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A new species of velvet gecko (Diplodactylidae: *Oedura*) from north-east Queensland, Australia

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Abstract

We describe a new species of velvet gecko (Diplodactylidae: *Oedura*) from north-east Queensland, Australia. *Oedura jowalbinna* **sp. nov.** is a robust, medium-sized (SVL 60–69 mm) gecko that is readily distinguished from its congeners by its distinctive dorsal colour pattern. The dorsum is grey with faint freckling and a pale, dark-edged band across the neck and another across the base of the tail. The combination of a yellow tail and a grey body is also distinctive. *Oedura jowalbinna* **sp. nov.** also differs significantly from the most similar congener, *O. coggeri*, in a multivariate analysis of morphology and scalation, primarily due to its smaller body size, higher interorbital, supralabial and infralabial scale counts, and lower subdigital lamellae scale count. These traits are generally non-overlapping between *O. jowalbinna* **sp. nov.** and *O. coggeri*, however, more individuals of *O. jowalbinna* **sp. nov.** need to be assessed to accurately determine variation within the new species. All *O. jowalbinna* **sp. nov.** were found at night on overhangs in dissected sandstone escarpment south-west of the town of Laura. Surveys are required to determine the distribution of *O. jowalbinna* **sp. nov.** across the sandstone escarpments of the Laura region. This species is the third reptile species (along with the skinks *Ctenotus quinkan* and *C. nullum*) described that has a highly localised range centred on the sandstone escarpments of the Laura region. Additionally, included herein is a comparison of *O. coggeri* and *O. monilis*. Typical dorsal colour pattern differs between these two species but the large amount of variation (particularly in *O. coggeri*) merges these differences. *Oedura coggeri* and *O. monilis* could not be distinguished in multivariate analyses of morphology and scalation. Genetic data and further analyses of colour pattern, morphology and scalation are required to resolve species boundaries within and between these two species.

Key words: *Oedura jowalbinna*, *Oedura coggeri*, *Oedura monilis*, *Oedura castelnaui*, Laura, Quinkan, sandstone, morphology, principal components analysis

Introduction

Oedura Gray 1842 is an endemic Australian gecko genus with 14 described species (Cogger 2000; Wilson & Swan 2003; Couper *et al.* 2007). The genus is distributed over much of Australia, with the highest diversity in northern and eastern Australia. *Oedura* are arboreal or rock-dwelling (Cogger 2000; Wilson & Swan 2003; Wilson 2005) with several species occurring primarily on rock (*O. coggeri* Bustard 1966; *O. lesueurii* Duméril & Bibron 1836; *O. tryoni* De Vis 1884) and four species found almost exclusively on rock (*O. filicipoda* King 1984; *O. gemmata* King & Gow 1983; *O. gracilis* King 1984; *O. obscura* King 1984) (Cogger, 2000; Wilson & Swan 2003). The four rock-restricted species are highly localised to the Kimberley sandstone escarpment in Western Australia (*O. filicipoda*, *O. gracilis*, and *O. obscura*) or the Arnhem sandstone escarpment of Northern Territory (*O. gemmata*).

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Oedura are moderately small to large geckos (60–100 mm snout to vent length) that are generally heavily patterned with bands, spots, blotches or zigzag markings. Species diagnosis is based primarily on dorsal colour pattern and, to a lesser degree, scalation and morphology (Cogger 2000; Wilson & Swan 2003; Wilson 2005; Couper *et al*. 2007). There are two reasonably distinct groupings within *Oedura*: a group of species with dorsal scales of similar size to the ventral scales and a dorsal pattern of bands, blotches, or spots; and a group of species with minute dorsal scales compared to the ventrals and a dorsal pattern consisting of a dark-edged pale vertebral band or series of markings. The name *Amalosia* is available for the latter species group (Wells & Wellington 1984), but its validity needs to be tested with genetic data (Couper *et al*. 2007). *Oedura* taxonomy has been relatively stable over recent time and, apart from *O. jacovae* Couper *et al*. 2007, only the four localised sandstone species of the Kimberley and Arnhem escarpments have been described over the last four decades (King & Gow 1983; King 1984). There is, however, considerable genetic, morphological and colour pattern variation within some species that remains to be resolved (Couper *et al*. 2007; Hoskin & Moritz, unpublished data).

We describe a new species of *Oedura* discovered on sandstone escarpment south-west of the town of Laura on Cape York Peninsula, north-east Queensland. This extensive area of heavily dissected sandstone escarpment rises from the surrounding floodplains and is associated with the Great Dividing Range. The sandstones are Dalrymple sandstones of the Battle Camp Formation, which extends from Bathurst Bay to south-west of Laura (De Keyser & Lucas 1968). For simplicity, herein we refer to the sandstone escarpments of this region as the 'Laura sandstones'. The climate is monsoonal, with wet summer seasons and dry winter seasons. The vegetation in the area is primarily tropical eucalypt woodland, with small areas of gallery forest containing rainforest elements along watercourses, particularly in the deeper gorges. The herpetofauna of the Laura sandstones is relatively poorly surveyed. Two skink species have highly localised distributions centred on the Laura sandstones: *Ctenotus quinkan* Ingram 1979 and *C. nullum* Ingram & Czechura 1990. *Ctenotus quinkan* is restricted to the Laura sandstones (Ingram 1979), while the distribution of *C. nullum* also extends to neighbouring areas, including granite outcrops (Ingram & Czechura 1990).

Methods

We conducted nocturnal surveys for herpetofauna at two sites on Jowalbinna Station, which includes a small section of the Laura sandstones, from 21–23 November 2007. *Oedura jowalbinna* **sp. nov.** was discovered at one of these sites and eight individuals were found. Data on morphology, colour pattern and reproductive condition were collected from all individuals in the field. Two of these individuals were collected and deposited in the Queensland Museum as the type series.

Measurements and scale counts: Measurements and scale counts follow those described in Couper *et al.* (2007). All individuals examined were adults. Descriptions of dorsal colour pattern were taken for all individuals. Measurements are as follows: snout to vent length (SVL), tip of snout to anterior margin of cloaca with body straightened; tail length (T), posterior margin of cloaca to tip of tail; head length (HL), mid anterior margin of ear to tip of snout; head width (HW), widest point across head (between eyes and ear openings); head depth (HD), lower jaw to top of head (between eyes); snout length (S), anterior margin of eye to tip of snout; eye to ear (EE) posterior margin of eye to mid anterior margin of ear; neck length (NL), axilla to mid posterior margin of ear; total length of forelimb (L1), insertion to tip of longest digit; forearm length (FL), palm to elbow (with wrist and elbow bent); total length of hindlimb (L2), insertion to tip of longest digit; hindleg length (HLL), heel to knee (with ankle and knee bent); axilla to groin (AG). Field measurements were taken using Mitutoyo vernier callipers to the nearest 0.1 mm, and measurements of preserved specimens were taken using Mitutoyo electronic callipers to the nearest 0.1 mm. Scale counts are as follows: subdigital lamellae (on hindlimbs (toes) and forelimbs (fingers)) from tip of digit to end of enlarged lamellae row, count terminates proximally when lamellae cease to be two-times the size of the adjacent scales; hindlimb subdigital lamellae

total, sum of all subdigital lamellae on the toes of one foot; supralabial and infralabial scale rows (starting at rostral and mental scales), count terminates posteriorly at the angle of the mouth where labials cease to be two-times the size of the adjacent head scales. All bilateral counts were scored for the left side only.

Multivariate comparison of morphology and scalation. A multivariate approach was taken to compare the morphology and scalation of *O. jowalbinna* **sp. nov.** to *O. coggeri*, *O. monilis* De Vis 1888, and *O. castelnaui* Thominot 1889. *Oedura coggeri* was included because it is the most similar species to *O. jowalbinna* **sp. nov.** in general appearance, *O. monilis* was included due to its similarity to *O. coggeri*, and *O. castelnaui* was included because it was common on trees in the vicinity of the type locality of *O. jowalbinna* **sp. nov.** *Oedura coggeri* and *O. monilis* both occur in north-east Queensland but have not been recorded as far north as the type locality for the new species. *Oedura rhombifer* Gray 1845 is the only other *Oedura* in north-east Queensland but this species is sufficiently distinct from *O. jowalbinna* **sp. nov.** in body form, colour pattern and scalation (see 'Comparison' section) to be excluded from the multivariate analyses.

Thirty-three preserved adult specimens held at the Queensland Museum were examined for their morphology and scalation: 1 female and 1 male *O. jowalbinna* **sp. nov.**, 10 female and 9 male *O. coggeri*, 3 female and 3 male *O. monilis*, and 3 female and 3 male *O. castelnaui* (see Appendix for specimen numbers and collection localities). The latter three species were identified based on species description papers and identification books (Cogger 2000; Wilson & Swan 2003; Wilson 2005).

Two separate principal components analyses (PCA) were carried out, one using morphological traits and one using scalation traits. These two types of traits were analysed separately so that the differences in morphology and scalation between species could be assessed independently. All morphology measurements and scale counts used are summarised in Table 1. Both PCAs were carried out using SPSS v15, with correlation matrices specified.

The morphology PCA used seven morphological traits: SVL, HL, HW, NL, AG, FL, and HLL. These traits were chosen as they should provide a good representation of variation in body size and shape. Tail length was not included due to the difference in length between original and regenerated tails. The seven morphological traits produced seven principal components (PCs) describing 100% of the variation in morphology among the 33 specimens measured.

The scalation PCA used four scale traits: number of interorbital, supralabial and infralabial scales, and total number of subdigital lamellae on one hindlimb. Other scale characters were not included as they did not vary among the species and therefore could not contribute to phenotypic differences among them. The four scale traits produced four PCs describing 100% of the variation in scalation among the 33 specimens examined.

To find the PCs that describe the differences among the four species in morphology and scalation, one-way analyses of variance (ANOVA) were carried out on each morphology and scalation PC using SPSS v15. Tests for homogeneity of variances were satisfied for all morphology and scalation PCs. For the PCs that did differ significantly among the four species, post-hoc comparisons were carried out between each species pair using Tukey's honestly significant difference (HSD) test in SPSS v15 to determine which species were different from each other.

Results

Colour pattern of *O. jowalbinna* sp. nov. vs. other *Oedura* species: *Oedura jowalbinna* **sp. nov.** differs obviously from all other species of *Oedura* in dorsal colour pattern (see 'Diagnosis' and 'Comparison' sections, and Fig. 1).

Morphology of *O. jowalbinna* sp. nov. vs. other *Oedura* species: Of the seven principal components (PCs) from the morphology PCA, only the first three PCs differed significantly among the four species in an

overall comparison (one-way ANOVA: PC1 $F_{3,32} = 18.4$, $P < 0.001$; PC2 $F_{3,32} = 3.8$, $P = 0.020$; PC3 $F_{3,32} = 4.2$, $P = 0.014$). The first principal component (PC1) accounted for 85% of the total variation in morphology among the 33 specimens measured. All seven traits loaded heavily on PC1: SVL 0.976, HL 0.950, HW 0.865, NL 0.839, AG 0.896, FL 0.922, and HL 0.911. The high and positive loadings for all body length measurements signifies that PC1 represents an overall measure of body size, with high values representing large overall body size and low values representing small overall body size (x-axis in Figure 2). PC1 significantly separated *O. jowalbinna* **sp. nov.** from each of the other three species (Tukey's HSD on morphology PC1 for *O. jowalbinna* **sp. nov.** vs.: *O. coggeri* $P = 0.050$, *O. monilis* $P = 0.003$, *O. castelnaui* $P < 0.001$). Therefore, *O. jowalbinna* **sp. nov.** is significantly smaller than *O. coggeri*, *O. monilis* and *O. castelnaui*.

The majority of the variation in the morphology among the specimens measured was due to body size. With the variation in morphology due to body size removed, the remaining 15% of variation in morphology among specimens was due to variation in body shape. The morphology PCs 2 and 3 describe 6% and 4.5% respectively of the variation in morphology among the specimens measured. *Oedura jowalbinna* sp. nov did not differ from *O. monilis* or *O. castelnaui* on PCs 2 and 3, indicating that no body shape differences were detected. *Oedura jowalbinna* **sp. nov.** was nearly significantly different from *O. coggeri* on PC2 (Tukey's HSD on morphology PC2 for *O. jowalbinna* **sp. nov.** vs. *O. coggeri* $P = 0.053$), and was significantly different on PC3 (Tukey's HSD on morphology PC3 for *O. jowalbinna* **sp. nov.** vs. *O. coggeri* $P = 0.017$). Body shape differences between *O. jowalbinna* **sp. nov.** and *O. coggeri* were primarily due to the relatively narrower head of *O. jowalbinna* **sp. nov.**

Scalation of *O. jowalbinna* sp. nov. vs. other *Oedura* species: Of the four scalation PCs, only PC1 was significantly different among the four species (one-way ANOVA: PC1 $F_{3,32} = 15.33$, $P < 0.001$). *Oedura jowalbinna* **sp. nov.** was significantly different from each of the other three species on PC1 (Tukey's HSD on scalation PC1 for *O. jowalbinna* **sp. nov.** vs.: *O. coggeri* $P < 0.001$, *O. monilis* $P < 0.001$, *O. castelnaui* $P < 0.001$). Scalation PC1 accounted for 65% of the total variation in scale count traits among the 33 specimens examined. The interorbital, supralabial and infralabial scale counts loaded highly and positively on PC1 (0.832, 0.790, 0.892 respectively) whereas total hindlimb subdigital lamellae count loaded highly but negatively (-0.773). *Oedura jowalbinna* **sp. nov.** has a significantly higher value of scalation PC1 (y-axis on Figure 2) than the other three species, signifying that it has a greater number of interorbital, supralabial and infralabial scales relative to a lower total number of subdigital lamellae on the hindlimb, than *O. coggeri*, *O. monilis*, and *O. castelnaui*.

Comparison of *O. coggeri, O. monilis* and *O. castelnaui*: Apart from the morphological difference of *O. jowalbinna* **sp. nov.** from the other three species (see results above), there were also significant size differences among *O. coggeri*, *O. monilis*, and *O. castelnaui*. On PC1, which represents overall body size, both *O. coggeri* and *O. monilis* were significantly smaller than *O. castelnaui* (Tukey's HSD on morphology PC1 for *O. castelnaui* vs.: *O. coggeri* $P < 0.001$, *O. monilis* $P = 0.025$), but were not significantly different in size from each other (see x-axis on Figure 2). Although morphology PC2 and PC3 were significantly different among the four species, and revealed differences in shape between *O. jowalbinna* **sp. nov.** and *O. coggeri* (see results above), they were not significantly different in pair-wise comparisons among *O. coggeri*, *O. monilis* and *O. castelnaui*, indicating that the three species do not differ significantly in body shape in this analysis.

The only scalation PC that differed significantly among the four species was PC1, on which *O. jowalbinna* **sp. nov.** was shown to be significantly different from the other three species (see results above). Additionally, *O. monilis* and *O. castelnaui* were marginally significantly different from each other on PC1 (Tukey's HSD on scalation PC1 for *O. monilis* vs. *O. castelnaui* $P = 0.050$). *Oedura monilis* had slightly higher values of PC1 than *O. castelnaui* (see y-axis on Figure 2), indicating generally higher interorbital, supralabial and infralabial counts relative to lower total hindlimb subdigital lamellae counts in *O. monilis* compared to *O. castelnaui*. Alternatively, *O. coggeri* was not significantly different from either *O. monilis* or *O. castelnaui* in scalation.

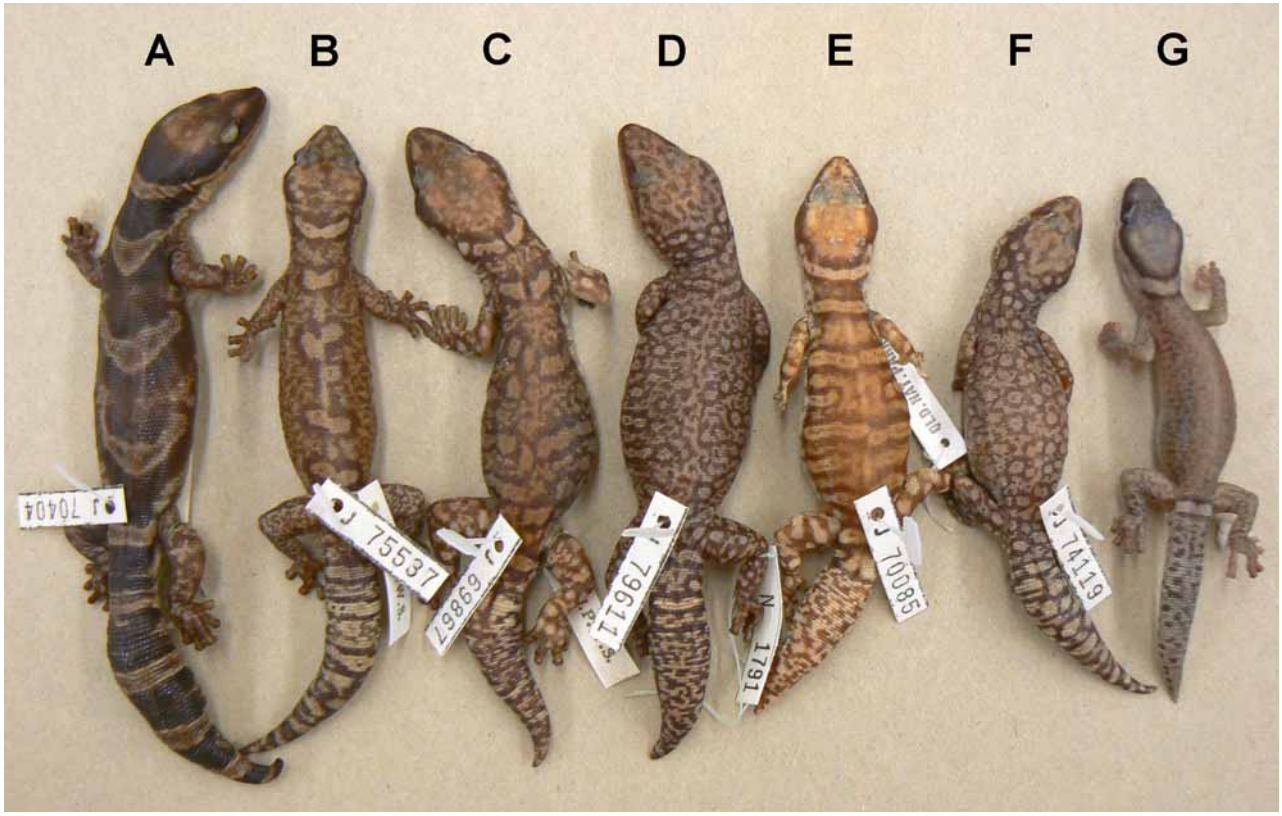

FIGURE 1. Comparison of size and dorsal pattern of four velvet geckos occurring in north-east Queensland: (A) *O. castelnaui* (QMJ70404) – size large, dorsal pattern of bold crescent-shaped bands; (B) *O. monilis* (QMJ75537) – size large, dorsal pattern typically consists of mottling overlain by a vertebral series of paired blotches (may be joined to form 'dumb-bells' or bars); (C, D, E, F) *O. coggeri* (QMJ69867, QMJ79611, QMJ70085, QMJ74119) – size and dorsal pattern highly variable, size large to moderate, dorsal pattern ranging from irregularly blotched, banded, to spotted; (G) *O. jowalbinna* **sp. nov.** (QMJ85932, holotype) – size moderate, dorsal pattern restricted to distinct band on neck and base of tail, otherwise back faintly speckled, tail with small dark spots.

Systematics

Oedura jowalbinna **sp. nov.** is assigned to *Oedura* based on the combination of external morphological characters outlined in Cogger (2000). The arrangement of the subdigital lamellae in *Oedura* is particularly diagnostic: single at base of toe, paired along digit, and ending in a distal pair that is distinct and discontinuous with the remaining subdigital lamellae (Cogger 2000).

***Oedura jowalbinna* sp. nov.**
Figs 1G and 3
Quinkan Velvet Gecko

Material examined: Holotype: QMJ85932, female, Pine Tree Ck, Jowalbinna Station, 34 km south-west of Laura, north-east Queensland (15°45′30″S, 144°12′15″E, elevation 250 m), C. J. Hoskin and M. Higgie, 23 November 2007. **Paratype:** QMJ85933, male, collection details as for holotype.

Additional material: Eight individuals were captured in the field. Morphological measurements, descriptions of colour pattern, and notes on breeding biology were recorded from seven of these individuals (Table

2), with one female escaping before morphological measurements were taken. Two of these individuals were collected (holotype and paratype), while the remaining six individuals were released due to uncertainty over the conservation status of the species.

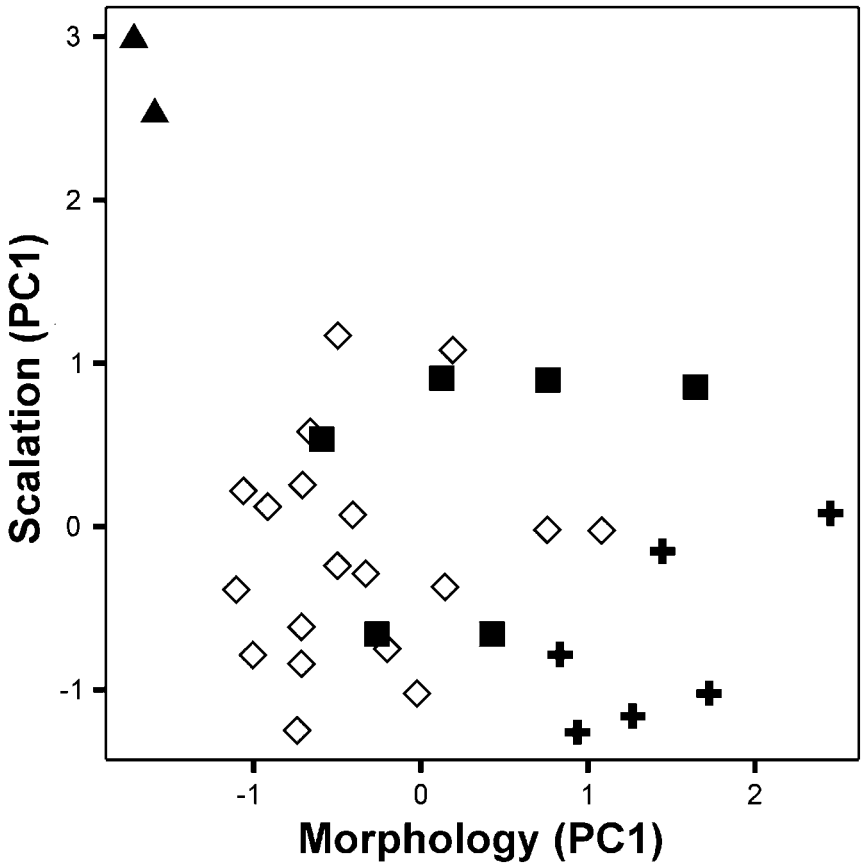

FIGURE 2. Separation of *Oedura jowalbinna* **sp. nov.** from *O. coggeri*, *O. monilis* and *O. castelnaui*, on both morphological and scalation traits. Morphology PC1 (x-axis) encompasses 83% of the variation in morphological traits among the specimens measured and is a multivariate representation of body size (high values represent large body size, while low values represent small body size). Scalation PC1 (y-axis) encompasses 65% of the variation in scale count traits among the specimens measured (high values represent high interorbital, supralabial and infralabial scale counts relative to a low total hindlimb subdigital lamellae count, while low values represent low interorbital, supralabial and infralabial scale counts with a high hindlimb subdigital lamellae count). ▲—*O. jowalbinna* **sp. nov.**, ◇—*O. coggeri*, ■—*O. monilis*, ✚—*O. castelnaui*.

Diagnosis: *Oedura jowalbinna* **sp. nov.** is a robust, medium-sized (SVL 60–69 mm) velvet gecko that can only be confused with its congeners. *Oedura jowalbinna* **sp. nov.** has a unique dorsal colour pattern (Figs 1G, 3A–C). The dorsal surface of the body, head and limbs are pale pinkish grey with faint freckling, and the only distinct markings are two pale, dark-edged bands—one across the neck, the other across the base of the tail. The original tail is yellow with small dark spots.

Etymology: *jowalbinna* is the name of the cattle station on which the species was discovered. The common name 'Quinkan Gecko' is used because the sandstone escarpments of the Laura region are commonly referred to as the Quinkan region. Quinkans are ancestral spirit people that inhabit the sandstone escarpments in the Laura region (Ang-Gnarra Aboriginal Corporation 1995) and are commonly depicted at rock art sites, including at the type locality.

Measurements and scale counts of holotype: QMJ85932 (female) SVL = 60.2 mm; T = 34.7 (original); HL = 15.3 mm; HW = 11.9 mm; HD = 5.2 mm; S = 6.4 mm; EE = 5.6 mm; NL = 14.5 mm; AG = 26.8 mm; L1 = 18.9 mm; FL = 7.7 mm; L2 = 24.1 mm; HLL = 9.7 mm; 21 interorbitals; 2 scales contacting dorsal edge

of rostral; rostral groove 1/3 of rostral depth; 6 scales bordering nostril; 11 supralabials; 12 infralabials; 6 rows of enlarged postmental scales; 3 scales bordering posterior edge of mental; postcloacal tubercules 1/1; no preanal pores evident; lamellae 1st toe = 6, 2nd toe = 6, 3rd toe = 7, 4th toe = 6, 5th toe = 6; lamellae 1st finger = 6, 2nd finger = 6, 3rd finger = 6, 4th finger = 6, 5th finger = 6.

Description of type series: Data presented as range followed by mean in brackets, n = 2. **Measurements.** SVL (mm): 60.2–61.6 (60.9); T = 34.7–36.8 (35.8); HL = 15.0–15.3 (15.1); HW = 11.5–11.9 (11.7); HD = 5.2–5.6 (5.4); S = 6.4–6.8 (6.6); EE = 5.6–5.6 (5.6); NL = 13.7–14.5 (14.1); AG = 26.8–27.6 (27.2); L1 = 18.9–19.4 (19.1); FL = 7.6–7.7 (7.6); L2 = 24.1–24.8 (24.5); HLL = 9.5–9.7 (9.6). **Proportions as % SVL.** T% = 57.6–59.8 (58.7); HL% = 24.3–25.4 (24.8); HW% = 18.6–19.7 (19.2); HD% = 8.6–9.0 (8.8); S% = 10.7–11.0 (10.8); EE% = 9.1–9.3 (9.2); NL% = 22.3–24.1 (23.2); AG% = 44.4–44.7 (44.6); L1% = 31.3–31.4 (31.4); FL% = 12.3–12.8 (12.5); L2 = 40.0–40.3 (40.2); HLL% = 15.4–16.1 (15.7).

Head. Narrow, elongate, moderately depressed, distinct from neck; head width 76.6–77.7% (77.2%) head length; head depth 43.8–48.5% (46.1%) head width; covered in small granules with slightly larger granules on the dorsal and lateral surfaces of the snout; 21 interorbital scales; rostral approximately twice as wide as deep, partially divided vertically by a medial groove (rostral groove 1/3 of rostral depth); rostral shield contacting nostril, bordered by 2 scales along its dorsal edge and the 1st supralabial on each side; 6 scales bordering nasal opening; 11–12 (11.5) supralabials, 1st supralabial narrower than 2nd supralabial, 1st supralabial taller than 2nd; 12 infralabials; 7 rows of noticeably enlarged granules extending back from mental scale, decreasing in size towards small ventral scales; ear opening small and horizontally elongate. ***Body.*** Moderately robust, slightly depressed, slightly pear-shaped, covered in small granules; granules on ventral surface about the same size as those on dorsum; granules on lateral and dorsolateral surfaces arranged as transverse rows; 1 enlarged postcloacal tubercule behind the lower posterior margin of the thigh in both sexes (better defined in males). A medially broken row of 15 preanal pores (8 on left side, 7 on right side) present in mature male, extending to underside of thigh; preanal pores not evident in female. ***Limbs.*** Moderately short and stout; digits dorsoventrally compressed and expanded distally, each with an enlarged pair of apical lamellae followed by a transverse series of lamellae that are divided distally and single proximally; apical pair of lamellae discontinuous with other lamellae; hindlimb with 5–6 (5.5) enlarged lamellae (including apical pair) on 1st toe, 6 on 2nd toe, 7 on 3rd toe, 6–7 (6.5) on 4th toe and 6 on 5th toe; basal webbing evident between digits 2, 3 and 4 of hindlimb, small between digits 2 and 3, and moderate between digits 3 and 4; forelimb with 6 enlarged lamellae (including apical pair) on 1st finger, 5–6 on 2nd finger, 6 on 3rd finger, 6 on 4th finger and 6 on 5th finger. ***Original tail.*** Relatively short, tapered; scales arranged in concentric rings, about the same size on the dorsal and on ventral surfaces. ***Regenerated tail.*** Not known.

Pattern in spirit (Fig. 1G)**:** Pattern of holotype and paratype very similar. Background colour of dorsal and lateral surfaces pale grey. Dorsal and lateral surfaces of back and limbs mottled/freckled with light brown markings; faint to absent along the vertebral zone. Top of head even grey. Distinct pale, dark-edged band across neck; pale band sweeps forward unbroken to the snout enclosing ear and running along lower jaw and supralabials; anterior dark edging passes through eye to snout. Distinct pale, dark-edged band across base of tail. Dorsal and lateral surfaces of tail grey with distinct, small, brown, evenly spaced dots. Lower ventral surfaces and ventral surfaces of body, head and limbs cream, except for grey belly and pinkish chin. Underside of hands and feet grey. Postanal tubercles white. Ventral surface of tail pale with faint, grey, irregular mottling.

Measurements of live individuals: Table 2 summarises measurements from seven live individuals (including the holotype and paratype) in the field. The holotype and paratype showed 1.3% and 3.8% shrinkage, respectively, between SVL measurement alive and preserved.

Pattern in life (Fig. 3)**:** Pattern was highly consistent across all individuals (N = 8), varying only in brightness. Background colour of dorsal and lateral surfaces pale pinkish grey. Dorsal and lateral surfaces of back and limbs freckled with light brown markings, markings fade out to become absent towards the vertebral

TABLE 1. Morphology and scalation of *O. jowalbinna* **sp. nov.**, *O. coggeri*, *O. monilis*, and *O. castelnaui* from preserved Queensland Museum specimens. Each morphological trait is presented with the raw measurement and as a proportion of snout-vent length. For each species, half of the specimens measured were female and half were male. Subdigital lamellae counts were taken from one hindlimb. See Appendix for specimen numbers and collection localities.

Traits	*O. jowalbinna* **sp. nov.**				*O. coggeri*				*O. monilis*				*O. castelnaui*			
	mean	min	max	N	mean	min	max	N	mean	min	max	N	mean	min	max	N
Morphology																
Measurements (mm)																
snout-vent length (SVL)	60.9	60.2	61.6	2	70.8	64.5	80.4	19	77.8	70.2	87.4	6	87.8	81.0	95.3	6
tail length: original (T)	35.8	34.7	36.8	2	45.4	40.4	48.1	7	55.7	52.5	58.8	2	52.6	51.1	54.2	2
tail length: regenerated					34.8	29.4	39.6	10	40.5	30.8	48.6	3	49.0	28.2	57.9	4
head length (HL)	15.1	15.0	15.3	2	18.1	16.8	20.2	19	18.7	16.8	21.4	6	20.8	19.8	22.6	6
head width (HW)	11.7	11.5	11.9	2	14.4	13.1	16.1	19	14.8	14.1	15.8	6	15.6	13.9	17.1	6
neck length (NL)	14.1	13.7	14.5	2	16.9	13.4	22.9	19	18.1	16.2	21.3	6	21.2	18.5	24.3	6
axilla-groin length (AG)	27.2	26.8	27.6	2	31.4	27.5	37.6	19	36.0	31.1	42.3	6	39.8	36.8	43.0	6
forearm length (FL)	7.6	7.6	7.7	2	8.0	7.3	9.5	19	9.1	8.4	9.7	6	9.9	9.6	11.0	6
hindleg length (HLL)	9.6	9.5	9.7	2	10.2	8.2	11.4	19	11.0	9.2	12.7	6	12.2	11.6	13.4	6
Proportions (as % of SVL)																
T: original %	58.7	57.6	59.8	2	66.4	59.7	70.1	7	70.2	67.4	73.0	2	59.0	56.6	61.4	2
T: regenerated %					48.4	39.2	57.3	10	52.2	43.9	62.7	3	55.8	34.8	67.7	4
HL %	24.8	24.3	25.4	2	25.7	24.3	27.1	19	24.1	23.1	26.3	6	23.7	23.0	25.1	6
HW %	19.2	18.6	19.7	2	20.4	19.0	21.9	19	19.1	17.7	20.5	6	17.8	16.3	18.7	6

to be continued.

TABLE 1. (continued.)

Traits	*O. jowalbinna* **sp. nov.**				*O. coggeri*				*O. monilis*				*O. castelnaui*			
	mean	min	max	N	mean	min	max	N	mean	min	max	N	mean	min	max	N
NL %	23.2	22.3	24.1	2	23.9	19.0	28.7	19	23.3	19.3	25.2	6	24.2	21.8	26.9	6
AG %	44.6	44.4	44.7	2	44.4	39.5	49.2	19	46.2	42.1	49.0	6	45.3	42.1	48.0	6
FL %	12.5	12.3	12.8	2	11.4	10.4	12.7	19	11.7	11.1	12.6	6	11.2	10.8	11.9	6
HLL %	15.7	15.4	16.1	2	14.4	12.7	15.8	19	14.1	12.2	15.6	6	13.9	13.0	14.6	6
Scalation																
interorbitals	21.0	21	21	2	17.4	15	20	20	18.7	18	20	6	17.0	16	18	6
contacting rostral dorsal edge	2.0	2	2	2	2.0	2	2	20	2.0	2	2	6	2.0	2	2	6
rostral division	0.33	0.33	0.33	2	0.44	0.25	0.50	20	0.63	0.50	0.75	6	0.63	0.50	0.75	6
contacting nostril	6.0	6	6	2	6.0	6	6	20	6.0	6	6	6	6.0	6	6	6
supralabials	11.5	11	12	2	10.4	9	11	20	10.7	10	11	6	10.0	9	11	6
infralabials	12.0	12	12	2	9.5	9	10	20	9.8	9	11	6	9.3	8	10	6
postcloacal tubercles/side	1.0	1	1	2	1.0	1	1	20	1.0	1	1	6	1.0	1	1	6
preanal pores	15.0	15	15	1	12.5	10	17	10	17.0	14	22	4	20.7	16	24	3
subdigital lamellae 1st toe	5.5	5	6	2	6.3	5	7	20	6.8	6	7	6	6.8	6	8	6
subdigital lamellae 2nd toe	6.0	6	6	2	7.0	6	9	20	6.7	6	7	6	6.8	6	7	6
subdigital lamellae 3rd toe	7.0	7	7	2	8.2	7	9	20	8.2	8	9	6	8.7	8	9	6
subdigital lamellae 4th toe	6.5	6	7	2	7.8	7	9	20	8.2	7	9	6	8.3	8	9	6
subdigital lamellae 5th toe	6.0	6	6	2	6.7	5	8	20	6.7	6	7	6	7.0	6	8	6
subdigital lamellae total	31.0	31	31	2	35.8	33	39	20	36.5	33	38	6	37.7	35	40	6

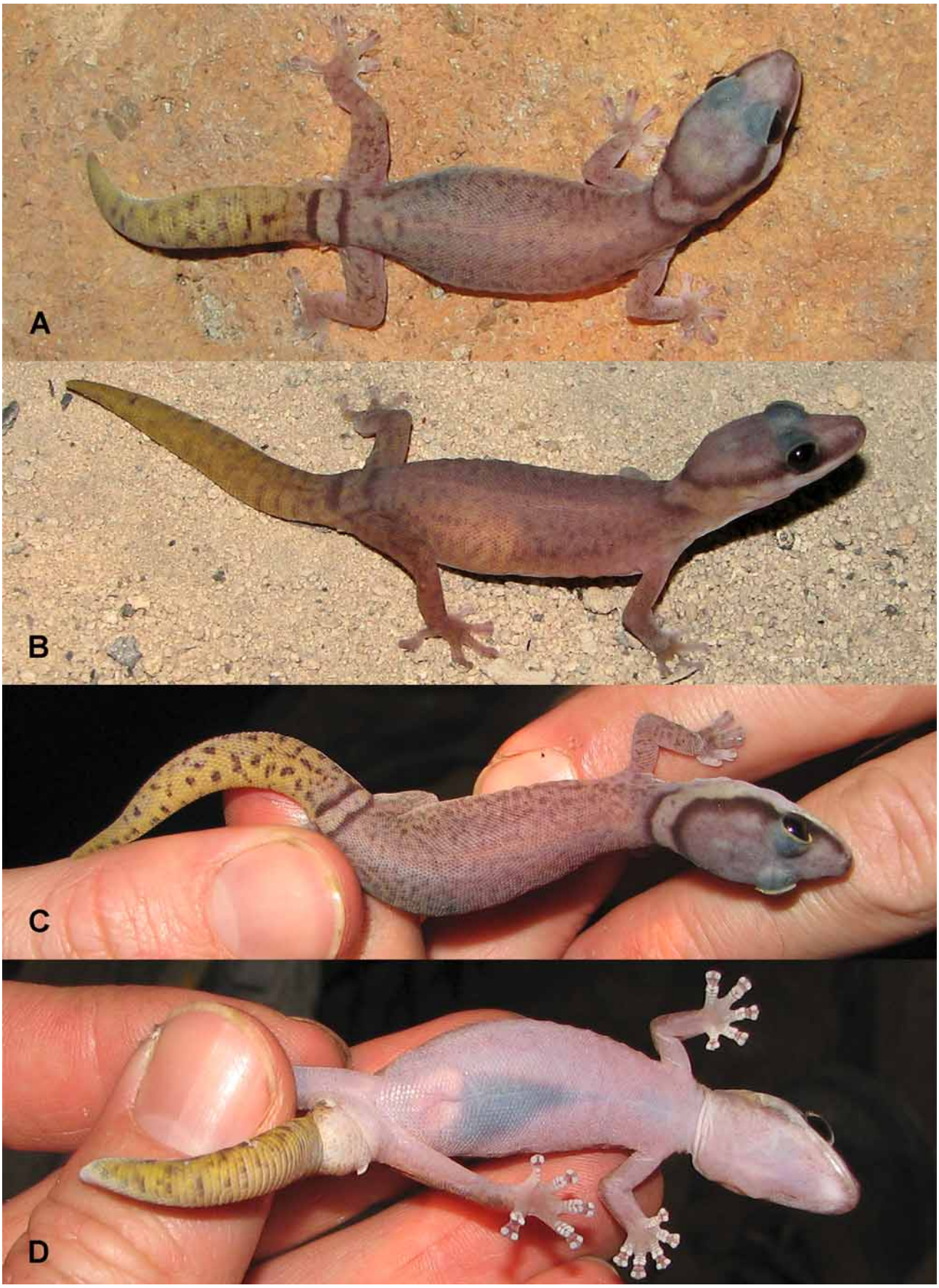

FIGURE 3. *Oedura jowalbinna* **sp. nov.** in life: (A) male; (B) gravid female; (C) female, QMJ85932, holotype; (D) male, ventral view.

TABLE 2. Field measurements of female (N = 3) and male (N = 4) *O. jowalbinna* **sp. nov.** from the type locality on Jowalbinna Station. All individuals had original tails.

Traits	Female			Male		
	mean	min	max	mean	min	max
snout-vent length (SVL)	66.0	61.0	69.0	66.3	64.0	69.0
tail length: original (T)	103.0	101.0	107.0	101.5	98.0	106.0
head length (HL)	15.8	15.0	16.2	15.5	15.0	16.1
head width (HW)	11.9	11.5	12.3	11.9	11.7	12.1
hindleg length (HLL)	9.7	9.4	10.0	9.5	9.0	10.0
weight	5.5	4.5	6.5	5.1	4.3	5.5

zone. Freckling is very faint to almost completely absent in some individuals, such that they appear unmarked. Fingers pale. Top of head unmarked, even pinkish grey. Distinct pale, dark-edged band across neck, sweeping forward to the snout; anterior dark edge of band passes from snout, through eye and over nape; pale band becomes white from in front of ear, along jaw to snout. Distinct pale, dark-edged band across base of tail. Dorsal and lateral surfaces of tail yellow or golden with distinct or diffuse small brown dots or grey mottling. Lower ventral surfaces and ventral surfaces of body, head and limbs pale pinkish. Postanal tubercles and lamellae of hands and feet white. Ventral surface of tail creamy yellow, with or without diffuse grey mottling. Eye very dark brown to black.

Comparison with other taxa: Colour pattern obviously differentiates *Oedura jowalbinna* **sp. nov.** from its congeners. The dorsal pattern of *Oedura jowalbinna* **sp. nov.**, consisting of a distinct band across the neck and across the base of tail separated by a back lacking distinct patterning, differs from all other *Oedura* species. The other *Oedura* have heavily marked dorsal patterns of bands, spots, blotches or zigzags that are consistent along the length of the dorsum. Furthermore, the combination of grey body and yellow tail also distinguishes *O. jowalbinna* **sp. nov.** from its congeners.

Some aspects of the external appearance of *O. jowalbinna* **sp. nov.** (e.g. pale colouration, weak pattern, relatively narrow head) show some similarities to other sandstone species of northern Australia. *Oedura jowalbinna* **sp. nov.** differs from these species by the characters above, and furthermore by lacking conspicuous lateral toe fringing (versus *O. filicipoda*), having more than three pairs of large, divided lamellae on the fourth toe (versus *O. gracilis*), being of smaller size (versus *O. filicipoda*, *O. gracilis* and *O. gemmata*), and by its robust form and lack of a long, slender tail (versus *O. gracilis* and *O. obscura*).

Oedura jowalbinna **sp. nov.** co-occurs at the type locality with *O. castelnaui* and *O. rhombifer.* The dorsal pattern of *O. castelnaui* (Fig. 1A), consisting of bold, crescent-shaped bands, differs obviously from that of *O. jowalbinna* **sp. nov.** (Fig. 1G). *Oedura castelnaui* is also a considerably larger species (Table 1, Fig. 2). *Oedura rhombifer* differs from *O. jowalbinna* **sp. nov.** in being slender, having a long slender tail, having a continuous zigzag vertebral band, and in having minute dorsal scales that are noticeably smaller than the ventrals. Although not recorded at the type locality, *O. coggeri* and *O. monilis* also occur in north-east Queensland. *Oedura coggeri* has been collected from south of the Laura sandstones, in the Palmer River region (16°09′S, 144°08′E), approximately 38 km south-west of the type locality of *O. jowalbinna* **sp. nov.** The closest specimens of *O. monilis* were collected from Forty Mile Scrub National Park (18°08′S, 144°49′E), approximately 270 km south of the type locality of *O. jowalbinna* **sp. nov.** (Queensland Museum data). *Oedura coggeri* (Fig. 1C–F) and *O. monilis* (Fig. 1B) both have heavily marked dorsal surfaces that vary from being spotted to banded and do not resemble the distinctive dorsal pattern of *O. jowalbinna* **sp. nov.** (Fig. 1G). These two species are also generally larger than *O. jowalbinna* **sp. nov.** (Table 1, Fig. 2).

Oedura jowalbinna **sp. nov.** shows greatest similarity in body size, body shape and scalation to *O. coggeri* and *O. monilis*. However, *O. jowalbinna* **sp. nov.** clearly differs from these two species in multivariate analy-

ses of morphology and scalation due to its generally smaller size and combination of higher interorbital, infralabial and supralabial scale counts, and lower total subdigital lamellae scale count (Fig. 2, Table 1). Considered individually, some of these traits are non-overlapping (Table 1), however, more individuals of *O. jowalbinna* **sp. nov.** need to be assessed to determine the full range of variation in these traits.

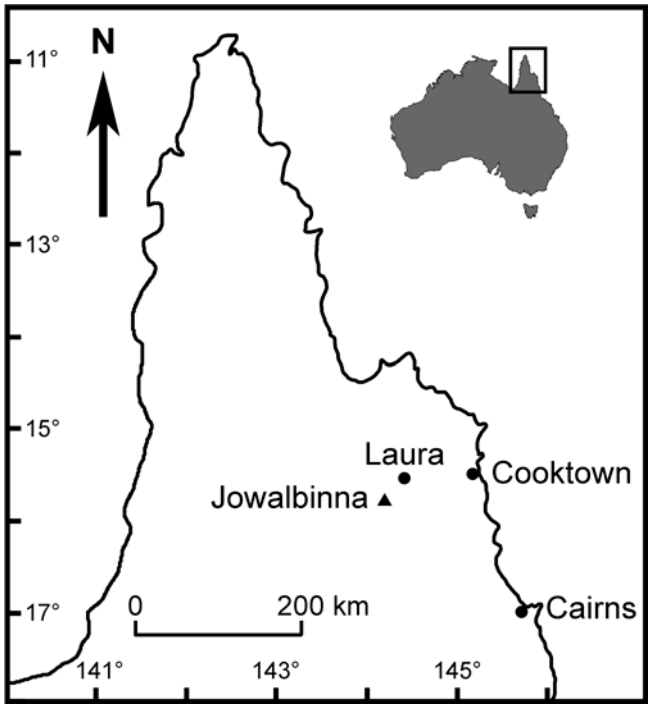

FIGURE 4. Map of north-east Queensland, showing the type locality of *Oedura jowalbinna* **sp. nov.** (▲).

Distribution: Only known from the type locality, heavily dissected sandstone escarpment in the headwaters of Pine Tree Creek, Jowalbinna station, 34 km south-west of the town of Laura, north-east Queensland (Fig. 4). All individuals were found within approximately 300 m of each other. The type locality is part of the Dalrymple sandstones of the Battle Camp Formation ('Laura sandstones'), an extensive area of sandstone escarpments extending from Bathurst Bay to south-west of Laura (De Keyser & Lucas 1968). The habitat occupied at the type locality appears similar to that seen in other areas of the Laura sandstones and therefore *O. jowalbinna* **sp. nov.** may be more widely distributed. We did not find the species during a gecko survey of the sandstone escarpment in the headwaters of Brady Creek (10 km south-east of the type locality) two days prior to the discovery of the species. Further, this species was not found on previous gecko surveys by us and others on sandstone outcrops south-east of the town of Laura (~35 km north-east of the type locality). However, these surveys represent limited survey effort given the extent of the sandstone escarpments in the Laura region.

Habitat and habits: *Oedura jowalbinna* **sp. nov.** appears to be a rock-restricted species. All eight individuals were found at night on the underside of rock overhangs along the base of a linked series of 5–15 m high sandstone walls (Fig. 5). Individuals were generally found along east facing walls. No individuals were found on exposed rock surfaces, on trees amongst the rocks, or in the surrounding open eucalypt woodland. Sandstone at the type locality is heavily weathered, with deep cracks and holes, and large overhangs. Sandstone in the overhangs is pale sandy yellow or orange in colour, while that on the exposed surfaces is dark grey.

Individuals were found between 19:30–23:30 on the 22 and 23 November 2007. Conditions were warm and humid (air temperature approximately 28 °C) and there were localised storms in the area. Four males and four females were found. All were adult and appeared to have original tails. There was no detectable differ-

ence between males and females in terms of body size, body shape or colour pattern. Three of the four females were gravid, each carrying two large white eggs visible through the skin on the ventral surface. Some individuals made a thin, high pitched 'peep' when being handled and some made a soft growl when held in cloth bags. Small crickets were common on the underside of the overhangs and may represent a significant component of the arthropod prey.

Other geckos found occupying the rock habitat at the type locality were *Cyrtodactylus louisiadensis* De Vis 1892, *Gehyra dubia* Macleay 1877, and *Oedura rhombifer.* The surrounding forest was open eucalypt woodland, some of which had been burnt in the last couple of years. Geckos found in the eucalypt woodland were *Oedura castelnaui*, *Gehyra dubia* and *Heteronotia binoei* Gray 1845.

Conservation: *Oedura jowalbinna* **sp. nov.** is only known from one site, where it is moderately common. No threats to the survival of this species at the type locality were apparent. Further surveys across the Laura sandstones are required to determine the distribution and abundance of *O. jowalbinna* **sp. nov.**

FIGURE 5. Sandstone habitat of *Oedura jowalbinna* **sp. nov.** at the type locality.

Discussion

The probable restriction of *O. jowalbinna* **sp. nov.** to the Laura sandstones brings to three the number of reptile species described with localised ranges centred on the sandstone escarpments of the Laura region. The skink *Ctenotus quinkan* is restricted to the Laura sandstones, while *C. nullum* also occurs in neighbouring rocky areas (Ingram 1979; Ingram & Czechura 1990). *Oedura jowalbinna* **sp. nov.** is probably not as widely distributed as these species as its habitat requirements (deeply weathered sandstone cliffs with deep overhangs

and crevices) appear more specialised than those of the two skinks (open forest with decomposed sandstone substrate and small to large sandstone rocks, and also the base of nearby granite outcrops for *C. nullum* (Ingram 1979; Ingram & Czechura 1990)). Further surveys in the Laura region would not only resolve the distribution of *O. jowalbinna* **sp. nov.** but may also uncover other new reptile species, especially given the diversity of species endemic to other Australian sandstone escarpment regions such as the Kimberley and Arnhem Land.

The evolutionary history of *O. jowalbinna* **sp. nov.** is of considerable interest. The similarity in morphology and scalation suggests a relationship with *O. coggeri* (and to a lesser degree *O. monilis*), which is supported by the fact that *O. coggeri* occurs primarily on rock (but generally granite) and is found immediately to the south of the Laura sandstones. Some aspects of the external appearance of *O. jowalbinna* **sp. nov.** (e.g. pale colouration, weak pattern, relatively narrow head) show some similarities to the sandstone species *O. gracilis*, *O. filicipoda*, *O. obscura* of the Kimberleys, and *O. gemmata* of Arnhem Land. However, we believe these similarities in appearance are due to convergence and it is most likely that the sandstone species of the Kimberleys, Arnhem Land and Laura region evolved from non-sandstone species independently in each of these areas, rather than the sandstone species being monophyletic. Genetic data is required to resolve the relationships of *O. jowalbinna* **sp. nov.** with other *Oedura*, and to test the hypothesis that *O. jowalbinna* **sp. nov.** has evolved from an ancestral *O. coggeri* population to the Laura sandstone habitat. Adaptation to sandstone habitat is a recurring feature in *Oedura* geckos. *O. jowalbinna* **sp. nov.** brings to five the number of *Oedura* that are restricted to (or primarily occur on) sandstone escarpments (*O. filicipoda*, *O. gracilis*, and *O. obscura* on the Kimberly escarpment in Western Australia; *O. gemmata* on the Arnhem Land escarpment in Northern Territory) (King & Gow 1983; King 1984).

The multivariate analyses of morphology and scalation herein distinguished *O. jowalbinna* **sp. nov.** and *O. castelnaui* from all other species in the analyses but did not enable separation of *O. coggeri* and *O. monilis* (Table 1, Fig. 2). This draws attention to the species distinction between *O. coggeri* and *O. monilis*. As portrayed in guide books (e.g. Cogger 2000; Wilson & Swan 2003; Wilson 2005), the 'typical' colour pattern of the two species differs in that *O. monilis* has a dorsal pattern of a paired vertebral series of blotches/ocelli that may be joined to form bars or dumbbells (Fig. 1B), while the pattern of *O. coggeri* is described as spots (Fig. 1D, F) that may be joined to form bars (Fig. 1C) or broken bands (Fig. 1E). Some of these 'typical' colour patterns are not particularly distinct between the two species (e.g. Fig. 1B vs. Fig. 1C) and the degree of variation beyond these 'typical' patterns in both species, particularly in *O. coggeri*, merges the purported differences in colour patterns. *Oedura coggeri* is also described as a smaller animal than *O. monilis* (70 mm vs. 80 or 85 mm SVL, Cogger 2000; Wilson & Swan 2003; Wilson 2005) but there is considerable overlap in body size (Table 1, Figs 1, 2). Genetic sequencing and further morphological analysis across the ranges of *O. coggeri* and *O. monilis* are required to assess regional variation and species boundaries within and between these two species.

Acknowledgements

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Appendix. Material examined

All specimens are in the Queensland Museum and all localities are in Queensland)

Oedura coggeri

QMJ20039, Mt Molloy area (16°41′S, 145°20′E); J45366, summit Mt Mulligan (16°53′S, 144°51′E); J53965, Lappa Junction (17°22′S, 144°53′E); J58910, 20 km west of junction of Gulf and Kennedy Highways (18°08′S, 144°38′E); J61281, Road Cave, Undara (18°33′S, 144°33′E); J62388, Palmer River (16°09′S, 144°08′E); J63475, Donna Cave, Chillagoe (17°10′S, 144°30′E); J69867, 100 Mile Swamp, Undara NP (18°12′S, 144°33′E); J70078, Amber Station, near Mt Surprise (17°45′S, 144°20′E); J70081, Amber Station, near Mt Surprise (17°44′S, 144°19′E); J70085, Amber Station, via Mt Surprise (17°44′S, 144°19′E); J70086, Amber Station, via Mt Surprise (17°44′S, 144°19′E); J70094, Lynd River, Amber Station (17°46′S, 147°20′E); J70109, Amber Hut (17°44′S, 144°19′E); J74119, 8 km along Black Mtn Rd, at Barracks, Kuranda State Forest (16°49′S, 145°38′E); J74565, Donkey Springs, Bulleringa NP (17°35′S, 143°48′E); J77899, Mt Zero Station, Paluma (19°01′S, 146°04′E); J79610, Hidden Valley (18°58′S, 146°03′E); J79611, Hidden Valley (18°58′S, 146°03′E); J79615, Hidden Valley (18°58′S, 146°03′E).

Oedura monilis

QMJ24962, 16 km south of Barmount (22°39′S, 149°16′E); J27190, 39 km west of Mitchell (26°28′S, 147°39′E); J30261, Magnetic Island (19°08′S, 146°50′E); J30449, Magnetic Island (19°08′S, 146°50′E); J37100, Palm Grove Fauna Reserve (24°57′S, 149°02′E); J37103, Emerald (23°31′S, 148°10′E); J75537, Fanning River Station (19°44′S, 146°26′E).

Oedura castelnaui

QMJ70404, Burlington Station (17°52′S, 144°26′E); J75024, Blue Water Scout Camp (19°11′S, 146°33′E); J75413, Fanning River, near Mingela (19°55′S, 146°28′E); J75536, Fanning River Station (19°44′S, 146°26′E); J76797, Yabulu (19°07′S, 146°22′E); J79351, Pallarenda NRC, Townsville (19°01′S, 146°46′E); J79352, west of Hervey Range (19°04′S, 146°33′E).