N. = Parque Nacional (National Park).

Etymology.—In the Tupi indigenous language, *acangaoba* is a head ornament, a “helmet” or “cap” by neologism (D’Abbeville, 1945; Barbosa, 1970). Used here as a noun in apposition, the name *acangaoba* refers to the highly domed head of the new species, in the region formed by the nasal, prefrontal, and frontal scales. We suggest that the vernacular names “Helmeted Worm Lizard” in English and “Anfisbena-de-Capacete” in Portuguese.

Distribution.—*Amphisbaena acangaoba* sp. nov. is known from the municipalities of Umburanas and Sento Sé, state of Bahia, northeastern Brazil (Fig. 4). The region has a hot semiarid climate

(BSH in Köppen’s climate classification; Alvares et al., 2013) and is located in the Caatinga ecoregion (Dinerstein et al., 2017)—considered a biome by the Brazilian government (IBGE, 2004). Native vegetation is composed by steppic savanna (caatinga), rupestrian grassland (campos rupestres), and arboreal savanna (cerrado típico). The soil is mostly sandy, composed by litholic neosol (leptosol) and haplic cambisol. The region of Umburanas and Sento Sé is in the so-called “Depressão Sertaneja Meridional,” composed mostly of low plains with rugged relief, dissected with deep valleys at some areas (Velloso et al., 2001). Specimens of *A.*

TABLE 4. Morphological comparison between *Amphisbaena acangaoba* sp. nov. and other species of *Amphisbaena* to which sympatry is known to occur or expected. Modal values, when available, are in parentheses.

Character ^a	<i>Amphisbaena</i> species						
	<i>acangaoba</i>	<i>alba</i>	<i>bahiana</i>	<i>frontalis</i>	<i>kiriri</i>	<i>pretrei</i>	<i>vermicularis</i>
BA	216–239	198–248	204–233	252–272	158–165	231–255	211–254
CA	13–17	13–21	14–17	23–29	12–14	22–26	24–30
AA	Absent	Absent	Absent	6–7	3–4	5–7	4–8
DS	18–24 (20)	30–42 (36)	12–16 (14)	14–16	14–16 (14)	20–27 (24)	18–26 (22)
VS	18–24 (22)	35–46 (38, 40)	14–16 (14)	14–16	15–16 (16)	22–28 (24)	18–25 (22)
PP	4–8 (6)	4–12	4	4	2	5–9 (8)	4
SL	4	3–4 (4)	3	3	4	3	4
IL	3	3	3	3	3	3	3

^a BA = body annuli; CA = caudal annuli; AA = autotomic annuli; DS = dorsal segments at a midbody annulus; VS = ventral segments at a midbody annulus; PP = precloacal pores; SL = supralabials; IL = infralabials.

acangaoba sp. nov. were collected in an area of approximately 360 km² at elevations ranging from 760 to 1,105 m.

Sexual Dimorphism.—All examined variables showed non-normal distribution. Statistical analyses indicate there is sexual dimorphism in *A. acangaoba* sp. nov. only for head length ($P < 0.001$) and head width ($P = 0.01$), with greater values in males (Table 3).

DISCUSSION

New species of amphisbaenians have been discovered at a constant rate of 1.4 new taxa per year in Brazil over the last decade (Costa and Bérnills, 2018). Many of the new descriptions were made in areas within the Caatinga (Mott et al., 2008, 2009; Roberto et al., 2014; Almeida et al., 2018; Ribeiro et al., 2018a), highlighting our lack of knowledge on the biodiversity of this biome. Among the species of *Amphisbaena* known for the Caatinga, six occur, or may occur, in sympatry with *A. acangaoba* sp. nov.: *Amphisbaena alba* Linnaeus, 1758; *A. bahiana* Vanzolini, 1964; *A. frontalis* Vanzolini, 1991; *A. kiriri* Ribeiro, Gomides and Costa, 2018a; *A. pretrei* Duméril and Bibron, 1839; and *A. vermicularis* Wagler, 1824 (Santos et al., 2008; Colli et al., 2016; Ribeiro et al., 2018a). The new species described here is easily distinguished from all previously described species (Table 4).

The tip of the tail of *Amphisbaena acangaoba* sp. nov. is slightly depressed dorsally. Two closely related Brazilian species that also inhabit mountain regions in northeastern Brazil, *A. uroxena* Mott, Rodrigues, Freitas and Silva, 2008 and *A. caetitensis* Almeida, Freitas, Silva, Valverde, Rodrigues, Pires and Mott, 2018, exhibit an extremely dorsally depressed and tuberculate tail tip (Mott et al., 2008; Almeida et al., 2018). The shape of the tail tip was previously used to recognize amphisbaenian genera (Vanzolini, 1992), but today it is known to be a very homoplastic character, along with the number of precloacal pores and even head shape (Mott and Vieites, 2009). The highly domed head of *Amphisbaena acangaoba* sp. nov. resembles *A. carli* (Pinna et al., 2010), and the species previously assigned to the genus *Bronia* Gray, 1865, among which *B. kraoh* Vanzolini, 1971 (now placed in *Amphisbaena*) is the only species described to present the nasals contacting each other plus a non-autotomic tail. But *Bronia* was found to be paraphyletic (Mott and Vieites, 2009), and the resemblances of *Amphisbaena acangaoba* sp. nov. with those species, particularly *A. kraoh*, could simply be due to convergence. Tissue samples were not taken from any *A. acangaoba*, precluding tests of its phylogenetic relationships using molecular markers. The acquisition of tissue samples rarely occurs during environmental assessment

studies and wildlife rescue activities in Brazil but should be encouraged in the future.

Our data suggest that males of *A. acangaoba* sp. nov. have longer and broader heads than do females. Relatively broad heads in males compared to females have been recorded for the South American species *A. nigricauda*, *Leposternon microcephalum*, and *Leposternon wuchereri* (Filogonio et al., 2009; Souza e Lima et al., 2014). In the African species *Monopeltis anchietae*, females have a broader head (Webb et al., 2000), whereas in *Trogonophis wiegmanni* males have a larger head (Martín et al., 2012), and in the Iberian taxon *Blanus cinereus* males have both longer and broader heads (Gil et al., 1993). The dimorphism in head size suggests that males and females of *A. acangaoba* sp. nov. may either exploit different prey sizes (Gil et al., 1993) or show differences in burrowing ability (Filogonio et al., 2009). In the shovel-headed *Leposternon* spp., broader heads allow more compression force for burrowing, although relatively slowly (Hohl et al., 2017), lending support for the latter hypothesis. Because soil compaction increases with depth, male *Amphisbaena acangaoba* sp. nov. could be able to burrow deeper than females.

Specimens of *Amphisbaena acangaoba* sp. nov. were collected close to the area where another species, *A. kiriri*, was recently discovered (Fig. 4; Ribeiro et al., 2018a). Moreover, new specimens of *A. kiriri* were collected in sympatry with *A. acangaoba* sp. nov. in Umburanas and Sento Sé (Appendix 1), 100 km west from its type locality (Campo Formoso) and 80 km southwest of the closest paratype locality. The Umburanas and Sento Sé region, locally known as Boqueirão da Onça (Jaguar's Canyon), supports large patches of native vegetation (Fig. 4) and is classified as extremely high biological importance for the conservation of Caatinga's biodiversity (Brasil, 2007). In 2018, after many years of debate, two adjacent protected areas were created in the region: a national park (Parque Nacional do Boqueirão da Onça [PNBO]) of 347,000 ha, and an "environmental protection area" (Área de Proteção Ambiental Boqueirão da Onça [APABO]), of approximately 505,000 ha (Fig. 4), and both areas fall under International Union for Conservation of Nature's category II and V, respectively (OECD, 2015).

Most records of *A. acangaoba* sp. nov. and *A. kiriri* are within the APABO. The elevation gradient of the region is better represented in the APABO than in the PNBO, and most of the highlands are in the APABO (Fig. 4). The APABO is a category of protected area that is composed of public and private lands and is designed to safeguard biodiversity allowing sustainable use of natural resources (Brasil, 2011). For this reason, wind farms were constructed at the APABO highlands, where most

specimens of *A. acangaoba* sp. nov. and *A. kiriri* were unearthed by bulldozers during vegetation removal.

We do not have detailed records of the soil where each specimen of *A. acangaoba* sp. nov. was collected. However, data indicate that the collection sites contain the two soil types haplic cambisol and litholic neosol (leptosol; Santos et al., 2018), with medium textures varying from sandy loam to loam (Nachtergaele et al., 2009). Most specimens were collected above 700 m, where litholic neosols, a very thin soil type common in mountainous regions (IUSS Working Group WRB, 2015), prevail in rupestrian grasslands. Below 700 m, specimens were collected in areas of cambisol, a very diversified soil type (IUSS Working Group WRB, 2015). In Boqueirão da Onça, cambisols seem to be restricted to the slopes of the plateau (Fig. 4). Because most specimens were collected in highlands during the installation of a wind farm, the lower number of records from lowlands is not necessarily because of habitat preferences but probably because of a sampling bias.

The fauna of the Caatinga has historically been thought to be simply composed of a subset of species inhabiting the South American diagonal of open formations and devoid of endemism (Vanzolini, 1974, 1988). However, the increase in collection efforts over the last decades has dispelled the notion of little endemism in the Caatinga region (Rodrigues, 2003; Garda et al., 2018). With the description of *A. acangaoba* sp. nov., 25 species of amphisbaenians are now known for Caatinga, many of which are endemic (Almeida et al., 2018; Ribeiro et al., 2018a). But the Caatinga is still under sampled (Oliveira et al., 2016). More than 63% of this semiarid region, unique to the Brazilian northeast, has been degraded by human activities (Silva and Barbosa, 2017), with 7.5% within protected areas, mostly in less restricted categories, such as APABO. Strictly protected areas such as the PNBO comprise only 1.13% of the Caatinga (Fonseca et al., 2017). The creation of this national park was a long-awaited step to improve the conservation network of northeastern Brazil, in a time when the country faces pressures to weaken environmental laws (Abessa et al., 2019). Given the proximity to the collection sites of *A. acangaoba* sp. nov. and *A. kiriri*, we believe that these two species can be found inside the PNBO. We hope that an effort will be soon directed to sampling the amphibians and reptiles of the park, including its subterranean herpetofauna, to test our hypothesis.

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APPENDIX 1

Specimens Examined in Addition to Those Cited by Costa et al. (2018a,b, 2019); Ribeiro et al. (2018a)

All from Brazil. AAGARDA: Adrian Antonio Garda field series, to be deposited in Universidade Federal da Paraíba; MFCH: Museu de Fauna da Caatinga, Coleção Herpetológica, Universidade Federal do Vale do São Francisco; MTR: Miguel Trefaut Rodrigues field series, laboratório de Herpetologia, Universidade de São Paulo.

Amphisbaena acangaoba: BAHIA: Sento Sé: Complexo Eólico Campo Largo: MFCH 4467 (10.5299°S, 41.5103°W), MFCH 4479 (10.4680°S, 41.4952°W), MFCH 4481 (10.4638°S, 41.4914°W), MFCH 4482 (10.4638°S, 41.4914°W), MFCH 4486 (10.4563°S, 41.4655°W), MFCH 4487 (10.4563°S, 41.4655°W), MFCH 4492 (10.4624°S, 41.4634°W), MFCH 4495 (10.4624°S, 41.4634°W), MFCH 4649 (10.5030°S, 41.5223°W), MFCH 4650 (10.5030°S, 41.5223°W), MFCH 4651 (10.5029°S, 41.5401°W), MFCH 4655 (10.5375°S, 41.5237°W), MFCH

4656 (10.5024°S, 41.5273°W), MFCH 4657 (10.5024°S, 41.5273°W), MFCH 4658 (10.5120°S, 41.5419°W), MFCH 4659 (10.5120°S, 41.5419°W), MFCH 4660 (10.5201°S, 41.4607°W), MFCH 4661 (10.5289°S, 41.4672°W), MFCH 4662 (10.4437°S, 41.4973°W), MFCH 4663 (10.4276°S, 41.4850°W), MFCH 4664 (10.4303°S, 41.4926°W), MFCH 4665 (10.4303°S, 41.4926°W), MFCH 4666 (10.4276°S, 41.4850°W), MFCH 4667 (10.5286°S, 41.4664°W), MFCH 4668 (10.4547°S, 41.4746°W) – paratypes. Umburanas: Complexo Eólico Campo Largo: MFCH 4652 (10.4725°S, 41.4593°W), MFCH 4653 (10.4725°S, 41.4593°W), MFCH 4669 (10.7385°S, 41.3971°W), MFCH 4670 (10.7385°S, 41.3971°W), MFCH 4671 (10.6598°S, 41.4319°W) – paratypes; MFCH 4654 (10.4725°S, 41.4593°W) – holotype.

Amphisbaena kiriri: BAHIA: Sento Sé: Complexo Eólico Campo Largo: MFCH 4646 (10.513°S, 41.492°W), MFCH 4647 (10.508°S, 41.496°W). Umburanas: Complexo Eólico Campo Largo: MFCH 4642, MFCH 4643 (10.659°S, 41.431°W), MFCH 4757, MFCH 4758 (10.742°S, 41.476°W).

Amphisbaena pretrei: BAHIA: Sento Sé: Complexo Eólico Campo Largo: MFCH 4659 (10.5120°S, 41.5419°W). RIO GRANDE DO NORTE: Nísia Florestal: AAGARDA 9815 (6.091°S, 35.209°W).

Amphisbaena vermicularis: BAHIA: Campo Formoso: Gameleira do Dida: MTR 24884 (10.188°S, 41.027°W). Casa Nova: Alagoado: MTR 11246 (9.483°S, 41.350°W). Gentio do Ouro: Santo Inácio: MTR 11162 (11.111°S, 42.723°W). Xique-Xique: Vacaria: MTR 11143 (10.659°S, 42.604°W). CEARÁ: Fortaleza: Sapiranga: MTR 18015 (3.796°S, 38.467°W). MINAS GERAIS: Jequitinhonha: MTR 17456 (16.434°S, 41.003°W). Serra do Cipó: MTR 20286 (19.417°S, 43.533°W). PIAUÍ: São Raimundo Nonato: Parque Nacional da Serra da Capivara: MTR 25251 (8.827°S, 42.657°W). TOCANTINS: Rio da Conceição: MTR 14625 (11.400°S, 46.883°W).