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ORIGINAL ARTICLE

Morphological characteristics of worm lizard, *Diplometopon zarudnyi* (Squamata: Trogonophidae), in the central region of Saudi Arabia



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Abstract We report morphometric data for 133 specimens of *Diplometopon zarudnyi* (Squamata: Trogonophidae) collected across its range within Riyadh province of Saudi Arabia. One-way analyses of variance revealed that differences exist in most characters. Snout-vent length and vent-tail length showed slight and inconsistent differences among samples. *D. zarudnyi* is characterized by 164–175 body annuli; 165–178 dorsal annuli; 13–17 caudal annuli with absence of caudal autotomy. In addition, 2–4 lateral annuli; 45–54 mid-body segments; 39–50 posterior segments; 4–5 head's plates and 4–6 pre-cloacal pores were recorded in both males and females without gender difference. The present study revealed the widespread distribution of this species in the studied region, since land topography in this area is characterized by the absence of any natural barriers which could restrict the spread of this amphisbaenian lizard *D. zarudnyi*.

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1. Introduction

Amphisbaenians, burrowing reptiles that live as subterranean predators (Pianka and Vitt, 2003) are poorly known ecologically due to their fossorial life style and the scarcity of researchers studying the group. Adaptations for underground

locomotion include a robust skull (Gans, 1975), elongated and cylindrical body covered by scales arranged in rings, rudimentary eyes (since they hunt mostly in darkness), limbless animals highly specialized for burrowing (Gans, 1978).

The limited locomotor abilities of amphisbaenians should have limiting dispersal, yet worm lizards occur widely distributed throughout the tropics and subtropics including the America, Europe, the Middle East and Africa (Vidal et al., 2008). There are over 200 species in 24 genera, usually distributed in four families—Bipedidae, Amphisbaenidae, Trogonophidae, and Rhineuridae (Kearney, 2003; Gans, 2005). Species in the Trogonophidae (four genera and six species) are sand specialists found in the Middle East, North Africa and the island of Socotra, while the Amphisbaenidae is the

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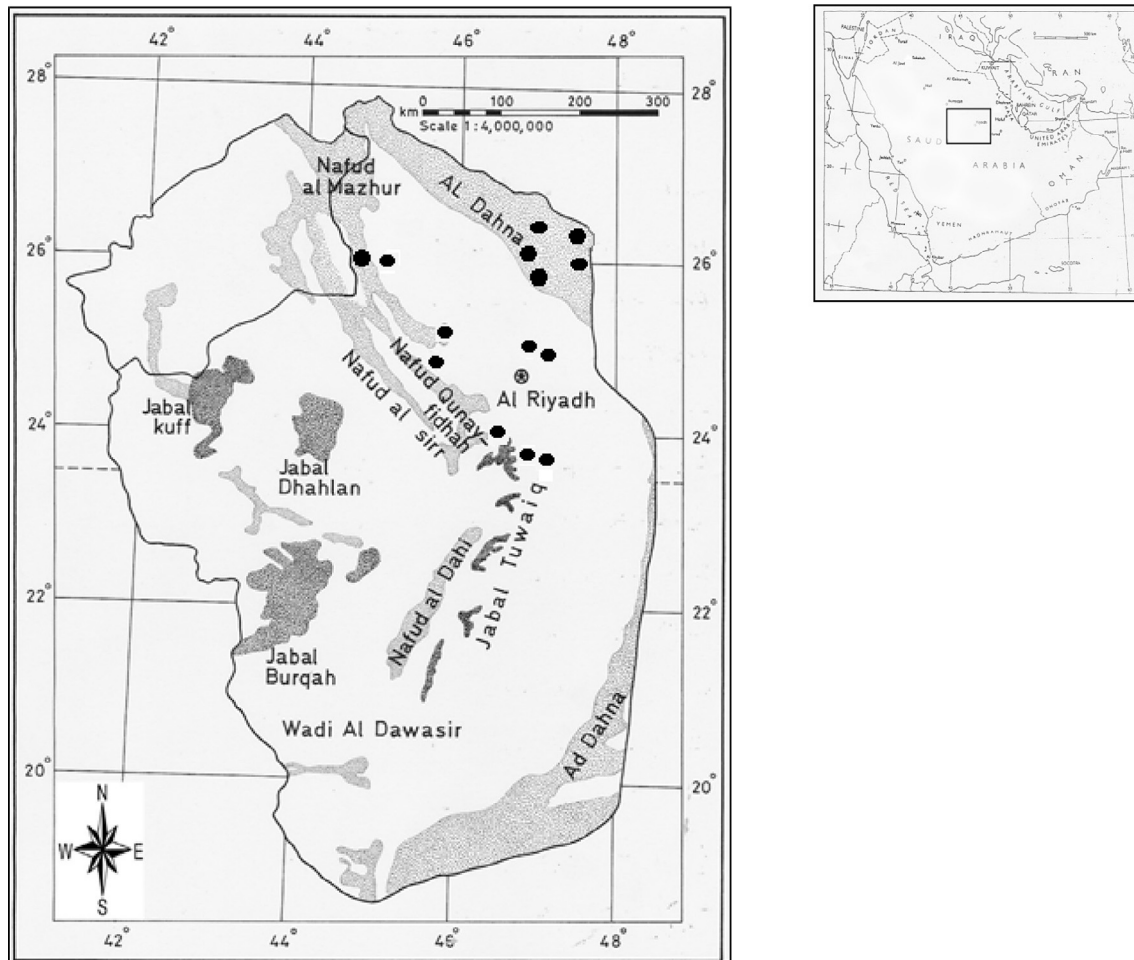


Figure 1 Map showing the distribution area from which specimens of *D. zarudnyi* were recorded in the Riyadh province, central region of Saudi Arabia. Specimens recorded (●).

largest and most diverse family, with about 180 species in 18 genera (Kearney and Stuart, 2004; Gans, 2005).

The species belonging to Trogonophidae family, share many derived features including acrodont dentition, absence of caudal autotomy, strong craniofacial angle, short tail, enlarged sternal plate and spade-shaped head with sharp cutting edges except genus *Trogonophis* (Kearney, 2003). These morphometric features were recently described and discussed in several other new species belonging to family Amphisbaenidae such as *Amphisbaena carli* (Pinna et al., 2010), *Amphisbaena littoralis* (Roberto et al., 2014) and *Amphisbaena metallurga* (Costa et al., 2015).

Among the four genera that belong to family Trogonophidae, *Agamodon* include four species *Pachycalamus* contain one species, *Trogonophis* include two species. However, *Diplometopon* is represented by a single species, *Diplometopon zarudnyi*, widespread in arid habitats in western Iran, southern Iraq, Kuwait, Oman, and northern Saudi Arabia (Gans, 1978; Al-Sadoon et al., 2016). It inhabits Aeolian sand deposits and emerges onto the surface to breed (Maisano et al., 2006) but there is little detailed information on the ecology of this species. The description of amphisbaenians have been based mainly on external morphological characters, for example, number of body annuli, segments per body annulus and num-

ber of preloacal pores (Ribeiro et al., 2016). Knowledge of amphisbaenian morphology is poor compared to other squamates. This paper deals with morphological characters of samples of *D. zarudnyi* collected from Al-Riyadh province, central region of Saudi Arabia.

2. Materials and methods

2.1. Study area

This study was conducted within the Riyadh province (24°38'N, 46°43'E), central region of Saudi Arabia (Fig. 1).

2.2. Sample collection

A total of 133 specimens of worm lizard *D. zarudnyi* (75 males and 58 females) were collected from the study area over a period extending from October, 2013 to September, 2014.

Field trips to the study area were conducted twice per month for a period of one year. During field visits, the animals were found through active search during which notable traces left on the soil surface were searched for, followed by digging 10–30 cm depth either using hands or with the help of hoe.

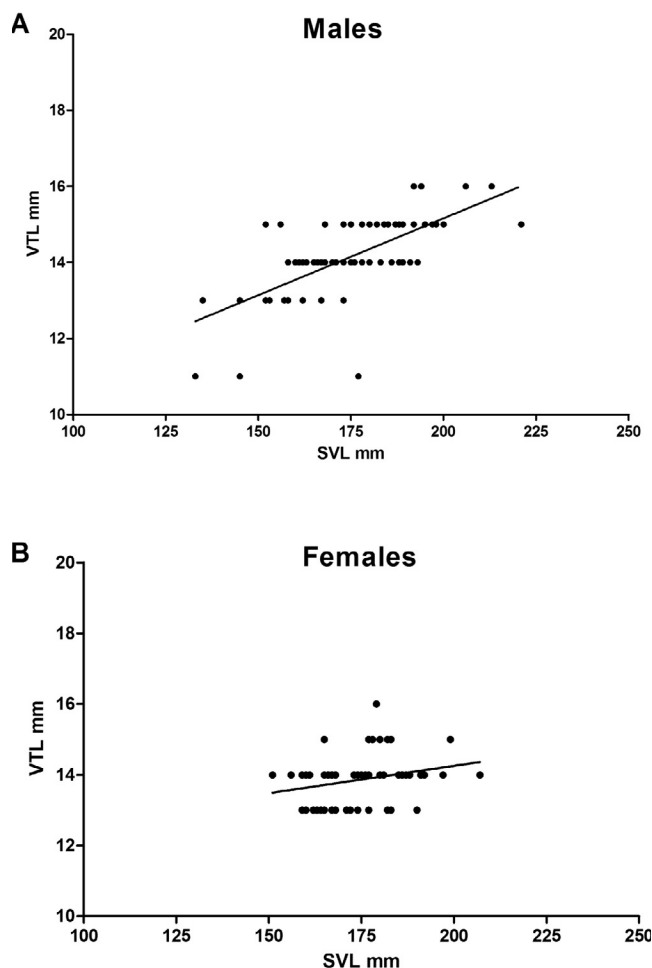


Figure 2 Relationship between snout-vent length (SVL) and Vent-Tail length (VTL) for *D. zarudnyi*, Males (A) and Females (B). Results found significant relationship between (SVL) vs (VTL): $r^2 = 0.44$, $P < 0.0001$, $n = 75$ for Males and $r^2 = 0.06$, $P < 0.05$, $n = 58$ for Females.

2.3. Laboratory procedures

Live animals were transported to the Animal Facility Room of the Zoology Department, King Saud University, Riyadh. The characters of the external morphology of males and females were recorded for each individual. Among morphometric characters, snout-vent length (SVL), vent-tail length (VTL) and total length (TL) were measured to the nearest millimeter using metric ruler. The scales of the body annuli count were taken according to the criteria of Gans and Alexander (1962), pre-cloacal pores and the shields on top of the head under a dissecting microscope (Nikon, X4–X10 magnification). Measurements of the body dimensions were taken using digital calipers to the nearest 0.01 mm. The animals were treated in accordance with the standards set out in the guidelines for the care and use of experimental animals by the King Saud University, Riyadh; Kingdom of Saudi Arabia.

2.4. Statistics

Statistical analyses were performed using the scientific analysis software package GraphPad Prism version 5 (GraphPad Software Inc., San Diego, CA, USA). Probability level of statistical significance was tested at $P < 0.05$ and all Statistical analyses involved the use of either one-tail (paired or unpaired as appropriate) Student's *t*-test.

3. Results

The results of an ANOVA test for snout-vent length and vent-tail length showed only slight and inconsistent differences among samples ($P > 0.05$) for males (SVL: $\bar{X} = 174.81 \pm 1.83$ mm; VTL: $\bar{X} = 14.25 \pm 0.10$ mm) and females (SVL: $\bar{X} = 175.67 \pm 1.40$ mm; VTL: $\bar{X} = 13.94 \pm 0.11$ mm). However, the relationship between SVL and VTL showed significant relationship between males ($r^2 = 0.44$, $P < 0.05$, $n = 75$) and females ($r^2 = 0.06$, $P < 0.05$, $n = 58$) (Fig. 2).

Table 1 Summary of the morphometric data of adult specimens of *D. zarudnyi*. Sample size for each sex shown in parentheses. Table shows mean value, standard error and Range. SVL = Snout-vent length, VTL = Vent-Tail, TL = Total-length length.

Body length (mm)	Male ($n = 75$)			Female ($n = 58$)		
	\bar{X}	\pm SE	Range	\bar{X}	\pm SE	Range
SVL	174.81	± 1.83	135–221	175.67	± 1.40	151–207
VTL	14.25	± 0.1	11–16	13.94	± 0.11	13–17
TL	188.9	± 1.9	148–236	189.60	± 1.47	165–221
VT/TL%	7.55	± 0.1	5.2–10.2	7.37	± 0.08	6.07–9.1
Body Diameter	8.53	± 0.22	5.1–14.3	7.97	± 0.12	6.1–10.4
<i>Body Annuli</i>						
Dorsal Annuli	172.3	± 0.26	166–178	172.43	± 0.29	165–177
Ventral Annuli	168.84	± 0.25	164–175	169.22	± 0.33	164–175
Caudal Annuli	15.85	± 0.09	14–17	15.85	± 0.09	13–17
Lateral Annuli			2–4			2–4
<i>Segment Annuli</i>						
Mid-body Segment	50.6	± 0.21	46–54	50.4	± 0.23	46–54
Posterior Segment	43.57	± 0.19	39–50	43.55	± 0.24	40–49
<i>Other countable traits</i>						
Cloacal scales			7–10			7–10
Per-cloacal pores			(4) (5) (6)			(4) (5)

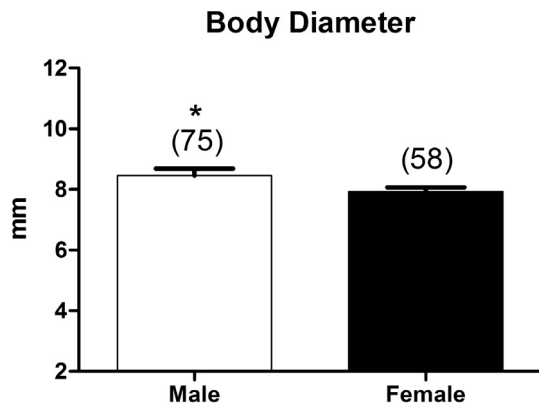


Figure 3 Comparison of the body diameter between males (Open bar) and females (Fill bar). Results found significant differences between males and females (unpaired Student's *t*-test $P < 0.05$).

Total length (TL) ranged between 148–236 mm for males ($\bar{X} = 188.98 \pm 1.90$ mm) and 165–221 mm for females ($\bar{X} = 189.61 \pm 1.47$ mm). However, the proportion of the tail

length to the total length VT/TL ranged between 5.20–10.20 mm for males ($\bar{X} = 7.55 \pm 0.1$) and 6.09–9.10 mm for females ($\bar{X} = 7.37 \pm 0.08$) (Table 1).

The meristic traits appeared to be less variable than the morphometric characters. Male ($n = 75$) and female ($n = 58$) dorsal annuli averaged 172.3 (SE ± 0.26 , 166–178,) and 172.43 (SE ± 0.29 , 165–177), respectively (Fig. 3F), however, the ventral annuli averaged 168.84 (SE ± 0.25 , 164–175) and 169.22 (SE ± 0.33 , 164–175) for males and females, respectively. Caudal annuli ranged between 14–17 ($\bar{X} = 15.85 \pm 0.09$) and 13–17 ($\bar{X} = 15.85 \pm 0.09$) for males and females, respectively, while the lateral annuli ranged between 2 and 4 for both males and females (Table 1). The scales of the pectoral region for this species are similar in size to the other body scales.

The mean number of the mid-body segments and posterior segments per annulus for the males were ($\bar{X} = 50.60 \pm 0.21$, range = 46–54) and ($\bar{X} = 43.57 \pm 0.19$, range = 39–50), respectively does not show significant difference from respective ones in females ($\bar{X} = 50.40 \pm 0.23$, range = 46–54) and ($\bar{X} = 43.55 \pm 0.24$, range = 40–49) (Table 1). Pre-cloacal

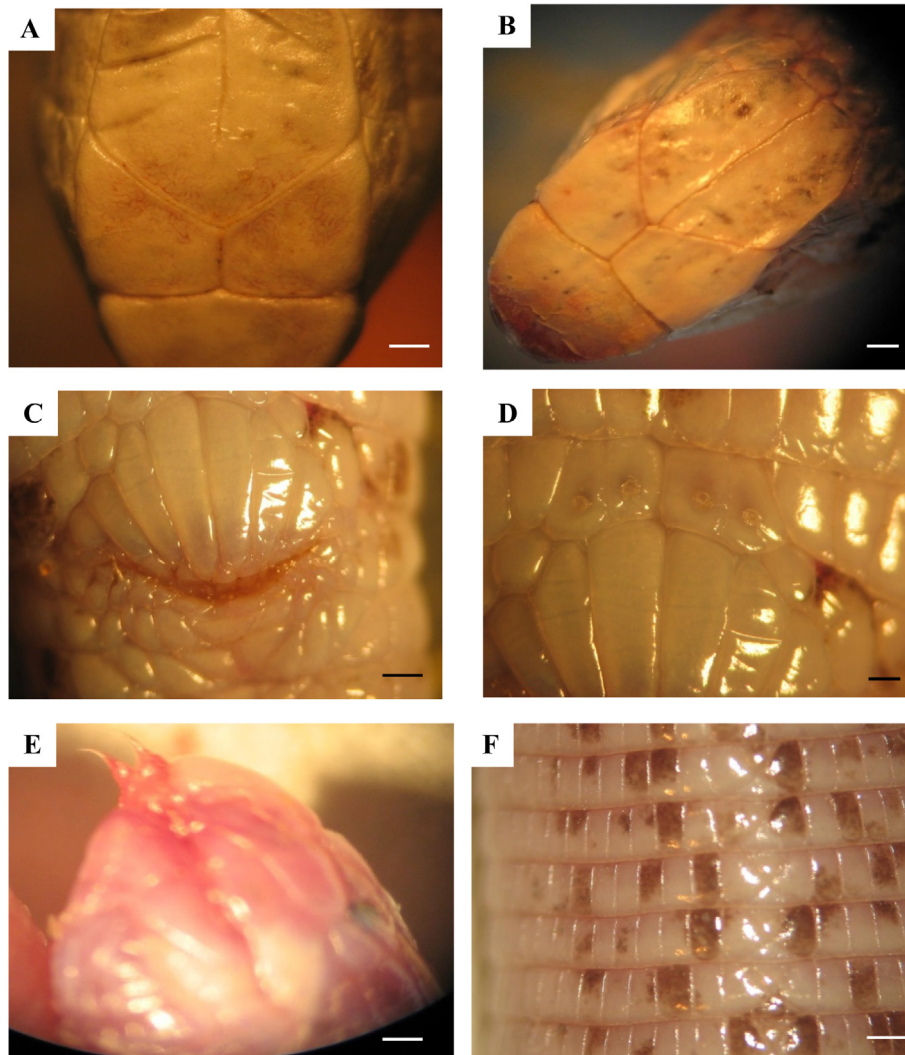


Figure 4 The two main patterns of the head scales (A) partially bisected, (B) completely bisected; (C) Cloacal scales; (D) Pre-cloacal pores; (E) Tongue bifurcated and (F) Dorsal annuli. Scale bars = 2 mm.

scales ranged between 7–10 for both males and females (Fig. 4C), however, pre-cloacal pores showed significant variation. The majority of the specimens showed four pores ($n = 125$, 93.23%) of the total 133 specimens, whereas 7 specimens ($n = 7$, 6.01%) showed five pores and only one male specimen showed six pores (Fig. 4D). Male and female body diameter exhibited significant difference ($P < 0.05$) ranged between 5.10 and 14.30 mm ($\bar{X} = 8.53 \pm 0.22$) and 6.1–10.4 ($\bar{X} = 7.97 \pm 0.12$) mm, respectively (Fig. 3).

Based on the large scale (post-frontal) that cover the top head, two main patterns of the head scales were observed in *D. zarudnyi*. Sixty-eight (51.13%) of the total samples [male = 41 (60.3%), female = 27 (39.14%)] showed partially bisected head scale (Fig. 4B). However, 56 (48.87%) of the total samples [male = 35 (53.85%), female = 30 (46.15%)] showed the completely bisected head scale where the groove separated the entire scale into two parts (Fig. 4A).

4. Discussion

The similarity of the climatic conditions as well as biological factors such as the availability of the vegetation cover among the different habitats of studied region, played a key role for wide spread of this worm lizard, *D. zarudnyi*. Additionally, a low number of predation risk due to its burrowing lifestyle as they spend most of their time under the surface of the soil. Identifications, diagnosis, and comparisons among different species of *Amphisbaena* rely mostly on similarity and are specially based on counts of body annuli, body segments, and number of pores (Rodrigues et al., 2003).

The morphological variation that was observed in this worm lizard in the Central region of Saudi Arabia appeared to be more expressed in the morphometric traits. Morphological characters such as pectoral region; head scales; tongue bifurcation and several other countable traits such as body length, body annuli, segment annuli, pre-cloacal scales and pre-cloacal pores were compared with other species within *Amphisbaenia*. The scales of the pectoral region for this species are similar in size to the other body scales, which match with the majority of all other *amphisbaenians*, except species that belong to the following genera: *Monopeltis*, *Leposternon*, *Dalophia*, *Aulura*, and *Rhineura* (Kearney, 2003).

The number of pre-cloacal pores in *Amphisbaenia* in general ranged between 2 and 12 (Vanzolini, 2002; Pinna et al., 2010; Robert et al., 2014; Costa et al., 2015). Both males and females of *D. zarudnyi* have 4–6 pre-cloacal pores in a continuous series. Majority of the specimens of *D. zarudnyi* (93.23%) usually present four pre-cloacal pores which agree with the majority of other *amphisbaenians* such as *Amphisbaena darwini*, *A. heterozonata* and *A. trachura*, *A. ibijara*, *A. cunhai*, *A. medemi*, *A. carvalhoi* and *A. frontalis* (Rodrigues et al., 2003; Costa et al., 2015) but few (6.01%) have five and only one specimen have six pre-cloacal pores. Although most *amphisbaenians* possess caudal autotomy e.g. *A. metallurga* (Costa and Bérnils, 2014), *A. Linnaeus* (Roberto et al., 2014), this morphological character is however absent in this species which is in agreement with the findings of Kearney (2003). In all *amphisbaenians*, a bifid anterior tongue tip is present, a bifurcated tongue tip and a non-bifurcated tongue tip—for squamates. The current study showed tongue bifurcation for

this species also, which supported the earlier observations of Kearney (2003).

The countable traits such as, body, ventral and caudal annuli, segments at mid body, pre-cloacal scales and pre-cloacal pores for specimens collected from the study area were compared with findings of Gans (1960) collected from other different areas. Number of ventral annuli (164–175) observed in the present study for both male and female correspond with the findings of Gans (1960) (172–180). Similarly, caudal annuli (male = 14–17) and (female = 13–17), segments at mid-body (46–54), pre-cloacal scales (7–10), pre-cloacal pores (4–6) for both males and females recorded in this study are in agreement with the reports of Gans (1960).

In conclusion, *Amphisbaenians* are arguably one of the least-studied squamate lineages and also one of the most troublesome phylogenetically due to their extreme morphological modifications. Further research is needed in several areas to make comparisons to other squamates. Even though *D. zarudnyi* is widespread and easily observed in the study area, conclusions about the species' social behavior and life history of this species from natural populations needed to be validated.

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References

- Al-Sadoon, M.K., Paray, B.A., Rudayni, H.A., 2016. Diet of the worm lizard, *Diplometopon zarudnyi* (Nikolsky, 1907), in Riyadh province, Saudi Arabia (Reptilia: Trogonophidae). *Zool. Middle East*. 62 (3), 227–230.
- Costa, H.C., Bérnils, R.S., 2014. Brazilian Reptiles: List of Species. Version 2014.1. Sociedade Brasileira de Herpetologia.
- Costa, H.C., Resende, F.C., Teixeira Jr., M., Vechio, F.D., Clemente, C.A., 2015. A new *Amphisbaena* (Squamata: Amphisbaenidae) from southern Espinhaço Range, southeastern Brazil. *An. Acad. Bras. Ciênc.* 87 (2), 891–901.
- Gans, C., 1960. Studies on *amphisbaenids* (*Amphisbaenia*: Reptilia). I. A taxonomic revision of the Trogonophidae and a functional interpretation of the *amphisbaenid* adaptive pattern. *Bull. Am. Mus. Nat. Hist.* 119, 129–204.
- Gans, C., 1975. Tetrapod limblessness: evolution and functional corollaries. *Am. Zool.* 15, 455–467.
- Gans, C., 1978. The characteristics and affinities of the *amphisbaenia*. *Trans. Zool. Soc. London* 34, 347–416.
- Gans, C., 2005. Checklist and Bibliography of the *Amphisbaenia* of the world. American Museum of Natural History, Central Park west at 79th Street, New York.
- Gans, C., Alexander, A.A., 1962. Studies on *amphisbaenids* (*Amphisbaenia*, Reptilia). On the *amphisbaenids* of the Antilles. *Bull. Mus. Comp. Zool.* 128, 65–158.
- Kearney, M., 2003. Systematics of the *amphisbaenia* (Lepidosauria: Squamata) based on morphological evidence from recent fossil forms. *Herpetol. Monogr.* 17 (1), 1–74.
- Kearney, M., Stuart, B.L., 2004. Repeated evolution of limblessness and digging heads in worm lizards revealed by DNA from old bones. *Proc. R. Soc. Lond. B* 271, 1677–1683.
- Pianka, E.R., Vitt, L.J., 2003. *Lizards: Windows to the Evolution of Diversity*. University of California Press, Berkeley, CA.

- Maisano, J.A., Kearney, M., Rowe, T., 2006. Cranial anatomy of the spade-headed amphisbaenian. *Diplometopon zarudnyi* (Squamata, Amphisbaenia) based on high resolution X-ray computed tomography. *J. Morphol.* 267, 70–102.
- Pinna, P.H., Mendonca, A.F., Bocchiglieri, A., Fernandes, D.S., 2010. A new two-pored Amphisbaena Linnaeus from the endangered Brazilian Cerrado biome (Squamata: Amphisbaenidae). *Zootaxa* 2569, 44–54.
- Ribeiro, S., Gomes, J.O., Rodrigues da Silva, H.L., Cintra, C.E.D., Silva Jr, N.J.D., 2016. A new two-pored species of Amphisbaena (Squamata, Amphisbaenidae) from the Brazilian Cerrado, with a key to the two-pored species of Amphisbaena. *Zootaxa* 4147 (2), 124–142.
- Roberto, I.J., Brito, L.B., Avila, R.W., 2014. A new six-pored Amphisbaena (Squamata: Amphisbaenidae) from the coastal zone of northeast Brazil. *Zootaxa* 3753 (2), 167–176.
- Rodrigues, M.T., Andrade, G.V., Lima, J.D., 2003. A new species of Amphisbaena (Squamata, Amphisbaenidae) from state of Maranhão, Brazil. *Phyllomedusa J. Herpetol.* 2 (1), 21–26.
- Vanzolini, P.E., 2002. An aid to the identification of the South American species of Amphisbaena (Squamata, Amphisbaenidae). *Pap. Avulsos de Zool. (São Paulo)* 42 (15), 351–362.
- Vidal, N., Azvolinsky, A., Cruaud, C., Hedges, S.B., 2008. Origin of tropical American burrowing reptiles by transatlantic rafting. *Biol. Lett.* 4 (1), 115–118.