Identity and history of an odd, old gecko
(*Gymnodactylus geckoides* Spix, 1825, Phyllodactylidae)
from the Zoologische Staatssammlung München, Germany

Herbert Rösler¹, Frank Glaw² and Hinrich Kaiser³,*

Abstract. We describe a gecko specimen that was initially catalogued in the Zoologische Staatssammlung München, Germany, under the name *Gymnodactylus marmoratus*, a species now known as *Cyrtodactylus marmoratus* from Java, Indonesia. A close inspection revealed that this very old specimen (catalogue number ZSM 245/0) is actually a member of the South American species *Gymnodactylus geckoides*. Intensive research of historic documents initially appeared to indicate that the specimen could be a lost Spix syntype, yet ultimately we were unable to pinpoint the specimen’s origin. Nevertheless, its provenance in the early part of the 19th Century makes for an intriguing historical herpetological anecdote that once again underlines the importance of active research in historical natural history collections.

Keywords. Phyllodactylidae, *Gymnodactylus geckoides*, Spix, Leuchtenberg, Brazil, gecko.

Introduction

The herpetological catalogue of the Zoologische Staatssammlung München, Germany (ZSM) shows under the accession number ZSM 245/0 a gecko listed as “*Gymnodactylus marmoratus* (Kuhl)” with locality “Java” (Fig. 1). The corresponding original entry into the collection’s permanent card index catalogue, in the same handwriting, was initially identical to that in the catalogue (Fig. 2). Subsequently, a correction was made to the species authority in the card entry, changing “(Kuhl)” to “(Gray, 1831)” (Fig. 2), the correct authority for *Cyrtodactylus marmoratus* and the name in current use for this taxon. The species identification on the jar label differs by the species authority, which is listed using another author, as “*Gymnodactylus marmoratus* (Fitz.)” (Fig. 3). The abbreviation “Fitz.” references the Austrian herpetologist Leopold Josef Fitzinger (1802–1884). In the following paragraphs, we describe this rather mysterious specimen, check the initial identification, and report on our attempts to trace its origin and its history.

Materials and Methods

We collected a variety of morphological data to ascertain the identity of ZSM 245/0 (Fig. 4), an adult male gecko specimen in poor condition. In order to compare the characteristics of this specimen with other geckos, we completed a series of measurements and compiled several scale counts. Measurements were taken to the nearest 0.1 mm using digital calipers. Scale counts were completed using a dissecting stereomicroscope. All data were taken on the right side of the specimen, unless stated otherwise. We report the scale count on both sides of the specimen by listing scales as R/L, where R denotes the right and L the left side. The number of subdigital lamellae was counted on fingers (F) and toes (T) in the usual a basal-to-apical direction on both right and left digits, with the number of enlarged subdigital lamellae given in parentheses. Thus, a lamellar count of
12 with four enlarged lamellae on the first finger of the right hand, with the first finger on the left hand missing, is reported as $F_1 = 12(4)/–$. In some cases scales could not be counted reliably because of the condition of the specimen, and such values are preceded by “ca.”

**Results**

Below, we provide relevant morphological characteristics of ZSM 245/0 to facilitate the comparisons subsequently presented.

**Description of ZSM 245/0**

**Sex.**—Adult male.

**Measurements (in mm).**—Snout–vent length 43.5, tail length 56.0, head length 10.5, head width 8.1, head depth 6.1, distance from the tip of the snout to the anterior edge of the orbit 4.6, distance from the posterior edge of the orbit to the posterior edge of the ear opening 4.4, orbital diameter 2.1, diameter ear opening 1.2, rostral width 2.1, rostral height 0.9, mental width 3.3, mental length 2.4.
Figure 2. Card index catalogue record of *Gymnodactylus marmoratus* in the Zoologische Staatssammlung München, Germany. Based on the order of entries (beginning at the top of the card), ZSM 245/0 must have been added in 1909 or thereafter. Note the corrections of species author from Kuhl to Gray 1831, and the reference at the top “siehe jetzt Cyrtodactylus” [see now *Cyrtodactylus*] to flag the change in genus. Red check marks next to specimen numbers indicate that these specimens were present in the collection during an inventory to determine which specimens survived the Second World War.

Figure 3. Label from the jar, in which specimen ZSM 245/0 is housed. The correction indicates that this type of label was initially produced to identify the collection of Lorenz Müller. In this case, one of Müller’s labels was altered to indicate its use for a specimen of the “old collection,” which pre-dated Müller. The taxon authority, given as “Fitz” to indicate Leopold Josef Fitzinger, is in error.

**External characters and pholidosis.**—Head slightly flattened, distinct from body. Pupil round with smooth edge. Rostral with a short, incomplete suture separating the upper thirds of the scale, 7/6 supralabials, 5/5 infralabials, 3/3 nasals, one internasal. Nares in contact with rostral and first supralabial, nasorostrals twice as large as postnasals. Snout not medially concave, snout scales medially twice as large as occipital granular
Canthal and interorbital scales of the same size. 13/14 scales between postnasals and orbit, ca. 33 scales between fourth supralabials, ca. 24 interorbitals. Occipital scales granular, no tubercles in the interorbital and occipital area. Nuchals granular, nuchal and temporal tubercles 1.5–2 times as large as bordering granular scales, round, conical, blunt to pointed. Mental U-shaped, wider than rostral. Two postmentals, as large in area as dorsal tubercles, triangular, medially separated by eight granular gular scales, in contact with 1st infralabials; no well-defined, differentiated lateral postmentals; scales bordering infralabials 3–4 times as large as occipital scales; throat scales granular, as large as occipital granules.

Dorsal and lateral scales as large as occipital scales, domed, smooth, non-overlapping. Dorsal and lateral tubercles in 13 regular longitudinal rows; tubercles triangular, conical, with a simple keel, bordered by 8–11 granular scales, with no (rarely one) granular scales separating tubercles longitudinally and 1–3 granular scales separating tubercles on their sides. Dorsal tubercles extending close to the vertebral line, with 5–7 granular scales separating the two medial tubercle rows across the vertebral line; ca. 47 paravertebral tubercles. Lateral fold absent. Belly scales twice as large as dorsal tubercles, flat, smooth, imbricate; 14 ventrals across the venter at mid-body. Pre-cloacal and femoral pores absent.

Scales on the upper and lower arm both anteriorly and posteriorly as large as the scales on the chest, flat, smooth, imbricate. Granular scales on the posterior surface of the forelimbs as large as occipital scales. Scales on the upper leg anteriorly and dorsally as large as ventrals, flat, smooth, imbricate. Granular scales on the posterior surface of the hind limbs as large as the medial snout scales. Tubercles absent on fore- and hind limbs. Toes not expanded, bent. Number of subdigital lamellae F1 = 12(4)/–, F4 = 13(5)/–, T1 = 9(2)/9(2), T4 = 17(8)/17(8). T1–T4 connected basally by narrow webbing.

Tail round in cross-section, with several indistinct tubercular whorls occurring on its proximal third. 1/1 cloacal tubercles. Tail scales dorsally twice as large as dorsal scales, laterally three times as large, flat, keeled, imbricate, with a pointed posterior edge, in regular whorls across the tail. Whorls 1–7 ventromedially separated by seven scales, tail tubercles in the first whorl 1.5 times the size as dorsal tubercles, triangular, longer than wide, weakly conical, keeled, pointed, size and number of tubercles declining continuously towards the tail tip. Whorl 1 with six, Whorl 2 with five, and Whorls 3–8 with two tubercles, no tubercles present in the more distal parts of the tail. Medial subcaudals enlarged, flat, smooth, imbricate, running along the tail in a single longitudinal row.

Colouration and pattern.—Dorsally and ventrally light olive green, patterning sepia. Dorsal flecks small, indistinct, in longitudinal rows. Upper part of tail with distinctly separated, narrow, dark rings, in the distal third with five light rings.
Remarks.—The specimen is damaged. The injuries include missing or loose skin both dorsally and ventrally, which appears to be a result of a poorly executed capture. The missing digits on the left hand, in contrast, are clearly the result of an earlier injury. The edges of those wounds are healed and covered with scales.

Comparison of ZSM 245/0 to Other Bent-Toed Geckos

Upon discovery of ZSM 245/0 we had immediate and significant doubts regarding its proper identification. A multitude of morphological characteristics (including size, pupil shape, dorsal tubercle arrangement, number of mid-body ventral scales, toe shape) did not fit those of *Cyrtodactylus marmoratus*. We began our comparisons by checking the specimen against species possessing similar toe morphologies known to occur on Java and on other islands in the region. When this investigation did not produce a match with any Asian gecko species, we decided to expand our comparisons to include geckos without any geographic bias.

Comparisons with *Cyrtodactylus*.—Four species of *Cyrtodactylus* are currently known from Java, the purported collection locality of ZSM 245/0: *Cyrtodactylus klakahensis* Hartmann et al., 2016; *C. marmoratus* Gray, 1831; *C. petani* Riyanto et al., 2015, and *C. semiaidi* Riyanto et al., 2014. ZSM 245/0 can be differentiated from these four species by the following characteristics (those of ZSM 245/0 are provided in parentheses): postmentals in contact (postmentals separated by granular scales), 30–40 ventral scales at mid-body (14), subcaudals not enlarged (enlarged). In addition, ZSM 245/0 differs from *C. klakahensis*, *C. marmoratus*, and *C. petani* by the absence of tubercles on the limbs and by the absence of precloacal and femoral pores (Rösler et al., 2007; Riyanto et al., 2015; Rösler, 2016). *Cyrtodactylus semiaidi* has 36 ventral scales at mid-body (14), 47 paravertebral tubercles (37–40), tubercles on its lateral fold (no lateral fold, no tubercles), 14–15 subdigital lamellae on the 4th toe (17), and subcaudals that are not enlarged (enlarged) (Riyanto et al., 2014). Furthermore, despite the relatively significant damage to the skin we were able to determine that ZSM 245/0 cannot belong to the genus *Cyrtodactylus* because of (1) the position, orientation, and type of dorsal tubercles, which occur in regular longitudinal rows and are usually in contact, (2) the very large ventral scales, and (3) the absence of precloacal and femoral pores (see Rösler and Glaw, 2008).

Comparisons with the genus *Cnemaspis* Strauch, 1887.—Round pupils, as evident in ZSM 245/0, exist among Asian geckos only in the genus *Cnemaspis sensu lato* (Smith, 1933; Underwood, 1954; Gamble et al., 2015). According to Grismer et al. (2014), the southernmost locality for a species from the Indochina/ Sunda clade of *Cnemaspis* in Asia is Pulau Karimata, where a population of *C. kendalli* (Gray, 1845) occurs. The species *C. timoriensis* (Duméril and Bibron, 1836), erroneously attributed to Timor Island, is not a member of the genus *Cnemaspis* (Rösler, 2016).

Species of *Cnemaspis* either lack dorsal tubercles entirely, or they possess only a few spiny, spaced-out tubercles arranged dorsally and laterally, as well as a greater number of relatively small ventral scales (Loveridge, 1947; Perret, 1963; Spawls et al., 2002; Das, 2005; Bauer et al., 2006; Manamendra-Arachchi et al., 2007; Trape et al., 2012; Grismer et al., 2014, 2015). ZSM 245/0 differs from all Asian forms, as well as from the African species that at this point remain in the genus *Cnemaspis* (see Gamble et al., 2011, 2012; Pyron et al., 2013; and Grismer et al., 2014 for additional comments on the taxonomy of the genus *Cnemaspis*), by the presence of many tubercle rows that closely align to the vertebral region, more dorsal tubercles that are longitudinally in contact, triangular, and keeled, and fewer, proportionally larger ventral scales. Since the listed characteristics preclude that this specimen could be a member of the genus *Cnemaspis*, the round pupils of ZSM 245/0 must therefore not be a species-level characteristic but, as sometimes occurs in other gecko species with slit-like pupils, an artifact of preservation (see Cassimiro and Rodrigues, 2009: Fig. 2B).

Comparisons with *Nactus*.—The genus *Nactus* Kluge, 1983 includes several species that are morphologically very similar to ZSM 245/0. The most significant areas for the diversity of *Nactus* include many islands southeast of Wallacea (Bauer, 1994; Kraus, 2005) as well as Australia (Heinicke et al., 2010; Cogger, 2014). Its distribution also extends across the entire Indian Ocean into the Mascarene Islands (Loveridge, 1951; Vinson and Vinson, 1969; Arnold and Bour, 2008), and it is therefore not inconceivable that *Nactus* would occur on Java. The locality of a Pacific *Nactus* species closest to Java is Pulau Salabubu, North Sulawesi, Indonesia (Koch et al., 2009). Comparison of body size as well as the numbers and shapes of dorsal tubercles, ventral scales, subdigital lamellae, and subcaudal scales readily allows morphological differentiation of ZSM 245/0 from all described (as well as some still unnamed).

Comparisons with Gymnodactylus.—Similar attributes to ZSM 245/0 in terms of size and pholidosis exist in species of the New World genus Gymnodactylus Spix, 1825. Comparisons showed that several species of Gymnodactylus possess chin shields and dorsal scales that conform to those of ZSM 245/0 (Gray, 1845; Barbour, 1925; Amaral, 1932; Vanzolini, 1982; Cassimiro and Rodrigues, 2009). The specimen in question can be distinguished from Gymnodactylus amarali Barbour, 1925, Gymnodactylus guttulatus Vanzolini, 1982, and Gymnodactylus vanzolinii Cassimiro and Rodrigues, 2009 by dorsal tubercles that are longitudinally aligned next to one another vs. separated by small scales. It can be distinguished from Gymnodactylus darwinii (Gray, 1845) by the smaller number of paravertebral tubercles (Cassimiro and Rodrigues, 2009; da Silva Junior, 2010; Vanzolini, 1982, 2004, 2005). However, the specimen agrees completely with Gymnodactylus geckoides Spix, 1825 based on the descriptions of Spix (1825), Boulenger (1885), Steindachner (1867), Strauch (1887), Grantsau (2003), Vanzolini (1953, 2004), and da Silva Junior (2010).

Our evaluation shows that both the species designation and the locality that had been assigned to this gecko to date are false and in need of correction. We hereby correct the species designation and place ZSM 245/0 into the neotropical species Gymnodactylus geckoides Spix, 1825. Gymnodactylus geckoides is the type species of the genus Gymnodactylus, which is currently typified only by the “iconotype” of the original illustration (Spix, 1825: Pl. 18, 1; Fig. 5 herein).

On the Origin of ZSM 245/0

During our investigation of the specimen’s origin, we initially considered that it could be the last remaining syntype of Gymnodactylus geckoides from the “zoological-zootomic collection” of Johann Baptist Ritter von Spix (1781–1826). We made this connection for a variety of reasons, which derived from the manner in which the ZSM acquired some of its oldest specimens. For example, in his list of animals collected in Brazil, von Martius (1831) included 130 species of amphibians (inclusive of reptiles, which were at that time still integrated into that class of animals), but unfortunately he did not provide specific information about the specimens themselves. There is nothing known about the number and later disposition of the Gymnodactylus geckoides specimens collected by Spix (Hoogmoed and Gruber, 1983; Franzen and Glaw, 2007). The last author who directly dealt with some of the material Spix brought to Munich was Wilhelm Carl Hartwig Peters (1815–1883). Alas, the Spix collection was no longer complete even in Peters’s days (Peters, 1877). A recent audit of specimens in the Museum für Naturkunde, Berlin, Germany (ZMB) at our request revealed that, despite historic loans between Munich and Berlin, at this time there is no specimen of Gymnodactylus geckoides in the ZMB collection that could have been collected by Spix (R. Günther and F. Tillack, pers. comm.). It therefore

Figure 5. The original illustration of Gymnodactylus geckoides (Spix 1825: Tafel 18, Fig. 1), which Vanzolini (2004) considered the holotype (as an “iconotype”).
appears that the material loaned to Peters from Munich by Carl von Siebold (1804–1885) was completely returned. Additionally, an inspection of material in the Naturalis Biodiversity Center, Leiden, The Netherlands (formerly the Rijksmuseum van Natuurlijke Historie, RMNH) ascertained that, beyond the material listed by Hoogmoed and Gruber (1983), there are no additional specimens collected by Spix in that collection (E. Dondorp, pers. comm.). Furthermore, the Spix collection in Munich suffered additional losses due to poor collection management practices and the circumstance that some of the specimens were made available for university teaching and may have been dissected and destroyed (Hoogmoed and Gruber, 1983; Schönitzer and Franzen, 2016). Thus, there did not appear to be any simple link from this specimen to Spix.

An important indicator that initially led us to identify ZSM 245/0 as one of the specimens collected by Spix was the fact that it is part of the “alte Sammlung” [old collection], which can be recognized by a running number, followed by a “/0”. The old collection mostly comprises the Spix collection, but also other material collected until 1907 (Glaw and Franzen, 2006). According to this numbering system, established by then-curator Lorenz Müller (1868–1953), Catalogues 1–3 of the ZSM include a majority of the amphibians and reptiles assembled by Spix, and ZSM 245/0 is included in Catalogue 1 (numbers 1/0 to 1824/0; Glaw and Franzen, 2006). While it is not known why this specimen was not part of a series of *G. geckoides* when it was accessioned, it is most likely that it had become separated from one of the Brazil collections before the establishment of the catalogues and therefore subsequently needed to be listed as an individual. It is also possible that the reason for its putative separation from a larger lot may have been the poor condition of the specimen itself, or that the doubts surrounding the South American origin of this specimen initially somehow led to specimen separation. By the same token, the distribution of a specimen series into several specimen jars was not necessarily unusual (e.g., Müller and Brongersma, 1933). Some individual exemplars may also have been donated to other collections or exchanged. This is the reason why there are several Spix type specimens in the RMNH (Müller and Brongersma, 1933; Hoogmoed and Gruber, 1983; Hoogmoed, 1986).

While the circumstances of the catalogue and card catalogue entries seemed to provide valuable circumstantial evidence for the age and disposition of ZSM 245/0, we soon realized through our consultation of historic documents that other possibilities existed for how this specimen could have become part of the ZSM collection. After Spix died, the holdings of South American geckos at the ZSM were expanded by several collectors (see Gruber, 1992; Franzen and Glaw, 2016). Substantial contributions at the beginning of the 20th century were made especially by Lorenz Müller. However, Müller started his expedition to Brazil only in 1909 (Müller, 1914) and all of his specimens from South America were registered in the new catalogue established by him in 1907. It is therefore improbable that he could have contributed ZSM 245/0 to the collection. On the other hand, ZSM 245/0 could have originated with the collection of Duke August von Leuchtenberg, Prince of Portugal (also known as Auguste Charles Eugène Napoléon de Beauharnais, 1811–1835). He was in friendly contact with the ZSM zoologist Johann Georg Wagler (1800–1832) until the latter’s death, and it is possible that Leuchtenberg received several specimens from Spix or Wagler for his own collection. Leuchtenberg’s collection was acquired by the ZSM in 1858 and contained a few herpetological specimens without locality data from Brazil (e.g., *Amphisbaena microcephalum*, ZSM 2623/0, a species collected by Spix and described by Wagler) but it remains unclear whether these specimens were collected by Spix or another collector.

Ultimately, our findings did not provide incontrovertible evidence for a connection with Spix. We did, however, make the following determinations.

- Based on the early entry in Catalogue 1, it is clear that ZSM 245/0 was collected in the 19th Century (Schönitzer and Franzen, 2016). The so-called old collection includes all of the type material deposited by Spix and Wagler, except those specimens, which were lost or exchanged.
- ZSM 245/0 was presumably labeled as *Gymnodactylus marmoratus* due to having been received with the locality “Java.” At the time of its accession into the Munich collection *G. marmoratus* was the only species of *Gymnodactylus* known from Java, even though clearly at least the species *G. geckoides* would already have been known to Spix, the taxon’s author. Lorenz Müller, who was active in the herpetological division of the Zoologische Staatsammlung München beginning in 1903, appears to have catalogued newly purchased or donated specimens in his card index catalogue before adding the old collection (see the order of entries in Fig. 2).
- Many of the Brazilian Spix types are still extant in the Zoologische Staatsammlung München (Fittkau, 1992; Hoogmoed and Gruber, 1983; Gruber, 1992),
whereas the type series of *Gymnodactylus geckoides* is considered lost (Hoogmoed and Gruber, 1983; Franzen and Glaw, 2007).

- Some specimens collected by Spix were donated or exchanged to other museums, and some may simply have been used up during dissections in anatomy classes. Some types of various species were exchanged with the Rijksmuseum van Natuurlijke History (now Naturalis Biodiversity Center), Leiden, The Netherlands (see Müller and Brongersma, 1933; Hoogmoed, 1986; Hoogmoed and Gruber, 1983). Among these are no specimens of *G. geckoides* collected by Spix (E. Dondorp, pers. comm.).

- Fitzinger (1827) was apparently able to examine the complete Spix collection, whereas Peters (1877) noted some gaps when he borrowed the specimens from Munich for his examination (a specimen of *Gecko cruciger* Spix, 1825 = *Hemidactylus mabouia* Moreau de Jonnès, 1818 was missing). In the collection at the Museum für Naturkunde, Berlin, Germany, there are currently no specimens of *G. geckoides* that could have been collected by Spix (R. Günther and F. Tillack, pers. comm.).

- It is possible that ZSM 245/0 is a specimen from the Leuchtenberg collection. The specimen may have been collected by the royal person himself during his five-month stay in Brazil (Voigt, 1835). Alternatively, the specimen could have been obtained by Leuchtenberg’s collector father from an animal dealer, or he may have obtained it via diplomatic channels from Brazil.

- The Leuchtenberg collection includes specimens from several regions with a global scope. Aside from Brazilian specimens, it does include some from Java. For individual specimens in this collection, uncertainties regarding their correct place of origin surfaced very early, which led to errors and confusion. For example, the type locality of *Cercosaura ocellata* Wagler, 1830 is given as “Asia?” in the original description (Wagler, 1830), whereas, according to the ZSM catalogue, the holotype came from South America and is part of the Leuchtenberg collection. Accordingly, it was most likely not collected by Spix. This discrepancy in data was only discovered because of our inquiries related to the ZSM 245/0 gecko specimen.

- Finally, ZSM 245/0 could have been collected by Moritz Wagner (1813–1887) or by an entirely unknown collector or donor. For various squamates that arrived during the time of Spix or Wagler, little or no collecting information exists.

**Discussion**

Our research into the history and provenance of a single specimen of uncertain identity and provenance in the ZSM collection shows once again that taxonomic treasure is almost certainly still hiding out in many natural history collections. Due to the complex and fragmented political history of the German-speaking parts of Europe, this may be particularly true for German natural history collections (e.g., Böhme, 2014; Mecke et al., 2016; Rösler and Kaiser, 2016; see Kaiser et al., 2017), but significant findings have also been reported recently for important collections in Italy, Sweden, the Netherlands, the United Kingdom, and the United States (e.g., Kathriner et al., 2014; Zug and Kaiser, 2014; Hartmann et al., 2016; Kieckbusch et al., 2016; O’Shea and Kaiser, 2016; O’Shea et al., 2015, 2016). Therefore, not only must we recognize the archival and historical nature of natural history collections, but also their active contributions to our studies of biodiversity. At a time when funding for fieldwork and molecular studies is awarded via highly competitive processes, it perhaps behooves both researchers and funding agencies to remember that natural history collections already hold material for a plethora of research questions.

**Acknowledgments.** We thank Rainer Günther and Frank Tillack (Museum für Naturkunde, Berlin, Germany) for conducting a comprehensive search of their collection for Spix specimens and for the loan of material. We greatly appreciate the help of Esther Dondorp (Naturalis Biodiversity Center, Leiden, The Netherlands), who confirmed that only Spix material already reported on in publications currently exists in the Leiden collection. For his work on the images of the gecko from Munich, we thank Gerd Trautmann (Laboe, Germany). For their excellent reviews and comments on an earlier version of the manuscript, we thank Aaron Bauer, Wolfgang Böhme, and Marinus Hoogmoed.

**References**


Manamendra-Arachchi, K., Batuwita, S., Pethiyagoda, R. (2007): A taxonomic revision of the Sri Lankan day-geckos (Reptilia: Gymn


