

CHAPTER IV

Morphological Variation in Butterfly Lizards, Genus *Leiolepis* (Reptilia: Agamidae)

Abstract

Morphological variations among three species of butterfly lizards, genus *Leiolepis* were studied from 287 adult specimens collected throughout Thailand. The body color, spot and stripe patterns of them were noticeable and could be used to identify the species and subspecies. The analysis of variance on the morphology of the body shape showed twenty-five characters with significant differences among species. Comparisons between *L. belliana belliana* and *L. belliana ocellata* indicated that they had similarity in most of their morphological characters. *L. belliana* had the longest head length, lower legs length, and hind limb length compared to other species. *L. boehmei* exhibited significant differences in three morphological characters compared to other species.

Sexual dimorphism was determined and showed that the snout vent length of *L. b. belliana* and *L. b. ocellata* in males was longer than in females. The hindlimb length of *L. r. rubritaeniata* in male was longer than in female. All samples of *L. boehmei* were female.

A key to these species, which was constructed on the basis of external morphological characters, was provided.

4.1 Introduction

The butterfly lizards, genus *Leiolepis* comprise seven known species. Four species are bisexual (*L. belliana* (Hardwick and Gray, 1827), *L. guttata* Cuvier, 1829, *L. reevesii* (Gray, 1831), *L. peguensis* Peters, 1971), and three are unisexual (*L. triploida* Peters, 1971, *L. guentherpetersi* Darevsky & Kupriyanova, 1993 and *L. boehmei* Darevsky & Kupriyanova, 1993) (Darevsky and Kupriyanova, 1993). Despite its local abundance and wide distribution over Southeast Asia, relatively little is known about their morphological characters and sexual dimorphism. Large samples of butterfly lizards from 36 localities in Thailand were captured and examined. This data set allows a more complete analysis of the external morphological features and sexual differences of this lizard than was previously possible. A dichotomous key to the three species of the genus *Leiolepis* from Thailand was provided.

4.2 Methodology

A total of 287 specimens, all adults, were obtained from field surveys in 36 localities (Fig. 4.1). Locality, sex and sample sizes for all species examined are given in Table 1. Color notes and photographs of live specimens were taken. Thirty-one characters were measured to nearest 0.1 mm using a dial caliper. Morphological characters include: snout-vent length (SVL), total length (TTL), tail length (TL), head length (HL), snout tip to nostril length (SNL), snout tip to eye length (SEyL), snout tip to ear opening length (SEaL), snout tip to mouth length (SML), nostril to eye length (NEyL), nostril to ear opening length (NEaL), eye to ear opening length (EyEaL), eye length (EyL), eye width (EyW), nostril width (NW), nostril length (NL),

collar to vent length (CVL), snout to collar length (SCL), upper arm length (UAL), forearm length (FAL), hand length (HaL), forelimb length (FLL), upper leg length (ULL), lower leg length (LLL), foot length (FoL), hindlimb length (HLL), axilla circumference length (ACL), lumbar circumference length (LCL), maximum of body circumference length (MCL), base of tail circumference length (TCL), axilla to groin length (AGL) and vent width (VW) (Fig. 4.2). Sex was determined by dissection and the examination of primary sexual characters was followed. In order to minimize size bias, the recorded morphological characters were transformed into relative quantity to snout-vent length (SVL). The mean relative parameters were compared among species and between sexes using the analysis of variance (ANOVA). Significant difference was considered from probability of $p \leq 0.05$. Statistical analysis was performed on computer procedure of SPSS for Windows release 11.5. These specimens were identified using the descriptions of Peters (1971) and Darevsky and Kupriyanova (1993). Some additional comments were added more to create a dichotomous key to the three species of the genus *Leiolepis* from Thailand. Catalogue numbers of specimens deposited in the herpetological collections of the Chulalongkorn University Museum of Zoology, are proceeded by CUB MZ R (see Appendix).

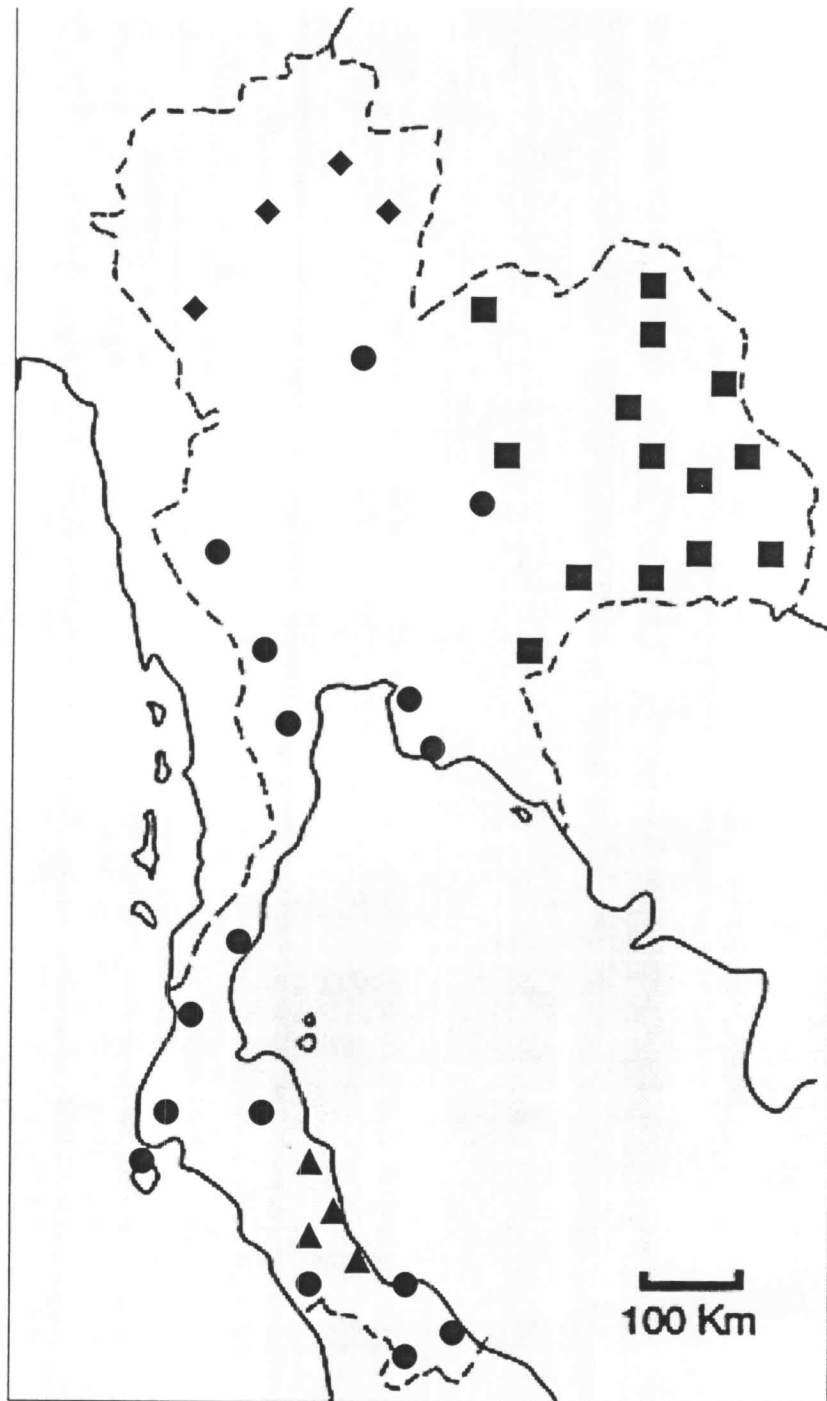


Figure 4.1 Map of Thailand, showing sampling localities for specimens used in the study. ●, *Leiolepis belliana belliana*; ◆, *Leiolepis belliana ocellata*; ■, *Leiolepis reevesii rubritaeniata*; ▲, *Leiolepis boehmei*.

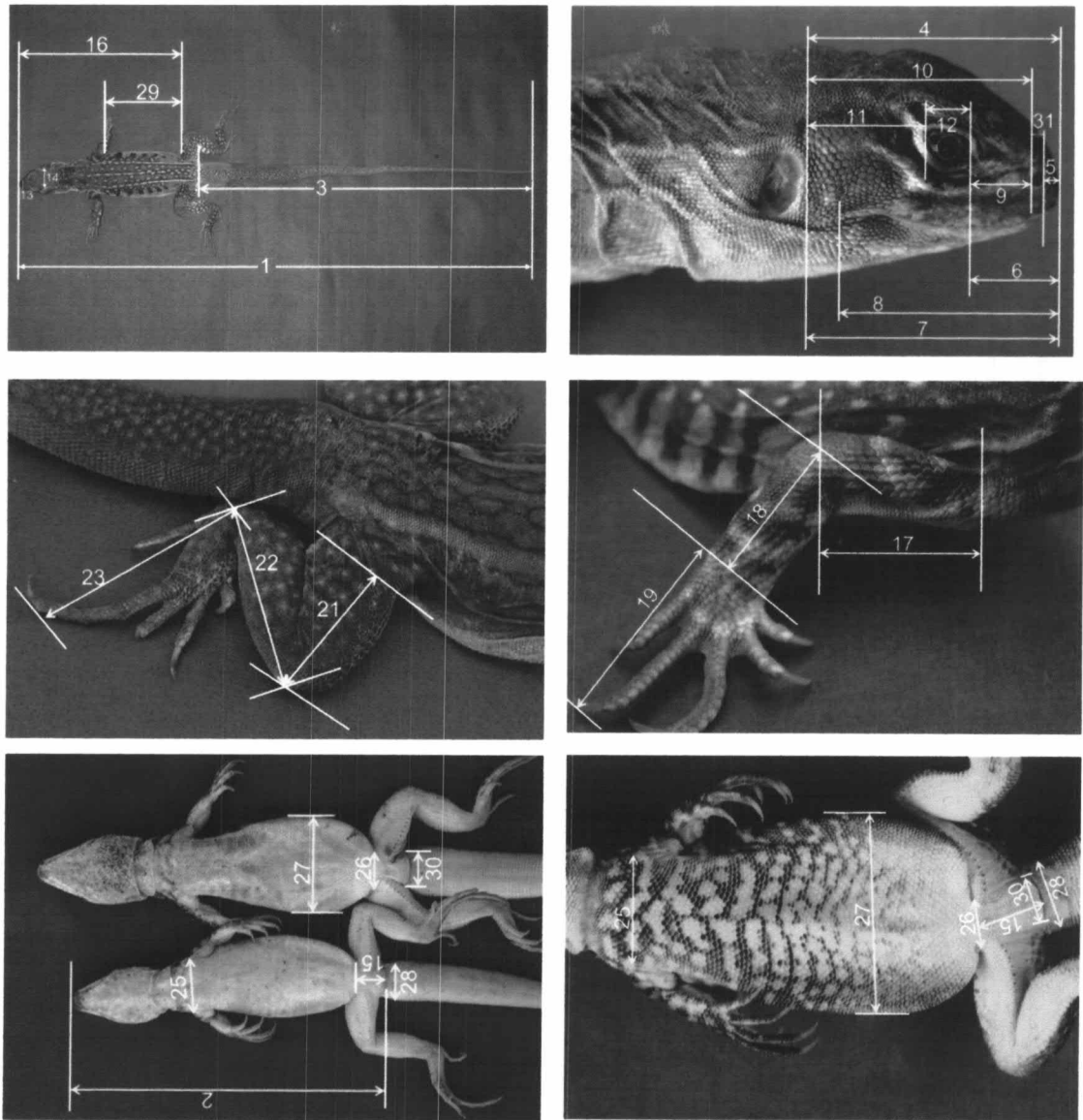


Figure 4.2 Thirty-one morphological characters that were measured for the study of species identification and the sexual dimorphism.

Table 4.1 Locality and sample sizes of each *Leiolepis* species used in the study.

Species	Locality (District, Province)	Sample Sizes	
		Male	Female
<i>L. belliana belliana</i>	Si Racha, Chonburi	3	1
	Lang Suan, Chumpon	3	1
	Bo Phloi, Kanchanaburi	3	2
	Tak Bai, Narathiwat	3	2
	Sikhiu, Nakhon Ratchasima	3	2
	Tha Sala, Nakhon Si Thammarat	3	2
	Muang, Pattani	3	1
	Thai Muang, Phangnga	3	1
	Ban Lat, Phetchaburi	3	1
	Wang Thong, Phitsanulok	4	2
	Thalang, Phuket	3	2
	Kapoe, Ranong	3	2
	Suan Phung, Ratchaburi	4	1
	Ban Khai, Rayong	4	2
	La-Ngu, Satun	3	1
	Muang, Yala	3	1
<i>L. belliana ocellata</i>	Mae Phrik, Lampang	8	8
	Wiang Sa, Nan	6	5
	Chiang Muan, Phayao	11	9
	Ban Tak, Tak	8	7
<i>L. reevesii rubritaeniata</i>	Muanh, Amnat Charoen	3	2
	Krasang, Buri Ram	5	3
	Sahatsakhan, Kalasin	5	3
	Muang, Loei	5	3

Table 4.1 (Continued)

Species	Locality (District, Province)	Sample sizes	
		Male	Female
<i>L. reevesii rubritaeniata</i>	Nong Sung, Mukdahan	4	2
	Non Sung, Nakhon Ratchasima	6	4
	Phon Phisai, Nong Khai	5	2
	Changhan, Roi Et	5	3
	Aranyaprathet, Sa Kaeo	3	1
	Sawang Daen Din, Sakhon Nakhon	5	3
	Khukhan, Si Sa Ket	4	2
	Sangkha, Surin	5	3
	Nam Yun, Ubon Ratchathani	3	2
	Pa Tiu, Yasothon	4	3
<i>L. boehmei</i>	Hua Sai, Nakhon Si Thammarat	-	22
	Chana, Songkhla	-	15
	Thepha, Songkha	-	10
	Muang, Songkhla	-	5

4.3 Results and Discussion

Variations in body color and body pattern

Variations in body color and body pattern of *L. b. ocellata*, *L. b. belliana*, *L. r. rubritaeniata* and *L. boehmei* were summarized in Table 4.2. *L. b. ocellata* and *L. b. belliana* have a series of black and orange (or yellow) vertical bars along the entire flank in common whereas other characters are distinct. *L. r. rubritaeniata*, which was found in the northeastern, has black and orange (or yellow)

vertical bars only in males and the series of bars extend to or less than half of the entire flank. The southern species, *L. boehmei*, has no black and orange bars. Other variations among the four groups can be concluded as follows:

Leiolepis belliana belliana (Gray, 1827)

Body color is light grey. The dorsal of the head is bluish grey. The back of the body has small yellow oval spots with black edges. Three or less complete longitudinal stripes (a median and two laterals) were presented on the back.

Leiolepis belliana ocellata Peters, 1971

On the back, there are numerous grey or pale yellow oval spots with black edges forming a reticulum. Head and body color are reddish brown. The chin is strongly tinged with red in female. Longitudinal stripes are present only at the pelvic region.

Leiolepis reevesii rubritaeniata (Gray, 1831)

Body color is blackish olive. Head is light brown with white and slightly blue spots. Black and orange colour along the entire flank are absent. There are small dorsal spots with black edges forming a continuous network on the back.

Leiolepis boehmei Darevsky and Kupriyanova 1993

They have grayish or brownish olive color on the upper body with two bold uninterrupted longitudinal stripes of light color that fade solely in the neck region. The ventral surface of the head is gray with white oblique bars and the dorsum of head is light grey or olive with a small pale yellowish spot on the lower eyelid.

Table 4.2 Body color and pattern of butterfly lizards.



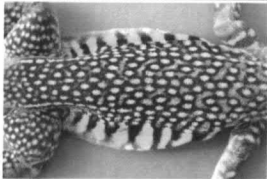




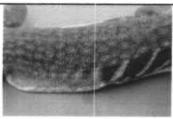
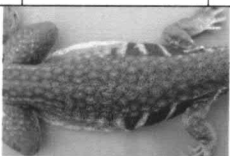

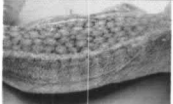

Species	Body Color and Pattern				
	Head Color	Flank	Dorsal Pattern		Background
			Spot Pattern	Stripe Pattern	Body Color
<i>L. b. ocellata</i>	Reddish brown (Chin is red in female)	Black and orange or yellow bars along the entire flank.	Numerous large grey or pale yellow oval spots with black edges forming a reticulum.	Longitudinal lateral stripes only appear in the pelvic region	Red brown
					
<i>L. b. belliana</i>	Bluish grey	Black and orange or yellow bars along the entire flank.	Small yellow oval spots and black edges not forming a reticulum	Three or less complete longitudinal stripes (a median & two laterals) on the back.	Light grey
					

Table 4.2 (Continued)

Species	Body Color and Pattern				
	Head	Flank	Dorsal Pattern		Background Body Color
			Spot Pattern	Stripe Pattern	
<i>L. r. rubritaeniata</i>	Light brown with white and slightly blue spots	Black and orange or yellow bands are present only in male, the extend about half of the entire flank	Small dorsal spots with black edges forming a reticulum on the back. Small pale ocelli located within the spots.	No or very short longitudinal stripes on the back.	Blackish olive
					
<i>L. boehmei</i>	Light grey or olive with a small pale yellowish spot on the lower eyelid.	Light vertical bars are present along the entire flank.	Pale ocelli on a dark polygonal network on the back	Two pale yellow continuous longitudinal lateral stripes	Grayish olive
					

Variations in body color and body pattern among *Leiolepis* species could be used to identify species and subspecies (Fig. 4.3). However, the differences between sexes were still unclear. Therefore, the analysis of variations in body shape was conducted in order to solve this problem.

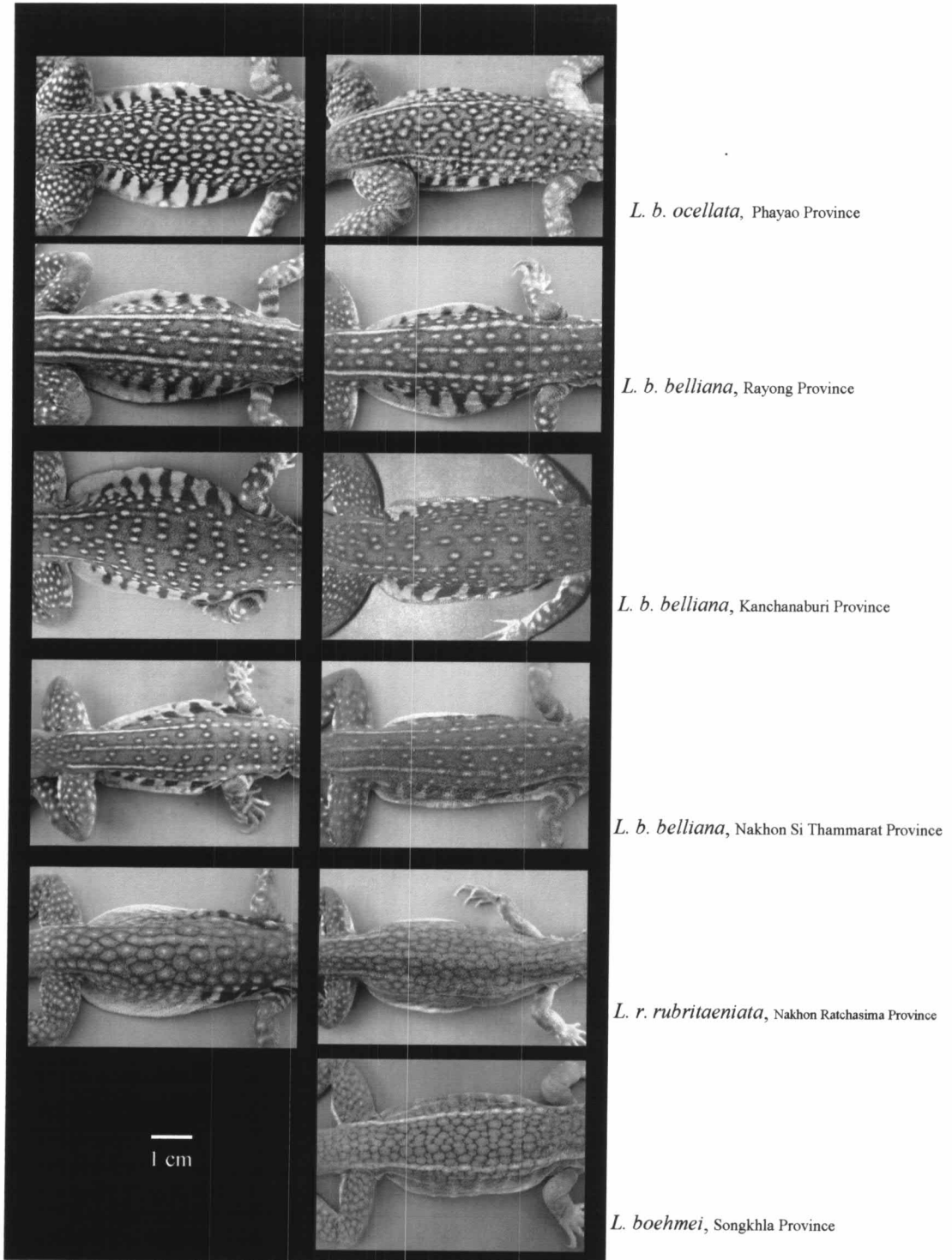


Figure 4.3 Body spot and stripe patterns in *Leiolepis* species: left (male), right (female).

Table 4.3 Variations in morphological characters (mean \pm SD, followed by ranges in parentheses) of the butterfly lizards from Thailand. All measurements are in mm.

Character	<i>L. b. belliana</i>		<i>L. b. ocellata</i>		<i>L. r. rubritaeniata</i>		<i>L. boehmei</i>
	Male	Female	Male	Female	Male	Female	Female
	N = 51	N = 24	N = 33	N = 29	N = 62	N = 36	N = 52
SVL	11.7 \pm 1.8 ^{bc} (6.7 - 16.6)	11.5 \pm 2.2 ^{abc} (7.6 - 16.8)	11.7 \pm 1.3 ^{bc} (9.1 - 16.0)	11.1 \pm 1.2 ^{ab} (8.4 - 14.1)	12.2 \pm 1.7 ^c (9.2 - 16.1)	10.9 \pm 1.0 ^a (8.2 - 12.5)	10.8 \pm 0.8 ^a (9.3 - 12.6)
TTL/SVL	2.7 \pm 0.5 (1.6 - 3.3)	2.9 \pm 0.3 (2.1 - 3.3)	2.9 \pm 0.4 (1.1 - 3.2)	2.8 \pm 0.5 (1.6 - 3.3)	2.8 \pm 0.4 (1.7 - 3.2)	2.8 \pm 0.4 (1.6 - 3.2)	2.7 \pm 0.5 (1.6 - 3.4)
TL/SVL	1.7 \pm 0.5 (0.2 - 2.3)	1.9 \pm 0.3 (1.1 - 2.3)	1.9 \pm 0.4 (0.2 - 2.2)	1.9 \pm 0.5 (0.7 - 2.3)	1.8 \pm 0.4 (0.8 - 2.2)	1.8 \pm 0.4 (0.7 - 2.2)	1.7 \pm 0.6 (0.6 - 2.6)
HL/SVL	0.2 \pm 0.0 ^d (0.2 - 0.3)	0.2 \pm 0.0 ^{cd} (0.2 - 0.2)	0.2 \pm 0.0 ^d (0.2 - 0.2)	0.2 \pm 0.0 ^{cd} (0.2 - 0.2)	0.2 \pm 0.0 ^{bc} (0.2 - 0.2)	0.2 \pm 0.0 ^a (0.2 - 0.2)	0.2 \pm 0.0 ^b (0.2 - 0.2)
SNL/SVL	0.0 \pm 0.0 ^{ab} (0.2 - 0.4)	0.0 \pm 0.0 ^{ab} (0.2 - 0.4)	0.0 \pm 0.0 ^b (0.3 - 0.4)	0.0 \pm 0.0 ^{ab} (0.2 - 0.4)	0.0 \pm 0.0 ^{ab} (0.0 - 0.0)	0.0 \pm 0.0 ^a (0.2 - 0.4)	0.0 \pm 0.0 ^a (0.2 - 0.3)
SEyL/SVL	0.1 \pm 0.0 ^{bc} (0.1 - 0.2)	0.1 \pm 0.0 ^{abc} (0.1 - 0.1)	0.1 \pm 0.0 ^c (0.1 - 0.2)	0.1 \pm 0.0 ^{bc} (0.1 - 0.1)	0.1 \pm 0.1 ^{ab} (0.1 - 0.1)	0.1 \pm 0.0 ^a (0.1 - 0.1)	0.1 \pm 0.0 ^{bc} (0.1 - 0.1)
SEaL/SVL	0.2 \pm 0.0 ^c (0.2 - 0.3)	0.2 \pm 0.0 ^{bc} (0.2 - 0.2)	0.2 \pm 0.0 ^c (0.2 - 0.2)	0.2 \pm 0.0 ^{bc} (0.2 - 0.2)	0.2 \pm 0.0 ^b (0.2 - 0.2)	0.2 \pm 0.0 ^a (0.2 - 0.2)	0.2 \pm 0.0 ^a (0.2 - 0.2)
SML/SVL	0.2 \pm 0.0 ^c (0.1 - 0.2)	0.2 \pm 0.0 ^b (0.1 - 0.2)	0.2 \pm 0.0 ^{bc} (0.1 - 0.2)	0.2 \pm 0.0 ^b (0.1 - 0.2)	0.2 \pm 0.0 ^b (0.1 - 0.2)	0.1 \pm 0.0 ^a (0.1 - 0.2)	0.1 \pm 0.0 ^a (0.1 - 0.2)
NEyL/SVL	0.0 \pm 0.0 ^{bc} (0.0 - 0.1)	0.0 \pm 0.0 ^{bcd} (0.0 - 0.1)	0.1 \pm 0.0 ^d (0.0 - 0.1)	0.1 \pm 0.0 ^{cd} (0.0 - 0.1)	0.0 \pm 0.0 ^{ab} (0.0 - 0.1)	0.0 \pm 0.0 ^a (0.0 - 0.1)	0.1 \pm 0.0 ^{cd} (0.0 - 0.1)
NEaL/SVL	1.9 \pm 0.3 ^{bc} (0.1 - 2.0)	1.9 \pm 0.4 ^{bc} (0.2 - 2.0)	2.0 \pm 0.2 ^c (0.2 - 2.0)	1.8 \pm 0.2 ^b (0.2 - 2.0)	2.0 \pm 0.3 ^b (0.1 - 2.0)	1.7 \pm 0.2 ^a (0.1 - 2.0)	1.7 \pm 0.2 ^a (0.0 - 2.0)
EyEaL/SVL	0.1 \pm 0.0 (0.1 - 0.2)	0.1 \pm 0.0 (0.1 - 0.1)	0.1 \pm 0.0 (0.1 - 0.2)	0.1 \pm 0.0 (0.1 - 0.1)	0.1 \pm 0.0 (0.1 - 0.1)	0.1 \pm 0.0 (0.1 - 0.2)	0.1 \pm 0.0 (0.1 - 0.2)
EyL/SVL	0.0 \pm 0.0 ^{ab} (0.0 - 0.1)	0.0 \pm 0.0 ^{ab} (0.0 - 0.1)	0.0 \pm 0.0 ^{ab} (0.4 - 0.6)	0.0 \pm 0.0 ^{bc} (0.0 - 0.1)	0.0 \pm 0.0 ^a (0.0 - 0.1)	0.0 \pm 0.0 ^{ab} (0.0 - 0.1)	0.0 \pm 0.0 ^c (0.0 - 0.1)
NW/SVL	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)	0.0 \pm 0.0 (0.0 - 0.1)
EyW/SVL	0.1 \pm 0.0 ^a (0.1 - 0.1)	0.1 \pm 0.0 ^c (0.1 - 0.1)	0.1 \pm 0.0 ^{bc} (0.1 - 0.1)	0.1 \pm 0.0 ^d (0.1 - 0.1)	0.1 \pm 0.0 ^a (0.1 - 0.1)	0.1 \pm 0.1 ^{ab} (0.1 - 0.1)	0.1 \pm 0.1 ^c (0.1 - 0.1)

Table 4.3 (Continued)

Character	<i>L. b. belliana</i>		<i>L. b. ocellata</i>		<i>L. r. rubritaeniata</i>		<i>L. boehmei</i>
	Male	Female	Male	Female	Male	Female	Female
	N = 51	N = 24	N = 33	N = 29	N = 62	N = 36	N = 52
CVL/SVL	0.1 ± 0.0 ^{abc} (0.1 - 0.2)	0.1 ± 0.0 ^a (0.1 - 0.2)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^{bc} (0.1 - 0.2)	0.1 ± 0.0 ^a (0.1 - 0.1)	0.1 ± 0.0 ^c (0.1 - 0.1)	0.1 ± 0.0 ^c (0.1 - 0.2)
SCL/SVL	0.8 ± 0.0 ^{ab} (0.8 - 0.9)	0.8 ± 0.0 ^a (0.8 - 0.9)	0.8 ± 0.0 ^a (0.8 - 1.0)	0.8 ± 0.0 ^{bc} (0.8 - 0.9)	0.8 ± 0.0 ^a (0.8 - 0.9)	0.8 ± 0.0 ^a (0.8 - 0.9)	0.9 ± 0.0 ^c (0.8 - 1.0)
UAL/SVL	0.1 ± 0.0 (0.1 - 0.1)	0.1 ± 0.0 (0.1 - 0.1)	0.1 ± 0.0 (0.1 - 0.1)	0.1 ± 0.0 (0.1 - 0.1)	0.1 ± 0.0 (0.1 - 0.2)	0.1 ± 0.0 (0.1 - 0.1)	0.1 ± 0.0 (0.1 - 0.1)
FAL/SVL	0.1 ± 0.0 ^d (0.1 - 0.1)	0.1 ± 0.0 ^{cd} (0.1 - 0.1)	0.1 ± 0.0 ^{cd} (0.1 - 0.1)	0.1 ± 0.0 ^{bc} (0.1 - 0.1)	0.1 ± 0.0 ^{ab} (0.1 - 0.1)	0.1 ± 0.0 ^a (0.1 - 0.1)	0.1 ± 0.0 ^{bc} (0.1 - 0.1)
HaL/SVL	0.2 ± 0.0 (0.1 - 0.3)	0.2 ± 0.0 (0.1 - 0.2)	0.2 ± 0.0 (0.1 - 0.2)	0.2 ± 0.0 (0.1 - 0.2)	0.2 ± 0.0 (0.1 - 0.2)	0.2 ± 0.0 (0.1 - 0.3)	0.2 ± 0.0 (0.1 - 0.2)
FLL/SVL	0.4 ± 0.0 ^{bcd} (0.3 - 0.4)	0.4 ± 0.0 ^{abcd} (0.3 - 0.4)	0.4 ± 0.0 ^d (0.3 - 0.4)	0.4 ± 0.0 ^{cd} (0.3 - 0.4)	0.4 ± 0.0 ^{ab} (0.3 - 0.5)	0.4 ± 0.0 ^a (0.3 - 0.4)	0.4 ± 0.0 ^{abc} (0.3 - 0.4)
ULL/SVL	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.1 ± 0.0 ^a (0.1 - 0.2)	0.1 ± 0.0 ^a (0.1 - 0.2)
LLL/SVL	0.2 ± 0.0 ^c (0.2 - 0.3)	0.2 ± 0.0 ^{dc} (0.2 - 0.2)	0.2 ± 0.0 ^{cd} (0.2 - 0.2)	0.2 ± 0.0 ^{bc} (0.2 - 0.2)	0.2 ± 0.0 ^b (0.2 - 0.2)	0.1 ± 0.0 ^{ab} (0.2 - 0.2)	0.1 ± 0.0 ^a (0.2 - 0.2)
FoL/SVL	0.3 ± 0.0 ^c (0.3 - 0.4)	0.3 ± 0.0 ^b (0.3 - 0.4)	0.3 ± 0.0 ^c (0.3 - 0.4)	0.3 ± 0.0 ^c (0.3 - 0.4)	0.3 ± 0.0 ^{ab} (0.2 - 0.4)	0.3 ± 0.0 ^a (0.2 - 0.4)	0.3 ± 0.0 ^{ab} (0.3 - 0.4)
HLL/SVL	0.7 ± 0.0 ^d (0.6 - 0.9)	0.7 ± 0.0 ^c (0.6 - 0.7)	0.7 ± 0.0 ^{cd} (0.6 - 0.7)	0.7 ± 0.0 ^{cd} (0.6 - 0.8)	0.7 ± 0.0 ^b (0.6 - 0.8)	0.6 ± 0.0 ^a (0.5 - 0.7)	0.6 ± 0.0 ^{ab} (0.6 - 0.7)
ACL/SVL	0.2 ± 0.0 ^c (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^{bc} (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.2 ± 0.0 ^{bc} (0.1 - 0.2)	0.2 ± 0.0 ^b (0.1 - 0.2)	0.1 ± 0.0 ^a (0.1 - 0.2)
LCL/SVL	0.1 ± 0.0 ^{bc} (0.1 - 0.2)	0.1 ± 0.0 ^{bc} (0.1 - 0.1)	0.1 ± 0.0 ^{bc} (0.1 - 0.1)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^{bc} (0.1 - 0.1)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^a (0.1 - 0.1)
MCL/SVL	0.3 ± 0.0 ^b (0.1 - 0.3)	0.3 ± 0.0 ^{ab} (0.2 - 0.3)	0.3 ± 0.0 ^{ab} (0.2 - 0.3)	0.2 ± 0.0 ^a (0.2 - 0.3)	0.3 ± 0.0 ^{ab} (0.2 - 0.3)	0.3 ± 0.0 ^b (0.2 - 0.4)	0.2 ± 0.0 ^{ab} (0.2 - 0.4)
TCL/SVL	0.1 ± 0.0 ^b (0.1 - 0.3)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^b (0.1 - 0.2)	0.1 ± 0.0 ^b (0.1 - 0.1)	0.1 ± 0.0 ^a (0.1 - 0.1)	0.1 ± 0.0 ^a (0.1 - 0.1)
AGL/SVL	0.5 ± 0.1 ^a (0.1 - 0.5)	0.5 ± 0.0 ^{ab} (0.4 - 0.5)	0.5 ± 0.0 ^{bc} (0.4 - 0.5)	0.5 ± 0.0 ^c (0.4 - 0.5)	0.5 ± 0.0 ^{abc} (0.4 - 0.5)	0.5 ± 0.0 ^{bc} (0.4 - 0.5)	0.5 ± 0.0 ^c (0.4 - 0.5)

Table 4.3 (Continued)

Character	<i>L. b. belliana</i>		<i>L. b. ocellata</i>		<i>L. r. rubritaeniata</i>		<i>L. boehmei</i>
	Male	Female	Male	Female	Male	Male	Female
	N = 51	N = 24	N = 33	N = 29	N = 62	N = 36	N = 52
VW/SVL	0.1 ± 0.0 ^{cd} (0.0 - 0.1)	0.1 ± 0.0 ^d (0.1 - 0.2)	0.1 ± 0.0 ^{bc} (0.0 - 0.1)	0.1 ± 0.0 ^a (0.0 - 0.1)	0.1 ± 0.0 ^a (0.0 - 0.1)	0.1 ± 0.0 ^a (0.0 - 0.1)	0.1 ± 0.0 ^b (0.0 - 0.1)
NL/SVL	0.0 ± 0.0 ^{ab} (0.0 - 0.0)	0.0 ± 0.0 ^b (0.0 - 0.0)	0.0 ± 0.0 ^{ab} (0.0 - 0.0)	0.0 ± 0.0 ^b (0.1 - 0.1)	0.0 ± 0.0 ^a (0.0 - 0.0)	0.0 ± 0.0 ^b (0.0 - 0.0)	0.0 ± 0.0 ^b (0.0 - 0.0)

Note: snout-vent length (SVL), total length (TTL), tail length (TL), head length (HL), snout tip to nostril length (SNL), snout tip to eye length (SEyL), snout tip to ear opening length (SEaL), snout tip to mouth length (SML), nostril to eye length (NEyL), nostril to ear opening length (NEaL), eye to ear opening length (EyEaL), eye length (EyL), eye width (EyW), nostril width (NW), nostril length (NL), collar to vent length (CVL), snout to collar length (SCL), upper arm length (UAL), forearm length (FAL), hand length (HaL), forelimb length (FLL), upper leg length (ULL), lower leg length (LLL), foot length (FoL), hindlimb length (HLL), axilla circumference length (ACL), lumbar circumference length (LCL), maximum of body circumference length (MCL), base of tail circumference length (TCL), axilla to groin length (AGL) and Vent width (VW)

Variations in body shape

Variations in the body shape were compared among seven groups of *Leiolepis*. Mean values and ranges in the external morphological characters of the samples were summarized in Table 4.3.

From thirty-one characters examined, there were no significant differences in six parameters among the seven groups including maximum length from the tip of snout to the tail tip (TTL/SVL), maximum length from tail base to the tail tip (TL/SVL), length from the posterior of the eye to the anterior of the ear

opening (EyEaL/SVL), width from right nostril to left nostril (NW/SVL), length from the shoulder joint to the elbow joint (UAL/SVL), and hand length (HaL/SVL).

The comparison between *L. b. belliana* and *L. b. ocellata*, showed four parameters with significant difference, consisting of length from the collar to the vent (CVL/SVL), lower leg length (LLL/SVL), length from the axilla to the groin (AGL/SVL), and width from the tip of right vent to the tip of left vent (VW/SVL). *L. b. belliana* had significantly lower degree of length from the axilla to the groin (AGL/SVL) than *L. b. ocellata*. These results exhibited that the degree of external morphological characters could not clearly discriminate.

L. b. belliana and *L. r. rubritaeniata*, had nine parameters with significant difference, comprising of snout tip to ear opening length (SEaL/SVL), snout tip to mouth length (SML/SVL), nostril to ear opening length (NEaL/SVL), forearm length (FAL/SVL), upper leg length (ULL/SVL), lower leg length (LLL/SVL), hindlimb length (HLL/SVL), base of tail circumference length (TCL/SVL) and vent width (VW/SVL). Of these, nostril to ear opening length (NEaL/SVL) of *L. b. belliana* was shorter than *L. r. rubritaeniata*.

Between *L. b. ocellata* and *L. r. rubritaeniata*, there were eleven parameters with significant difference, including snout tip to eye length (SEyL/SVL), tip to mouth length (SML/SVL), nostril to eye length (NEyL/SVL), nostril to ear opening length (NEaL/SVL), eye length (EyL/SVL), snout to collar length (SCL/SVL), forearm length (FAL/SVL), forelimb length (FLL/SVL), lower leg length (LLL/SVL), foot length (FoL/SVL), and hindlimb length (HLL/SVL).

Head length, lower legs length, and hind limb length of *L. belliana* was the longest parameters compared to other species.

L. boehmei showed three morphological characters with no significant difference compared to other species including length from the posterior of the eye to the anterior of the ear opening (EyEaL/SVL), width from right nostril to left nostril (NW/SVL), and length from the shoulder joint to the elbow joint (UAL/SVL). These comparisons suggested that *L. boehmei* differs from other congeneric species and supported Darevsky and Kupriyanova (1993) who accorded the full species status to this form.

The mean relative parameters between sexes were compared using the analysis of variance. *L. b. belliana* exhibited one morphological character with significant difference between male and female which was hindlimb length (HLL/SVL).

Males and females of *L. b. ocellata* displayed significantly different in nostril to ear opening length (NEaL/SVL) which the males showed higher degree of this parameters than the females.

L. r. rubritaeniata had six morphological characters with significant differences in sexes, the snout-vent length (SVL), tip to mouth length (SML/SVL), nostril to ear opening length (NEaL/SVL), upper leg length (ULL/SVL), lower leg length (LLL/SVL), and hindlimb length (HLL/SVL). The mean of these parameters in males was higher than in males.

All of *L. boehmei* samples were female. They were morphologically similar which supported the status of parthenogenetic species.

To conclude the morphological characters dealing with the butterfly lizards from Thailand, a conclusive key to the individual taxa has been attempted.

Key to species of the genus *Leiolepis* in Thailand

- 1 Black and orange or yellow bars along the entire flank of both sexes are clear and complete.....2
- No Black and orange or yellow bars along the entire flank of both sexes.....3
- 2 Numerous large grey or pale yellow oval spots with black edges forming a reticulum. Longitudinal stripes only appear in the pelvic region. Chin is red in female.....*L. belliana ocellata* (Fig. 4.5)
- Small yellow oval spots and black edges not forming a reticulum. Three or less longitudinal stripes on the back.....*L. belliana belliana* (Fig. 4.4)
- 3 Black and orange or yellow bars are present only in male, extend about half of the entire flank. Small dorsal spots with black edges forming a reticulum on the back. small pale ocelli located within the spots.....*L. reevesii rubritaeniata* (Fig. 4.6)
- Two pale yellow continuous longitudinal lateral stripes. Pale ocelli on a dark polygonal network on the back. Light vertical bars are present along the entire flank. Head is light grey or olive with small pale yellowish spot on the lower eyelid.....*L. boehmei* (Fig. 4.7)

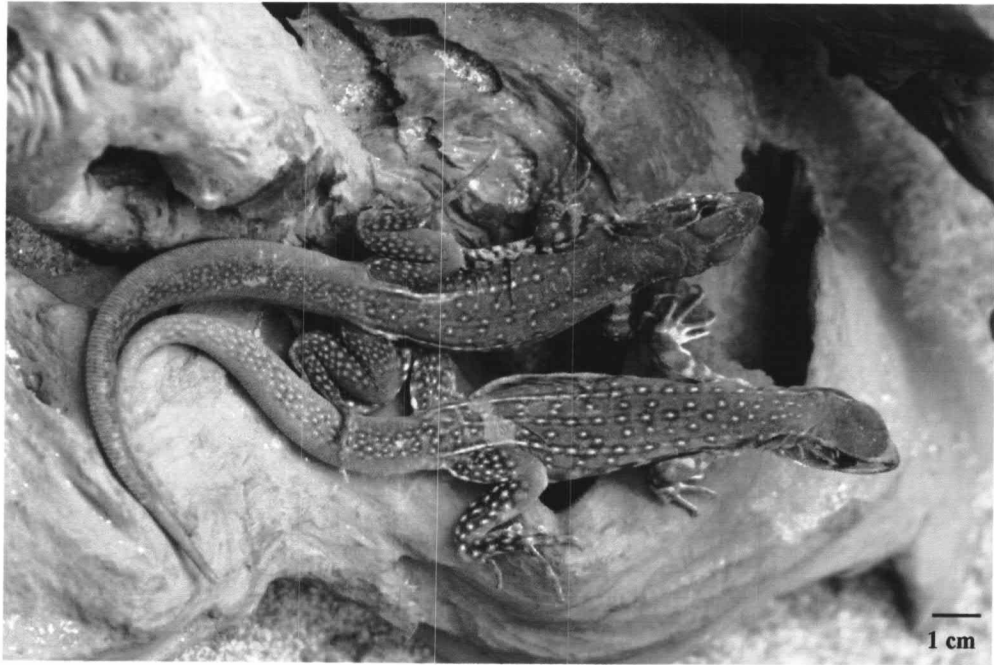


Figure 4.4 *Leiolepis belliana belliana*.



Figure 4.5 *Leiolepis belliana ocellata*.

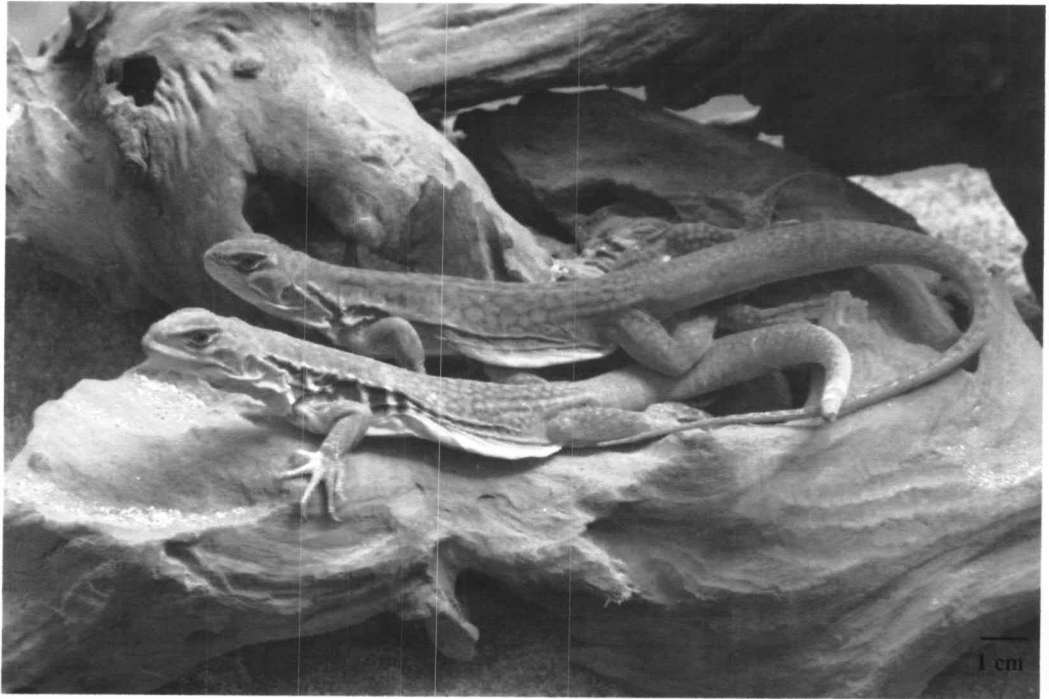


Figure 4.6 *Leiolepis reevesii rubritaeniata*.

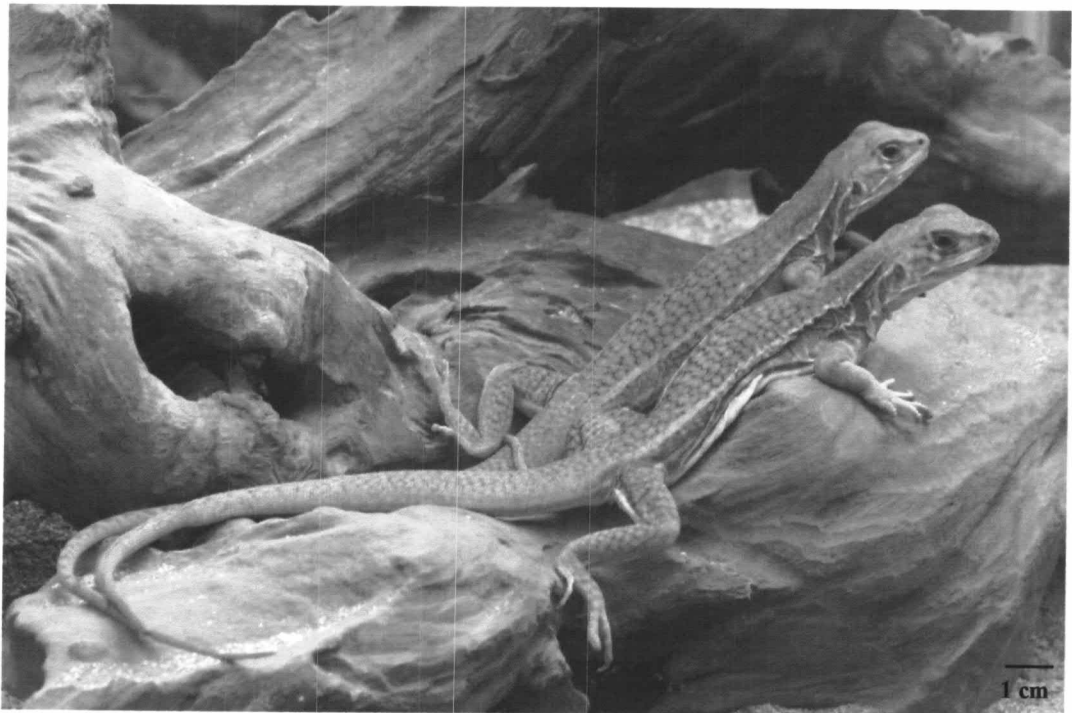


Figure 4.7 *Leiolepis boehmei*.

APPENDIX

Voucher specimens deposited in the Chulalongkorn University Museum of Zoology were proceeded by CUB MZ R.

Voucher specimens: *Leiolepis boehmei*, CUB MZ R 2004.1-22, Hua si, Nakhon Si Thammarat Province; CUB MZ R 2004.26-45, Cha Na, Songkhla; CUB MZ R 2004.51-55, Muang, Songkhla; CUB MZ R 2004.61-65, Thepha, Songkhla. *Leiolepis belliana belliana*, CUB MZ R 2004.66-69, Chonburi; CUB MZ R 2004.70-73, Chumpon; CUB MZ R 2004.74-78, Kanchanaburi; CUB MZ R 2004.79-83, Narathiwat; CUB MZ R 2004.84-88, Nakhon Ratchasima; CUB MZ R 2004.89-93, Nakhon Si Thammarat; CUB MZ R 2004.94-97, Pattani; CUB MZ R 2004.98-101, Phangnga; CUB MZ R 2004.102-105, Phetchaburi; CUB MZ R 2004.106-111, Phitsanulok; CUB MZ R 2004.112-116, Phuket; CUB MZ R 2004.117-121, Ranong; CUB MZ R 2004.122-126, Ratchaburi; CUB MZ R 2004.127-132, Rayong; CUB MZ R 2004.133-136, Satun; CUB MZ R 2004.137-140, Yala. *Leiolepis belliana ocellata*, CUB MZ R 2004.141-156, Lampang; CUB MZ R 2004.156-166, Nan; CUB MZ R 2004.167-186, Phayao; CUB MZ R 2004.187-201, Tak. *Leiolepis reevesii rubritaeniata*, CUB MZ R 2004.202-206, Amnat Charoen; CUB MZ R 2004.207-214, Buri Ram; CUB MZ R 2004.215-222, Kalasin; CUB MZ R 2004.223-230, Loei; CUB MZ R 2004.231-236, Mukdahan; CUB MZ R 2004.237-246, Nakhon Ratchasima; CUB MZ R 2004.247-253, Nong Khai; CUB MZ R 2004.254-261, Roi Et; CUB MZ R 2004.262-265, Sa Kaeo; CUB MZ R 2004.266-273, Sakhon Nakhon; CUB MZ R 2004.274-279, Si Sa Ket; CUB MZ R 2004.280-287, Surin; CUB MZ R 2004.288-292, Ubon Ratchathani; CUB MZ R 2004.293-299, Yasothon.