

MORPHOLOGICAL CHARACTERISTICS OF THE GARDEN LIZARD POPULATIONS *Calotes versicolor* (Daudin, 1802) (Squamata: Agamidae: Draconinae) IN THANH HOA, NGHE AN, AND HA TINH PROVINCES

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Abstract. The Garden Lizard populations *Calotes versicolor* have much difference in the number of lamellas under fingers and toes, size of the leg, and parts of the head. The snout-vent length is more related closely to head length (R^2 : 0.7300-0.8846) than tail length (R^2 : 0.6508-0.8324) and trunk length (R^2 : 0.6829-0.7509). There have been interruptions of geographical variation and morphological differences between the populations in Thanh Hoa and those in Nghe An and Ha Tinh.

Keywords: North Central Vietnam, taxonomy, geographical variation.

1. INTRODUCTION

The Garden lizard *Calotes versicolor* has a large distribution, from West Asia area, across Pakistan, India, to south-west China, Southeast Asia, and Indonesia (Smith, 1935; Bourret, 1943; Nguyen et al., 2009; Truong Quang Nguyen, 2011; Hoang Xuan Quang et al., 2012). The geographical and ecological distribution of the garden lizards in Indochina (including Vietnam) was also studied by Bain and Hurley (2011). In Vietnam, *Calotes versicolor* was first recorded in Tay Nguyen, and distributed in habitats that are less than 915 m (Smith, 1935). After, Bourret (1937) also recorded the Garden lizards in Vinh (Nghe An province) and Nha Trang (Khanh Hoa province), with SVL (Snout-vent length) and TailL (Tail length) measurements of 88 mm + 213 mm and 78 mm + 220 mm, respectively. The continuous studies have further documented the distribution of garden lizards in various geographical regions of Vietnam including the Northwest, Northeast, North Central, Central, and Southern parts (Nguyen et al., 2009).

Several studies on the taxonomy of *Calotes versicolor* have been published. Nguyen & Ho (1996), Nguyen et al. (2005, 2009) provide insights into the taxonomy of Amphibians and Reptiles in Vietnam, including the taxonomy of *Calotes versicolor*. Hoang XQ (1993) also contributed a key to species identification and described morphological characteristics of species in the genus *Calotes* in North Central Vietnam. Borbov and Semenov (2008) also contributed to identification keys and provided abstracts on morphological characteristics and distribution maps of lizards in Vietnam, including

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Calotes versicolor. Nguyen Quang Truong (2011) conducted a detailed study on Agamidae family in North Vietnam analyzing morphological characteristics, geographical distribution, and proposing the separation of internal species of the Garden lizards based on molecular data.

Previous studies on morphological characteristics, biology, taxonomy, and the geographical distribution of *Calotes versicolor* have shown that the garden lizards in Indian, Pakistan have a larger body size compared to those in Indochina. Body sizes SVL and TailL range from 120 + 300 - 350 (India) and 90 + 290 (Pakistan), while in Vietnam they range from 82 - 87 + 237 - 246 (this study); and have a geographical variation about body scales, lamellas of IV toes,... (Smith, 1935; Bourret, 1943). Similarly, Aufenberg and Rehmann (1993) studied clina variation in body scales, angles of body scale, gular scales, and lamellas of fourth toes of *Calotes versicolor* in South Asia, including Pakistan, India, Myanmar, also highlighting differences between the northern Pakistan population and others.

Based on molecular data, Zug et al. (2006) suggested that the Garden lizard has two groups: Indian-Myanmar and Myanmar - Southeast Asia, and two new species from the Central dry zone of Myanmar are described. In 2004, Hoang & Hoang studied two populations of the Garden lizard in Nghe An province, Vietnam. The authors analyzed the differences in morphological and biological characteristics between two populations in Vinh city and Nghia Dan district. The survey results showed differences in infralabials, the number of lamellas on the first finger, and the number of body scales. However, studies on the morphological variation of this species are rare in Vietnam.

In this paper, we present the results of analyzing geographical variety and the separation of morphological characteristics between the Garden lizard's populations in Thanh Hoa, Nghe An, and Ha Tinh provinces, belonging to North Central Vietnam. This area consists largely of hills and mountains, and the deltas are classified as accretion and abrasion deltas (Vu, 2010).

The climate of the area is tropical monsoon, with cold in the winter, and rain in the summer. In Thanh Hoa province, there are two months where the temperature falls below 18.0 °C (17.1 °C in January, 17.2 °C in February) with an average temperature of 23.6 °C; Nghe An and Ha Tinh provinces experience only one month with temperature below 18.0 °C (January, Nghe An 17.6 °C and Ha Tinh 17.4 °C), with average temperature 23.9 °C (Nguyen et al., 2000). Additionally, the study area spans two geographic landscape regions: Thanh Hoa belongs to the Hoa Binh - Thanh Hoa region; Nghe An and Ha Tinh belong to the Nghe - Tinh region (Vu, 2010).

2. MATERIALS AND METHODS

Analyzed 88 specimens of the Garden lizards: 30 specimens were collected by Le Thi Tuyen, Tran Van Tuan, Tran Thanh Tay, from May 05-07, 2019 in Thong Nhat town (Yen Dinh district, Thanh Hoa province); 33 specimens were collected by Luu Thi Thuong, Tran Van Tuan, from May 01-10, 2019, in Nghia Phu commune (Tan Ky District, Nghe An Province); and 25 specimens were collected by Le Quang Vinh, from

April 30 to May 06, 2019, in Huong Phong town (Huong Khe district, Ha Tinh province). Specimens were collected by hand, preserved in 80% ethanol, and deposited in the collection of the Zoological Laboratory, Vinh University.

Species were identified according to the materials by Smith (1935), Bourret (1943), Dao Van Tien (1979), Borbov and Xemenov (2008), Nguyen (2011), Hoang et al. (2012).

Morphological characteristics were analyzed according to Hoang et al. (2012), Ngo and Nguyen (2015). Morphological measurements included: snout-vent length (SVL); tail length (TailL); tail wide (TailW); head length (HL); head wide (HW); head high (HH); orbital diameter (OrbD); ear length (EarL); trunk length (TrunkL); crus length (CrusL); shin length (ShinL); toe^{4th} length, including claw (4TL); toe^{5th} length, including claw (5TL); forearm length (ForeaL); snout-ear distance (SnEar); snout-eye distance (SnEye); nasal-eye distance (NarEye); eye-ear distance (EyeEar); distance between two supranasal; distance between nares (InterNar); interorbital distance (InterOrb); distance from snout to shoulder (SFL). Supralabials (SL); infralabials (IL); supraciliary (SpC); scale rows around midbody (SMB); scales across back (SAB); scales across the belly in the middle of the body (SB), scales along the belly (SLB); the number of sub-digital lamellae: under fingers I (FIS), fingers III (FIIS), fingers IV (FIVS), under toes I (TIS), toes III (TIIS), toes IV (TIVS).

A linear regression method was used to determine the correlation between snout-vent length (SVL) and tail length (TailL), head length (HL), and trunk length (TrunkL). Variation characteristics of populations were analyzed by the coefficient of variation (CV), differences between populations compared by the coefficient of difference (CD), and T-test. The PCA method was employed to determine relationships between populations by creating scattering charts and analyzing the incorporation of morphological indicators that show differentiation in populations (Mayr, 1974).

3. RESULTS

3.1. Morphological characteristics of *Calotes versicolor*

Calotes versicolor (Daudin, 1802)

Agama versicolor F. M Daudin 1802. Hist. Nat. Gen. Rept, Paris, 3:395

Agama tiedmanni H. Kuhl, 1820

Calotes cristatus Jacquemont, 1844

Calotes viridis J. E Gray, 1846

Description. Head length 1.5 times its width; head width and height nearly equal; eyes with eyelids and small scales, no spines on the orbit; tympanum shallow and clear, with two separate spines above, spines less than 2 mm high. The row of spines extends from the nuchal and the neck, continuing along the mid-dorsum to the lower backward.

The frontal-parietal is slightly concave with sharp ridges on the cheek and supraocular; nostril round, nasal touching the first supralabial; rostral rectangle, width double the height, boarded by five small scales and two supralabials; mental triangular, its

border larger than rostral. Four post-mental pairs, the first pair in contact with the mental and the first infralabial; the next pair separated from the infralabials by one or two rows of small scales. Supralabials 10-11; infralabials 9-11 on each side.

The head scales smooth, heterogeneous, scales on the frontal larger than on the occipital; dorsal scales are larger than ventral scales, clamping towards the back and upwards; scales row around midbody 39-46; sub-digital lamellae under toe IV (TIVS) 21-25; indent before shoulder and gular pouch absent.

Coloration. Dorsum dark brown, light brown, or gray; lateral sides with rectangle or triangular dark brown bands, 2-4 scales wide, arranged in opposite or staggered on either side; jaw angle marked by a bluish-black or pale green streak extending to the neck, the shoulders, and slightly below the chin.

Measurements.

Measurements morphological of Garden Lizards populations in study areas are shown in Table 1.

Table 1. *The morphological measurements of Garden lizard populations in Thanh Hoa, Nghe An, Ha Tinh provinces*

No.	Characters	Thanh Hoa (n = 30)		Nghe An (n = 33)		Ha Tinh (n = 25)	
		X ± mx	CV	X ± mx	CV	X ± mx	CV
Measurements							
1	SVL	83.18 ± 1.13	0.07	82.35 ± 1.28	0.09	83.30 ± 1.44	0.09
2	TailL	241.87 ± 2.80	0.06	238.28 ± 3.28	0.08	245.39 ± 4.99	0.10
3	TailW	9.09 ± 0.20	0.12	9.23 ± 0.17	0.11	9.26 ± 0.33	0.18
4	HL	25.30 ± 0.40	0.09	23.45 ± 0.44	0.11	24.88 ± 0.58	0.12
5	HW	14.67 ± 0.21	0.08	15.01 ± 0.39	0.15	14.84 ± 0.35	0.12
6	HH	13.48 ± 0.22	0.09	13.16 ± 0.26	0.11	13.65 ± 0.40	0.15
7	OrbD	7.01 ± 0.11	0.09	6.91 ± 0.16	0.13	6.72 ± 0.15	0.12
8	EarL	2.73 ± 0.07	0.15	3.15 ± 0.07	0.12	2.96 ± 0.06	0.11
9	TrunkL	39.59 ± 0.57	0.08	40.44 ± 0.61	0.09	39.53 ± 0.72	0.09
10	CrusL	19.92 ± 0.27	0.08	19.12 ± 0.26	0.08	19.20 ± 0.30	0.08
11	ShinL	19.19 ± 0.20	0.08	18.28 ± 0.24	0.07	18.59 ± 0.32	0.09
12	4TL	17.02 ± 0.19	0.06	16.23 ± 0.18	0.06	16.98 ± 0.29	0.08
13	5TL	11.26 ± 0.18	0.09	10.70 ± 0.13	0.07	11.30 ± 0.22	0.10
14	ForeaL	11.32 ± 0.16	0.08	13.68 ± 0.22	0.09	12.17 ± 0.26	0.11
15	SnEar	19.27 ± 0.24	0.07	18.83 ± 0.35	0.11	19.01 ± 0.44	0.12
16	SnEye	8.47 ± 0.15	0.10	8.54 ± 0.20	0.13	8.56 ± 0.20	0.12
17	NarEye	3.70 ± 0.08	0.12	4.66 ± 0.12	0.14	3.78 ± 0.13	0.17
18	EyeEar	4.57 ± 0.08	0.10	5.47 ± 0.15	0.16	4.64 ± 0.15	0.16
19	INS	4.21 ± 0.13	0.17	4.12 ± 0.15	0.21	3.07 ± 0.14	0.23
20	InterNar	5.22 ± 0.15	0.16	5.58 ± 0.10	0.10	5.52 ± 0.12	0.11
21	InterOrb	2.51 ± 0.06	0.12	2.72 ± 0.03	0.07	2.64 ± 0.06	0.12
22	SFL	30.05 ± 0.46	0.08	29.29 ± 0.58	0.11	30.79 ± 0.71	0.12

PHẦN 1. NGHIÊN CỨU CƠ BẢN TRONG SINH HỌC

No.	Characters	Thanh Hoa (n = 30)		Nghe An (n = 33)		Ha Tinh (n = 25)	
		$\bar{X} \pm mx$	CV	$\bar{X} \pm mx$	CV	$\bar{X} \pm mx$	CV
Counts							
23	SL	10.03 ± 0.12	0.07	9.67 ± 0.12	0.07	10.12 ± 0.12	0.06
24	IL	10.27 ± 0.12	0.07	9.55 ± 0.11	0.06	10.00 ± 0.12	0.06
25	SpC	11.30 ± 0.13	0.07	11.27 ± 0.10	0.05	11.16 ± 0.15	0.07
26	SMB	41.57 ± 0.31	0.04	42.85 ± 0.18	0.02	43.32 ± 0.30	0.03
27	SAB	6.60 ± 0.09	0.07	7.39 ± 0.10	0.07	6.72 ± 0.15	0.11
28	SB	13.73 ± 0.10	0.04	13.58 ± 0.16	0.07	14.28 ± 0.15	0.05
29	SLB	14.03 ± 0.13	0.05	14.00 ± 0.14	0.06	14.56 ± 0.12	0.04
30	FIS	8.40 ± 0.09	0.06	7.33 ± 0.09	0.07	7.24 ± 0.09	0.06
31	FIIS	18.60 ± 0.13	0.04	16.76 ± 0.24	0.08	17.48 ± 0.13	0.04
32	FIVS	18.90 ± 0.13	0.04	17.73 ± 0.12	0.04	17.88 ± 0.12	0.03
33	TIS	8.60 ± 0.10	0.06	7.48 ± 0.10	0.07	7.32 ± 0.10	0.07
34	TIIS	18.90 ± 0.11	0.03	17.91 ± 0.13	0.04	18.12 ± 0.15	0.04
35	TIVS	23.73 ± 0.13	0.03	23.39 ± 0.15	0.04	23.48 ± 0.16	0.04

In the Thanh Hoa population, the degree of variation of characteristics: population ranges from 0.03 to 0.17. The highest levels of variation belong to INS (CV 0.17), InterNar (CV 0.16), and EarL (CV 0.15). Following are the TailW, InterOrb, and NarEye (CV 0.12). The count characteristics have lower variation (CV 0.03–0.07), with TIIS and showing the lowest variation TIVS (CV 0.03), along with SMB, SB, FIIS, and FIVS (CV 0.04).

In Nghe An population, the degree of variation ranges from 0.02 to 0.21. Characteristics showing high levels of variation include INS (CV 0.21), EyeEar (CV 0.16), HW (CV 0.15), NarEye (CV 0.14), OrbD, and SnEye (CV 0.13), along with EarL (CV 0.12). The lowest variations belong to SMB (CV 0.02), FIIS, TIIS, and TIVS (CV 0.04).

In Ha Tinh population, the degree of variation ranges from 0.03 to 0.23; the highest level of variation is observed in INS (CV 0.23), TailW (CV 0.18), NarEye (CV 0.17), EyeEar (CV 0.16), HH (CV 0.15). The lowest variation is observed in SMB, FIVS (CV 0.03), FLB, FIIS, TIIS, and TIVS (CV 0.04).

For comparison of the difference between populations, the coefficient of difference is calculated for each pair of populations (Table 2).

Table 2. Comparison of the difference between Garden lizard populations

No.	Characters	Thanh Hoa - Nghe An		Thanh Hoa - Ha Tinh		Nghe An - Ha Tinh	
		CD	t	CD	t	CD	t
1	SVL	0.06	0.47	0.01	0.06	0.07	0.48
2	TailL	0.10	0.81	0.09	0.63	0.16	1.22
3	TailW	0.07	0.52	0.06	0.44	0.01	0.08
4	HL	0.39	3.02*	0.08	0.59	0.26	1.96
5	HW	0.10	0.73	0.06	0.41	0.04	0.31
6	HH	0.12	0.91	0.05	0.39	0.14	1.04
7	OrbD	0.06	0.47	0.21	1.53	0.12	0.87
8	EarL	0.53	4.15	0.33	2.33	0.26	1.92

No.	Characters	Thanh Hoa - Nghe An		Thanh Hoa - Ha Tinh		Nghe An - Ha Tinh	
		CD	t	CD	t	CD	t
9	TrunkL	0.13	0.99	0.01	0.07	0.13	0.95
10	CrushL	0.27	2.08	0.24	1.72	0.03	0.21
11	ShinL	0.37	2.84*	0.22	1.62	0.10	0.76
12	4TL	0.38	2.94*	0.01	0.10	0.31	2.28
13	5TL	0.32	2.47	0.02	0.14	0.32	2.40
14	ForeaL	1.11	8.46*	0.39	2.85*	0.59	4.37*
15	SnEar	0.13	1.00	0.07	0.53	0.04	0.31
16	SnEye	0.04	0.29	0.05	0.35	0.01	0.05
17	Nar Eye	0.86	6.55*	0.08	0.55	0.68	4.99*
18	EyeEar	0.69	5.05*	0.06	0.45	0.52	3.78*
19	INS	0.05	0.42	0.80	5.77*	0.67	4.89*
20	InterNar	0.27	2.06	0.21	1.50	0.05	0.40
21	InterOrb	0.43	3.28*	0.20	1.46	0.17	1.23
22	SFL	0.13	0.99	0.12	0.88	0.22	1.61
23	SL	0.27	2.13	0.07	0.50	0.35	2.59
24	IL	0.56	4.38*	0.21	1.52	0.38	2.83*
25	SpC	0.02	0.16	0.09	0.68	0.09	0.64
26	SMB	0.47	3.57*	0.55	3.94*	0.19	1.39
27	SAB	0.77	5.95*	0.10	0.71	0.52	3.93*
28	SB	0.11	0.79	0.42	3.04*	0.42	3.08*
29	SLB	0.02	0.17	0.41	2.92*	0.40	2.86*
30	FIS	1.04	8.12*	1.25	9.02*	0.10	0.70
31	FIIS	0.88	6.40*	0.82	5.92*	0.35	2.35
32	FIVS	0.86	6.71*	0.78	5.63*	0.12	0.89
33	TIS	1.00	7.83*	1.24	8.92*	0.16	1.17
34	TIIS	0.73	5.65*	0.59	4.29*	0.14	1.05
35	TIVS	0.22	1.67	0.16	1.19	0.05	0.38

Notes: * The different characters were statistically significant with $p < 0.01$.

The populations of *C. versicolor* in Thanh Hoa and Nghe An showing 16 morphological characteristics (45.71%) are differences statistically significant at 99% confidence level. The most significant differences are observed count characters such as: FIS (CD: 1.04; t 8.12; $p < 0.01$), TIS (CD 1.0; t 7.83; $p < 0.01$), FIIS (CD: 0.88; t 6.4; $p < 0.01$), FIVS (CD: 0.86; t 6.71; $p < 0.01$), SAB (CD: 0.77; t 5.95; $p < 0.01$).

Conversely, between the populations in Thanh Hoa and Ha Tinh showing 10 morphological indicators are statistically significant differences, belonging to the number of sub-digital lamellae under toe and finger: FIS (CD: 1.25; t 9.02; $p < 0.01$), FIIS (CD: 0.82; t 5.92; $p < 0.01$), FIVS (CD: 0.78; t 5.63; $p < 0.01$), TIS (CD: 1.24; t 8.92; $p < 0.01$), TIIS (CD: 0.59; t 4.29; $p < 0.01$).

Between Nghe An and Ha Tinh populations, eight morphological characteristics are significantly differences. The differences are predominantly in measurements such as

NarEye ($CD\ 0.68; t\ 4.99; p < 0.01$), INS ($CD\ 0.67; t\ 4.89; p < 0.01$), ForeaL ($CD\ 0.59; t\ 4.37; p < 0.01$), and EyeEar ($CD\ 0.52; t\ 3.78; p < 0.01$). Characteristics like SAB, SB, SLB indicate the lowest level of difference, with SD from 0.40 to 0.52 ($p < 0.01$).

3.2. Linear relationship in morphological characteristics

The relationship between the snout-vent length (SVL) and other measurements such as tail length (TailL), head length (HL), and trunk length (TrunkL) is shown in Figures 1 to 3.

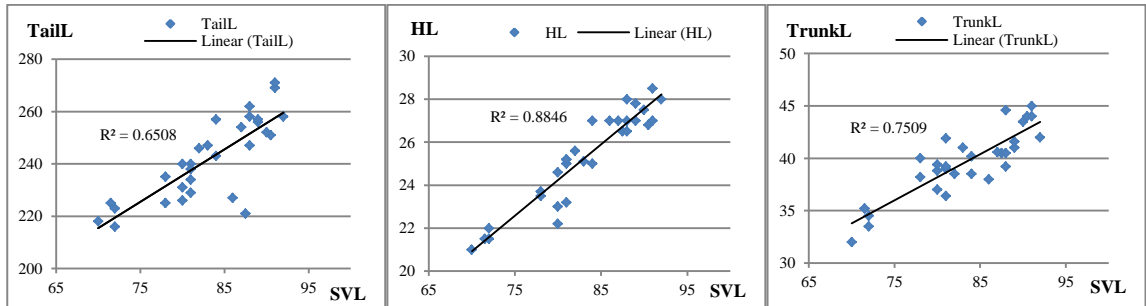


Fig. 1. The linear relationship between SVL with TailL, HL, TrunkL of the Garden lizard population in Thanh Hoa

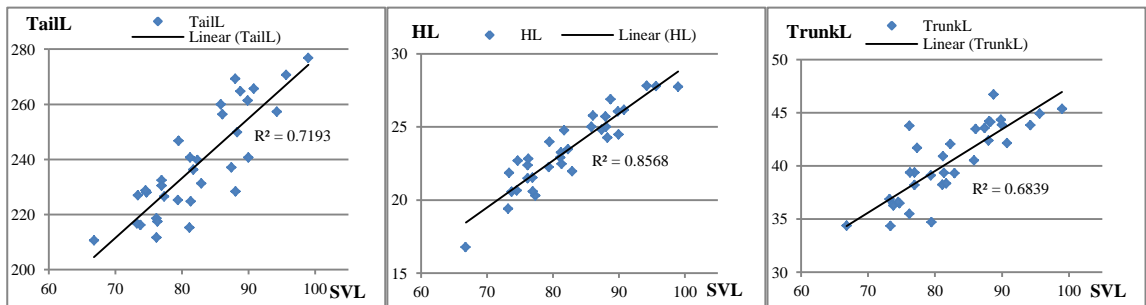


Fig. 2. The linear relationship between SVL with TailL, HL, TrunkL of the Garden lizard population in Nghe An

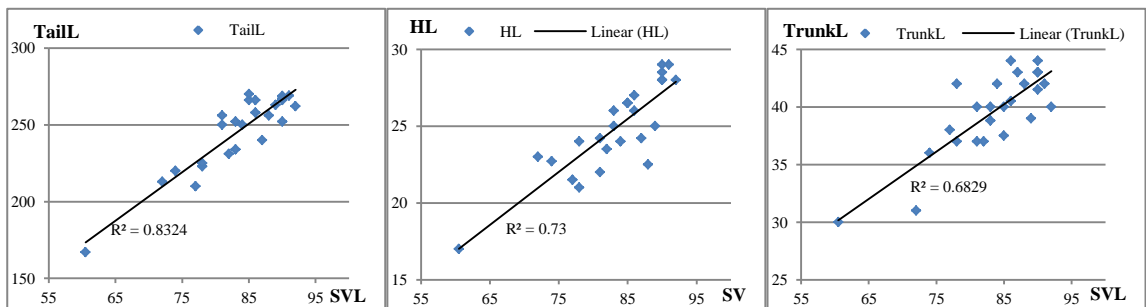


Fig. 3. The linear relationship between SVL with TailL, HL, TrunkL of the Garden lizard population in Ha Tinh

In the Thanh Hoa population, the relationship between SVL and HL is tightest ($R^2 = 0.8846$) compared to SVL with TrunkL ($R^2 = 0.7509$), and SVL with TailL ($R^2 = 0.6508$).

In Nghe An population, the relationship between SVL and HL is tight ($R^2 = 0.8568$); SVL with TailL, also SVL with TrunkL are less tight than (SVL-TailL: $R^2 = 0.7139$; SVL-TrunkL: $R^2 = 0.6839$).

In the Ha Tinh population, the relationship between SVL with TailL is tightest ($R^2 = 0.8324$) compared to SVL with HL ($R^2 = 0.73$) and SVL with TrunkL ($R^2 = 0.6829$).

If calculated for all three populations, SVL with HL has the relationship tightest with $R^2 = 0.7683$; the next is SVL - TailL with $R^2 = 0.7217$; between SVL with TrunkL have a relationship is less tighter than with $R^2 = 0.6755$.

3.3. The differentiation of study populations

Table 3 shows several morphological characteristics which have interruption between populations include sequential variation.

Table 3. Geographical variation of some morphological characteristics in populations

Characters	Thanh Hoa (n = 30)		Nghe An (n = 33)		Ha Tinh (n = 25)	
	X ± mx	CV	X ± mx	CV	X ± mx	CV
TailW	9.09 ± 0.20	0.12	9.23 ± 0.17	0.11	9.26 ± 0.33	0.18
OrbD	7.01 ± 0.11	0.09	6.91 ± 0.16	0.13	6.72 ± 0.15	0.12
SnEye	8.47 ± 0.15	0.10	8.54 ± 0.20	0.13	8.56 ± 0.20	0.12
SMB	41.57 ± 0.31	0.04	42.85 ± 0.18	0.02	43.32 ± 0.30	0.03
FIS	8.40 ± 0.09	0.06	7.33 ± 0.09	0.07	7.24 ± 0.09	0.06
TIS	8.60 ± 0.10	0.06	7.48 ± 0.10	0.07	7.32 ± 0.10	0.07
FIIS	18.60 ± 0.13	0.04	16.76 ± 0.24	0.08	17.48 ± 0.13	0.04
FIVS	18.90 ± 0.13	0.04	17.73 ± 0.12	0.04	17.88 ± 0.12	0.03
TIIS	18.90 ± 0.11	0.03	17.91 ± 0.13	0.04	18.12 ± 0.15	0.04

The variation in morphological characteristics between populations Garden lizard populations appear to exhibit both sequential and discontinuous patterns. Sequential variations are observed either descending from Thanh Hoa to Nghe An, Ha Tinh (OrbD, FIS, TIS), or ascending (TailW, SnEye, SMB). On the other hand, an interrupted variation nature is expressed in the features FIIS, FIVS, TIIS; and the population in Thanh Hoa is larger than Nghe An and Ha Tinh populations.

Remarkable, among nine feature variations, there are six numerical features with low coefficient of variation (CV 0.03-0.08), and have significant differences ($p < 0.01$), only three measurement characteristics (TailW, OrbD, SnEye) have sequential variation but differences are not significant, these characteristics have a higher degree of variability (CV 0.09-0.18). This demonstrates the critical nature of the number of body scale rows (SMB) and sub-digital lamellae of Garden lizard populations in the geographical areas.

The result of PCA (principal component analysis) shows that in 16 of the 35 morphological characteristics studied in this work, there is a significant difference

between the Thanh Hoa population and with Nghe An and Ha Tinh populations (Fig. 4). These characteristics are divided into two groups:

- First group: SL, IL, FIS, FIIS, FIVS, TIS, TIIS, TIVS.
- Second group: ForeaL, EarL, NarEye, EyeEar, InterNar, InterOrb, SMB, and SAB.

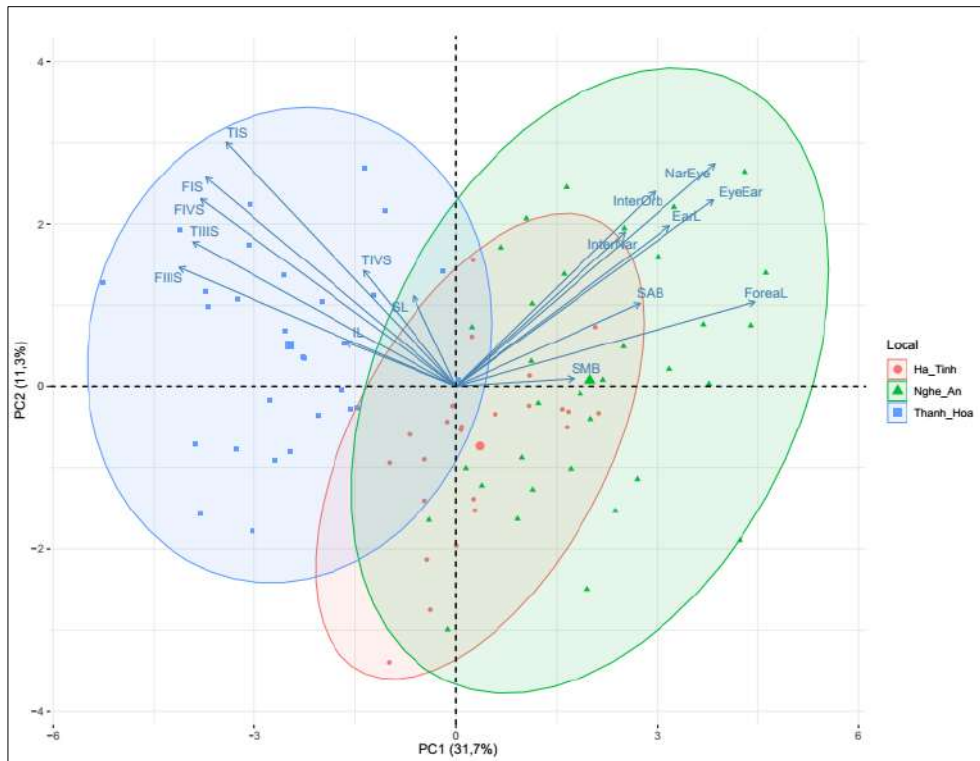


Fig. 4. Diagram expressed the differentiation between Garden lizard populations by PCA method (The length of the arrow represents the degree of difference, the length larger show that the higher significance of that trait for differentiation)

Fig. 4 shows that Thanh Hoa's population has separated, while Nghe An and Ha Tinh's populations have overlapped more, as shown in the overlap on the scatter chart. Remarkable, the characteristics expressed in the differentiation between the population of Thanh Hoa with Nghe An and Ha Tinh are discontinuous (the number of sub-digital lamellae, SL, and IL), while the differentiation direction of the populations of Nghe An and Ha Tinh is mostly continuous characteristics, interrupted characteristics appear but have little significance for differentiation (SMB, SAB).

The results by PCA are consistent with the comparison results of morphological characteristics according to geographical distribution reflected in the statistical value. The difference in topography and climate in distribution areas “appears a natural barrier determines the presence of interruptions” (according to Mayr, 1974). The study area belongs to two landscape geographical areas of the Northwest and North Central Vietnam natural geographical regions: Hoa Binh - Thanh Hoa area and Nghe Tinh area (Vu, 2010).

The disruption of morphological characteristics between the populations is closely related to the natural conditions of the geographic - landscape area, where the populations of Garden lizards are distributed.

3.4. Discussion

The morphological characteristics of *Calotes versicolor* in this study are not much different from previous studies. The population in Nghia Dan district and Vinh city, SVL 83.32-85.86, SMB 42-44, TIVS 20-25 (Hoang & Hoang, 2004); in Bach Ma National Park, SVL 78-120, SMB 43-51, TIVS 20-25 (Hoang et al., 2012) [8]; and Northern Vietnam: SVL 78-140, SMB 32-52 (Nguyen, 2011).

From statistical data, there is variation in morphological characteristics in three populations (Table 1). There are a few variations in the increasing or decreasing direction from Thanh Hoa to Ha Tinh. In the direction of increasing gradually, there is TailW (9.09-9.23-9.26), SnEye (8.47-8.54-8.56), SMB (41.57-42.85-43.32), and in the descending direction is OrbD (7.01-6.91-6.72), FIS (8.40-7.33-7.24) và TIS (8.60-7.48-7.32).

Gender difference: in the SVL, Pakistan 70-114 (♂), 64-79 (♀); India 78-138 (♂), 57-121 (♀); Myanmar, 71-91 (♂), 57-121 (♀); Thailand 73-96 (♂), 67-88 (♀) (Auffenberg và Rehmann, 1993). In the populations of study: Thanh Hoa population 70-92 (♂), 80-81 (♀); Nghe An population 73,2-99 (♂), 66,8-95,6 (♀); Ha Tinh population 74-92 (♂); 60,5-87 (♀).

The number of midbody scale rows in the study population from 39-46, less than in Pakistan, 43-48; wider range from India, 41-44; South China, 40-47; Indochina and Northern Vietnam is 32-52. The number of sub-digital lamellae under toes IV (TIVS): Pakistan 20-24, India 23-25; in this study is 21-25, not much different from the above areas, but higher than Thailand (20), Myanmar (22-23), Malaysia (23).

4. CONCLUSIONS

Morphological characteristics of *Calotes versicolor* populations in Thanh Hoa, Nghe An, and Ha Tinh within the variation range of the species compared to other distribution zones in the country as well as in neighboring areas.

There appeared discontinuous geographical variation and differentiation of morphological characteristics between Thanh Hoa with Nghe An and Ha Tinh populations. A significant characteristic of this differentiation is the number of sub-digital lamellae under the toes and fingers.

The study determined that the correlation between snout-vent length (SVL) with head length ($R^2 = 0.7300-0.8846$) was tighter than between SVL with tail length ($R^2 = 0.6508-0.8324$) and trunk length ($R^2 = 0.6829-0.7509$).

REFERENCES

Auffenberg, W., Rehmann, H., 1993. Studies on Pakistan Reptiles, pt.3 *Calotes versicolor*. Asiatic Herpetological Research, Vol. 5, pp. 14-30.

- Bain, R.H., Hurley, M.M., 2011. A Biogeographic synthesis of the Amphibian and Reptiles of Indochina. Bulletin of the American Museum of Natural History, pp. 114-115.
- Bobrov, V.V., Xemenov, D.V., 2008. Iaserisur Vietnama. Tavarisextvo Nautnuc Izdanii KMK, Moxcva.
- Bourret, R., 1937. Notes Francaise sur Herpestologiques l'Indochine. Bulletin General de l'Instruction Publique.
- Bourret, R., 1943. Comment determiner un Lizard d'Indochine. Instr. Publ. Indochine, Hanoi: pp. 1-32.
- Dao, V.T, 1979. Identification of Lizards in Vietnam. Journal of Biology, Vol. 1(1): 2–10.
- Hoang, X.Q, 1993. Contribute to the study Amphibians and Reptiles in North Central Vietnam (except sea reptile). Doc. Thesis, Biological Sciences, Hanoi University of Education, 207 pp.
- Hoang, X.Q., Hoang, N.T., Ngo, D.C., 2012. Amphibian and Reptiles in Bach Ma National Park. Agricultural Publishing House, Ha Noi, 220 pp.
- Hoang, N.T., Hoang, X.Q., 2004. Contribute to the study of biological characteristics of two populations of *Calotes versicolor* (Daudin, 1802) in Nghia Dan and Vinh city, Nghe An Province. Journal of Science, Vinh University. Vol. 23(2A): 52-60.
- Mayr, E., 1974. Principles of the classification of animals. Science & Technology Publishing House, Ha Noi.
- Ngo, D.C., Nguyen, Q.T., 2015. Investigation and monitoring of animal biodiversity. Hue University Publishing House, pp. 108-110.
- Nguyen, V.S., Ho, T.C., 1996. Checklist of Amphibians and Reptiles in Vietnam. Science & Technology Publishing House, Hanoi, 264 pp.
- Nguyen, V.S., Ho, T.C., Nguyen, Q.T., 2005. Checklist of Amphibians and Reptiles in Vietnam. Agricultural Publishing House, Ha Noi, 180 pp.
- Nguyen, V.S., Ho, T.C., Nguyen, Q.T., 2009. Herpetofauna of Vietnam. Edition Chimaira, Frankfurt am Main.
- Nguyen, Q.T., 2011. Systematics, ecology, and conservation of the Lizard fauna in Northeastern Vietnam, with special focus on the genera *Pseudocalotes* (Agamidae), *Gopidophorus* (Scincidae) from this country. Doc. Thesis, Bonn, pp. 131-132.
- Nguyen, K.V., Nguyen, T.H., Phan, K.L., Nguyen, T.H., 2000. Viet Nam's bio-climate chart. Hanoi National University Publishing House.
- Smith, M.A., 1935. The Fauna of British India, Including Ceylon and Burma, Reptilia and Amphibia, Vol. 2. Sauria. Taylor and Francis, London, 440 pp.
- Taylor, E.H., 1963. The Lizard Fauna of Thailand. Univ. Kansas Sci. Bull., Vol. XLVI, No.14, pp. 687-1077.

- Vu, T.L., 2010. Vietnamese natural geography. Pedagogical University Publishing House, Ha Noi, pp. 9-34.
- Zug, G.R., Brown, H.H.K., Schulte, II, J.A., and Vindum, J.V., 2006. Systematics of the Garden Lizards, *Calotes versicolor* Group (Reptilia, Squamata, Agamidae), in Myanmar: Central Dry Zone Populations. Reprinted from Proceedings of the California Academy of Science, Fourth Series. 57(2): 35-68.

**ĐẶC ĐIỂM HÌNH THÁI CÁC QUẦN THỂ LOÀI NHÔNG XANH
Calotes versicolor (Daudin, 1802) (Squamata: Agamidae:
Draconinae) Ở CÁC TỈNH THANH HÓA, NGHỆ AN VÀ HÀ TĨNH**

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Tóm tắt. Các quần thể Nhông xanh *Calotes versicolor* có sai khác nhiều về số lượng bản móng dưới các ngón của chi, kích thước các chi và các phần ở đầu. Dài thân (SVL) có quan hệ chặt với dài đầu (HL) ($R^2: 0,7300-0,8846$) hơn so với dài đuôi ($R^2: 0,6508-0,8324$) và dài nách bẹn (TrunkL) ($R^2: 0,6829-0,7509$). Đã xuất hiện sự ngắt quãng của biến dị địa lý và phân hóa đặc điểm hình thái giữa quần thể ở Thanh Hóa với quần thể ở Nghệ An và Hà Tĩnh.

Từ khóa: Bắc Trung Bộ, phân loại học, biến dị địa lý.

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