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# Morphological and molecular assessment of the *Diplodactylus savagei* species complex in the Pilbara region, Western Australia, with a description of a new species

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## Abstract

The gecko *Diplodactylus savagei* is restricted to the rocky Pilbara and Ashburton regions of Western Australia. Recent collections have enabled a reappraisal of morphological and genetic diversity within the taxon. Analysis of 1200 base pairs of the mtDNA gene *ND2* and surrounding tRNA found strong support for three lineages within *D. savagei*: an eastern clade (which includes the type location of *D. savagei* from Marble Bar), a southern clade and a north-central clade. The eastern and southern clades did not differ in morphology or dorsal pattern. Although there are several subtle differences in morphological characters between the eastern and southern clades compared to the north-central form, there were clear differences in dorsal pattern with the north-central forms having finer, widely-scattered spots, a pale dorsal border to the loreal stripe and a gradual transition between the dorsal and ventral colouration. We describe the north-central form as a new species, *D. galaxias* **sp. nov.**, based on the distinctiveness of its colour pattern, subtle morphological differences, mtDNA divergence and maintenance of these differences at the edge of the western Hamersley Range where the north-central and southern clades come into contact.

**Key words:** cryptic species, Diplodactylidae, gecko, lizard, *ND2*, tRNA

## Introduction

The genus *Diplodactylus* Gray, 1832 is an Australian clade of geckos that has seen large changes in content in the past two decades. First, Russell and Rosenberg (1981) separated the tail-squirting geckos to the genus *Strophurus* Fitzinger, 1843. This was followed by the removal of the more slender, narrow-toed species of *Diplodactylus* to the genus *Lucasium* Wermuth, 1965 by Oliver *et al.* (2007a). Despite the reduction in *Diplodactylus* diversity owing to these generic rearrangements, several new species of *Diplodactylus* have recently been described or redescribed that show only subtle morphologically differences but exhibit deep genetic splits among lineages (Aplin & Adams 1998; Doughty *et al.* 2008; Hutchinson *et al.* 2009).

*Diplodactylus savagei* Kluge, 1963 is only known from the Pilbara and Ashburton regions of Western Australia (Storr *et al.* 1990; Cogger 2000; Wilson & Swan 2008). Kluge described this species as distinct from other members of the *D. vittatus* Gray, 1832 species-group, especially *D. conspicillatus* Lucas & Frost, 1897 – a taxon also with a similar elongate body and a ‘beaked’ face, possibly owing to specialised feeding on termites or ants (Storr *et al.* 1990). Kluge had only four specimens available to work with for his description (see also Kluge 1967), and the collection of Pilbara reptiles has been slow until recent decades owing to expanding mining activity in the area (Fig. 1). More extensive, recent collections of *D. savagei* within the Pilbara region have revealed consistent morphological differences in back pattern, with north-central populations having fine, widely-scattered spots whereas southern and eastern populations tend to have heavier spots arranged in transverse rows (Fig. 2). Many of the recently collected specimens had tissue samples taken

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for genetic analyses, and we tested whether there was a correspondence between back patterns and genetic history within the region. We found strong evidence for the recognition of a second species within *D. savagei*, which we describe as a new species below.

## Material and methods

**Morphology.** We examined all specimens of *D. savagei* from the collections of the Western Australian Museum, Perth (WAM) (Appendix 1). The legend in Table 1 lists the morphological characters measured and their abbreviations. All measurements are in mm. We measured 21 individuals from the north-central and 20 individuals from the eastern + southern clades encompassing each distinct back pattern morph. We tested taxon and sex for differences in body size with a 2-way ANOVA and for TrunkL with a 2-way ANCOVA with SVL as a covariate. With a few exceptions, there was little variation in morphology or scale characteristics (see Results), so our morphological diagnoses focus on the more conspicuous back pattern elements that show limited variation within each population.

**Genetic analyses.** Tissue samples were obtained for 29 *D. savagei* from the Pilbara region (indicated in Fig. 1). For all individuals a 1200 base pair (bp) region of the mitochondrial genome was sequenced that included the entire mitochondrial NADH dehydrogenase subunit 2 (*ND2*) gene and the flanking transfer RNA (tRNA) genes $tRNA^{Met}$ (partial), $tRNA^{Trp}$ (entire), $tRNA^{Ala}$ (entire) and $tRNA^{Asn}$ (partial). Details of primers and lab protocols are outlined in Pepper *et al.* (2006). *Rhynchoedura ornata* Günther, 1867, *D. fulleri* Storr, 1978 and *D. pulcher* Steindachner, 1870 were used as outgroups for all analyses. We used unweighted parsimony and Bayesian approaches to analyse the data. Heuristic parsimony analyses were implemented with the computer program PAUP*4.0b10. We used TBR branch swapping and ran the parsimony analysis five times from random starting points to make sure overall tree space was well searched. Bayesian analyses were run with the computer program MrBayes v3.1.2 and we allowed all parameters to be estimated from the data during the run. We ran the full analyses five times to make sure overall tree-space was well sampled and to avoid getting trapped in local optima. We ran each analysis for a total of 2,000,000 generations and sampled the chain every 100 generations, resulting in 40,000 sampled trees. We discarded the first 20,000 trees as the burn-in and used the last 20,000 trees to estimate Bayesian posterior probabilities. We used the results of 10,000 'fast' unweighted non-parametric parsimony bootstrap replicates and Bayesian posterior probabilities to assess branch support.

## Results

**Morphology.** There were consistent differences in dorsal pattern between the north-central clade and the eastern and southern clades (Figs. 2, 3). Preliminary observations indicated there were few differences between the eastern and southern populations, so these populations were pooled as '*D. savagei*' whereas the north-central populations were treated as a tentative new species. Table 1 shows the results of the morphological analysis. The ANOVA on SVL revealed significant differences for population ($F_{1,38} = 6.719$, $P = 0.0135$) and sex ($F_{1,38} = 53.94$, $P < 0.0001$), with north-central populations and males having smaller body sizes. The 2-way ANCOVA on TrunkL, however, was not significant for the main factors, although the trends were in the same direction as for SVL (population – $F_{1,37} = 1.537$; $P = 0.2229$; sex – $F_{1,37} = 3.646$, $P = 0.0640$; SVL – $F_{1,37} = 31.806$, $P < 0.0001$). In addition to body size, there were other subtle differences between the populations. The north-central populations had tails that were longer and thinner (Table 1) and had less gabled dorsal scales compared to typical *D. savagei*. Colour pattern, however, showed consistent variation between the two forms. Compared to eastern and southern populations, north-central populations had a lighter ground colour and a pale upper border to the dark loreal stripes on the snout. More conspicuously, north-central populations had finer spotting that rarely aligned to form transverse rows. In contrast, eastern and southern populations had heavier spots that formed transverse rows on the dorsum (Figs. 2, 3). In addition, the transition between the dorsal and ventral colouration also differed consistently between north-central *versus* eastern and southern populations. Eastern and southern populations had an abrupt transition between dorsal and ventral colouration at the ventrolateral edge of the body, often marked by small spots or fine stippling. In contrast, north-central forms had a very subtle transition, with no obvious point at which the dorsal and ventral colours changed over.

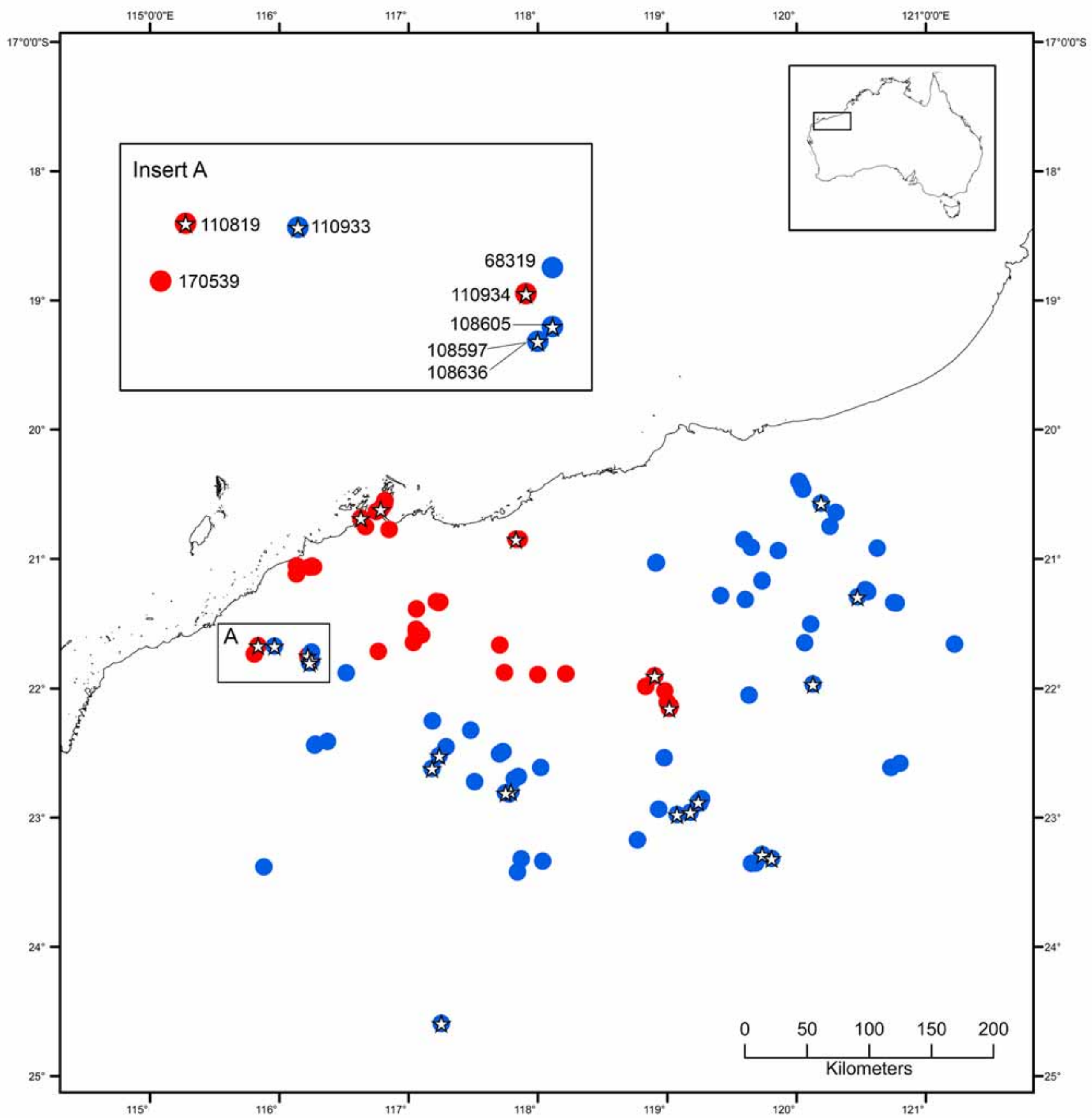


**FIGURE 1.** Distribution of *Diplodactylus savagei* populations in the Pilbara and Ashburton regions of Western Australia. Key: blue circles—*D. savagei*; red circles—*D. galaxias* **sp. nov.**; stars—genotyped individuals.

**Genetic analyses.** The edited alignment comprised 1188 characters and of these 391 (33%) were variable and parsimony informative when outgroups were included and 231 (19%) were variable and parsimony informative when outgroups were excluded. Unweighted parsimony analyses and Bayesian analyses produced very similar topologies and similar level of support for major branches. Figure 4 shows one of four most parsimonious trees saved during the unweighted parsimony analysis. Branch lengths, parsimony bootstrap support values and Bayesian posterior probabilities are shown for major branches only. The tree shows three strongly supported clades that differ from each other by uncorrected genetic distances of 8.6–10.5% but the relationship between the three clades is not resolved with these data. The eastern and southern clades correspond to *D. savagei* and include the type locality for the species (Marble Bar). The third clade represents specimens from the northern coastal and central regions of the Pilbara. These specimens are morphologically distinct from *D. savagei* (see above) and also occur geographically in close proximity with typical *D. savagei* near the western edge of the Hamersley Range near Pannawonica.

**Taxonomy.** The genetic analyses indicate three clades of *D. savagei* within the Pilbara region: an eastern clade (corresponding to the type locality for *D. savagei*), a southern clade centered on the Hamersley Range and a north-central clade. As the first two clades do not differ in morphology or back pattern, we treat these as *D. savagei sensu stricto.* The north-central clade is distinct genetically and shows limited variation in back pattern which differs consistently from *D. savagei* from the eastern and southern Pilbara and Ashburton regions. That these two entities represent real evolutionary species is corroborated by noting that near the western edge of the Hamersley Range the two taxa come into close contact yet maintain their genetic and morphological identity (Fig. 1), indicating that reproductive isolation has evolved between the two forms. The concordance of these two independent lines of evidence form compelling support for the recognition of the north-central form as a separate species from *D. savagei*. Based on this combined evidence, we describe the north-central population of *D. savagei* as a new species.

Below we provide a brief generic description and a composite description of the '*D. savagei*' complex (i.e., *D. savagei* and *D. galaxias* **sp. nov.**). We then briefly redescribe *D. savagei* (see also Kluge's detailed description of the holotype in his original description) and describe *D. galaxias* **sp. nov.** based on the characters that differ between these two species.

## Diplodactylidae Underwood, 1954

### *Diplodactylus* Gray, 1832

**Type species**: *D. vittatus* Gray, 1832, by monotypy.

**Diagnosis.** A genus of the Diplodactylidae (sensu Han *et al.* 2004) distinguished from all but *Lucasium* and *Rhynchoedura* by having both lateral and medial pairs of cloacal bones present. Distinguished from *Lucasium* and *Rhynchoedura* by the anteriorly enlarged jugal bone that enters the floor of the lacrimal foramen, by having relatively high numbers of preanal spinose scales (generally > 5), absence of preanal pores and shorter, stouter proportions of the body and tail (fourth toe on hind foot approximately four times as long as wide, tail generally swollen and less than 80% of SVL) (Oliver *et al.* 2007a). The genetic data of Oliver *et al.* (2007b) clearly places *D. savagei* within *Diplodactylus*.

### *Diplodactylus savagei* species complex

**Diagnosis.** Differs from other *Diplodactylus* in possessing a beaked face with nostril excluded from rostral, no enlarged labial scales (except for first), 6–10 rows of paired moderately-enlarged subdigital lamellae, reddish-brown dorsal colouration and short cylindrical tail.

**Comparison with other taxa.** The two members of the *D. savagei* species complex share with *D. conspicillatus*, *D. pulcher* and *D. klugei* Aplin & Adams, 1998 a pointed snout with no tall labial scales and rostral scale excluded from nostril, distinguishing all the taxa above from all other *Diplodactylus*. *Diplodactylus savagei* species complex members are distinguished from the sympatric *D. conspicillatus* by red background colouration, cylindrical (*versus* flattened) tail and two rows of enlarged subdigital lamellae. They share with *D. pulcher* and *D. klugei* a reddish background colour but can be distinguished by having either small spots that form transverse rows or fine widely-scattered spots, whereas the other two taxa have large blotches along the back or a vertebral stripe.

**FIGURE 2.** Photographs of live *Diplodactylus galaxias* **sp. nov.** (above) from the Burrup Peninsula and *D. savagei* (below) from near the type locality. Photographs – B. Maryan.

***Diplodactylus savagei*** **Kluge, 1963**
Southern Pilbara Beak-faced Gecko
(Figs. 2, 3)

**Holotype.** R14369, an adult female collected at Marble Bar, Western Australia, Australia on 22 September 1960 by G.M. Storr.

**Paratypes.** None.

**Diagnosis.** Differentiated from *D. galaxias* **sp. nov.** in having slightly larger body size, more gabled dorsal scales, slightly shorter and wider tail, heavy yellowish spots that form transverse rows (not scattered fine spots) on darker reddish-brown background colour, pale dorsal border to dark loreal stripe rarely present and dorsal-ventral colouration transition abrupt or marked by spots or stippling (not gradual).

**Description.** Small-bodied *Diplodactylus* with cylindrical body shape and a small, depressed head; tail cylindrical, slightly increasing in width towards tip until about four-fifths of length, then tapering at roughly a 60° angle to tip. Eyes small with no spiny ridges on upper eyelid; snout relatively long and pointed with blunt tip. Scales contacting nostril: supranasal and 4–6 postnasals; rostral roughly hexagonal without crease, bordered by enlarged supralabials, supranasals and internarials; other than first, enlarged supralabials absent with scales along upper jaw similar in size to adjoining rows of scales; mental wider than long with adjacent enlarged gular scales in 2–3 rows; no enlarged infralabials scales with typical-sized scales along lower jaw; ear aperature small and located near retroarticular process.

Limbs slender and of moderate length; undersurfaces of digits terminating with claw between moderately enlarged apical plates and 6–10 rows of enlarged paired lamellae along length of digit until decreasing to the size of tubercles on palmar and plantar surfaces.

Scales on body small; dorsal and ventral scales approximately the same size. Dorsal scales slightly gabled, with the apex towards the posterior edge of scale. Caudal scales on original tail enlarged and flattened, tending to form transverse rows; scattered enlarged scales on tail tip.

**Colouration.** In life, dorsum a rich reddish brown with small (1–5 scales) yellowish spots that usually align and/or abut to clearly form 8–12 transverse rows between nape and base of tail; spots rarely extending onto limbs but, if present, also tending to form rows; dark loreal-temporal streak through eye, weakly connecting nape; dorsal border loreal streak rarely with pale edge; top of head slightly pale compared to rest of dorsal colouration. Transition from dorsal to ventral colouration abrupt: demarcated by a sharp transition or stippling. Ventral surfaces pale cream. In preservative, ground colour faded, pale cap on head more prominent and spots creamy white (almost no trace of yellow colour).

**Measurements.** See Table 1.

**Variation.** Males possess an average of 7 enlarged pointed cloacal spurs on either side of cloaca. Females attain larger body sizes and trunk lengths than males (Table 1). Ground colour shows some limited variation in hue, but the pattern of spotting is more variable, and even more variable than in *D. galaxias* **sp. nov.** In some individuals the spots align to form solid transverse bars across the dorsum, although the individual spots comprising the bars are still evident (e.g., R162852, R170211, R170196, R170275; Fig. 3). The size of the spots also varied, from very small (< 5; e.g., R158144) to large (~10 scales; e.g., R170127). R160112 had an unusual pattern of strong transverse rows that alternated with a weak transverse row of spots (Fig. 3).

**Habitat.** Collection records of *D. savagei* indicate an association with stony hills with spinifex, scree slopes, *Eucalyptus* and *Acacia* spp, but also occasionally recorded from termitaria, cracking clays and loamy plains.

**Distribution.** Pilbara and Ashburton regions (Fig. 1): eastern Pilbara from Wodgina to the edge of the Great Sandy Desert, then extending south and west along the Hamersley Range, not occurring north of the Fortescue Marsh. Two widely-separated southeastern locality records are from the Barlee Ranges and Waldburg Station; however, the intervening area is poorly surveyed and the species may be common there.

**Etymology.** Named after American herpetologist Jay M. Savage.

**TABLE 1.** Summaries of characters and ratios measured for *Diplodactylus galaxias* **sp. nov.** and *D. savagei*. Mean±S.D. (range). Sample sizes are listed in column headings, unless noted for individual characters below and are based on all specimens examined in the type series and Appendix 1. Abbreviations: snout-vent length—SVL; trunk length (from axilla to groin)—TrunkL; head length (from tip of snout to retroarticular process)—HeadL; head width (at widest point)—HeadW; head depth (at deepest point): HeadD; ratio of length/width of mental scale—MenL/W; internarial distance (measured at medial edge of nares)—INar; interorbital width (at anterior centre of eyes)—IO; number of interial scales—IntNar; number of postnasal scales—PostNas; foreleg length (from elbow to base of palm)—ArmL; tibia length (from upper surface of knee to heel) – LegL; number of rows of lamellae on fourth finger—4FLam; number of rows of lamellae on fourth toe—TLam; tail length (original tails only)—TL; tail width (at widest point on original tails)—TailW; tail length as a percentage of SVL – Tail%SVL; number of subcaudal scales (from fracture plane to tip)—NoSC; number of enlarged cloacal spurs—CSpurs.

| Character | *D. galaxias* **sp. nov.**<br>N = 21 | *D. savagei*<br>N = 20 |
|---|---|---|
| SVL | Females (N = 10): 43.8±2.7 (37.0–46.0)<br>Males (N = 11): 38.1±2.0 (34.0–41.0) | Females (N = 10): 46.2±3.6 (38.0–50.0)<br>Males (N = 10): 40.0±2.0 (36.5–44.0) |
| TrunkL | Females (N = 10): 22.6±2.4 (17.9–24.8)<br>Males (N = 11): 18.7±1.3 (16.8–21.4) | Females (N = 10): 24.4±1.9 (21.2–26.9)<br>Males (N = 10): 20.1±1.6 (16.6–22.2) |
| HeadL | 8.1±0.6 (7.0–9.8) | 8.2±0.5 (7.1–9.3) |
| HeadW | 6.4±0.4 (5.8–7.1) | 6.3±0.5 (5.4–7.2) |
| HeadD | 4.2±0.3 (3.7–5.0) | 4.1±0.3 (3.6–4.6) |
| MenL/W | 0.56±0.10 (0.36–0.73) | 0.60±0.11 (0.46–1.00)<br>N = 18 |
| INar | 0.9±0.1 (0.7–1.1) | 0.9±0.1 (0.8–1.1) |
| IO | 3.3±0.1 (3.1–3.7)<br>N = 20 | 3.3±0.3 (2.9–3.9) |
| IntNar | 2 scales: N = 6<br>1 scale: N = 14 | 2 scales: N = 2<br>1 scale: N = 19 |
| PostNas | 5.7±0.7 (4–7) | 5.1±0.4 (4–6) |
| ArmL | 5.5±0.4 (4.4–6.1) | 5.7±0.4 (4.8–6.2) |
| LegL | 5.9±0.5 (5.0–6.8) | 6.1±0.5 (4.8–7.4) |
| 4FLam | 6.6±0.7 (6–8) | 6.2±0.4 (6–7) |
| 4TLam | 8.1±0.7 (7–9) | 8.1±1.0 (6–10) |
| TailL | 17.9±1.4 (16.0–21.0)<br>N = 13 | 16.8±0.5 (16.0–17.0)<br>N = 4 |
| TailW | 5.0±0.5 (4.0–5.8)<br>N = 13 | 5.2±0.2 (5.0–5.5)<br>N = 4 |
| Tail%SVL | 45±4 (38–53)<br>N = 13 | 42±4 (36–45)<br>N = 4 |
| NoSC | 54±6 (42–67)<br>N = 13 | 52±5 (48–59)<br>N = 4 |
| Cspurs | 8.1±1.9 (5–11)<br>N = 11 | 6.8±1.6 (5–10)<br>N = 10 |


**FIGURE 3.** Variation of dorsal pattern within *Diplodactylus galaxias* **sp. nov.** (top row) and *D. savagei* (bottom row).

***Diplodactylus galaxias*** **sp. nov.**
Northern Pilbara Beak-faced Gecko
(Figs. 2, 3, 5)

**Holotype.** R113624, an adult female collected 42km NNE Munjina Roadhouse, Western Australia, Australia (2159'S; 11845'E) on 15 April 1992 by B. Bush.

**Paratypes.** R146616 (female) – 203 km S Port Hedland, Western Australia, Australia; R158145 (male) – 24.5 km N Cowra Line Camp, Western Australia, Australia; R165134 (male) – 2.6 km WNW Python Pool, Western Australia, Australia; R165502, R165516 and R165532 (males) – West Intercourse Island, Western Australia, Australia; R166639 (female) – Mons Cupri Mine, Western Australia, Australia.

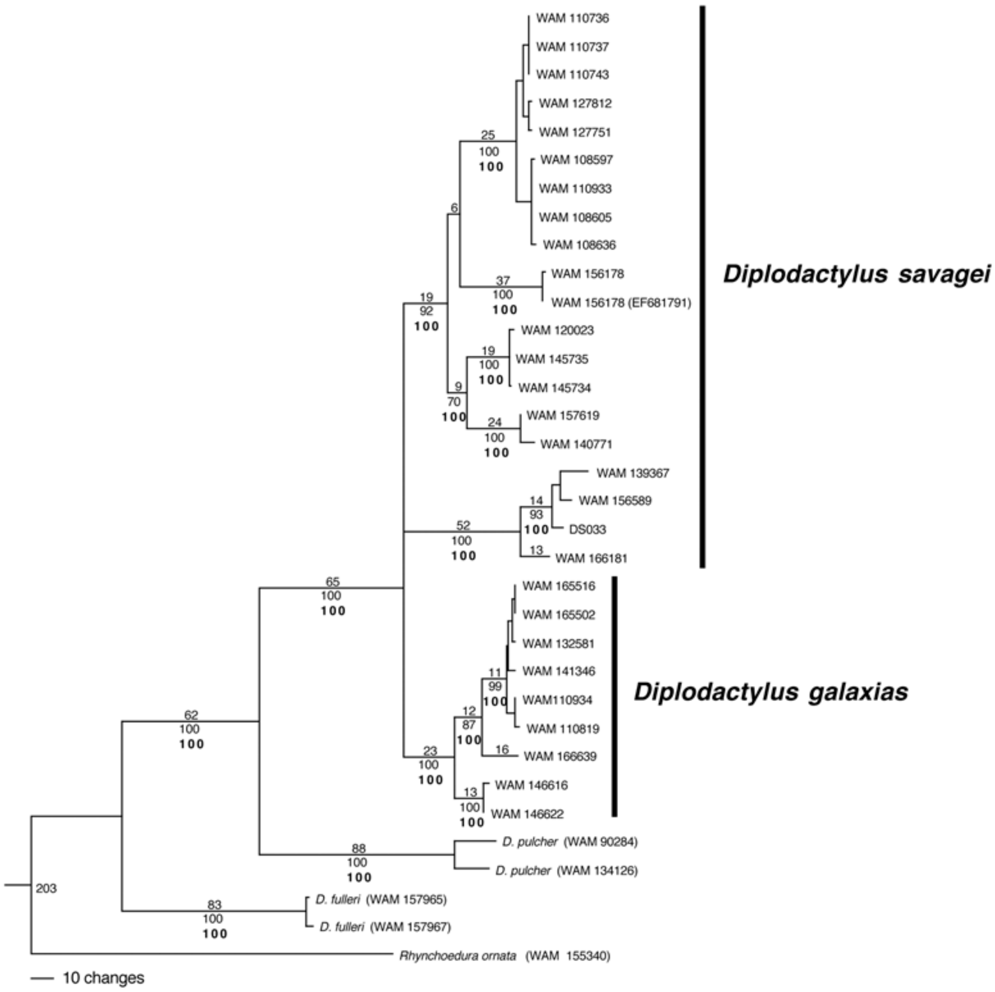


**FIGURE 4.** Summary of phylogenetic results of the *ND2*+tRNA data set of *Diplodactylus savagei* based on parsimony and Bayesian analyses. A parsimony phylogram is shown but the results for the Bayesian analysis were similar. Numbers above the branches are parsimony branch lengths and numbers below the branches are parsimony bootstrap values and Bayesian posterior probabilities (bold), respectively.

**Diagnosis.** Differentiated from *D. savagei* in having smaller body size (means: *galaxias* – ♂ 38.1 mm, ♀ 43.8 mm; *savagei* – ♂ 40.0 mm, ♀ 46.2 mm), less gabled dorsal scales, longer (*galaxias* – 17.9 mm; *savagei* – 16.8 mm) and thinner (*galaxias* – 5.0 mm; *savagei* – 5.2 mm) tail, scattered fine spots (not heavy spots that form transverse rows) on lighter reddish-brown background colour, pale dorsal border to dark loreal stripe and gradual dorsal-ventral colouration transition (not abrupt or marked by spots or stippling).

**Description.** Small-bodied *Diplodactylus* with cylindrical body shape and a small, depressed head; tail cylindrical, slightly increasing in width towards tip until about four-fifths of length, then tapering at roughly a 60° angle to tip. Eyes small with no spiny ridges on upper eyelid; snout relatively long and pointed with blunt tip. Scales contacting nostril: supranasal and 6 postnasals; rostral roughly hexagonal without crease, bordered by enlarged supralabials, supranasals and internarials; other than first, enlarged supralabials absent with scales along upper jaw similar in size to adjoining rows of scales; mental wider than long with adjacent enlarged gular scales in 2–3 rows; no enlarged infralabials scales with typical-sized scales along lower jaw; ear aperature small and located near retroarticular process.

Limbs slender and of moderate length; undersurfaces of digits terminating with claw between moderately enlarged apical plates and 6–9 rows of enlarged paired lamellae along length of digit until decreasing to the size of tubercles on palmar and plantar surfaces.

**FIGURE 5.** Holotype of *Diplodactylus galaxias* **sp. nov.** (WAM R113624, an adult female). Photograph – B. Bush.

Scales on body small; dorsal and ventral scales approximately the same size. Dorsal scales low, apex not prominent and located at centre of scale. Caudal scales on original tail enlarged and flattened, tending to form transverse rows; scattered enlarged scales on tail tip.

**Colouration.** In life, dorsum reddish with fine (1–5 scales) pale yellowish spots scattered (not typically forming transverse rows); spots continue to limbs; dark loreal-temporal streak through eye and weakly connecting on nape; a pale border dorsal to loreal streak; top of head slightly pale compared to rest of dorsal colouration. Transition from dorsal to ventral colouration gradual (not demarcated by sharp transition or stippling). Ventral surfaces pale off-white. In preservative, ground colour faded, pale cap on head more prominent and spots creamy white (almost no trace of yellow colour).

**Measurements of holotype.** SVL—46; TrunkL—23.9; TailL—18; TailW—4.9; ArmL—5.9; LegL—6.4; HeadL—.2; HeadW—6.4; HeadD—3.8; INar—1.0; IO—3.4; IntNar—2; PostNas—6; MentL/W—0.58; 4FLam—6; 4TLam—8.

**Variation.** Table 1 presents the ranges of values for the characters measured. Males possess an average of 8 enlarged pointed cloacal spurs on either side of cloaca. Females attain larger body sizes and trunk lengths than males (Table 1). Ground colour showed some limited variation. In some individuals the spotting shows a weak tendency to form rows instead of widely scattered spots (e.g., moderate in R165532 and more pronounced in R165134); some individuals have spots with darker borders that contrast with background colour (e.g., R110149, R160861); spotting on the limbs is also variable but tends to be much weaker than on dorsum (Fig. 3).

**Habitat.** *Diplodactylus galaxias* is associated with stony hills with spinifex, *Eucalyptus* and *Acacia* spp. Individuals shelter in Spinifex clumps and under rocks.

**Distribution.** Pilbara region (Fig. 1): along the coast from the mouth of the Fortescue River east to the Burrup Peninsula and slightly inland to Whim Creek; west to Peedamulla Station and vicinity of Pannawonica then extending east and inland along the Chichester Range (not occurring south of the Fortescue River) to the headwaters of the Western Shaw River. Also known from West Intercourse Island in the Dampier Archipelago.

**Etymology.** *galaxias* (Greek) is in reference to the widely-scattered spots on the dorsum which resemble stars in a galaxy. Used as a noun in apposition.

**Comparison with *D. savagei*.** *Diplodactylus galaxias* can be distinguished from *D. savagei* by the spots being finer and never tightly aligning to form transverse bars. Some individuals of *D. galaxias* have the fine spots in weak rows, but the spots remain widely separated; this is in contrast to the transverse rows in *D. savagei* that are formed by rows of heavier spots in contact that usually form solid bars (Figs. 2, 3). Furthermore, along the ventrolateral zone the transition from the dorsal to ventral colouration is very gradual in *D. galaxias*, whereas it is abrupt in *D. savagei*. In *D. savagei*, the lateral zone also tends to have small spots or fine stippling where the dorsal and ventral colouration meet. *Diplodactylus galaxias* has a smaller mean and maximum body size than *D. savagei* and a longer and thinner tail (Table 1). The shape of the dorsal scales also differs subtly, with *D. galaxias* having quite low scales whereas *D. savagei* has more gabled scales with the apex towards the posterior edge of the scale.

## Discussion

Diplodactylid geckos diverged long ago from other extant lizard groups (Han *et al.* 2004; Oliver and Sanders 2009), yet some lineages show strong conservatism in morphology (Oliver *et al.* 2007b, 2009). However, the *D. conspicillatus* species-group (including *D. savagei*) exhibits a suite of morphological characters that differ noticeably from other diplodactylines, especially the combination of 'beaked' face and short tail. Recent molecular research has revealed that different species may not differ conspicuously in morphology, yet they can be separated by extremely large genetic differences indicating a long history of isolation (Pepper *et al.* 2006; Oliver *et al.* 2007b, 2009; Doughty & Hutchinson 2008; Doughty *et al.* 2008; Hutchinson *et al.* 2009; see also Couper *et al.* 2008a,b for examples in the Carphodactylidae). Recent taxonomic work has described or redescribed many such species (see citations above). Similar to these others cases, *D. savagei* and *D. galaxias* do not differ overtly in the standard morphological characters used for *Diplodactylus* such as the scales around the tip of the snout, subdigital lamellae or tail shape. Instead, the two species differ subtly but consistently in colouration, and this was the motivation to test whether there were two species with molecular data. The molecular data were not concordant with the back pattern data: *D. galaxias* was a clear independent lineage in the analysis, with a genetic difference of about 10% from the two lineages within *D. savagei*. Within *D. savagei* there were no differences in back pattern between the eastern and southern clades despite evidence of a history of isolation between them. Thus, the genetic pattern may indicate a history of isolation between the two clades, despite coming into contact near the headwaters of the Fortescue River. Further research into gene flow among the clades and how it differs from other Pilbara species is currently in progress (Pepper *et al.* 2008; unpublished data).


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We thank Jim Rolfe (DEC) for bringing to our attention the consistent difference in back pattern from specimens collected as part of WA Department of Environment and Conservation's Pilbara Biodiversity Survey. We thank B. Maryan and B. Bush for photographs and C. Stevenson for preparing the distribution map and photographs. P. Oliver, B. Maryan, A.M. Bauer and two reviewers provided helpful comments on earlier drafts. PD thanks the Australia and Pacific Science Foundation and MP and JSK thank the Australian Research Council for support.

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## Appendix 1. Material examined (WAM and R prefixes not shown).

*Diplodactylus galaxias*

Males—110137, 110149, 158066, 158080, 158145, 160871, 160928, 165134, 165502, 165516, 165532.

Females—110211, 113624, 146616, 158081, 159951, 160861, 161001, 161024, 166639, 170801.

*Diplodactylus savagei*

Males—110743, 156617, 160112, 170114, 170196, 170211, 170215, 170256, 170275, 170277.

Females—110933, 111924, 111985, 158144, 160146, 162852, 170111, 170127, 170183, 170207.