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Sexual Size Dimorphism in *Hyla savignyi* Audouin, 1827 (Anura: Hylidae) from Kermanshah Province, Western Iran

Rastegar-Pouyani, N[a,b*], Fattahi, A[a,b], Karamiani, R[a,b], Takesh, M[a,b]

[a] *Department of Biology, Faculty of Science, Razi University, 6714967346 Kermanshah, Iran*
[b] *Iranian Plateau Herpetology Research Group (IPHRG), Faculty of Science, Razi University, 6714967346 Kermanshah, Iran*

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We investigated sexual size dimorphism in the tree frog, *Hyla savignyi* using 33 males and 22 females from the western and northwestern regions of Kermanshah Province, western Iran. Out of sixteen measured morphometric characters, four were significantly larger in females than in males. These characters were nostril-eye length, brachium length, elbow-longest finger length and hind limb length.

Key words: *Hyla savignyi*, sexual size dimorphism, Kermanshah Province, western Iran

INTRODUCTION

Sexual dimorphism in morphology is widespread among animals (Woolbright, 1983; Greenwood and Wheeler, 1985; Cooper and Vitt, 1989; Winquist and Lemon, 1994). The traditional explanation for morphological differences between the sexes is based on Darwin's (1871) theory of sexual selection. Sexual dimorphism is the outcome from a balance of many selective pressures differing between the sexes in strength and/or in direction. Sexual selection (acting via female choice or male–male contest for mating opportunities), fecundity selection (leading to larger body size or body volume in females) and other factors such as natural selection acting to reduce intersexual resource competition and differential mortality between the sexes due to differences in longevity can all be potential causes of sexual dimorphism (Shine, 1989; Hews, 1990; Andersson, 1994; Olsson et al., 2002).

Amphibians are an excellent group for investigating SSD, because of their great diversity of morphologies, habitats and life-histories (Shine, 1979). In the present study, sexual size dimorphism in a tree frog, *Hyla savignyi*, Audouin, 1827 was investigated and it was shown that there is a relatively clear pattern of dimorphism in the metric characters between the sexes. Based on our opinion, fecundity selection is a force which is behind the female-biased SSD in *Hyla savignyi*.

MATERIALS AND METHODS

During March and July 2012, a total of 55 (33♂ and 22♀) adult specimens of *Hyla savignyi* were collected in the vicinity of Qhasr-e-Shirin (34º27´N 45º37´E) and Ravansar (34º42´N 46º36´E), in Kermanshah Province, western Iran. Sixteen metric traits were chosen to measure by digital caliper (±0.01 mm). Sex was determined by the presence of a vocal sac in males. Following collection, they were preserved in ethanol 75% and kept in the RUZM (Razi University Zoological Museum).

The following metric characters were measured: From the tip of snout to the vent as the representative of length of body (SVL); the length of head measured axially to the

*Corresponding Author: nasrullah.r@gmail.com

beginning of arms (HL); from the tip of snout to the anterior rim of the eye (SEL); the distance between the two nostrils (DN); from behind the nostril to the anterior rim of the eye (NEL); eye diameter measured horizontally (ED); Width of head at the widest part (WH); height of head at the widest part (HH); the distance between the eyes at their anterior ends (DE); from the base of the hand to the end of the longest finger as the representative of hand length (FLL), from the base of the hand to the elbow as the representative of brachium length (BL), from the elbow to the tip of the longest finger (EFL), from the base of leg to the knee as the representative of thigh length (LT), from the knee to the tip of the longest toe (KTL), from the base of leg to the tip of the longest toe as the representative of whole leg length (HLL), the length of trunk (TL) from rear of arms to end of body (Table 1).
To determine the significance of sexual size dimorphism in *Hyla savignyi,* one-way ANOVA as well as Principal Component Analysis (PCA: correlation matrix) were applied. The SPSS statistical software (version 16) was used for the statistical analyses. Results were considered statistically significant at $P \leq 0.05$.

RESULTS

A One-Way ANOVA revealed significant differences between the sexes in four out of sixteen morphological characters. All the four metric characters have larger values in females than in males. These were the nostril-eye length (p = 0.001), brachium length (p = 0.04), elbow-longest finger length (p = 0.007) and hind limb length (p = 0.033). The values for these traits as well as direction of differences are summarized in Table 1. Further, multivariate analysis techniques including Principal Component Analysis (PCA) were carried out to identify the factors that statistically explain the patterns of discrimination between the sexes, which identify the characters that are mainly responsible for the observed variation.

TABLE 1. Comparison of 16 morphological characters in males and females of *Hyla savignyi*. Std: standard deviation, D of d: Direction of difference. All measurements in millimeter (mm). Abbreviations: SVL (snout-vent length), HL (Head length), SEL (Snout-eye length), DN (Distance of nostrils), NEL (Nostril-eye length), ED (Eye diameter), WH (Width of head), HH (Height of head), DE (Distance of eyes), FLL (Front limb length), BL (Brachium length), EFL (Elbow-longest finger length), LT (Length of Thigh), KTL (Knee-toe length), HLL (Hind limb length), and TL (Trunk length).

SEX	SVL	HL	SEL	DN	NEL	ED	WH	HH
♂ Mean (N=33)	39.59	13.07	5.92	3.05	3.95	2.84	12.28	6.99
Std	4.53	1.53	0.70	0.55	0.58	0.67	1.40	9.66
♀ Mean (N=22)	41.64	13.16	6.23	3.33	4.58	3.22	13.17	6.44
Std	5.03	1.70	0.94	0.60	0.80	0.81	1.92	1.03
D. of d.	F>M	F>M	F>M	F>M	F>M	F>M	F>M	M>F
***p*-value**	0.122	0.795	0.166	0.078	0.001	0.063	0.052	0.793

SEX	DE	FLL	BL	EFL	LT	KTL	HLL	TL
♂ Mean (N=33)	7.31	23.36	7.29	7.68	17.81	17.44	57.19	22.16
Std	1.02	2.71	1.01	0.91	2.23	1.83	7.74	3.00
♀ Mean (N=22)	7.84	24.80	7.94	8.77	18.54	18.33	61.78	23.17
Std	1.33	3.20	1.24	1.96	2.73	2.29	7.48	3.16
D. of d.	F>M	F>M	F>M	F>M	F>M	F>M	F>M	F>M
***p*-value**	0.106	0.079	0.040	0.007	0.281	0.110	0.033	0.232

TABLE 2. Loadings from a Principal Component Analysis of metric characters of *Hyla savignyi*. Abbreviations: NEL (snout-vent length), BL (length of tail), EFL (head length), HLL (head width).

Variable	PC1	PC2
NEL	0.782	-0.311
BL	0.726	0.232
EFL	0.707	0.580
HLL	0.778	-0.430
Eigenvalue	2.24	0.64
% Variance	56.08	16.80
Cumulative	56.08	72.89

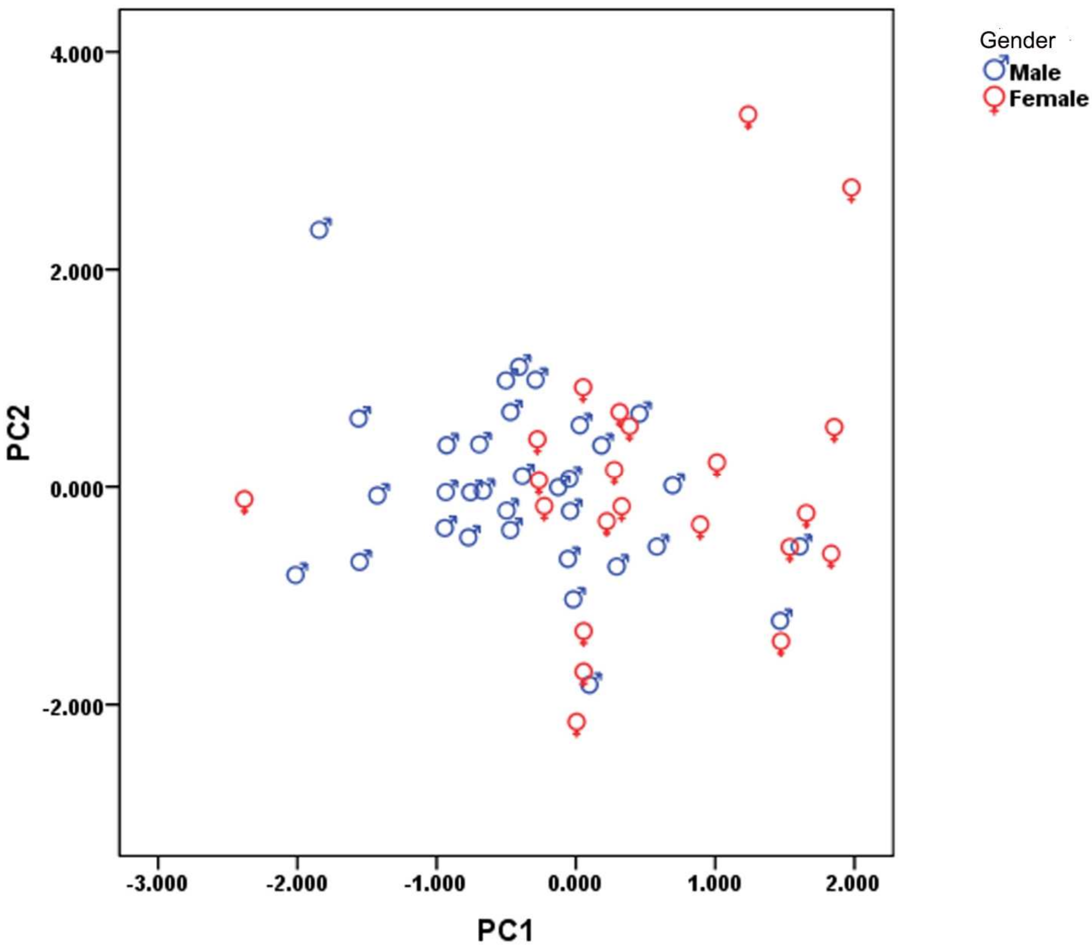

FIGURE 1. Ordination of the individual males and females of *Hyla savignyi* on the first two principal components. Note the relative degree of isolation between the sexes.

The first two PCA factors jointly explain 72.89 of total information (Table 2). Of this, 56.08 is explained by the PC1 and 16.80 by the PC2 (Fig. 1 and Table 2). For calculating the eigenvalues, the four significant variables entered into the analysis including NEL, BL, EFL and HLL showed maximum (p = 0.782) and minimum (p = 0.707) participation in the PC1. Furthermore, the maximum (p = 0.580) and minimum (p = 0.232) participation in the PC2 are devoted to EFL and BL, respectively (Table 2).

DISCUSSION

Such sexual size dimorphism (SSD) as observed here is the evolutionary result of selection acting differently on body size and the rest of male and female traits (Andersson, 1994). Several hypotheses have been proposed to explain the interspecific variation in SSD (reviewed in Shine, 1989; Andersson, 1994; Blanckenhorn, 2005). First, increased female body size relative to male size (female-biased SSD) may be the result of selection for fecundity (Andersson, 1994; Sandercock, 2001; Shine, 1979, 1989). Second, if resources are scarce and differential exploitation between the sexes arises, then changes in morphology and body size may follow in species (Shine, 1989; Sandercock, 2001; Temeles and Kress, 2003). Third, sexual selection acting on either sex may select for SSD (Raihani et al., 2006). For instance, male-male competition may favour large body size in males of those species in which males compete intensely for females (Mitani et al., 1996; Dunn et al., 2001; Lindenfors et al., 2003; Raihani et al., 2006). Thus, large size may be advantageous for males in polygynous species (Clutton-Brock and Harvey, 1977; Owens and Hartley, 1998). Finally, the selective advantage of body size may depend on whether the competition occurs on the ground or in the air (Payne, 1984; Jehl and Murray, 1986). If males compete or display in the air then small male size may be advantageous (Andersson and Norberg, 1981; Blomqvist et al., 1997; Székely et al., 2000, 2004; Serrano-Meneses and Székely, 2006), whereas large size may be beneficial in those species where males display or compete on the ground (Clutton-Brock et al., 1982; Anderson and Fedak, 1985; Lindenfors and Tullberg, 1998). These selection processes may be reinforced via female choice (reviewed in Thornhill and Alcock, 1983; Choe and Crespi, 1997). To our idea, the best fit for explanation of the SSD in *Hyla savignyi* is the first hypothesis (fecundity selection) in which higher reproductive success in females is related to their larger body size relative to the males.

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