Amphibian & Reptile Conservation 5(1):92-97.

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

[1]BEHZAD FATHINIA, [1,4]NASRULLAH RASTEGAR-POUYANI, [2]HAMID DARVISHNIA, [3]HOSSEIN MOHAMADI, AND [1]HIWA FAIZI

[1]*Department of Biology, Faculty of Science, Razi University, 6714967346 Kermanshah, IRAN* [2]*Department of Biology, Payam-e-Noor University, Talesh, Guilan, IRAN;* [3]*Head of Biodiversity and Wildlife Management, Department of the Environment, Tehran, IRAN*

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

Citation: Fathinia B, Rastegar-Pouyani N, Darvishnia H, Mohamadi H, Faizi H. 2012. Sexual size dimorphism in *Rana* (*Pelophylax*) *ridibunda ridibunda* Pallas, 1771 from a population in Darr-Shahr Township, Ilam Province, western Iran. *Amphibian & Reptile Conservation* 5(1):92-97(e44).

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; Feriche 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 handmade butterfly net in streams, brooks, and cultivation waterways. Twelve morphometric characters were chosen and measured by a digital caliper to the nearest 0.01

Correspondence. *Email:* [4]*nasrullah.r@gmail.com*

mm and are presented in Table 1. Morphometric varible 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 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).

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 4th toe

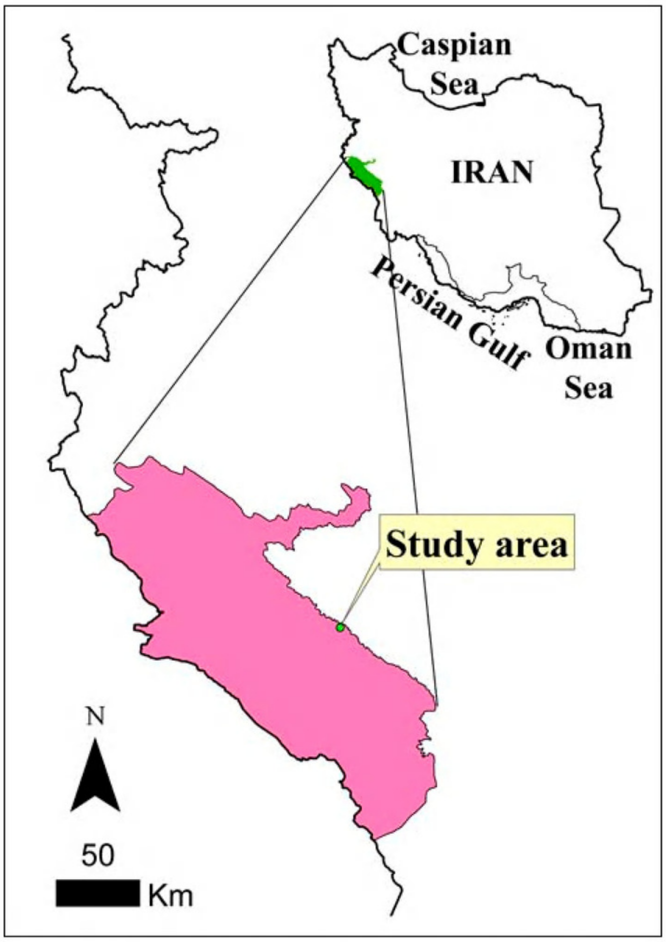

Figure 1. Map showing the study area in Ilam province, western Iran.

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

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*
♂	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
(*n* = 44)	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
♀	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
(*n* = 52)	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
p-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*.

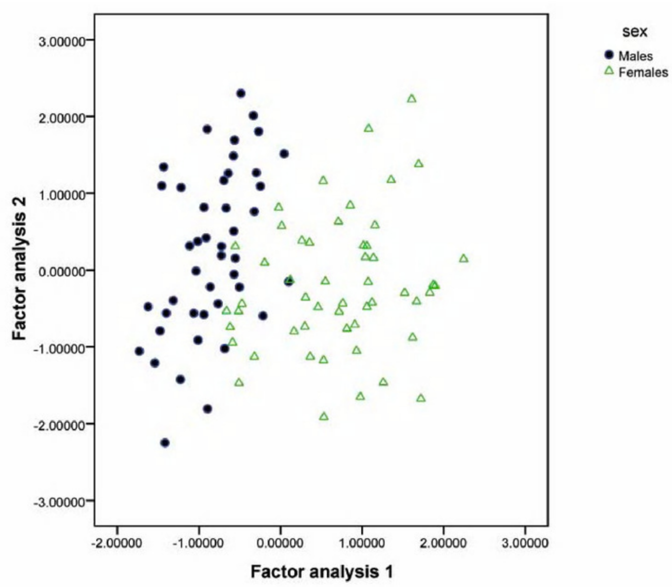

Figure 3. Ordination of the individual males and females of *Rana* (*Pelophylax*) *ridibunda ridibunda* on the first two principal components. Note the relative degree of isolation between males and females, which is mainly attributed to SVL, LHL, LFL, HL, and HW in the PC1 and EEL and ELW in the PC2.

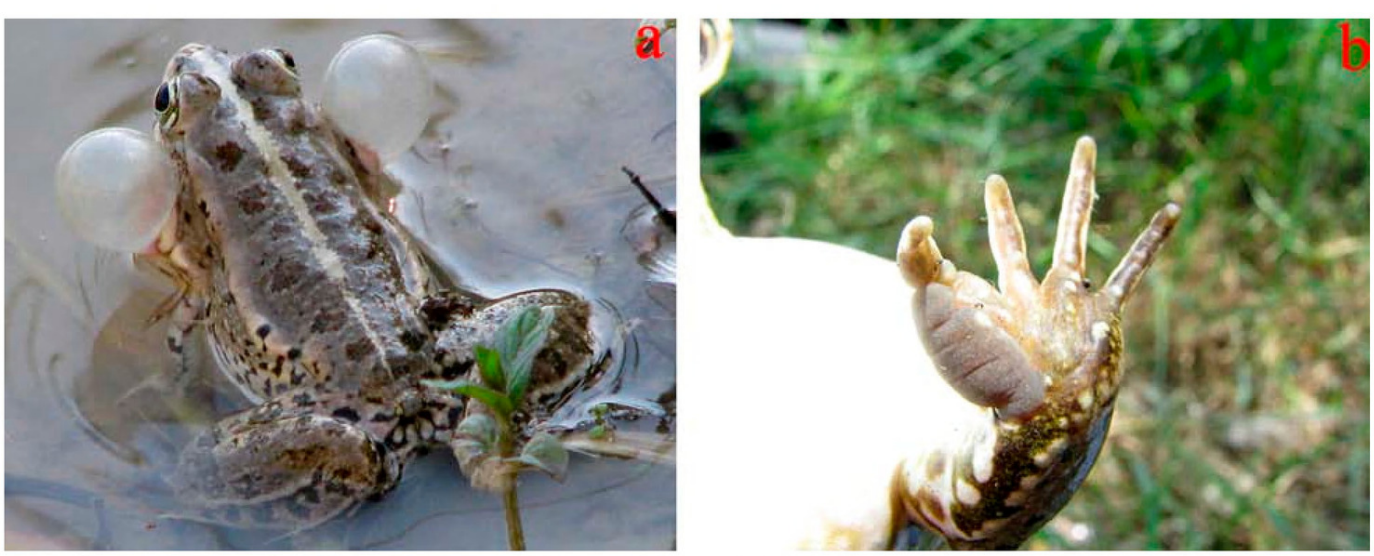

Figure 2. The presence of vocal pouches (a) and digital pads (b) in male *Rana* (*Pelophylax*) *ridibunda ridibunda* distinguishes them from females.

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

Acknowledgments.—The authors wish to thank the Ilam Province Department of the Environment for their support during field work in Ilam Province.

Literature cited

ANDERSSON M. 1994. *Sexual Selection*. Princeton University Press, Princeton, New Jersey. 624 p.

BAIRD TA, VITT LJ, BAIRD TD, COOPER JR WE, CALDWELL JP, PÉREZ-MELLADO V. 2003. Social behavior and sexual dimorphism in the Bonaire whiptail, *Cnemidophorus murinus* (Squamata: Teiidae): The role of sexual selection. *Canadian Journal of Zoolology* 81(11):1781-1790.

BALOUTCH M, KAMI HG. 1995, *Amphibians of Iran*. Tehran University Publication, Tehran. 177 p. (In Persian).

BOLNICK DI, DOEBELI M. 2003. Sexual dimorphism and sympatric speciation: Two sides of the same ecological coin. *Evolution* 57(11):2433-2449.

BRANDT Y, ANDRADE MCB. 2007. Testing the gravity hypothesis of sexual size dimorphism: Are small males faster climbers? *Functional Ecology* 21(2):379-385.

BRUNER E, COSTANTINI D, FANFANI A, DELL'OMO G. 2005. Morphological variation and sexual dimorphism of the cephalic scales in *Lacerta bilineata*. *Acta Zoologica* (Stockholm) 86(4):245-254.

BUTLER MA, SCHOENER TW, LOSOS JB. 2000. The relationship between sexual size dimorphism and habitat use in greater Antiliean Anolis lizards. *Evolution* 54(1):259-272.

CAROTHERS JH. 1984. Sexual selection and sexual dimorphism in some herbivorous lizards. *American Naturalist* (Chicago) 124(2):244-254.

COX RM, SKELLY SL, JOHN-ALDER HB. 2003. A comparative test of adaptive hypotheses for sexual size dimorphism in lizards. *Evolution* 57(7):1653-1669.

CROOK JH. 1972. Sexual selection, dimorphism, and social organization in the primates In: *Sexual Selection and the Descent of Man*. Editor, Campbell R. Chicago, Aldine. 231-281.

FAIRBAIRN DJ. 1997. Allometry for sexual size dimorphism: Pattern and process in the coevolution of body size in males and females. *Annual Review of Ecology and Systematics* 28:659-687.

FAIRBAIRN DJ, SHINE R. 1993. Patterns of sexual size dimorphism in seabirds of the southern hemisphere. *Oikos* 68:139-145.

FAIZI H, RASTEGAR-POUYANI N, RAJABIZADEH M, HEIDARI N. 2010. Sexual dimorphism in *Trachylepis aurata transcaucasica* Chernov, 1926 (Reptilia: Scincidae) in the Zagros Mountains, western Iran. *Iranian Journal of Animal Biosystematics* 6(1):1-8.

FERICHE M, PLEGUEZUELOS JM, CERRO A. 1993. Sexual dimorphism and sexing of mediterranean Colubrids based on external characteristics. *Journal of Herpetology* 27(4):357-362.

HAYEK L-A, HEYER RW. 2005. Determining sexual dimorphism in frog measurement data: Integration of statistical significance, measurement error, effect size and biological significance. *Annals of the Brazilian Academy of Sciences* 77(1):45-76.

KALIONTZOPOULOU A, CARRETERO MA, LLORENTE GA. 2007. Multivariate and geometric morphometrics in the analysis of sexual dimorphism variation in *Podarcis* lizards. *Journal of Morphology* 268(2):152-165.

KMINIAK M, KALUZ S. 1983. Evaluation of sexual dimorphism in snakes (Ophidia, Squamata) based on external morphological characters. *Folia Zoologica* 32:259-270.

KUO C-Y, LIN Y-T, LIN Y-S. 2009. Sexual size and shape dimorphism in an agamid lizard, *Japalura swinhonis* (Squamata: Lacertilia: Agamidae). *Zoological Studies* 48(3):351-361.

MCGARRITY ME, JOHNSON SA. 2008. Geographic trend in sexual size dimorphism and body size of *Osteopilus septentrionalis* (Cuban treefrog): Implications for invasion of the southeastern United States. *Biological Invasions* 11(6):1411-1420.

MOLINA-BORJA M. 2003. Sexual dimorphism of *Gallotia atlantica atlantica* and *Gallotia atlantica mahoratae* (Lacertidae) from the eastern Canary islands. *Journal of Herpetology* 37(4):769-772.

MONNET J-M AND CHERRY MI. 2002. Sexual size dimorphism in anurans. *Proceedings of the Royal Society of London B Biological Sciences* 269(1507):2301-2307.

ROCHA CFD. 1996. Sexual dimorphism in the sand lizard

Liolaemus lutzae of southeastern Brazil In: *Herpetologia Neotropical*. Editor, Péfaur JE. Mérida, Universidad de los Andes, Conselho de Publicaciones. Volume 2. 131-140.
Schäuble CS. 2004. Variation in body size and sexual dimorphism across geographical and environmental space in the frogs *Limnodynastes tasmaniensis* and *L. peronii*. *Biological Journal of the Linnean Society* (London) 82(1):39-56.
Schoener TW. 1967. The ecological significance of sexual dimorphism in size in the lizard *Anolis conspersus*. *Science* 155(3761):474-477.
Selander RK. 1966. Sexual dimorphism and differential niche utilization in birds. *Condo* 68(2):113-151.
Selander RK. 1972. Sexual selection and dimorphism in birds In: *Sexual Selection and the Descent of Man*. Editor, Campbell, B. Chicago, Aldine. 180-230.
Shine R. 1978. Sexual size dimorphism and male combat in snakes. *Oecologia* 33(3):269-277.
Shine R. 1979. Sexual selection and sexual dimorphism in the Amphibia. *Copeia* 1979(2): 297-306.
Shine R. 1993. Sexual dimorphism in snakes In: *Snakes: Ecology and Behavior*. Editors, Seigel RA, Collins JT. McGraw-Hill, New York. 49-86.
Shine R. 1994. Sexual size dimorphism in snakes revisited. *Copeia* 1994(2):326-346.
Shine R, Olsson MM, Moore IT, Lemaster MP, Mason RT. 1999. Why do male snakes have longer tails than females? *Proceedings of the Royal Society of London B* 266:2147-2151.
Stamps JA. 1983. Sexual selection, sexual dimorphism and territoriality in lizards In: *Lizard Ecology: Studies on a model organism*. Editors, Huey RB, Pianka ER, Schoener TW. Harvard University, Cambridge, Massachusetts. 169-204.
Temeles EJ. 1985. Sexual size dimorphism of bird-eating hawks: The effect of prey vulnerability. *American Naturalist* 125(4):485-499.
Temeles EJ, Pan IL, Brennan JL, Horwitt JN. 2000. Evidence for ecological causation of sexual dimorphism in a hummingbird. *Science* 289(5478):441-443.
Tinkle D, Wilbur H, Tilley S. 1970. Evolutionary strategies in lizard reproduction. *Evolution* 24:55-74.
Trivers RL. 1976. Sexual selection and resource-accruing abilities in *Anolis garmani*. *Evolution* 30:253-269.
Vargas-Salinas F. 2006. Sexual size dimorphism in the Cuban treefrog *Osteopilus septentrionalis*. *Amphibia-Reptilia* 27(3):419-426.
Verrastro L. 2004. Sexual dimorphism in *Liolaemus occipitalis* (Iguania, Tropiduridae). *Iheringia. Série Zoologia* 94(1):45-48.
Wiklund C, Karlsson B. 1988. Sexual size dimorphism in relation to fecundity in some Swedish satyrid butterflies. *American Naturalist* 131(1):132-138.
Woolbright LL. 1983. Sexual selection and size dimorphism in anuran Amphibia. *American Naturalist* 121(1):110-119.

Received: 19 September 2011
Accepted: 22 November 2011
Published: 07 April 2012

BEHZAD FATHINIA earned his B.A. and M.S. from Isfahan and Lorestan universities, respectively. His M.S. research focused on "The Biosystematic Study of Lizards of Ilam Province." He is a Ph.D. student at Razi University, Kermanshah, western Iran under the supervision of Nasrullah Rastegar-Pouyani, Mozafar Sharifi, and Eskandar Rastegar-Pouyani. His dissertation reaserch involves ecology, phylogeography, molecular systematics, and population genetics of the Iranian viper *Pseudocerastes urarachnoides* in western Iran. He is also interested in other reptiles, especially snakes.

NASRULLAH RASTEGAR-POUYANI earned his B.S. in zoology from Razi University Kermanshah, Iran in 1986 and his M.S. in zoology from Tehran University, Tehran, Iran in 1991, where he studied herpetology with the agamids as the central object. He started his Ph.D. in Gothenburg University, Sweden in 1994 under the advisement of Professor Göran Nilson and graduated in 1999, working on taxonomy and biogeography of Iranian Plateau agamids with *Trapelus* as the main objective. His research interests include taxonomy and biogeography of the Iranian Plateau, the Middle East and central Asian herpetofauna.

HAMID DARVISHNIA earned a B.A. from Booali University of Hamadan and his M.S. from Shahid Beheshti University of Tehran (his thesis was on developmental biology). He is currently a faculty member of the Department of Biology, Payam-e-Noor University, Talesh, Guilan, north of Iran. Darvishnia is interested in systematics, ecology, and ethology of amphibians and reptiles.

HUSSEIN MOHAMADI is the Head of Natural History Museums and genetic resources, Environmental Protection Organization, Tehran, Iran. He earned his B.A. and M.S. degrees from the Natural Resource College of Tehran University. His M.S. thesis was "The Ecological study of the Marsh crocodile, *Crocodylus palustris*, in Baluchistan." He is now continuing his study as a Ph.D. student in environmental science, branch of science and research at Islamic Azad University. The subject of his Ph.D. thesis is "The assessment of changing trends and modeling of habitat preference in yellow Persian deer, *Dama dama mesopotamica*."

HIVA FAIZI earned his B.Sc. in plant biology from Shahid Beheshti University (SBU) and his M.Sc. in Animal Biosystematics from Razi University. During his M.Sc. he studied the genus *Trachylepis* in Iran from different perspectives, including morphology, osteology, parasitology, and systematics of *Trachylepis aurata transcaucasica*. He studied the Near Eastern fire salamander, *Salamandra infraimmaculata seminovi*, from Kurdistan province, western Iran. Currrently, he is collecting data and samples of *Neurergus microspilotus* and *Neurergus kaiseri* to start a Ph.D. project on population genetic and genetic diversity of the two mentioned species.