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A new species of *Underwoodisaurus* (Squamata: Gekkota: Carphodactylidae) from the Pilbara region of Western Australia

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Abstract

Ongoing surveys and systematic work focused on the Pilbara region in Western Australia have revealed the existence of numerous unrecognized species of reptiles. Here we describe *Underwoodisaurus seorsus* **sp. nov.**, a new species similar to *U. milii*, but differing in its relatively plain dorsal and head patterns with only sparsely scattered pale tubercles, a much more gracile build, including longer snout, limbs and digits, smaller and more numerous fine scales on the dorsum, and the enlarged tubercles on the tail tending not to form transverse rows. The new species is known from few specimens and has only been encountered at mid elevations in the Hamersley Ranges, widely separated from the closest populations of *U. milii* in the northern Goldfields and Shark Bay in Western Australia. Given its rarity and small (potentially relictual) distribution this species may be of conservation concern.

Key words: conservation, gecko, *Underwoodisaurus milii*, relictual distribution

Introduction

The Pilbara region of Western Australia supports one of the most diverse reptile faunas on the Australian continent (How & Cowan 2006; Powney *et al.* 2010). Species diversity within the Pilbara, however, is currently underestimated (Doughty *et al.* 2011a). Ongoing surveys by government departments and consulting companies for environmental impact statements for mining proposals have continued to improve collections of reptile specimens from the Pilbara. In many cases, these collections have provided crucial additional material (including tissue samples for genetic analyses) of suspected new taxa based on few specimens, or have discovered entirely new species (Aplin *et al.* 2006; Pepper *et al.* 2006; Horner 2007; Smith & Adams 2007; Shoo *et al.* 2008; Mecke *et al.* 2009; Doughty *et al.* 2010, 2011b; Oliver *et al*. 2010).

The gecko fauna of the Pilbara is especially diverse with over 40 described species representing all four families found in Australia. The carphodactylid geckos are currently represented in the Pilbara by three species in two relatively closely related genera (indeed until a recent revision many authors placed all three species in the same genus, *Nephrurus* (Oliver and Bauer 2011)). Pilbara *Nephrurus* include two relatively common and widespread endemic subspecies; *N. levis pilbarensis* and *N. wheeleri cinctus* (Storr 1963). The second genus present, *Underwoodisaurus* is much rarer, and known from relatively few specimens and scattered observational records from the Hamersley Range (including the Packsaddle Range) in the southern Pilbara region (Menz and Cullen 2006; Thompson *et al.* 2009). Currently these specimens are referred to *Underwoodisaurus milii* (the single recognized species in this genus); however, they are separated from the nearest populations of *U. milii* by over 450 km to the south-east (in the northern Goldfields) and 600 km to the south-west (Fig. 1). The first specimen of the Pilbara *Underwoodisaurus* was collected in 1997, but lack of further specimens prevented a proper assessment of its taxonomic distinctiveness. Recent collections and photographic records have provided sufficient material for a comparison with *U. milii* and evidence to warrant its formal description as a new species.

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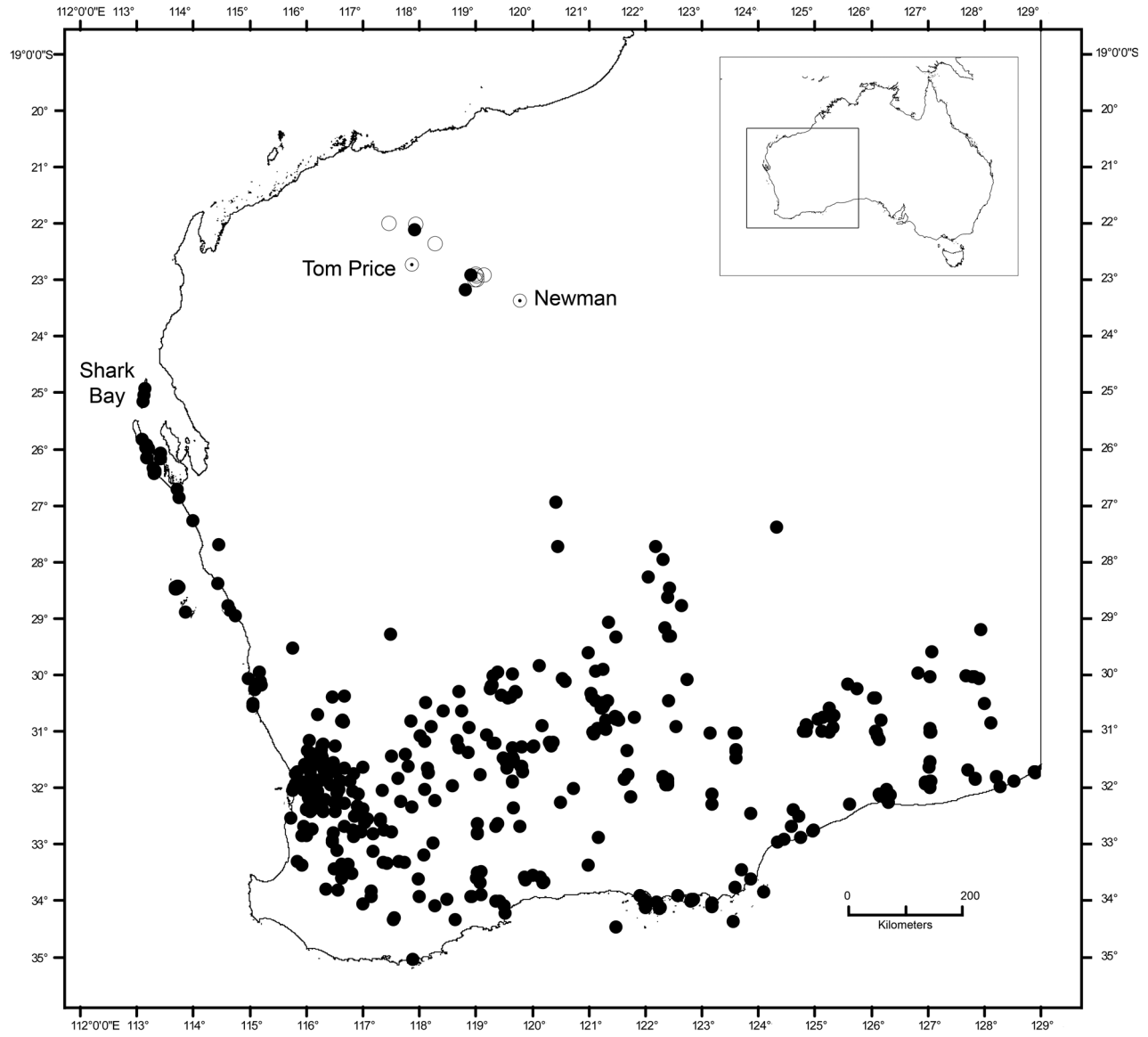

FIGURE 1. Distribution of *Underwoodisaurus seorsus* **sp. nov.** (north of 24ºS) and *U. milii* (south of 24ºS) in Western Australia. Open circles in the range of *U. seorsus* **sp. nov.** represent observations.

Methods

All four adult specimens (three females; one male) and two juveniles of the new taxon were measured and scored for characters. In the description, for quantitative data we present ranges based on the large specimens only but for scalation and coloration we include the two juvenile specimens. Measurements (Table 1) were made with digital callipers taken to the nearest 0.1 mm and were taken from the left side of the body for symmetrical characters, unless damaged. We also calculated the following ratios: TrunkL/SVL, ArmL/SVL, LegL/SVL, HeadL/SVL, HeadW/SVL, HeadW/HeadL, NE/IN, 4FL/SVL, and 4TL/SVL. We also measured 20 large (from 72–100 mm SVL) specimens of *U. milii* from Western Australia, including the type locality (Shark Bay; Shea 2002). Small sample sizes of the new species precluded parametric statistical analysis, so we present data for the six vouchered individuals for all characters and scores measured and carried out Mann-Whitney U-tests for key variables (see Results). All specimens are deposited in the collections of the Western Australian Museum (WAM).

TABLE 1. Abbreviations and measurements taken.

Abbreviation	Measurement
SVL	Snout-vent length—from tip of snout to anterior margin of cloaca with body straightened
TrunkL	Trunk length—from axilla to groin
TailL	Tail length—from posterior margin of cloaca to tail tip (only original tails)
ArmL	Arm length—from elbow to base of wrist
LegL	Leg length—from knee to heel
HeadL	Head length—from tip of snout to retroarticular process on jaw
HeadW	Head width—at widest part of head
HeadD	Head depth—measured between base of jaw and top of head between eyes
IO	Inter-orbital distance—measured at anterior corner of eye
NE	Naris-eye distance—measured from nare to anterior corner of eye
IN	Inter-narial distance
SupLab	Number of supralabial scales (from rostral scale, terminating posteriorly at angle of the mouth when labials cease to be twice the size of adjacent granules)
InfLab	Number of infralabial scales (from mental, otherwise as above)
4FL	Fourth finger length—measured from base of finger to tip, excluding claw
4TL	Fourth toe length—measured from base of toe to tip, excluding claw
4FLam	Number of expanded fourth finger lamellae
4TLam	Number of expanded fourth toe lamellae

Taxonomy

Genus *Underwoodisaurus* Wermuth, 1965

Type species *Phyllurus milii* Bory de Saint-Vincent, 1823 by original designation. Original type locality 'Australasie sur les rives de la baie des Chiens-Marins' [= Shark Bay, Western Australia]. Neotype locality:'Bernier Island, Shark Bay'. Note: Shea (2002) demonstrated that the type of *P. milii* was, in fact, a specimen illustration of *Nephrurus levis occidentalis* but maintained current usage of the epithet *milii* for the species of *Underwoodisdaurus* to which it has uniformly been applied, and designated a neotype to fix the name.

Diagnosis. A moderately large (adult SVL to 100 mm) genus of carphodactylid geckos with transverse subdigital lamellae, anterior loreals minute and strongly differentiated from posterior loreals, labial scales much larger than neighboring scales, mean of 26 presacral vertebrae, phalangeal formula unreduced (2.3.4.5.3/2.3.4.5.4), and original tail long with 33–42 postsacral vertebrae, post pygal pleurapophysis absent or reduced, rounded in cross section, and gradually tapering to tip lacking a terminal 'knob'.

Underwoodisaurus seorsus sp. nov.

Pilbara Barking Gecko
Figs. 2–5

Holotype. WAM R157525, adult female with original tail, Packsaddle Range (22.9144ºS, 118.9158ºE, elevation 638 m), Pilbara region, Western Australia, collected by P. Cullen and M. Menz on 7 May 2004.

Paratypes. WAM R129895 (male), West Angelas, 100 km north-east of Newman (23.1833ºS, 118.8142ºE, elevation 775 m) on 14 June 1997; WAM R157520 (male), WAM R157522 (female), WAM R157513 (juvenile), Packsaddle Range (22.9144ºS, 118.9158ºE, elevation 861 m) collected on 7 May 2004; WAM R163638, female, 60 km north of Tom Price (22.1191ºS, 117.9183ºE, elevation 579 m) collected on 18 November 2008; all from the Pilbara region, Western Australia.

FIGURE 2. Upper: holotype in life of *Underwoodisaurus seorsus* **sp. nov.** (WAM R157525) from the Packsaddle Range in the Pilbara region; lower: *U. milii* from Bakers Hill, near Perth, Western Australia (photographs—B. Maryan).

Diagnosis. A typically-sized (to ~100 mm SVL) *Underwoodisaurus* with transverse subdigital lamellae, minute anterior loreals compared to larger posterior loreals, labial scales larger than neighboring scales, unreduced phalangeal formula (2.3.4.5.3/2.3.4.5.4), and long original tail gradually tapering to tip. Distinguished from *U. milii* by possessing an elongate snout (NE/IN: 1.74–1.89), relatively long limbs (ArmL/SVL: 0.18–0.20; LegL/SVL:

0.20–0.22) and digits (4FL/SVL: 0.064–0.084; 4TL/SVL: 0.076–0.095), higher density of smaller enlarged tubercles scattered across the dorsum but with lower, more acute tubercles with anterior keel more common and conspicuous, relatively deep mental (projecting to level of, or beyond, first secondary infralabial) and often terminating posteriorly in a point (v. rounded), enlarged tubercles on original tails not forming transverse rows. Reddish-brown ground color with relatively plain head without light blotching or patterning, dorsal pattern consisting of sparsely scattered small pale tubercles and a narrow band across the nape.

Description. A large carphodactylid gecko with large head, long slender limbs and digits, and long tail terminating in a point (Figs. 2–4). Table 2 presents measurements and scores for meristic characters. Large and triangular head, nearly as wide as body, slightly depressed, terminating in a relatively straight-edged blunt snout; large and protruding eyes with overhanging supraciliary ridge, medial portion of dorsal eye bulges separated by 12–15 scales; dorsal skin on head not loose; wide nostrils in lateral view, narrow dorsally, directed posteriorly; vertical and elongate ear opening, recessed tympanum; labial scales enlarged relative to neighboring scales, first largest, then gradually decreasing along jaw; wide rostral, lacking a medial crease, and not in contact with nostril; anterior edge of nostril bordered anteriorly by 3 enlarged scales and 8–10 fine postnasal scales; relatively straight, slightly concave loreal region; extremely small loreal scales closest to nostrils compared to larger loreal scales nearer to the eye and elsewhere on head; mental deep, usually extending beyond scale posterior to first secondary infralabial, and ending in a sharp point; narrow neck, approximately half the width of head.

TABLE 2. Summary of meristic (mm) and mensural data for the type series of *Underwoodisaurus seorsus* **sp. nov.**

WAM R#	157525	163638	157522	157520	157513	129895
Sex	female	female	female	male	juvenile	juvenile
SVL	78	96	99	80	45	62
TrunkL	36.7	45.6	47.7	36.3	18.0	22.4
TailL	61	Na	Na	76	28	51
ArmL	15.4	18.4	18.3	15.6	9.9	11.6
LegL	16.7	21.2	19.8	17.8	10.0	14.0
HeadL	22.2	25.9	26.5	22.5	14.7	18.4
HeadW	15.2	18.8	19.0	16.5	10.2	13.9
HeadD	9.5	11.7	10.8	10.3	6.5	8.3
IO	7.1	8.2	8.7	7.1	5.8	6.9
NE	6.0	7.0	6.9	6.1	3.5	4.7
IN	3.2	3.7	3.8	3.5	2.3	3.2
SupLab	14	13	14	12	13	13
InfLab	12	14	12	12	11	11
4FL	5.8	6.1	6.3	6.7	4.3	5.1
4TL	6.9	7.4	7.5	7.6	4.6	6.4
4FLam	17	17	15	18	17	16
4TLam	20	19	18	23	19	20

Body covered with small relatively flat scales with much larger tubercles scattered across dorsum with higher density towards flanks (Fig. 5); tubercles heterogeneous in size; tubercles round or slightly keeled anteriorly (especially in nuchal region), apex directed posteriorly; ventral surface covered with flat slightly oblong scales, scales on venter larger than those on dorsum; scales below neck and gular region small; scale rows medial to infralabials enlarged relative to gulars and in ca. 6 rows.

Very long and slender limbs, pentadactyl; long fingers (4FL/SVL: 0.064–0.084) and toes (4TL/SVL: 0.076–0.095), terminating in a sharp claw; limbs covered in fine scales with scattered moderately-sized tubercles; digits moderately compressed and covered in small scales on the dorsal and lateral surfaces, but with narrow lamellae that span the width of the fingers (4FLam: 15–18) or toes (4TLam: 18–23); no expanded lamellae at tips; claw surrounded by sheath formed by a ring of enlarged scales.

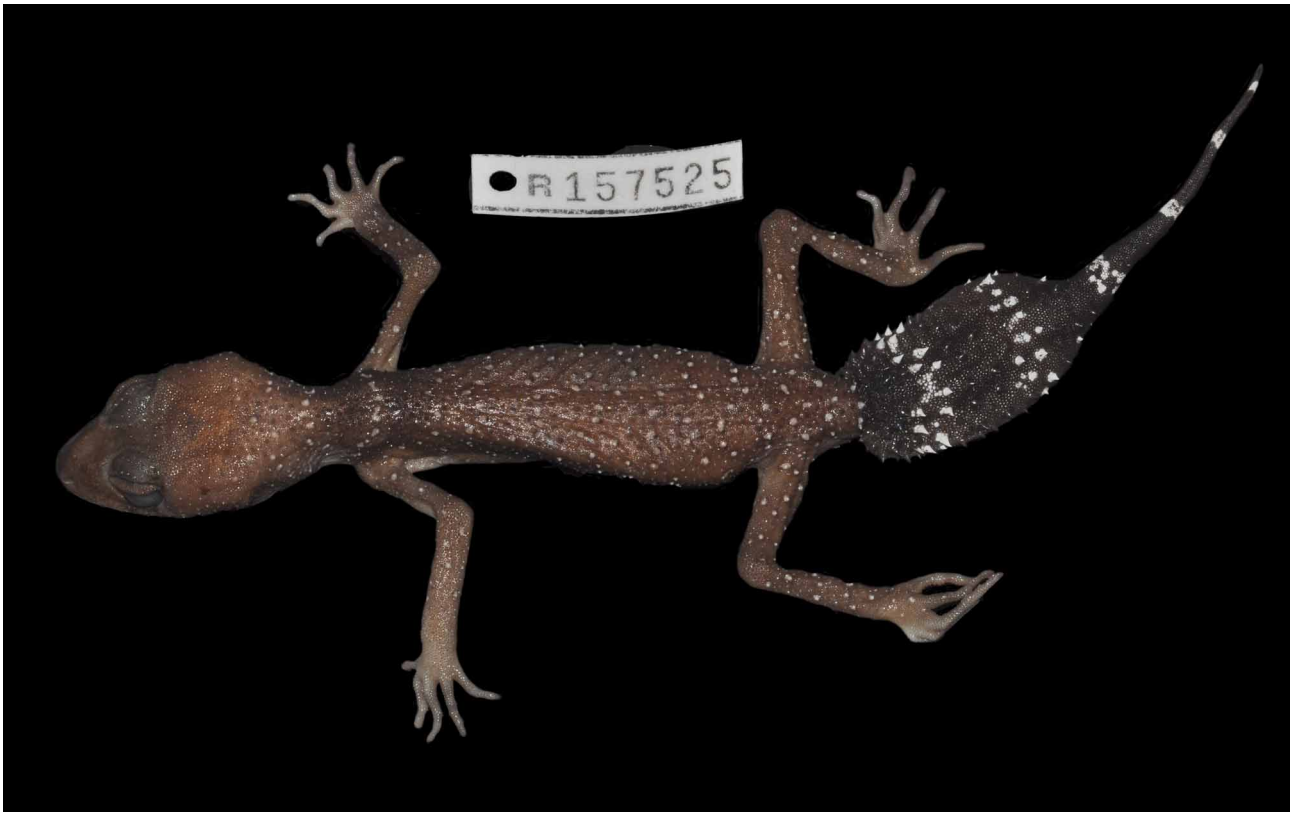

FIGURE 3. Holotype of *Underwoodisaurus seorsus* **sp. nov.** (WAM R157525).

Tail long (78 and 95% of SVL), constricted at base widening ca. 5 mm past cloaca in two adult specimens with original tails; proximal half wide with thick medial portion and tapering laterally; scattered dorsal tubercles on proximal half, tending not to form transverse rows, and encircled by a row of scales at base of tubercle; distal half of tail narrows, gradually tapering to a fine point. No pre-anal or femoral pores; 11 or 13 enlarged cloacal spurs to either side of base of tail of single adult male specimen (WAM R157520), 4–6 enlarged cloacal spurs on females; hemipenes strongly bifid.

Coloration. Ground color light to medium reddish-brown, overlain with numerous small pale spots corresponding to tubercles that tend to form irregular bands across the dorsum; plain and unpigmented ventral surface of body, legs, feet and tail; dark reddish brown original tail with five pale stripes: two on wide proximal half of tail consisting of separate small white spots and three on thin distal half of tail that are more defined but still broken (Figs. 2–4).

Variation. Meristic and mensural variation is provided in Table 2. The largest specimens were females, approaching 100 mm SVL. Pattern variation was slight, although the background coloration appeared darker in smaller individuals (Fig. 4). Regrown tails were more mottled, without the regular bands of original tails.

Distribution. Known only from the Hamersley Range in the Pilbara region of Western Australia: from north of Tom Price in the western Hamersley to West Angelas mine near Newman to the south-east (Fig. 1). These three points are supplemented by other observations of *U. seorsus* **sp. nov.** where specimens were not collected, but confirmed by observations of knowledgeable herpetologists and/or photographs examined by the authors (see Appendix 2; open circles in Fig. 1). The closest populations of *U. milii* are approximately 450 km to the south-east near Wiluna and 600 km to the south-west in Shark Bay and offshore islands (Fig. 1).

Habitat. Encountered in rocky areas of the Hamersley Range. Some of the specimens from the type series were collected on a graded road running through a 'major gully', and one was sheltering under a rock slab (Menz & Cullen 2006). They have also been observed at the bottom of a rocky gorge with a low tree cover (Thompson *et al.* 2009). Vegetation associated with other observations (Appendix 2) is shown in Fig. 6 and consists of low sparse trees of *Eucalyptus leucophloia*, low shrubs of *Acacia pilbara* and *Triodia wiseana* (M. O'Connell & B. Maryan, pers. comm.).

Etymology. *seorsus* is Latin for 'apart' or 'separate' in reference to the large distance between the distributions of *U. seorsus* **sp. nov.** and *U. milii*. Used as a noun in apposition.

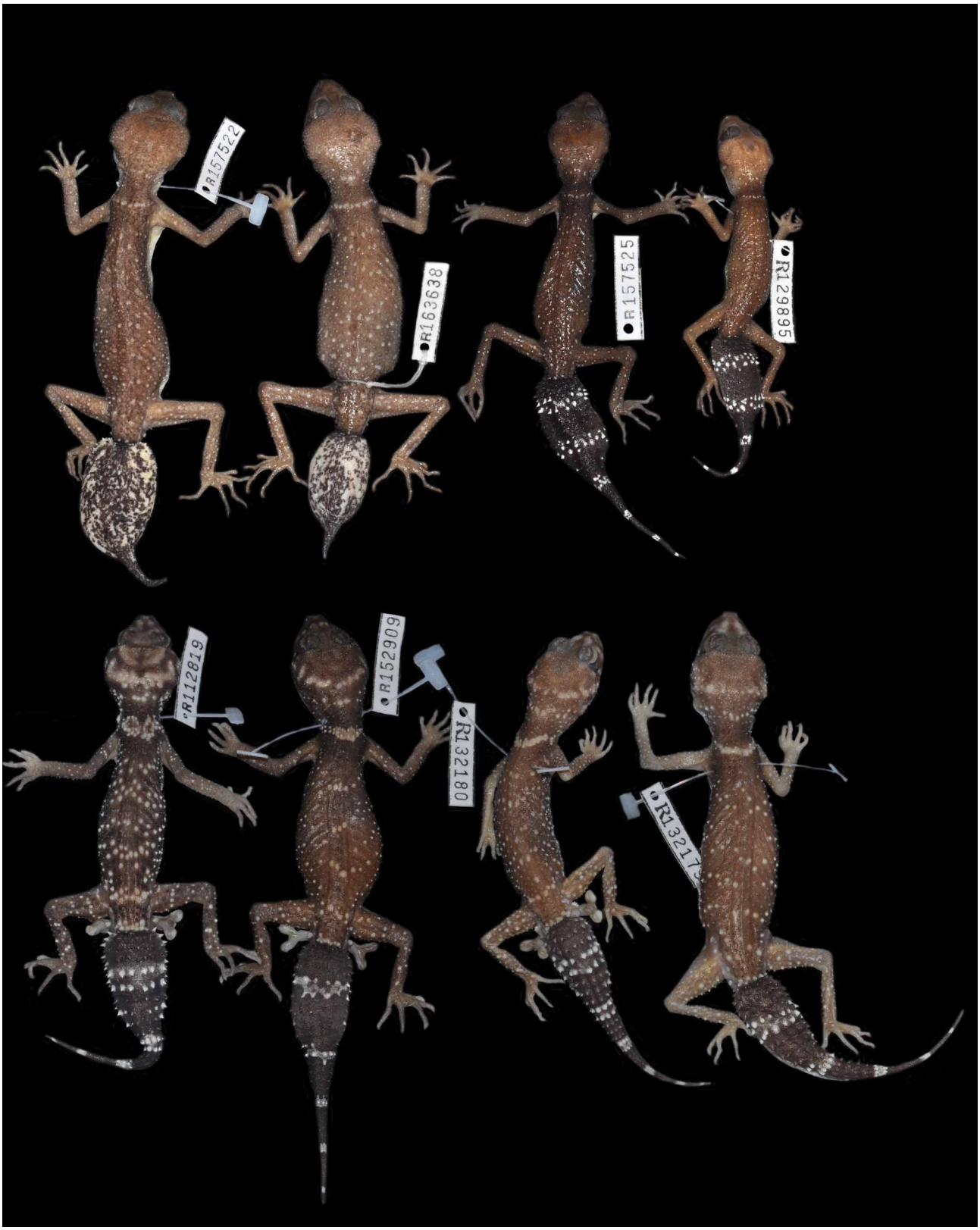

FIGURE 4. Comparison of *Underwoodisaurus seorsus* **sp. nov.** (upper row) and typical *U. milii* (lower row; left-most specimen is from Shark Bay), showing variation within and between species.

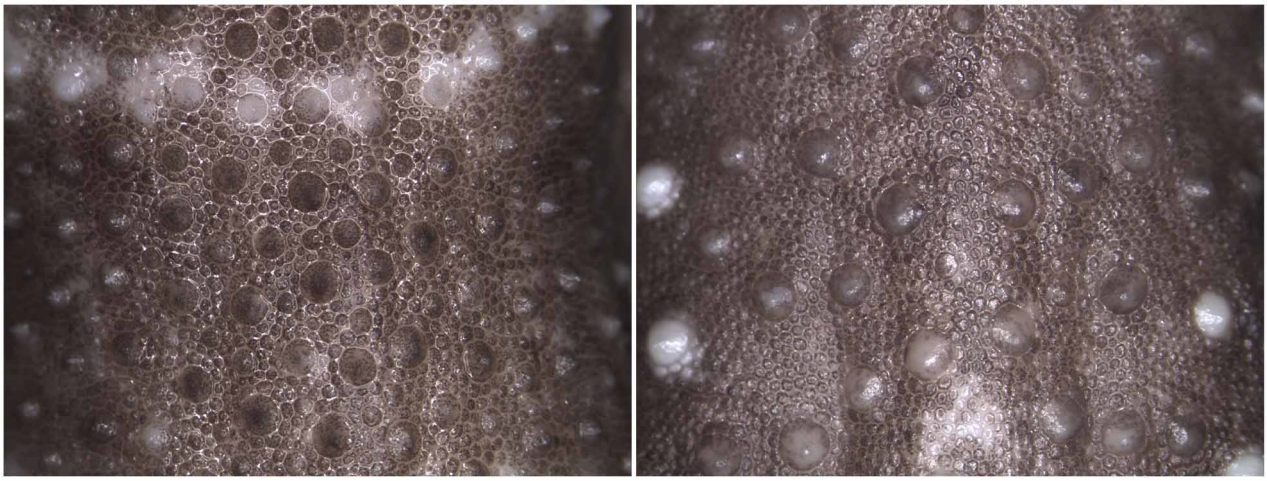

FIGURE 5. Close-up view of dorsal scalation of *Underwoodisaurus seorsus* **sp. nov.** (paratype WAM R163638, SVL—96.0 mm; left) and *U. milii* (WAM R166876, SVL—92.0 mm) (photographs taken at the same scale).

Comparison with other species. *Underwoodisaurus seorsus* **sp. nov.** can be distinguished from the two *Nephrurus* species in the Pilbara by absence of the enlarged knob at the end of the tail. In the absence of an original tail, *N. wheeleri cinctus* possesses large tubercles scattered on the dorsum and also enlarged scales on the head; in addition, this species has conspicuous bands. *Nephrurus levis pilbarensis* has multiple wide nuchal bands, whereas *U. seorsus* **sp. nov.** has only a single narrow band.

Although widely allopatric, *Underwoodisaurus seorsus* **sp. nov.** is only likely to be confused with *U. milii*. In overall appearance, *U. seorsus* **sp. nov.** is relatively more slender than *U. milii*, and has a longer snout, narrower head, more infralabials, longer limbs and toes (Table 3), more numerous but smaller, more acute, and lower scattered dorsal tubercles, and a deeper angular mental scale. The pattern and color also differ: *U. seorsus* **sp. nov.** has a relatively simple dorsal pattern on both head and body comprised of widely scattered pale tubercles. In contrast, *U. milii* often has relatively well-defined transverse bands made up of larger spots, and usually has considerable areas of lighter patches on the head, including the labial scales and often extending across the top of the head (Figs. 2, 4). The pale-headed pattern is most apparent in populations from Shark Bay, one of the closest populations to *U. seorsus* **sp. nov.** and the type locality for *U. milii* (Shea 2002).

Remarks. While early biogeographic studies did not identify the Pilbara as an area of high faunal endemism (Schall & Pianka 1978; Cracraft 1991), it is becoming increasingly clear that the Pilbara is a center of faunal endemism within Australia (How & Cowan 2006; Powney *et al.* 2010; Doughty *et al.*2011a, submitted). Based on the limited numbers of studies that have been published it appears that endemic Pilbara lineages have a wide range of geographic associations; some are southern isolates of northern lineages (Fitch *et al.* 2006; Catullo *et al.* 2011), some are sister to arid zone lineages (Aplin *et al.* 2006; Pepper *et al.* 2006) and some are northern isolates of lineages with otherwise more southerly distribution (Doughty *et al.* 2008). This diverse pattern of relationships of Pilbara taxa to other regions is not surprising given the size, geographic complexity and age of the Pilbara landform.

Within the Pilbara, a disproportionate number of endemic species have saxicoline habits compared to other parts of the arid zone (Doughty *et al.*2011a, submitted). The occurrence of *U. seorsus* **sp. nov.** in the Pilbara is consistent with the pattern of saxicoline endemics, as individuals have only been collected from rocky areas, and *U. milii* from their extensive southern range are frequently associated with rocks (e.g. Storr *et al.* 1990; Swan *et al.* 2004). The distribution of *U. seorsus* **sp. nov.** and *U. milii* suggests that their common ancestor was once more widely distributed, but that aridification and/or increasing temperature eliminated populations in the Gascoyne region. The rocky gorges and moderately high elevations of the southern Pilbara ranges may have acted as a relatively moist and potentially cooler refugium, allowing an isolated population of *Underwoodisaurus* to persist especially the rocky gorges at moderately high elevations where individuals have been observed to occur. Relative to southern *U. milii*, *U. seorsus* **sp. nov.** are much more slender with a longer snout, larger scales and longer digits and limbs. This elongation of the body and limbs may aid climbing in the rocky areas this species appears to favor, but further observations of behavior are necessary to test this idea.

TABLE 3. Comparison of average and range of key ratios and meristic characters for *Underwoodisaurus seorsus* **sp. nov.** and *U. milii*. Ratios are based on adult specimens of both species, while meristic counts (*) include the entire type series of *U. seorsus* **sp. nov.**

	U. seorsus **sp. nov.** N = 4 or 6*	*U. milii* N = 20	Statistics: Mann-Whitney U
SVL	88.3 (78.0–99.0)	84.7 (72.0–100.0)	47.5, $P = 0.627$
TrunkL/SVL	0.47 (0.45–0.48)	0.44 (0.39–0.47)	78.0, $P = 0.001$
ArmL/SVL	0.19 (0.18–0.20)	0.17 (0.16–0.18)	77.0, $P = 0.001$
LegL/SVL	0.21 (0.20–0.22)	0.20 (0.17–0.21)	69.0, $P = 0.023$
HeadL/SVL	0.28 (0.27–0.28)	0.28 (0.26–0.29)	44.0, $P = 0.794$
HeadW/SVL	0.20 (0.19–0.21)	0.21 (0.19–0.22)	69.0, $P = 0.023$
HeadD/HL	0.72 (0.68–0.73)	0.75 (0.69–0.82)	50.0, $P = 0.477$
NE/IN	1.83 (1.74–1.89)	1.64 (1.44–1.81)	78.5, $P < 0.001$
SupLab*	13.2 (12–14)	12.4 (10–14)	83.0, $P = 0.176$
InfLab*	12.0 (11–14)	10.9 (9–12)	95.0, $P = 0.033$
4FL/SVL	0.071 (0.064–0.084)	0.061 (0.052–0.070)	58.0, $P = 0.183$
4TL/SVL	0.084 (0.076–0.095)	0.074 (0.063–0.085)	67.0, $P = 0.037$
4Flam*	16.7 (15–18)	16.1 (14–19)	80.0, $P = 0.242$
4TLam*	19.8 (10–23)	19.3 (17–23)	71.5, $P = 0.533$

FIGURE 6. Habitat of *Underwoodisaurus seorsus* **sp. nov.** on Packsaddle Range, Pilbara region, showing ground cover and ranges in the distance (photograph—M. O'Connell).

Within the Pilbara, *U. seorsus* **sp. nov.** seems to be rare and have a relatively small distribution. Despite extensive survey effort in recent years they have only been found at a small number of sites. This combination of rarity and small relictual distribution indicates this species may be of conservation concern. The possible effects of increases in global temperature in the coming decades on what is seemingly already a relictual species are of particular concern. We recommend that *U. seorsus* **sp. nov.** is classified as Priority 2 (Department of Environment & Conservation, Western Australia) which will afford this species a high level of protection within the state.

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APPENDIX 1. Comparative material examined.

Underwoodisaurus milii from Western Australia (all specimens from WAM, R-prefixes excluded):

54567 (male, 1 km south of Tamala Homestead—26°43'S; 113°43'E); 57494 (female, West Wallabi Island, Houtman Abrolhos—28°29'S; 113°42'E); 65990 (male), 65995 (female), 65996 (male) (Mt Linden—29°19'S; 122°25'E); 84585 (female, Lake Throssel—27°23'S; 124°20'E); 91507 (female, 4 km east of Zanthus—31°02'S; 123°36'E); 112819 (male, West Wallabi Island, Houtman Abrolhos—28°27'21"S; 113°41'02"E); 113650 (male, Notch Point, Dirk Hartog Island—25°56'S; 113°10'E); 132179, 132180 (males, Old Camp, 9 km northeast of North Pinnacle, Bandya—27°57'20"S; 122°18'33"E); 132276 (female, Dryandra State Forest—32°46'52"S; 116°58'10"E); 140412 (female, Leinster Downs Station—27°43'50"S; 116°27'02"E); 143354 (male, Haddelton Nature Reserve—33°36'20"S; 116°37'39"E); 144927 (male, Black Flag vicinity—30°34'S; 121°15'E); 152909 (male, Koolyanobbing area—30°21'35"S; 119°27'31"E); 153945 (male, Bindoon military training area—32°17'50"S; 123°16'24"E); 157874 (female, Eyre Highway—32°17'50"S; 123°11'03"E); 165298 (female, Cape Burney—26°56'21"S; 120°24'34"E); 166876 (male, Honeymoon Well—26°56'21"S; 120°24'34"E).

APPENDIX 2. Observational records of *Underwoodisaurus seorsus* **sp. nov.**

Latitude (ºS)	Longitude (ºE)	Elevation (m)	Date	Observer
22.353	118.2814	760	May 2005	M. Kearney
22.90553	118.99471	772	15 Oct 2009	M. O'Connell
22.91835	119.13447	620	15 Mar 2010	M. O'Connell
23.00212	119.00604	685	15 Mar 2010	M. O'Connell
22.99308	119.01466	683	10 April 2010	M. O'Connell
22.99196	118.97208	711	10 April 2010	M. O'Connell
22.99207	119.01461	685	10 April 2010	M. O'Connell
22.0	117.45528	543	-	R. Browne-Cooper
22.01	117.9339	439	12 April 2010	J. Vos