

Refinement of locality data for FitzSimons' Garter Snake *Elapsoidea sundevallii fitzsimonsi* Loveridge, 1948 provides a better estimation of its distribution

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Foundational data on species taxonomy, distribution and ecology forms the basis of assessing species for their conservation status. For African reptiles, distributional data are sorely lacking for many taxa, sometimes resulting in inadequate conservation assessments (Tolley et al., 2016). In South Africa, some geographic areas are poorly sampled with gaps exceeding 15,000 km² in which there are no locality records (see Branch, 2014) and the implications of this could be considerable in terms of assessing species for extinction risk. To address these information gaps, we surveyed in the poorly sampled arid western Kalahari region of North West Province, South Africa during 2019.

During a night drive on 27 March 2019 at 19:55 h in the evening, we collected an *Elapsoidea sundevallii* Smith, 1848 specimen 17.5 km north of Vostershoop, North West Province (25.6871°S, 23.0862°E; 1015 m a.s.l.) on a dirt road that runs between regional roads R378 and R379 (Fig. 1). This specimen was deposited in the National Museum in Bloemfontein, South Africa (accession number NMB R11788). There are no other records of this species from the area, the closest records being *E. s. fitzsimonsi* Loveridge, 1944, 210 km to the

north and 220 km to the north-east. We made scale counts in order to assign our new specimen to one of the currently recognised subspecies. Our individual measures 395 mm snout-vent length (SVL) and 35 mm tail length, is dark grey dorsally with white ventral scales and one row of white dorsal scales bordering the ventral scales, has 165 ventral scales, 21 divided subcaudal scales (Fig. 2; Table 1) and is a male, as confirmed by probing. The scale counts fall within the range for males of four subspecies: *E. s. fitzsimonsi*, *E. s. longicauda* Broadley, 1971, *E. s. sundevallii* and *E. s. media* Broadley, 1971, but falls outside the range indicated for *E. s. decosteri* Boulenger, 1888, ruling that subspecies out (Table 1). Cross-barring colour patterns are sometimes used as diagnostic features between subspecies of *Elapsoidea sundevallii* (Broadley, 1971; Broadley, 1983). Although the banding appears to fade with age among all the subspecies, it does appear to be retained throughout life in the nominal form *E. s. sundevallii* (Broadley, 1971; Marais, 2004; Broadley and Blaylock, 2014). Because our specimen bore no such markings, we also ruled out *E. s. sundevallii*, leaving *E. s. fitzsimonsi*, *E. s. longicauda* and *E. s. media* as potential candidates.

Using the dichotomous keys for the genus *Elapsoidea* in Broadley (1971, 1983), the new male specimen (with 165 ventrals and 21 subcaudals) keys out as *E. s. media* (males: 157–168 ventrals, 19–23 subcaudals). In the key, the ventral scale range is a mismatch for *E. s. fitzsimonsi* (males: 167–180 ventrals, 19–23 subcaudals) and the subcaudal range does not match *E. s. longicauda* (164–179 ventrals, 29–33 subcaudals). However, literature (e.g. Broadley, 1998; Broadley and Blaylock, 2014) and museum records (Table 1) subsequent to Broadley (1971, 1983) show that the range of ventral scale counts in those keys are inaccurate. Our specimen matches museum and literature scale counts for *E. s. fitzsimonsi*, *E. s. media* and *E. s. longicauda* (Table 1).

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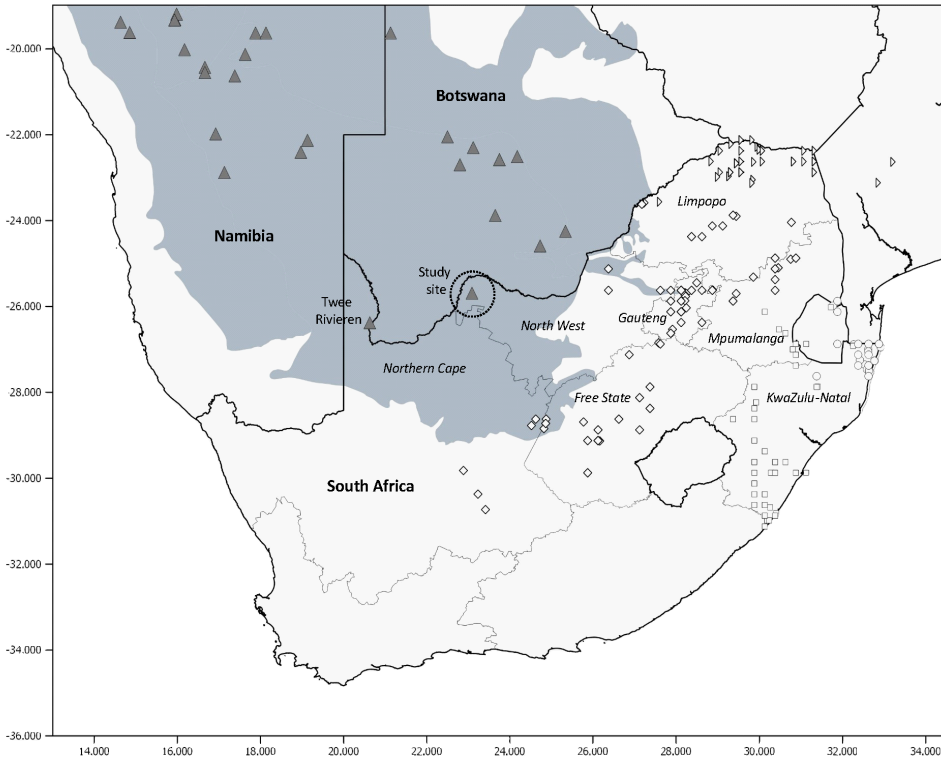


Figure 1. Distribution records of *Elapsoidea sundevallii* subspecies: *E. s. fitzsimonsi* (grey triangles), *E. s. media* (white diamonds), *E. s. longicauda* (side triangles), *E. s. sundevallii* (white squares), *E. s. decosteri* (white circles). The new record from Vostershoop, North West Province is indicated by the dotted circle. Grey shading indicates the Kalahari arid savanna and Mopane regions. Relevant provinces of South Africa are labelled.

Table 1. Scale counts for the *Elapsoidea sundevallii fitzsimonsi* individual collected in this study (NMB R11788), and the range of counts from literature records and museum specimens (Table 3). Unless otherwise indicated, literature data are from Broadley (1983), which provides the most comprehensive dataset. Ranges are provided only for individuals of known sex.

	Subcaudals		Ventrals	
	Female	Male	Female	Male
NMB R11788	-	21	-	165
<i>E. s. fitzsimonsi</i> (museum specimens)	16–17	21–25	156–161	171–181
<i>E. s. fitzsimonsi</i> (other literature sources)	16–20	22–23	156–161 (155–161) ^{1,2}	167–180 (162–177) ¹ (162–180) ³
<i>E. s. fitzsimonsi</i> (all sources)	16–20	21–25	155–161	162–181
<i>E. s. media</i>	13–18	19–23	140–154	157–168
<i>E. s. longicauda</i>	24–28	21–33	148–156 148–158 ⁴	164–179
<i>E. s. decosteri</i>	22–26	26–28	138–144	152–159 150–159 ⁴
<i>E. s. sundevallii</i>	16–21	20–28	147–156	163–181

Range of counts from ¹Loveridge 1944; ²Broadley & Blaylock 2014; ³Broadley 1998; ⁴Jakobsen 1997



Figure 2. *Elapsoidea sundevallii fitzsimonsi* (NMB R11788) collected in the North West Province, South Africa: a) dorsal head, b) ventral head, c) lateral head, d) specimen in life (Photos: Krystal Tolley and Nicolas Telford).

Given that we could not identify the specimen based on scale counts alone, we interrogated the distributional data for clarification. Although the four nearest records are of *E. s. fitzsimonsi*, *E. s. media* has been recorded approximately 400 km south-east and *E. s. longicauda* about 550 km north-east (Fig. 1). *Elapsoidea s. longicauda* occurs in mesic savannah, while *E. s. media* is generally associated with grassland, mesic savannah and Nama-Karoo. Our record, as well as all *E. s. fitzsimonsi* records are from Kalahari (arid

savannah (Broadley, 1971; Auerbach, 1987; Broadley and Blaylock, 2014; see Mucina and Rutherford, 2006; Fig. 1). The balance of evidence derived from scalation metrics, proximity of existing records and the habitat association suggest that our specimen is best assigned to *E. s. fitzsimonsi*.

Despite the overlap in the range of scale counts for the subspecies and lack of consistency across the literature regarding diagnostic counts (e.g. Sternfeld, 1910; Broadley, 1983; Branch, 1998; see Pietersen

Table 2. Measurements and scale counts (with range of values) for specimens assigned to *Elapsoidea sundevallii fitzsimonsi* by NM: National Museum Bloemfontein, TM: Ditsong National Museum of Natural History, FMNH: Field Museum of Natural History, NMN: National Museum of Namibia, MCZ: Museum of Comparative Zoology, PEM: Port Elizabeth Museum, ZMB: Museum für Naturkunde, Berlin. SVL: snout-vent length (mm). T: Type specimen, P: Paratype. F: female, M: male, J: juvenile.

Catalogue no.	Sex	SVL	Tail	Subcaudals	Ventrals
NMB R11788	M	326	30	21	165
FMNH 17666 (P)	F(?)	570	36 ³	17 ³	157
FMNH 17667 (T) ¹	M	671	43	21	181
MCZ 46795 (P) ² (FMNH 17668)	M	432	34	22 ⁴	177
NMN 1726	–	194	19	21	158
NMN 8252	–	700	46	20	165
NMN 9152	–	530	37	20	164
NMN 9155	–	604	39	21	168
NMN 9156	–	357	34	23	164
NMN 9157	–	490	36	20	167
PEM R14989	M	555	44	23	175
PEM R8743	F	485	31 ³	15 ³	161
TM 12711	J	210	18	22	171
TM 14707 (P)	M	695	50	23	172
TM 14708 (P) ⁵	M	716	50	–	–
TM 24644	F	367	28	17	157
TM 30880	J	163	15	21	158
TM 45765	F	458	33	16	156
TM 64046	M	375	34	22	171
TM 69145	M	525	48	25	173
ZMB 21664	F	424	29	17 ⁶	157
Ranges					
Juveniles		163–210	15–18	21–22	158–171
Females		367–570	28–36	16–17	156–161
Males		326–716	30–50	21–25	165–181
Unknown		194–700	19–46	20–23	158–168

¹ Counts are from Loveridge 1944

² Transferred from FMNH to MCZ collection in 1943 and assigned new catalogue number

³ Tail truncated

⁴ Re-count made on specimen by MCZ disagrees with FitzSimons (1944) which indicates 23

⁵ Specimen missing

⁶ Recorded as 18 subcaudals in Sternfeld 1910. Re-counted by ZMB in April 2019

et al., 2013), these characters are considered as indicative for the subspecies of *E. sundevallii*. We argue that the overlap in counts is substantial enough to make them unreliable for taxonomic purposes. To examine this further, measurements and scale counts for an additional 20 museum voucher specimens of *Elapsoidea sundevallii fitzsimonsi* were made by either museum personnel or where this was not possible, from scaled images provided by the museums (Table 2). In all cases, scale counts were made following guidelines in

Branch (1998) and Dowling (1951), and measurements made either directly on the specimen or from the images using ImageJ freeware (<https://imagej.nih.gov/ij/>). The resulting scale count ranges differ slightly from those reported in the historical literature sources (Table 1). We noted that the scale counts did not depend on body or tail length (ventral scales, $r^2 = 0.14$, $p = 0.13$; subcaudal scales $r^2 = 0.06$, $p = 0.35$, respectively), suggesting that any bias in specimen size in these collections does not play a role in the range of values for scale counts.

Table 3. Records of *Elapsoides sundevallii fitzsimonsi* collated directly from museum databases. Existing database coordinates were verified as part of this study, or were estimated using Google Earth (see coordinate uncertainty column). A lack of data is indicated by a dash. QDS: Quarter degree grid square. NM: National Museum Bloemfontein, TM: Dissong National Museum of Natural History, FMNH: Field Museum of Natural History, NMN: National Museum of Namibia, MCZ: Museum of Comparative Zoology, PEM: Port Elizabeth Museum, ZMB: Museum für Naturkunde, Berlin. Lat: Latitude, Long: Longitude. †Transferred from FMNH to MCZ collection in 1943 and assigned a new catalogue number.

Catalogue no.	Sex	Record type	Collector	Country	Locality	Lat	Long	Coordinate uncertainty	QDS	Date	Source
NMB R 11788	M	Specimen	This study	South Africa	North West Province, 17 km north of Vostershoop	-25.69	23.09	+/-3m	2523CA	2019-Mar-27	NMB catalogue (this study)
TM 24644	F	Specimen	Braim, C.K.	South Africa	Northern Cape Province, Twee Rivieren	-26.38	20.63	QDS centre point	2620BC	1957	TM catalogue
FMNH 17666	F	Paratype	Lang, H.	Botswana	Between Gomodimo and Kuke	-22.51	24.18	Halfway between Gomodimo & Kuke (FitzSimons 1937)	2223DD	1930-Apr	FMNH catalogue; FitzSimons 1937
FMNH 17667	M	Holotype & images	Lang, H.	Botswana	Gomodimo Pan	-22.58	23.75	Unknown (FitzSimons 1937)	2223DA	1930-Apr	FMNH catalogue; FitzSimons 1937
MCZ 46795 (FMNH 17668) [†]	M	Paratype	Lang, H.	Botswana	Gomodimo Pan	-22.58	23.75	Unknown (FitzSimons 1937)	2223DA	1930-Apr	FMNH/MCZ catalogue; FitzSimons 1937
NMZB 9326	?	Specimen	de Graaf, J.	Botswana	22 km NW of Molepolole	-24.25	25.34	22 km NW of Molepolole (FitzSimons 1937)	2425AD	1988-Jan-04	NMZB catalogue
PEM R 14989	M	Specimen	Tilbury, C.	Botswana	Jwaneng	-24.59	24.73	Google Earth: Jwaneng	2424DA	1996-Apr-30	PEM catalogue
PEM R8743	F	Specimen	Tilbury, C.	Botswana	Tshwaane, Kwaneng Pan	-23.88	23.65	Google Earth: largest pan in QDS	2323DC	-	PEM catalogue
TM 14707	M	Paratype	Fitzsimons, V.	Botswana	Okwa River	-22.30	23.12	Unknown (FitzSimons 1937)	2221BC	1930-Apr	TM catalogue; FitzSimons 1937
TM 14708	M	Paratype	Fitzsimons, V.	Botswana	Damara Pan	-22.05	22.50	Unknown (FitzSimons 1937)	2222BA	1930-Apr	TM catalogue; Fitzsimons 1937
TM 30880	J	Specimen	Haacke, W.D.	Botswana	Ngamiland, Dobe	-19.57	21.03	GEO Locate: Dobe	1921CA	1965-Apr-08	TM catalogue
TM 64046	M	Specimen	Joubert, G.	Botswana	Kang	-22.70	22.80	Google Earth: Kang	2223DB	1985-Feb	TM catalogue
NMN 1726	-	Specimen	Swanepoel, D.J.S.	Namibia	Farm Leutwein 218	-22.83	17.12	GEO Locate: Leutwein 218	2217CC	1972-Oct	NMN catalogue; photos
NMN 7551	-	Specimen	-	Namibia	Eastern National Water Carrier (Omatako section)	-	-	-	-	-	NMN catalogue; Broadley 1998

Table 3. Continued.

Catalogue no.	Sex	Record type	Collector	Country	Locality	Lat	Long	Coordinate uncertainty	QDS	Date	Source
NMN 8252	–	Specimen	Pack, R.	Namibia	Farm Dowan 384, Gobabis District	-22.13	19.13	QDS centre point	2219AA	1965-Mar-30	NMN catalogue; photos
NMN 8884	–	Specimen	–	Namibia	Ojjiwarongo, Eastern National Water Carrier	–	–	–	–	–	NMN catalogue; Broadley 1998
NMN 8885	–	Specimen	–	Namibia	Ojjiwarongo, Eastern National Water Carrier	–	–	–	–	–	NMN catalogue
NMN 8886	–	Specimen	–	Namibia	Ojjiwarongo, Eastern National Water Carrier	-20.63	17.38	–	2017CB	–	NMN catalogue
NMN 8887	–	Specimen	–	Namibia	Eastern National Water Carrier	–	–	–	–	–	NMN catalogue
NMN 8888	–	Specimen	–	Namibia	Eastern National Water Carrier	-20.13	17.63	–	2017BA	–	NMN catalogue
NMN 8889	–	Specimen	–	Namibia	Eastern National Water Carrier	-19.63	17.88	–	1917DB	–	NMN catalogue
NMN 8890	–	Specimen	–	Namibia	Ojjiwarongo, Eastern National Water Carrier	–	–	–	–	–	NMN catalogue
NMN 8891	–	Specimen	–	Namibia	15 km S of Okaukuejo	-19.32	15.94	Google Earth: 15 km S of Okaukuejo	1915BD	1986-Feb-26	NMN catalogue; Broadley 1998
NMN 8892	–	Specimen	–	Namibia	Ojjiwarongo, Eastern National Water Carrier	–	–	–	–	–	NMN catalogue; Broadley 1998
NMN 8893	–	Specimen	–	Namibia	Ojjiwarongo	-20.43	16.66	Google Earth: Ojjiwarongo	2016BC	–	NMN catalogue; Broadley 1998
NMN 8894	–	Specimen	–	Namibia	Etosha National Park, Gaseb road to Gembokvlakte	-19.19	15.98	Google Earth: Gaseb road	1915BD	–	NMN catalogue; Broadley 1998
NMN 9142	–	Specimen	–	Namibia	Kamanjab	-19.62	14.85	Google Earth: Kamanjab	1914DB	–	NMN catalogue
NMN 9152	–	Specimen	–	Namibia	10 km north of Oujjo	-20.02	16.17	Google Earth: 10 km north of Oujjo	2016AA	1994-Jan	NMN catalogue; photos
NMN 9155	–	Specimen	–	Namibia	2km east of entrance to Etosha National Park	-18.80	17.07	Google Earth: 2 km east of Etosha entrance	1915BD	1997-Nov-01	NMN catalogue; photos
NMN 9156	–	Specimen	Ossborn, T.	Namibia	Ombika, Etosha National Park	-19.33	15.93	Google Earth: Ombika	1915BD	1998-Feb-28	NMN catalogue; photos

Table 3. Continued.

Catalogue no.	Sex	Record type	Collector	Country	Locality	Lat	Long	Coordinate uncertainty	QDS	Date	Source
NMN 9157	–	Specimen	Theophilus	Namibia	Ombika, Etosha National Park	-19.33	15.93	Google Earth: Ombika	1915BD	–	NMN catalogue; photos
SMF 32673	–	Specimen	–	Namibia	Okahandja (12 km south of Otjiwarongo)	-20.55	16.66	Google Earth: Highway B1, 12 km south of Otjiwarongo	2016BC	–	NMN catalogue; Broadley 1971
TM 12711	J	Specimen	Bradfield, R.D.	Namibia	Otjiwarongo Province, Okahandja	-21.98	16.92	Google Earth: Okahandja	2116DD	1926-Aug	TM catalogue
TM 45765	F	Specimen	Odendaal, F.	Namibia	Kaokoveld, Farm Rustig, 30km NNW Kamanjab	-19.38	14.63	QDS centre point	1914BC	1975-Feb-05	TM catalogue
TM 69145	M	Specimen	Owen, C.	Namibia	Eastern National Water Carrier	-19.63	18.13	QDS centre point (Google Earth: Grootfontein)	1918CA	1988-Dec	TM catalogue
ZMB 21664	F	Specimen	Lübbert, E.F.A.	Namibia	Gobabis	-22.41	18.97	Google Earth: Gobabis	2218BD	1910	ZMB catalogue

The lack of consistent diagnostic differences between the subspecies based on scale counts suggest that the currently defined subspecies require confirmation, preferably within a phylogenetic framework with comprehensive sampling from across the range of each subspecies (Alexander, 2014).

It is notable that the records assembled here for *E. s. fitzsimonsi* show some differences to the historical literature (e.g. FitzSimons, 1962; Broadley, 1983; Auerbach, 1987), but largely correspond with more recent literature (e.g. Broadley, 1998). In particular, the only other South African record (TM 24644 from the Ditsong National Museum of Natural History - formerly Transvaal Museum) is from Twee Rivieren (Kgalagadi Transfrontier Park), but FitzSimons (1962) also indicates that there are specimens from “Mata Mata” and “Waterpoort” (both in South Africa) in the Ditsong Museum. However, there are no *E. s. fitzsimonsi* specimens from these localities in the Ditsong Museum catalogue, nor do they appear on FitzSimons’ map (Map 61), suggesting that these localities are in error. A perplexing issue relates to a specimen of *E. s. fitzsimonsi* (“RMNH 1719”) from “13 km NW of Molepolole” (Botswana) referenced in Broadley (1998). The Naturalis Museum, Netherlands (RMNH), confirms that such a specimen does not exist in their collection, and the accession number is assigned to an Asian amphibian (*Polypedates*). There is a specimen of *E. s. decosteri* in their collection, but identification, accession number (ZMA.RENA.13740) and locality information (captive individual from Artis Amsterdam Royal Zoo) all differ from that provided by Broadley (1998). Thus, the specimen indicated in Broadley (1998) cannot be traced at present.

The locality maps provided in the historical literature differ from each other (e.g. FitzSimons, 1962; Broadley, 1971, 1983, 1998; Auerbach, 1987; Broadley and Blaylock, 2014), despite these publications usually referring to the same set of records. We therefore produced an updated distribution map of *E. s. fitzsimonsi*. We mapped our new record together with coordinates from museum databases and by estimating the coordinates from the locality descriptor where coordinates were not available (Fig. 1, Table 3). Our collated data and the addition of the new record provide a clearer picture of the geographic distribution of this subspecies and suggest that it may occur more extensively in Botswana, Namibia and notably, South Africa, than previously supposed (compare to maps in Branch, 1998; Marais, 2004; Alexander, 2014). Despite

this, the subspecies is probably not widespread across South Africa and is most likely restricted to the arid Kalahari regions. The region is poorly surveyed, with many quarter degree grid squares (QDS) containing few or no reptile records (see Bates *et al.*, 2014) across an area that totals more than 15,000 km². The lack of survey data over a large swathe of the Kalahari region where the subspecies potentially occurs may have previously biased our interpretation of its distribution. Given that *Elapsoidea sundevallii* is fossorial but moves on the surface at night (Broadley, 1971), we conclude that detection probability is low. Thus, poor survey effort and low detection probability are compounded, resulting in few records, but this should not be confused with rarity or absence.

The morphological traits used to differentiate between the subspecies of *E. sundevallii* are of questionable value and provide motivation for new analyses that include the use of modern phylogenetics to better understand the subspecies designations (Alexander, 2014). Furthermore, our new record shows that this subspecies is more widespread and highlights the need for basic survey data in under-sampled areas (e.g. Tolley *et al.*, 2016). Without good representation of records across all regions, species distributions, as well as patterns of diversity and richness, are likely to be misunderstood.

Acknowledgements. Field work was funded by the National Research Foundation of South Africa, Foundational Biodiversity Information Program (Grant no. 115944). Thanks to Declan Hofmeyr, Carmen Hofmeyr (Molopo Nature Reserve) and John Power (North West Province, Department of Rural, Environment and Agricultural Development) for logistical assistance. We are grateful to Adriaan Jordaan (Ditsong National Museum of Natural History, Pretoria), Werner Conradie (Port Elizabeth Museum), Frank Tillack (Museum für Naturkunde, Berlin), Alan Resetar and Josh Mata (Field Museum of Natural History) and José Rosado (Museum of Comparative Zoology) for providing scale counts on specimens, Francois Becker for providing data and photos from the National Museum of Namibia, Lauretta Mahlangu for access to the Ditsong National Museum of Natural History data, Aaron Bauer for verifying the NMN data and Werner Conradie for very helpful comments and advice on the manuscript. Field work was carried out under permit NW 7299/02/2019.

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Accepted by Werner Conradie