

Sexual size dimorphism in *Rana (Pelophylax) ridibunda ridibunda* Pallas, 1771 from a population in Darre-Shahr Township, Ilam Province, western Iran

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Abstract.—In this survey we investigated occurrence of sexual size dimorphism (SSD), in a population of *Rana (Pelophylax) ridibunda ridibunda* Pallas, 1771 from Darre-Shahr Township, Ilam Province, western Iran. Ninety-six specimens (52 females and 44 males) were captured, measured and released into their natural habitat. Twelve metric characters were measured by digital calipers to the nearest 0.01 mm. Statistical analyses showed considerable differences between sexes for measured characters. The largest female and male were 89.55 and 73.16 mm SVL, respectively, while the smallest female and male were 68.52 and 61.65 mm SVL, respectively. SPSS version 16 was used for running the analysis. The Independent-Sample *t*-test (2-tailed) showed that each character has significant differences between the sexes ($p \leq 0.01$), and for each variable the female value was larger than for males on average.

Key words. Sexual size dimorphism (SSD), *Rana (Pelophylax) ridibunda ridibunda*, Principal Component Analysis (PCA), Ilam Province, western Iran

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Introduction

Sexual dimorphism refers to the existence of phenotypic differences between males and females of a species, and is widespread in animals (Andersson 1994; Faizi et al. 2010). Kuo et al. (2009) considers the presence of morphological differences between males and females of species to have two aspects, size and shape, but Selander (1972) credits behavioral aspects as well. Different factors can influence sexual dimorphism including female reproductive strategy (Tinkle et al. 1970; Verrastro 2004), sexual selection (Carothers 1984; Verrastro 2004), and competition for food resources (Schoener 1967; Verrastro 2004). Sexual size dimorphism (SSD) is a common and widespread phenomenon in animal taxa, but highly variable in magnitude and direction (Andersson 1994; Fairbairn 1997; Brandt and Andrade 2007). Sexually dimorphic traits have been surveyed in different classes of vertebrates, including birds (Selander 1966, 1972; Temeles 1985; Temeles et al. 2000), primates (Crook 1972), amphibians (Shine 1979; Woolbright 1983; Monnet and Cherry 2002; Schäuble 2004; Vargas-Salinas 2006; McGarrity and Johnson 2008), lizards (Stamps 1983; Rocha 1996; Carothers 1984; Trivers 1976; Molina-Borja 2003; Baird et al. 2003; Verrastro

2004; Bruner et al. 2005; Kaliontzopoulou et al. 2007), and snakes (Shine 1978, 1993, 1994; Ferliche et al. 1993; Kminiak and Kaluz 1983; Shine et al. 1999).

To our knowledge, such a survey has not yet been documented for the Marsh frog, *Rana ridibunda ridibunda* in Iran. The Marsh frog, *Rana (Pelophylax) ridibunda ridibunda* Pallas, 1771, has a relatively wide distribution throughout Iran, except for southeastern regions (i.e., Sistan and Baluchistan Province; Baloutch and Kami 1995). We analyzed sexual size dimorphism in this species to reveal sexually dimorphic traits that can be important in systematic and evolutionary research.

Materials and methods

The current survey was carried out about five km from Darre-Shahr city, Ilam province, western Iran (Fig. 1), 33°11' N and 47°22' E, 620 m above sea level (asl) and with 486 millimeter (mm) annual precipitation. All 96 specimens (52 ♀ and 44 ♂) were collected using a hand-made butterfly net in streams, brooks, and cultivation waterways. Twelve morphometric characters were chosen and measured by a digital caliper to the nearest 0.01

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mm and are presented in Table 1. Morphometric variable measurements were obtained from as many specimens as possible per locality and released unharmed at the original capture location. The same procedure was repeated in localities separated as far as possible to ensure that none of the individuals were counted twice. Two distinctive characters were used to distinguish males from females: first, the vocal pouches at the ends of buccal slits, just under the tympana at the sides of head and second, the digital pads on thumbs (Fig. 2). To test significance of sexually dimorphic characters, Independent Sample *t*-test (2-tailed) as well as Principal Component Analysis (PCA: correlation matrix) at the significance level of 0.01 were employed. SPSS software version 16 was used for running the statistical analyses.

Results

Independent-Samples *t*-test (2-tailed)

The results of the Independent-Samples *t*-test (2-tailed) show all variables differed significantly between sexes ($p \leq 0.01$), with each variable being greater in females than males (Table 2).

Principal Component Analysis (PCA)

The two axes of the PCA explain 82.08% of the total variation. The Principal Component One (PC1) accounts for 73.95% and the Principal Component Two (PC2) for 8.13% of the total variation (Table 3). For PC1, the variables SVL, LHL, LFL, FHL, HL, HW, NNL, TL, and L4T (see Table 1 for the morphometric characters used in the study) are the most sexually dimorphic characters. All these variables have the same direction (positive = larger females) but not the same magnitude (Fig. 3). The values of the females along PC1 do overlap, to some extent, with those for males, indicating that the sexes are

Table 1. The morphometric characters used in this study.

| Characters | Definition |
|------------|-----------------------------------|
| SVL | Snout to vent length |
| LHL | Length of hindlimb |
| LFL | Length of forelimb |
| FHL | Forelimb to hindlimb length |
| HL | Head length |
| HW | Head width |
| EEL | Eyelid to eyelid length |
| SEL | Snout to eye length |
| ELW | Eyelid width |
| NND | Distance between nostrils |
| TL | Tympanum length |
| L4T | Length of the 4 th toe |

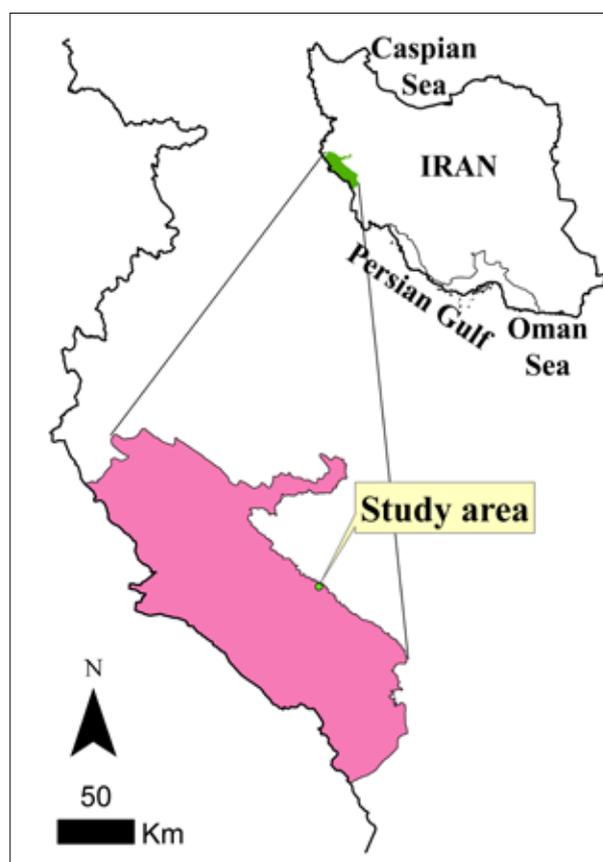


Figure 1. Map showing the study area in Ilam province, western Iran.

not fully separated from each other. The first axis is a reflection of size with about 45% of males and 23% of females inseparable in these characters. The PC2 on the other hand shows almost no discrimination between the sexes, explaining only 8.13% of the total variation in which the characters EEL and ELW having the most important role (Fig. 3, Table 3).

Conclusion

There is an accepted hypothesis that explains the status and direction of sexual size dimorphism in anurans, where males are usually smaller than females as a result of sexual selection (Monnet and Cherry 2002). In 90% of the anuran species, the females are larger than males (Shine 1979). As is obvious from Table 2, each character tested for *Rana r. ridibunda* was significantly ($p \leq 0.01$) different for males and females on average and 100% of the measured characters are indicative of the presence of sexual dimorphism in size.

In some species of frogs, males are much smaller than females and it is not necessary to carry out statistical analyses (Hayek and Heyer 2005). But for *R. r. ridibunda* it was not completely clear that males are smaller than females without the help of statistical analyses. Shine (1979) showed that in species exhibiting male combat, males are often larger than females, but in our analyses

Sexual size dimorphism in *Rana (Pelophylax) ridibunda ridibunda*

Table 2. Comparison of morphometric characters (mm) in males and females of *Rana ridibunda ridibunda*. *n*: number; SEM: standard error of mean; * = significant at level 0.01. Morphometric abbreviations: SVL (snout-vent length), LHL (length of hindlimb), LFL (length of forelimb), FHL (forelimb to hindlimb length), HL (head length), HW (head width), EEL (eyelid to eyelid length), SEL (snout to eye length), ELW (eyelid width), NND (distance between nostrils), TL (tympanum length), L4T (length of the 4th toe).

| SEX | | SVL* | LHL* | LFL* | FHL* | HL* | HW* | EEL* | SEL* | ELW* | NNL* | TL* | L4T* |
|---------------------------------|------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| ♂ (<i>n</i> = 44) | mean | 67.16 | 103.33 | 36.27 | 30.36 | 18.80 | 23.12 | 3.33 | 10.50 | 4.82 | 3.97 | 4.74 | 18.54 |
| | SEM | 0.48 | 0.70 | 0.25 | 0.32 | 0.16 | 0.18 | 0.05 | 0.09 | 0.09 | 0.04 | 0.05 | 0.14 |
| ♀ (<i>n</i> = 52) | mean | 78.36 | 120.14 | 41.12 | 36.04 | 21.71 | 26.52 | 3.94 | 12.29 | 5.19 | 4.47 | 5.45 | 21.13 |
| | SEM | 0.78 | 1.01 | 0.37 | 0.43 | 0.24 | 0.31 | 0.07 | 0.22 | 0.07 | 0.05 | 0.06 | 0.17 |
| <i>p</i>-value (≤ 0.001) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 |
| Difference between means | | 11.2 | 16.81 | 4.85 | 5.68 | 2.91 | 3.4 | 0.61 | 1.79 | 0.37 | 0.5 | 0.71 | 2.59 |

here, all measured characters in Table 2, size of female characters are significantly larger than males. According to Shine (1979), in most cases the causes of sexual dimorphism in frogs are not known and also in *R. r. ridibunda* the actual causes of this high degree of sexual dimorphism in our data are not fully understood. Given this, it seems that there is an outstanding problem in statistical significance versus biological significance when evaluating sexual dimorphism in measured characters of *R. r. ridibunda*. Regardless of any evolutionary or ecological causes of observed sexual dimorphism in *Rana r. ridibunda*, with respect to the three usual and accepted hypotheses of sexual size dimorphism in all animals: (1) fecundity selection on female body size (Wiklund and Karlsson 1988; Fairbairn and Shine 1993), (2) sexual selection on male body size (Cox et al 2003), and (3) ecological divergence between sexes due to intraspecific competition (Butler et al. 2000; Bolnick and Doebeli 2003); there is an uncertainty in clarifying the main force(s) causing a high degree of sexual size dimorphism in this species. More profound surveys are needed to uncover the main cause(s) of SSD in *R. r. ridibunda*.

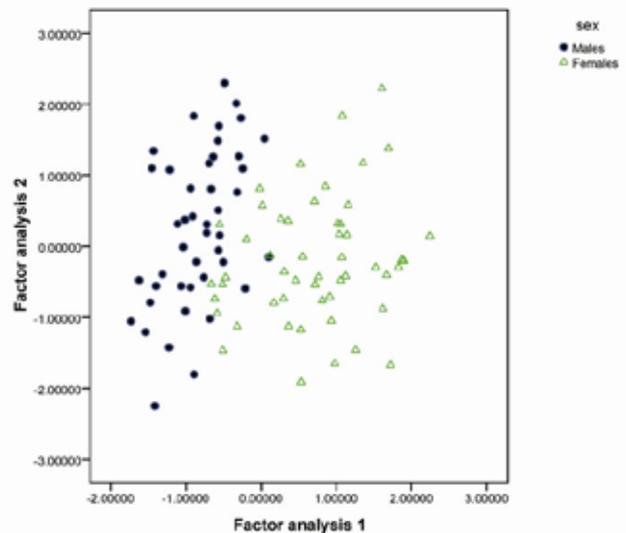


Figure 3. Ordination of the individual males and females of *Rana (Pelophylax) ridibunda ridibunda* on the first two principal components. Note the relative degree of isolation between males and females, which is mainly attributed to SVL, LHL, LFL, HL, and HW in the PC1 and EEL and ELW in the PC2.



Figure 2. The presence of vocal pouches (a) and digital pads (b) in male *Rana (Pelophylax) ridibunda ridibunda* distinguishes them from females.

Table 3. Extraction of Principal Components 1-3 using the component matrix. Variables loading strongly on each principal component are bold. Abbreviations: SVL (snout-vent length), LHL (length of hindlimb), LFL (length of forelimb), FHL (forelimb to hindlimb length), HL (head length), HW (head width), EEL (eyelid to eyelid length), SEL (snout to eye length), ELW (eyelid width), NND (distance between nostrils), TL (tympanum length), T4T (length of the 4th toe).

| Variables | PC 1 | PC 2 | PC 3 |
|-----------------------|--------------|---------------|---------------|
| SVL | 0.964 | 0.002 | 0.041 |
| LHL | 0.941 | -0.164 | -0.124 |
| LFL | 0.900 | -0.230 | -0.121 |
| FHL | 0.877 | -0.134 | 0.069 |
| HL | 0.953 | 0.145 | 0.068 |
| HW | 0.951 | -0.087 | 0.042 |
| EEL | 0.678 | -0.540 | 0.311 |
| SEL | 0.766 | 0.128 | -0.431 |
| ELW | 0.669 | 0.660 | 0.106 |
| NNL | 0.848 | 0.105 | 0.311 |
| TL | 0.866 | 0.210 | 0.037 |
| L4T | 0.841 | -0.225 | -0.269 |
| Eigenvalue | 8.857 | 0.976 | 0.507 |
| % variation explained | 73.956 | 8.130 | 4.225 |

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