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Geographic variation in *Trachylepis vittata* (Olivier, 1804) (Sauria: Scincidae): two populations from the Turkish-Iranian Plateau

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In this research on the Banded Skink, *Trachylepis vittata* (Olivier, 1804), the patterns of geographic variation was analyzed for four meristic and 21 morphometric characters of this species belonging to two populations, one from western Iran and the other from Turkey. The univariate analyses including Independent sample T-test and one-way ANOVA (LSD Test) were used to explore the patterns of geographic variation. Results of the analyses indicated significant differences and a relatively clear pattern of separation between the two studied populations of *T. vittata*.

Key words: *Trachylepis vittata,* Geographic variation, Western Iran, Turkey

INTRODUCTION

The family Scincidae currently contains more than 1,300 species grouped in over 85 genera Durmuş et al. (2011). This family consists of four subfamilies: Scincinae, Acontinae, Feyliniinae and Lygosominae (Greer, 1970a). Of these, the Lygosominae contains 45 genera and over 600 species (Matsui, 1992) distributed mainly from temperate to tropical areas of the Old World (East, Southeast and South Asia, Australasia, sub-Saharan Africa, and Indian Ocean islands including Madagascar), and also in some areas of the New World Honda et al. (2003). About 100 skinks are included in the lygosomine genus *Mabuya* (sensu Greer, 1977), which is the only lizard genus with a circumtropical distribution Mausfeld et al. (2000). *Mabuya* contains about 15 Neotropical (Blackburn & Vitt, 1992) and about 30 Asian species. The largest number of *Mabuya* species (ca. 60) occur in Africa [(Greer, 1977); Mausfeld et al. (2000)]. Eleven described species are known from Madagascar [(Nussbaum & Raxworthy, 1998); Köhler et al. (1998)]. In the Indian Ocean, two endemic species are found on the Seychelles, one species on the Comoros, and one species on the small Europa Island (Brygoo, 1981). One interpretation of its wide range based on natural dispersal is that *Mabuya* first colonized the rest of southern Asia from this area, then the African plate including Arabia, and finally reached the Cape Verde islands Carranza et al. (2001) and tropical America by rafting westwards across the Atlantic ocean [(Greer, 1977); (Carranza & Arnold, 2003)]. Mausfeld et al. (2002) partitioned the collective genus *Mabuya* Fitzinger, 1826, into four genera: Asian species were placed in *Eutropis* Fitzinger, 1843, African and Malagasy species in *Euprepis* Wagler, 1830 [and subsequently *Trachylepis* Fitzinger, 1843 (Bauer, 2003)], species from the Cape Verde islands became *Chioninia* Gray, 1845, again, whereas, the South American species retained the name *Mabuya* Durmuş et al (2011).

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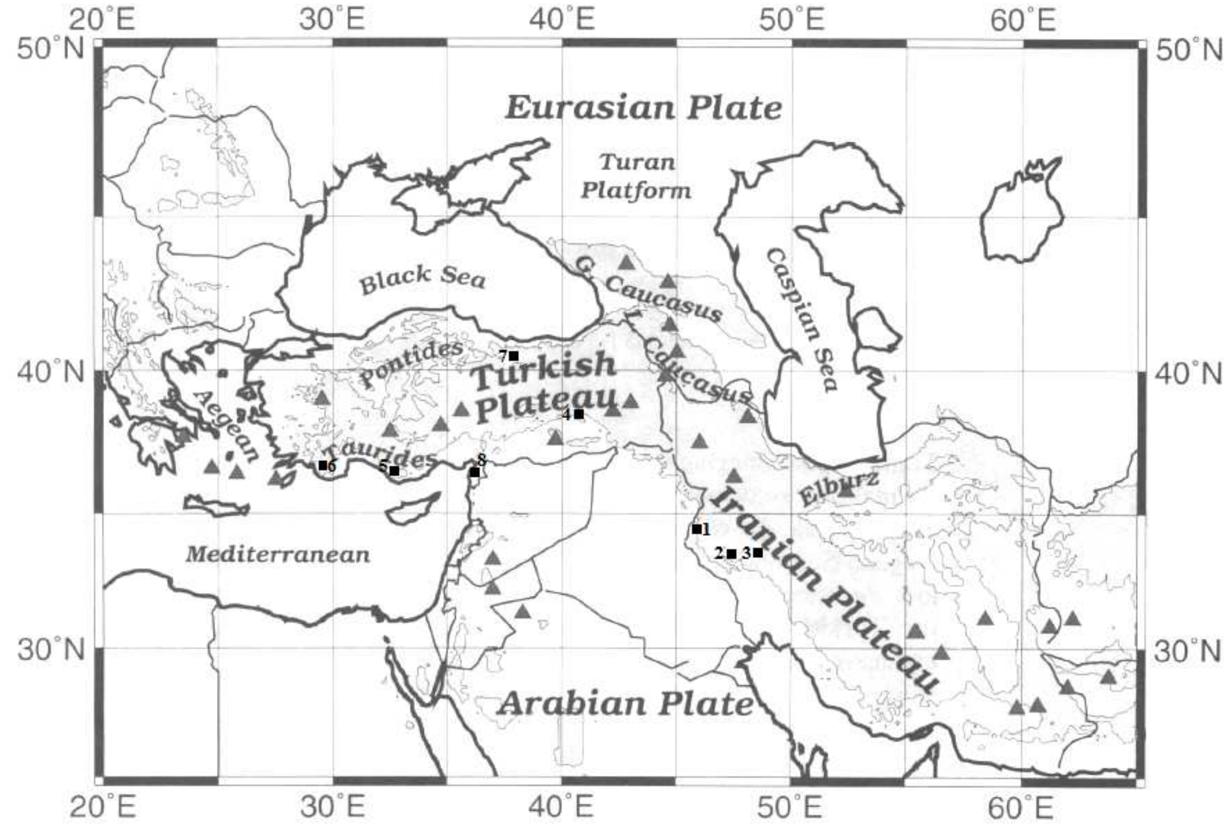

FIGURE. 1. Map of sampling localities from the Turkish-Iranian Plateau for specimens used in this research. (1) Sarpol-e zahab, (2) Darreh shahr, (3) Poldokhtar, (4) Diyarbakir, (5) Mersin, (6) Antalya, (7) Tokat, (8) Antakya.

On the Iranian Plateau, six genera of scincids consisting of about 15 species occur which are as follows: *Ablepharus* (2 species), *Scincus* (1 species), *Ophiomorus* (6 species), *Eumeces* (3 species), *Chalcides* (1 species), and *Trachylepis* (3 species) (Faizi & Rastegar-Pouyani, 2006). The genus *Trachylepis* Fitzinger, 1843 encompasses 78 species that includes three species in Iran, *T. septemtaeniata* (Reuss, 1834), found in southern regions of the Zagros Mountains; *T. aurata transcaucasica* Chernov, 1926 inhabiting northern to central parts of the Zagros Mountains, and *T. vittata* (Olivier, 1804), distributed west of the Zagros Mountains Faizi et al. (2010). Distribution of *T. vittata* shows us that Zagros Mountains carried out the main role as a great barrier to the species distribution Fattahi et al. (2013). The Bridled skink, *Trachylepis vittata*, is one of the widely distributed species of the genus occurring from western Iran to Algeria (Anderson, 1999), around Mediterranean Sea, especially Israel, Lebanon Leviton et al. (1992). The aim of this study is to explore various aspects of divergence in morphological traits among geographic populations of *T. vittata* in the Turkish-Iranian Plateau.

MATERIAL AND METHODS

A total of 28 specimens of *T. vittata* (Olivier, 1804) were collected, or borrowed from museum collections, from two localities, western regions of the Iranian Plateau (eight males and 10 females) and Turkey (four males and six females) (Fig. 1). The examined specimens, preserved in 70% ethanol, are housed in the Razi University Zoological Museum (RUZM) and Gothenburg Natural History Museum, Gothenburg, Sweden. The metric and meristic characters were measured for each specimen using digital calipers to the nearest 0.1mm (Table 1). The independent sample t-test was carried out to determine the existence of sexual dimorphism in males and females and also to explore forms and patterns of geographic variation in morphological traits between the two populations of *T. vittata*. In the next step, significant differences among the characters means investigated by the one-way ANOVA (LSD-Test). Statistical analyses were performed using the program SPSS version 16.0 and S-Plus 8.0. Analyses were carried out for males and females separately to avoid statistical bias.

RESULTS

Based on the statistical analysis (Independent sample *t*-test), existence of sexual dimorphism in the measured traits in male and female specimens of two populations of *T. vittata* showed that there is a relatively clear pattern of separation between the sexes.

UNIVARIATE ANALYSES FOR MALES

The One-way ANOVA (LSD-Test) and Independent sample *t*-test were done in male individuals of two populations of *T. vittata* to investigate the patterns of morphological variation. Results of statistical analyses exhibited significant geographic variation ($P < 0.05$) in four morphometric and one meristic characters between the two groups so that the means of metric characters such as FIL, LBT, PW, LFO were higher in the Iranian population, (Mean= 4.4, 7.4, 2.8, 11.5 mm, respectively) than in the Turkish population (Mean= 4.05, 6.04, 2.5, 10.2 mm, respectively). Also the mean scale counts from mental to anterior edge of cloaca (NMC) was significantly higher in the Iranian population (Mean= 62.4 mm) than in the Turkish population (Mean= 59.5 mm). The ranges, mean ± standard deviation (SD) for the examined characters in each population are given in Table 2. The error bar diagram for the male specimens of *T. vittata* is shown in Fig. 2.

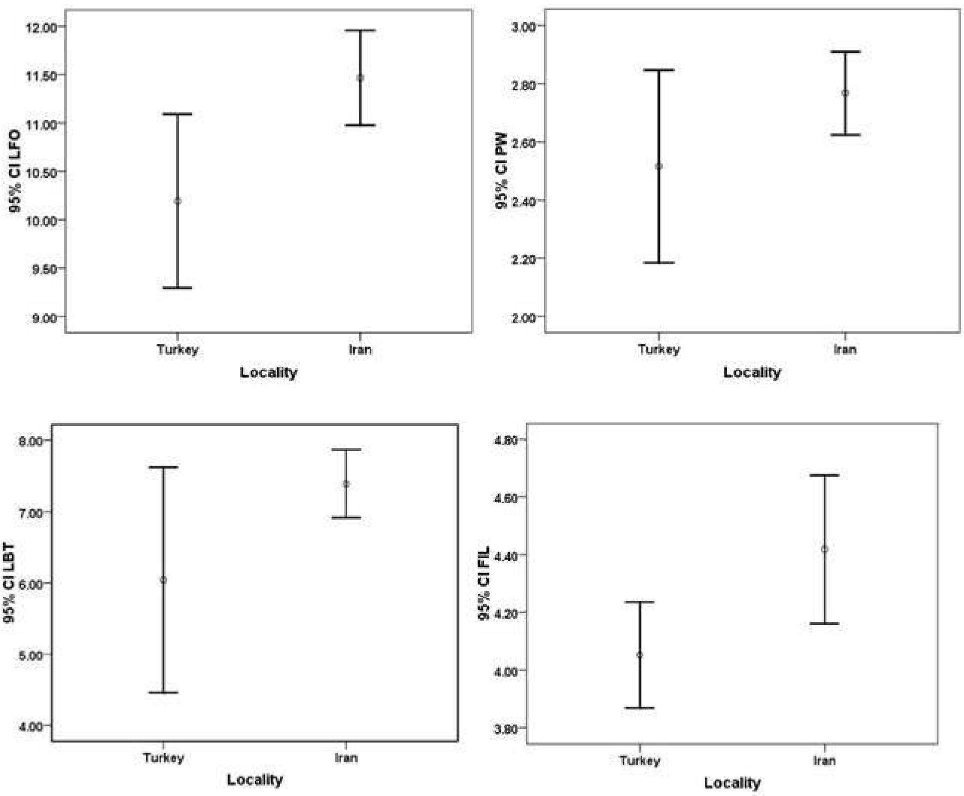

FIGURE 2. Ordination of geographic variation between male individuals of Iran and Turkish populations of *Trachylepis vittata* for significant ($P \leq 0.05$) morphological characters.

TABLE 1. The morphometric and meristic characters employed in geographic variation of *T. vittata*.

Character	Definition
SVL	Length of snout to vent (from tip of snout to anterior edge of cloaca)
HL	Head length (from tip of snout to anterior edge of tympanum)
HH	Head height (from lower edge infralabial to tip of supraocular)
LFL	Length of forelimb
LHL	Length of hindlimb
LE	Length of eye (from anterior corner to posterior corner of eye)
IORD	Interorbit distance (between anterior corner of orbit)
NL	Neck length (from the posterior edge of tympanum to anterior edge of shoulder)
SW	Snout wide
FIL	4th finger Length
MSOL	Maximum of Length of subocular
SEL	Length of snout to eye
LFO	Length of forearm
LHF	Length between hindlimb and forelimb
LCL	Length of cloaca
HHL	Length of between a hindlimb to other hindlimb
FFL	Length of between a forelimb to other forelimb
LBT	Length of widest part of tail base
FIPL	Length frontal to Interparietal (from anterior corner of frontal to posterior corner of Interparietal)
PW	wide of parietal
PL	Length of parietal
SDLT	Subdigital lamellae under the forth toe
SDLF	Subdigital lamellae under the forth finger
NDS	Number of dorsal scales around body
NMC	Number of scales from mental to anterior edge of cloaca

UNIVARIATE ANALYSES FOR FEMALES

In the One-way ANOVA and Independent sample t-test analyses, clear differences in the value of variables are revealed in female individuals of the two populations. 20 morphometric characters between pooled samples of the two examined populations of *T. vittata* were significantly different: the mean values for SVL, LH, HH, LFL, LHL, LE, IORD, NL, SW, LBT, FIPL, PW, PL, MSOL, SEL, LFO, LHF, LCL, HHL, FFL were significantly higher in the Iranian specimens than in Turkish specimens (Table 3). The error bar diagram for the females of *T. vittata* is shown in Fig. 3.

DISCUSSION

Studies of geographic variation within and among closely related taxa have provided crucial information on the nature of species and the process of speciation (Mayr, 1963). The analysis of intra- and inter-specific variation in life-history traits provides raw material for understanding evolutionary patterns. Ectotherms are of particular interest because most aspects of their morphology, behavior, physiology and reproduction are strongly influenced by environmental factors, mainly of climatic nature. In this regard, reptiles are one of the most studied taxon Zuffi et al. (2009). In this study, geographical variation was explored between two populations from the Turkish Anatolian Plateau and the Iranian Plateau in *T. vittata*. Patterns of geographic variation may be change in the apparent characteristics of individuals by altitude, latitude and longitude. The difference in these factors is caused by changes in weather, temperature, vegetation, geology, etc. These environmental variables by changes in genetic factors make a difference in individual characters. Patterns of geographic variation in individual characters (i.e., some vary with latitude,

TABLE 2. Results of One Way ANOVA (LSD-Test) and Independent sample *t*-test for measured characters of male specimens in two studied populations of *T. vittata*. Ranges, Mean ± Standard Deviation

Characters	Iran (*N* = 8)		Turkey (*N* = 4)		F-Value	P-Value
	Range	mean ± SD	Range	mean ± SD		
SVL	65.1 – 74.9	70.5 ± 3.2	51.4 – 71.6	62.8 ± 9.6	4.704	0.055
LH	11.5 – 13.1	12.3 ± 0.6	11.1 - 13	12 ± 0.99	0.494	0.498
HH	5.2 – 7.4	6.5 ± 0.7	4.9 – 6.8	5.7 ± 0.8	3.627	0.086
LFL	16 – 21	17.7 ± 1.6	15.5 – 17.3	16.3 ± 0.9	2.481	0.146
LHL	23.4 – 28.5	26.2 ± 1.7	23.1 - 31	26.4 ± 3.8	0.009	0.927
EL	2.8 – 4.3	3.3 ± 0.4	2.6 – 3.1	2.8 ± 0.2	3.828	0.079
IORD	5.1 – 6	5.5 ± 0.3	4.8 - 6	5.2 ± 0.6	1.055	0.329
NL	9.1 – 12.6	10.5 ± 1.2	8.2 – 11.8	8.2 ± 11.8	1.435	0.259
SW	3.7 – 4.7	4.1 ± 0.3	3.7 – 3.8	3.8 ± 0.1	4.443	0.061
FIL	4.1-4.8	4.4 ± 0.3	3.9 – 4.2	4.1 ± 0.1	5.076	0.048
FIPL	7.3 – 8.3	7.7 ± 0.4	7 – 8.5	7.5 ± 0.7	0.176	0.684
PW	2.5 – 3	2.8 ± 0.2	2.2 – 2.7	2.5 ± 0.2	5.039	0.049
PL	3.6 – 4.1	3.8 ± 0.2	3.4 - 4	3.7 ± 0.3	1.600	0.235
MSOL	2.3 – 3.4	2.6 ± 0.3	2.2 – 2.4	2.3 ± 0.1	2.298	0.160
SEL	5.1 – 5.9	5.4 ± 0.3	4.8 - 6	5.3 ± 0.5	0.065	0.804
LFO	10.8- 12.6	11.5 ± 0.6	9.6 – 10.7	10.2 ± 0.6	12.892	0.005
LHF	33.7 – 39.6	37.2 ± 2.3	30.3 – 36.1	34.2 ± 2.7	3.964	0.075
LCL	6.3 – 8.8	7.1 ± 0.8	4.4 – 6.6	5.9 ± 1.1	4.877	0.052
HHL	6 – 7.4	6.7 ± 0.5	5.1 – 7.2	6.2 ± 0.9	1.566	0.239
FFL	7.9 – 9.5	9.1 ± 0.5	7.8 – 9.5	8.4 ± 0.8	3.509	0.091
LBT	6.6 – 8.2	7.4 ± 0.6	4.6–6.9	6.04 ± 0.99	9.294	0.012
NMC	60 – 65	62.4 ± 1.8	59 - 60	59.5 ± 0.6	9.636	0.011
NDS	31- 33	31.9 ± 0.6	32 – 32	32 ± 0.00	0.145	0.711
SDLT	16 – 18	17 ± 0.5	16 – 17	16.8 ± 0.5	0.606	0.454
SDLF	11 – 12	11.6 ± 0.5	11 – 12	11.3 ± 0.5	1.429	0.260

TABLE 3. Results of One-way ANOVA (LSD-Test) and Independent sample *t*-test for measured characters of female specimens in two studied populations of *T. vittata*. Ranges, Mean ± Standard Deviation

Characters	Iran (N = 10)		Turkey (N = 6)		F-Value	P-Value
	Range	mean ± SD	Range	mean ± SD		
SVL	73.4 – 86.6	78.6 ± 3.9	52.4 – 76.1	66.3 ± 10.1	12.298	0.003
HL	12 – 13.8	12.6 ± 0.59	9.9 – 12.7	11.6 ± 1.1	5.321	0.037
HH	6.1 – 7.5	7 ± 0. 5	4.3 – 6.8	5.9 ± 1.05	7.998	0.013
LFL	16.2 – 19.4	18.3 ± 0.99	13.9 – 17.2	16.3 ± 1.3	13.297	0.003
LHL	26.5 – 29.5	27.6 ± 0.9	20.4 – 27.5	25.2 ± 2.5	8.008	0.013
LE	2.6 – 3.6	3.2 ± 0.3	2.7 – 3.2	2.9 ± 0.2	5.526	0.034
IORD	5.5 – 6	5.7 ± 0.19	4.3 – 5.9	5.1 ± 0.6	8.339	0.012
NL	9.9 – 12.5	11 ± 0.77	7.8 – 9.9	9 ± 1	19.509	0.001
SW	4 – 4.6	4.3 ± 0.22	3.2 – 4.2	3.8 ± 0.4	10.578	0.006
FIL	4.1 – 5	4.5 ± 0.3	3.4 – 4.8	4.3 ± 0.6	1.494	0.242
FIPL	7.7 – 8.5	8 ± 0.26	6 – 7.9	7 ± 0.8	8.939	0.010
PW	2.6 – 3.2	2.9 ± 0.16	2.1 – 2.9	2.6 ± 0.4	7.604	0.015
PL	3.7 – 4.4	4.1 ± 0.21	3.2 – 4.2	3.7 ± 0.4	6.611	0.022
MSOL	2 – 2.9	2.6 ± 0.29	1.8 – 2.6	2.2 ± 0.3	5.343	0.037
SEL	5.3 – 6	5.6 ± 0.23	4.2 – 5.9	5.2 ± 0.7	4.636	0.049
LFO	11.4 – 12.6	12.2 ± 0.42	9.1 – 11.4	10.4 ± 1	21.819	0.000
LHF	40 – 50	44 ± 2.8	31.4 – 43.2	35.7 ± 4.4	24.056	0.000
LCL	7.4 – 8.9	8.1 ± 0.52	5.4 – 7.4	6.5 ± 0.86	24.056	0.000
HHL	6.7 – 7.7	7.2 ± 0.4	5 – 6.8	6 ± 0.7	17.301	0.001
FFL	8.8 – 11.2	10.4 ± 0.7	6.7 – 9.5	8.3 ± 1.2	21.404	0.000
LBT	7.4 – 8.7	8.2 ± 0.4	5.3 – 7.9	6.7 ± 1.1	15.747	0.001
NMC	59 – 66	61.8 ± 2.4	59 – 68	62.3 ± 3.3	0.142	0.712
NDS	30 – 33	31.8 ± 0.8	30 – 32	31.3 ± 1	1.046	0.324
SDLT	16 – 18	16.8 ± 0.63	16 – 17	16.3 ± 0.52	2.318	0.150
SDLF	11 – 12	11.6 ± 0.52	11 – 12	11.3 ± 0.52	1.000	0.334

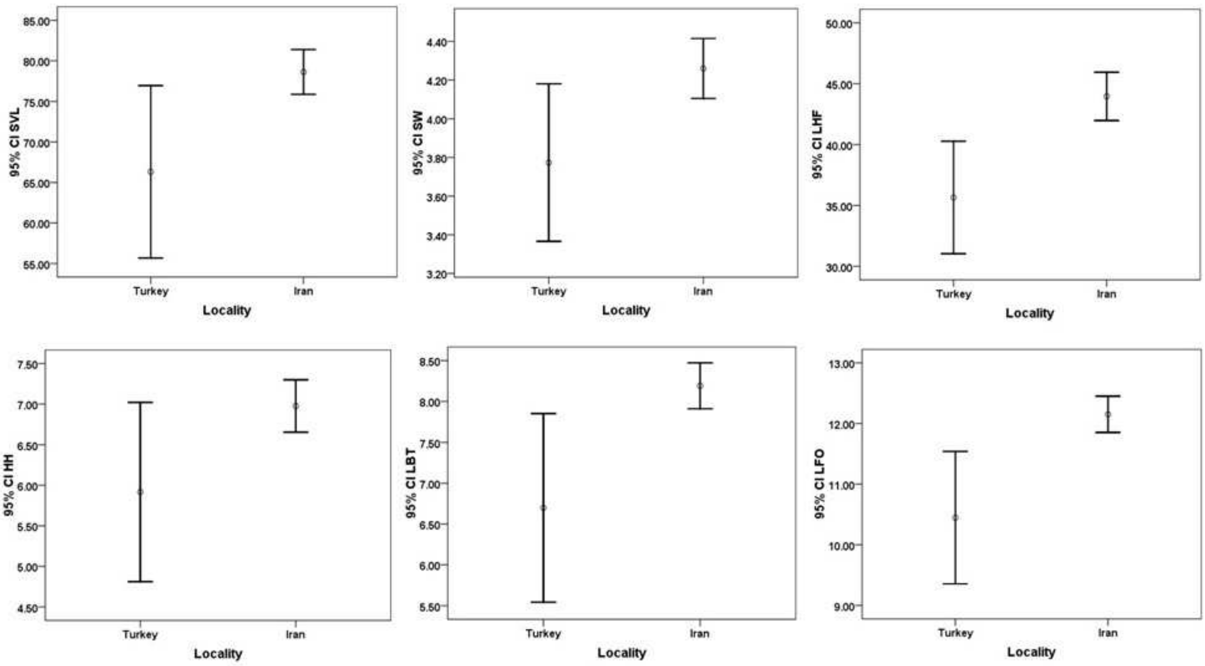

FIGURE 3. The ordination of geographic variation between the Iranian and Turkish populations of *Trachylepis vittata* (females) for significant ($P \leq 0.05$) morphological characters.

some with altitude and some with longitude) are consistent with the hypothesis that ecogenetically caused geographic variation may result in lower inter-character congruence than phylogenetically caused geographic variation Thorpe and Baez (1993). Univariate analyses revealed that the means of SVL was significantly higher in the Iranian Plateau population than in the Turkey population ($P<0.02$). It has been repeatedly argued both from theoretical and empirical bases, that the body size of vertebrate populations may change drastically in either of two directions (i.e. increasing or decreasing), chiefly depending on the presence or absence of territoriality in the animals, and the quality and quantity of available food [e.g. (Case, 1978); (Shine, 1987); (Schwaner, 1980); Kohnno and Ota (1991)]. If female body size varies geographically, thereby influencing reproduction, it has no evident independent effects on offspring characteristics. Nevertheless, climatic features (e.g. basking opportunities) play an additive role on some life-history traits (e.g. rainfall versus pre-partum body mass or average offspring body mass), thus interacting with other factors such as food availability Zuffi et al. (2009). Based on this scenario, we may assume a lower productivity in the Turkey population than the Iranian population. These explanations all assume that patterns of geographic variation in body size are the result of natural selection Ashton et al. (2000). The importance of geographic variation studies is also based on adaptation as a result of natural selection. Because character variation is assumed to be produced by adaptation. Therefore, natural selection is an important issue to understand the causes of geographic variation patterns. Patterns of geographic variation in morphology are usually described by adaptation, via natural selection Perktaş et al. (2010). *T. vittata* exhibits geographic variation in body size between the two populations from Iran and Turkey.

Furthermore, other characters, mentioned earlier, show significant differences between the females of two studied populations. The same trend is visible in males and results of the ANOVA analysis and Independent sample t-test for morphometric and meristic characters showed that in males, the Iranian individuals tend to have higher mean scale counts from mental to anterior edge of cloaca, relatively longer 4th finger, wider tail base, longer forearm, and a wider relative to the Turkish population.

In summary, the study of geographic variation between the two above-mentioned populations of *T. vittata* disclosed significant differences in external morphology between these populations. Totally, the results of statistical analyses presented very clear patterns of geographic variation between populations of this taxon from Turkey and western Iran.

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