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# First captive breeding of a night skink (Scincidae: *Eremiascincus*) from Timor-Leste, Lesser Sunda Islands, with remarks on the reproductive biology of the genus

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**Abstract.** We report two instances of captive breeding in a species of Timorese night skink (genus *Eremiascincus* Greer, 1979) in October and December 2012. Four and three neonates, respectively, with total lengths of ca 40 mm each, were discovered during routine maintenance of a terrarium, in which three adult animals (1 male, 2 females) were kept. The absence of eggshells in the terrarium and the unlikelihood of post-eclosion oophagy by the adults suggest that the reproductive mode of the species is viviparous. We also provide a summary of available information pertaining to the reproductive biology of other members of the genus *Eremiascincus*.

Key words. Reptilia, Squamata, Lygosominae, *Eremiascincus*, skink, reproductive mode, viviparity, Timor-Leste.

**Zusammenfassung.** Wir berichten über die Nachzucht einer Nachtskink-Art (Gattung *Eremiascincus* Greer, 1979) aus Timor-Leste. Bei Routinearbeiten im Terrarium der drei Adulti (1 Männchen, 2 Weibchen) wurden im Oktober und Dezember 2012 vier, beziehungsweise drei Jungtiere mit Gesamtlängen von je ca. 40 mm entdeckt. Da keine Eierschalen im Terrarium gefunden wurden und das Fressen der Schalen durch die Adulti nach dem Schlupf der Jungtiere unwahrscheinlich ist, liegt der Schluss nahe, dass es sich bei diesem Taxon um eine lebendgebärende Skinkart handelt. Wir präsentieren zudem eine aktuelle Übersicht zur Reproduktionsbiologie der Gattung *Eremiascincus*.

Schlüsselwörter: Reptilia, Squamata, Lygosominae, *Eremiascincus*, Skink, Reproduktionsmodus, Viviparie, Timor-Leste.

## Introduction

Night skinks (genus *Eremiascincus* Greer, 1979) are small- to medium-sized skinks (max. SVL ca 125 mm) that inhabit tropical and subtropical environments in the Lesser Sunda Archipelago and Australia, where some taxa have also invaded the continent's central arid zone (Mecke et al. 2009, 2013). Four of the 14 *Eremiascincus* species hitherto described occur in the Lesser Sundas, including *E. antoniorum* (Smith, 1927), *E. butlerorum* (Aplin et al., 1993), *E. emigrans* (van Lidth de Jeude, 1895), and *E. timorensis* (Greer, 1990), all of which were previously assigned to the *Glaphyromorphus isolepis* group (Greer 1990). Evidence is currently emerging that *E. emigrans* may be a species complex (Mecke et al. unpubl. data) and many candidate taxa (both in the Lesser Sundas and Australia) still await scientific description.

Lesser Sundan *Eremiascincus* species possess smooth and very glossy scales, a cylindrical body with a long tail, and, in part (some Timor Island populations), a brightly-coloured venter (yellow, orange, pink). Bright ventral coloration is a character state that Timorese *Eremiascincus* have likely retained from a common ancestor; it is also found in *Hemiergis*, the putative sister group of *Eremiascincus* as inferred from molecular phylograms by Reeder (2003), Skinner (2007), and Rabosky et al. (2007). This conspicuous coloration begins either in the gular region or at the level of the forelegs. The majority of *Eremiascincus* species (all Australian members of the genus and the *Eremiascincus emigrans-butlerorum* group) appear to be lacking this distinctive feature, and the significance of the character, in terms of either its function in these crepuscular and nocturnal forms or its loss within the genus, is unknown at present. The dorsal ground colour of the Sundan taxa is brownish; the flanks are usually dark (especially in the anterior portion of the body) and spotted with white or cream. Some populations from Timor Island may ultimately be described as new species (Kaiser et al. 2011, 2013, O'Shea et al. 2015). One of these, an elongated, relatively short-legged taxon with a yellow venter, similar in overall morphology to *E. antoniorum*, occurs in the northwestern highlands of Timor-Leste (Ermera District) and is herein referred to as *Eremiascincus* "Ermera."

Since systematic and phylogenetic analyses based on morphology and/or genetic data can be significantly improved by supplemental information from ecological, ethological, or reproductive data (see Salthe 1967, Scholz 1995, in den Bosch & Zandee 2001, Haddad et al. 2005), we collected specimens of *Eremiascincus* "Ermera" in order to make observations on live specimens in captivity. We here report the first captive breeding of an *Eremiascincus* species from the Lesser Sunda Islands and outline the current knowledge of reproduction in the genus.

## Materials and methods

During our herpetofaunal surveys in Timor-Leste (summarized in Kaiser et al. 2011, 2013, O'Shea et al. 2012, 2015, Sanchez et al. 2012), we collected specimens of *Eremiascincus* "Ermera," a little known cryptozoic skink species (Fig. 1A, B), from under rock piles and deadwood in a rainforest environment located at the Meleotegi River near Eraúlo, Ermera District, Timor-Leste (Fig. 1C). Voucher specimens for taxonomic work were collected in low numbers and euthanised by intracardiac injection of 5% procaine. Standards for processing (e.g., preparation and preservation methods) were summarized by Kaiser et al. (2011). Preserved specimens are housed in the United States National Museum of Natural History, Smithsonian Institution, Washington D.C., USA (USNM). Four live adult specimens were collected in February of 2012, transported to Germany, and housed in a terrarium at the Philipps-Universität Marburg (see Results and discussion – Husbandry). These individuals have received field numbers and we intend to deposit them in the USNM after their natural deaths.

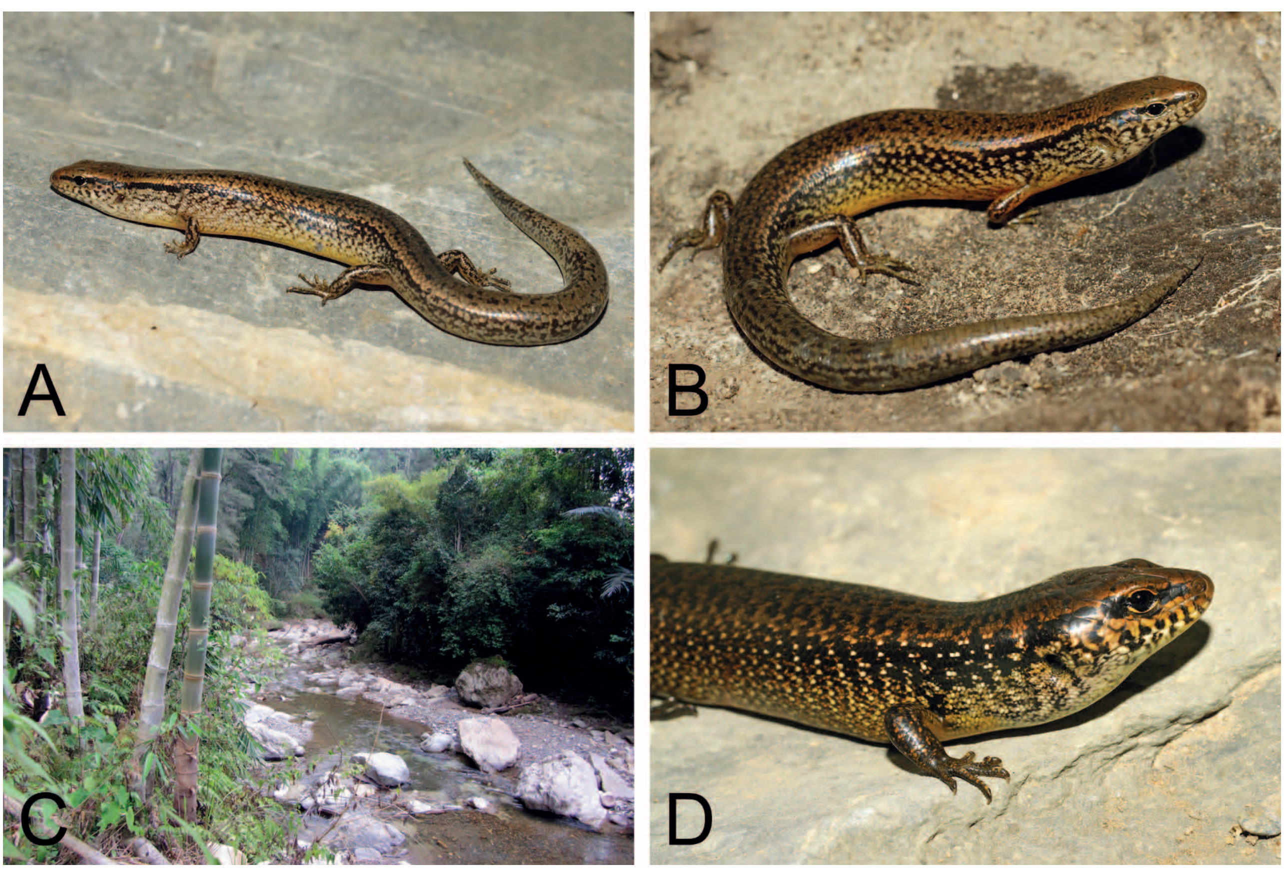


Figure 1. A + B) Lateral views of adult specimens of *Eremiascincus* "Ermera" from Ermera District, Timor-Leste; C) Rainforest habitat of *Eremiascincus* "Ermera" and *E. timorensis* at the Meleotegi River, near Eraúlo, Ermera District; D) Lateral view of an adult specimen of *Eremiascincus timorensis*. Photos by Sven Mecke.

## Results and discussion

### Habitat and natural history, husbandry, and captive breeding

Habitat and natural history. – *Eremiascincus* "Ermera" is known from only a single location in the evergreen, high mountain rainforest (altitude ca 1,200 m) at the Meleotegi River near Eraúlo, Ermera District, Timor-Leste (08°47' S, 125°27' E) and appears to be restricted to this habitat. The rainforest most likely represents a secondary forest that largely resembles an original old-growth stage. Human activities during the Second World War (as inferred from Japanese buildings in the area) may have altered at least part of this forest area that lies within a region also used for agricultural purposes, including plantations.

The area experiences an average annual precipitation of ca 2,600 mm, although strong intra-annual fluctuations in rainfall occur. Average humidity is > 70% during most months of the year, with average peak values of > 80%. Average temperatures throughout the year fluctuate between a minimum of ca 15°C and a maximum of 25°C, with maximum peak temperatures > 30°C. More detailed climate data can be found on the website of the Seeds of Life project hosted by the Ministry of Agriculture and Fisheries, Timor-Leste, at seedsoflifetimor.org.

The montane rainforest is home to four species of frogs (as of October 2012), including the introduced toad *Duttaphrynus melanostictus* (Schneider, 1799), a putatively new species of rice paddy frog (genus *Fejervarya*), the river frog *Limnonectes timorensis* (Smith, 1927), and the tree frog *Litoria everetti* (Boulenger, 1897). Lizards are more diverse, with at least seven species recorded (as of October 2012), including the agamid *Draco timoriensis* Kuhl, 1820, two putatively new four-fingered skink species (genus *Carlia*), the night skinks *Eremiascincus* "Ermera" and *E. timorensis*, the sun skink *Eutropis* cf. *multifasciata*, and two putatively new species of forest skinks (genus *Sphenomorphus*). Interestingly, no geckos or snakes have so far been recorded from this habitat.

*Eremiascincus* "Ermera" is a crepuscular and nocturnal skink that inhabits permanently humid microhabitats and its occurrence largely depends on substrate moisture (S. Mecke pers. obs.). Our experience indicates that during wet weather conditions, individuals can be found under rock piles at fairly high densities (up to four individuals per rock pile, depending on its size), whereas the species is less commonly encountered during dry periods. *Eremiascincus* "Ermera" specimens were encountered in close proximity to paths and the riverbed (most frequently under human-assembled rock piles), as well as in rainforest covering slopes (under dead wood). They were absent from the surrounding coffee plantations, an environment that largely lacks understorey and undergrowth. This species is found in syntopy with the larger Timor night skink (*E. timorensis*; Fig. 1D). In the event of an external threat, these semi-fossorial skinks attempt to burrow into the substrate by means of lateral undulation, which will often allow them to escape capture. Cursory observations during dissection revealed a food spectrum that appears to consist primarily of arthropods and their larvae.

Husbandry. *Eremiascincus* "Ermera" specimens were housed in a terrarium at the Philipps-Universität Marburg, Germany, where three animals (1 male, 2 females) are still in residence at the time of this writing. One animal died shortly after its arrival, although it was well nourished and had weathered the stress of transportation quite well; it is possible that intraspecific rivalry caused the animal's death. Antagonistic behaviour between these skinks, however, has never been observed, and we therefore had no reason to separate individuals. The unfortunate incident suggests that individuals of this taxon should probably best be kept in small groups of only a single male and one or two females. In spite of the loss of this specimen husbandry in general is progressing successfully and has resulted in captive-bred progeny.

The three adult night skinks have a mean snout–vent length (SVL) of 57 mm (individual lengths of 54, 56, and 60 mm). The individual with the greatest SVL has an original tail measuring 88 mm, whereas the tails in the other two specimens are partly regenerated and measure 78 mm (at 54 mm SVL) and 62 mm (at 56 mm SVL), respectively. All animals weigh close to 4.6 g. One individual is depicted in Fig. 2A.

The skinks are kept in a terrarium measuring 50 × 30 cm with height of 30 cm (Fig. 2B). A fertiliser-free, 5-cm peat-clay mix serves as a bottom substrate, which is richly structured with small rocks, dead wood, pieces of bark, leaf litter, and vegetation. Deadwood and pieces of bark are partly buried in the soil to provide refuges. The animals also burrow in more compact substrate, or "swim" through loose soil in the manner of some deserticolous, psammophilic reptiles. Some *Eremiascincus* species from Australia's arid zone are called "sand swimmers" for this reason (see Greer 1979), and Mecke et al. (2013) called them "Australische Sandfische," translating as "Australian sand fish" from German.

The rear wall of the terrarium consists of pieces of hollow clay tiles that are planted with epiphytic plants (*Tillandsia* spp., Bromeliaceae) and wandering jew (*Tradescantia zebrina*, Commelinaceae). The sidewalls are covered with corkboard. Plants covering the ground include bastard copperleafs (*Acalypha* cf. *chamaedryfolia*, Euphorbiaceae), devil's ivy (*Epipremnum aureum*, Araceae), peace lilies (*Spathiphyllum* sp., Araceae), prayer plants (*Marantha leuconeura*, Marantaceae), and small ferns.

The terrarium of this sciaphilic species that is sensitive to heat jams is illuminated during the warmer months of the year with a low-heat 25-W spotlight, mounted inside the terrarium. A warming, 60-W light bulb is operated outside the terrarium in winter. Neither of these light sources provides bright light, ensuring optimal lighting conditions for the species. UV irradiation is provided by a Lucky Reptile Bright Sun UV Jungle® (Waldkirch, Germany; luckyreptile.com) through the terrarium's mesh lid, for three hours every other day, even though nocturnal lizards probably require no UV-B light (Adkins et al. 2003).

The ambient room temperature, in conjunction with the spotlight, creates a temperature range of 22–29°C inside the terrarium; the basking spot right below the light bulb is warmed to temperatures of 29–34°C. This temperature regime is concordant with daytime temperatures in the natural habitat. We also recommend reducing the temperature by 2–4°C at night. *Eremiascincus* are "cryophilic" lizards (Bennett & John-Alder 1986, John-Alder & Bennett 1987) prone to heat stroke and should therefore never be exposed to excessive temperatures. The vegetation and substrate are sprayed with moderate amounts of water once or twice daily, maintaining a relative humidity of approximately 70%. Although relative humidity in the natural environment might be higher (> 80%), substrate moisture would appear to be of greater importance for emulating natural conditions.

These skinks are only infrequently observed basking and usually only if the basking spot is not exposed to view (e.g., concealed by overhanging vegetation). Usually only the anterior part of the body protrudes from a hiding place (see also Rankin 1978), and the animals will quickly disappear into the substrate when they notice movements in their surroundings. In our experience, night skinks rarely bite, even when handled, but will readily autotomise their tails (see Brown 2012).

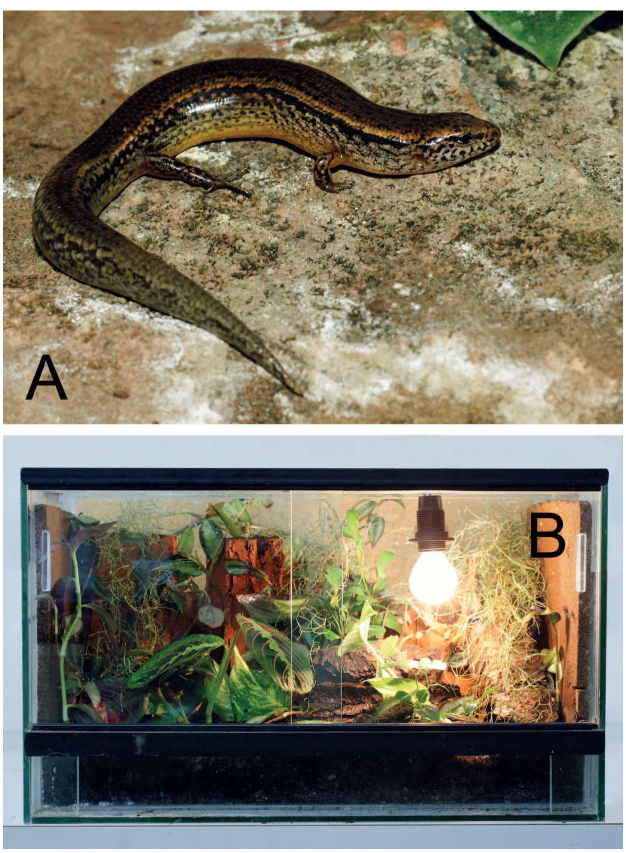


Figure 2. A) A captive specimen of *Eremiascincus* "Ermera" in a terrarium at the Philipps-Universität Marburg, Germany; B) The terrarium of the first author in which three adult specimens of *Eremiascincus* "Ermera" are kept. Photos by Thomas Beitz.

The *Eremiascincus* "Ermera" specimens in our care are fed with insects (e.g., fruit flies, stick insects, small crickets, locusts, and mealworms). During the summer months, the skinks are also fed a wide variety of non-protected, field-collected arthropods and caterpillars. Live feeder animals are regularly dusted with supplementary mineral aggregate mixtures, such as Korvimin® (WDT, Garbsen, Germany; wdt.de) and Sera® Reptil (Sera, Heinsberg, Germany; sera.de). The size of food items does not appear to play a significant role in the nutrition of these skinks. Small insects (offered in large quantities) are consumed equally readily as medium-sized crickets or mealworms. We never observed the skinks drinking. Interestingly, the captive *Eremiascincus* individuals defecate only in one particular spot of the terrarium, a habit that has also been recorded from the skink genera *Egernia* and *Liopholis* (D. Brown in litt.).

Captive breeding and raising of juveniles. The reproduction of the night skinks in our care in late 2012 came as a surprise, and happened under circumstances similar to those described by Rankin (1978) for the Queensland endemic *E. pardalis* (Macleay, 1877). During routine maintenance on 15 October 2012 (a date corresponding to the late dry season in Timor-Leste), a neonate skink of ca 40 mm in total length was found on a vertically arranged piece of bark in the upper part of the terrarium. A thorough search was performed immediately, and three additional juveniles with reddish flanks were captured (one juvenile is depicted in Fig. 3A, B). The small skinks were found hiding under items of decoration or in the bottom substrate, where they would be reasonably safe from potential cannibalism by the adults. Subsequently, the terrarium was cleaned out (the rear wall at that time was covered with corkboard only) and the bottom substrate removed; the latter was thoroughly searched for eggshells, but none were found.

On 9 December 2012 (a date corresponding to the early wet season in Timor-Leste) three more juveniles were captured in the terrarium, and once again a search yielded no eggshells (see Reproductive mode of *Eremiascincus* "Ermera"). No courtship behaviour or copulation events were ever observed by us, likely due to the secretive lifestyle of these skinks.

The juveniles were separated from the adults, and housed and raised in small plastic terraria (18 × 11.5, height 11.5 cm; one terrarium for one or two young), as a precaution against potential cannibalism by the adults. They were fed the same types of small invertebrates as the adults; the first feeding session took place the day after the juveniles were found and food was provided at least every other day. All their food was supplemented with Korvimin® and hatchlings were exposed to UV irradiation twice weekly. Unfortunately, three hatchlings died in early January 2013 when the heating system for the room housing the terraria and the terrarium lighting failed on a cool winter weekend.

Based on our overall experience, we advise against trying to raise juvenile tropical *Eremiascincus* in small terraria like those described above. Although these seem to be more easily managed (e.g., individuals can be captured quickly), an adequately naturalistic microclimate is difficult to emulate, and shortfalls in this regard (e.g., deficient substrate moisture) may quickly result in moulting problems or overheating. The remaining juveniles were transferred to larger, densely planted tanks, measuring at least 30 × 20 cm. The young skinks became used to the presence of a caretaker quickly and even began taking food from tweezers.

These two instances of captive breeding are the first ones documented for a Lesser Sundan *Eremiascincus*, and only the second published for a tropical taxon of this genus. Given the exploratory nature of keeping these skinks, we intentionally did not measure all hatchlings in an effort to minimise stress. We therefore measured the SVL and tail length (TailL) of only a single representative individual from the first litter (captured on 15 October 2012) in order to establish a baseline and expecting that growth in all individuals would follow a similar pattern. One month after having been found, this individual had a total length of 51 mm (SVL = 24 mm; TailL = 27 mm), indicating that TailL approximately equals SVL during the first phase of ontogeny (SVL/TailL = 0.89). At seven months of age, on 14 May 2013, the same individual had a total length of 101 mm (SVL = 40 mm, TailL = 61 mm). This individual had nearly doubled in length (+ 49.5%) during the intervening 6-month period (mid-November 2012 to mid-May 2013). The increase in SVL was less (+ 40.0%) than in TailL (+ 55.7%) and the SVL/TailL ratio decreased from 0.89 to 0.66. By comparison, the largest adult specimen with an original tail measured 148 mm with an SVL/TailL ratio of 0.68. Thus, after approximately half a year, individuals may reach body proportions that match those of adults. When the second set of measurements were taken, the characteristic yellow ventral coloration was also noticed for the first time. Maximum body size appears to be reached approximately one year after hatching. At that point in their development, two specimens from the second litter had SVLs of 52 and 53 mm with TailLs of 77 and 80 mm, respectively, arriving at SVL/TailL ratios of 0.68 and 0.66.

We were not able to verify whether the skinks reproduced in 2013 and 2014. Because the first author was conducting fieldwork overseas during the months that included the period of deposition in 2012, it is possible that the skinks reproduced but that resultant juveniles were overlooked by stand-in caretakers and fell victim to cannibalistic adults. There is also the possibility that the females of this species may not reproduce annually.

## Reproduction in *Eremiascincus*

Reproductive mode of *Eremiascincus* "Ermera". – Owing to the fact that authors use the terms "ovoviviparity" and "ovoviviparous" to distinguish between quite different reproductive patterns, we herein use "viviparity" and "viviparous" (= live-bearing) sensu Blackburn (1994: 65) to describe "species in which the female retains eggs to term in her reproductive tract and bears fully-developed, autonomous offspring." Species with offspring that are still surrounded by an egg membrane at birth, but hatch immediately are also considered viviparous. The terms "oviparity" and "oviparous" are used in their literal sense, i.e., in reference to taxa that deposit unhatched eggs that continue to develop extracorporeal. For a discussion of these terms see Blackburn (1994).

The subject population of *Eremiascincus* from the Timor-Leste highlands (altitude ca 1,200 m) is apparently viviparous, as no remains of eggshells could be traced after either instance of our unexpectedly-found juveniles. Whereas Rankin (1978) concluded on the basis of a similar observation that *E. pardalis* was a live-bearer (or at least certain populations of this species), he offered as an alternative explanation that adults could have consumed any eggshell remnants. Although this scenario is theoretically

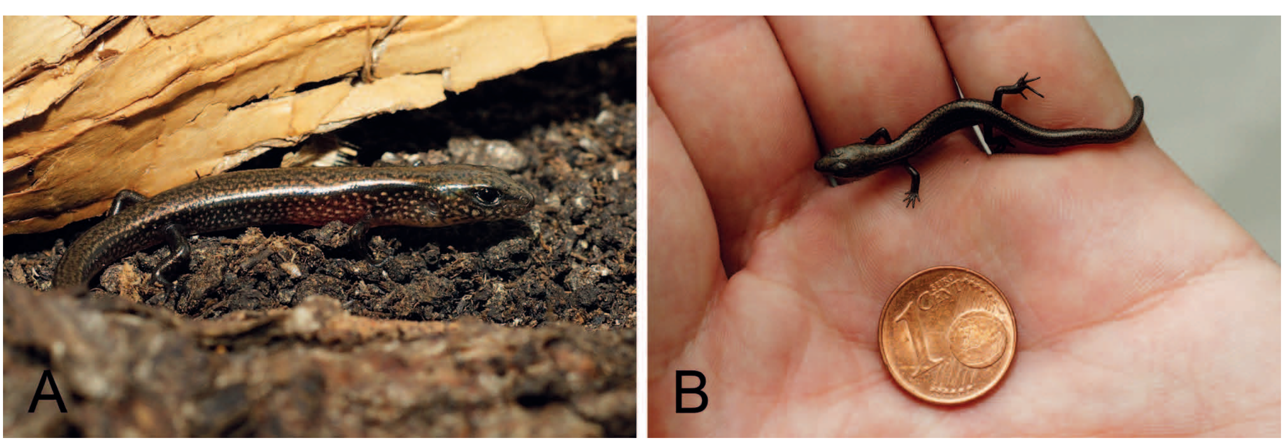


Figure 3. A + B) A juvenile specimen of *Eremiascincus* "Ermera". Note the differences between the juvenile and adult colour pattern (cf. Fig. 2A). The specimen was approximately two days old when it was photographed. Photos by Thomas Beitz.

Table 1. Reproductive data for night skink species (genus *Eremiascincus*). Sample size [n] is given in square brackets, mean values in parentheses. Abbreviations: (?) – reproductive mode unknown; O – oviparous; V – viviparous; NSW – New South Wales; NT – Northern Territory; SA – South Australia; QLD – Queensland; WA – Western Australia; SVL – snout–vent length; TailL – tail length; TL – total length. See also James & Losos (1991) whose data we did not use for this table due to the problems summarized in the "Results and discussion" section (Reproduction in *Eremiascincus*). No data on the reproductive biology of *E. brongersmai* and *E. timorensis* are available.

| Species | Country | SVL of gravid females (mm) | Brood size | Reproductively active[1]/ oviductal eggs or oviposition/ birthing period[2] | Egg size (mm) | Size of juveniles after hatching or birth (mm) | References |
|---|---|---|---|---|---|---|---|
| *E. antoniorum* (?) | Indonesia (Timor) | 64 [1] | – | [1] from late August on (mid-dry season) | – | – | Greer (1990) |
| *E. butlerorum* (?) | Indonesia (Sumba Island) | – | – | [1] late dry to early wet season | – | – | Aplin et al. (1993) |
| *E. douglasi* (O) | Australia (NT, northern wet/dry tropics) | 70 [1] | 5 [1] | [1] November to January (mid-wet season) (James 1983 quoted in Greer 1989) | – | – | Greer (1989) |
| *E. emigrans* (O) | Indonesia (widely distributed in Lesser Sundas) | – | – | [1] specimens collected in November (late dry season) on Komodo with follicular development | – | – | Auffenberg (1980) |
| *E. fasciolatus* (O; V – reports questionable) | Australia (eastern QLD) | 123 [1] | 8 [1] | [2] early December (early wet season) | – | – | Mecke et al. (2013) (cf. Waite 1929, Worrell 1963, Greer 1979, 1989) |
| *E. intermedius* (O) | Australia (arid NT, northeastern WA) | 74–82 (78.3) [3] | 4–5 (4.5) [2] | [2] early November to mid-March (wet season) | – | – | S. Mecke pers. obs. |
| *E. isolepis* (O) species complex, the Mitchell Plateau form reproduces at a smaller size and tends to have smaller clutches* | Australia (WA, NT, QLD, northern wet/dry tropics) | – | 4 [1] | [1] September to February (mid-wet season) (James 1983 quoted in Greer 1989); specimens examined by S. Mecke had oviductal eggs from mid-October to end of January. A single specimen in WAM (R132597) collected in May contained large oviductal eggs. | – | – | Loveridge (1949) |
| | | 51–64 (58.8) [4] | 3–8 (4.8) [4] | | – | – | Greer (1989) |
| | | 51–72 (59.6) [17] | 1–9 (5.2) [14] | | 4.0–9.2 × 2.8–5.9 (6.8 × 4.7) [9] | – | S. Mecke pers. obs. |
| *E. musivus* (O) | Australia (WA, Pilbara) | 57 [1] | 3 [1] | [2] mid-February (mid-wet season) | 11.4 × 5.7–6.2 (11.4 × 6.0) [3] | – | S. Mecke pers. obs. |
| *E. pallidus* (O) | Australia (arid WA, western NT, northwestern SA) | 65–69 (67) [2] | 1 [1] | [2] mid-October to January (early to mid-wet season) | 7.4 × 5.1 [1] | – | S. Mecke pers. obs. |
| *E. pardalis* (O, V) | Australia (QLD, Cape York) | – | 4 [1] | [2] end of January (mid-wet season) | – | SVL=25–26 TailL=34–35 | Rankin (1978) (reported as V) |
| | | 67–68 (67.5) [2] | 3–6 (4.5) [2] | – | – | – | Greer (1989; reported as O; see Greer & Parker 1974) |

| Species | Country | SVL of gravid females (mm) | Brood size | Reproductively active[1]/ oviductal eggs or oviposition/ birthing period[2] | Egg size (mm) | Size of juveniles after hatching or birth (mm) | References |
|---|---|---|---|---|---|---|---|
| *E. phantasmus* (O) | Australia (inner Lake Eyre basin) | – | 2–7 [?] | – | 16–17× 10–12 [?] | SVL=32–36 TailL=72–75 | Brown (2012); Mecke et al. (2013) |
| | | 84–93 (87.2) [5] | 3–4 (3.3) [3] | [2] early to mid-November | – | – | S. Mecke pers. obs. |
| *E. richardsonii* (O) species complex; the Nullarbor Plain form reproduces at a smaller size (61–71) (66) [2] | Australia (arid WA, SA, NT, QLD, NSW) | 79–116 (94.6) [5] | 3–7 (4.6) [5] | – | – | – | Greer (1989) |
| | | – | 2–8 [?] | – | 16.5–19.5× 9.9–10.1 [?] | SVL=31–34 TailL=77–80 | Brown (2012) |
| | | 89–113 (94) [5] | 5–6 (5.5) [5] | [2] mid-October to mid-February | – | – | S. Mecke pers. obs. |
| *E.* "Ermera" (V) | Timor-Leste | ~55 | 3–4 (3.5) [2] | [2] October to December (late dry to early wet season) | – | TL=~40 | S. Mecke pers. obs. |

* Here we refrain from drawing inferences on species delimitation. In most contexts it is better to use a conservative approach than to potentially falsely delimit entities that do not represent actual evolutionary lineages. Hence, the data here presented for *E. isolepis* are data combined from different populations.

possible, we consider such behaviour unlikely. Species of *Eremiascincus* do not show any type of nest-, clutch-, or egg-guarding behaviour that could provide an opportunity for concomitant post-eclosion oophagy (e.g., to prevent potential predators from discovering newly hatched skinks). Furthermore, while there may be a nutritional reason to consume eggshells, which are an excellent source of dietary calcium, adults would have had to find such shells serendipitously and independently after the two described events, and also after the one described by Rankin (1978). We have also been unable to locate documented case examples of post-eclosion oophagy in lacertilian taxa; studies only report the well-known phenomenon of pre-eclosion oophagy, in which eggs are consumed whole as part of the diet (e.g., Angelici et al. 1997, Martínez-Torres 1999, Schwenk 2000). Reproductive data for *Eremiascincus* "Ermera" and other members of the genus (e.g., on brood size, reproductive and birthing period, and egg size), including some observations by the first author, are summarized in Table 1.

Notes on the reproductive biology of other *Eremiascincus* and related taxa. Information on the reproductive biology of the genus *Eremiascincus*, both in the wild and captivity, is quite limited and only available for selected species (e.g., Rankin 1978, Greer 1989, 1990, James & Losos 1991, Mecke et al. 2009, 2013, Brown 2012), most of which are oviparous. Table 1 shows that little data are available for egg and hatchling sizes. Data on the reproductive biology of Lesser Sundan *Eremiascincus* are practically non-existent, whereas species from Australia, especially arid-zone taxa, have been better, even if still not adequately, studied.

Although James & Losos (1991) published a comprehensive study on the reproductive biology of what they considered to be *E. richardsonii* (Gray, 1845) and *E. fasciolatus* (Günther, 1867), some of their data should be used with caution. It now appears that the desert-dwelling, broad-banded *E. richardsonii* actually represents a species complex (S. Mecke unpubl. data), and the narrow-banded *E. fasciolatus* (*E. fasciolatus* sensu lato) that was formerly thought of as widespread has recently been restricted to eastern Queensland (*E. fasciolatus* sensu stricto). This species is often confused with *E. richardsonii* in museum collections because of similar body proportions and its robust build (Mecke et al. 2013). The species diversity within the banded *Eremiascincus* is still significantly underestimated. Thus, James & Losos (1991) may inadvertently have combined data from specimens representing different taxa, and in the absence of a list of voucher specimens in their publication, it is not possible to reconcile which data came from which form. In general, their data show that females with oviductal eggs were collected, or are known to deposit clutches, between mid-October and mid-February. These data are consistent with those summarized for other members of the genus in Table 1. Brood size averaged 4–5 (James & Losos 1991; see also Table 1).

Viviparity has been reported for two taxa (*E. fasciolatus* sensu lato and *E. pardalis*), but some of these reports have been considered doubtful. Greer (1979) summarized and critically evaluated information on the occurrence of viviparity in *E. fasciolatus* sensu lato. Mecke et al. (2013) examined 22 specimens of the Queensland-endemic *E. fasciolatus* sensu stricto, and found that one female (QM J39996; SVL = 123 mm) collected in early December (early wet season) contained eight shelled oviductal eggs. James & Losos (1991) also reported that *E. fasciolatus* laid shelled oviductal eggs, and the data summarized in Table 1 likewise indicate that all narrow-banded *Eremiascincus* species formerly lumped in "*E. fasciolatus*", including *E. fasciolatus* sensu stricto, *E. intermedius* (Sternfeld, 1919), *E. pallidus* (Günther, 1875), and *E. phantasmus* Mecke et al., 2013, are oviparous. Evidence for the viviparity of *E. pardalis* was presented by Rankin (1978), who discovered four hatchlings in a terrarium housing an adult pair. Despite a thorough search, Rankin failed to locate eggshells in the tank, which contained a bottom substrate that was too dry to facilitate subterraneous egg incubation. He therefore concluded that *E. pardalis* must be a live-bearer, in contrast to Greer & Parker (1974), who reported the species as oviparous. On the basis of our observations and the description by Rankin (1978), we surmise that *Eremiascincus* "Ermera" also gives birth to live young (see above).

The incubation period in *Eremiascincus* can be very short, shorter than for most other lacertilian taxa for which data are available (based on a table of selected clutch and incubation parameters provided by Köhler 2003: Appendix III). Brown (2012 and in litt.) noticed that at least some *Eremiascincus* species seem to possess the ability to retain eggs and incubate them "in utero" (oviparous egg retention sensu Blackburn 1994), a reproductive mode that has been considered a step towards the evolution of viviparity (e.g., Shine 1983, 1985, 2004; Guillette 1993, Blackburn 2006; Parker & Andrews 2006). Brown (2012 and in litt.) was able to record extracorporeal incubation periods as short as 21 days for "*E. richardsonii*" and New South Wales *E. phantasmus* (listed as *E. fasciolatus*), and it seems likely that intrauterine embryonic development is found in more than these two *Eremiascincus* species, including mesic forms.

Short extracorporeal incubation periods (< 20 days) are rarely documented in lizards (see Köhler 2003, Appendix III), with the phrynosomatid *Sceloporus aeneus* Wiegmann, 1828 being one such example (12–14 days; Köhler 2003). This species is also known to retain eggs and incubate them "in utero" (Guillette & Lara 1986, García-Collazo et al. 2012), a mechanism known from other members of the Iguania (Pianka & Vitt 2003). Among the Lacertidae, viviparous populations of *Zootoca vivipara* (Lichtenstein, 1823) and *Iberolacerta monticola* (Boulenger, 1905) are able to retain eggs and show an advanced intrauterine embryogenesis (e.g., Brana et al. 1991, Rodríguez-Díaz & Brana 2011). The same applies to some populations of *Lacerta agilis* (Linnaeus, 1758) and *Dinarolacerta mosorensis* (Kolombatovic, 1886), the latter of which has been reported to have incubation periods as short as 17–19 days (Brana et al. 1991, Köhler 2003, Ljubisavljevic et al. 2007). Within the family Scincidae, egg retention and intrauterine embryogenesis is known from *Lerista bougainvillii* (Gray, 1839) and *Saiphos equalis* (Gray, 1825) (Qualls 1996, Linville et al. 2010, Stewart et al. 2010).

A small number of species within the Scincomorpha (and only taxa within this group) are well known to be reproductively bimodal: *Zootoca vivipara*, *Trachylepis capensis* (Gray, 1831), and *Lerista bougainvillii* (see Qualls et al. 1995; these authors listed more reproductively bimodal species, some of which were later identified as comprising several distinct taxa, all of which showed an unimodal reproductive lifestyle). However, the number of species that include both oviparous and viviparous populations might be much greater, considering that so little is known about the ecology and reproductive biology of taxa within the Scincidae in particular.

A comparative study on the reproductive biology of *Eremiascincus* under laboratory conditions would help to improve our knowledge concerning oviparous egg retention and the possible occurrence of egg retention at extreme levels (i.e., viviparity) in the genus and constitute an opportunity to shed light on the selective forces driving these modes on ontogenetic and phylogenetic levels.

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## Appendix

Material examined

*Eremiascincus intermedius.* Northern Territory: NTM 15110, 12 km southwest Sangsters Bore, 20°52’0” S, 130°16’0” E. NTM 23342, 12 mile Stock Yards, Elsey National Park, 14°57’8” S, 133°13’8” E. NTM 33007, Alice Springs, 23°46’0” S, 133°52’60” E. NTM 32992, Tanami, 20°13’0” S, 131°46’0” E.

*Eremiascincus isolepis.* Northern Territory: AMS 60089, 60092, Burrells Creek., 29 km south Adelaide River on Stuart Highway, 13°21’0” S, 131°11’0” E. AMS 106815, West Island, Sir Edward Pellew Islands. Western Australia: AMS 123863, 123873, Mitchell Plateau, upstream from Mitchell Falls, 14°50’0” S, 125°41’0” E. WAM 20330, Derby, 17°18’0” S, 123°37’0” E. WAM 22361, Kimberley Research Station., Ord River, 15°39’ 0” S, 128°42’0” E. WAM 61566, Myaree Pool, Maitland River, 20°53’0” S, 116°37’0” E. WAM 77677, Mitchell Plateau, 14°35’0” S, 125°45’0” E. WAM 79027, Barred Creek Bore, Waterbank Station, 17°39’0” S, 122°12’0” E. WAM 83364, 16 km south southwest Mount Elizabeth Homestead., 16°27’0” S, 126°13’0” E. WAM 83550, 37 km north Broome, 17°38’0” S, 122°11’0” E. WAM 132597, Burrup Peninsula, 20°31’54” S, 116°47’41” E. WAM 135279, 7.5 km east Mount Hodgson, 20°48’36” S, 121° 13’54” E. WAM 139066, Mandora, 19°47’52” S, 121°26’52” E. WAM 139079, Mandora; WAM 139090, Mandora, 19°45’16” S, 121°26’59” E.

*Eremiascincus musivus.* Western Australia: WAM 135896, 10 km south southwest Mandora Homestead., 19°49’0” S, 120°48’0” E.

*Eremiascincus pallidus.* Western Australia: AMS 111617, Yule River, approx. 20 km south Port Hedland, 20°29’0” S, 118°10’0” E. WAM 161696, 43 km north northwest Goldsworthy, 19°59’54” S, 119°21’31” E.

*Eremiascincus phantasmus.* New South Wales: AMS 14449, Top Hut Road., 4.6 km east of Pooncarie – Wentworth Rd., 33°41’0” S, 142°28’0” E. AMS 155262, Sturt National Park, 13 km (by road) west of Binerah Downs Homestead on Middle Road, 29°01’30” S, 141°25’17” E. AMS 155285, 155405, Sturt National Park, 5.7 km west (by road) along Whitecatch Gate Road., 29°07’52” S, 141°08’57” E. South Australia: SAMA 63811, Cordillo, southwest Bloodwood Bore, 26°55’30” S, 140°54’41” E.

*Eremiascincus richardsonii.* South Australia: SAMA 44965, St. Mary Pool, 29°34’36” S, 139°24’52” E. SAMA 48982, 2.6 km east southeast of Lake Dam, South Gap Station., 31°47’4” S, 137°39’1” E. SAMA 58189, site BBB 00601, 17.3 km west northwest of Pile Hill, 28°45’06” S, 134 31’53” E. SAMA 61208, Whyalla, 8.5 km south southwest Moonbie Hills, 33°19’42” S, 137°12’53” E. South Australia (Nullarbor Plain): SAMA 9403, Ooldea, 30°27’ S, 131°50’ E. SAMA 62305 Noonina, 184 km south southwest of Wartaru, 28°30’31” S, 129°14’30” E. Queensland: AMS 60003, 13 miles north Blackall on Landsborough Highway, 24°16’0” S, 145°21’0” E.