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A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia

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ABSTRACT – *Varanus* lizards in Australia are moderately diverse and include a radiation of small-bodied species that occur in arid or tropical environments. *Varanus brevicauda* is the smallest species, with an elongate body and short prehensile tail and is associated with spinifex clumps in arid environments. Recently collected unusual specimens at the north-western edge of the range of *V. brevicauda* on the Dampier Peninsula, Western Australia, had an even more elongate body and also co-occurred with typical *V. brevicauda*. This led us to conduct a morphological and molecular genetic systematic appraisal of the two morphotypes. We found that the more elongate specimens were highly divergent genetically from both typical *V. brevicauda* and another related species, *V. eremius*, with the three lineages forming a polytomy. Morphologically, the elongate specimens are most similar to *V. brevicauda*, but possess a more elongate body, less robust head and limbs, distinctive scales on the front of the arms that are large, squarish and lacking surrounding granules and a plainer pattern and colouration. The co-occurrence of both forms on the Dampier Peninsula in combination with the extent and pattern of genetic divergence and presence of key morphologically diagnostic traits unequivocally demonstrates that more elongate form is a new species, which we describe here. The new species may be of conservation concern owing to the small range of the only known specimens and development proposals in the area.

KEYWORDS: Goanna, monitor lizard, *Varanus brevicauda*, *Varanus sparnus* sp. nov.

INTRODUCTION

Lizards of the genus *Varanus* Merrem, 1820, commonly referred to as goannas or monitors, are a moderately diverse group with over 70 species from Australia, south-east Asia, India, the Middle East and Africa. Australia is the most species-rich region with 31 species, including a radiation of small to very small-bodied species within the subgenus *Odatria* Gray, 1838 (Pianka et al. 2004). *Varanus* show strong conservatism in body shape, with most species having long, pointed heads and tails (King and Green 1999). Body proportions, however, can differ substantially among species, with relative head and tail lengths differing widely in association with differences in ecology (Thompson and Withers 1997; Openshaw and Keogh 2014).

Within the small-bodied Australian *Odatria* group there are three widely-distributed arid zone species: *V. brevicauda* Boulenger, 1898, *V. acanthurus* Boulenger, 1885 and *V. eremius* Lucas & Frost, 1895. *Varanus brevicauda* is the smallest species of *Varanus*, with a snout-vent length of around 120 mm and a total length of about 250 mm owing to its short tail (hence the specific name) (Storr et al. 1983; Pianka 2004). It occurs along the west coast and extends eastwards and inland through the sandy deserts as far as the Simpson Desert in western Queensland (Wilson and Swan 2010). This species is an active burrower, with relatively straight claws on the hands, capable of digging their own tunnels and foraging for food among *Triodia* clumps and along sand dunes (Pianka 2004).

Recently, several unusual specimens assignable to *V. brevicauda* have been collected from the extreme north-west of the species' range, from near Coulomb Point on the Dampier Peninsula, north of Broome in the western Kimberley region (Figure 1). This area is characterised by sandy soils and pindan vegetation communities (McKenzie 1983). The specimens have a more elongate and gracile appearance than typical *V. brevicauda* and a more subdued pattern. We carried out

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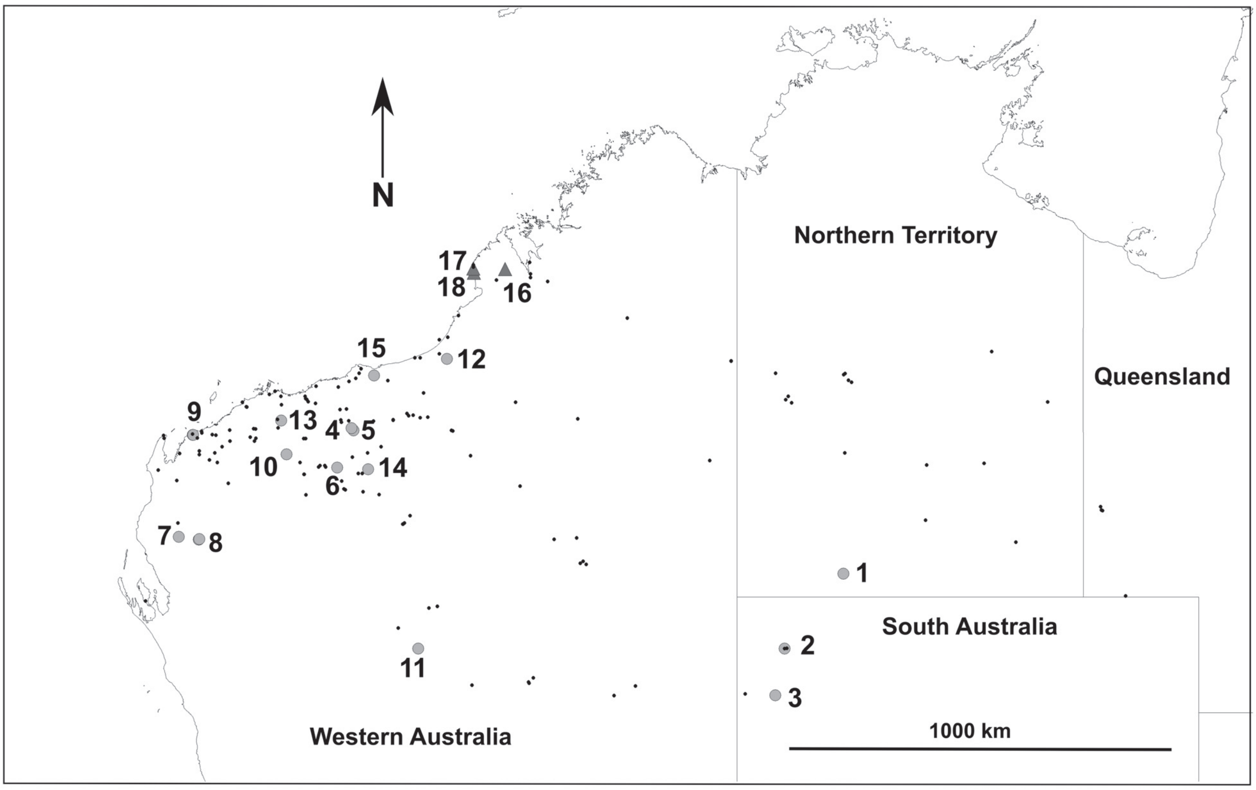

FIGURE 1 Map showing the distribution of *Varanus brevicauda* (dots) and *V. sparnus* sp. nov. (triangles) based on Atlas of Living Australia voucher records (small dots) and locations from which molecular genetic data were obtained (large symbols).

a molecular genetic analysis to assess the distinctiveness of these specimens from 'typical' *V. brevicauda* sampled throughout its range. This genetic evidence indicated that the elongate specimens are equally distant genetically to *V. brevicauda* and *V. eremius*. Examination of specimens also revealed a suite of morphological characters to distinguish the new form. Here we describe this population as a new species of *Varanus*.

METHODS

MORPHOLOGY

Specimens were examined from the collections of the Western Australian Museum (WAM; where new type material is deposited). We examined three preserved specimens of the elongate form, plus one live captive specimen, and compared these with 20 *V. brevicauda* from throughout the rest of its range in Western Australia, including from the Dampier Peninsula (Appendix 1). We compared the two forms qualitatively and measured and counted other characters. Table 1 presents the morphological variables assessed and how they were measured. Measurements were made with electronic callipers to the nearest 0.1 mm, with SVL, TailL and TrunkL to 0.5 mm (broken tails were excluded). Individuals were sexed on the basis of everted hemipenes in males or of conspicuous gravidity in females, or by direct examination of the gonads.

MOLECULAR GENETICS

Frozen or alcohol preserved tissues were available from 31 *Varanus* vouchers (Appendix 1). DNA was extracted from using a Puregene DNA isolation kit (Gentra Systems, Minneapolis, U.S.A.) following the manufacturer's protocol for DNA purification from solid tissue. An ~886 bp fragment of the mitochondrial genome, including the 3′ end of the *NADH dehydrogenase* subunit *4* (*ND4*) gene (710 bp) and the tRNA genes *tRNAHis*, *tRNASer* and the 5′ end of *tRNALeu* (176 bp), hereafter referred to as *ND4*, was amplified and sequenced using the forward primers *ND4*: 5′-TGACTACCAAAAGCTCATGTAGAAGC-3′ or *ND4*: 5′-ACCTATGACTACCAAAAGCTCATGTAGAAGC-3′ with the reverse primer Leu1: 5′-CATTACTTTTTACTTGGATTTGCACCA-3′. Each PCR was carried out in a volume of 25 ml with a final concentration of 1X GeneAmp PCR Gold buffer, 2–4 mM MgCl2, 200 M of each dNTP, 0.2 mM of each primer and 0.5 U of AmpliTaq Gold DNA polymerase (Applied Biosystems, Foster City, CA, U.S.A.). Amplifications consisted of an initial denaturation step of 94°C for 9 min, followed by 34 cycles of PCR with the following temperature profile: denaturation at 94°C for 45 s, annealing at 55°C for 45 s, and extension at 72°C for

TABLE 1 Morphological characters measured.

Character	Description
SVL	Snout-vent length
LegL	Leg length, measured from the knee patella to the tip of the 4th toe including claw
HeadL	Head length, measured obliquely from tip of snout to anterior margin of tympanum
HeadW	Head width, measured at the widest point
HeadD	Head depth, measured level with centre of the tympanum, at the highest point
SupLab	Number of supralabial scales
InfLab	Number of infralabial scales, ending with the last small scale in contact with the posterior margin of the last upper labial
MBSR	Number of midbody scale rows, counted midway between axilla and groin
4TLam	Number of enlarged subdigital lamellae under fourth toe, counted from toe junction to base of claw
PCP	Number of pre-cloacal pores
TailL	Tail length, measured from the base of the cloaca to the tip of the tail
CloSpu	Number of cloacal spurs present
ILL	Inter-limb length, measured between the forelimb and hindlimb
UArmL	Upper arm length, measured from the lower side of the axilla to the outside of the elbow
LArmL	Lower arm length, measured from the outside of the elbow to the inside of the wrist
HandL	Hand length, measured from the inside of the wrist to the tip of the 4th toe, excluding the nail
ULegL	Upper leg length, measured from the lower side of the groin to the outside of the knee
LLegL	Lower leg length, measured from the outside of the knee to the inside of the ankle
FootL	Foot length, measured from the inside of the ankle to the 4th toe, excluding the nail

1 min, with an additional final extension at 72°C for 6 min. The double-stranded amplification products were visualised on 1.5% agarose gels and purified using an UltraClean PCR clean-up DNA purification kit (Mo Bio Laboratories Inc., CA, U.S.A.) before cycle-sequencing using the BigDye Terminator v3.1 cycle-sequencing kit (Applied Biosystems). The cycling protocol consisted of 25 cycles of denaturation at 96°C for 30 s, annealing at 50°C for 15 s, and extension at 60°C for 4 min. All samples were sequenced on an Applied Biosystems 3700 DNA sequencer. These sequences were aligned with previously published *Varanus ND4* sequences, including species from clades related to *V. brevicauda* as identified by Fitch et al. (2006) and Vidal et al. (2012) (Appendix 1) with MAFFT v6.814b (Katoh et al. 2005) implemented in Geneious Pro v5.5.2.

Bayes factors were used to assess all possible alternative partitioning strategies for four data subsets: 1st, 2nd and 3rd codon positions and the tRNA in PartitionFinder v1.0.0 (Lanfear et al. 2012). The Akaike Information Criterion (AIC) and Bayes Information Criterion (BIC) were used to assess the best fit partition strategy and nucleotide substitution model for each data subset in the selected partition strategy. Sequences were analysed phylogenetically using Bayesian and maximum likelihood methods. Bayesian analysis was conducted using MrBayes v3.1.2 (Ronquist and Huelsenbeck 2003). The analysis was run with model parameters unlinked using default priors for two million generations with two independent runs and two chains sampling every 1000 generations. The first 25% of sampled trees were discarded as burn-in and convergence was assessed by examining effective sample sizes (ESS values), split frequencies of clades across runs and likelihood plots through time in TRACER v1.4.1 (Rambaut and Drummond 2007).

Net average sequence divergence between lineages (dA) was calculated in MEGA v5 (Tamura et al. 2011) as: $dA = dXY - (dX + dY)/2$, where, dXY is the average distance between groups X and Y, and dX and dY are the within-group means. Net average sequence divergence between taxa was calculated from our data and the data of Fitch et al. (2006), Smith et al. (2007), Smissen et al. (2013), Maryan et al. (2014) and GenBank accessions for *V. komodoensis* Ouwens, 1912 for sister species pairs of *Varanus* where more than one sequence was available for each member of the pair.

RESULTS

MOLECULAR GENETICS

The partioning scheme and models of nucleotide substitution for the *ND4* alignment of 460 bp chosen in Partition Finder were first codon position with HKY+G, second codon position with HKY+G and third codon position with TIM+G. Figure 2 shows a Neighbor-Joining phylogram showing relationship among mitochondrial *ND4* sequences from *V. brevicauda* and near relatives. This topology was also recovered with the Bayesian analysis. Specimens resembling *V. brevicauda* fell into two highly divergent groups: the first is widespread across the arid zone, while the second appears to be geographically restricted to the Dampier Peninsula at the north-western edge of the range of *V. brevicauda sensu lato* (Figures 1, 2). The relationships of these two groups with *V. eremius* are unresolved by our data but net average sequence divergence (*dA*) between the three exceeds that between many other sister species pairs of varanids (Table 2).

MORPHOLOGY

Table 3 presents a summary of the morphological differences between *V. brevicauda* from across its range and the elongate individuals from the Dampier Peninsula (Figure 3). The two taxa had similar dorsal patterning, although *V. brevicauda* tended to have more pronounced ocelli than the elongate specimens, giving it a bolder pattern (Figure 4). Morphologically, the elongate specimens had a more gracile appearance (Figure 4), with longer inter-limb lengths (Table 3). We also found that head depth was shallower in the elongate individuals as well (Figure 5).

FIGURE 2 Neighbour-Joining (NJ) phylogram of relationships among mitochondrial *ND4* sequences of *Varanus brevicauda* and near relatives. Numbers at nodes are NJ bootstrap proportions (left) and Bayesian posterior probabilities (right).

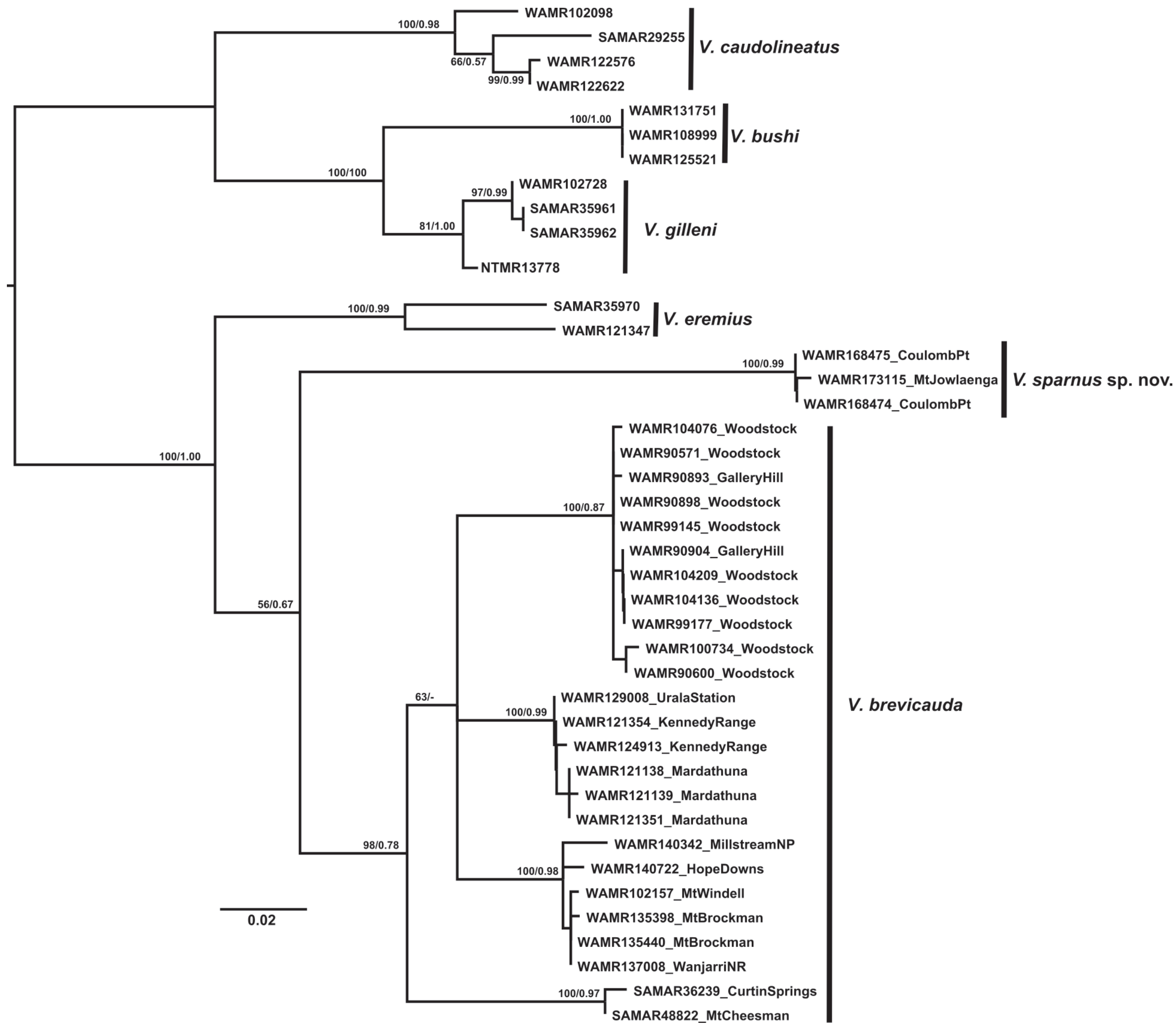

TABLE 2 Net average sequence divergence (*dA*) between sister species pairs of varanids and among *Varanus brevicauda*, *V. sparnus* sp. nov., *V. eremius* and other more distantly-related species pairs.

Sister species pair	*dA*
V. brevicauda-sparnus sp. nov.	0.134
V. eremius-sparnus sp. nov.	0.143
V. brevicauda-eremius	0.085
V. komdoensis-varius	0.125
V. mitchelli-semiremex	0.121
V. gouldii-rosenbergi	0.112
V. bushi-gilleni	0.066
V. pilbarensis-hamersleyensis	0.063
V. acanthurus insulanicus-baritji	0.019

A key difference between the two taxa observed was the appearance of the scales on the front and leading edge of the arms. The scales on the arms of *V. brevicauda senso stricto* are oval in shape and possess a ring of granules around them (Figure 6), similar to scales elsewhere on the body. In contrast, the elongate individuals had large, squarish scales on the front and leading edge of the arms, and the scales lacked small granules at their periphery (Figure 6). A further difference is that, in ventral view, the transition from the large squarish scales on the elongate individuals is quite abrupt, whereas in *V. brevicauda* the scales encircling the arm are similar in appearance with no abrupt transition (Figure 6).

TAXONOMIC CONCLUSIONS

The molecular genetic evidence strongly supported the existence of two independently evolving lineages within *V. brevicauda senso lato* (including the elongate specimens) based on reciprocal monophyly in the mitochondrial nucleotide sequence data and the extent of net average sequence divergence between the lineages relative to other recognised sister species pairs of *Varanus* (Table 2). Furthermore, nuclear gene sequence data from more than 300 loci produced from an anchored enrichment phylogenomic approach (Lemmon and Lemmon 2012) supports the highly divergent nature of the two lineages (Donnellan, Keogh, Lemmon and Lemmon, unpublished data).

The morphological evidence also supports the existence of two species, with the new species more elongate and gracile than *V. brevicauda*, and differences in scalation on the arms. Patterning and colouration differences were less apparent, although there was a trend for specimens of the elongate form to be less well-marked and to be a darker reddish-brown (at least in the two adults). Significantly, the two species are in sympatry on the Dampier Peninsula, where typical *V. brevicauda* specimens (WAM R40273, R40274, R44329) were collected 7 km to the north of the holotype of the new species. There was no evidence of individuals demonstrating intermediate morphological states, indicating a lack of gene flow between the two species.

Taken together, morphology, molecular genetics and the overlapping distributions of the two forms strongly demonstrate that the more elongate Dampier Peninsula specimens represent a new species distinct from *V. brevicauda*, which we describe below.

TAXONOMY

Family Varanidae Merrem, 1820

Genus *Varanus* Merrem, 1820

TYPE SPECIES

Lacerta varia (= *Varanus varius*) White, 1790, by subsequent designation.

Varanus sparnus sp. nov.

Dampier Peninsula Goanna

Figures 3–6

http://www.zoobank.org/urn:lsid:zoobank.org:act:039C783D-5A6C-4B79-9069-94E1C51E77C7

MATERIAL EXAMINED

Holotype

Australia: ***Western Australia***: WAM R168486, adult male collected by R.J. Teale and G. Harold on 10 March 2009, from Coloumb Point, Dampier Peninsula (-17.4277ºS, 122.1522ºE).

Paratypes

Australia: ***Western Australia***: WAM R168475, adult female from Coloumb Point, Dampier Peninsula, collected on 14 March 2009 (-17.4608ºS, 122.1525ºE); WAM R168474, subadult, from Coloumb Point, Dampier Peninsula (-17.5736ºS, 122.1694ºE).

Additional material

Australia: ***Western Australia***: WAM R173115, live subadult female from 9 km south-west of Mt Jowlaenga, Dampier Peninsula (-17.4865ºS, 122.9650ºE).

DIAGNOSIS

A very small *Varanus* (< 120 mm SVL) with short limbs, elongate body, ridged, circular and short prehensile tail (TailL/SVL: 0.92–0.99), and relatively plain reddish-brown dorsum with widely scattered small black spots. Further distinguished from *V. brevicauda* by having a more elongate body, shorter limbs, less robust head, body and tail, and presence of enlarged squarish scales not encircled by granules on front of the arms.

TABLE 3 Summaries of characters and ratios measured for *Varanus brevicauda* and *V. sparnus* sp. nov. Means±S.D and ranges on the second line for each character are presented. See Table 1 for abbreviations. Sample sizes are listed in column headings, unless noted for individual characters below.

	V. brevicauda	*V. sparnus* sp. nov.			
Character:	N = 20 (8□, 12□)	R168486 (□)	R168475 (□)	R168474 (J)	R173115 (□)
SVL	102.0±8.2	116.0	116.4	72.1	110.0
	90.5–120.5				
TailL	98.1±10.9	111.5	108.4	69.0	101.0
	79–117				
HeadL	18.2±1.2	20.1	17.9	13.6	15.9
	16.0–20.5				
HeadW	10.8±0.8	10.5	9.5	6.9	9.5
	9.4–12.6				
HeadD	8.1±0.9	7.6	7.0	5.0	7.5
	6.0–9.7				
SupLab	17.5±1.5	16	17	16	18
	15–21				
InfLab	17.1±1.1	16	16	15	18
	15–19				
MBSR	88.4±6.8	79	86	66	
	80–103				
4TLam	16.1±1.6	15	16	14	
	14–19				
PCP	0.4±1.4	0	0	0	0
	0–6				
ILL	58.2±5.7	66.6	74.1	40.2	79.7
	49.2–69.1				
UArmL	8.4±0.8	8.3	8.7	6.2	6.3
	7.0–9.8				
LArmL	6.8±0.7	6.9	7.0	4.9	7.6
	4.7–7.8				
HandL	9.3±0.6	10.1	8.9	6.0	8.4
	8.4–10.3				
ULegL	9.7±0.8	10.0	9.0	6.1	8.0
	7.8–11.0				
LLegL	8.7±1.0	7.6	7.8	5.6	7.3
	6.6–10.2				
FootL	10.5±1.2	9.9	9.6	7.2	8.6
	7.4–12.3				

DESCRIPTION OF HOLOTYPE (WAM R168486)

Head short (HeadL/SVL – 0.173), narrow (HeadW/SVL – 0.091) and shallow (HeadD/SVL – 0.066); snout slightly concave dorsally, narrowing to broadly rounded tip when viewed dorsally; in lateral view, snout gradually narrows to nostrils, then angles downwards to tip of snout; upper jaw protrudes slightly beyond lower jaw; eyes relatively large; nares large and directed posteriorly, posterior edge straight and defined by ridge, narrowing anteriorly; nostril opening small and positioned anteriorly and ventrally within narial opening; external ear opening large (~1.5 times width of eye), ventral portion angled forwards, anterior edge curved slightly and posterior edge straight for uppermost 1/3, then angled anteriorly; line of mouth gradually rising from snout tip to below posterior edge of eye, then straight to ventral edge of ear opening. Longitudinally oriented scales on top of head behind eyes with pronounced, straight keels; scales on top of snout protruding and irregular, lacking keels; scales above eyes with short keels; keels at back of head angled outwards.

Mental two times longer than wide, sides gradually narrowing then angling at 45º to meet at posterior terminal point; first, second and third infralabials enlarged, gradually decreasing in size from mental until the size of surrounding scales. Gular scales near edge of jaw flattened and elongate, gradually rounding towards gular fold; gular fold strong, with underlying granular scales underneath fold.

FIGURE 3 Images in life of *Varanus sparnus* sp. nov. Upper image – WAM R173115 (image by R. Ellis); lower image – holotype WAM R168486 (image by G. Harold).

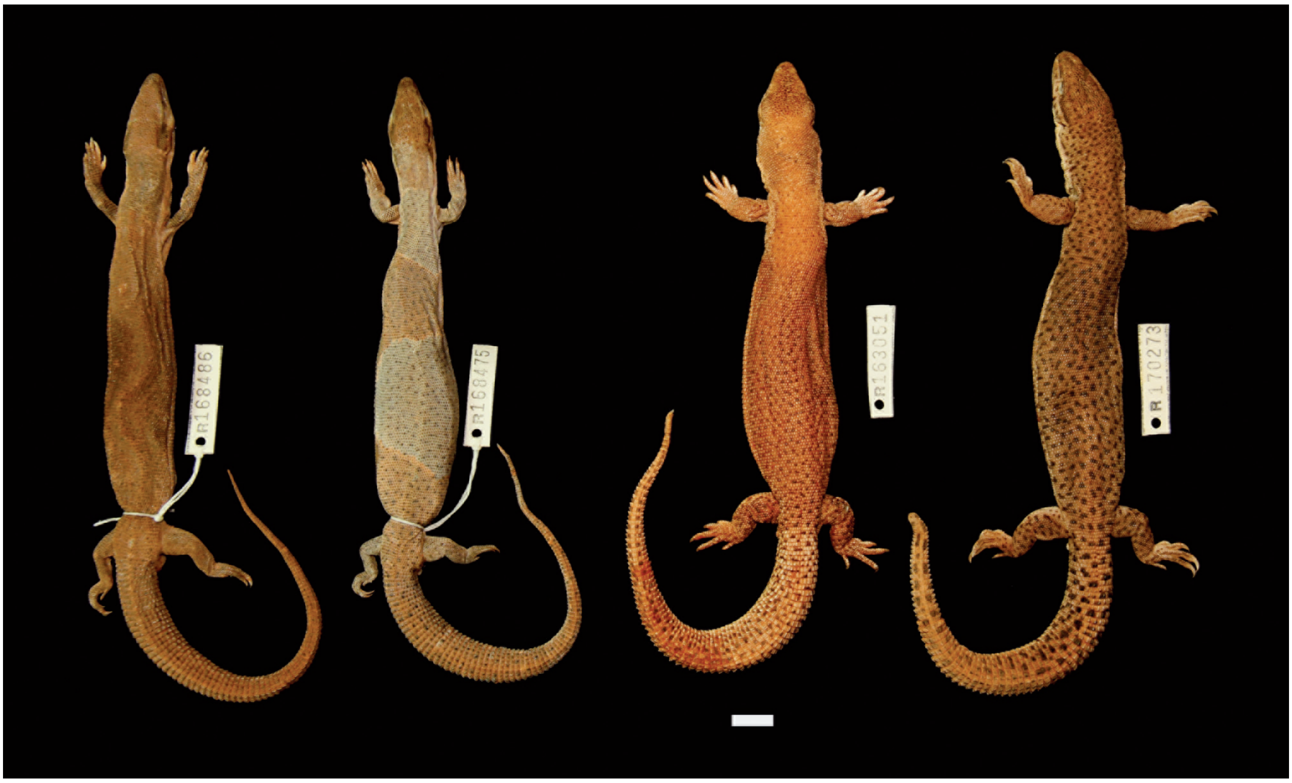

FIGURE 4 Preserved specimens of *Varanus sparnus* sp. nov. (holotype – WAM R168486; paratype – 168475), and *V. brevicauda* (WAM R163051, WAM R170273). Scale bar = 1 cm.

Torso extremely elongate (ILL/SVL – 0.57); covered in rows of small scales; dorsal scales non-overlapping and oblong with low keels bordered by 8–12 small granules (except for anterior edge); scales on sides lack keels and are rounder (less oblong); ventral scales non-overlapping, smooth (i.e. no perforation visible) and rectangular with slightly rounded posterior edge.

Limbs extremely short (UArmL/SVL – 0.072; LArmL/SVL – 0.059; ULegL/SVL – 0.086 LLegL/SVL – 0.066), with relatively large hands (HandL/SVL – 0.087) and feet (FootL/SVL – 0.085); absolute lengths: hand length > lower arm > upper arm, upper leg > foot length > lower leg. Lower arm compressed; scales on dorsal surface of lower and upper arm large, squarish and flattened, lacking surrounding granules; scales on ventral surface small; abrupt transition of scale size at leading edge of lower arm: from rows of large scales of inner lower arm to smaller scales on ventral surfaces. Scales on upper and lower surfaces of legs similar to dorsal scales on body, but smaller; scales on anterior surface enlarged and flattened, lacking surrounding granules; scales on posterior edge very small, almost granular; medial rows of scales on dorsal surfaces of hands and feet enlarged and with tightly grouped non-overlapping flat scales; palmar and plantar surfaces with small rounded scales. Fingers long with long recurved claws; toes moderately long with long recurved claws.

Cloacal spurs to either side of vent, each with 20–25 spurs arranged in 3 or 4 irregular rows; spurs flattened at base and curve upwards to fine point. Tail short and covered in regular rows of scales; dorsal scales strongly keeled and angled dorsally at posterior edge; ventral scales strongly keeled and flat; tail tip gradually tapering to a fine point; tail tip very flexible and prehensile. Measurements of the holotype and all other specimens are presented in Table 3.

Colouration

In life, ground colour of dorsum and lateral surfaces light reddish-brown; freckled with fine black spots (no ocelli present) that occupy a single scale; ventral surfaces dull yellowy-white; head with a dark blackish streak from the eye to the dorsal portion of ear opening; upper labials and scales below eye pale with light grey stippling (Figure 3). In preservative, ground colour darker reddish-brown and lower surfaces dull yellowy-white; otherwise similar to life (Figure 4).

VARIATION

The adult female (WAM R168475) is similar in most respects to the male holotype, however, this specimen has a longer torso and more gracile proportions (including slender head and neck, and thinner tail). The patterning also differs in that 1–4 scales comprise the black spots scattered on the dorsum, giving them a darker appearance. Cloacal spurs in the same position as for the male, but much shorter and without sharp tips. The juvenile (WAM R168474) is more heavily spotted in appearance than the adult female, with the black spots comprised of 4–6 scales. Otherwise, the colouration is similar in most respect to the adults. The live specimen (WAM R173115) is a subadult female, with a very subdued pattern (Figure 3).

FIGURE 5 Comparison of lateral view of heads of *Varanus sparnus* sp. nov. (top two images) and *V. brevicauda* (bottom two images). From top to bottom: WAM R168475, WAM R168486, WAM R163051, WAM R170273. Scale bar = 1 cm.

HABITAT

The three Coloumb Point specimens were collected in areas with alluvial or sandstone deposits, and broadly classed as 'pindan shrubland'. A detailed vegetation assessment for the three type specimens is provided below (M. Maier, Biota Environmental Consultants, pers. comm.). The holotype, WAM R168486, occurred with *Corymbia* sp. low trees over *Acacia monticola, A. colei, A. eriopoda* tall open scrub over mixed open grassland, on pindan soil on plain. The paratype WAM R168474 was associated with *Corymbia dampieri* and *C. polycarpa* scattered low trees over *Acacia*

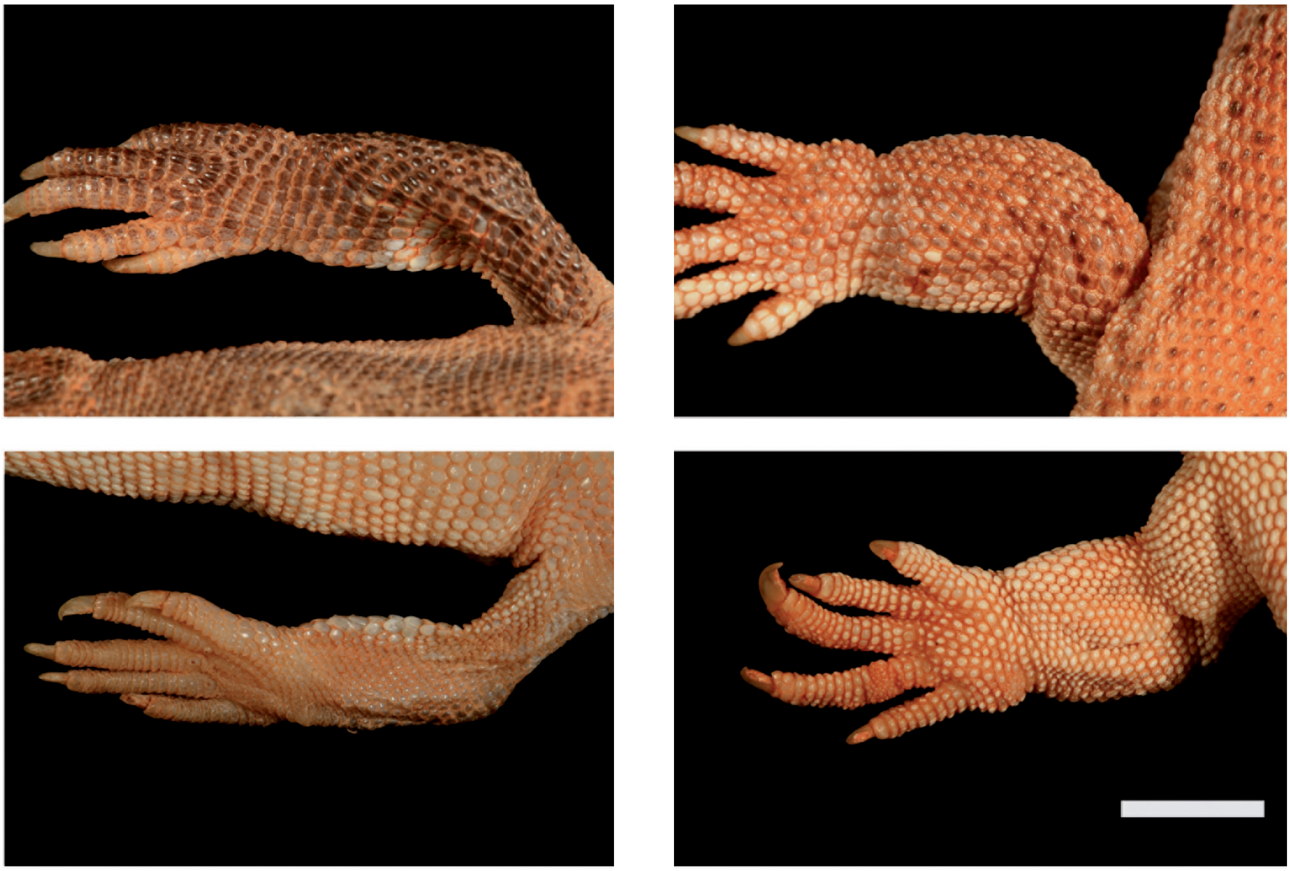

FIGURE 6 Close up comparison of the difference in arm scalation between *Varanus sparnus* sp. nov. (upper left – dorsal view; lower left – ventral view; WAM R168486) and *V. brevicauda* (upper right – dorsal view; lower right – ventral view; WAM R163051). Scale bar = 0.5 cm.

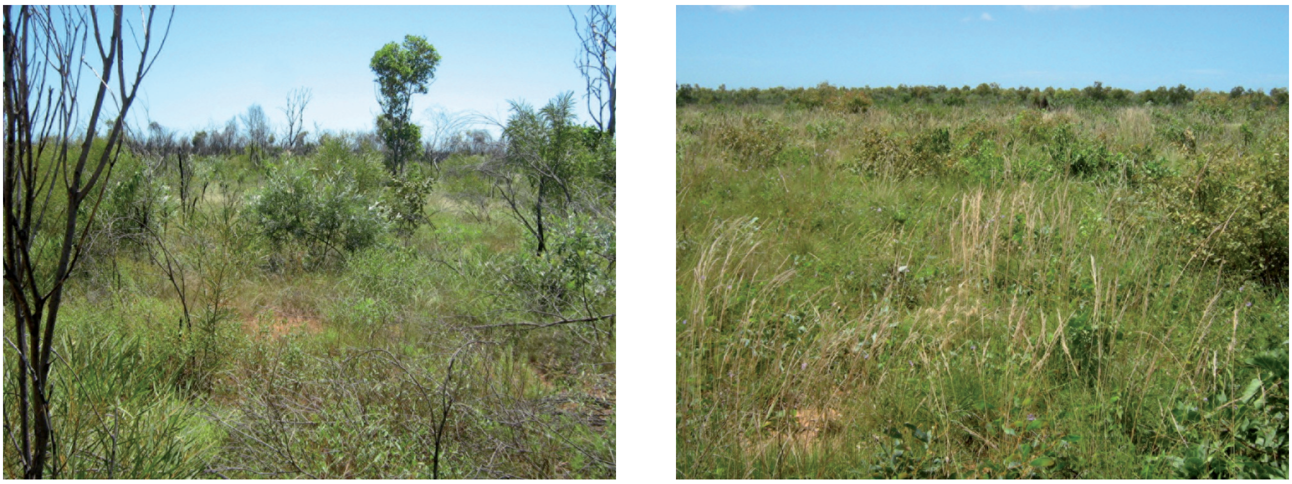

FIGURE 7 Habitat shots from the type series of *Varanus sparnus* sp. nov. from near Coloumb Point, Dampier Peninsula, Western Australia. Collection locations of paratypes WAM R168474 (left) and WAM R168475 (right).

eriopoda open shrubland; on pindan soil on plain. The paratype WAM R168475 was found amongst *Eucalyptus miniata, Terminalia ferdinandiana* low open woodland over *Acacia tumida* var. *kulparn* low closed heath over *Triodia schinzii* very open hummock grassland on exposed coastal fringe; on coastal sand in dune swale (Figure 7). The Mt Jowelaenga individual (WAM R173115) was collected in a funnel trap in pindan woodland with dense shrubs of *Acacia tumida*, scattered *Triodia caelestialis* and *Sorghum timorense* and soil consisting of red-brown sandy loam (N. Jackett, Ecologia Environment, pers. comm.).

BEHAVIOUR

Observations of the captive individual (WAM R173115) indicate that this species is a highly active burrower, excavating underneath all hard structures, such as flat pieces of wood and a heating stone (L. Umbrello, pers. comm.). This specimen readily consumed both live food (*Tenebrio* larvae, crickets) and wet cat food. Attempts to photograph this species in life were difficult, as the animals were constantly moving and rarely paused (G. Harold, R. Ellis, pers. comm.). The tail is highly prehensile, similar to that of *V. brevicauda*, possibly functioning to assist in navigating through *Triodia* clumps and shrubs.

DISTRIBUTION

The four individuals were collected from two locations approximately 90 km apart in the central portion of the Dampier Peninsula in the western Kimberley (Figure 1). This species is likely to be restricted to the peninsula (~15,000 km^2). No specimens from outside of the Dampier Peninsula (i.e. the western deserts and Pilbara region) were detected when sorting through the *V. brevicauda* specimens in the WAM collections.

ETYMOLOGY

sparnos is Greek for 'rare' or 'scarce', in reference to this species' isolation and small range on the Dampier Peninsula. Latinised to *sparnus*, and used as an adjective.

REMARKS

Descriptions of new Australian goanna species in the past 10 years have all come from Western Australia: two from the southern Pilbara region (Aplin et al. 2006; Maryan et al. 2014), and now *V. sparnus* from the south-western Kimberley, approximately 700 km to the north. The description of *V. sparnus* further establishes Australia's status as the most species-rich region for *Varanus* globally, with approximately 32 of 75 species (Uetz 2014).

Varanus sparnus has an apparently extremely restricted distribution, completely confined to the relatively small Dampier Peninsula area. This is in contrast to its two closest relatives, *V. brevicauda* and *V. eremius*, which nearly range across the entire arid zone that comprises the majority of the Australian continent (Pianka et al. 2004). All three species occupy sandy substrates, so other factors would explain the distributional patterns of these taxa. The sandy arid regions of the west coast of Australia has a disproportionately high number of endemics with small ranges (McKenzie et al. 2000; How and Cowan 2006; Doughty et al. 2011). Although most of these species occur further south in the mid-west and Pilbara regions, the same processes (e.g. changes in sea level that affect sand-associated taxa) may affect taxa in the Dampierland region as well. As the distribution of *V. sparnus* appears to be extremely restricted, it would be prudent for wildlife and conservation agencies to consider this species for some kind of protected status until more is known about its true range and biology.

Varanus sparnus is slightly smaller than *V. brevicauda* in maximum body size, making it the smallest known *Varanus*. In contrast, the largest member of the genus, *V. komodoensis*, reaches sizes of over 1.5 m in SVL, 3.0 m in total length and 80 kg (Jessop et al. 2006), compared to *V. sparnus* with an SVL of 116 mm, total length of 227.5 mm and mass of only 16.3 g, a remarkable size difference within a single genus of reptiles (e.g. King and Green 1999; Pianka et al. 2004; Openshaw and Keogh 2014).

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APPENDIX 1 Specimens examined for morphological[M] and molecular genetic analyses. Numbers in bold preceding localities refer localities from which genetic data were obtained (see Figure 1). *Short sequences that we did not include in Figure 2, but fall within the *V. brevicauda* clade (sequences not on GenBank but available from the authors).

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus brevicauda						
SAMA R36239	**(1)** Curtin Springs	NT		KP076412	-25.392	131.767
SAMA R48822	**(2)** Mt Cheesman	SA		KP076413	-27.337	130.237
SAMA R62377*	**(3)** 166 km SSE Watarru	SA		*	-28.549	129.998
WAM R13837[M]	Derby	WA	□	-	-17.300	123.617
WAM R20350[M]	32 km S Derby	WA	□	-	-17.600	123.633
WAM R28029[M]	La Grange	WA	□	-	-18.683	121.767
WAM R40274[M]	Coloumb Point	WA	□	-	-17.367	122.150
WAM R44329[M]	Coloumb Point	WA	□	-	-17.367	122.150
WAM R46168[M]	Anna Plains	WA	□	-	-19.250	121.483
WAM R90571	**(4)** Woodstock	WA		KP076403	-21.6097	118.9878
WAM R90600[M]	**(4)** Woodstock	WA	□	KP076409	-21.6116	118.9556
WAM R90893[M]	**(5)** 200 m S Gallery Hill	WA	□	KP076410	-21.6677	119.0408
WAM R90898[M]	**(4)** Woodstock	WA	□	DQ525115	-21.6116	118.9556
WAM R90904[M]	**(5)** 200 m S Gallery Hill	WA	□	KP076411	-21.6677	119.0408
WAM R99145[M]	**(5)** 200 m S Gallery Hill	WA	□	KP076402	-21.6677	119.0408
WAM R99177	**(5)** 200 m S Gallery Hill	WA		KP076408	-21.6677	119.0408
WAM R100734	**(4)** Woodstock	WA		KP076407	-21.6094	118.9878
WAM R102157	**(6)** Mt Windell	WA		DQ525116	-22.6300	118.6139
WAM R104076	**(4)** Woodstock	WA		KP076404	-21.6166	118.9500
WAM R104136	**(4)** Woodstock	WA		KP076405	-21.6166	118.9500
WAM R104209	**(4)** Woodstock	WA		KP076406	-21.6166	118.9500
WAM R121138[M]	**(7)** 8 km NW Mardathuna Homestead	WA	□	KP076419	-24.4288	114.5000
WAM R121139[M]	**(7)** 8 km NW Mardathuna Homestead	WA	□	KP076417	-24.4288	114.5000
WAM R121351[M]	**(7)** 8 km NW Mardathuna Homestead	WA	□	KP076418	-24.4288	114.5000
WAM R121354[M]	**(8)** Kennedy Range National Park	WA	□	KP076416	-24.4930	115.0306
WAM R124913	**(8)** Kennedy Range	WA		KP076414	-24.5008	115.0175
WAM R129008	**(9)** Urala Station	WA		KP076420	-21.7836	114.8633
WAM R135398[M]	**(10)** Mt Brockman	WA	□	KP076399	-22.3000	117.3000
WAM R135440[M]	**(10)** Mt Brockman	WA	□	KP076398	-22.2919	117.2989
WAM R137008[M]	**(11)** Wanjarri NR	WA	□	KP076415	-27.3333	120.7167
WAM R139065*	**(12)** Mandora	WA		*	-19.8083	121.4639
WAM R140342[M]	**(13)** Millstream-Chichester	WA	□	KP076401	-21.4116	117.1561
WAM R140722	**(14)** Hope Downs	WA		KP076400	-22.6736	119.4161
WAM R140985*[M]	**(9)** Urala Station	WA	□	*	-21.7827	114.8697
WAM R161599*	**(15)** Goldsworthy	WA		*	-20.2419	119.5740

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus sparnus sp. nov.						
WAM R168486[M]	Coulomb Point	WA	□		-17.4277	122.1522
WAM R168474[M]	**(18)** Coulomb Point	WA	-	KP076422	-17.5736	122.1694
WAM R168475[M]	**(17)** Coulomb Point	WA	□	KP076423	-17.4608	122.1525
WAM R173115[M]	**(16)** 9 km SW Mt Jowlaenga	WA	□	KP076421	-17.4865	122.9650
Varanus eremius						
SAMA R35970	2 km W Purni Bore	SA	-	DQ525114	-26.28	136.08
WAM R121347	30 km S Carnarvon	WA	-	DQ525113	-25.1313	113.7681
Varanus caudolineatus						
SAMA R29255	57 km S Leonara	WA	-	DQ525139	-29.37	121.27
WAM R102098	Wongida, Barlee Range	WA	-	DQ631874	-22.9666	115.8500
WAM R122622	18.5 km SE Wooramel	WA	-	DQ631876	-25.7105	114.5994
WAM R122576	18 km SE Wooramel	WA	-	DQ631875	-25.6805	114.6217
Varanus bushi						
WAM R131751	Hamersley Station	WA	-	DQ631883	-22.4452	117.8797
WAM R125521	North Pilbara	WA	-	DQ631882	-21.5000	117.5000
WAM R129912	West Angelas iron ore mine	WA	-	DQ631877	-23.1858	118.7544
Varanus gilleni						
WAM R102728	Little Sandy Desert	WA	-	DQ631872	-24.5925	120.2631
SAMA R35961	Alka Seltzer Bore	SA	-	DQ525138	-26.33	136.01
NTM R13778	no locality data	-	-	DQ525137	-	-