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Sexual Dimorphism in *Trapelus ruderatus ruderatus* (Olivier, 1804) (Sauria: Agamidae) in Southern Iraq

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Sexual dimorphism was studied in 45 (27 males, 18 females) specimens of *Trapelus ruderatus ruderatus* which collected from three localities: Bahr AL-Najaf, AL-Najaf Province; Albedhan village, Said dekheel county, Dhi-Qar Province and Khor AL-Zubair, AL-Basra Province, southern Iraq. Of 23 studied characters in males and females, statistical analysis using SPSS software version 20.00 showed significant differences in 11, out of 23, characters (male-biased): SVL, TL, HW, HH, DCC, RP, NP, CT, VL, AbnL and LHS. In comparison to females, males had different color pattern, much darker and more developed gular folds and darker ventral regions.

Key words: *Trapelus ruderatus ruderatus*, Sexual size dimorphism, Coloration, Ornamentation, AL-Najaf, Dhi-Qar, AL-Basra.

INTRODUCTION

The genus *Trapelus* Cuvier, 1816, is one of the genera of the family Agamidae, is widely distributed throughout the desert and semi-desert regions of north Africa, Middle East, and Central Asia. *Trapelus r. ruderatus* Olivier (1804) [type locality: northern Arabia and Persia (Iran)], as the western representative of the complex, distributed from upland areas of Jordan and Syria, northward to the central and eastern Turkey, southern parts of Azerbaijan Republic, and eastward into northern and eastern regions of Iraq, western, central, and southcentral parts of the Iranian Plateau as far south as Shiraz (Fars province) (Anderson, 1966a; Leviton et al., 1992; Rastegar-Pouyani, 1995).

As reviewed in Andersson (1994), sexual dimorphism is the difference in morphology between male and female members of the same species. It includes differences in size, coloration, or body structure between the sexes. In any given species, a difference in the body size of conspecific males and females is defined as sexual size dimorphism (SSD), is a ubiquitous biological phenomenon. Such dimorphisms to sex differences in the selective forces acting on body size, and more than a century of subsequent research has focused primarily on the evolutionary causes of SSD. By contrast, relatively little is known about the underlying physiological mechanisms that mediate sex differences in growth (Cox et al., 2006). It 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).

Body length is the most common trait used in the study of SSD in reptiles. However, body length combines lengths of different body parts, notably head and abdomen. Males have relatively larger heads, whereas females have relatively larger abdomens.This consistent difference points to body length being an imperfect measure of lizard SSD because it comprises both abdomen and head lengths, which often differ between the sexes. Female lizards of many species are under fecundity selection to increase abdomen size, consequently enhancing their reproductive output (enlarging

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either clutch or offspring size), in support of this, abdomens of lizards laying large clutches are longer than those of lizards with small clutches (Scharf & Meiri, 2013).

Sexual selection and natural selection can interact in complex ways to influence the form of secondary sexual traits. For instance, sexual is through to favor conspicuous coloration or ornamentation, while natural selection often favours cryptic coloration and reduced ornamentation (Endler, 1983; Andersson, 1994). Population and species can vary greatly in the form and extent of sexual dimorphism in coloration and ornamentation depending on the relative importance of these selective pressures (Stuart-Fox & Ord, 2004). Current study aimed to clarifying the differences between both sexes of the Iraqi population of the species *Trapelus r. ruderatus* despite these differences were common and not interesting at present time, but because of little information in relevant Iraqi reptiles in general, and lizard fauna in special.

MATERIAL AND METHODS

Data Collection

A total of 45 adult specimens (27 ♂and 18 ♀) were collected during 20th September 2013 to 16th December 2014 from three localities in southern Iraq (Fig. 1). Of these, 42 specimens were collected from Bahr AL-Najaf, AL-Najaf Province with geographical coordinates 31 52′ 30.5″ N, 044 15′ 47.2″ E, at an elevation of 14m; two specimens were collected from Albedhan villages, Said dekheel county, Dhi-Qar Province with geographical coordinates: 31° ′ 09 ′ 54.3 ″ N, 046° 20 ′ 13.8″ E, at an elevation of 4m, and one specimen was collected from Khor AL-Zubair, AL-Basra Province 30° 18 ′ 51 ″ 4 N, 047° 44 ′ 50.4″ E, at an elevation of 6m. All the collected specimens were fixed by injection of 96% ethanol, tagged, photographed then preserved in 75% ethanol. The voucher specimens are deposited in the Razi University Zoological Museum (RUZM) in Kermanshah under the number (AT12.5-49). Morphological measurements include 23 metric and meristic characters (Table 1), based on Rastegar-Pouyani (1999, 2005) and Torki (2007) using digital caliper. The ratios of the characters were used to avoid the effect of age in analyzing the morphometric data.

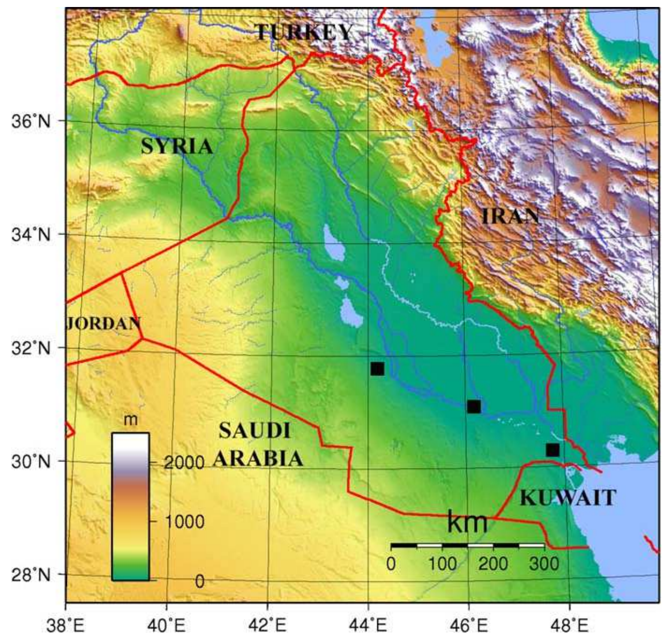

FIGURE 1. Map showing the coordinates of sampling sites (black squares) for *Trapelus r. ruderatus* in southern Iraq.

TABLE 1. The morphometric and meristic characters examined in both sexes of *Trapelus r. ruderatus*.

	Character	Definition
Metric characters	DCC	Tail length
	TL	Distance between collar and cloaca
	HL	Head length
	HH	Head height
	HW	Head width
	FLL	Forelimb Length
	HLL	Hind limb Length
	VL	Vent length
	DFH	Distance between forelimb and hind limb
	AbnL	Abdomen length
Meristic characters	IN	Internasal nostril
	SEBH	Scale between eyes across head
	RP	Row of preanal pore (number of transverse rows of preanal pore)
	NP	Number of preanal pore (number of on preanal pore)
	CT	Cross bar on dorsal tail
Ratios of characters	TLS	TL/ SVL
	HLS	HL/SVL
	HHS	HH/SVL
	HWS	HW/SVL
	LFS	LFL/SVL
	LHS	LHL/SVL
	DCS	DCC/SVL

Statistical Analysis

All data were analyzed statistically using the SPSS software version 20. For testing the significance of sexual dimorphism, the ANOVA table and Principal Component Analysis (PCA: correlation matrix), were employed and the significance level for all the statistical tests was set at $P \leq 0.05$.

RESULTS

Statistical analysis by using the ANOVA table of measured characters shows the obvious significant differences between the two sexes of *Trapelus r. ruderatus* in relation to 11 characters SVL,TL, HW, HH, DCC, RP, NP, CT, VL, AbnL and LHS (out of 23 studied characters) as shown in Fig. 2.

Metric variables

Males of the agamid lizard *Trapelus r. ruderatus* have greater mean values than females for all significant characters (Table 2). In the case of body length (SVL) and the tail length (TL) respectively, males had values of 88.02±1.97, 136.09±3.14, and females had 78.55±2.63, 119.76±3.99. Regarding the differences in head dimensions, also males had higher values in head width and head height (18.04±0.32, 12.69±0.17respectively) while females had relatively lower values (16.08±0.53, 11.59±0.37 respectively). Another metri character that showed a significant difference is the distance between collar and cloaca which is longer in males in comparison to females (males had mean 58.24±1.36 and females had 52.83±1.56). In regards to the last two metric characters (VL and Abn L), once again males had greater values for both vent length and the length of abdomen respectively (8.05±0.22, 65.91±1.53 respectively in comparison to females with 6.8±0.31, 58.09±2.01 respectively.

Meristic variables

As well, in relation to the studied meristic characters (NP, RP, and CT) males significantly had greater values than females and the values were: 10.14±0.24, 1.18±0.07 and 15.22±0.3 for males and 2.66±0.93, 0.33±0.11 and 14±0.47 for females respectively (Table 3). In other words, only 11 of the 23 studied morphological characters were significantly male biased.

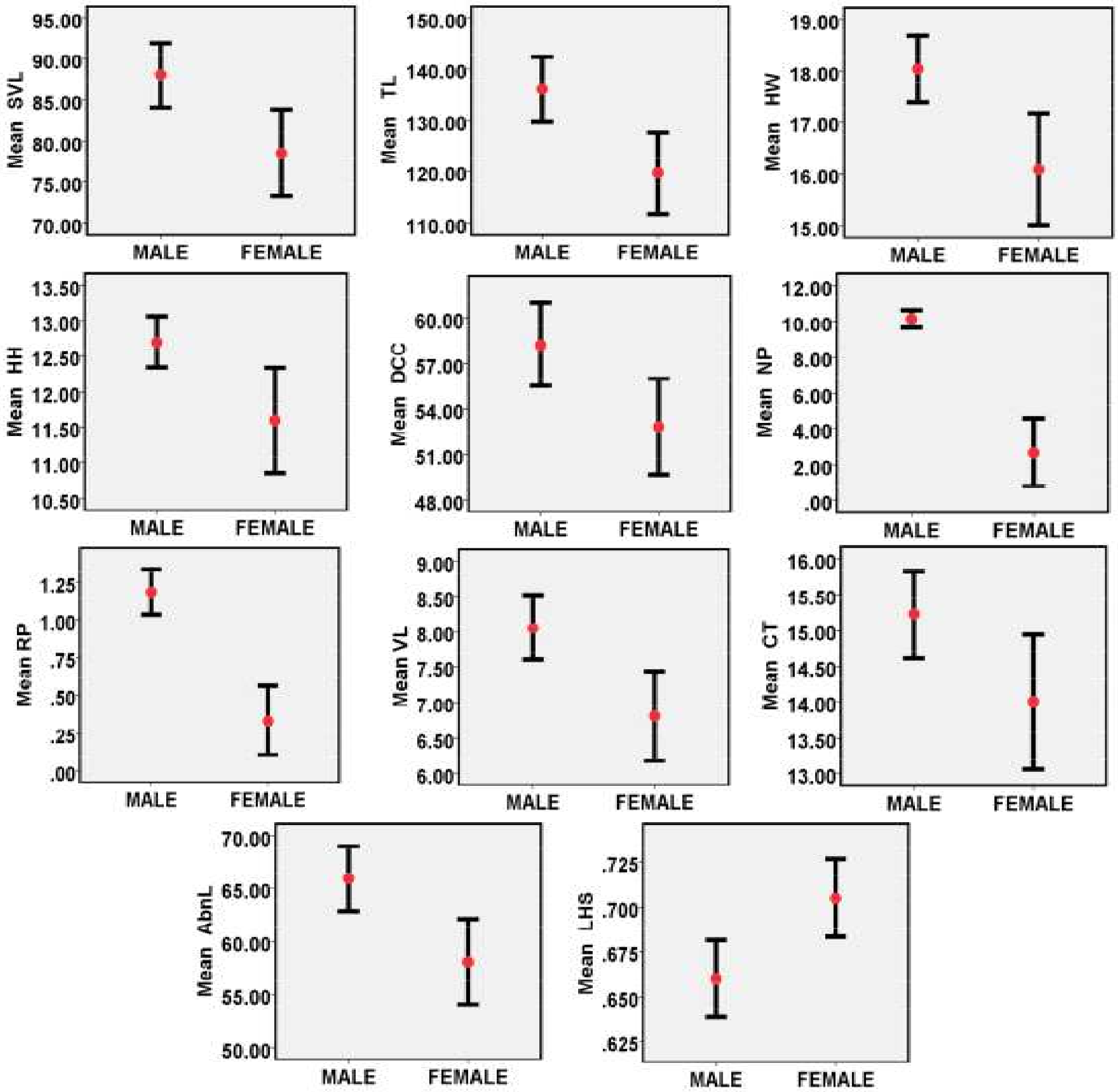

FIGURE 2. The mean and standard error for significantly different characters between males and females of *Trapelus r. ruderatus* revealed from the analysis of variance (ANOVA).

PRINCIPAL COMPONENT ANALYSIS

The PCA performed on the dataset yielded two axes which are summarized in Table 4. As is revealed, the first two principle components (PC1-PC2) account for 70.10%, and 15.88% of the total information respectively. These two axes jointly explain 85.98% of the total information.

In the PC1 which the characters SVL, TL, HW, HH, VL, AbnL and DCC having greater values, hence having more contribution and importance in sexual dimorphism. The PC1 highlights a size (metric) difference. The scores of the males along this axis (Fig. 3) showed an overlap with those for females, indicating that although sexual dimorphism occurs between males and females, the two sexes are not completely separated from each other in these characters. The second axis (PC2) is a meristic axis that records individuals at one end with relatively large NP, RP and CT and small SVL, TL, HW, HH, VL, AbnL and DCC, compared with individuals having relatively small NP, RP and CT, and large SVL TL, HW, HH, VL, AbnL and DCC.

Corolation

In females at least anterior oval vertebral spots linked together to form an undulating gray or lavender stripe on neck and back, bordered by darker brown stripes extending onto dorsal pattern of dark and light longitudinal stripes and a distinct, though fainter, vertebral pattern; A dark stripe on side of neck extends across temporal region to eye, and a brown stripe crosses head at level of anterior part of the orbits; there is a tendency for the paravertebral light spots to link together to form longitudinal lines, in mature males the dorsal pattern is less distinct, and back and flanks are flecked with white; often these white flecks are single, slightly enlarged scales, and the effect is to make these scales look larger, the pholiodosis more heterogenous; all have a pattern of six crossbars containing vertebral and paravertebral light spots from shoulders to sacrum. Male with distinct gular sac which tend to be more developed and bright metallic blue. When the male lizard is alarmed or frightened, also the flanks and dorsal surface of limbs change in coloration.

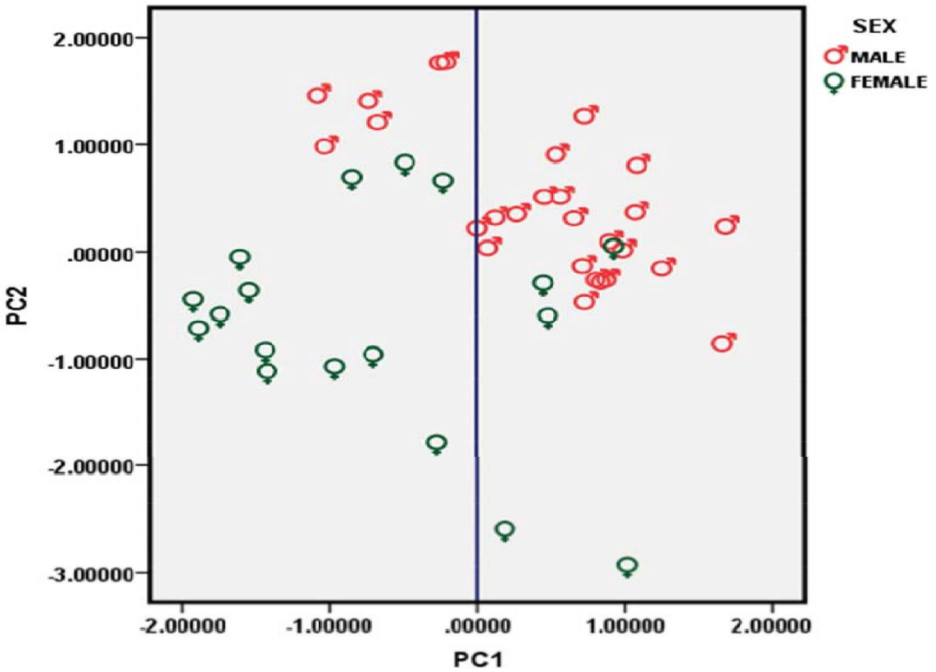

FIGURE 3. The scatter plot resulted from the PCA analysis to showing sexual dimorphism in *Trapelus r. ruderatus*. Note the relative degree of isolation of males and females.

FIGURE 4. (A), Dorsal view of a male (right) and a female (left) of *Trapelus r. ruderatus*; (B), habitat and the color pattern of an adult male of *Trapelus r. ruderatus*.

TABLE 2. Descriptive analysis and independent ANOVA of metric characters in male and female specimens of *Trapelus r. ruderatus*.

SEX	Measurements	SVL	TL	HW	HH	HL	HLL	FLL	DCC	DFH	VL	AbnL
MALE	Mean	88.02	136.09	18.05	12.70	22.11	57.82	39.76	58.24	42.69	8.06	65.92
(N=27)	Std. Error of Mean	1.97	3.15	0.32	0.18	0.83	1.14	1.40	1.37	1.60	0.23	1.54
	Minimum	66.51	103.72	15.07	10.80	4.70	39.00	8.37	46.04	11.53	4.44	47.91
	Maximum	105.52	170.03	20.78	14.27	26.63	65.69	48.57	72.00	55.57	10.00	78.89
FEMALE	Mean	78.56	119.77	16.09	11.59	20.46	54.93	37.98	52.84	38.79	6.81	58.10
(N=18)	Std. Error of Mean	2.63	3.99	0.54	0.37	0.65	1.27	1.18	1.57	1.30	0.31	2.02
	Minimum	63.83	99.53	13.19	9.74	16.87	47.63	29.04	43.68	28.29	4.52	46.96
	Maximum	99.98	153.94	20.62	15.18	25.23	64.26	46.63	64.50	49.10	9.00	74.75
	F- value	8.57	10.46	11.10	8.81	2.07	2.78	0.81	6.56	3.05	10.83	9.77
	P- value	0.005	0.002	0.002	0.005	0.158	0.103	0.372	0.014	0.088	0.002	0.003

TABLE 3. Descriptive analysis and independent ANOVA of meristic characters and the ratios of the characters in male and female specimens of *Trapelus r. ruderatus*.

SEX	Measurement s	SEBH	IN	NP	RP	CT	TLS	HLS	HHS	HWS	LFS	LHS	DCS
MALE	**Mean**	17.11	4.52	10.15	1.19	15.22	1.55	0.25	0.15	0.21	0.45	0.66	0.66
(N=27)	**Std. Error of Mean**	0.47	0.15	0.25	0.08	0.30	0.01	0.01	0.00	0.00	0.01	0.01	0.01
	Minimum	12.00	3.00	8.00	1.00	12.00	1.44	0.06	0.13	0.19	0.11	0.50	0.54
	Maximum	20.00	5.00	12.00	2.00	19.00	1.67	0.28	0.18	0.23	0.52	0.75	0.71
FEMALE	**Mean**	16.67	4.56	2.67	0.33	14.00	1.53	0.26	0.15	0.20	0.48	0.71	0.67
(N=18)	**Std. Error of**												
Mean		0.59	0.20	0.94	0.11	0.47	0.01	0.00	0.00	0.00	0.01	0.01	0.00
Minimum		11.00	3.00	0.00	0.00	11.00	1.38	0.24	0.14	0.19	0.43	0.59	0.64
Maximum		20.00	5.00	9.00	1.00	18.00	1.64	0.27	0.17	0.22	0.52	0.77	0.70
***F*- value**	0.355		0.022	83.472	41.73	5.229	1.021	1.168	0.752	0.275	2.781	8.007	1.704
***P*- value**	0.5546		0.8832	0.0000	0.000	0.0272	0.3180	0.2859	0.3908	0.6028	0.1026	0.0071	0.198

DISCUSSION

It is often postulated that different selection pressures are responsible for the increase in size of males and females. In other words the evolutionary result of selection acting differently on body size dimorphism (SSD) (Anderson, 1994). Both the proximate (growth patterns) and ultimate (evolutionary payoffs) causes are responsible for sexual dimorphism (Cox et al., 2003). Regarding size dimorphism, the proximate cause is an agent which creates intersexual differences in growth rate. One of these proximate causes, differences in growth hormone concentrations and trade-offs in allocating energy between growth and reproduction (John-Adler et al., 2007; Kuo et al., 2009; Fathinia et al., 2011). Presence of dimorphism between males and females are defined by three main forces including: sexual, fecundity and natural selection (Cox et al., 2003).

The most consistently dimorphic traits being head size (males have larger heads), snout-vent length and trunk (abdomen) length respectively (Torki, 2007; Fathinia & Rastegar-Pouyani, 2011). This case is true for *Trapelus ruderatus ruderatus* as well. Since head dimensions are directly related to bite force which have been considered as weapons in aggressive encounters, though it is effect on dominance, is a performance trait under sexual, and also, natural selection (Cheatsazan et al., 2006). Longer tail (136.09±3.14) was assumed to be the result of morphological constraints imposed by the male copulatory organs on tail autotomy, or it may have evolved as a result of improved escape abilities in the sex more likely subjected to heavier predation pressure (Kratochvil et al., 2003). Males are territorial and large size enhances male reproduction success (Shine et al., 1998), this may be nearest reason as explanation for why males of *T. r. ruderatus* get longer tail and trunk (the distance between collar and cloaca: 58.24±1.36 and abdomen length: 65.91±1.53). However, both sexes have approximately equal long limbs (no significant differences *i.e.,* hindlimbs and forelimbs in males 57.82±1.13; 39.76±1.4 respectively, whereas in females were: 54.92±1.27; 37.98±1.18 respectively). Longer limbs in both sexes may be for increasing maximum sprint speed, allowing lizards to catch prey or escape predators more efficiently (Calsbeek & Smith, 2005; Fathinia & Rastegar-Pouyani, 2011). As to the role of preanal pores in males in increasing the chance of reproduction, via pheromone secretion, one or two (mean: 1.18±0.07) rows each of which consists of 10.14±0.24 pores. These pores are located on the anterior region of cloaca of males, while females have or have not (rarely found) preanal pores (mean0.33±0.11 rows, consist of 2.66±0.93 pores), since the preanal pores are more strongly developed during the reproductive season, we may infer that they secrete pheromones for attracting the females. However, little is known about the chemistry of the secretions of preanal pores (Fathinia & Rastegar-Pouyani, 2011).

Using morphological variation in ecologically relevant characters as a surrogate for ecological variation, agamid lizards vary in their structural habitat use, including species that primarily use rocks, trees or terrestrial surfaces as well as some semi- arboreal species that frequently use both trees and terrestrial surfaces. Because the ability to move about and hold position in the environment is partly a consequence of structural habitat use and because movement is important to the performance of ecological tasks, such as foraging, evading predation and defending territory, these four types of habitat use may contribute differently to ecomorphological diversification in agamid lineages (Collar et al., 2010).

Agamid lizards occupy different habitats: they can be found in harshest desert and semi-desert regions, thus represent an excellent group within which to conduct a comparative test of how sexual selection and natural selection interact in the evolution of conspicuous coloration. For example, changes in dichromatism or ornament dimorphism may result from both gains and losses of either male or female coloration or ornaments, similarly, coloration or ornaments may be lost with occupation of open habitats or gained with occupation of closed habitats (Wiens, 2001).

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