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Redescription of *Eremiascincus fasciolatus* (Günther, 1867) (Reptilia: Squamata: Scincidae) with clarification of its synonyms and the description of a new species

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Abstract

We present an assessment of the systematic status of populations currently assigned to *Eremiascincus fasciolatus* across Australia using morphological data. Our analyses show that these populations actually comprise four species: a large and robust, narrow-banded taxon from eastern Queensland and three slender, desert-dwelling taxa from the western, northern, and south-eastern Australian arid zone respectively. These data necessitate: 1) the redescription of *E. fasciolatus*, a species endemic to the dry forests of eastern Queensland, 2) the resurrection of *E. pallidus* for the western taxon, 3) the resurrection of *E. intermedius* for the northern taxon, and 4) the description of the south-eastern desert-dwelling taxon, which largely occurs in the Lake Eyre Basin, as a new species. The new species, *Eremiascincus phantasmus* sp. nov., can be distinguished from congeners by its large size, pale color, depressed snout, and small circular ear opening, as well as by several scale characteristics. Body proportions, a depressed snout, small ear opening, and pale color suggest that this species is fossorial and predominantly occurs in habitats with loose substrate, such as dune systems and sandy plains. A synopsis of each species and a key to the narrow-banded species of *Eremiascincus* are provided.

Key words: Sauria, Skink, Lygosominae, *Eremiascincus pallidus*, *Eremiascincus intermedius*, *Eremiascincus phantasmus* sp. nov., species boundaries, morphology, taxonomy, Australia, South Australia, arid zone

Zusammenfassung

Unter Verwendung morphologischer Daten untersuchen wir in der vorliegenden Studie Populationen aus ganz Australien, die derzeit dem Taxon *Eremiascincus fasciolatus* zugerechnet werden. Unsere Analysen zeigen, dass es sich bei diesen Populationen um vier Arten handelt: Eine große und robuste, gestreifte Art aus Ost-Queensland und drei schlanke, wüstenbewohnende Arten aus den australischen Trockengebieten (westlich, nördlich, südöstlich). Diese Daten erfordern: 1) die Neubeschreibung von *E. fasciolatus*, einer Art, die in den Trockenwäldern von Ost-Queensland endemisch ist, 2) die Re-Etablierung von *E. pallidus* als westliche Art, 3) die Re-Etablierung von *E. intermedius* als nördliche Art und 4) die Beschreibung der südöstlichen Form, die im Eyre-See-Becken weit verbreitet ist, als neue Art. Die neue Art, *Eremiascincus phantasmus* sp. nov., unterscheidet sich von verwandten Arten durch ihre Größe, helle Färbung, abgeflachte Schnauze und kleine Ohröffnung sowie durch mehrere Schuppenmerkmale. Körperproportionen, die abgeflachte Schnauze, kleine Ohröffnung und helle Färbung deuten darauf hin, dass diese Art in lockerem Substrat gräbt und überwiegend in Dünsystemen und auf Sandflächen zu finden ist. Eine Übersicht jeder Art und ein Bestimmungsschlüssel für die Arten der Gattung *Eremiascincus* mit schmalen Banden werden bereitgestellt.

Schlüsselwörter: Sauria, Skink, Lygosominae, *Eremiascincus pallidus*, *Eremiascincus intermedius*, *Eremiascincus phantasmus* sp. nov., Verbreitungsgrenzen, Morphologie, Taxonomie, Australien, Südaustralien, Trockengebiete

Introduction

With more than 1500 species (Uetz *et al.* 2013), skinks are the largest family of lizards (e.g., Pianka & Vitt 2003; Whiting *et al.* 2003). In Australia, 439 species of skinks are currently recognized (Uetz *et al.* 2013), comprising about two-thirds of the lizard fauna of the continent. Evolutionary relationships of and within some Australian scincid lizard groups, however, have proved difficult to resolve, often due to pronounced homoplasy among taxa and/or a complex taxonomic history, and in many groups the alpha taxonomy is insufficiently resolved owing to an abundance of cryptic species (e.g., Adams *et al.* 2003; Horner 2007; Smith & Adams 2007).

The Australian scincid genus *Eremiascincus* Greer, 1979¹ has endured a problematic history and was once treated as a morphologically conservative, ditypic taxon. A revision of the genus resulted in eight newly combined species epithets and the description of a new species (Mecke *et al.* 2009).

Species within *Eremiascincus* are a prominent component of the herpetofauna of Australia and the Lesser Sunda Islands (*Eremiascincus* species do not occur on the Sunda Shelf as erroneously stated in Mecke *et al.* 2009). They occur in a variety of different habitats, including monsoonal forests and tropical woodlands and have also invaded the desert environments of the Australian interior (Mecke *et al.* 2009). All species are either ground dwellers or (semi-)fossorial and predominantly insectivorous. They are cryptozoic and favor mesic and moist microhabitats, generally only occurring in deep shade and usually observed at dusk or after dark (e.g., Worrell 1963; Pianka 1969; Houston 1973; Cogger 2000). A total of 11 *Eremiascincus* species are currently recognized (Mecke *et al.* 2009), including four forms from the Lesser Sunda Islands—*E. antoniorum* (Smith, 1927); *E. butlerorum* (Aplin, How & Boeadi, 1993); *E. emigrans* (van Lidth de Jeude, 1895), and *E. timorensis* (Greer, 1990)—and seven from mainland Australia—*E. brongersmai* (Storr, 1972); *E. douglasi* (Storr, 1967); *E. fasciolatus* (Günther, 1867); *E. isolepis* (Boulenger, 1887); *E. musivus* Mecke, Doughty & Donnellan, 2009; *E. pardalis* (Macleay, 1877), and *E. richardsonii* (Gray, 1845), many of which represent species complexes (S. Mecke, pers. obs.). Recent investigations are revealing additional undescribed species both from the Australian mainland and the Lesser Sunda Islands (this study; Mecke *et al.*, unpubl. data).

Three species inhabit the Australian arid zone: *E. fasciolatus*, *E. musivus*, and *E. richardsonii*. The taxonomic history of *E. fasciolatus* and *E. richardsonii* is complex, and both species have several synonyms. Our morphological examinations, which included the type material of *E. fasciolatus* and synonymous forms, revealed taxonomic chaos. Most of the original historic species descriptions of *Eremiascincus* taxa are short and based mainly on color pattern and a few traditional scalation characteristics. Because of these reasons, and compounded by misinterpretations, Storr (1967, 1974) synonymized many taxa in his revisions without consulting the relevant type material.

With Storr's conservative concept, the species currently known as *E. fasciolatus* became one of the most widespread lizard species of the Australian arid zone. However, some authors have noted that the species richness of the desert-inhabiting species *E. fasciolatus* and *E. richardsonii* may be underestimated (Greer 1979; Storr *et al.* 1999). Several recent studies have shown that so-called widespread Australian arid zone reptile species proved to be more than a single taxon (e.g., Oliver *et al.* 2009; Fujita *et al.* 2010; Pepper *et al.* 2011; Doughty *et al.* 2012). Here we examine variation in morphology across the geographic range of *E. fasciolatus sensu lato* to evaluate the systematic status of this species and the synonyms associated with it.

Material and Methods

Morphological sampling, characters, and selection of analytical units

Adult specimens of *Eremiascincus fasciolatus sensu lato* ($n = 280$, see Appendix) from Australia (Western Australia [WA], Northern Territory [NT], South Australia [SA], New South Wales [NSW], and Queensland [QLD]) were used for morphological analyses. Juvenile specimens were used to quantify variation in color pattern among the respective groups. Preserved specimens examined were mainly from the collections of the WA Museum, Perth (WAM), SA Museum, Adelaide (SAMA), Australian Museum, Sydney (AMS), QLD Museum, Brisbane (QM),

1. Note that commas separate author plus date only when referring to the authority of a taxon name (e.g., *Eremiascincus* Greer, 1979), but no commas are used between author and date in reference to literature (e.g., Mecke *et al.* 2009).

and the Museum and Art Gallery of the NT, Darwin (NTM). We also examined the relevant type material housed in the Natural History Museum, London (formerly British Museum of Natural History) (BMNH), Naturmuseum und Forschungsinstitut Senckenberg, Frankfurt am Main (SMF), and Naturhistorisches Museum Wien, Vienna (NHMW).

TABLE 1. Morphometric, meristic, and qualitative characters and their abbreviations used in this study.

Character	Description
SVL	Snout-vent length
TrunkL	Trunk length from axilla to groin
TailL	Tail length of original tail from vent to tip
ArmL	Foreleg length from axilla to tip of fourth finger, excluding claw
LegL	Hindleg length from groin to tip of fourth toe, excluding claw
AxillaEar	Axilla to posterior margin of the ear
HeadL1	Head length from tip of snout to anterior margin of the ear
HeadL2	Head length from tip of snout to posterior margin of parietals
HeadW	Head width, measured level with centre of the ear opening
HeadH	Head height, measured level with centre of the eye
SnoutL	Snout length from tip of snout to anterior margin of orbit
EarL	Ear length of tympanum at centre (horizontally)
EarH	Ear height of tympanum at centre (vertically)
FootL	Foot length from base of foot to tip of fourth toe, excluding claw
Toe3L	Length of third toe
Toe4L	Length of fourth toe
MBSR	Number of midbody scale rows, counted midway between axilla and groin
PVS	Paravertebral scales, counted in one line from the posterior margin of the parietals to the beginning of the hindlegs
SupraLab	Number of supralabial scales
InfraLab	Number of infralabial scales, ending with the last small scale in contact with the posterior margin of the last upper labial
SubInfraLab	Presence of subinfralabials
DividLab	Presence and location of divided supralabials
SupraCil	Number of supraciliaries, beginning with the scale adjoining the prefrontal and loreal, and ending with the scale still contacting ciliaries and last supraocular
4TLam	Number of enlarged subdigital lamellae under fourth toe, counted from toe junction to base of claw
BandsDorsum	Number and shape of cross-bands on the dorsum
BandsTail	Number and shape of cross-bands on the tail

For each specimen, 26 external characters (16 metric, 6 meristic, 4 qualitative) were recorded and used for our comparisons and analyses (Table 1). Detailed descriptions of other characters (e.g., head scalation, coloration, and pattern details) not used for the multivariate analyses are presented separately in the formal description of each species. A row of scales between infralabials and chin shields is herein referred to as subinfralabials for the first

time. Scalation features occurring bilaterally, such as supraciliaries, supra- and infralabials, and subdigital lamellae, were counted on the left side. Plantar scales were counted in a mid-line between the basal subdigital lamella of the third digit and the terminal imbricate scale of the limb. Measurements of preserved specimens were taken to the nearest 0.1 mm using electronic digital callipers or a steel rule. Ear diameters were measured using a measuring magnifier. All individuals with broken or regenerated tails were excluded from comparisons of TailL. We also calculated the following ratios: percent TailL to SVL, TrunkL/SVL, ArmL/SVL, LegL/SVL, ArmL/LegL, HeadL1/SVL, HeadL2/SVL, HeadW/HeadL1, SnoutL/HeadL1, SnoutL/HeadL2, and HeadH/HeadW (for the meaning of abbreviations we used in the analytical sections and the type descriptions, see Table 1).

Craniological characters for *E. fasciolatus sensu lato* were described by Greer (1979) and are attributed to the taxa we describe herein on the basis of collection locality data and/or examination of alcohol material (torsos) from which skulls were taken for the original study.

Color patterns are defined as follows: a band is an encircling marking of contrasting color on the dorsum (including the tail) running perpendicular to the long axis of the body. For terms of convenience we sub-divided this pattern into three types (a–c): ‘type a’ is a narrow band < 0.5 scales wide, ‘type b’ a narrow band 0.5–2.0 scales wide, and ‘type c’ a broad band > 2.0 scales wide. ‘Spots’ are contrasting areas of color occupying ≥ 1 scale, ‘flecks’ are pigmented areas < 1 scale, usually much smaller and often confined to the edge of a scale.

Reproductive data recorded include sex, maturity state (immature or mature), and level of gonadal development in females (yolking ovarian follicles or oviductal eggs; see James & Losos 1991). Females with a snout-vent length equal to or longer than that of the smallest female in the population containing oviductal eggs were assumed to be sexually mature. Sexual maturity of males was judged by the presence of enlarged, white testes and epididymides.

As a first step towards the identification of distinct taxonomic groups within *Eremiascincus fasciolatus sensu lato*, we thoroughly examined the type material associated with that taxon and synonymous forms, as well as respective topotypic material. We were able to identify characters (metric, meristic, qualitative) or combinations of traits helpful to distinguish between those local groups. Subsequently, we pooled specimens with similar traits from different localities across Australia into Operational Taxonomic Units (OTUs). OTUs were defined using a combination of morphological characters, geographic proximity, collecting gaps, and potential zoogeographic barriers. Four OTUs are used in this study: OTU 1—eastern Australia (eastern QLD), OTU 2—western Australia (WA, extreme western NT, and north-western SA), OTU 3—northern Australia (NT and extreme eastern WA), OTU 4—south-eastern Australia (Lake Eyre Basin and adjacent regions).

For the distribution map, we used the characters from our diagnoses to identify specimens in museum collections not used in the multivariate analyses. We also present some limited ecological data based on field observations.

Terminology of name-bearing types (onymophoronts) follows Dubois (2005).

Additional abbreviations used in the text or appendix include: IUCN (International Union for Conservation of Nature); MCZ (Museum of Comparative Zoology, Harvard University, Cambridge), ZMB (Zoologisches Museum Berlin).

Statistical analyses of morphological data

To minimize variation due to body size (potential ontogenetic variation between OTUs) metric variables of adult specimens were first adjusted to the mean SVL across all groups (e.g., Thorpe 1975; 1983; Turan 1999; Vogel *et al.* 2007; van Rooijen & Vogel 2008, 2010). The normalization equation applied to adjust the metric character values to what they would be if the specimens were of mean body size was:

$$Y_{\text{adj}} = Y - \beta (SVL - SVL_{\text{mean}})$$

(e.g., Vogel *et al.* 2007; van Rooijen & Vogel 2008, 2010) where Y_{adj} is the adjusted value of the allometric dependent variable of the i^{th} specimen, Y is the original value of the allometric dependent variable of the i^{th} specimen, SVL is the independent variable of the i^{th} specimen, SVL_{mean} is the grand mean (the overall mean SVL of the independent variable), and β is the pooled regression coefficient of Y against SVL . For multivariate statistical analyses we used allometrically adjusted values and SVL , since *Eremiascincus fasciolatus sensu lato* populations differ somewhat in length. Thus multivariate analyses include both shape and size variables.

The SPSS (14.0) and Excel 2003 statistical packages were used to run the analyses. Comparisons between male and female specimens were made using Mann-Whitney U-tests. In the *Sex ratio and sexual dimorphism* sections for each taxon males and females are compared and, where appropriate, asterisks indicate probability levels for significant differences (in rank-sums) between sexes as follows: * < 0.01; ** < 0.005; *** < 0.001.

Principal Component(s) Analysis (PCA) was used to evaluate the morphological data and to explore phenotypic variation (and morphospace structure) in *E. fasciolatus sensu lato*. PCA was chosen to see whether groups are distinguishable without previous definition external to the data (user-specified criteria) and whether groups identified by PCA correspond to our suggested *a priori* OTUs.

Multivariate normality was assumed and not explicitly tested. PCA is quite insensitive to violations of normality (e.g., Tabachnick & Fidell 2007) and (within limits) our assumptions of normality are regarded as not influential statistically even if a violation occurs (e.g., Cliff 1987), making our results reasonably robust given the large sample sizes used.

PCA is a multivariate ordination technique that attempts to retain the intrinsic structure and variance of the data while reducing the complexity of the representation by a reduction of dimensionality of the data set. That is, given data points in a multidimensional space are projected into a two- (or three-) dimensional space, while maximizing the amount of information retained. The orthogonal axes of this space are linear combinations of the original variables (so-called components or factors) that account for most of the variance in the individual variables. The first principal component extracted accounts for the majority of variation in the data and each succeeding component accounts for as much of the remaining variance as possible. Essentially one of the main benefits of PCA is that it provides an X-Y two-dimensional plot of multidimensional data.

We carried out a PCA (PCA 1) based on a correlation matrix (mean = 0, variance = 1) using $n = 232$ specimens with data for 12 variables. SVL, the adjusted metric characters TrunkL, ArmL, LegL, HeadL, HeadW, HeadH, and SnoutL, and the meristic characters MBSR, PVS, SupraLab, and 4TLam were subjected to the PCA. Potentially redundant characters, characters with little explanatory capacity, and qualitative variables were not used to run the PCA, the latter characters are used, however, to diagnose species beyond the multivariate analysis. The discrepancy between the total number of specimens used in this study and the number of specimens used to run the PCA is the result of the elimination of incomplete datasets.

We carried out a subsequent PCA (PCA 2) with data of the taxon clustering outside the main morphospace removed (215 specimens used). Variables used to separate the remaining groups are identical to the variables subjected to the first PCA, with the exception that PVS was excluded (variable showed a small individual measure of sampling adequacy (MSA) value [< 0.5], indicating low explanatory capacity).

Varimax option was selected for rotation, a rotation method that minimizes the complexity of the components by making large loadings closer to 1 and small loadings closer to 0 within each component; this is one of the most often used rotation methods. Only axes corresponding to variables with eigenvalues > 1 were extracted and plotted.

Results

Principal Component(s) Analysis

The PCAs performed were deemed appropriate because they yielded correlation matrix determinants > 0.0001 , indicating that multicollinearity and singularity were not problems in our data (e.g., Field 2000). Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for all variables was > 0.8 for PCA 1 and > 0.7 for PCA 2. KMO varies from 0 to 1, with a value close to 1 indicating that the pattern of correlation between the variables is relatively compact and so the PCAs should yield distinct and reliable components. Kaiser (1974) recommends accepting values larger than 0.5. Moreover, the individual MSA values in the anti-image correlation (AIC) matrix were > 0.5 for the variables used to run PCA 1 and PCA 2 (with most MSA values ranging in Kaiser's 'meritorious' evaluation [> 0.8]). The majority of the off-diagonal values in the AIC matrix were close to 0 in both settings. The number of off-diagonal elements $> |0.09|$ in the anti image covariance matrix of PCA 1 was 9.1% and 18.2% for PCA 2. Bartlett's test of sphericity was statistically highly significant in both settings ($\chi^2 = 1927.45$, $P < 0.0001$ [PCA 1]; $\chi^2 = 1063.68$, $P < 0.0001$ [PCA 2]), indicating that the matrix was not an identity matrix and that data are approximately multivariate normal (George & Mallery 2003). All values indicated suitability of our data

for conducting PCAs. Due to common practice, loadings above 0.6 are considered ‘high’, loadings between 0.6 and 0.4 ‘moderate’, and those below 0.4 ‘low’.

PCA 1 performed on eight metric and four meristic characters of 232 specimens of *E. fasciolatus sensu lato* (129 males, 96 females, and 7 unsexed types or topotype specimens) extracted four components that explain, respectively (values before/after rotation): 43.8/40.1%, 17.2/15.7%, 10.6/14.7%, and 8.8/9.9% of the total data variance.

Table 2 displays each variable’s factor loading for the extracted PCs after rotation.

TABLE 2. Factor loadings (after varimax rotation) for the four extracted Principal Components (PCs) from a correlation matrix of SVL, seven adjusted metric*, and four meristic variables for 232 *Eremiascincus* specimens (OTUs 1–4).

Variable	PC1	PC2	PC3	PC4
SVL	0.328	0.834	0.051	0.074
TrunkL*	-0.791	0.045	-0.179	0.085
ArmL*	0.409	0.181	0.795	-0.111
LegL*	0.069	0.040	0.934	0.007
HeadL*	0.897	0.164	0.284	-0.087
HeadW*	0.915	-0.036	0.088	-0.133
HeadH*	0.892	0.130	0.064	-0.177
SnoutL*	0.834	-0.042	0.234	-0.007
MBSR	0.626	-0.547	0.037	0.274
PVS	-0.150	0.083	-0.110	0.915
SupraLab	-0.149	0.894	0.141	0.076
4TLam	-0.581	0.002	0.204	0.433
Eigenvalues (after rotation)	4.815	1.883	1.765	1.188
Cumulative percent variance (after rotation)	40.122	55.812	70.525	80.422

HeadW, HeadL, HeadH, SnoutL, TrunkL, and MBSR (in descending order) are the highest loading traits (i.e., $> |0.6|$) on the first component (PC1), and SupraLab and SVL are the major loading traits for PC2. PC3 has a high loading for LegL and ArmL and PC4 for PVS only (and no loadings in the moderate range); thus the latter component may be not well defined.

Projection of the first two components shows that two larger groups exist within *E. fasciolatus sensu lato* (Fig. 1 A). Hand-drawn polygons delineate the clusters of morphologically similar specimens designated *a priori* (OTUs 1–4). The first group (OTU 1) contains morphological distinct specimens from eastern QLD, including the unsexed type material of *E. fasciolatus*, as indicated by arrows (a, b = symphoronts of *E. fasciolatus*). The second major group includes specimens from the Australian arid zone, which were previously regarded as conspecific with *E. fasciolatus* (OTUs 2–4). This cluster of arid taxa is well separated from the cluster of eastern Australian specimens. Specimens of each of the three OTUs (2–4) of desert-dwelling taxa cluster together according to the *a priori* classification, each occupying a well-defined morphospace, in clear display that morphologically distinct forms exist. The type material of *Hinulia pallida* Günther, 1867 and *Lygosma [sic] (Hinulia) fasciolatum intermedium* Sternfeld, 1919, both currently regarded as synonyms of *E. fasciolatus*, cluster within OTU 2 and OTU 3, respectively, as indicated by arrows (c = holophoront of *H. pallida*; d = holophoront of *L. f. intermedium*). PCA 1 did not clearly separate OTUs 2 and 3 with the characters specified in the *Material and methods* section but has produced an area of broad overlap. It is apparent, however, that OTU 2 and OTU 3 only slightly overlap with OTU 4 (only a single specimen of OTU 2 and OTU 3 respectively are nested within OTU 4, extending the morphospaces of the first two groups into the periphery of the scatter plot of OTU 4). Given the overall similarity

among the arid zone forms, the subspace overlap, as part of the morphospace occupation was a result not unexpected.

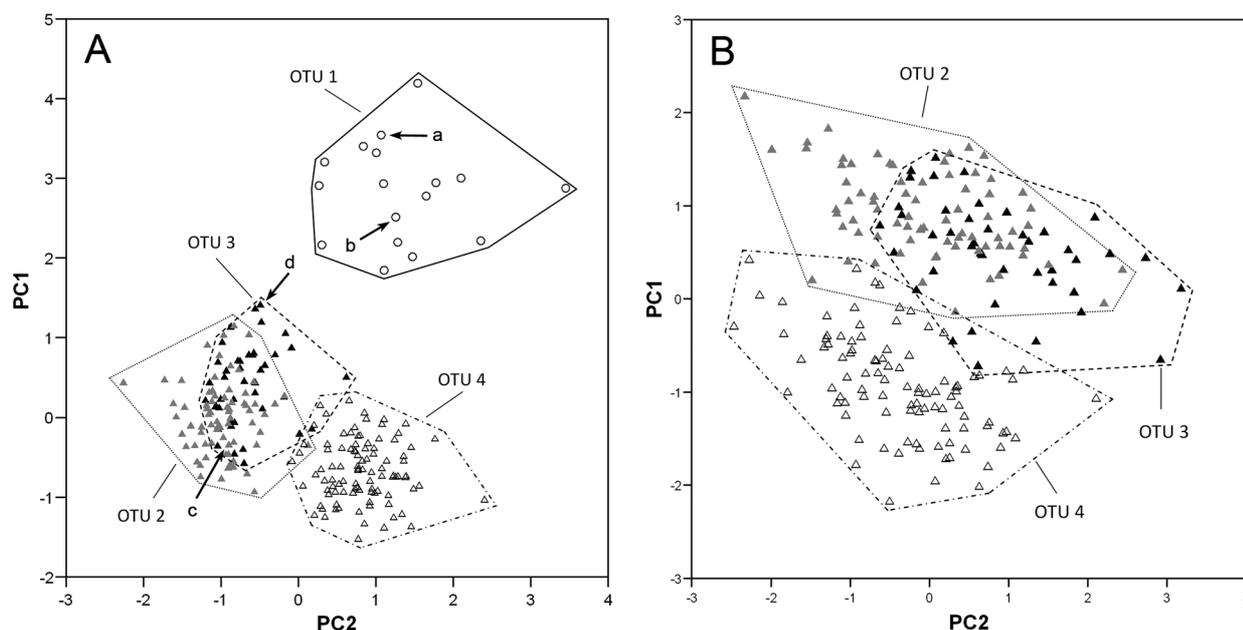


FIGURE 1. Projection of the first two principal components of (A) PCA 1 run on 232 specimens assignable to OTUs 1–4, (B) PCA 2 run on 215 specimens assignable to OTUs 2–4. Arrows indicate (a, b) symphoronts of *Eremiascincus fasciolatus*, (c) holophoront of *Hinulia pallida*, and (d) holophoront of *Lygosoma (Hinulia) fasciolatum intermedium*. OTU designations were determined *a priori*. Hand-drawn polygons indicate *a priori* OTUs and provide comparison to the way the PCA grouped the specimens.

PCA 2 performed on eight metric and three meristic characters of 215 specimens of *E. fasciolatus sensu lato*, *viz.* with data of the taxon clustering outside the main morphospace removed, extracted three components that explain, respectively (values before/after rotation): 38.9/25.2%, 18.4/22.3%, and 9.8/19.7% of the total data variance.

Table 3 displays each variable's factor loading for the extracted PCs after rotation. SupraLab, SVL, and MBSR (in descending order) are the highest loading traits (i.e., > |0.6|) on the first component (PC1) of PCA 2, and HeadH, HeadW, 4TLam, and HeadL are the major loading traits for PC2, while all other traits are of moderate to minor weight. PC3 has high loadings for ArmL and LegL only.

Projection of the first two components shows that specimens of each of the remaining OTUs (2–4) group together according to the *a priori* classification (Fig. 1 B), forming morphospaces similar to those shown in Fig. 1 A. There is little overlap between OTU 4 and the other OTUs, with OTU 4 appearing well separated. The morphospaces of the western and northern desert-dwelling forms (OTUs 2 and 3) again show some overlap, suggesting fluidity in variation.

In summary, PCA 1 shows that OTU 1 is clearly different from the other three OTUs. Owing to the fact that there exist even more characters (e.g. qualitative head scale characters) to distinguish between OTU 1 and OTUs 2–4, and that the type material of *E. fasciolatus* groups within OTU 1, the name *fasciolatus* has to be applied to OTU 1 (eastern Australia/QLD) only. OTU 1 also differs from OTUs 2–4 in ecology and habitat preferences, highlighting its distinctiveness (see descriptions, below). OTUs 2–4 each occupy their own morphospace in PCA 1, but with overlap between the OTUs, which is likely the result of shared ancestry and similar habitat requirements. PCA 2 excluded the eastern OTU 1 and considered the three OTUs of desert living taxa only. In PCA 2, OTU 4 is (as in PCA 1) separable from the scatter plots of OTU 2 and OTU 3. The latter OTUs show (again) an extensive overlap in the projection of PCA 2.

The distinctiveness of OTU 4 in the PCAs indicates the existence of a *hitherto* unnamed taxon. Additional (qualitative) characters are available to distinguish among the desertycolous groups (see *Discussion* and *Taxonomy*), which also differ in spatial distribution.

TABLE 3. Factor loadings (after varimax rotation) for the three extracted Principal Components (PCs) from a correlation matrix of SVL, seven adjusted metric*, and three meristic variables for 215 *Eremiascincus* specimens (OTUs 2–4).

Variable	PC1	PC2	PC3
SVL	- 0.800	0.019	0.077
TrunkL*	- 0.551	- 0.282	- 0.275
ArmL*	- 0.030	0.004	0.886
LegL*	- 0.053	- 0.108	0.885
HeadL*	0.334	0.606	0.541
HeadW*	0.483	0.719	0.090
HeadH*	0.232	0.791	0.014
SnoutL*	0.450	0.517	0.403
MBSR	0.748	0.214	0.036
SupraLab	- 0.813	- 0.306	0.112
4TLam	0.014	- 0.665	0.192
Eigenvalues (after rotation)	2.770	2.451	2.165
Cumulative percent variance (after rotation)	25.185	47.464	67.145

Unadjusted metric characters, additional meristics, ratios, and color pattern

Narrow-banded *Eremiascincus* differ in size (Table 4), with OTU 1 being the largest taxon (compare SVL, TrunkL, and TailL). A comparison of the means and ranges of metric head characters (e.g., HeadL1, HeadW, HeadH, and SnoutL) also indicates major size differences between eastern '*fasciolatus*' (OTU 1) and other narrow-banded *Eremiascincus* (Table 4). Compared with all other taxa, the ear opening of OTU 1 appears to be elliptical, rather than circular (*cf.* EarL and EarH). Among scale characters, labial scales (e.g., SupraLab) can be used to distinguish between taxa as indicated by the multivariate analysis (see also Table 4). The eastern (OTU 1) and south-eastern forms (OTU 4) both usually have 8 SupraLab, whereas all other taxa have usually 7. Furthermore, OTU 1 is unique in having (at least) the last SupraLab divided horizontally and in having SubInfraLab scales. For 4TLam, OTU 1 has the lowest counts (range = 18–23, $n = 22$) of all narrow-banded taxa.

Percentages and ratios were used as measure of shape (Table 4). Percent TailL to SVL, differed most between the eastern (OTU 1) and northern taxon (OTU 2) and between OTU 1 and *E. musivus*, while being relatively similar between OTU 2 and 4. OTU 4 exhibits the largest relative TrunkL. Leg length ratios are shown to discriminate most between OTU 1 and the three desert-dwelling forms (OTUs 2–4). Compared with all other taxa OTU 4 has a relatively smaller head, while OTU 1 and OTU 3 have relatively wider heads than all other taxa, and OTU 1 has a relatively shorter snout.

Differences in color pattern include variation in dorsal banding (present in OTU 1 and OTU 3 *vs.* [almost always] absent [or by far less conspicuous] in OTU 2 and OTU 4) and the number and shape of the caudal bands, with OTU 1 having the lowest number (range = 25–35). The characters summarized in Table 4 likewise indicate that OTU 1 differs from OTUs 2–4 in a variety of morphological characters, while OTUs 2–4 appear to be relatively similar in overall morphology and can only be distinguished by a few striking characters.

TABLE 4. Summary of characters and ratios measured for the narrow-banded forms of *Eremiascincus* from across Australia, including the valid type material. Characters and ratios for *E. musivus* are repeated from Mecke *et al.* (2009). Sample sizes are listed in column headings, unless noted for individual characters below. Mean \pm SD (range). Color pattern characters are based on a larger series of specimens (including juveniles) and photographs. For a key to the variables see Table 1.

Species Character	<i>Eremiascincus fasciolatus sensu lato</i>				
	OTU 1 (eastern) <i>n</i> = 22	OTU 2 (western) <i>n</i> = 94	OTU 3 (northern) <i>n</i> = 47	OTU 4 (south-eastern) <i>n</i> = 117	<i>E. musivus</i> <i>n</i> = 27
Metrics [mm]					
SVL	96.1 \pm 13.8 (65.5–123.4)	64.8 \pm 6.2 (47.9–77.0) [<i>n</i> = 92]	73.8 \pm 6.7 (59.9–88.5)	81.2 \pm 7.1 (62.6–92.5)	51.8 \pm 4.1 (43.9–59.2)
TrunkL	50.3 \pm 8.9 (32.7–70.4)	34.9 \pm 3.8 (25.4–43.9) [<i>n</i> = 93]	39.2 \pm 4.9 (31.7–51.4)	45.5 \pm 4.5 (34.3–54.1) [<i>n</i> = 115]	26.6 \pm 3.2 (19.1–32.8)
TailL	110.7 \pm 14.4 (82.2–128.1) [<i>n</i> = 11]	76.6 \pm 7.1 (63.9–91.8) [<i>n</i> = 18]	99.4 \pm 11.0 (82.1–117.7) [<i>n</i> = 13]	98.0 \pm 10.1 (80.4–111.7) [<i>n</i> = 15]	69.6 \pm 5.2 (58.7–79.0) [<i>n</i> = 11]
ArmL	23.4 \pm 1.8 (18.3–25.8) [<i>n</i> = 20]	17.9 \pm 1.5 (14.1–21.4) [<i>n</i> = 93]	19.7 \pm 1.5 (16.8–22.5)	21.0 \pm 1.4 (17.2–24.5) [<i>n</i> = 115]	14.9 \pm 0.8 (13.5–16.3)
LegL	30.8 \pm 2.3 (25.6–34.2)	25.2 \pm 2.1 (19.4–29.2) [<i>n</i> = 89]	27.6 \pm 1.9 (23.8–31.3) [<i>n</i> = 45]	29.6 \pm 2.0 (25.2–33.0) [<i>n</i> = 115]	21.1 \pm 1.0 (19.1–23.1)
AxillaEar	17.1 \pm 1.9 (12.5–20.8) [<i>n</i> = 21]	12.0 \pm 1.5 (8.4–14.9) [<i>n</i> = 93]	13.7 \pm 1.2 (11.2–16.2)	14.2 \pm 1.3 (11.2–16.9) [<i>n</i> = 109]	9.9 \pm 1.1 (7.7–12.4)
HeadL1	20.7 \pm 2.5 (14.7–25.0)	12.7 \pm 1.1 (9.8–14.8) [<i>n</i> = 91]	14.4 \pm 1.2 (12.1–16.7)	14.9 \pm 1.2 (12.1–17.2) [<i>n</i> = 113]	11.0 \pm 0.6 (10.0–12.0)
HeadL2	18.6 \pm 1.8 (13.7–22.4) [<i>n</i> = 21]	11.7 \pm 1.0 (9.2–13.5) [<i>n</i> = 93]	13.2 \pm 1.0 (11.0–15.0)	13.8 \pm 1.0 (11.0–15.9) [<i>n</i> = 115]	10.3 \pm 0.6 (9.1–11.3)
HeadW	13.7 \pm 1.7 (9.1–16.2) [<i>n</i> = 19]	7.8 \pm 0.9 (5.8–9.8) [<i>n</i> = 91]	9.4 \pm 1.0 (7.6–11.1)	9.2 \pm 0.9 (7.3–10.9) [<i>n</i> = 111]	6.9 \pm 0.6 (5.6–8.1)
HeadH	9.8 \pm 1.1 (7.1–12.4) [<i>n</i> = 21]	5.4 \pm 0.6 (4.2–6.9) [<i>n</i> = 92]	6.5 \pm 0.6 (5.3–8.1)	6.4 \pm 0.6 (4.9–7.6) [<i>n</i> = 112]	4.9 \pm 0.4 (4.3–5.7)
SnoutL	8.2 \pm 0.8 (6.2–10.0) [<i>n</i> = 21]	5.5 \pm 0.5 (4.0–6.6) [<i>n</i> = 92]	6.0 \pm 0.5 (5.1–7.0)	6.3 \pm 0.5 (5.1–7.6)	4.6 \pm 0.4 (3.9–5.5)
EarL	1.6 \pm 0.2 (1.4–2.1) [<i>n</i> = 20]	0.9 \pm 0.2 (0.5–1.3) [<i>n</i> = 84]	1.1 \pm 0.2 (0.5–1.5) [<i>n</i> = 45]	1.1 \pm 0.2 (0.7–1.8)	0.8 \pm 0.1 (0.6–1.1) [<i>n</i> = 26]
EarH	2.3 \pm 0.3 (1.6–2.8) [<i>n</i> = 20]	0.9 \pm 0.2 (0.5–1.3) [<i>n</i> = 84]	1.2 \pm 0.2 (0.8–1.8) [<i>n</i> = 45]	1.1 \pm 0.2 (0.7–1.8) [<i>n</i> = 106]	0.8 \pm 0.2 (0.6–1.2) [<i>n</i> = 26]
FootL	12.1 \pm 1.0 (10.5–14.1) [<i>n</i> = 20]	10.8 \pm 0.8 (9.0–12.6) [<i>n</i> = 84]	11.2 \pm 0.9 (9.3–12.9) [<i>n</i> = 42]	11.9 \pm 0.8 (9.7–13.8) [<i>n</i> = 115]	9.0 \pm 0.6 (7.8–10.2)
Toe3L	6.2 \pm 0.4 (5.4–6.7) [<i>n</i> = 20]	5.4 \pm 0.5 (4.2–6.5) [<i>n</i> = 84]	5.5 \pm 0.5 (4.4–6.7) [<i>n</i> = 39]	6.1 \pm 0.5 (4.7–7.2) [<i>n</i> = 113]	4.6 \pm 0.4 (3.8–5.5)
Toe4L	8.1 \pm 0.6 (7.2–9.3) [<i>n</i> = 19]	7.5 \pm 0.6 (5.8–8.9) [<i>n</i> = 84]	7.7 \pm 0.7 (5.4–8.9) [<i>n</i> = 40]	8.3 \pm 0.6 (6.8–9.5) [<i>n</i> = 115]	6.3 \pm 0.4 (5.6–7.1)

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TABLE 4. (Continued)

Character	<i>Eremiascincus fasciolatus sensu lato</i>				<i>E. musivus</i> <i>n</i> = 27
	OTU 1 (eastern) <i>n</i> = 22	OTU 2 (western) <i>n</i> = 94	OTU 3 (northern) <i>n</i> = 47	OTU 4 (south-eastern) <i>n</i> = 117	
Meristics & qualitative scalation characters					
MBSR	33.5±1.4 (32–36)	32.5±1.2 (30–36) [<i>n</i> = 81]	33.0±1.3 (30–36) [<i>n</i> = 45]	30.3±1.3 (28–33) [<i>n</i> = 113]	30.5±1.2 (29–34) [<i>n</i> = 26]
PVS	62.0±2.7 (56–67)	64.6±2.9 (58–72) [<i>n</i> = 93]	64.7±3.1 (57–73)	65.9±2.7 (60–71) [<i>n</i> = 114]	56.3±2.4 (52–62)
SupraLab	8.0±0.5 (7–9)	7.0±0.2 (6–8)	7.0±0.2 (7–8)	8.0±0.3 (7–9)	7.0±0.2 (6–7)
InfraLab	7.7±0.9 (6–9) [<i>n</i> = 21]	6.2±0.5 (5–8) [<i>n</i> = 92]	6.7±0.8 (5–8)	7.5±0.7 (6–9)	6.0±0.3 (5–7)
SubInfraLab	+	–	–	–	–
DividLab	last and/or penultimate labial scale divided	–	–	–	–
SupraCil	8.9±0.8 (8–11) [<i>n</i> = 18]	8.1±0.7 (7–10) [<i>n</i> = 84]	8.0±0.5 (7–9) [<i>n</i> = 43]	8.4±0.6 (7–10)	8.4±0.7 (7–10)
4TLam	20.7±1.2 (18–23)	24.2±2.4 (20–31) [<i>n</i> = 89]	24.1±1.8 (20–29)	25.2±2.0 (20–30) [<i>n</i> = 114]	21.9±2.1 (18–26)
Percent TailL to SVL	116.9±8.8 (103.2–133.5) [<i>n</i> = 11]	126.3±7.7 (114.5–143.0) [<i>n</i> = 18]	136.9±6.5 (129.4–151.3) [<i>n</i> = 13]	129.1±5.0 (122.7–137.8) [<i>n</i> = 15]	135.0±11.5 (108.1–150.5) [<i>n</i> = 11]
TrunkL/SVL	0.52±0.03 (0.48–0.57) [<i>n</i> = 21]	0.54±0.02 (0.48–0.59) [<i>n</i> = 92]	0.53±0.03 (0.46–0.60)	0.56±0.02 (0.50–0.62) [<i>n</i> = 115]	0.51±0.03 (0.42–0.58)
ArmL/SVL	0.24±0.02 (0.21–0.28) [<i>n</i> = 19]	0.28±0.02 (0.24–0.32) [<i>n</i> = 91]	0.27±0.02 (0.23–0.30)	0.26±0.01 (0.23–0.29) [<i>n</i> = 115]	0.29±0.02 (0.25–0.31)
LegL/SVL	0.32±0.03 (0.27–0.39)	0.39±0.02 (0.33–0.43) [<i>n</i> = 88]	0.38±0.02 (0.33–0.43) [<i>n</i> = 45]	0.37±0.02 (0.32–0.40) [<i>n</i> = 115]	0.41±0.02 (0.38–0.45)
ArmL/LegL	0.75±0.03 (0.70–0.81) [<i>n</i> = 20]	0.71±0.03 (0.65–0.78) [<i>n</i> = 89]	0.71±0.02 (0.63–0.76) [<i>n</i> = 45]	0.71±0.02 (0.63–0.78) [<i>n</i> = 113]	0.70±0.02 (0.66–0.76)
HeadL1/SVL	0.22±0.01 (0.20–0.23)	0.20±0.01 (0.18–0.21) [<i>n</i> = 89]	0.20±0.01 (0.18–0.21)	0.18±0.01 (0.17–0.20) [<i>n</i> = 113]	0.21±0.01 (0.20–0.23)
HeadL2/SVL	0.19±0.01 (0.18–0.21) [<i>n</i> = 20]	0.18±0.01 (0.16–0.20) [<i>n</i> = 91]	0.18±0.01 (0.16–0.20)	0.17±0.01 (0.16–0.20) [<i>n</i> = 115]	0.20±0.01 (0.19–0.22)
HeadW/HeadL1	0.65±0.03 (0.60–0.72) [<i>n</i> = 19]	0.62±0.03 (0.57–0.72) [<i>n</i> = 89]	0.65±0.03 (0.59–0.75)	0.62±0.02 (0.56–0.67) [<i>n</i> = 108]	0.62±0.03 (0.54–0.68)
SnoutL/HeadL1	0.39±0.01 (0.37–0.43) [<i>n</i> = 21]	0.43±0.02 (0.39–0.48) [<i>n</i> = 90]	0.42±0.02 (0.39–0.46)	0.42±0.01 (0.39–0.46) [<i>n</i> = 113]	0.42±0.03 (0.38–0.53)
SnoutL/HeadL2	0.44±0.01 (0.41–0.46) [<i>n</i> = 21]	0.47±0.02 (0.41–0.51) [<i>n</i> = 92]	0.46±0.02 (0.40–0.51)	0.45±0.01 (0.41–0.53) [<i>n</i> = 115]	0.45±0.03 (0.41–0.54)
HeadH/HeadW	0.72±0.03 (0.64–0.76) [<i>n</i> = 18]	0.69±0.04 (0.57–0.79) [<i>n</i> = 90]	0.69±0.04 (0.59–0.78)	0.70±0.03 (0.62–0.78) [<i>n</i> = 111]	0.72±0.05 (0.63–0.81)
Coloration					
Bands/Dorsum	10–16	not present or discernible only on sides	6–16	not present or very faded laterally	not present [pale and dark flecks]
Bands/Tail	25–35	diffuse, rather oblique than transverse	35–42	29–39	± 35
			perfectly transverse	perfectly transverse, often very faded	diffuse, aligning darker scales, ‘bands’ divided medially

Discussion

Our examination of the type material and a large series of specimens from Australian and European museums indicate that four groups exist within *E. fasciolatus sensu lato*. The eastern taxon (OTU 1) forms a well separated group in PCA 1 (Fig. 1 A) whose morphospace does not overlap with the three other groups. The morphospace of OTU 1 contains the type material of *E. fasciolatus* (Günther, 1867). Hence, this distinct eastern taxon represents *E. fasciolatus sensu stricto*, a species endemic to the dry forests of eastern QLD (eastern Bassian subregion) that we redescribe below.

Although the western (OTU 2) and northern taxonomic units (OTU 3) are superficially similar in morphology as indicated by the plots of PCA 1 and PCA 2, both taxa are separable by qualitative characters not used in the multivariate analyses. The shape of the scales on the dorsal surface of the digits, the morphology of the subdigital lamellae, and color pattern on the dorsum can also be used to differentiate these two groups (see *Taxonomy*). In addition, the distribution of the two forms to our knowledge only overlaps slightly (with no hybrid populations known), and morphological similarities may be the result of shared ancestry and similar habitat requirements (see also *Concluding Discussion*). Thus there is sufficient evidence to allocate to each form the rank of species, which necessitates the removal of two names from the synonymy of *E. fasciolatus*. For the western taxon we apply the name *E. pallidus* (Günther, 1875) *comb. nov.* and for the northern taxonomic unit the name *E. intermedius* (Sternfeld, 1919) *comb. nov.* Both taxa must be considered valid, desert-inhabiting species of *Eremiascincus* (see *Taxonomy*). *Eremiascincus intermedius* is elevated to the species rank, because the morphological data (including our exploratory statistics) presented herein indicate that this species does not resemble *E. fasciolatus*, to which it may be only distantly related.

The recent concept of *E. fasciolatus sensu lato*, however, also hides one undescribed taxon (the south-eastern taxonomic unit—OTU 4) for which no name is available. This form appears to be distinct in our PCA analyses and can be furthermore distinguished from OTU 2 and 3 on the basis of a combination of morphological characters including features not used in the PCA (see *Comparison with other species* sections). The taxon also appears to be geographically largely separated from all other OTUs. With the exception of *Euprepes striatulus* Steindachner, 1867, which is a junior synonym of *E. fasciolatus* as shown in the *Taxonomy* section of the latter species, no other name is available for the OTU in question. Because of our findings we consider the south-eastern taxonomic unit a species not formally recognized. Thus we describe this species from the deserts of southern Australia below.

Taxonomy

Family Scincidae Opper, 1811

Subfamily Lygosominae Mittleman, 1952

Eremiascincus Greer, 1979, *Records of the Australian Museum*, 32 (7): 321–338

English: Glossy Night Skinks, Sand-swimming Skinks (some banded arid species)

German: Glatte Nachtskinke, Australische Sandfische (einige gestreifte Arten)

Nucleospecies: *Hinulia richardsonii* Gray, 1845: 271, by original designation (Greer 1979)

Eremiascincus fasciolatus (Günther, 1867)

English name: Eastern Narrow-banded Skink, Thick-tailed Skink

German name: Östlicher Streifenskink

(Figs. 2–5)

Hinulia fasciolata Günther, 1867: 47. Original description based on two specimens. Lectophoront herein designated: BMNH 1946.8.3.49 (formerly 1864.7.22.16) (Fig. 2), unsexed, with entire original tail. Type locality: Port Curtis, QLD. Presented by G. Krefft, Esq. (Boulenger 1887, plate XIV. fig. 1). Paralectotype: BMNH 1946.8.13.91, unsexed, with partly regenerated tail. Type locality: Rockhampton, QLD.

Synonyms:

Hinulia fasciolata Günther, 1867; Ann. Mag. Nat. Hist. (3) 20: 47

Euprepes striatulus Steindachner, 1867; in 'Reise der Novara' (1) 3: 49

Lygosoma fasciolatum Boulenger, 1887; Cat. Liz. Brit. Mus. Nat. Hist. 3: 236

Sphenomorphus fasciolatus fasciolatus Loveridge, 1934; Bull. Mus. Comp. Zool. 77 (6): 354

Lygosoma (Sphenomorphus) fasciolatum Smith, 1937; Rec. Ind. Mus. (39) 3: 220

Sphenomorphus fasciolatus Mittleman, 1952; Smiths. Misc. Coll. (117) 17: 24

Lygosoma (Sphenomorphus) fasciolatum fasciolatum Worrell, 1963; Rept. Aust.: 55

Subsequent authors (after Worrell 1963) opted for a broader concept of 'fasciolatus' (*fasciolatus sensu lato*).

Diagnosis and description based on material cited in the Appendix and color photographs by B. Maryan (Fig. 4 A), C. Thomson (Figs. 4 B, 5), P. Tremul (not shown), and Wilson & Swan (2010).



FIGURE 2. Lectophoront of *Eremiascincus fasciolatus* (BMNH 1946.8.3.49 [formerly 1864.7.22.16]). Photograph—S. Mecke.

Taxonomic history

The taxonomic history of the lizards currently assigned to the genus *Eremiascincus* Greer, 1979 dates back to the first half of the 19th century (description of *Hinulia richardsonii* Gray, 1845). In addition to the two species originally included in the genus, nine more were added by Mecke *et al.* (2009). In 1983 a new genus (*Mawsoniascincus* Wells and Wellington, 1983; nucleospecies *Lygosoma isolepis* Boulenger, 1887) was erected for different members of the genus (some species previously assigned to the *Glaphyromorphus isolepis* species-group), but this name has not been used by professional herpetologists (see Greer 1990), and is a junior synonym of *Eremiascincus* (Mecke *et al.* 2009).

Eremiascincus fasciolatus was first described by Günther (1867) from Port Curtis and Rockhampton in QLD under the name *Hinulia fasciolata* (lectophoront shown in Fig. 2). Steindachner (1867) described a similar species from NSW under the name *Euprepes striatulus* (holophoront shown in Fig. 3) by original designation, which was also listed by Günther (1875) under the name *H. striatula*. Boulenger (1887) placed *H. fasciolata* in his extremely large, polyphyletic genus *Lygosoma* and listed *E. striatulus* as a possible junior synonym of that species (marked

with a question mark). A supposed subspecies of *Lygosoma* [sic] (*Hinulia*) *fasciolatum*, viz. *intermedium* was described by Sternfeld (1919) (see also Sternfeld 1925). Sternfeld characterized his new subspecies as a connecting taxon between *Lygosoma fasciolatum* and *L. monotropis* Boulenger (1887) (junior synonym of *Eremiascincus richardsonii*, synonymy after Cogger *et al.* 1983). However, because of identical midbody scale counts and superficial similarities such as coloration pattern, Sternfeld placed *intermedium* within *fasciolatum*, attributing subspecies rank to that taxon (see also Loveridge 1934). Mittleman (1952) regarded *Sphenomorphus fasciolatus* distinct from *intermedius* as did Worrell (1963) who still recognized two subspecies (*sensu* Sternfeld 1919). Worrell, however, did not restrict the nominotypical taxon to QLD, noting that this taxon is widely distributed in other states, but presented a photograph of *Lygosoma* (*Sphenomorphus*) *fasciolatum* that appears to be an eastern QLD specimen.



FIGURE 3. Holophoront of *Euprepes striatulus* (NHMW 9720). Photograph—H. Grillitsch.

In 1967, Storr synonymized *Lygosoma* (*Hinulia*) *fasciolatum intermedium* with *Sphenomorphus fasciolatus fasciolatus* without consulting the relevant onomatophores and without examining topotypic specimens from QLD. Instead, Storr only examined supposed *fasciolatus* specimens from the NT. Storr also argued that Sternfeld evidently had no comparative material and relied on descriptions and measurements in Boulenger (1887) for his concepts. However, Storr (1967) (who was aware of Boulenger's (1887) descriptions) did not consider important taxonomic characters, including head scalation, which was figured in Boulenger (1887: plate XIV, specimen in lateral view). Storr further complicated the taxonomy of *Eremiascincus* by transferring *Hinulia pallida* Günther, 1875 (original designation—known as *Sphenomorphus pallidus* at that time) to *Sphenomorphus fasciolatus*, downgrading that taxon to subspecies rank (as *Sphenomorphus fasciolatus pallidus*). Later, in his revision of his *Sphenomorphus richardsonii* species-group, Storr (1974) noted that *S. f. pallidus* did not even warrant a rank of subspecies, regarding it as pale, dune-dwelling 'ecotypic variant' of *S. fasciolatus*. Although Storr this time

examined *fasciolatus* from across Australia, including specimens from eastern QLD and listed some morphological differences, he believed in a highly evolutionarily labile species, rather than in several distinct taxa. Greer (1979) appeared to follow Storr's species concepts, by only including two species to his new genus *Eremiascincus* (*E. richardsonii* and *E. fasciolatus*). However, Greer also indicated these taxa may be species complexes and mentioned that a number of poorly-understood characters exist, some of which are used herein to identify and define additional taxa.

At least since Greer (1979) erected *Eremiascincus*, *E. fasciolatus* has been treated as one of the most geographically widespread and morphologically diverse taxa of the Australian sphenomorphine skinks (e.g., Wilson & Knowles 1988; James & Losos 1991; Cogger 2000; Wilson & Swan 2008, 2010). Although occurring in a variety of different ecosystems (e.g., dry forests, spinifex grassland, and dune environments without vegetation), *E. fasciolatus sensu lato* seemed to predominantly inhabit sandy environments. While the name *fasciolatus* was misapplied for decades to several taxa after Greer's description of *Eremiascincus*, the topotypic *fasciolatus* was often confused with *E. richardsonii* (*sensu* Greer 1979), probably because of similarly robust body proportions, a contrasting pattern on the dorsum (*cf.* Storr 1974), and a preference for harder substrate (based on data from collector's notes in museum databases).

We consider Storr's (1974) and Greer's (1979) concept of *E. fasciolatus* to be oversimplified and hence problematic, as we delineated four species within it. Another problem within the banded forms of *Eremiascincus* is the proper delimitation of taxon boundaries at the specific level which led in the past to considerable confusion on the identity of taxa. Although this paper deals with the narrow-banded forms of *Eremiascincus*, this definition is mainly an aid to identification. The validity of a natural group containing all the narrow-banded species of the genus is not demonstrable and unlikely. Although all desert inhabiting species of this group (*E. pallidus*, *E. intermedius*, and the unnamed species) show superficial similarities, their probable close relationship requires confirmation with additional characters. We herein restrict *E. fasciolatus* to eastern QLD. A comparison with the relevant onomatophores and *E. musivus* is given in the *Comparison with other species* section.

Diagnosis. A large (snout-vent length up to 123 mm), robust narrow-banded *Eremiascincus* with 7–9 supralabials (usually 8), with the last, or the last and penultimate scale divided horizontally; a row of subinfralabials between infralabials and the last chin shields; only one infralabial in contact with the postmental scale; scales on top of the fourth toe in multiple rows with oblique sutures, reaching almost to the claw; 18–23 subdigital lamellae in multiple rows/ divided (usually two scales in a row), bluntly keeled or callused, keels ending in a mucro; plantar scales 9–12, callused; 32–36 scale rows at mid-body; head large, snout not depressed, and ear opening large and almost always elliptical; body smooth but tail with ridged scales; coloration pattern strongly banded (type b), composed of 10–16 narrow dark cross-bands on body between neck and attachment of hind limbs (broadest often on the neck), often breaking medially, branching laterally, and pointing forwards; 25–35 very narrow bands on tail.

Description. *Dimensions and general characteristics.* A large (snout-vent length of adult specimens 65.5–123.4 mm, mean = 96.1, $n = 22$), robust *Eremiascincus*; head relatively large (HeadL1/SVL 0.20–0.23, mean = 0.22, $n = 22$); snout short (SnoutL/HeadL1 0.37–0.43, mean 0.39, $n = 21$), top of snout concave, tip of snout obtusely pointed; canthus rostralis rounded; lower eyelid movable, scaly; ear opening vertically elliptic, large (not rounded and small as erroneously indicated by Günther (1867) in the original type description) (maximum length 2.1 mm, maximum height 2.8 mm), and at least about half the area of eye aperture, but often much larger, with small granular scales at anterior border, tympanum visible; limbs pentadactyl, overlapping when adpressed, moderately long (hind legs ~30% the length of snout-vent length); fingers and toes moderately long, circular in section; third and fourth finger of same size; fourth toe longer than third; tail up to ~134% of snout-vent length (range 103.2–133.5%, mean 116.9%, $n = 11$), with strong ridges or keels, round in cross section, very thick; hemipenis deeply bifurcated, not columnar.

Scalation. Nasals widely separated; frontal arrowhead-shaped, ~30% longer than interparietal, much larger than prefrontals; width of rostral-frontonasal suture less than half width of frontonasal; prefrontals narrowly separated; frontal contacting frontonasal; frontoparietals free (paired); interparietal normally free, smaller than a frontoparietal; parietals large, in contact behind interparietal; each parietal bordered posteriorly by upper secondary temporal and (if present) enlarged nuchal scales; nuchals 0–3; supraoculars 4, normal in shape and orientation; first and last approximately as wide as long, medial two much longer than wide, 2 or 3 in contact with frontal; loreals 2, as tall as wide, squarish; supranasal scale absent; preoculars 2, lower larger; presuboculars usually 2, rarely 3; 8–11

(mostly 9, mean 8.9, $n = 18$) supraciliaries, first largest; 7–9 (usually 8, mean 8.0, $n = 22$) supralabials, last or last and penultimate scale divided (Figs. 5, 17 A(1)), last supralabial scale overlaps lower secondary temporal; 6–9 infralabials; postmental contacting first infralabial only; subinfralabial scales present, projecting anteriorly until beginning of third or second chin shield (Figs. 5, 17 A(2)); one primary and two secondary temporals; 32–36 (mostly 32–34) scale rows at mid-body (mean 33.5, $n = 22$), laterals smallest; 56–67 paravertebrals (mean 62.0, $n = 22$); 18–23 subdigital lamellae under fourth toe (mean 20.7, $n = 22$), scale under fourth toe divided medially, callose (with a calli per single scale); scales on top of toes in multiple series, except distal two or three scales (Fig. 17 D(2)); scales on soles of hands and feet with rounded apex; body and head shiny-scaled; scales on body smooth; trailing edges of dorsal and lateral scales angularly 3-sided rather than smoothly rounded; subcaudal scales larger than ventrals; tail above strongly keeled (keels forming three parallel longitudinal dorsal ridges on each side); two median preloacal scales distinctly enlarged.

Coloration and pattern in preservative (ethanol). Upper surface (head, dorsum, tail, and limbs) medium gray or copper to dark brown with a color pattern composed of distinct narrow dark brown or blackish cross-bands (on back and tail) (type b); 10–16 bands on body (mean 12.2, $n = 34$), each 1–1.5 scales wide (type b) (sometimes two scales are included for parts of a band, rarely a broad banding is evident on the neck (type c)), often branching and/or broken mid-dorsally, and separated by a pale interspace of 2–5 (usually 3–4) scales, cross-bands often obliquely descending forwards laterally; 25–35 bands (type b) on tail (mean 30.6, $n = 13$) occupying a single row of scales or restricted to the posterior half of a scale row and separated by two rows of paler scales; occasionally with dark spots on head and limbs, dark flecks on head and neck (if present) much smaller than scales and not coalescing into a band; labials pale or maculated; underneath immaculate ivory or silvery white, scales on chin and gular region not colored differently, rarely with light brown flecks; palmar and plantar surfaces gray-white; iris as dark as pupil; tongue pale. Juveniles often show a more intense striping on the dorsum, which becomes more faded in adult specimens.

Color and pattern in life. Generally similar to color in preservative, usually grayish or light brown; scales with a noticeable gloss; belly cream to pinkish. For pictures of live animals see Figs. 4 & 5 and Wilson & Swan (2010).

Craniology. According to the data presented in Greer (1979, fig. 3 & table 2) this species has nine premaxillary teeth, the surface exposure of the postorbital bone in the supratemporal arch is long (i.e., reaching the supratemporal fenestra), and an ectopterygoid process extends anteriorly along the anterolateral edge of the palatal ramus and completely excludes the latter from the suborbital foramen.

Sex ratio and sexual dimorphism. The sex ratio of all specimens examined approached parity (males: females—9:11). All meristic and morphometric variables (including indices) were tested for sexual dimorphism, with significant differences only being found for **plantar scales** (males: mean = 11.8, SD = 0.7, median = 12 $n = 9$; female: mean = 10.5, SD = 0.8, median = 10, $n = 11$; $Z = -3.085^{**}$).

Synonymous taxa. The holophoront of *Euprepes striatulus* in the collection of Naturhistorisches Museum Wien, Vienna (NHMW 9720) (Fig. 3) is in good accordance with the lectophoront (BMNH 1946.8.3.49 (1864.7.22.16)) and the paralectotype (BMNH 1946.8.13.91) of *Eremiascincus fasciolatus* in overall appearance (including head scalation characters, in particular the presence of subinfralabials and a divided last supralabial) and coloration (details given below). Therefore we maintain the synonymy of *Euprepes striatulus* with *Eremiascincus fasciolatus* as first proposed by Boulenger (1887). The type locality of *Euprepes striatulus* (Steindachner, 1867) is given as ‘New South Wales’. Although NSW covered a vast land mass during the time the Novara Expedition (during which the holophoront supposedly was collected) took place, including today’s QLD, the only brief stopover on the Australian continent is reported from the Sydney-area of today’s mid-eastern NSW. However, *E. fasciolatus* has not been recorded from NSW and we assume that the vague location data is erroneous. All other specimens in the collection of NHMW assignable to *E. fasciolatus* that were purchased by Steindachner (NHMW 9719:1–2, 9722:1–2, 16663) or are labelled as being collected during the ‘Novara Expedition 1857–59’ (NHMW 16662:1–3) come (according to their museum labels) from QLD with two specimens 9719:1–2 (present from Steindachner) having the locality data ‘Rockhampton’ (same type locality as for BMNH 1946.8.13.91). Steindachner apparently mixed up specimens that he received from different sources, resulting in incorrect type localities given in his species descriptions. The type locality for *Denisonia maculata* Steindachner, 1867, for example, is given as NSW as well and undoubtedly in error, as the species only occurs in the drainage system of the Fitzroy and Dawson Rivers of mid-eastern QLD (McDonald *et al.* 1991; Cogger *et al.* 1993). Thus we assume that the type specimen of *Euprepes striatulus* was most likely collected in QLD.



FIGURE 4. *Eremiascincus fasciolatus* in life (both unvouchered). **(A)** *E. fasciolatus* from about 55 km ESE Moranbah, QLD. The specimen was observed at night in Eucalyptus woodland over grasses with stony rises. Photograph—B. Maryan. **(B)** *E. fasciolatus* in life from Curtis Island, QLD. The specimen was observed on the forest floor. Photograph—B. Thomson. Note the dark narrow bands on dorsum and tail, the robust build, and the elliptical ear aperture.



FIGURE 5. Head of *Eremiascincus fasciolatus* in life (unvouchered specimen). Note the divided last supralabial (last upper supralabial divided into two smaller scales on the right side of the figured specimen). Photograph—B. Thomson.

Details of lectophoront (Fig. 2) (BMNH 1946.8.3.49) [unsexed adult]. SVL 95.8 mm, TrunkL 46.2 mm, TailL 110.6 mm, ArmL 23.6 mm, LegL 31.2 mm, AxillaEar 18.6 mm, HeadL1 21.6 mm, HeadL2 19 mm, HeadW 15.4 mm, SnoutL 8.3 mm, HeadH 9.9 mm, ear opening 1.5 x 2.3 mm, MBSR 34, PVS 61, SupraLab 8 (DividedLab: last 2 SupraLab), InfraLab 8, SubInfraLab present (projecting anteriorly until middle of second enlarged chin shield), SupraCil 10, prefrontals separated, presuboculars 3, nuchals 0, 4TLam 21, upper surface of fourth toe with scales in multiple rows (14) with oblique sutures and the last 3 scales in a single row with transverse sutures, plantar scales 10, BandsDorsum (type b) 13, covering a single scale row, BandsTail (type b) ~24.

Details of holophoront of *Euprepes striatulus* (Fig. 3) (NHMW 9720) [juvenile male]. SVL 57.0 mm, TrunkL 29.0 mm, TailL 61.0 mm (partly regenerated), ArmL 13.9 mm, LegL 17.8 mm, HeadL1 11.9 mm, HeadL2 11.4 mm, HeadW 9.3 mm, SnoutL 4.6 mm, HeadH 7.6 mm, AxillaEar 11.5 mm, ear opening 1.5 x 1.5 mm, MBSR 36 (specimen stated to have 32 MBSR in the original description), PVS 69, SupraLab 8 (DividLab: last SupraLab divided horizontally), InfraLab 8, SubInfraLab present (projecting anteriorly until level of second enlarged chin shield and fourth InfraLab), SupraCil 10, prefrontals separated, presuboculars 3, nuchals 1, 4TLam 21, upper surface of fourth toe with scales in multiple rows (18) with oblique sutures and the last 2 scales in a single row with transverse sutures, plantar scales 8, BandsDorsum (type b) 12, covering a single scale row, most vertebrae interrupted, sometimes branching, BandsTail (type b) 22–23.

Comparison with other species. Generally distinguished from other narrow-banded species (including *E. musivus*) of the genus by its large snout-vent length (up to 123.4 mm) and robust build. It can be further distinguished by: the last or last and penultimate supralabial scale divided horizontally, subinfralabials present, only one infralabial in contact with the postmental scale, scales on top of the fourth toe in multiple rows with oblique sutures (*cf.* Fig. 17 A, B, D), 18–23 subdigital lamellae under fourth toe which are bluntly keeled/callose and divided, 9–12 callused plantar scales. The snout is not depressed and the ear aperture large and elliptical. The color pattern comprises narrow bands which are not only restricted to the tail but also form a pattern on the dorsum. Superficially similar to *E. intermedius* because of coloration (*cf.* Fig. 16 B, C) but distinguishable from that species

by its larger size, divided supralabial scales, the presence of subinfralabials, multiple rows of scales with oblique sutures along almost entire digits, followed by 2–3 scales in single rows with transverse sutures (single rows with transverse sutures (usually about 7) cover at least the distal third of the digits in *E. intermedius* (cf. Fig. 17 E), fewer digital lamellae and plantar scales, and different head proportions. Most similar in these respects to some populations of *E. richardsonii* (*sensu* Greer 1979) from eastern Australia (southern QLD and NSW), from which it is distinguishable by the presence of subinfralabials, scales on top of the fourth toe in multiple rows with oblique sutures followed by 2–3 single scales vs. multiple rows usually followed by at least 5 single scales (single scales usually cover approximately distal third of digit), fewer subdigital lamellae under fourth toe, fewer plantar scales, and bands (type b) on dorsum and tail only covering a single scale row vs. bands (type c) usually covering more than two scale rows. *Eremiascincus richardsonii* is further distinguished from *E. fasciolatus* in usually having four chin shields and two median chin shields (gular shields between the enlarged lateral chin shields) (Fig. 17 C) vs. three chin shields and one median chin shield in *E. fasciolatus*. In museum collections, *E. fasciolatus* was often confused with *E. richardsonii* (*sensu* Greer 1979), probably due to its large size and robust build. Another similarity with *E. richardsonii* is that the bands on the tail can be oblique, rather than being perfectly transverse (characteristic of *E. pallidus*, *E. intermedius*, *E. phantasmus* sp. nov.). *Eremiascincus fasciolatus* is distinguished from all other mesic taxa (*E. antoniorum*, *E. brongersmai*, *E. butlerorum*, *E. douglasi*, *E. emigrans*, *E. isolepis*, *E. pardalis*, and *E. timorensis*) by the presence of a simple pattern of dark cross-bands on the dorsum and the tail, last and/or penultimate SupraLab scale divided, and SubInfraLab scales present.

Comparison of *Eremiascincus fasciolatus* with the type of *Hinulia ambigua* de Vis, 1888. *Hinulia ambigua* (QM J242) de Vis, 1888 was described from Charleville, QLD. Although its type locality lies outside the known range of *E. fasciolatus* a comparison is necessary, as *E. fasciolatus* was often confused with broad-banded *Eremiascincus* from QLD (see also Loveridge (1934), who regarded *Hinulia ambigua* as a junior synonym of *Sphenomorphus fasciolatus fasciolatus* = *Eremiascincus fasciolatus*). The holophoront of *Hinulia ambigua* resembles in scalation and coloration *E. richardsonii* (*sensu* Greer 1979 and Cogger *et al.* 1983). The typical characteristics of *E. fasciolatus* (divided supralabials, subinfralabial scales, narrow banding) are lacking in this specimen.

Distribution. *Eremiascincus fasciolatus* is a species endemic to eastern QLD with most museum vouchers having been collected from the Brigalow Belt and the South East QLD bioregions (Fig. 18). The area of distribution extends from Purga in the south inland to Moonie and Roma in the Darling Downs area, and northwards to Nathan Gorge. The species approaches the coast via areas of dry woodlands, tropical and subtropical grasslands, and savannas at Eurimbulah, Rockhampton, Port Curtis (type locality), and Curtis Island (B. Thomson, photo voucher taken, Fig. 4 B) from where the area of distribution extends west to Emerald. From the type locality the distribution extends to Collaroy Holding (Connor's Range) at the coast, inland to Epping Forest National Park. For a photograph of a specimen from about 55 km ESE Moranbah see Fig. 4 A. The northernmost records of *E. fasciolatus* are from Mount Cooper Station and Blackbraes National Park, 180 km north-east of Hughenden.

The Great Dividing Range may largely act as a natural barrier to the species' distribution into the western grasslands and savannas. Compared with other taxa of narrow-banded skinks this species is relatively rare in collections, so further range extensions are possible.

Geographic variation. Color pattern is very conservative—all specimens have a light to dark gray or gray-brown dorsum with 10–16 narrow cross-bands. The major color pattern variations consist of the presence of flecks on head, neck, and limbs of some specimens. Geographic variation in color does not appear to be much greater than local variation, as all populations are well identifiable as *E. fasciolatus* on the basis of scalation characters.

Divisions in the supralabial scales are diagnostic in combination with other traits as described in the *Description* and shown in Table 4. However, although usually only the last supralabial scale is divided, some specimens (including the lectophoront and the paralectotype) have both the last and the penultimate scale divided horizontally. Two specimens had the upper part (division) of the last supralabial itself divided (vertically) into two smaller scales. In other respects these specimens are typical for *E. fasciolatus*.

Habitat and ecology. *Eremiascincus fasciolatus* occurs in open subtropical forests (temperate broadleaf and mixed sclerophyll forests; Fig. 6), semiarid woodlands and heathlands (P. Tremul and B. Maryan, pers. comm.). Some specimens have been collected from *Banksia*, *Corymbia*, *Eucalyptus*, and *Xanthorhoea* woodlands, and forests over *Pteridium* and grasses, such as *Heteropogon*, others from *Acacia* and *Callitris* forests. *Eremiascincus fasciolatus* is known from localities that are characterized by sub-humid and humid conditions (annual rainfall ~600–1600 mm).



FIGURE 6. Habitat of *Eremiascincus fasciolatus* (near Glenmorgan, QLD) illustrating a typical Brigalow forest. Photograph—S. Cochrane.

Unlike other narrow-banded forms of *Eremiascincus* that are fossorial or semifossorial, *E. fasciolatus* appears to prefer hard soil (P. Tremul and B. Maryan, pers. comm.). Morphological features such as a large ear aperture, multiple rows of scales on top of fingers and toes (typical for mesic taxa within *Eremiascincus*), and divided, callused subdigital lamellae support *E. fasciolatus* being a non-fossorial species. Like its congeners, *E. fasciolatus* is crepuscular and nocturnal, favoring damp places, such as logs during the day (B. Maryan, pers. comm.). Food consists of arthropods and probably small vertebrates. The species is oviparous with the largest female examined (QM J39996) containing eight shelled oviductal eggs. Little is known about the ecology of *E. fasciolatus* at present.

Etymology. The specific name ‘*fasciolatus*’ is Latin for ‘small bands’.

Remarks. Although the area of distribution of *E. fasciolatus* extends from Purga in south-eastern QLD about 1270 km north to Blackbraes National Park, most specimens have been collected from the south-east (including the Darling Downs and the Capricorn Coast). The southern populations of *E. fasciolatus* (some of which might already be extinct) are located within a region with a high population density and growth, and some subregions are extensively clear-cut and developed for urban facilities, infrastructure, and agricultural uses (e.g., Joint Commonwealth and QLD Regional Forest Agreement Steering Committee [JCQFASC] 1999). The woodland ecosystems in some subregions are fragmented and under pressure from development (JCQFASC 1999). Even if natural habitats exist, the impact of clearing and development from adjacent land may have a substantial effect on biodiversity of neighboring areas. The South East QLD bioregion in particular is recognized for its high number of rare, threatened, and endemic species, including several reptiles. Wilson (2005) noted that *Eremiascincus* is uncommon in the South East QLD bioregion, indicating that only *E. richardsonii* occurs in the dry parts of this region. However, *E. fasciolatus* had a population in that bioregion with vouchers collected from Purga, Laidley, and Gatton between 1974 and 1981. Surveys need to determine whether this species is still present in that area.

A major gap in our knowledge of *E. fasciolatus* includes ecological and life history data. Thus the quantitative ranking method (Millsap *et al.* 1990) adopted by Cogger *et al.* (1993) is not applicable to assess the conservation

status of *E. fasciolatus* at present. Under IUCN criteria, we recommend that *E. fasciolatus* is categorized as ‘Data Deficient’. Suitable habitats for *E. fasciolatus* seem to exist even in populated areas, and some specimens have been collected from disturbed ecosystems (P. Tremul, pers. comm.).

***Eremiascincus pallidus* (Günther, 1875)**

English name: Western Sand-swimming Skink, Western Narrow-banded Skink

German Name: Westaustralischer Streifenskink

(Figs. 7 & 8)

Hinulia pallida Günther, 1875: 12. Holophoront: BMNH 1946.8.3.38 (formerly 1867.2.19.48) (Fig. 7), unsexed, without original tail. Type locality: Nickol Bay, WA. Presented by Mr. Duboulay (Boulenger 1887; plate XIII. fig. 2).

Synonyms:

Hinulia pallida Günther, 1875; in Richardson & Gray’s ‘Zool. Erebus & Terror’ 2: 12

Lygosoma pallidum Boulenger, 1887; Cat. Liz. Brit. Mus. Nat. Hist. 3: 233

Lygosoma (Sphenomorphus) pallidum Smith, 1937; Rec. Ind. Mus. (39) 3: 220

Sphenomorphus pallidus Mittleman, 1952; Misc. Coll. (117) 17: 28

Sphenomorphus fasciolatus pallidus Storr, 1967; Roy. Soc. West. Aust. 50 (1): 15–16

Sphenomorphus fasciolatus (part.) Storr, 1974; Rec. West. Aust. Mus. 3 (1): 68–70 (‘*pallidus*’ = p. 69)

Eremiascincus fasciolatus (part.) Greer, 1979; Rec. Aust. Mus. (32) 7: 323 *et seqq.*

Eremiascincus fasciolatus (part.) Cogger *et al.*, 1983; Zool. Cat. 1, Aust. Amphib. Reptil.: 163; & Cogger, 2000; Rept. Amphib. Aust.: 477

Eremiascincus fasciolatus Mecke *et al.*, 2009; Zootaxa 2246: 1–20

Eremiascincus ‘pallidus’ Doughty *et al.*, 2011, Rec. West. Aust. Mus. Suppl. 78: 322

Diagnosis and description based on material cited in the Appendix and color photographs by B. Maryan (Fig. 8 and not shown), Storr *et al.* (1999), and Wilson & Swan (2010).

Taxonomic history. Günther (1875) first described *Hinulia pallida* from a specimen collected at Nickol Bay, WA (holophoront see Fig. 7). Werner (1910), Smith (1937), Mittleman (1952), and Glauert (1961) regarded this taxon as a valid species until Storr (1967) relegated *Sphenomorphus pallidus* to a subspecies of *S. fasciolatus* by examining a single museum specimen of the first taxon. In his description of *Sphenomorphus fasciolatus pallidus*, Storr (1967) even doubted that this taxon should require subspecies rank by a comparison of that subspecies with *Sphenomorphus f. fasciolatus* (= *E. intermedius*, as all specimens were collected from the NT; no topotypic *fasciolatus sensu stricto* specimens were examined). Seven years later, Storr (1974) synonymized *S. f. pallidus* with *S. f. fasciolatus*. Subsequent authors followed Storr’s concept and the specific epithet ‘*fasciolatus*’ has been incorrectly applied to *E. pallidus* for more than 45 years.

Diagnosis. A medium-sized (snout-vent length up to 77 mm), slender narrow-banded *Eremiascincus* having 6–8 undivided supralabials (usually 7); one infralabial in broad contact with the postmental scale (rarely 2); scales on top of the fourth toe in single rows with transverse sutures; 20–31 subdigital lamellae in one row (not grooved), un- or only feebly keeled; plantar scales 14–18, smooth; 30–36 scale rows at mid-body; head small and snout depressed; ear opening small and circular; dorsum with keels posteriorly and tail with ridged scales; coloration pattern usually comprises 32–37 perfectly transverse dark narrow bands (type b, rarely a) on the tail; body usually without banding or at most faint bands on side of body; pale.

Description. *Dimensions and general characteristics.* A medium-sized (snout-vent length of adult specimens 47.9–77 mm, mean 64.8, $n = 92$), slender *Eremiascincus*; head relatively small (HeadL1/SVL 0.18–0.21, mean 0.20, $n = 89$); snout long (SnoutL/HeadL1 0.39–0.48, mean 0.43, $n = 90$), top of snout depressed, tip of snout pointed; canthus rostralis rounded; lower eyelid movable, scaly; ear opening circular and small (maximum length 1.3 mm, maximum height 1.3 mm), about a quarter the area of eye aperture, with minute granules at anterior border; ear opening followed by a depression of the integument; tympanum sunk; limbs pentadactyl, overlapping when adpressed, moderately long (hind legs ~40% length of snout-vent length); fingers and toes relatively long, circular in section; third and fourth finger of same length; fourth toe longer than third; tail up to 143% of snout-vent length (range 114.5–143.0%, mean 126.3, $n = 18$), with smooth ridges or keels, round in cross section; hemipenis deeply bifurcated, not columnar.



FIGURE 7. Holophoront of *Hinulia pallida* (BMNH 1946.8.3.38). Photograph—S. Mecke.

Scalation. Nasals widely separated; frontal arrowhead-shaped, ~60% longer than interparietal, much larger than prefrontals; width of rostral-frontonasal suture less than half width of frontonasal; prefrontals separated by approximately the length by which the nasal scales are separated; frontal contacting frontonasal; frontoparietals free (paired); interparietal normally free, as large as a single frontoparietal; parietals large, in contact behind interparietal; each parietal bordered posteriorly by upper secondary temporal and enlarged nuchal scales or up to 3 smaller unfused scales; nuchals 0–1; supraoculars 4, normal in shape and orientation; medial 2 much longer than wide; 2 or 3 in contact with frontal; loreals 2, as tall as wide, squarish; supranasal scale absent; preoculars 2, lower larger; presuboculars usually 2; supraciliaries 7–10, (usually 8–9, mean 8.1, $n = 84$), first largest; supralabials 6–8 (usually 7, mean 7.0, $n = 94$), undivided, last supralabial overlapped by penultimate supralabial and first temporal and overlaps lower secondary temporal; infralabials 5–8; postmental contacting first infralabial; 1 primary and 2 secondary temporals; 30–36 (mostly 32–34) scale rows at mid-body (mean 32.5, $n = 81$), laterals smallest; 58–72 paravertebrals (mean 64.6, $n = 93$); 20–31 subdigital lamellae under fourth toe (mean 24.2, $n = 89$); scales under fourth toe undivided, not grooved, and usually without keels (not strongly keeled as reported by Glauert 1961); scales on top of toes in single series; scales on soles of hands and feet smooth; body and head shiny-scaled; scales on body smooth; trailing edges of dorsal and lateral scales angularly three-sided rather than smoothly rounded; subcaudal scales larger than ventrals; tail above smoothly keeled (keels forming longitudinal ridges); 2 median precloacal scales distinctly enlarged.

Coloration and pattern in preservative (ethanol). Upper surface (head, dorsum, and limbs) pale straw yellow to pale brown, rarely with fine bands (type a, b) discernible only on sides of body or dark brown mottling; margins of body scales usually darker; 32–37 narrow bands (type b) on tail, occupying a single perfectly transverse row of scales and separated by 2 rows of paler scales (sometimes only the posterior part of a single scale row is darkened, type a); regenerated tails usually display no banding, rather a longitudinal mottling; head scales are usually uniformly pale but occasionally show dark flecks; subocular region appears to be dark bluish because of the subjacent eye socket; labials pale; venter immaculate whitish or yellowish; sometimes displaying a strong contrast

between the pale dorsal and the ivory or white lateroventral surface; scales on chin and gular region not colored differently; palmar and plantar surfaces not darkened; iris as dark as pupil; tongue pale. Juveniles are similar to adults in most respects but often show a more intense color pattern.

Color and pattern in life. Ground color variable, varying from light reddish, orange, or pinkish to a light to moderate yellow or grayish brown; sides are usually paler than dorsum; belly cream to pinkish; sometimes with obscure indication of banding between axilla and groin; tail with dark bands (type b); all body scales glossy. For pictures of live animals see Fig. 8, Storr *et al.* (1999), and Wilson & Swan (2010). The 'fasciolatus'-specimen illustrated by Greer (1979, fig. 2) also depicts *E. pallidus*.

Craniology. Not known.

Sex ratio and dimorphism. The sex ratio of specimens favored males (54:39). All meristic and morphometric variables were tested for sexual dimorphism, with significant differences being found for: **LegL** (males: mean = 25.6, SD = 2.3, median = 26.1, $n = 51$; females: mean = 24.7, SD = 1.6, median = 24.6 $n = 37$; $Z = -2.803^*$), **HeadL2** (males: mean = 11.9, SD = 1.1, median = 12.0, $n = 54$; females: mean = 11.4, SD = 0.8, median = 11.4, $n = 38$; $Z = -2.647^*$) The following ratios likewise showed significant differences between sexes: **TrunkL/SVL** (males: mean = 0.53, SD = 0.02, median = 0.53, $n = 53$; females: mean = 0.55, SD = 0.02, median = 0.55 $n = 38$; $Z = -2.827^{**}$), **ArmL/SVL** (males: mean = 0.28, SD = 0.01, median = 0.28, $n = 53$; females: mean = 0.27, SD = 0.02, median = 0.27, $n = 37$; $Z = -3.352^{***}$) and **ArmL/TrunkL** (males: mean = 0.53, SD = 0.04, median = 0.53, $n = 53$; females: mean = 0.50, SD = 0.03, median = 0.50, $n = 38$; $Z = -3.768^{***}$), **LegL/SVL** (males: mean = 0.40, SD = 0.02, median = 0.40, $n = 51$; females: mean = 0.38, SD = 0.02, median = 0.38, $n = 36$; $Z = -3.067^{**}$) and **LegL/TrunkL** (males: mean = 0.75, SD = 0.05, median = 0.75, $n = 51$; females: mean = 0.70, SD = 0.04, median = 0.70, $n = 37$; $Z = -7.908^{***}$), and **HeadL1/SVL** (males: mean = 0.20, SD = 0.01, median = 0.20, $n = 52$; females: mean = 0.19, SD = 0.01, median = 0.19, $n = 36$; $Z = -4.452^{***}$)

Details of holophoront (Fig. 7) (BMNH 1946.8.3.38) [unsexed adult]. SVL 72.6 mm, TrunkL 37.4 mm, tail broken, ArmL 18.6 mm, LegL 25.6 mm, HeadL1 13.7 mm, HeadL2 12.7 mm, HeadW 8.8 mm, SnoutL 5.8 mm, snout depressed, HeadH 6.3 mm, AxillaEar 12.6 mm, ear opening 0.6 x 0.9 mm, MBSR 32, PVS 61, SupraLab 7 (DividedLab: none/undivided), InfraLab damaged, SupraCil 9, prefrontals separated, presuboculars 2, nuchals 0, 4TLam 23, upper surface of fourth toe with scales in single rows with transverse sutures along almost entire digit, plantar scales 16, no bands or pattern noticeable on body or base of broken tail.

Distribution. Sandy parts of arid WA including the north-west coastal plains from Goldsworthy (Dampierland) along the coastline of the Pilbara to the Cape Range area (Carnarvon xeric shrublands) and south to the western Murchison region, the Gascoyne area, the Little Sandy Desert, and the Great Sandy Desert west to Anna Plains, Warrawagine, and the Nooloo Soak area, and east to Lake Mackay on the WA-NT border. The species also occurs in the Gibson Desert from Kiwirrkurra south to the Clutterbuck Hill area and the Central Ranges from Pungkulpirri south to the Blackstone area and east into SA (Tomkinson Ranges) and the adjacent far south-western NT. *Eremiascincus pallidus* is also distributed in the Great Victoria Desert from Empress Springs in the west to Neale Junction Nature Reserve in the south and east into SA with the easternmost voucher from the Maryinna Hill region. Although the species is found in most parts of northern WA it does not occur in the stony hill country of the Pilbara region (*cf.* Fig. 18). R. Lloyd (pers. comm.) has recently reported the species from the Newhaven area of the NT, where he found it in sympatry with *E. intermedius* (photo vouchers taken).

Habitat and ecology. *Eremiascincus pallidus* occurs in desert environments, such as hummock and tussock grassland, low open shrubland and woodland (e.g., *Acacia*, *Eucalyptus*, *Grevillea*, *Ligulata*, *Melaleuca*, *Stenobotrya*), heathland (e.g., *Maisonneuvei*, *Thryptomene*), and sand dunes without or with only sparse vegetation present (Fig. 9). The species is fossorial and predominantly found in habitats with loose sand/soil, such as crests of dunes and is absent from stony areas. It is crepuscular and nocturnal and an arthropod feeder but also preys upon small desert lizards, such as the sand-swimming *Lerista bipes* (Fischer, 1882) (examinations of stomach contents; S. Mecke, pers. obs.). During the day the species shelters under rocks, logs, vegetation, or in burrows and is also frequently encountered under rubbish, such as iron sheets. The species is occasionally seen on tracks and bitumen roads at dusk or at night (B. Maryan, pers. comm.).

Etymology. The specific name '*pallidus*' is Latin for 'pale' in reference to the pale dorsal coloration of that species.



FIGURE 8. *Eremiascincus pallidus* in life. **(A)** *E. pallidus* from Empress Springs, WA. **(B)** *E. pallidus* from Cape Lambert, WA. Note the unicolored dorsum and the perfectly transverse dark bands (type a, b) on the tail, the slender build, and the small circular ear aperture. Photographs—B. Maryan.



FIGURE 9. Habitat of *Eremiascincus pallidus* (Little Sandy Desert, WA) characterized by red sand associated with dunefields and plains covered with shrub steppe over *Spinifex* (*Triodia* sp.). Photograph—B. Maryan.

Comparison with other species. This medium-sized *Eremiascincus* is generally distinguishable from all other narrow-banded skinks by its pale dorsal coloration. This character is shared only with the larger *E. phantasmus* **sp. nov.** (cf. Fig. 16 D, E) from south-eastern Australia, which is easily distinguished from *E. pallidus* in usually having 8 supralabial shields instead of usually 7, and almost always 2 infralabial scales in contact with the postmental scale, vs. 1 infralabial in contact with the postmental shield. Uncertainties in the identification of specimens from central Australia (Curtin Springs area), where the borders of distribution of *E. pallidus* and *E. phantasmus* **sp. nov.** overlap, may indicate that hybrid zones exist among some of the described members of the desert-dwelling narrow-banded *Eremiascincus* (see *Concluding discussion*).

Eremiascincus intermedius (Sternfeld, 1919)

English name: Northern Narrow-banded Skink

German name: Nordaustralischer Streifenskink

(Figs. 10 & 11)

Lygosma [*sic*] (*Hinulia*) *fasciolatum intermedium* Sternfeld, 1919: 81. Lectophoront (designated by Mertens (1967)): SMF 14446 (Fig. 10), male, with original tail. Type locality: Hermannsburg Mission, upper Finke River, NT, Australia; *leg.* M. v. Leonhardi (1908). Paralectotypes: SMF 14447–50 (unsexed adults), and SMF 144451 (juvenile); MCZ 33530 is evidently from Sternfeld's original symphoront series and marked as 'cotype' (equivalent of a 'syntype') in Loveridge (1934) and hence a paralectotype.

Cogger *et al.* 1983 erroneously referred to SMF 14446 as a 'holotype'.

Synonyms:

Lygosma [*sic*] (*Hinulia*) *fasciolatum intermedium* Sternfeld, 1919; Senck. Biol. 1 (3): 81

Sphenomorphus fasciolatus fasciolatus (*part.*) Storr, 1967; J. Roy. Soc. West. Aust. 50 (1): 15–16

Sphenomorphus fasciolatus intermedius Mertens, 1967 Senck. Biol. 48: 74

Sphenomorphus fasciolatus (*part.*) Storr, 1974; Rec. West. Aust. Mus. 3 (1): 68–70

Eremiascincus fasciolatus (part.) Greer, 1979; Rec. Aust. Mus. (32) 7: 323 *et seqq.*

Eremiascincus fasciolatus (part.) Cogger *et al.*, 1983; Zool. Cat. 1, Aust. Amphib. Reptil.: 163; & Cogger, 2000; Rept. Amphib. Aust.: 477

Diagnosis and Description based on material cited in the Appendix and color photographs by Paul Horner (Fig. 11 A), D. Nelson (Fig. 11 B), and R. Lloyd (not shown).

Taxonomic history. Sternfeld (1919, 1924) classified the prevailing form of narrow-banded skink from the NT as *Lygosma* [incorrect spelling of *Lygosoma* Hardwicke & Gray, 1827] (*Hinulia*) *fasciolatum intermedium* (holophoront see Fig. 10). Later the subspecies was synonymized with *Sphenomorphus fasciolatus fasciolatus* by Storr (1967), a concept that was followed by subsequent authors (e.g., Greer 1979; Cogger *et al.* 1983). Storr (1967) was critical of Sternfeld's concept of *Lygosoma f. intermedium* ('...supposed differences in size, length of appendages, and coloration.' [p.15]), stating that Sternfeld did not have enough comparative material and relied on the descriptions in Boulenger (1887) for '*fasciolatus*'. However, Storr (1967) examined no topotypic specimen of '*fasciolatus*' from eastern QLD, but '*fasciolatus*' specimens from the NT which are identifiable as *E. intermedium* based on Storr's general description and the figured area of distribution (see map (fig. 1) and list of examined material in Storr 1967). The obvious differences in size between the types of '*intermedium*' and '*fasciolatus*' were accepted by Storr, but the relatively shorter tail of the '*fasciolatus*' specimen (measurements in Boulenger (1887)) was thought to be regenerated ['...it is certainly so in the specimen figured by Boulenger' (p. 15)] and not an adequate character to distinguish between the two forms. However, the measurement given as 110 mm precisely matches with the tail length of the lectophoront, which has an original, unbroken tail. Furthermore, it is doubtful that the animal that appears in Boulenger (1887: XIV) has a regenerated tail. A regenerated tail is usually indicated by differences in the scale pattern (scales appear to be more elongate and irregular), which is the case in the type specimen of *E. monotropis* (also figured on plate XIV) but not in the illustrated *E. fasciolatus*. We found that *E. intermedium* has a relatively longer tail than *E. fasciolatus* with tail to snout-vent length showing little overlap between the two species (Table 4) and differs from *E. fasciolatus* not only in body proportions but also in significant scale characters (including head scalation).



FIGURE 10. Holophoront of *Lygosoma* (*Hinulia*) *fasciolatum intermedium* (SMF 14446). Photograph—S. Mecke.

Diagnosis. A medium-sized (snout-vent length up to 88.5 mm), slender, narrow-banded *Eremiascincus* usually having 7 undivided supralabial scales; a single infralabial in broad contact with the postmental scale (rarely 2); scales on top of the fourth toe in single rows with transverse sutures for at least distal third of digit; 20–29

subdigital lamellae under fourth toe, deeply grooved (usually for more than half of digit), basally divided, often bluntly keeled or callused, keels ending in a mucro; plantar scales 10–17, slightly raised; 30–36 scales ordered around midbody; head small and snout somewhat depressed; ear opening small and subcircular; dorsum with keels posteriorly and tail with ridged scales; coloration pattern comprises a banded dorsum (type b) with 6–16 narrow bands between neck and attachment of hind limbs and up to 42 perfectly transverse dark bands (type b) on the tail.

Description. *Dimensions and general characteristics.* A medium-sized (snout-vent length of adult specimens 59.9–88.5 mm, mean 73.8 mm, $n = 47$), slender *Eremiascincus*; head relatively small (HeadL1/SVL 0.18–0.21, mean 0.20, $n = 47$); snout short (SnoutL/HeadL1 0.39–0.46, mean 0.42, $n = 47$), top of snout somewhat depressed, tip of snout obtusely pointed; canthus rostralis rounded; lower eyelid movable, scaly; ear opening subcircular, small (maximum length 1.5 mm, maximum height 1.8 mm), and at least about one-third the area of eye aperture, with small granular scales at anterior border; tympanum visible but sunk; limbs pentadactyl, overlapping when adpressed, moderately long (hind legs ~40% length of snout-vent length); fingers and toes moderately long, circular in section; third and fourth finger length similar; fourth toe longer than third; tail up to ~151% of snout-vent length (range 129.4–151.3%, mean 136.9%, $n = 13$) with ridges or keels, round in cross section; hemipenis deeply bifurcated, not columnar.

Scalation. Nasals widely separated; frontal arrowhead-shaped, ~50–80% longer than interparietal, much larger than prefrontals; width of rostral-frontonasal suture less than half the width of frontonasal; prefrontals narrowly separated; frontal contacting frontonasal; frontoparietals free (paired); interparietal normally free, as large or insignificantly smaller than a frontoparietal; parietals large, in contact behind interparietal; each parietal bordered posteriorly by upper secondary temporal and (if present) enlarged nuchal scales; nuchals 0–1; supraoculars 4, normal in shape and orientation; first and last relatively wide, medial 2 much longer than wide, usually 3 in contact with frontal; loreals 2, approximately as tall as wide, squarish; supranasal scale absent; preoculars 2, lower larger; presuboculars usually 2; superciliaries 7–9 (mostly 8, mean 8.0, $n = 43$), first largest; supralabials 7–8 (usually 7, mean 7.0, $n = 47$), undivided, last supralabial scale overlaps lower secondary temporal; infralabials 5–8; postmental contacting first infralabial (rarely first and second infralabial shields); 1 primary and 2 secondary temporals; 30–36 (mostly 32–34) midbody scale rows (mean 33.0 $n = 45$), laterals smallest; 57–73 paravertebral scales (mean 64.7, $n = 47$); 20–29 subdigital lamellae on fourth toe (mean 24.1, $n = 47$), scale under fourth toe deeply grooved medially (up to 19 scales grooved), callose (with keels); scales on top of toes in multiple series with oblique sutures followed by single scales with transverse sutures (for approximately a third of the length of the fourth toe, with usually 7 or more single rows) (see Fig. 17 E); scales on soles of hands and feet slightly raised; body and head shiny-scaled; scales on body smooth; trailing edges of dorsal and lateral scales angularly three-sided rather than smoothly rounded; subcaudal scales larger than ventrals; tail above keeled; 2 median precloacal scales distinctly enlarged.

Coloration and pattern in preservative (ethanol). Upper surface (head, dorsum, tail, and limbs) light to medium brown with dark narrow bands (type b) on the dorsum (6–16) and tail; bands on tail as dark, perfectly transverse cross-bands of a single scale row, separated by 2 rows of paler scales (up to 42 bands on tail), regenerated tails usually display no banding, rather a longitudinal mottling; subocular region appears slightly darker because of the underlying eye socket; labials pale or with light flecks; sometimes each parietal with a dark fleck posteriorly; underneath immaculate ivory or silvery white; scales on chin and gular region not colored differently; palmar and plantar scales not colored differently; iris as dark as pupil; tongue pale. Hatchlings appear similar to adult specimens.

Coloration and pattern in life. Ground color medium brown, with dark dorsal and caudal banding (type b); sides are usually somewhat paler than dorsum; belly cream to white; all body scales glossy. For pictures of live animals see Fig. 11. The specimen figured in Horner (1991, fig. 83) also depicts *E. intermedius*.

Craniology. According to the data presented in Greer (1979) this species has 9 (probably also 8) premaxillary teeth, the surface exposure of the postorbital bone in the supratemporal arch is short (i.e., only exposed laterally for a short distance in the supratemporal arch), however, the ectopterygoid process is variable (i.e., weakly developed, extending only part way to the palatine, or completely excludes the palatal ramus from the suborbital foramen).

Sex ratio and dimorphism. The sex ratio of specimens approached parity (males:females—23:20). All meristic and morphometric variables were tested for sexual dimorphism, with significant differences being found for the following ratios only: **HeadL1/SVL** (males: mean = 0.20, SD = 0.01, median = 0.20, $n = 23$; females: mean = 0.19, SD = 0.01, median = 0.19, $n = 20$; $Z = -3.401^{***}$). **ArmL/SVL** and **LegL/SVL** did not differ between sexes, but the probability level was close to the critical level.



FIGURE 11. *Eremiascincus intermedius* in life. **(A)** *E. intermedius* (NTM R6944) from Frewena, NT. **(B)** *E. intermedius* (unvouchered) near Stuart Highway, 50 km south of Alice Springs (some 80 kms away from type locality), NT. Note the banded dorsum of the specimens and the perfectly transverse dark bands on the tail (type b), the slender build, and the small ear aperture. Photographs—**(A)** P. Horner, **(B)** D. Nelson.



FIGURE 12. Habitat at the type locality of *Eremiascincus intermedius* near Hermannsburg, NT. Photograph—D. Mullet.

Details of the holophoront (Fig. 10) (SMF 14446) [adult male]. SVL 77.5 mm; TrunkL 42.7 mm; TailL 111 mm; ArmL 20.9 mm; LegL 29 mm; HeadL1 15.6 mm; HeadL2 13.9 mm; HeadW 10.3 mm; SnoutL 6.3 mm, snout depressed; HeadH 6.8 mm; AxillaEar 14.7 mm; ear opening 0.9 x 1.1 mm; MBSR 34; PVS 69; SupraLab 7 (DividLab: none/undivided); InfraLab 6 or 7; SupraCil 8; prefrontals separated; presuboculars 3; nuchals 0; 4TLam 24; upper surface of fourth toe with 7 scales in single rows with transverse sutures distally and 10 scales in 2 or more rows basally; plantar scales 12; BandsDorsum (type b) 10, covering 2 scale rows, sometimes broken medially and branching; BandsTail: ~39 (faded due to preservation).

Distribution. The area of distribution of *E. intermedius* (Fig. 18) extends from Elsey National Park, approximately 380 km south-east of Darwin, westwards to Broadmere Station at the Gulf of Carpentaria, and south to Dungowan. Whereas the species is rare in the tropical and subtropical savannas of the northern parts of the NT, it is common in the Tanami Desert, Great Sandy Desert, and adjacent areas of the NT with several specimens also collected from the Tanami Desert of eastern WA. In the NT arid zone the distribution extends from Snake and Lillies Bore (Supplejack area) in the west to Frewena in the east and south to Newhaven Sanctuary in the Great Sandy Desert, Hermannsburg (type locality, Fig. 12), and Mount Ormerod. From Mount Ormerod the species extends east to Maryvale and north to Ringwood station, at the border of the Simpson Desert, up to the Alywarre desert area (easternmost record). It is likely that the species also occurs in the Barkly Tableland of western QLD, based on a photograph of an individual from Mount Isa presented in Wilson (2005).

Geographic variation. Variation in color pattern, e.g., the basal part of tail with oblique bands that distally become transverse, occurs in some individuals but for other characters (e.g., labial scalation) populations are relatively uniform.

Habitat and ecology. *Eremiascincus intermedius* predominantly occurs in desert sandridges and sandy plains with tree steppe, shrubs, and open hummock grassland of the NT arid zone (see also Horner (1991) and Fig. 12). It also occurs in the more humid tropical and subtropical savannas of the Top End.

Photographs and overall morphology indicate that the species, is semifossorial, and Horner (1991) indicates that the species usually shelters in shallow depressions or small burrows located in soft, loose sand and is often found under rocks or other ground debris. Horner (1991) also notes that this species has been usually found in sand dug from within the burrows of *Varanus gouldii* (Gray, 1838). *Eremiascincus intermedius* is crepuscular and nocturnal and an arthropod feeder, but also preys upon small desert lizards, such as the sand swimming *Lerista bipes* and juvenile gekkotan species, such as *Lucasium stenodactylum* (Boulenger, 1896) (examinations of stomach contents, S. Mecke, pers. obs.). The species is occasionally seen on tracks and bitumen roads at dusk or at night. Little is known about its habitat and ecology in the wild at present.

Etymology. The specific name '*intermedius*' is Latin for 'intermediate'. The name was proposed by Sternfeld in allusion to the intermediate morphological and geographical position of this species, supposedly linking '*fasciolatus*' in the east with '*monotropis*' (= *E. richardsonii*) in the west.

Comparison with other species. This medium-sized *Eremiascincus* differs from *E. fasciolatus* by the presence of 7 undivided supralabials (vs. usually 8 with at least the last one divided in *E. fasciolatus*), in having no subinfralabials, a smaller ear opening, a higher number of single scale rows on top of the fourth toe, perfectly transverse bands on the tail, and different body proportions (see Table 4). *Eremiascincus intermedius* differs from *E. phantasmus* **sp. nov.** by usually having 7 supralabial shields and usually 1 infralabial in contact with the postmental scale (vs. 8 supralabial scales and almost always 2 infralabial scales in contact with the postmental), and narrow dark bands, both on the tail and on the dorsum (cf. Fig. 16 C, E). The conspicuous differences between *E. intermedius* and *E. pallidus* are limited to color pattern (dorsal bands present in *E. intermedius* and absent in *E. pallidus*), but there also exist differences in the dorsal scalation of the fourth toe (with rows of single scales restricted to approximately the distal third in *E. intermedius* (see Fig. 17 E) and single rows on almost the entire digit in *E. pallidus*) and the ventral scalation of the fourth toe (subdigital lamellae in *E. intermedius* divided at least basally, followed by grooved scales, and often strongly callused [with a calli on each side of a grooved scale]). *Eremiascincus intermedius* is usually distinguishable from *E. richardsonii* by a high number of narrow (type b) and perfectly transverse bands on the tail (cf. Fig. 16 A, C), 3 lateral chin shields and 1 median chin (or gular) shield (vs. often 4 lateral chin shields and 2 median chin (or gular) shields), the presence of 7 supralabial shields (vs. usually 8 supralabials in *E. richardsonii*), and smaller size. Moreover, *E. richardsonii* is notably rare in the NT: about 6% of the *Eremiascincus*-species from the NT arid zone belong to this taxon (based on specimens in the collection of NTM); the distribution map for *E. richardsonii* presented in Horner (1991) is likely based on misidentified specimens (a revised distribution map for *E. richardsonii* will be published elsewhere, Mecke *et al.* soon to be submitted). A single specimen in the collection of AMS (R84488), however, shows characters of both species (large size and four chin shields like in *E. richardsonii*, but 7 supralabials and a high number of transverse narrow bands (type b) on the tail as in *E. intermedius*). This may indicate that in the eastern parts of the known range of *E. intermedius* introgression between this species and *E. richardsonii* occurs. Although *E. intermedius* also occurs in the more mesic parts of the NT's tropical region, confusion with *E. isolepis* and *E. douglasi* is not likely owing to the strikingly different coloration (bands present in *E. intermedius* and absent in the other species).

***Eremiascincus phantasmus* sp. nov.**

English name: Ghost Skink

German names: Südlicher Streifenskink, Gespenstskink

(Figs. 13 & 14)

Synonyms:

Sphenomorphus fasciolatus (part.) Storr, 1974 Rec. West. Aust. Mus. 3 (1): 68–70 ('Ghost Skink' = p. 69)

Eremiascincus fasciolatus (part.) Greer, 1979; Rec. Aust. Mus. (32) 7: 323 *et seqq.* ('Ghost Skink' = p. 325)

Eremiascincus fasciolatus (part.) Cogger, 2000; Rept. Amphib. Aust.: 477

Type material of the species herein described as new has been deposited in the SAMA, QM and AMS collections.

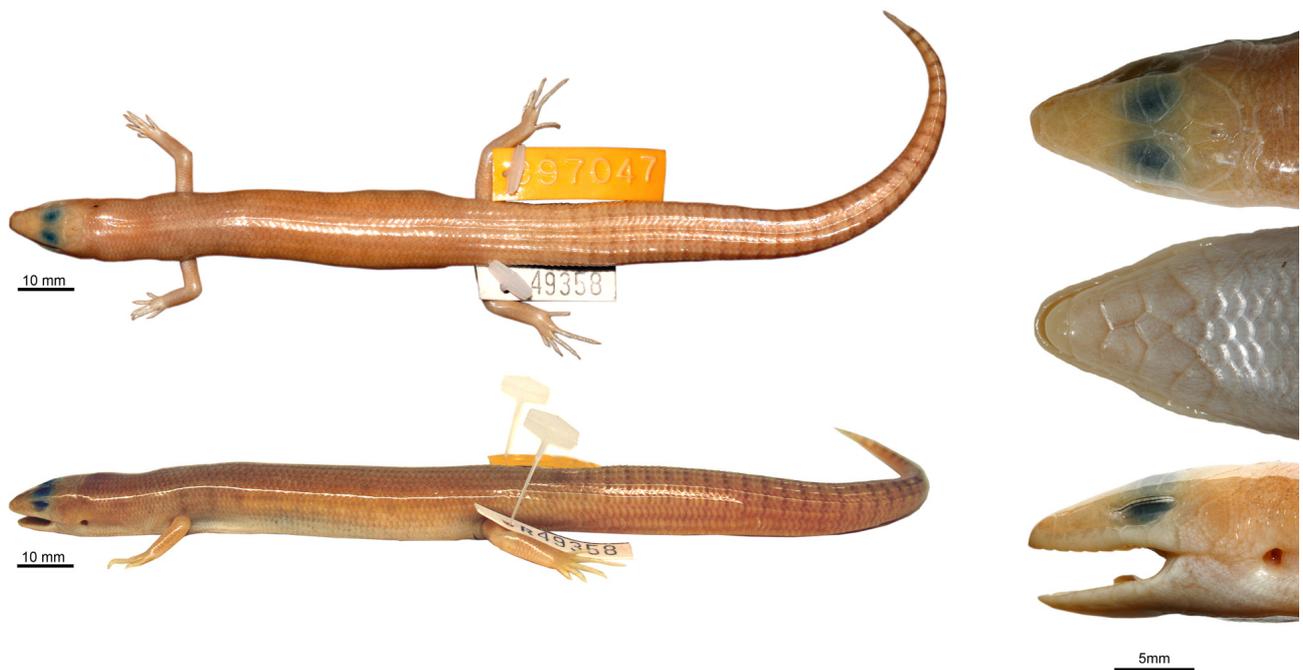


FIGURE 13. Holophoront of *Eremiascincus phantasmus* sp. nov. (SAMA R49358) Photograph—C. Stevenson.



FIGURE 14. *Eremiascincus phantasmus* sp. nov. (unvouchered specimen) in life from Mootwingee, NSW. Note the pale dorsum and the perfectly transverse very faded narrow bands on the tail (partly regenerated in the illustrated specimen), the slender build, and the small ear aperture. Photograph—P. Tremul.

Holophoront: SAMA R49358 (field number C97047) (Fig. 13), male. Type locality: collected 5.5 km SE of Red Lake Yard, E side of Lake Hope Channel, SA (28°15'29"S, 139°12'29" E); *leg.* M. Hutchinson.

Paratypes (22 specimens): **SAMA R49896** (F)—43.7 km east of Purni Bore, on the Rig Road, SA,

26°19'17"S, 136°31'53"E; R50047 (unsexed juvenile)—66.8 km E Purni Bore, Big RD, SA, 26°19'17"S, 136°31'53"E; R50888 (F)—29.1 km NNW Murda Hill, Simpson Desert Regional Reserve, SA, 26°42'09"S, 138°15'44"E; R51482 (M)—25.1 km NW Atna Hill, Simpson Desert CP, SA, 26°16'29"S, 137°19'37"E; R51436 (M)—1.1 km SSE Approddinna Attora Knolls, SA, 26°04'50"S, 137°36'43"E; R54137 (M)—37.1 km WNW of Muloorina Homestead, SA, 29°09'45"S, 137°32'01"E; R54255 (unsexed juvenile)—15.3 km WNW Kannakaninna Waterhole, Kalamurina, SA, 27°53'09"S, 137°49'13"E; R55437 (F)—17 km NW Karrathunka Waterhole, SA, 26°06'07"S, 139°08'45"E; R55447 (M)—12.4 km NW Karrathunka Waterhole, SA, 26°08'27"S, 139°09'54"E; R55507 (M)—30.2 km ESE Mulka Hill, SA, 28°26'51"S, 138°52'06"E; **AMS** R113164 (M)—25 km N of Poeppel Corner, Simpson Desert, NT, 25°46' S, 138°00'E; R155329 (M)—Sturt National Park, 1.8 km W (by road) along Whitecatch Gate Road, NSW, 29°06'51"S, 141°10'54"E; **QM** J41600 (F), J41602 (F)—Durrie Station, Glennie Well, QLD, 25°55'48"S, 139°55'49"E; J44070 (F)—Simpson Desert, QLD, 25°40'48"S, 138°31'48"E; 48473 (M)—Chookoo, 30 km WSW Jackson, QLD, 27°34'48"S, 141°54'00"E; J75056–57 (M), J75060 (M), J75067 (unsexed juvenile)—2 km W of Birdsville (behind Airstrip), QLD, 24°53'60"S, 139°18'00"E.

Diagnosis and Description based on material cited in the Appendix and color photographs by P. Tremul (see also Fig. 14).

Taxonomic history. Whereas Waite's (1929) concept of *Hinulia fasciolata* in southern Australia is rather unsatisfactory and misleading as the morphology for the SA populations seems to be largely based on the type description in Boulenger (1887) (see also Greer [1979] for a discussion on data of reproduction for *Hinulia fasciolata* presented by Waite [1929]), Worrell (1963) was probably the first author who used the colloquial name 'Ghost Skink' for a pale, undescribed species of desert-dwelling skink and attributed the scientific name *Lygosoma (Sphenomorphus) monotropis* to that species. *Lygosoma (Sphenomorphus) monotropis*, however, is a junior synonym of the heavily banded *Eremiascincus richardsonii* (Cogger *et al.* 1983) and is clearly distinct from the form Worrell described. The area of distribution Worrell suggested includes the central parts of SA and the arid parts of WA. Because Worrell did not include '*pallidus*' in his *Reptiles of Australia* it may be that he believed the 'Ghost Skink' and '*pallidus*' to be conspecific. Although Worrell's species concept remains mysterious, and *Lygosoma (Sphenomorphus) monotropis sensu* Worrell (1963) might be better regarded a *nomen ambiguum* rather than a synonym, the name 'Ghost Skink' was generally used by subsequent authors (e.g., Storr 1974; Greer 1979) to refer to the patternless, extreme pale form of "*E. fasciolatus*" from the Lake Eyre region of north-eastern SA.

Diagnosis. A medium to large-sized (snout-vent length up to 92.5 mm), slender narrow-banded *Eremiascincus* having 8–9 undivided supralabials (usually 8); 2 infralabials usually in broad contact with the postmental scale; 20–30 subdigital lamellae, at least basally in two rows and at least basally keeled; plantar scales 12–18, smooth; 28–33 scale rows at mid-body; head small, snout depressed, and ear opening small and circular; dorsum with keels posteriorly and tail often with strong ridges; coloration pattern usually comprises 29–39 perfectly transverse narrow, often very pale bands on the tail (type a, b); body without bands or with indication of light narrow bands (type a, b) dorsally or more frequently on sides of body, usually pale, without any indication of banding visible.

Description. *Dimensions and general characteristics.* A medium to large-sized (snout-vent length of adult specimens 62.6–92.5 mm, mean 81.2, $n = 117$), slender *Eremiascincus*; head small (HeadL1/SVL 0.17–0.20, mean 0.18, $n = 113$); snout long (SnoutL/HeadL1 0.39–0.46, mean 0.42, $n = 113$) top of snout depressed, tip of snout obtusely pointed; canthus rostralis rounded; lower eyelid movable, scaly; ear opening circular in shape and small (maximum length 1.8 mm, maximum height 1.8 mm), about a quarter the area of eye aperture, with minute granules at anterior border; ear opening followed by a depression of the integument; tympanum sunk; limbs pentadactyl, overlapping when adpressed, moderately long (hind legs ~40% length of snout-vent length); fingers and toes moderately long, circular in section; third and fourth finger length similar; fourth toe longer than third; tail up to ~138% of SVL (range 122.7–137.8%, mean 129.1%, $n = 15$), with strong ridges or keels, round in cross section; hemipenis deeply bifurcated, not columnar.

Scalation. Nasals widely separated; frontal arrowhead-shaped, ~70% longer than interparietal, much larger than prefrontals; width of rostral-frontonasal suture less than half width of frontonasal; prefrontals narrowly separated; frontal contacting frontonasal; frontoparietals free (paired); interparietal normally free, almost as large as a frontoparietal; parietals large, in contact behind interparietal; each parietal bordered posteriorly by upper secondary temporal and (if present) enlarged nuchal scales; nuchals 0–1; supraoculars 4, normal in shape and orientation; medial 2 much longer than wide, 2 or 3 in contact with frontal; loreals 2, second usually wider than tall, squarish or rectangular; supranasal scale absent; preoculars 2, lower larger; presuboculars usually 2; supraciliaries 7–10 (mostly 8, mean 8.4, $n = 117$), first largest; supralabials 7–9 (usually 8, mean 8.0, $n = 117$), supralabial scales

undivided, last supralabial scale overlaps lower secondary temporal; infralabials 6–9; postmental in contact with first and second infralabial (Fig. 17 B); no trace of subinfralabial scales; 1 primary and 2 secondary temporals; 28–33 (mostly 30–32) scales at mid-body (mean 30.3, $n = 113$), laterals smallest; 60–71 paravertebral scales (mean 65.9, $n = 114$); 20–30 subdigital lamellae under fourth toe (mean 25.2, $n = 114$), scale under fourth toe divided medially, at least basally but often grooved for more than half of digit; weakly keeled or callose (with a single keel per side of a grooved scale); scales on top of toes variable, usually with multiple series covering base or up to half of the length of the digits, sometimes only single scale rows present; scales on soles of hands and feet granular and smooth; body and head shiny-scaled; scales on body smooth; trailing edges of dorsal and lateral scales angularly three-sided rather than smoothly rounded; subcaudals larger than ventrals; tail above usually strongly keeled (keels forming ridges); 2 median preloacal scales distinctly enlarged.

Coloration and pattern in preservative (ethanol). Upper surface (head, dorsum, tail, and limbs) whitish to pale gray, rarely with a fine banding discernible laterally or dorsolaterally (never forming conspicuous dark bands across the dorsum); bands usually absent altogether or only evident on the tail as pale brown cross-bands of a single scale row or less and separated by 2 rows of paler scales (if discernible 29–39 bands on tail) (type a, b), regenerated tails usually display no banding; subocular region appears to be dark bluish because of the underlying eye socket; labials pale; underneath immaculate ivory or silvery white, sometimes displaying a strong contrast between the pale dorsal and the ivory or white lateroventral side; scales on chin and gular region, palmar and plantar scales not colored differently; iris as dark as pupil; tongue pale. Hatchlings are similar in most respects to adults but with more intense bands on the tail, which become more faded with age.

Coloration and pattern in life. Ground color pale yellowish, brownish or whitish with very faded caudal striping; sometimes with obscure indication of bands laterally or dorsolaterally, rarely with a fine very light banding on dorsum; sides are usually paler than dorsum; belly cream to pinkish; all body scales glossy. Juveniles sometimes display a maculated dorsum. The coloration has resulted in the common name ‘Ghost Skink’. Fig. 14 shows a specimen in life.

Craniology. According to the data presented in Greer (1979), this species has 9 premaxillary teeth, the surface exposure of the postorbital bone in the supratemporal arch is short, and an ectopterygoid process is not evident or only weakly developed.

Sex ratio and dimorphism. The sex ratio of specimens favored males (67:50). All meristic and morphometric variables were tested for sexual dimorphism, with significant differences found for **ArmL** (males: mean = 21.4, SD = 1.3, median = 21.6, $n = 66$; females: mean = 20.5, SD = 1.2, median = 20.6, $n = 49$; $Z = -3.718^{***}$), **LegL** (males: mean = 30.3, SD = 2.0, median = 30.3, $n = 66$; females: mean = 28.8, SD = 1.7, median = 28.8, $n = 49$; $Z = -4.215^{***}$), **FootL** (males: mean = 12.1, SD = 0.9, median = 12.2, $n = 66$; females: mean = 11.6, SD = 0.7, median = 11.5, $n = 49$; $Z = -3.357^{***}$), **ToeL3** (males: mean = 6.2, SD = 0.5, median = 6.3, $n = 65$; females: mean = 5.9, SD = 0.5, median = 5.9, $n = 48$; $Z = -3.177^{**}$), **ToeL4** (males: mean = 8.4, SD = 0.6, median = 8.4, $n = 66$; females: mean = 8.1, SD = 0.6, median = 8.0, $n = 49$; $Z = -2.883^{**}$), **HeadL1** (males: mean = 15.4, SD = 1.1, median = 15.7, $n = 64$; females: mean = 14.3, SD = 1.0, median = 14.4, $n = 49$; $Z = -4.588^{***}$), **HeadL2** (males: mean = 14.1, SD = 1.0, median = 14.4, $n = 65$; females: mean = 13.3, SD = 1.0, median = 13.5, $n = 50$; $Z = -4.203^{***}$), **HeadW** (males: mean = 9.5, SD = 0.8, median = 9.6, $n = 64$; females: mean = 8.8, SD = 0.8, median = 8.8, $n = 49$; $Z = -4.372^{***}$), **SnoutL** (males: mean = 6.4, SD = 0.5, median = 6.5, $n = 67$; females: mean = 6.0, SD = 0.4, median = 6.0, $n = 50$; $Z = -4.243^{***}$), **HeadH** (males: mean = 6.6, SD = 0.6, median = 6.7, $n = 65$; females: mean = 6.1, SD = 0.5, median = 6.2, $n = 47$; $Z = -4.584^{***}$). The following ratio likewise showed significant differences between sexes: **HeadL1/SVL** (males: mean = 0.19, SD = 0.00, median = 0.19, $n = 64$; females: mean = 0.18, SD = 0.01, median = 0.18, $n = 49$; $Z = -5.182^{***}$). **TrunkL/SVL** did not differ between sexes, but probability level was close to the critical level.

Details of holophoront (Fig. 13) (SAMA R49358) [adult male]. SVL 90.5 mm, TrunkL 50.6 mm, TailL 109.1 mm (tip regenerated), ArmL 21.9 mm, LegL 29.9 mm, HeadL1 15.8 mm, HeadL2 14.9 mm, HeadW 10.3 mm, SnoutL 6.7 mm, snout depressed, HeadH 6.6 mm, AxillaEar 16.9 mm, ear opening 1.3 x 1.3 mm, MBSR 28, PVS 65, SupraLab 9 (DividedLab: none/undivided), InfraLab 8, SupraCil 9, prefrontals separated, presuboculars 2, nuchals 1, 4TLam 25, upper surface of fourth toe with scales in single rows with transverse sutures along almost entire digit, plantar scales 13, no bands or pattern noticeable on body, BandsTail (type b) 32.

Distribution. *Eremiascincus phantasmus* **sp. nov.** predominantly occurs in the low elevation deserts of the Lake Eyre Basin with the main distribution area in north-eastern SA (Fig. 18). The area of distribution extends from south of Lake Frome north-west to the mound spring area of Emerald and Strangways Springs and north to

Witjiara National Park at the western border of the Simpson Desert, where it predominantly occurs in the Marla-Oodnadatta and the Marree Soil Conservation Districts. In the NT, *E. phantasmus* **sp. nov.** extends from Andado in the south, north-west to Charlotte Waters with the northernmost records from Illogwa Creek in the south-east central NT and Lake Caroline in the east. In the south-eastern corner of the NT, *E. phantasmus* **sp. nov.** is poorly collected. The species also occurs in the Central Ranges xeric scrubland in the Curtin Spring and Uluru area, where it may be sympatric with *E. pallidus*. *Eremiascincus phantasmus* **sp. nov.** has not been collected from the central Finke bioregion. In QLD the species occurs in the Channel Country of the extreme south-west. It occurs from the Mirrica Bore region in the north, south to Mount Leonard. The species is also found in the Baryulah area south to the border of NSW. From Cameron's Corner, the species extends south-east to Tero Creek. In south-west NSW the distribution extends from the Broken Hill area in the north to Wentworth on the Victorian border and east to Mungo National Park (see also Swan 1990 for a report of an eastern range extension). *Eremiascincus phantasmus* **sp. nov.** to date has not been recorded from the far north-west of Victoria.

Geographic variation. Variation in color pattern (e.g., subdued narrow dorsolateral bands) is present in some specimens, but in other respects (e.g., labial scalation) these localized entities are typical of *E. phantasmus* **sp. nov.**

Habitat and ecology. The species inhabits low lying flood-prone areas and sandy rises with *Spinifex* cover or without vegetation (Fig. 15) and is often found in association with buildings and under rubbish piles. The very glossy, smooth-scaled skink is a sand-swimmer as one would expect from its overall morphology and habitat and occurs on substrates sandy enough to support a range of burrowing species (P. Tremul, pers. comm.). *Eremiascincus phantasmus* **sp. nov.** is crepuscular and nocturnal in its activity, becoming most active in the late afternoon and the first few hours of darkness. Like its congeners, the species feeds on insects, small skinks, and geckos. Clutch size varies from 2–7 eggs, measuring approximately 16–17 x 10–12 mm. Hatchlings have a SVL of 32–36 mm and a TailL of 72–75 mm (D. Brown, pers. obs. of *E. phantasmus* from QLD held in captivity).



FIGURE 15. Habitat of *Eremiascincus phantasmus* **sp. nov.** (Simpson Desert, west of Birdsville, QLD) characterized by sand dunes covered with sparse vegetation. Photograph—S. Fulcher.

Etymology. The specific name '*phantasmus*' is Latin for 'ghost' and used as a noun in apposition. It is the Latin translation for a vernacular name Worrell proposed in 1963.

Comparison with other species. This medium-sized to large *Eremiascincus* is generally distinguishable from all other narrow-banded skinks by its pale dorsal coloration. This character is only shared with the smaller *E. pallidus* from the western arid zone, which is distinguishable from *E. phantasmus* in usually having 7 supralabial shields (instead of usually 8) and 1 infralabial in contact with the postmental scale (*vs.* almost always 2 infralabials in contact with the postmental).

Conclusions

Distribution and habitat requirements of the narrow-banded skinks. *Eremiascincus fasciolatus*, a narrow-banded skink significantly differing in morphology and ecology from the other narrow-banded species described herein, is separated from these species by at least 700 km (Fig. 18). That some species within the narrow-banded skinks show spatially separated distribution patterns (allopatry) was unexpected, as all distribution maps published previously (e.g., Greer 1979; Cogger 2000; Wilson 2005; Wilson & Swan 2008, 2010; but see Storr 1974) indicated a continuous area of distribution for *E. fasciolatus sensu lato*.

Eremiascincus fasciolatus shows strong fidelity to a topography and habitat type largely differing from that of the other narrow-banded species. This species occurs in the dry woodlands of eastern QLD and prefers hard, stony substrate, whereas *E. pallidus*, *E. intermedius*, and *E. phantasmus* **sp. nov.** are common in the Australian arid zone and are known to burrow in loose substrate. These three species are superficially similar in overall appearance which is likely a result of shared ancestry and their adaptation to sandy desert habitats. The three species are apparently parapatric. In the sandy desert environments of Australia occupied by these sand-swimming skinks, the number of ecological niches which could support those taxa is limited (the niche of a nocturnal, sand-swimming lizard that prefers moist conditions; see *Evolutionary scenario*), which makes abutment of ranges more likely than sympatry.

Craniology. Craniological characters for *E. fasciolatus sensu lato* were described by Greer (1979), who reported geographic variation for that species based on anatomical features of the skull (as illustrated in Greer 1979, fig. 3). Although his sample sizes were low, Greer listed some anatomical features that may be helpful to identify the taxa described here. However, the characters described and discussed by Greer may be more variable among species we recognize, and thus a more comprehensive anatomical study is required. W. Gelnaw (pers. comm.) recently examined skulls of *E. phantasmus* **sp. nov.** and found wide variation in skull characters of that species (W. Gelnaw, unpubl. data); however, a comparison with other narrow-banded skinks has yet not been carried out.

Phylogenetic relationships. Within *Eremiascincus*, there exists a group of desert-dwelling skinks, which may represent close relatives based on morphological characters and ecological requirements. *Eremiascincus pallidus*, *E. intermedius*, and *E. phantasmus* are characterized by the following combination of character states: a relatively depressed and slender head, a small circular ear aperture, 3 chin shields and 1 median chin (or gular) shield between second pair of chin shields, scales on top of the fourth toe with single rows with transverse sutures on at least distal third of digit, pale body coloration or distinct black bands (type b) on dorsum, bands (type a, b) on tail (when present) always transverse and sharply defined ($n > 400$). Further more detailed morphological and molecular studies are needed to reveal the relationships among taxa we recognize. A molecular genetic study is currently underway to test hypotheses of relationships within *Eremiascincus* (Donnellan *et al.*, unpublished data).

Hybridization. Natural hybridization may occur between the desert-dwelling narrow-banded *Eremiascincus* as hypothesized in the *Taxonomy* section (see *E. pallidus*). A central Australian population herein treated as a disjunct population of *E. phantasmus*—as specimens resemble that taxon in most morphological characters—may harbor (at least to some extent) hybrid specimens (unpubl. data), as in that region the distribution areas among the narrow-banded *Eremiascincus* abut. However, the occurrence of a hybrid population among the desert-dwelling *Eremiascincus* species has not yet been resolved adequately, and further studies need to investigate populations from areas with potential geographic overlap between taxa, to resolve their status. R. Lloyd for example (pers. comm.) found *E. pallidus* and *E. intermedius* occurring in sympatry in the Newhaven area of the NT, with both species being easily identifiable (photo vouchers taken), indicating that hybridisation in that area would be unlikely.

Evolutionary scenario. Little is known about the evolutionary history of *Eremiascincus*. One or more lineages within the genus have invaded the Australian arid zone, occupying an unusual ecological niche, similar to that of the North African *Scincopus* (see Greer 1979). All desert species or complexes are crepuscular or nocturnal

displaying a preference for low temperatures (Huey & Bennett 1987), and some are (semi-)fossorial. Although desert-dwellers, they seek out moist microhabitats and are often seen around wells and abandoned buildings, and can occur in the root systems of trees (pers. obs.; B. Maryan, pers. comm.).

The ear opening in the more mesic forms of the genus is generally large (and often elliptical), the dorsal surface of fingers and toes (especially the fourth toe which was examined herein) is usually covered with multiple scales in oblique rows, and bands on dorsum and tails are usually lacking. The psammophilus arid zone species tend to have smaller, circular ear openings, the top of fingers and toes is covered with a reduced number of multiple scales (the digits are covered with a high number of single scales in transverse rows), and bands are present (but may be limited to the tail in sand-swimming species of dune systems and are completely lacking in some populations). Notable is also the more depressed snout of the dune-living taxa. All of these characters may have evolved as adaptation to burrowing in loose substrate, some of which were also discussed by Arnold & Leviton (1977) for the Saharo-Arabian genus *Scincus*, which shows similar, yet more specialized adaptations to sandy desert environments, indicating that the banded *Eremiascincus* radiation(s) may be relatively young.

The narrow-banded *Eremiascincus fasciolatus* is an inhabitant of at least seasonally dry habitats (savannas and woodlands) in east QLD (the Great Dividing Range obviously acts as a natural barrier to the species' distribution into the western grasslands and savannas) and might be regarded as similar to the ancestral forms that (pre)adapted to invade the desert environments (i.e., the retention of a robust build and large ear aperture; toes and fingers covered with multiple scales in oblique rows). Hence, *E. fasciolatus* is the least specialized taxon of the (narrow- = narrow-banded) banded members of the genus.

The reduction of multiple dorsal scale rows especially of the toes and the occurrence of a higher number of single rows with transverse sutures (fusions of multiple scales) (also present in *E. richardsonii*) seem to be associated with the invasion of the Eremean zone, which was possibly entered from the tropical zones of the NT and WA (from where the genus also expanded north to the Lesser Sundas).

We hypothesize that the expansion of populations from the northern tropics to the south resulted in the formation of new species and species-groups (most of which display strong banding), while expansion to other arid areas may have resulted in the differentiation of the latter. Possibly the whole interior of Australia was once occupied by one or more *E. fasciolatus*-like species that gave rise to *E. pallidus*, *E. intermedius*, *E. phantasmus*, and the *Eremiascincus richardsonii*-complex.

Adaptation to desert habitats is seen most clearly in the sand-swimming species *E. phantasmus* and *E. pallidus*, where both species appear to have lost their dorsal banding due to their fossorial lifestyle in dune systems. In contrast, species also occurring on firmer substrates than sand, such as *E. richardsonii* and *E. intermedius* display strong dorsal banding (the distribution of both species includes tropical coastal woodlands). The lack of dorsal banding might also be the result of character displacement with *E. richardsonii* which occurs in the range of *E. phantasmus* and *E. pallidus* (in contrast the narrow-banded *E. intermedius* from the NT, which is possibly largely allopatric with *E. richardsonii* as inferred from museum databases, displays a strong dorsal banding).

Eremiascincus phantasmus and *E. pallidus* also have a small ear opening and depressed snout (to burrow in loose substrate), and in the latter species the dorsal surface of the toes is covered with scales in single rows only. The subdigital lamellae in *E. pallidus* are usually undivided and smooth, possibly to reduce friction while burrowing in loose substrate. *Eremiascincus phantasmus*, a species found predominantly in the central Australian Lake Basin, and *E. pallidus* of the western Australian deserts are both candidates for derived forms within the genus.

Although the neighboring territories inhabited by the desert-dwelling, narrow-banded species we described herein and their overall morphological similarity might reflect a close relationship (the most parsimonious scenario), parallel evolution is possible, as sand habitats are known to produce striking convergences or parallelism in lizards (including the family Scincidae) (see Arnold 1999).

Key to the narrow-banded species of *Eremiascincus*

Where appropriate, the features discussed are illustrated (see Figs. 16 & 17).

- 1 a Pattern of the dorsum composed of dark and pale flecks (Fig. 16 F) [restricted to northern WA] *E. musivus*
- b Pattern of the dorsum either banded (type b) or plain, but no trace of dark or whitish flecks (Fig. 16 B–E). 2
- 2 a Last supralabial scale divided into 2 (Fig. 17 A (1)); a row of subinfralabials present (Fig. 17 A (2)); scales on top of the fourth

- toe in multiple rows with oblique sutures along almost entire digit (Fig. 17 D)[restricted to eastern QLD] *E. fasciolatus*
- b Last supralabial undivided; no row of subinfralabials present; scales on top of the fourth toe with transverse sutures along distal third to entire digit (Fig. 17 E) 3
- 3 a Usually 8 supralabials and 2 infralabials in broad contact with the postmental scale (Fig. 17 B) [restricted to the south-eastern Australian deserts] *E. phantasmus*
- b Usually 7 supralabials and one infralabial scale in contact with postmental scale 4
- 4 a Dark cross-bands (type b) on the dorsum present (Fig. 16 C) [restricted to the northern Australian deserts and savannas] *E. intermedius*
- b Dark cross-bands (type b) on the dorsum absent, sometimes discernible only on sides (Fig. 16 D) [restricted to the western Australian deserts] *E. pallidus*

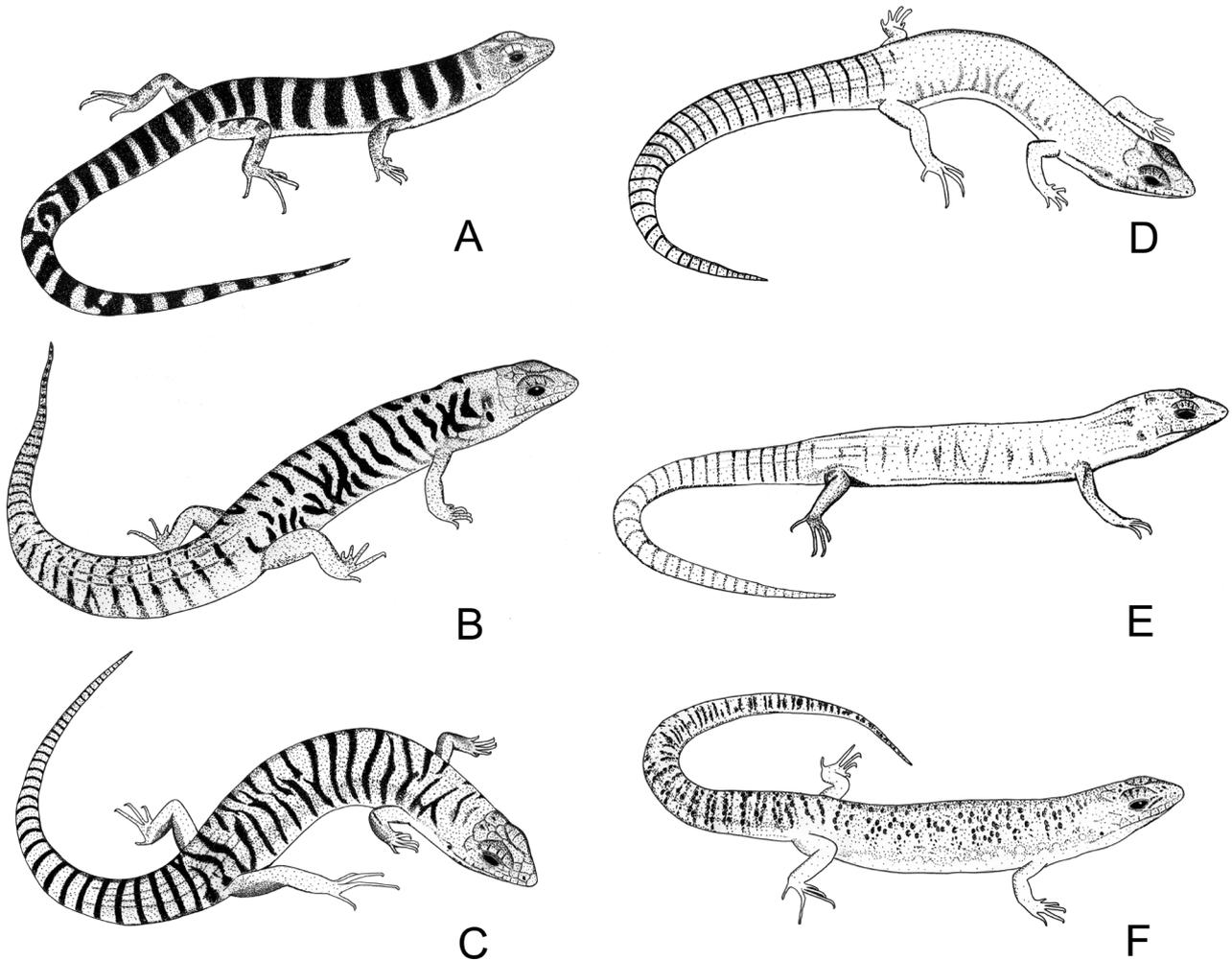


FIGURE 16. Sketches of *Eremiascincus* species showing differences in color pattern: (A) *E. richardsonii* with broad, oblique dorsal and caudal banding; (B) *E. fasciolatus* with narrow bands on the dorsum and diffuse caudal banding; (C) *E. intermedius* with narrow bands on dorsum and perfectly transverse caudal bands; (D) *E. pallidus* with plain-colored dorsum and perfectly transverse narrow bands on tail; (E) *E. phantasmus* sp. nov. with pale dorsum and transverse but often very faded narrow caudal bands; (F) *E. musivus* with flecks on the dorsum and diffuse caudal bands (bands divided medially). Modified from photographs by B. Maryan (A, F), P. Tremul (B, E), P. Horner (C), and P. Doughty (D).

Eremiascincus richardsonii differs from the species included in this key by oblique and often branching bands on the tail which are usually up to as wide as the pale interspaces and 4 chin and 2 median chin (or gular) shields (Fig. 17 C). However, the latter character is difficult to interpret as fusions in the chin shield region can be quite often observed (most notably in south and eastern Australia), e.g., a chin shield fuses with the adjacent first median chin (or gular) shield and thus is enlarged, or 2 chin shields fuse, giving the impression of just 3 chin shields being present. It is therefore advisable to count the chin shields on both sides of the head and diagnose *E. richardsonii* by a combination of character traits. A comparison of the dorsal and caudal pattern of the desert inhabiting species is presented in Fig. 16.

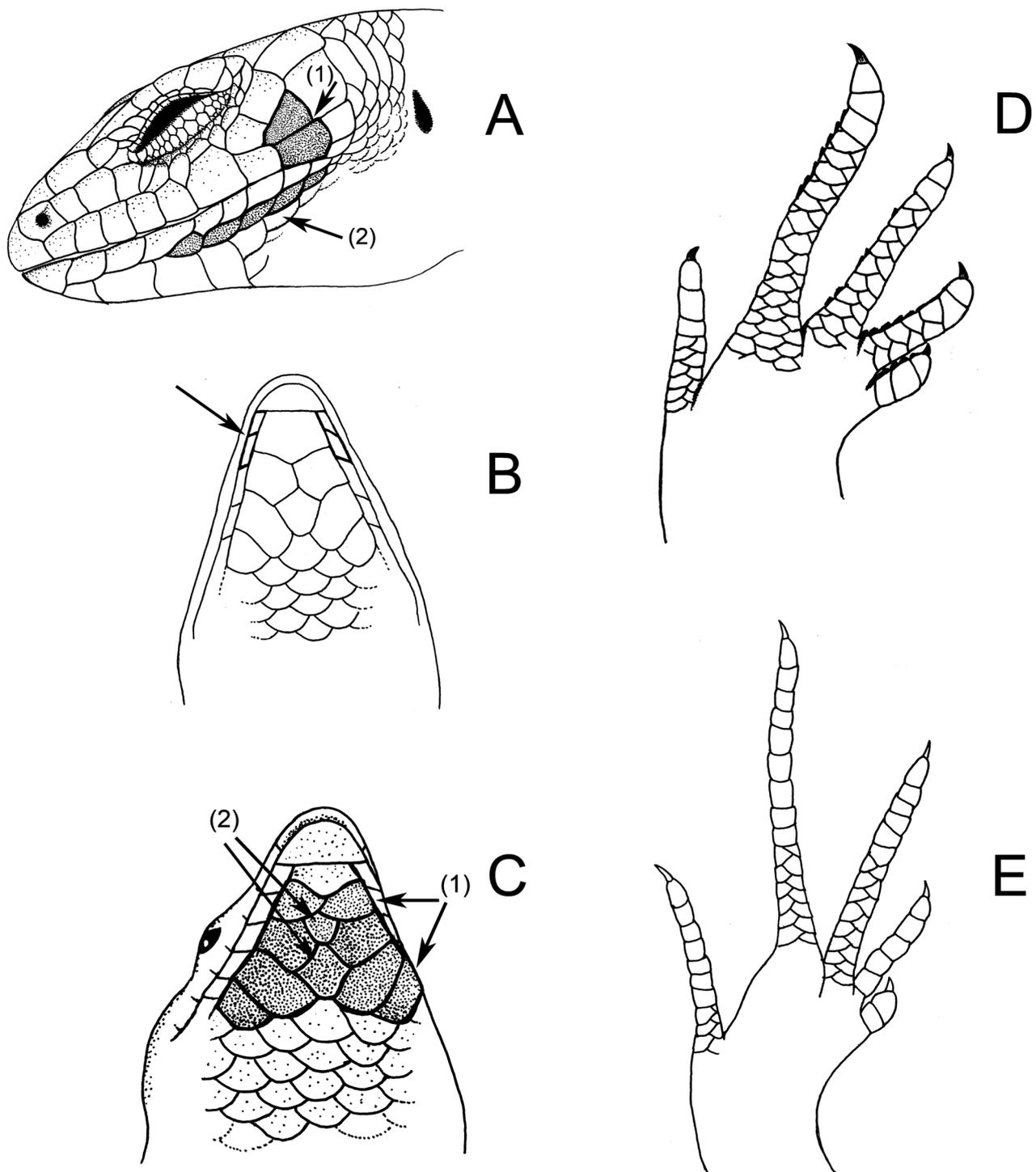


FIGURE 17. Explanatory sketches to the key for the narrow-banded skinks of *Eremiascincus*: **(A)** head of *E. fasciolatus* in lateral view with divided last supralabial scale (1) and subinfralabials (2) highlighted; **(B)** head of *E. phantasmus* **sp. nov.** in lateral view with two infralabials in contact with the postmental scale (indicated by arrow); **(C)** head of *E. richardsonii* in ventral view with four chin shields (1) and two median chin shields (= gular scales) between second and third pair of chin shields (2); **(D)** foot of *Eremiascincus* with multiple scale rows with oblique sutures covering almost the entire dorsal side of the fourth toe; **(E)** foot of *Eremiascincus* with single rows of scales with transverse sutures on at least distal third of dorsal side of the fourth toe.

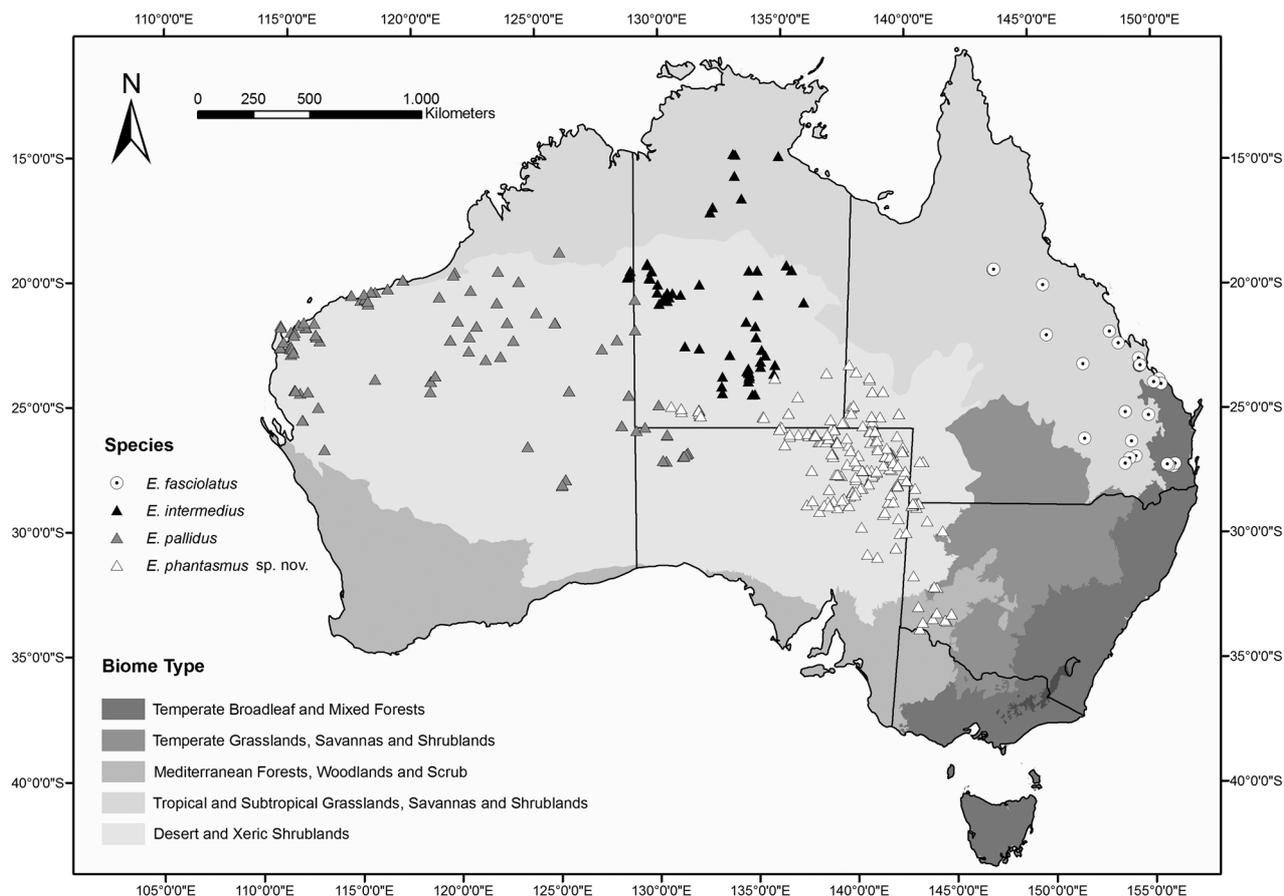


FIGURE 18. Map of Australia showing distribution of *Eremiascincus fasciolatus* ○, *E. intermedius* ▲, *E. pallidus* ▲, and *E. phantasmus* sp. nov. △.

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Appendix

Material examined

A museum acronym (underlined) is shown only for the first specimen of a series housed in the respective institution. Prefixes referring to institutional sections (e.g. herpetology, terrestrial vertebrates) are excluded.

Eremiascincus fasciolatus. LECTOPHORONT—BMNH 1946.8.3.49 (formerly 1864.7.22.16), Port Curtis, QLD; PARALECTOTYPE—BMNH 1946.8.13.91, Rockhampton, QLD; HOLOPHORONT of *Euprepes striatulus*—NHMW 9720 (juv.), NSW (in error). ADDITIONAL SPECIMENS used for analyses—NHMW 9719:1–2, Rockhampton, QLD; 9722:1–2, QLD; 16663, QLD; SAMA 15419, Barakula 50 miles N Chinchilla, QLD, 26°26'S 150°30'E; 60807, Boyne Valley, QLD, 24°16'44"S 151°16'38"E; AMS 6382, Port Curtis, QLD, 23°55'S 151°23'E; 16963, Kogan, QLD, 27°02'S 150°46'E; QM 25430–2, Purga, QLD, 27°43'12"S 152°43'48"E; 30863, Mt Crosby road, Lot 76, Swensen's road, Kolo Park, 27°30'S 152°49'E; 39305, Braemar SF, via Kogan, QLD, 27°13'12"S 150°49'48"E; 39996–7, Eurimbulah, Sandmining Lease, adj. to Park, QLD, 24°10'12"S 151°22'48"E; 74209, Emerald, near airport, QLD, 23°34'48"S 148°10'48"E; 80383, Blackbraes NP, 180 km NE of Hughenden, QLD, 19°34'48"S 144°03'E; 80727, Blackbraes NP, Gorge Creek road, QLD, 19°33'36"S 144°04'12"E. ADDITIONAL MATERIAL (juveniles)—BMNH 1874.8.11.10 Rockhampton, QLD; 1994.6.29.33, QLD/Christiania Museum; AMS 58932, 3 miles W Miles, 26°40'S 150°08'E; 37828, Yeppoon, Limestone Creek, QLD, 23°07'48"S 150°43'48"E.

Eremiascincus pallidus. HOLOPHORONT—BMNH 1946.8.3.38 (formerly 1867.2.19.48), Nickol Bay, WA. ADDITIONAL SPECIMENS used for analyses—WAM 17060, 26764, 14 km SW Mundabullangana, WA, 20°37'S 117°57'E; 27025, Well 24, Canning Stock Route, WA, 23°07'S 123°20'E; 61190, 3 km E Giraliala HS, WA, 22°41'S 144°24'E; 61420, Vlaming Head, WA, 21°48'S 144°06'E; 61420, Tobin Lake, WA, 21°45'S 125°41'E; 63724, 31 km 169 degree Nooloo Soak, WA, 22°53'S 122°00'E; 64254, 39 km 210 degree McTavish Claypan, WA, 20°56'S 123°15'E; 69531, Ankatell Ridge, WA, 20°26'S 121°11'E; 71379 (now at ZMB), 16 km SE Mardathuna HS MT Cahill Outcamp, WA, 24°32'S 144°42'E; 80344, 80627, Carrawella Well, 38 km NNW MT Minnie Homestead, WA, 21°43'S 115°31'E; 88537, 3 km NW Bullara HS, 22°39'S 114°02'E; 88650, 55 km S Anna Plains Homestead, 19°42'S 121°32'E; 94787, ca. 1 km S Christmas Creek HS, 18°53'S 125°55'E; 102988, Percival Lakes, WA; 108914, 108933, 108937, 25 km SE Telfer, WA, 21°53'S 122°22'E; 119950, 127043, Nifty Mine site, ca. 40 km E Woodie Woodie Mine, WA, 21°40'S 121°35'E; 122733, 7.7 km W Mardathuna HS on road to NW coastal highway, WA, 24°25'44"S 114°30'E; 126698, 9.7 km NE of Meedo Homestead, WA, 25°37'23"S 114°41'39"E; 132243, Urala Station, WA, 21°46'40"S 114°52'14"E; 132453–4, 2 km W Bullara, WA, 22°41'S 114°01'E; 134328, 8 km N Exmouth, WA, 21°52'12"S 114°07'01"E; 134384, Lake Mackay, WA, 22°26'47"S 128°17'33"E; 136287, Muggon Station, WA, 26°49'08"S 115°32'06"E; 139021, 139036, Mandora, WA, 19°48'44"S 121°28'25"E; 139422, Mount Minnie, WA, 21°52'28"S 115°09'22"E; 139445–6, Cane River, WA, 22°15'55"S 115°35'19"E; 139601, 1390605, 7.5 km E Mount Hodgson, WA, 22°26'37"S 121°13'54"E; 140982, Urala Station, WA, 21°47'18"S 114°52'03"E; 142396, 8 km N Exmouth, WA, 21°52'12"S 114°07'01"E; 154346, Doole Island, WA, 22°28'S 114°10'E; 154358, Exmouth Gulf, WA, 22°04'S 114°31'E; 154913, 50 km E Roebourne, WA, 20°48'21"S 117°32'43"E; 156776, Onslow area, WA, 21°40'52"S 115°05'50"E; 156823–25, Port Hedland area, WA, 20°21'15"S 118°42'04"E; 156831–2, Empress Springs, WA, 26°46'00"S 124°21'58"E; 157283, Yanrey Station, WA, 22°12'24"S 114°37'22"E; 157954, Lake Disappointment, WA, 23°14'03"S 122°42'05"E; 158401, Giraliala Station, WA, 22°39'09"S 114°27'48"E; 158473, Giraliala Station, WA, 22°53'13"S 114°33'26"E; 160001, 161254, 12.5 km S Whim Creek Hotel, WA, 20°56'59"S 117°50'59"E; 161454, 161484 (now at ZMB), 23 km NE Warrawigne Homestead, WA, 20°41'54"S 120°51'23"E; 163002, 163038, 9.5 km S MT Minnie, WA, 22°11'19"S 115°33'13"E; 163374, Neale Junction Nature Reserve, WA, 28°06'09"S 125°57'31"E; 163375, Neale Junction Nature Reserve, WA, 28°21'26"S 125°47'23"E; 163376 (now at ZMB), 163378, Neale Junction Nature Reserve, WA, 28°18'09"S 125°48'58"E; 163377, Neale Junction Nature Reserve, WA, 28°06'26"S 125°57'56"E; 164168–9, Salt Creek Mine, WA, 20°45'04"S 117°43'42"E; 164259, 164294–95 Mina Mina Clutterbuck Hills, Gibson Desert, WA, 24°31'02"S 126°13'04"E; 164331, 164333, Cape Lambert, WA, 20°36'50"S 117°09'05"E; 164332, 164334, Cape Lambert, WA, 20°34'04"S 117°42'00"E; 166370–3, 5.3 km SSE Pungkulpirri Waterhole, WA, 24°42'26"S 128°45'37"E; 166374–6, 166378–9, 166380, 18.5 km ENE Blackstone, WA, 25°55'50"S 128°27'09"E; 166630, Mons Cupri Mine, WA,

20°51'26"S 117°50'03"E; 166643, 166857, Mons Cupri Mine, WA, 20°50'59"S 117°50'22"E; SAMA 46138, 40 km NE Pipalyatjara, NT, 25°59'04"S 129°27'22"E; 48587, 4.5 km NW Mt Cheesman, SA, 27°22'26"S 130°21'44"E; 48800, 13.2 km NW Mt Cheesman, SA, 27°20'09"S 130°13'34"E; AMS 95424, Tomkinson Ranges, SA, 26°07'S 129°05'E; 101574, 32.2 km S of Onslow by Road, WA, 21°54'S 114°02'E, 101595, W of Bullara Homestead, WA, 22°42'S 114°02'E; AMS 111617, Yule River approx. 20 km S Port Hedland, WA, 20°29'S 118°10'E; 117773, approx. 2.7 km E Minilya-Exmouth road via roads to Bullara Homestead, Bullara Station, WA, 22°41'S 114°01'E. ADDITIONAL MATERIAL (juveniles)—WAM 122554, 10.9 km NE Meedo Homestead, WA, 25°37'31"S 114°42'15"E; 130695, Lake Mackay, WA, 22°26'47"S 128°17'33"E; 157270, Yanrey Station, WA, 22°05'12"S 114°40'08"E; 164167, Salt Creek Mine, WA, 20°45'28"S 117°43'32"E; 166369, 5.3 km SSE Pungkulpirri Waterhole, WA, 24°42'26"S 128°45'37"E; 166377, 18.5 km ENE Blackstone, WA, 25°55'50"S 128°27'09"E; 170412, 7.5 km E MT Hodgson, WA, 22°26'37"S 121°13'54"E.

Eremiascincus intermedius. LECTOPHORONT—SMF 14446, Hermannsburg Mission, upper Finke River, NT. PARALECTOTYPES—SMF 14447–9, 144450–1. Hermannsburg Mission, upper Finke River, NT; ADDITIONAL SPECIMENS used for analyses—WAM 24145, 6 km S Larrimah, NT, 15°38'S 133°13'E; 24350, Taylors Well, 42 km NE Barrow Creek, NT, 21°15'S 134°07'E; 110585, Tanami Desert, WA, 19°55'47"S 128°45'39"E; 110605, Tanami Desert, WA, 19°55'25"S 128°50'53"E; 110611, 110613 Tanami Desert, WA, 19°51'59"S 128°50'46"E; 157450, Tanami Desert, WA, 19°39'40"S 128°53'00"E; SAMA 11176, 29 M NW Refrigerator Well, NT, 20°51'S 130°22'E; 57781, Wauchope Caravan Park, NT, 20°38'28"S 134°13'23"E; AMS 10887, Hermannsburg, NT, 23°57'S 132°46'E; 35247, Ringwood Station, ca.70 miles E Alice Springs, NT, 23°49'S 134°57'E; 52068, 52070, Ellery Creek, near Hermannsburg, NT, 23°55'S 133°55'E; 86355, 51.4 km W Alice Springs via Namatjira Drive, NT, 23°46'S 133°24'E; NTM 2472, Tanami Bore, NT, 19°58'48"S 129°43'12"E; 6944, 7004, 8479, 8841, Frewena, NT, 19°25'48"S 135°24'00"E; 15101, 15110, 15114, 15174, 12 km SW Sangsters Bore, NT, 20°52'12"S 130°16'12"E; 15620, Glen Annie, Ruby Gap National Park, NT, 23°28'12"S 135°00'00"E; 15703, Lawrence Gorge, Waterhouse Ranges, MacDonnell Ranges, NT; 15689, Claraville Homestead, 7 km NW, MacDonnell Ranges, NT; 15987, 7 km NW Atartinga, NT; 22°21'00"S 134°10'48"E; 17657, Ewaninga, 40 km S Alice Springs, NT; 24°00'S 133°54'E; 23342, 12 M Stock Yards, Elsey National Park, NT, 14°56'60"S 133°13'12"E; 26817, 7 km NW of Mount Ormerod, Palmer River, NT, 24°36'36"S 132°46'48"E; 26938, Maryfield Station, Sturt Plateau, NT, 15°49'12"S 133°11'60"E; 32982, Broadmere Station/Parakeelya Swamp, NT, 15°00'36"S 135°00'00"E; 32990, Maryvale, NT; 24°40'12"S 134°06'12"E; 32992, Tanami Desert, NT; 20°13'12"S 131°46'12"E; 32997, 50 km S Alice Springs, NT, 24°07'48"S 133°52'48"E; 32998–9, Sangsters Bore, NT, 20°52'48"S 130°25'12"E; 33007, Alice Springs, NT, 23°46'12"S 133°52'48"E; 33010–1, Newland Caves, NT, 21°00'36"S 130°04'48"E; 33016, Mongrel Downs Airstrip, NT, 20°33'00"S 130°25'12"E; 34675, Ord River, WA [?], 15°18'36"S 129°05'60"E. ADDITIONAL MATERIAL (juveniles)—WAM 110612, Tanami Desert, WA, 19°51'59"S 128°50'46"E.

Eremiascincus phantasmus. HOLOPHORONT—SAMA 49358, 5.5 km SE Red Lake Yard, east side Lake Hope Channel, SA, 28°15'29"S 139°12'29" E. PARAPHORONTS (20 specimens)—SAMA 49896, 43.7 km E Purni Bore, on the Rig Road, SA, 26°19'17"S 136°31'53"E; 50047 (juv.), 66.8 km E Purni Bore, Big Road, SA, 26°19'17"S 136°31'53"E; 50888, 29.1 km NNW Murda Hill, Simpson Desert, SA, 26°42'09"S 138°15'44"E; 51482, 25.1 km NW Atna Hill, Simpson Desert CP, SA, 26°16'29"S 137°19'37"E; 51436, 1.1 km SSE Approddinna Attora Knolls, SA, 26°04'50"S 137°36'43"E; 54137, 37.1 km WNW of Muloorina HS, SA, 29°09'45"S 137°32'01"E; 54255 (juv.), 15.3 km WNE Kannakaninna, Kalamurina Station, SA, 27°53'09"S 137°49'13"E; 55437, 17 km NW Karrathunka Waterhole, SA, 26°06'07"S 139°08'45"E; 55447, 12.4 km NW Karrathunka Waterhole, SA, 26°08'27"S 139°09'54"E; 55507, 30.2 km ESW Mulka Hill, SA, 28°26'51"S 138°52'06"E; AMS 113164, 25 km N Poeppel Corner, Simpson Desert, NT, 25°46' S 138°00'E; 155329, Sturt National Park. 1.8 km W (by road) along Whitecatch Gate Road, NSW, 29°06'51"S 141°10'54"E; QM 41600, 41602, Durrie Station, Glennie Well, QLD, 25°55'48"S 139°55'49"E; 44070, Simpson Desert, QLD, 25°40'48"S 138°31'48"E; 48473, Chookoo, 30 km WSW Jackson, QLD, 27°34'48"S 141°54'00"E; 75056, 75057, 75060, 75067 (juv.), 2 km W Birdsville (behind Airstrip), QLD, 24°53'60"S 139°18'00"E. ADDITIONAL SPECIMENS used for analyses—SAMA 11175, 41 M N Marree, Birdsville Track, SA, 29°08'S 138°23'E; 14866, Lake Eyre marginal area on south side, SA, 28°30'S 137°30'E; 18061, Simpson Desert Conservation Park, SA, 26°24'S 137°40'E; 19860, Coongie Lake area, SA, 27°11'S

140°10'E; 24540, Cooper Creek area, SA, 27°52'S 139°25'E; 24555, 24568, Cooper Creek area, SA, 27°38'S 140°06'E; 24572, Gidealpa Station, 10 km W Gidealpa HS, SA, 27°41'S 140°12'E; 24575, 1.6 km S Tooroowatchie Waterhole, SA, 27°03'S 140°08'E; 24581, King Lookout, SA, 26°56' S 140°36'E; 24582, 28.7 km N Kudriemitchie Waterhole, SA, 27°05'S 140°12'E; 24611, Innamincka Station NNW Lake Apamburra, SA, 26°59'S 140°05'E; 24637–8, 13 km SSW Merty Merty HS, SA, 28°40' S 140°13'E; 24648–9, Cooper Creek area, SA, 27°38'S 140°06'E; 24696, Innamincka Station NNW Apanburra Yard, SA, 27°01'S 140°04'E; 24729, 2 km N Toolache, SA, 28°21'S 140°25'E; 25939, 25940, Lake Oolgoopiarie, Clifton Hills Station, SA, 27°08'S 139°52'E; 29871, 4 km NNE Curtin Springs Homestead, NT, 25°17'S 131°46'E; 29874, 29885, 24.3 km along Mulga park road, SSE Curtin Springs HS, NT 25°31'S 131°49'E; 36093, 36137, 36114, Yulara Township, 1 km down Giles Road, NT, 25°14' S 131°01'E; 36195–6, Curtin Springs HS, NT, 25°19'S 131°45'E; 36226, 13.6 km along Mulga Park Road from Lasseters Highway, NT 25°26'S 131°47'E; 40683, 500 miles E Cooroomunchena Waterhole, SA, 27°45'S 139°32'E; 48532, 7.9 km S Woorana Waterhole, Macumba Station, SA, 27°43'30"S 136°41'50"E; 49887, 67.5 km E Purni Bore, SA, 26°19'29"S 136°46'13"E; 49888, 64.8 km E Purni Bore, SA, 26°19'26"S 136°44'35"E; 49908, 42.5 km E Purni Bore, SA, 26°19'14"S 136°31'13"E; 49960, 38 km E Purni Bore, SA, 26°13'49"S 136°28'18"E; 49982, 80.2 km SW Approddinna Attora Knolls, Rig Road, SA, 26°34'41"S 137°02'06"E; 49986, 74.4 km SW Approddinna Attora Knolls, Rig Road, SA, 26°34'36"S 137°07'06"E; 50034, 69.8 km E Purni Bore, Colson Track, SA, 26°15'36"S 136°47'39"E; 50895, 3.6 km NNW Murda Hill, Simpson Desert, SA, 26°55'05"S 138°21'04"E; 51000, 8 km SW Wimma Hill, SA, 27°24'02"S 140°14'36"E; 51018, 22.5 km SE Wimma Hill, SA, 27°30'40"S 140°26'35"E; 51315, 22.5 km N Miandana Waterhole, Simpson Desert, SA, 27°03'24"S 137°33'56"E; 51322, 25.6 km N Miandana WH, Simpson Desert, SA, 27°03'28"S 137°32'44"E; 51379, 8.9 km WNW Beal Hill, Simpson Desert, SA, 26°35'45"S 137°46'19"E; 51389, 1.1 km SSE Approddinna Attora Knolls, Rig Road, SA, 26°04'50"S 137°36'43"E; 51402, 4 km NNE Approddinna Attora Knolls, Rig Road, SA, 26°02'08"S 137°37'10"E; 51471, 19.5 km WNW Atna Hill, Simpson Desert, SA, 26°19'31"S 137°21'20"E; 52708–9, 4 km S Kalamurina HS, S Warburton River, SA, 27°55'51"S 137°59'48"E; 52729, 52730, 11 km NW old Kalamurina HS, S Warburton River, SA, 27°53'32"S 137°53'00"E; 54131, 59.3 km WNW Muloorina HS, SA, 29°07'41"S 137°18'32"E; 54191, 54203, 51.5 km NNW Clayton Hills, SA, 28°51'28"S 138°09'07"E; 54205, 49.5 km NW Clayton HS, SA, 28°55'18"S 138°04'22"E; 58743, 47.9 km NNE Approddinna Attora Knolls, Rig Road, SA, 25°39'57"S 137°26'38"E; 63841, Cordillo, 13.4 km NNW Marimion Bore, SA, 26°52'32"S 140°48'32"E; 63082, Cordillo, 6.8 km SW Bloodwood Bore, SA, 26°52'37"S 140°53'26"E; 63811, Cordillo, 10.9 km SSW Bloodwood Bore, SA, 26°55'30"S 140°54'41"E; 63863, Cordillo, 10.1 km SSE Union Bore, SA, 26°50'19"S 140°41'53"E; 63893, Innamincka, 76 km N Innamincka, SA, 27°13'25"S 140°39'54"E; 63903, Innamincka, 58 km N Innamincka, SA, 27°03'07"S 140°39'56"E; 64062, Curnamona, 0.4 km N Chocolate Dam, SA, 31°20'40"S 140°41'42"E; AMS 17738, Innamincka, SA, 27°44'S 140°46'E; 35224, 8 miles NW of Birdsville, QLD, 25°52'S 139°15'E; 35246, Lake Oolgoopiarie, 90 M SSE Birdsville, SA, 27°09'S 139°52'E; 54614, Tero Creek. Gumpoplah Station, NSW, 30°08'S 142°36'E; 57109, 'Nappadricka' Dam, 'Adrai Downs', 37 M W Birdsville, QLD, 25°55'S 138°50'E; 64117, Tilcha Bore, W Tilcha HS, SA, 29°40'S 140°36'E; 93017, 1 km W Sandringham Station Homestead, 55 km NW Bedourie, QLD, 24°03'S 139°03'E; 110322, 8 km N Mirrica Bore, Ethabuka Station, NW Bedourie, QLD, 23°44'S 138°28'E; 113166, 113168, 113170–1, 120096, 25 km N Poeppel Corner, Simpson Desert, NT, 25°46'S 138°00'E; 113173–4, Simpson Desert, 37 km W Muncoonie HS, NW Birdsville, QLD, 25°11'S 138°17'E; 127871, Native Well Campsite, Simpson Desert, NT, 25°47'S 137°57'E; 151637, Sturt National Park, 13.5 km E (by road) on Middle Road, from Camerons Corner Road, NSW, 29°02'39"S 141°18'15"E; 152350, Sturt National Park, 21.6 km W on West Loop Road, from Tibooburra Road, NSW, 29°02'14"S 141°12'10"E; 155244, Sturt National Park, Camerons Corner Road, 3.4 km N Middle Road turnoff by road, NSW, 29°02'02"S 141°11'49"E; 155250, Sturt National Park, 5.7 km W (by road) along Whitecatch Gate Road, NSW, 29°07'52"S 141°08'57"E; 155253, Sturt National Park, Camerons Corner Road, 0.75 km N Middle Road turnoff by road, NSW, 29°02'08"S 141°11'44"E; 155262, Sturt National Park, 13.0 km (by road) W of Binerah Downs HS on Middle Road, NSW, 29°01'30"S 141°25'17"E; 155285, Sturt National Park, 5.7 km W (by road) along Whitecatch Gate Road, NSW, 29°07'52"S 141°08'57"E; 155318, Sturt National Park, 1.8 km W (by road) along Whitecatch Gate Road, NSW, 29°06'51"S 141°10'54"E; 155326–7, Sturt National Park, 9.8 km (by road) W of Binerah Downs HS on Middle Road, NSW, 29°01'52"S 141°27'03"E; 155331, Sturt National Park, Camerons Corner Road, 3.4 km N Middle Road turnoff by road, NSW, 29°02'02"S 141°11'49"E; 155405, 155424, Sturt National Park, 13.5 km E (by road) on Middle Road from Camerons Corner Road, NSW, 29°02'39"S 141°18'15"E; 155468, Sturt National Park, Camerons Corner

Road, 3.4 km N Middle Road turnoff by road, NSW, 29°02'08"S 141°11'44"E; 156599, Popiltah Station, Shearers Quarters, NSW, 33°12'09"S 141°45'28"E; 160335, Tarcoola Station, NSW, 33°26'41"S 142°37'12"E; QM 44066, 44069, Mt Leonard, Pelican Waterhole, QLD, 25°40'48"S 140°37'12"E; 41609, sand dune 1.5 km E Muncoonie HST, QLD, 25°10'12"S 138°40'12"E; 75061, 2 km W Birdsville (behind airstrip), QLD, 24°53'60"S 139°18'00"E. JUVENILES—SAMA 50047, 66.8 km E Purni Bore, Rig Road, QLD, 26°19'28"S 136°45'47"E; 54255, 15.3 km WNW Kannakaninna waterhole, Kalamurina Station, SA, 27°53'09"S 137°49'13"E; QM 75067, 2 km W Birdsville (behind airstrip), QLD, 24°53'60"S 139°18'00"E.