Short communications

Taxonomic status and distribution of the South African lizard *Tetradactylus breyeri* Roux (Gerrhosauridae)

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The taxonomic status of the poorly known South African gerrhosaurid *Tetradactylus breyeri*, described by Roux in 1907 on the basis of a single specimen from the Transvaal, was investigated. The holotype and 14 other preserved specimens were examined and are described in detail. Prior to this study, only six specimens had been described in the literature. No evidence was found to warrant subspecific status for lizards from any part of the species' range, despite the apparently isolated nature of populations, and *T. breyeri* is thus considered monotypic. The species occurs as three apparently isolated montane grassland to highveld grassland populations in the South African provinces of Mpumalanga, north-eastern Free State and KwaZulu-Natal. Despite recent surveys, very few specimens have been found, and the 'rare' status afforded the species in the South African Red Data Book should be retained.

The genus *Tetradactylus* Merrem comprises six species of small, terrestrial, diurnal and serpentiform lizards restricted to the southern half of Africa (Branch 1988; Lang 1991). Only *T. ellenbergeri*, a grassland species of eastern Angola, southern Zaire, western and northern Zambia, and south-eastern Tanzania (Broadley & Howell 1991), occurs outside the borders of South Africa (Branch 1988) and Swaziland (where only *T. a. africanus* occurs; Boycott 1992). The various taxa exhibit a transition from pentadactyle lizards (*T. seps*) to serpentiform lizards possessing only minute, monodactyle hindlimbs (*T. a. fitzsimonsi*, *T. ellenbergeri*) (Loveridge 1942; FitzSimons 1943; Berger-Dell'mour 1983).

Roux (1907) described and illustrated *T. breyeri* on the basis of a single specimen collected by Dr Breyer in 1896 at the type locality vaguely described as 'Transvaal'. Boulenger (1910) examined what later proved to be the second known specimen of *T. breyeri*, collected at Rietvlei near the source of the Umvoti River in KwaZulu-Natal, but identified it as *T. africanus*. Loveridge (1942) examined specimens from Umvoti (= Rietvlei) and Weenen County in KwaZulu-Natal, while FitzSimons (1943) examined these and another from Umgeni Poort in KwaZulu-Natal. These were all identified as *T. breyeri*. De Waal (1978:49–50) subsequently examined a specimen collected on the farm Zwartkoppies in the north-eastern Free State, noting that it 'differs from typical *breyeri* in having three femoral pores on either side instead of two; upper head shields smooth instead of ribbed; first two supraoculars instead of first three in contact with frontal; frontoparietals in contact, not separated by interparietal'. De Waal (1978:50) added that 'while the Zwartkoppies specimen probably represents an undescribed subspecies a new name is not proposed in the absence of a series of specimens which can serve to define variation in the subspecies, especially as so little is known about variation within the nominate race'. Bourquin & Channing (1980) later recorded a specimen of *T. breyeri* from Cathedral Peak Forest Reserve in KwaZulu-Natal, while Jacobsen (1989) described two specimens collected in Mpumalanga province. Specimens from the farm Stratherrick in the north-eastern Free State were briefly discussed by Bates (1993a).

In the present study variation in morphology and scutellation in the 15 known specimens of *T. breyeri* was examined, and De Waal's (1978) proposal that the Zwartkoppies specimen represents a distinct subspecies was re-evaluated. The distribution, habitat and conservation status of *T. breyeri* were also studied.

The holotype, housed in the Zoologisch Museum at the University of Amsterdam (The Netherlands), together with all 14 available specimens of *T. breyeri* in southern African museums and private collections, was examined (Appendix 1). All characters used in previous descriptions of *T. breyeri* (Roux 1907; Loveridge 1942; FitzSimons 1943; De Waal 1978; Jacobsen 1989) were examined. The format and terminology used in describing specimens is similar to that used by FitzSimons (1943).

Scale counts and position of head scales were determined for both sides of the head. If the number or position of scales was not the same on both sides, this was indicated in the description. Head length was measured from the tip of the rostral to the posterior border of the ear opening, on the left side of the head, using vernier calipers (0.02 mm accuracy). Snout-vent length and tail length were measured using vernier calipers or a steel rule and values expressed to the nearest millimeter. Transverse rows of dorsals were counted from the first row posterior to the nuchals (even if the nuchal row had the appearance of a dorsal row) to the row above the vent. Transverse rows of ventrals were counted from the row immediately posterior to the rear margin of the forelimb insertion to the row immediately anterior to the enlarged precloacal plates. Gender was usually determined after dissection of the belly and examination of gonads (NM 1204 was identified as a male on account of its everted hemipenes), but in poorly preserved specimens sex determination was tentatively based on the presence of a pair of prominent, claw-like scales on either side of the vent (males) versus small, flattened or inconspicuous scales at the vent (females). Some of the specimens examined had faded colour patterns (including the holotype) or missing dorsal scales, and the description of colour pattern was therefore based mainly on recent material (e.g. NMB R1073).

Re-description of *Tetradactylus breyeri* Roux, 1907

Data for the holotype (a male, testis examined) and 14 additional specimens are included below and in Table 1. In general, Roux's (1907) description of the holotype is largely accurate, although 14, not 12, longitudinal dorsal scale rows are present (scales of the lateral rows are much reduced), there are four supraciliaries on either side of the head, not four on one side and five on the other; and a series of eight, not seven, scales are present on the outer surface of each hindlimb. The dorsal and lateral head scalation of the holotype approximates that of NM 593, as figured by FitzSimons (1943: 295), but the frontoparietals of the holotype are longer (about twice as long as broad).

Morphology and scalation

Serpentiform, original tail 2.13–2.99 (2.99 in holotype) times snout-vent length (mean 2.57; *SD* 0.333; *n* = 8); limbs minute, about as long as the head is wide; forelimb slender, didactyle, digits clawed, inner digit half to less than half the length of outer (one-third length of outer in holotype and NMB R1073); hindlimb stout, monodactyle, clawless, slightly shorter than forelimb. Scales on outer surface of forelimb 7–10 (seven in holotype) (excluding digits), 2–3 (three in holotype) on outer digit, one on inner digit (*n* = 12); scales on outer surface of hindlimb 6–10, usually eight as in holotype (*n* = 12). Head length 0.122–0.155 (0.155 in holotype) times snout-vent length (mean 0.139; *SD* 0.0123; *n* = 11). Upper head shields smooth to feebly ribbed longitudinally on some scales (only frontal with median fold in holotype); frontal always with a weak median 'keel' or fold longitudinally. Nostril pierced between two nasals and well separated from first supralabial and rostral (NMB R1073 has a minute scale between the nasals on the right side). Frontonasals and rostral separated by nasals; anterior nasal of NMB R6853 fragmented, creating impression of small scale separating nasals. Four supraoculars, first two or three (usually, and in holotype) in contact with frontal; first and third supraoculars usually in very narrow contact with frontal (in the holotype only the third supraoculars are in very narrow contact with the frontal); second supraocular the longest and broadest and always in contact with frontal. Frontal elongated, about twice as long as broad, posteriorly making contact with interparietal and frontoparietals (except in NMB R1073 and AJL 2751 where frontoparietals are in narrow contact and separate interparietal from frontal). Interparietal somewhat elongate, 2–3 times (two times in holotype) as long as broad; fused with parietal on right side of head, and frontoparietals separated by a tiny scale, in TM 78785. Parietals large, about one-and-a-half times as long as broad; right side parietal of TM 56692 fragmented. Four supralabials, two anterior to the narrow, elongated subocular (= third supralabial); in NM 1204 there are five supralabials on the right side with three anterior to the subocular. Three infralabials (four on left side of TM 56692), the second much elongated. Supraciliaries usually four, but three on left side of NMB R6853 and five on right side of TM 56692; second supraciliary the longest. Two pairs of chin shields in broad contact posterior to mental, second pair by far the largest. Usually two distinct postoculars (as in holotype). Temporals in diagonal series of 2 + 2 + 1 (2 + 1 + 1 on right side of TM 78785), the most posterior scale by far the largest. Dorsal scales of body and tail multicarinated with a strong median keel (multicarinate but not keeled on nape), in 14 longitudinal and 70–80 (70 in holotype) (mean 74.1; *SD* 2.37) transverse rows on back; outermost longitudinal dorsal scale row on either side with reduced, often more weakly keeled scales (unkeeled and about one-third size of adjacent dorsals in holotype). Ventral plates smooth, in eight longitudinal and 53–63 (55 in holotype) (mean 57.1; *SD* 2.23) transverse series; subcaudal scales elongate and distinctly unicarinate; first two transverse subcaudal scale rows smooth. Three enlarged pre-cloacal plates, median one subtriangular and equal to, or slightly larger than (as in holotype), laterals; plates are either smooth (e.g. holotype) or with a weak longitudinal median keel on the central plate, but in NMZB-UM 3027 all plates are weakly unicarinate. Claw-like scale present at the lateral ends of the first transverse subcaudal scale row, slightly smaller in size than a median dorsal scale; pointed, prominent and claw-like in males, less prominent and more or less flattened against the tail, or inconspicuous (NMZB-UM 3027, TM 56792), in females. Femoral pores usually two per thigh (e.g. holotype), but three in both NMB R1073 and NMB R6853.

Size

Largest males: 64 + 147 = 211 mm (AJL 2751, Dargle); 56 + 164 = 220 mm (NM 1204, near Greytown).

Largest female: 72 + 196 = 268 mm (LR 1817, Highmoor State Forest).

Colour pattern

Dorsal surfaces olive-brown; a dark lateral band from the back of the head to the forelimb insertion, where it usually divides into 2–3 narrow stripes (the innermost usually the most conspicuous and bold) which continue to the base of the tail; a somewhat darker and wider dorso-lateral stripe originates posterior to the nape and continues onto the tail; a short (as in holotype) dark, broken or continuous, median stripe usually present on the nape. Ventral surfaces bluish-grey to cream (e.g. holotype). Top and sides of head with brown spots or patches; a series of up to 13 short, brown, vertical bars or spots (largely faded in holotype) on side of neck inferiorly.

Taxonomic status

Examination of all available material of *T. breyeri* showed that variation occurs in all four character states considered by De Waal (1978) to be indicative of his putative Zwartkoppies 'subspecies'. Variation in two of these characters, as well as size and numbers of transverse dorsal and ventral scale rows, is indicated in Table 1.

Apart from the Zwartkoppies lizard, only one other specimen (NMB R6853) had three femoral pores per thigh, but this specimen was collected in microsympatry with a specimen (NMB R6852) having only two femoral pores per thigh.

The degree or extent of ribbing on the upper head shields is variable and can be reported only in a somewhat subjective manner, making it a poor character to use when distinguishing between taxa. Head shields were either smooth or with feeble ribbing on some scales; however, all specimens exhibited a weak to very weak median longitudinal fold on the frontal. Despite De Waal's (1978:49) comment that the Zwartkoppies specimen had 'upper head shields smooth instead of ribbed', the head shields of his specimen were the most distinctly ribbed of all specimens examined, although this can only be effectively demonstrated when a series is available for comparison. In his description of *T. s. laevicauda*, FitzSimons (1943) noted that the head shields were 'smooth or but feebly ribbed' and Branch (1990) also noted variation in this condition in additional specimens of *T. seps*, again indicating that this character is variable in *Tetradacty-*

lus. The extent of ribbing on the head shields may in fact be ontogenetic and related to skin shedding (Branch 1990).

There was also variation in the number of supraoculars in contact with the frontal in specimens from both Mpumalanga and KwaZulu-Natal populations (Table 1). The first (most anterior) and third supraoculars are usually in very narrow contact with the frontal, and when only two are in contact, the first or third is very narrowly excluded, suggesting that this is of little taxonomic importance. The same variation occurs in *T. seps* (FitzSimons 1943) and *T. tetradactylus* (FitzSimons 1943; unpublished observations).

The final distinguishing character used by De Waal (1978) was that the frontoparietals of the Zwartkoppies specimen were in contact and not separated by the interparietal. However, this was also the case in a specimen (AJL 2751) from Dargle in KwaZulu-Natal, and is a condition which also varies in both *T. tetradactylus* and *T. africanus* (FitzSimons 1943).

The variation discussed above indicates that the Zwartkoppies specimen (NMB R1073) does not represent a distinct subspecies as suggested by De Waal (1978), and all specimens examined are considered representative of a single monotypic species.

Distribution

All accurately documented localities for *T. breyeri* (Appendix 1) are plotted in Figure 1 using the quarter-degree grid and locus code method (De Waal 1978).

Roux (1907) gave the type locality of *T. breyeri* as 'Transvaal'. The species was named after Breyer, who collected several lizards in Rustenburg and 'Pretoria District' in 1896, which were later documented and described by Roux (1907). The holotype of *T. breyeri* may have been collected in either of the two above-mentioned areas (both have at least some apparently suitable grassland habitat), although the area east of Pretoria has more of the suitable habitat and is in closer proximity to the nearest accurately documented Transvaal records. Nevertheless, it seems appropriate at this time to restrict the type locality of *T. breyeri* to Mpumalanga province, South Africa (Figure 1).

Boulenger's (1910) misidentification of a South African Museum *T. breyeri* (as *T. africanus*) from 'Umvoti' (i.e. SAM ZR4220) was corrected by both Loveridge (1942) and FitzSimons (1943), the latter giving the locality as 'Rietvlei nr. Umvoti, Natal'. This locality refers to the community of Rietvlei near the source of the Mvoti River. Loveridge (1942) listed 'Weenen County', and FitzSimons (1943) 'Weenen, Natal', as locality records for *T. breyeri*. They were referring to specimen TM 682 which, according to the Transvaal Museum catalogue, was collected at 'Weenen Co., Natal' (Ms S. Ritter, personal communication, 1993). However, according to Dr O. Bourquin (personal communication, 1993), what was once known as 'Weenen County' stretched from the town of Weenen westwards into the Natal Drakensberg, and it is therefore not possible to plot this record on a map. The town of Weenen itself is situated in Valley Bushveld, veld type no. 23 (Acocks 1988, figure 45), a very different habitat to that known for other *T. breyeri*. FitzSimons (1943) also gave 'Umgeni Poort' as a locality (listed as 'Umgenipoort, Durban, Natal' in his list of place names) with reference to a Natal Museum specimen (i.e. NM 593). This record was plotted at locus 2930DA by Jacobsen (1988). However, according to Dr O. Bourquin (personal communication, 1993), Umgeni Poort is situated at locus 2929BD, a locality well within the general range of the species.

T. breyeri occurs in what appears to be three isolated populations in South Africa: a) montane and highveld grasslands of the Transvaal Drakensberg escarpment, b) montane grasslands of the Natal Drakensberg, and c) Patchy Highveld to

Table 1 Variation in size and scalation of 15 *Tetradactylus breyeri* specimens

Specimen no.	Sex	Snout-vent length (mm)	Tail length (mm)	Femoral pores/ leg	Supra-oculars in contact with frontal	Transverse rows Dorsals	 Ventrals
AJL 2751	?M	64	147	2	3	72	57
TM 682	?M	63	–	2	3	74	53
ZMA 10974 (holotype)	M	56	166	2	3	70	55
NM 1204	M	56	164	2	2	75	56
NMB R6852	M	54	95r	2	3	71	56
TM 56692	M	50	112	2	3	73	57
SAMZR4220	?M	–	–	2	3	75	59
LR 1817	F	72	200	2	2	80	63
NMB R1073	F	69	–	3	2	76	58
TM 78785	?F	66	164	2	3	74	57
NM 593	F	62	–	2	3	76	56
TM 56792	?F	60	163	2	2	73	58
NMZB-UM 3027	F	±58	100+	2	3	73	57
NMB R6853	F	49	104	3	3	74	59
TM 22674	F	–	–	2	3	75	56

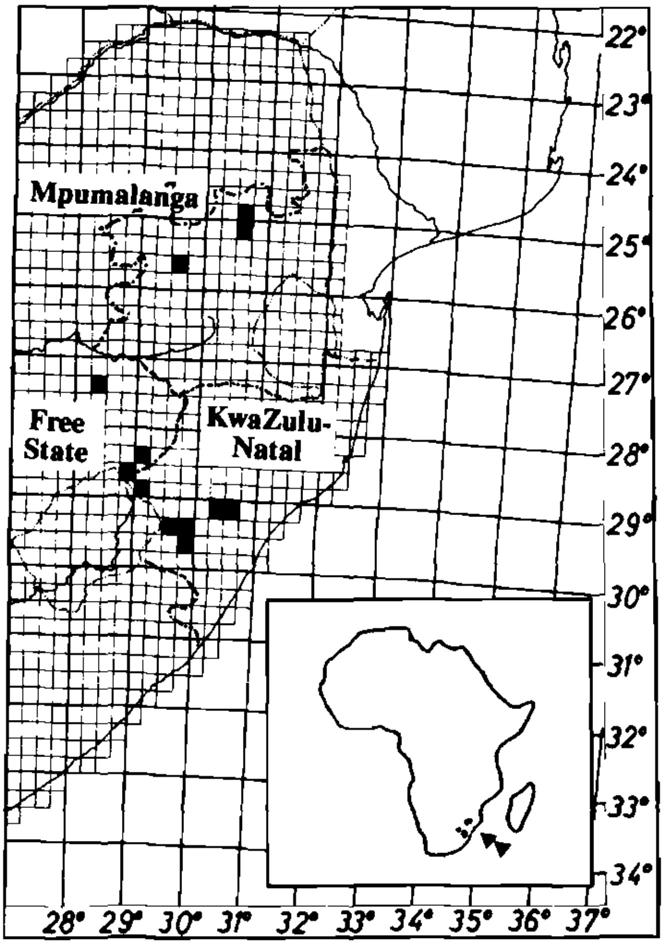

Figure 1 Geographical distribution of the South African gerrhosaurid *Tetradactylus breyeri*.

Cymbopogon–Themeda Veld Transition (grassland), veld type 53 (Acocks 1988) in the north-eastern Free State (Figure 1). The latter locality (Zwartkoppies farm) is intermediate between Mpumalanga and KwaZulu-Natal populations, but may be the north-westerly limit of the Natal Drakensberg population.

Conservation

Very little is known about the life history of *T. breyeri*. Specimens have been found on soil under rocks, at the perimeter of a moribund termitarium (Jacobsen 1989) and on stones (Bates 1993a), in highveld and montane grasslands at elevations of 1400–2000 m above sea level. Two of the 15 specimens examined were females of somewhat robust appearance, containing enlarged pre-ovulatory follicles: NMB R1073 was collected on 26 February 1973 and contained two such follicles, while TM 22674 was collected in April 1953 and contained a single enlarged follicle with a corpus luteum present in only one ovary (Bates 1993b).

The species is listed as 'rare' in the latest *South African Red Data Book — Reptiles and Amphibians* because, apart from the limited number of distribution records, it is threatened by habitat destruction in the form of man-made grass fires, use of land for crop farming, grazing of the remaining areas resulting in reduced sheltering sites, and afforestation (especially in Mpumalanga province) (Jacobsen 1988, 1989). This status should be retained.

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Appendix 1

Tetradactylus breyeri specimens examined

Abbreviations used: AJL = A.J.L. Lambiris Private Herpetological Collection, Hillcrest; LR = Lynn Raw Private Herpetological Collection, Pietermaritzburg; NM = Natal Museum, Pietermaritzburg; NMB = National Museum, Bloemfontein; NMZB-UM = Natural History Museum of Zimbabwe, Bulawayo; SAM = South African Museum, Cape Town; TM = Transvaal Museum, Pretoria; ZMA = Zoologisch Museum, Amsterdam.

The date of collection (when known) is indicated in parentheses after the museum catalogue number, followed by locality (including magisterial district) and quarter-degree locus code:

AJL 2751	(15 Feb. 1987), Dargle, near source of Umgeni (= Mgeni) River, Impendle district, KwaZulu-Natal (2929DB)
LR 1817	(Oct. 1982), Highmoor State Forest, Mooirivier district, KwaZulu-Natal (2929BC)
NM 593	(Dec. 1935), Umgeni Poort, headwaters of Umgeni (= Mgeni) River, vicinity of Le Sueur farm no. 15185, Impendle district, KwaZulu-Natal (2929BD)
NM 1204	near Greytown, Umvoti district, KwaZulu-Natal (2930BA)
NMB R1073	(26 Feb. 1978), Zwartkoppies farm no. 520, Frankfort district, Free State (2728AD)
NMB R6852-53	(21 Dec. 1992), Stratherrick farm no. 186, Sterkfontein Dam Nature Reserve, Harrismith district, Free State (2829AC)
NMZB-UM 3027	(8 Feb. 1908), 'Bushmans Cave' (precise location could not be traced), Witsieshoek, KwaZulu-Natal/Free State border (2828DB)
SAM ZR4220	(c. 1900), Rietvlei, near source of Umvoti (= Mvoti) River, Lions River district, KwaZulu-Natal (2930AB)
TM 682	(28 Mar. 1910), Weenen 'County', KwaZulu-Natal (precise location unknown)
TM 22674	(Apr. 1953), Cathedral Peak Forest Reserve, Bergville district, KwaZulu-Natal (2829CC)
TM 56692	(Feb. 1983), The Staircase, Long Tom Pass, Mauchsberg, Lydenburg district, Mpumalanga province (2530BA)
TM 56792	(Jul. 1983), Mount Sheba, Grootfontein farm no. 562KT, Pilgrim's Rest 2 district, Mpumalanga province (2430DC)
TM 78785	(13 Dec. 1993), De Kuilen farm no. 205JT, Sterkspruit Nature Reserve, Lydenburg district, Mpumalanga province (2530BA)
ZMA 10974	Holotype (1896), 'Transvaal'

Additional records

Mount Sheba Nature Reserve, Pilgrim's Rest 2 district, Mpumalanga province (2430DC; sight records; Jacobsen 1988).

Hoedspruit farm no. 346JS, Middelburg district, Mpumalanga province (2529DA; sight record; Jacobsen 1989).

Does calcium constrain reproductive activity in insectivorous bats? Some empirical evidence for Schreibers' long-fingered bat (*Miniopterus schreibersii*)

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Insects are a poor source of dietary calcium and since they are seasonally abundant, it has been suggested that calcium availability may play a significant role in controlling the timing of reproduction in insectivorous bats. To assess the possible role of dietary calcium, we have measured bone calcium concentrations in female and male long-fingered bats (*Miniopterus schreibersii*) through a full reproductive cycle. The results indicate that winter was not a period of calcium stress and, therefore, that seasonal changes in insect abundance and dietary calcium availability are not a satisfactory explanation for the occurrence of delayed implantation in the long-fingered bat. Bone calcium concentrations of females did not differ significantly throughout pregnancy, indicating that the insects available in winter and early summer were sufficient to meet the calcium demands of pregnancy. Lactating females had the lowest bone calcium concentrations of all specimens, supporting the suggestion that lactation is indeed a period of severe calcium stress in aerial insectivores. We conclude that parturition is probably timed so that lactation coincides with the period of maximal insect abundance and corresponding dietary calcium availability.

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It has been suggested that litter size in insectivorous bats may be constrained by calcium availability to a greater extent than by energetic considerations (Barclay 1994, 1995). Young are born at about 25% of adult mass, are weaned at 70–80% of adult mass and after weaning their bones have to withstand the stresses of flight (Barclay 1994, 1995). A number of previous studies have indirectly addressed the question of calcium demand during pregnancy and lactation in bats and have shown that they are periods of calcium stress (Kwiecinski, Krook & Wimsatt 1987a; Kwiecinski, Wimsatt & Krook 1987b; Studier, Viele & Sevick 1991; Sevick & Studier 1992; Studier, Sevick, Keeler & Schenka 1994a; Studier, Sevick, Ridley & Wilson 1994b). Insects are a particularly poor source of calcium (1–4 mg/g; Studier *et al.* 1994a) and since insects are seasonally abundant in temperate latitudes, it is reasonable to suggest that not only litter size but also the timing of reproduction may be constrained by calcium availability. We have investigated this hypothesis by measuring seasonal changes in bone calcium concentration of Schreibers' long-fingered bat. Bone calcium is in a constant state of flux and when dietary calcium does not meet the demands of, for example, pregnancy and lactation, calcium is resorbed from the bones. Changes in bone calcium therefore reflect the extent to which dietary calcium meets the calcium requirements of the bat. Schreibers's long-fingered bat is a small insectivorous species in which there is a period of delayed