African Journal of Herpetology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ther20

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Sylvestre Boudzoumou[a], Daniel Hoops[b], Victor Mamonekene[a] & Kate Jackson[c]

[a] Groupe d'Etude et de Recherche sur la Diversité Biologique, Brazzaville, Republic of Congo

[b] Ecology, Evolution & Genetics, Research School of Biology, The Australian National University, Canberra, Australia

[c] Department of Biology, Whitman College, Walla Walla, WA, USA

Published online: 04 Feb 2013.

To cite this article: Sylvestre Boudzoumou, Daniel Hoops, Victor Mamonekene & Kate Jackson (2013) Morphological variation in Monopeltis guentheri from forest habitat in Brazzaville, Republic of Congo (Squamata: Amphisbaenidae), African Journal of Herpetology, 62:2, 117-124, DOI: 10.1080/21564574.2012.761284

To link to this article: http://dx.doi.org/10.1080/21564574.2012.761284

African Journal of Herpetology,
Vol. 62, No. 2, October 2013, 117–124

Morphological variation in *Monopeltis guentheri* from forest habitat in Brazzaville, Republic of Congo (Squamata: Amphisbaenidae)

Sylvestre Boudzoumou[1], Daniel Hoops[2]*, Victor Mamonekene[1] & Kate Jackson[3]

[1]*Groupe d'Etude et de Recherche sur la Diversité Biologique, Brazzaville, Republic of Congo;* [2]*Ecology, Evolution & Genetics, Research School of Biology, The Australian National University, Canberra, Australia;* [3]*Department of Biology, Whitman College, Walla Walla, WA, USA*

Abstract.—Sixty-four *Monopeltis guentheri* were collected in a small patch of remnant forest within the city of Brazzaville, Republic of the Congo, and were measured for morphological characters traditionally used to classify five species of Central and West African *Monopeltis* amphisbaenians. Based on the intraspecific variation found in our specimens, we concluded that the characters considered are of limited usefulness for identification of this species. We found total annuli number to have potential for use as a taxonomic character while there is little diagnostic value in body and tail length, number of anal plates, number of pre-anal pores, and number of dorsal and ventral segments. We conclude that currently utilised morphological characters are insufficient to identify *Monopeltis guentheri*.

Key words.—Amphisbaenia, *Monopeltis*, Congo, taxonomy, identification, morphology

Résumé.—Dans un bosquet de forêt résiduelle de la ville de Brazzaville en République du Congo, nous avons collecté 64 spécimens de *Monopeltis guentheri* dont nous avons mesuré les caractères morphologiques traditionnellement utilisés pour la classification des cinq espèces d'amphisbènes *Monopeltis* d'Afrique centrale et occidentale. Compte tenu de la variation intraspécifique observée chez nos spécimens, nous concluons que ces caractères sont d'une utilité limitée pour l'identification de cette espèce. Nous avons trouvé que le nombre total d'anneaux est plus pertinent comme caractère taxonomique alors que l'intérêt pour la diagnose de la longueur du corps et de la queue, du nombre de pores pré-anales et du nombre de segments dorsaux et ventraux est limité.

Amphisbaenians are among the least-known reptiles in the world (Böhm *et al*. 2013). Furthermore, the herpetofauna of Central Africa and of the Republic of Congo in particular are among the world's most poorly known vertebrate groups (Lawson & Klemens 2001; Jackson *et al*. 2007). Geographically widespread, African *Monopeltis* amphisbaenians have been reported in an area ranging from central South Africa to Cameroon in the west and southern Tanzania in the east (de Witte & Laurent 1942; Gans & Lafiti 1971; Gans & Lehman 1973; Broadley *et al.* 1976; Gans 1976, 2005; Broadley 1997). Five species are known from Central and West Africa: *M. guentheri* (Boulenger 1885), *M. schoutedeni* (de Witte 1933), *M. galeata* (Hallowell 1852), *M. jugularis* (Peters 1880), and *M. vanderysti* (de Witte 1922). *M. guentheri* and

*Corresponding author. Email: daniel.hoops@anu.edu.au

ISSN 2156-4574 print/ISSN 2153-3660 online

http://dx.doi.org/10.1080/21564574.2012.761284
http://www.tandfonline.com

M. schoutedeni are found in close geographical proximity and are sympatric in Brazzaville, N'ganchou, Diele (Republic of Congo) and Kinshasa (Democratic Republic of Congo) (Gans & Lehman 1973). Although similar, *Monopeltis guentheri* reportedly differs from *M. schoutedeni* by virtue of its lower pre-anal pore count (5–9 versus 8–13) and lower number of body annuli (236–261 versus 261–289) (Table 1). Both species differ from the geographically close species pair of *M. galeata* and *M. jugularis* by having higher pre-anal pore and body annuli counts. The latter two species differ from one another with regard to numbers of caudal annuli and dorsal and ventral segments per midbody annulus. *M. vanderysti* differs from most other Central and West African species by its lower number of tail annuli, but from *M. jugularis* by having a lower number of body annuli (Table 1).

Despite being the traditional and most frequently used method of species differentiation, morphological characters show remarkable intraspecific variation. Gans and Latifi (1971) examined 89 specimens of *M. guentheri* from locations across the Congo basin and found both geographical and ontogenetic variation in morphology. Broadley *et al*. (1976) documented considerable geographic variation in *Monopeltis* species in a large-scale study comparing specimens throughout southern Africa. Subsequently, Broadley (1997) focused on the widely distributed *M. capensis* species complex and documented sufficient geographical variation to warrant dividing two formerly recognised species into five. Recently, Mott and Vieites (2009) discovered enough morphological homoplasy in the course of a molecular phylogenetic study of South American amphisbaenians as to justify the sinking of five genera. Although amphisbaenians continue to be described based on a consistent suite of morphological characters, the paucity of museum specimens hinders our ability to judge the diagnostic value of various morphological traits.

In the 1971 study by Gans and Latifi, variation in morphology of *M. guentheri* is attributed to geography and ontogeny, but little consideration is given to how much natural variation exists within populations. Great variation is evident within as well as between geographic locations in their study, although it is unknown over how great a geographic distance animals were collected and classified as being from Brazzaville, Kinshasa or Pointe Noire. Due to the relative paucity of useful locality markers in the region, it is possible that specimens collected over a wide area were identified as being from the same locale.

We set out to assess the usefulness of taxonomic characters traditionally used to describe *M. guentheri* by measuring animals from a small and long-isolated patch of forest, where they represent a single, likely reproductively isolated population. We documented variability in characters such as number of anal plates and number of pre-anal pores. We also quantitatively tested the robustness of number of annuli as a character to distinguish *Monopeltis* species. We hypothesised that the number of annuli might increase ontogenetically (using the total length of the animal as a proxy), making it an unreliable character for distinguishing species. On the other hand, if the number of annuli remains constant throughout the animal's lifetime, then this character might be a useful species-specific character for taxonomic classification.

We collected 64 specimens of *M. guentheri* from the ORSTOM Forest Park (Fig. 1), a small patch of dense, semi-deciduous forest (6.83 km^2) located within the city of Brazzaville (S 4° 16' 40.82'' E 15° 14' 26.28'' elevation 764 m). The park was formerly the Brazzaville office of the French Office de la Recherche Scientifique et Technique

Table 1. Characters used to describe Centraland West African species of *Monopeltis*.

Species	Number of specimens	Head shield pattern	Pectoral shield pattern	Snout – vent length (mm)	Tail length (mm)	Number of anal plates	Number of pre-anal pores	Number of body annuli	Number of tail annuli	Number of dorsal segments (ventral segments)	References
M. guentheri (this study)	64	2 fused in adults	Elongate parallel	50–292	10–31	6–8	6–10	232–251	26–29	17–23 (13–16)	
M. guentheri (literature)	89	2 fused in adults	Elongate parallel	109–356	14–39	6–8	5–9	236–261	22–29	14–24 (12–18)	b, c, d
M. galeata	42	2 unfused	Elongate parallel	206–436	26–37	6–8	0–4	210–233	15–20	9–12 (7–10)	a, b, d, e, f, g
M. jugularis	15	2 unfused	Short non-parallel	341–640	18–37	4-6	0	200–211	7–17	14–22 (14–18)	b, d, f
M. schoutedeni	32	2 fused in adults	Elongate parallel	140–660	16–81	8-10	8–13	261–289	25–34	16–23 (14–17)	b, d
M. vanderysti	38	2 fused in adults	Elongate parallel	220–346	24	4-6	0	214–241	13–17	18–23 (14–16)	b, h

Sources of information: a. Schmidt (1919); b. Laurent (1947); c. Gans & Latifi (1971); d. Gans & Lehman (1973); e. Branch *et al.* (2003); f. Chirio & LeBreton (2007); g. Pauwels & Vande weghe (2008); h. Broadley *et al.* (1976).

Figure 1. (A) A live *Monopeltis guentheri* collected as part of our study; (B) The study site: ORSTOM Forest Park in Brazzaville.

Outre-Mer (ORSTOM), now the Institut de Recherche pour le Développement (IRD). It is currently operated by the Congolese Ministry of Scientific Research. The park is subject to frequent disturbance from foot traffic, subsistence farming, and wood harvesting for cooking. Within this park we manually excavated 49 specimens and found the remaining 15 on the ground during and after rain. All specimens were deposited with the Groupe d'Étude et de Recherche en Diversité Biologique (GERDIB) at the Université Marien Ngouabi, Brazzaville, Republic of the Congo (catalogue numbers GERDIB500 to GERDIB563).

The following characters and measurements were recorded for each individual as described in Gans and Latifi (1971): (1) snout–vent length (SVL); (2) tail length;

(3) number of anal plates; (4) number of pre-anal pores; (5) number of annuli on body; (6) number of annuli on tail; (7) number of dorsal segments and number of ventral segments in a midbody annulus; and (8) body mass. We considered the total length to be the sum of the snout–vent and tail lengths. We used linear regressions to examine the relationships between body mass and total body length and between total body length and number of annuli on body. The results of our measurements are presented in Table 1 along with accepted character values for the Central and West African species of *Monopeltis*. Below we discuss the relative value of each character trait for identifying our *Monopeltis* specimens.

Head shield pattern

No species can be distinguished on the basis of this character alone as all of the Central and West African *Monopeltis* species have two head shields. In *M. guentheri*, *M. schoutedeni* and *M. vanderytsi* the two head shields fuse as the animal ages while they remain unfused in *M. galeata* and *M. jugularis* (Table 1). Our specimens were unlikely to belong to the latter two species, as they possessed two fused head shields.

Pectoral shield pattern

With the exception of *M. jugularis*, all of the species possess an elongate parallel pectoral shield pattern (Table 1). Given that an elongate parallel pectoral shield pattern was observed in our specimens, this character did not prove useful for identification in our case, but would provide a quick means of identifying *M. jugularis*.

Total length

This is a character with so much overlap between species that it is of potential use only at the upper and lower extremes. For example, both *M. vanderysti* and *M. guentheri* can be ruled out as possibilities if a specimen has a total length exceeding 395 mm (Gans & Lehman 1973; Broadley *et al*. 1976). The range of total length for our specimens is 60–323 mm, and therefore this trait did not prove useful for identification. We hypothesise that the shortest animals we collected represent juveniles, although this casts doubt on the alleged lower limits of all species.

Nor are we confident in the accuracy of the upper limits. Compared to other taxonomic groups, amphisbaenians are difficult to obtain and poorly represented in museum collections. Our compilation of character variation known from the literature (Table 1) includes some species known from relatively large sample sizes, such as 89 individuals for *M. guentheri* (Gans & Latifi 1971), but compares them with others known from only a few individuals, such as 15 individuals for *M. jugularis* (Gans & Lehman 1973). The actual length ranges of different species may turn out, with additional sampling, to be much broader than currently recognised.

Number of anal plates

Table 1 shows that this character is of limited potential usefulness as a taxonomic character. In our sample of 64 individuals, 39 had six anal plates and 25 had eight.

While the specimens with six anal plates could be confidently identified as *M. guentheri*, those with eight anal plates could not be ruled out as *M. schoutedeni*. The remaining three species were ruled out based on the number of pre-anal pores (see below and Table 1).

Number of pre-anal pores

There is confusion in the literature regarding the number of pores for each species and some species, as currently described, show wide variability in the number of pre-anal pores (Table 1). The number of pre-anal pores in our specimens ranges from 6 to 10, overlapping with the reported ranges of both *M. guentheri* and *M. schoutedeni* (Table 1). The number of pre-anal pores on both the left and right sides ranged from three to five. Fifty-four specimens had symmetrical pre-anal pores, while the number of pre-anal pores was asymmetrical in the remaining 10 individuals. It would be interesting to compare the asymmetry of pre-anal pores across species. Schmidt (1919) describes one specimen of *M. galeata* with asymmetrical pre-anal pores. From the odd maximum number of pre-anal pores reported for *M. schoutedeni* (13) we can conclude that anal-pore asymmetry is present in this species as well, although no other source discusses pre-anal pore symmetry.

None of our 64 specimens lacked anal pores. This is consistent with *M. guentheri* and *M. schoutedeni* but not with *M. galeata*, where pre-anal pores are present in males only, and *M. jugularis* and *M. vanderysti*, which completely lack pre-anal pores (Gans & Lehman 1973; Branch *et al.* 2003; Pauwels & Vande weghe 2008).

Number of dorsal/ventral segments

This character shows considerable variation in each of the described species, and our results also show a considerable range of values. Furthermore, there is almost complete overlap of values between all species except *M. galeata*. Number of dorsal/ventral segments may therefore be a potentially useful taxonomic character in identifying *M. galeata*, but it is not a useful character in the identification of *M. guentheri*.

Number of annuli on body and tail

We tested the hypothesis that the total number of annuli found on the body and tail increased with ontogeny, by comparing number of annuli with total length. We found no significant correlation ($r^2 = 0.05568$, $p = 0.0605$) between number of annuli and total length (Fig. 2). Data from previous authors (Table 1) indicate little or no overlap in total number of annuli in different species. In our sample of 64 specimens, we found 232–251 annuli on the body and 26–29 annuli on the tail. These values fall almost completely within the range of *M. guentheri*. Barring an expansion of ranges of annuli to the point of significant overlap (resulting from increasing sample sizes for the species studied), the total number of annuli appears to represent a useful character for distinguishing *Monopeltis* species from Central and West Africa.

This preliminary study of morphological variation in *Monopeltis guentheri* at the population level draws attention to the limitations of characters traditionally used

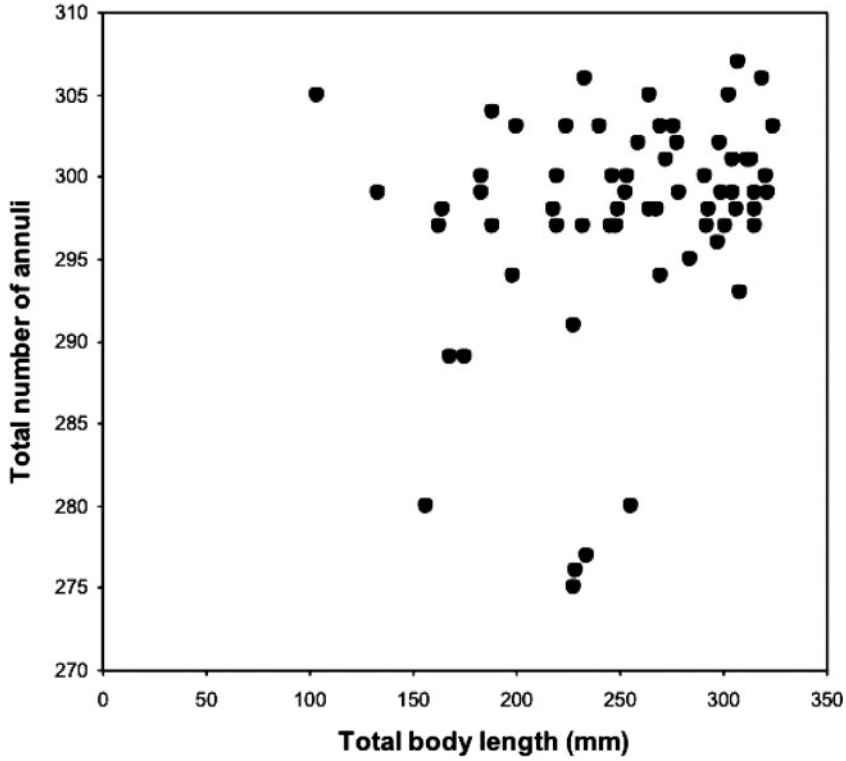

Figure 2. Total number of annuli (body + tail) as a function of total length (SVL + tail length) in *Monopeltis guentheri* collected from ORSTOM Forest Park in Brazzaville, Republic of Congo.

for the taxonomic study of Central and West African *Monopeltis*. Our results demonstrate some of the shortcomings of the sparse literature currently available for this genus and species, and for African amphisbaenians in general.

Acknowledgements

We thank S.V. Pangou and I. Mady-Goma Dirat for access to research facilities. G. Lenglet and O.S.G. Pauwels provided helpful documents. T. Knight provided advice on statistical analysis of the data, and C. Laveissière corrected the French resumé. We are grateful to A.-G. Zassi-Boulou and J. Goma-Tchimbakala for guidance during the preparation of the manuscript, and we thank T. Giri for improvements to the original version.

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Received: 6 August 2012; Final acceptance: 18 December 2012