Morphological Variation of Asian Small Lizards genus *Tytthoscincus* Linkem, Diesmos & Brown (Squamata : Scincidae) in Indonesia

Richo Firmansyah[1*], Awal Riyanto[2], Nia Kurniawan[1]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, University of Brawijaya, Malang, Indonesia
[2]Museum Zoologicum Bogoriense, Research Center of Biology, National Research and Innovation Agency (BRIN), Bogor, Indonesia

Abstract

Morphological variations in species with a relatively broad distribution, including the genus *Tytthosincus*, were likely a result of island isolation. This research was conducted to map the morphological variations of the genus *Tytthoscincus* in Indonesia. A total of 32 specimens of the Tytthoscincus scientific collection in the Zoologicum Bogoriense Museum (MZB) - National Research and Innovation Agency (BRIN) and identified as *T. temmincki*, *T. textus*, and *T. parvus* have been examined and data collection which includes six morphometric characters and 12 meristic characters. Morphometric data were analyzed in univariate and multivariate. Univariate analysis was carried out by the Kruskal-Wallis test, while multivariate analysis was done with the Principal Component Analysis (PCA) test. The results showed morphology in *T. temmincki* and *T. textus*, namely the number of loreal scales and tympanum diameter. Both *T. temmincki* and *T. textus* consist of two groups, but the morphological variation in *T. temmincki* and *T. textus* in this study has yet to provide certainty as a different species. However, one was *T. textus* Type 2, isolated from other species on Jampea Island, Sulawesi. Further research was needed to clarify the taxonomic status of these variations by increasing the number of adequate samples supported by the molecular analysis approach.

Keywords: meristic, morphometric, species, *Tytthoscincus*, variation.

INTRODUCTION

In 2011, Linkem et al. Classified *Sphenomorphus* species into a new genus, *Tytthoscincus*. Genetic and morphological data show that small mountain species such as *S. butleri* (Boulenger), *S. Ishaki* (Grismer), and others form a monophyletic group centered phylogenetically on the genus *Tytthoscincus* [1]. The morphological characteristics of the genus *Tytthoscincus* are a body size of less than 45 mm (SVL= *Snout Vent Length*), and temporal scales cannot be distinguished from lateral body scales in either size or shape [2]. *Tytthoscincus* weighs around 0.63 – 3.25 grams. The genus *Tytthoscincus* is distributed in the Southeast Asian region such as Malaysia, Indonesia, to the Philippines [3].

Lygosoma temmincki was described by Duméril and Bibron in 1839, with morphological characteristics of this species having jaws parallel to the snout, smooth scales, small longitudinal slit-shaped ear holes, and short limbs. *Lygosoma temmincki* was found on Java Island [4]. Mueller, in 1894 described a species found on the island of Sulawesi at an altitude of 3900 meters above sea level as *Lygosoma texum*. This species has morphological characteristics such as a short and pointed snout, no supranasal, and five supraocular scales. The ventral part of the chin is gray. The head length of *L. texum* is around 50 mm, with a tail of 56 mm [5]. In 1897, *Lygosoma parvum* was described by Boulenger with the morphological characteristics of an elongated body shape with a total body length of 78 mm, a short and blunt snout, scaly lower eyelids, four supraocular scales, eight supraciliary scales, no supranasal, unclear tympanum hole, hind limbs longer than forelimbs, and a brown body with dorsal yellowish brown dots. *Lygosoma parvum* was found in Luhu, Central Sulawesi, at 1000 - 1600 feet [6].

Linkem *et al.* [7] redescribed *T. Parvus* characterized by a small body size of less than 45 mm, small fingers, and a fourth finger longer than or equal to the third finger. This species is found on the island of Sulawesi [7]. Meanwhile, Grismer *et al.* [1] described *T. Temmincki* with morphological characteristics having a range of 4 - 5 supralabial scales, two loreal scales, 68–80 paravertebral scales, 62–72 ventral scales, 9–11 scales on the lamella of the fourth toe, smooth lamella texture, and a dark line on the dorsolateral [1]. The distribution of *T. temmincki* is in Java, Sumatra, and Sulawesi [8]. Grismer *et al.* in 2016 described *T. textus* with a short snout, 42 mm SVL size, reddish brown above with reticulation, and dark limbs [1]. Karin *et al.* in 2016 also hypothesized that *S. textus* belongs to the *Tytthoscincus* group,

*Correspondence address:
Richo Firmansyah
Email : richo.firmansyah25@gmail.com
Address : Dept. Biology, University of Brawijaya, Veteran Malang 65145, Indonesia.

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characterized by an adult body size of 38 mm and a bright stripe on the postorbital and dorsolateral [2]. This hypothesis was proven by Grismer *et al.* in 2017 by confirming that *S. textus* is included in the phylogeny of the genus *Tytthoscincus* [9]. This study aimed to map the morphological variation of the genus *Tytthoscincus* in Indonesia.

MATERIAL AND METHOD

Data Collection

The research data were taken from scientific collections in the form of wet-preserved specimens at the Museum Zoologicum Bogoriense (MZB), Herpetology Laboratory, Center for Biosystematics and Evolution Research, Indonesian National Research and Innovation Agency (BRIN), Cibinong. Morphometric and meristic character data were collected to compare the genus *Tytthoscincus* in Indonesia (Fig. 1).

Morphometric characters refer to Grismer *et al.* [9], and specimens were measured using Image J software [10]. These morphometric characters include snout-cloaca distance length (SVL = snout-vent length) measured from the rostral end to the cloaca margin, head length (HdL) measured from the anterior edge of the ear hole to the rostral end, tympanum diameter (TD, tympanum depth) measured from the anterior to the posterior edge of the tympanum, length of the distance between the armpit and the thigh fold (AXG, axilla groin length), forelimb length (FL, forelimb limbs), and hind limb length (HL, hind limbs). Meristic characters include the number of supralabials, infralabials, supraoculars, supraoculars attached to frontal scales, loreals (Fig. 2), middle, paravertebral, ventral scale rows, third finger lamellae, fourth finger lamellae, and meristic character with the shape of the tympanum.

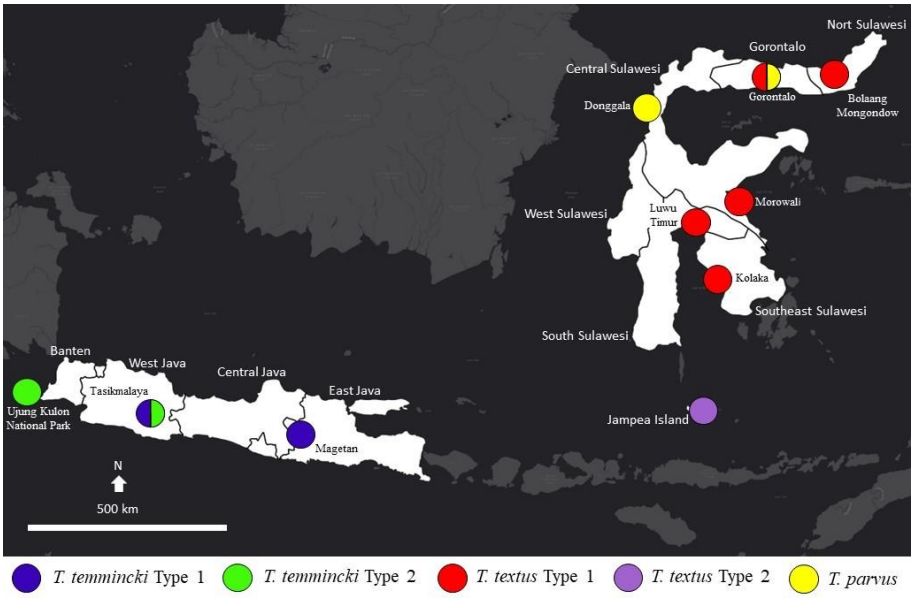

Figure 1. Distribution of variation *Tytthoscincus*.

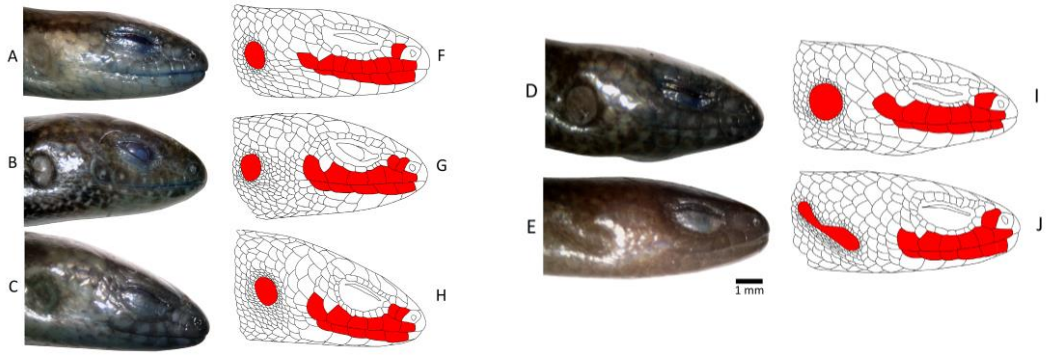

Figure 2. Morphological variation of *Tytthoscincus* based on the loreal scale number and tympanum diameter. A = F, *T. temmincki* type 1; B = G, *T. temmincki* type 2; C = H, *T. textus* type 1; D=I, *T. textus* type 2; E = J, *T. parvus*

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Data Analysis

A total of 32 adult *Tytthoscincus* specimens (from Java and Sulawesi Island) were used in the analysis, and due to the small sample size, the statistical analysis did not differentiate between males and females. These specimens were initially grouped into four operational taxonomic units (OTU/Operational Taxonomy Units) based on variations of loreal scales number and shape.

Morphometric data were standardized in ratios (HdL/SVL, TD/SVL, AXG/SVL, FL/SVL, HL/SVL, and TD/HdL). Kruskal-Wallis analysis was carried out separately for each morphometric character to determine whether there were differences between OTUs (*T. temmincki* type 1, *T. temmincki* type 2, *T. textus* type 1, *T. textus* type 2 and *T. parvus*). This analysis method followed the Zar method [11]. Each morphometric character is a dependent variable, and OTU is an independent variable or predictor. Multivariate analysis used the principal component analysis (PCA) test to reduce multidimensional correlations into several uncorrelated variables. All analyzes were performed by RStudio statistical software.

RESULT AND DISCUSSION

Tytthoscincus temmincki is grouped into two, namely, type 1 with the characteristic of only having one loreal scale and type 2 for specimens with two loreal scales. The same applies to *T. textus* in type 1 and type 2. Meanwhile, *T. parvus* is only one group because there is no variation in the number of loreal scales (Fig. 2). The results of the Kruskal-Wallis analysis showed that only two ratio characters had significantly different values between OTUs, consist of TD/SVL and TD/HdL (Table 1). Of all OTUs, *T. parvus* had the smallest tympanum size (TD/SVL and TD/HdL). The largest tympanum belonged to *T. textus*, with *T. textus* type 1 and *T. textus* type 2.

Multivariant analysis with PCA on PC1 and PC2 showed that only *T. parvus* separated from *T. temmincki* type 1 and type 2, and *T. textus* type 1 and type 2. PC1 and PC2 cumulatively explained 73.8% of the variation (Table 2, Fig.3). In PC_1, the morphometric ratio AXG/SVL had negative loading, while the other five morphometric ratios TD/SVL, TD/HdL, FL/SVL, HL/SVL, and HdL/SVL had positive loading values. As for PC2, AXG/SVL, TD/HdL, FL/SVL, and TD/SVL had positive loading values, while HL/SVL and HdL/SVL had negative loading values.

Based on this study, *T. parvus* is distinct from *T. temmincki* and *T. textus*. The variation in the number of loreal scales in both *T. temmincki* and *T. textus* should be suspected as a phenomenon of intra-species variation. This variation may be part of the ongoing speciation process. Another possibility is that the number of samples for morphometric analysis in both *T. temmincki* type 1 and type 2 and *T. textus* type 2 needed to be more significant (more samples needed).

The wide distribution area likely influences morphological variation in *T. temmincki* and *T. textus*. The distribution area includes not only one large island but also small islands with complex structures [3]. Geographical barriers play a role in causing variation. The range limit of a species is usually aligned with a significant barrier to dispersal, such as a river, sea, or mountain [12].

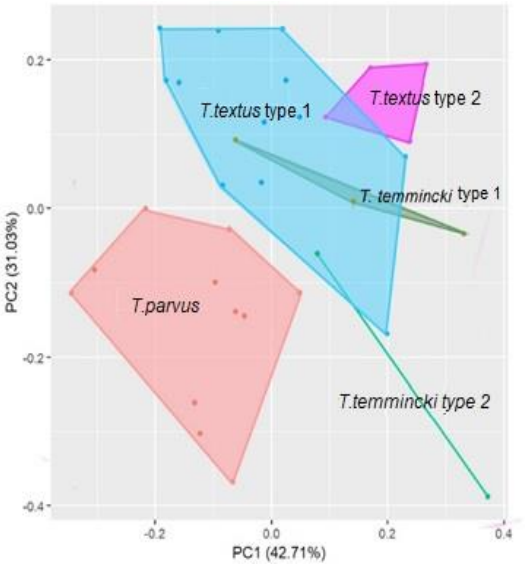

Figure 3. Biplot principal component analysis of *Tytthoscincus* morphological variations on PC1 and PC2

In this study, the distribution of *T. textus* type 2 was isolated from the distribution of other species on Jampea Island (Fig. 1). This allows the variation to be very different from *T. textus* type 1, which originates from Sulawesi Island. The morphological variations found can be used as a future taxonomic review and to provide certainty whether *T. textus* type 2 from Jampea Island is different from *T. textus* type 1 from Sulawesi Island as a distinct species, through molecular analysis and larger/ representative sample size.

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Table 1. Mean values and Kruskal-Wallis test statistics on variation in morphometric ratios between OTUs and comparison of meristic characters.

Character	OTU					X^2	*P-value*
	T. temmincki type1	*T. temmincki* type2	*T. textus* type1	*T. textus* type2	*T. parvus*		
N	type 1 (n=3)	type 2 (n=2)	type 1(n=12)	type 2 (n=4)	(n=11)		
HdL/SVL	0.203 ± 0.007	0.221 ± 0.017	0.200 ± 0.013	0.206 ± 0.014	0.205 ± 0.015	4.0686	0.3968
SVL	0.033 ± 0.004*	0.033 ± 0.003*	0.034 ± 0.003*	0.040 ± 0.003*	0.024 ± 0.003*	24.825*	$5.456e^{-05}$*
AXG/SVL	0.545 ± 0.024	0.479 ± 0.103	0.562 ± 0.020	0.536 ± 0.036	0.546 ± 0.025	6.1551	0.1879
FL/SVL	0.185 ± 0.012	0.175 ± 0.005	0.159 ± 0.016	0.173 ± 0.013	0.158 ± 0.016	8.0561	0.08954
HL/SVL	0.283 ± 0.043	0.229 ± 0.013	0.251 ± 0.024	0.272 ± 0.021	0.257 ± 0.022	7.3068	0.1205
TD/HdL	0.164 ± 0.011*	0.148 ± 0.000*	0.170 ± 0.012*	0.196 ± 0.004*	0.116 ± 0.015*	26.624*	$2.368e^{-05}$*
Supralabials	8(1), 6(2)	6	6	6	7(1), 6(10)		
Infralabials	5	5	5	6(1), 5(3)	5		
Supraoculars	4	4	4	4	4		
Loreals	1	2	2 (10), 1(2)	1	1		
Distribution	West Java, East Java	West Java	Gorontalo, Southeast Sulawesi, Central Sulawesi	South Sulawesi	Sulawesi, Gorontalo, Central Sulawesi		

Notes: * significant; HdL = head length, SVL = snout-vent length, AXG = axilla groin length, FL = forelimb length, HL = hind limb length, and TD = tympanum diameter.

Table 2. Principle component analysis (PCA) and factor loading.

PCA variable	PC1	PC2	PC3	PC4	PC5	PC6
SD	1.601	1.365	0.935	0.709	0.442	0.057
Proportion of variance	0.427	0.310	0.146	0.084	0.033	0.001
Cumulative	0.427	0.738	0.883	0.967	0.999	1.000
Loading						
HdL/SVL	0.304	- 0.452	- 0.462	0.598	0.300	0.208
TD/SVL	0.464	0.427	- 0.347	0.052	0.014	- 0.692
AXG/SVL	-0.316	0.448	0.262	0.780	- 0.149	- 0.011
FL/SVL	0.452	0.035	0.684	0.042	0.569	- 0.004
HL/SVL	0.505	- 0.287	0.295	0.128	- 0.748	0.007
TD/HdL	0.365	0.574	- 0.204	- 0.117	- 0.067	0.691

Notes: HdL = head length, SVL = snout-vent length, AXG = axilla groin length, FL = forelimb length, HL = hind limb length, and TD = tympanum diameter.

The existence of habitat isolation was formed due to evolutionary factors, consisting of population differentiation between isolated islands during the Pleistocene era, which resulted in fluctuating sea levels and the separation of land by shallow seas [13]. Spatial and temporal variation in intraspecific body size or morphology is driven by differences in the heritability of phenotypic traits and the basis of evolution and adaptation to environmental changes [14].

CONCLUSION

Morphological variations in *T. temmincki* and *T. textus* are based on the number of loreal scales and the diameter of the tympanum. As for *T. parvus*, no such variation was found. Both *T. temmincki* and *T. textus* consist of two groups. The morphological variations in this study in *T. temmincki* and *T. textus* do not provide certainty as different species. However, one of them, *T. textus* type 2, is isolated from other species on the Island of Jampea, Sulawesi. Further research is needed to clarify the taxonomic status of these variations by adding an adequate number of samples supported by molecular analysis approaches.

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