Iranian Journal of Animal Biosystematics (IJAB)
Vol.9, No.2, 125-133, 2013
ISSN: 1735-434X

Sexual dimorphism in *Trapelus lessonae* (De Filippi, 1865) (Sauria: Agamidae) from western Iranian Plateau

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We collected 60 adult males and 85 adult females of *Trapelus lessonae* De Filippi, 1863 in early May 2008 from central Iranian plateau to study sexual dimorphism in morphological traits as well as female reproductive traits. Size-related sexual dimorphism occurred in all the compared body dimensions. The largest female was 83.88 mm in snout-vent length, and the largest male was 73.12 mm. As well, adult males were larger in head size and tail length, whereas females were larger in body size and abdomen length. Males and females also presented differences in color pattern, and in the presence of preanal pores. The results suggest that, in *Trapelus lessonae,* sexual dimorphism in size is determined by sexual selection, competition between males and fecundity selection, fecundity advantage for large female size. A pattern generated by fecundity advantages enjoyed by large females.

Key words: Agamidae, *Trapelus lessonae,* Sexual dimorphism, Sexual selection, Fecundity selection, Iranian Plateau

INTRODUCTION

Sexual dimorphism is the difference in morphology between male and female members of the same species. Sexual dimorphism includes differences in size, coloration, or body structure between the sexes. In any given species sexual size dimorphism (SSD) may be the result of differential natural and sexual selection pressures on the two sexes, as well as evolutionary, genetic and physiological constraints (Brandt et al., 2007). Charles Darwin (1871) recognized that sexual selection and natural selection may work in opposition, so that the degree of elaboration of a trait may be determined by a balance between the benefits conferred by sexual selection and the costs imposed by natural selection (Andersson, 1994).

This kind of balance between competing selective forces may control the degree of expression of many sexually selected traits (Andersson, 1994). For example, head size is largest in males under sexual selection. Individuals with wider heads could be more successful in male-male combat where jaws are the major offensive weapon (Andersson, 1994; Blanckenhorn, 2005).The taxonomy and distribution of most taxa of the southwest Asian group of ground agamids of the genus *Trapelus* Cuvier, 1816 have remained unresolved for many years. However, Rasteger-Pouyani (2000) attempted to determine the taxonomic status and distribution of some of the most controversial species of *Trapelus.*

According to Rastegar-Pouyani (2000), the holotype of *Trapelus lessonae* (De Filippi, 1865) is the representative of populations previously known as *Trapelus r. ruderatus* (Olivier, 1804) hence comes under the original name *lessonae* and the new combination is *Trapelus lessonae* (De Filippi, 1865).

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The *Trapelus lessonae* complex mainly occurring in northern, northwestern, western, and west-central regions of the Zagros Mountains in the Iranian Plateau (Anderson, 1999; Rastegar-Pouyani, 2000; Rastegar-Pouyani et al., 2006, 2007). The aim of this study is to describe and analyses sexual dimorphism in size and shape of the body in *Trapelus lessonae*.

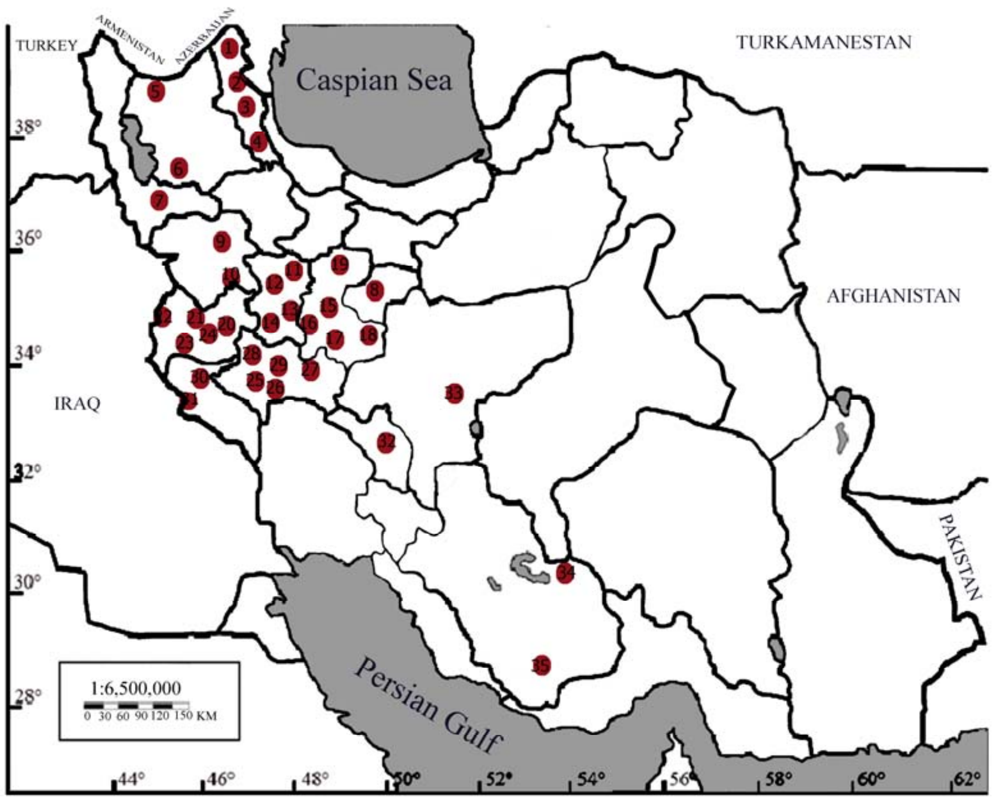

FIGURE 1. Sampling sites of *T. lessonae* in the Iranian Plateau.

MATERIAL AND METHODS

Data collection

The study was carried out from May 2008 till August 2010, in 39 localities in western regions of the Iranian Plateau. Attempts were done in all places which this species was expected to occur (Fig. 1). Lizards were caught by hand. The locality data and their habitat features were recorded for all species encountered during the study. All the collected specimens were fixed and preserved in accordance to the standard methods, kept in 75% ethanol and deposited at the Razi University Zoological Museum (RUZM). Some material borrowed from various museum collections. Collectively 177 specimens of *Trapelus lessonae* (74 males and 103 females) were examined for this study (see *material examined*). Of these, 145 (60 adult males and 85 adult females) were used to run the analyses.

Statistical analysis

All the specimens were examined for 35 metric and meristic characters (Table 1). Metric variables which used in the analysis were snout-vent length (SVL) tail length (TL), head width (HW), head length (HL), length of forelimb (LFL), length of hind limb (LHL), TL/ SVL (TLS), length of widest

TABLE 1. The morphometric and meristic characters examined in both sexes of *T. lessonae.*

Character	Definition
SVL	Length of snout to vent
DCA	Distance between collar and anus
HL	Head length
HH	Head height
HW	Head width
LFL	Length of forlimb
LHL	Length of hindlimb
LBT	Length of widest part of tail base
HBT	Tail width
LE	Length of eye (from anterior corner to its posterior)
TD	Tympanum diameter (largest size)
DEE	Distance from ear to eye
ESF	Enlarge scales on femor
NSL	Number of supralabial scales
NIL	Number of infralabial scales
SDLT	Subdigital lamella under the 4th toe
IN	Internasal nostril
SO	Number scales of the upper part of the eyes
NVS	Number of ventral scale (from gular to vent)
NDS	Scales around midbody (number of scales in a single row around of body)
NGS	Number of gular scales (from chinshild to collar)
RIHS	Reverse imbrication of head scale
SL	Snout Lenght
LWB	Length of widest part of belly
RP	Row of preanal pore (number of transverse rows of preanal pore)
NP	Number of preanal pore (number of on preanal pore)
UHS	shape of head scales
VS	shape of ventral scales
TLS	TL/ SVL
HLS	HL/SVL
HHS	HH/SVL
HWS	HW/SVL
LFS	LFL/SVL
LHS	LHL/SVL
DCS	DCA/SVL

part of belly (LWB), and also scales around mid body (NDS). The ratios of the characters were used to avoid effect of age in analyzing the morphomertic data.

Measurements were taken by a digital caliper to the nearest 0.01 mm. The largest snout-vent length observed was 83.88 mm in females, and 73.12 mm in males. The mean value for adult females was 61.58 mm, and for adult males, 53.23 mm. Statistical comparisons were made using the SPSS (16), and S-Plus (2000) packages. The significance level for all the statistical test was set at $P \leq 0.05$. Additionally, the presence of pre-anal pores was analyzed. Dorsal and ventral color pattern were compared between males and females. The patterns of sexual dimorphism were described using unpaired t-tests and principal component analysis (PCA).

Population means ranged from 85-93 mm in females and 79-92 mm in males. Differences in SVL between the sexes were initially assessed using t-test. Because body size (SVL) is an important determinate of appendage size (TL, HL and HW), we used the Analysis of Variance (ANOVA) to control for the possible influence of SVL on the other measured variables (Table 2).

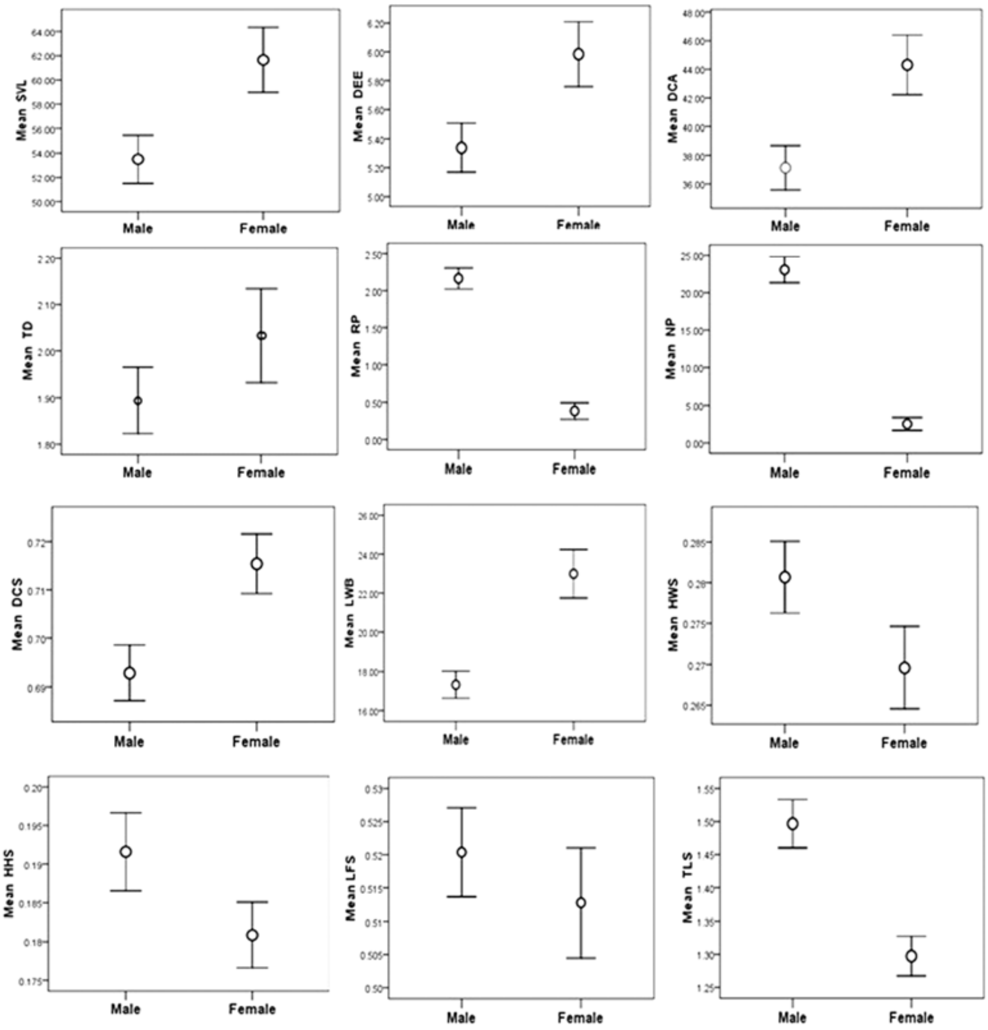

FIGURE 2. The mean and standard error for significantly different characters between males and females of *T. lessonae* revealed from the Analysis of Variance (ANOVA).

Table 2. Descriptive analysis and independent Anova of morphological characters in male and female specimens of *T. lessonae.*

Characters	Mean		Range		*F*-Value	*P*-Value
	Male (*N* = 61)	Female (*N* = 86)	Male	Female		
SVL	53.49	61.65	38.39-73.12	30.45-83.88	20.462	.000
TL	80.56	79.19	45.91-112.26	37.35-104.48	.285	.594
DCA	37.14	44.30	26.07-54.42	19.61-62.44	26.013	.000
HL	17.27	31.29	12.22-23.09	10.00-24.65	5.346	.022
HW	14.92	16.41	10.00-18.25	8.80-23.30	13.939	.000
HH	10.16	10.97	6.60-13.11	6.14-14.42	9.362	.003
LFL	27.80	18.27	18.34-34.61	16.31-38.31	18.596	.000
LHL	42.30	45.72	28.17-53.88	21.86-57.97	7.585	.007
LBT	7.60	6.83	3.90-11.19	2.50-12.86	7.239	.008
HBT	5.63	5.36	3.10-7.45	2.11-8.60	1.527	.219
SL	3.51	3.92	2.71-4.41	2.39-6.97	15.332	.000
DEE	5.33	5.98	3.54-6.53	2.85-7.91	18.197	.000
ED	4.69	4.85	3.69-6.06	2.50-6.41	1.665	.199
TD	1.89	2.03	1.42-2.51	.65-3.04	4.288	.040
RP	2.16	.38	.00-3.00	.00-2.00	402.950	.000
NP	23.08	2.52	.00-38.00	.00-18.00	531.879	.000
SDLT	17.00	17.16	14.00-20.00	14.00-19.00	.723	.397
NGS	32.54	31.82	28.00-37.00	27.00-37.00	3.524	.062
NRHS	25.60	26.84	12.00-42.00	10.00-48.00	1.081	.300
RRHS	4.21	4.13	2.00-6.00	2.00-6.00	.316	.575
SO	6.96	6.95	6.00-8.00	5.00-9.00	.012	.912
NSL	15.18	15.19	13.00-18.00	12.00-17.00	.008	.928
NIL	14.93	14.98	12.00-18.00	12.00-18.00	.074	.787
IN	5.09	5.04	5.00-6.00	4.00-6.00	1.052	.307
ESF	14.96	16.82	6.00-23.00	4.00-40.00	3.868	.051
UHS	1.94	2.30	1.20-3.00	1.20-3.00	6.795	.010
VS	1.09	1.30	1.00-2.20	1.00-2.20	11.416	.071
SBLT	4.09	4.23	2.00-6.00	2.00-6.00	.944	.333
LWB	17.32	22.99	11.89-26.00	9.23-33.73	50.651	.000
NVS	70.62	71.55	60.00-79.00	60.00-84.00	1.426	.234
HW/SVL	.28	.26	.22-.31	.22-.33	9.941	.002
HL/SVL	.19	.18	.15-.23	.15-.22	10.696	.001
TL/ SVL	1.49	1.29	1.20-1.83	.77-1.73	71.574	.000
DCA/SVL	.69	.71	.64-.75	.64-.82	26.303	.000
LFL/SVL	.52	.51	.45-.58	.43-.64	1.793	.183

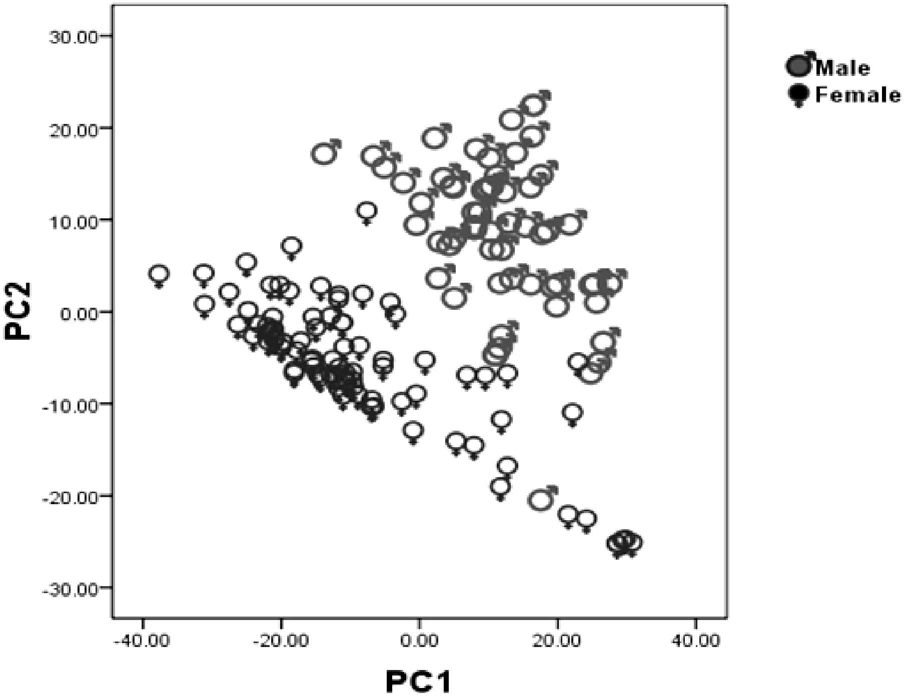

FIGURE 3. The scatter plot resulted from the PCA analysis to showing sexual dimorphism in *T. lessonae*.

TABLE 3. Factor loadings on the first three Principal Component (PC) axes in the three different populations of *T. lessonae*.

VARIABLE	PC1	PC2	PC3
SVL	-.907	.306	-.033
DCA	-.931	.265	-.066
HL	-.577	.232	.511
RP	.516	.791	.067
NP	.555	.767	.056
NC	.391	.717	.038
LWB	-.882	.037	-.060
HW/SVL	.763	-.327	.219
HL/SVL	.722	-.251	.401
TL/ SVL	.594	.385	-.456
DCA/SVL	-.700	.046	-.219
LFL/SVL	.590	-.322	-.454
EIGENVALUE	5. 82	2.37	.950
PERCENT(%)VARIABILITY	48.51	19.75	7.91
CUMULATIVE PERCENT,%	48.51	68.26	76.18

RESULTS

Univariate analysis

Our analysis suggests that *Trapelus lessonae* shows sexual dimorphism in some metric characters such as SVL, TL and head size (Table 2, Fig. 2).

The SVL significantly differed between males and females. Males have significantly wider and longer heads and tail than females. On the other hand, females having greater values for SVL and LWB (Length of widest part of belly) (Fig. 2).

Multivariate analysis: Results of the multivariate analysis were again consistent with those of the univariate analysis. The principal component analysis (PCA) was employed to more clearly explore the patterns of sexual dimorphism between the sexes. As is shown in (Table 3), the first three principal components accounted for 76.18% of the total variation.

The PC1 accounted for 48.51% of the variation and strongly and positively loaded for HW/SVL and HL/SVL. The PC2 accounted for another 19.75% of the variation and strongly and positively loaded for NP and RP. And the PC3 accounted for 7.91% of the total variation and strongly and positively loaded for HL/SVL and HL (Table 3 and Fig. 3).

Qualitative characters

In addition to the biometric differences, morphological differences in qualitative characters between males and females were also noted. In females the preanal pores are absent; while in the males there are 1-2 rows of relatively developed preanal pores (Fig. 4).

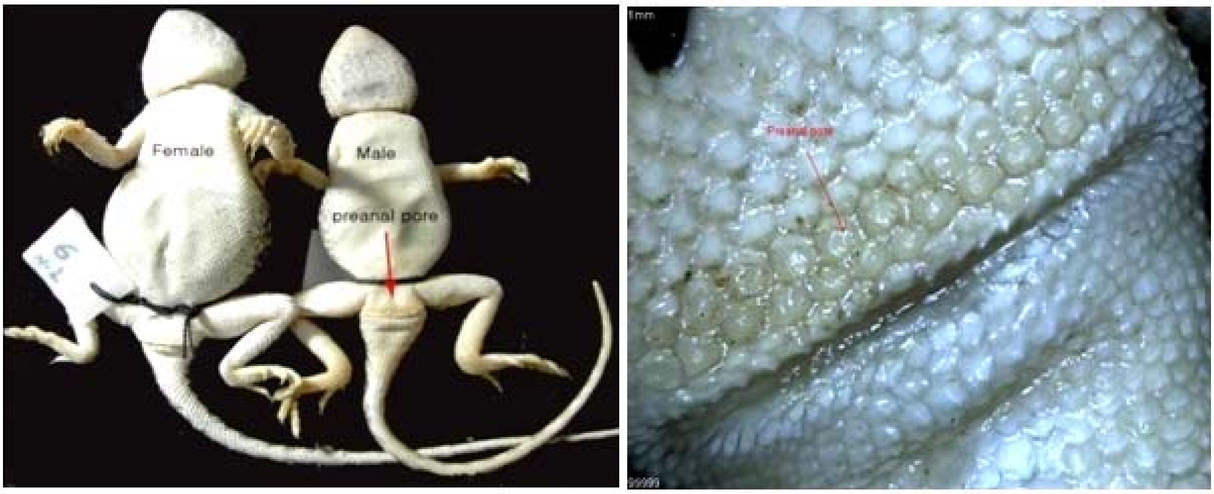

FIGURE 4. Morphological sexual dimorphism in the form of the anal region and pre-anal pores in *T. lessonae*: male (right), female (left).

Coloration

Males and females are also different in color pattern. Adult males usually present a bright yellow stripe running along body and with light blue cast on chin. Females usually have a sandy gray or grayish-brown coloration. The gular region of adult males can be covered or spotted by an intense gray or blue color, and pink in females which is more evident soon after hatching or during the breeding season (Anderson, 1999; Rastegar-Pouyani et al., 2007).

DISCUSSION

Our study showed that *Trapelus lessonae* exhibits sexual dimorphism in general body size and several body parts as well as in some qualitative characters.

In nearly all the localities, sex differences were female-biased (females were the larger sex). It is likely that adaptation of the female body with respect to production of offspring (eggs) is the main determining factor for a larger body in females. For instance, the elongated abdomens of female lacertid lizards (relative to males), a possible outcome of fecundity selection for increased clutch volume (Braña, 1996), may limit their acceleration capacity (Van Damme and Vanhooydonck, 2002; Van Damme et al., 2008). This is also the case with *Trapelus lessonae.*

On the other hand, males have significantly wider and longer head and tail than those of females. Having a large, wide head in males is crucial for making a stronger bite force in competition between males, via aggressive encounters, for food resources as well for reproduction (Herrel et al., 2001b; Cox et al., 2003).

Larger heads have been considered as weapons in aggressive encounters (Cheatsazan et al., 2006) and may relate to reproductive success. Larger head size in male *Trapelus lessonae* is also likely the result of sexual selection acting through male-male agonistic behaviors, since the individual with the larger head and jaw adductor muscle may be better able to exert control over his opponent and maintain a dominant position (Gienger et al., 2007). In *Trapelus lessonae* larger tail may allow an individual to form a higher body arch, and increase the chance of emerging on top hence winning the combat sequence.

Some workers have suggested that sexual differences in body size or morphology between the sexes may have evolved and developed due to the importance of ecological factors (e.g., Darwin, 1874; Schoener, 1967; Shine, 1989). According to the 'niche hypothesis', the males and females of a species may adapt to different microhabitats or diets to avoid competition (Moorhouse, 1996).

In various taxa (lizards as an example), fecundity selection contributes to differences in size and shape between the sexes (e.g. Braña, 1996; Preziosi *et al.*, 1996; Coddington *et al.*, 1997). While in larger lizards, for instance *Laudakia nupta*, sexual selection predominates and males have a larger body size to be a winner in the competition with the other males, in the small-sized lizards such as *Trapelus lessonae*, the fecundity selection is more practical for giving the females to lay as many eggs as possible to ensure passing through their genes into the next generation.

Since in our study the number of females was more than that of males, we can infer that males are more nimble and for this, females are easier to catch. One reason may be that females weight that are more than male's as a result of their eggs or for longer male tails or conoid shape of males which makes them more speedy.

As to the role of preanal pores in males in increasing the chance of reproduction, via pheromone secretion, one, two or three rows of these pores are located on the anterior region of the cloacae. Usually there are 11 to 38 preanal pores on each row. The preanal pores are rarely found in females. Since the preanal pores were more strongly developed during the reproductive season, we may infer that they secret pheromones for attracting the females. However, little is known about the chemistry of the secretions of preanal pores.

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