



ORIGINAL RESEARCH PAPER

**MORPHOLOGICAL CHARACTERISTICS OF THE FIRE SALAMANDER  
POPULATION (*Salamandra salamandra*, Salamandridae) FROM ŠAR PLANINA  
MOUNTAIN**

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**SYNOPSIS**

In this paper we present the results of the analysis of morphological characteristics of fire salamander population from Šar planina Mountain (Serbia). Univariate and multivariate statistical analyses have been performed on the samples taken from eight localities. The basic parameters of descriptive statistics for 17 morphometric characters have been calculated, separately by sexes. The analysis of variance (ANOVA) showed that sexes significantly differed in four characters. Males had larger forelimb length, hindlimb length and forefoot length, while females were larger in head width. Also, percentages of states for three qualitative traits were presented. Symmetrical pattern type of dorsal blotches prevails.

**SINOPSIS**

**MORFOLOŠKE KARAKTERISTIKE POPULACIJE ŠARENOG  
DAŽDEVNJAKA (*Salamandra salamandra*, Salamandridae)  
SA ŠAR PLANINE**

U radu su prikazani rezultati analize morfoloških karakteristika populacije šarenog daždevnjaka sa Šar planine (Srbija). Na uzorcima sakupljenim sa osam lokaliteta, urađene su univarijantne i multivarijantne statističke analize. Za 17 morfometrijskih karaktera izračunati su osnovni parametri deskriptivne statistike, odvojeno po polovima. Analiza varijanse (ANOVA) je pokazala da se polovi statistički razlikuju u četiri karaktera. Mušjaci imaju duže prednje ekstremitete, zadnje ekstremitete i stopala prednjih nogu, dok ženke imaju širu glavu. Takođe je izračunat i procenat zastupljenosti stanja, tri kvalitativne osobine. Preovlađuje simetričan tip dorzalne šare.

**Key words:**

fire salamander,  
morphology,  
gender differences,  
qualitative traits.

**Ključne riječi:**

šareni daždevnjak,  
morfologija,  
razlike među polovima,  
kvalitativne osobine.

## INTRODUCTION

The fire salamander, *Salamandra salamandra* (Linnaeus, 1758), inhabits southern and central parts of Europe, from the Iberian Peninsula to the Black Sea, and from Italy to northern Germany. Fire salamander populations are absent in Great Britain, Ireland and Scandinavia (Griffiths, 1996; Veith, 1997).

The fire salamander could be found in the highland area in central Balkans, up to 1750m a.s.l. (Krizmanić, 1998; Kalezić et al., 2000). In Serbia, it is widely distributed. They mostly inhabit thermophilic and mesophilic oak-beech and beech-fir mountain forests (Džukić, 1993). It is most common in dark and damp areas litter-covered forest on the slopes of hills.

It is widely accepted that the fire salamander is a polytypic species (Griffiths, 1996; Veith, 1997; Steinfartz et al., 2000; García-París et al., 2003; Martínez-Solano et al., 2005; Reis et al., 2011). Intraspecific differentiation is the most pronounced in the Iberian Peninsula where the ten subspecies were recognized (Steinfartz et al., 2000; García-París et al., 2003; Köhler & Steinfartz, 2006; Reis et al., 2011). The central parts of Europe are inhabited by *Salamandra salamandra terrestris* populations, the east part of Europe by the nominotypic *Salamandra salamandra salamandra* (Steinfartz et al., 2000). The Balkan Peninsula is inhabited by three subspecies (*S. salamandra salamandra*, *S. salamandra beschkovi* and *S. salamandra wernerii*, (Džukić & Kalezić, 2004). *S. salamandra beschkovi* and *S. salamandra wernerii* are the endemic taxa of the southwestern part of Bulgaria and Peloponnese, respectively, while *S. salamandra salamandra* occurs in the rest of the Balkans.

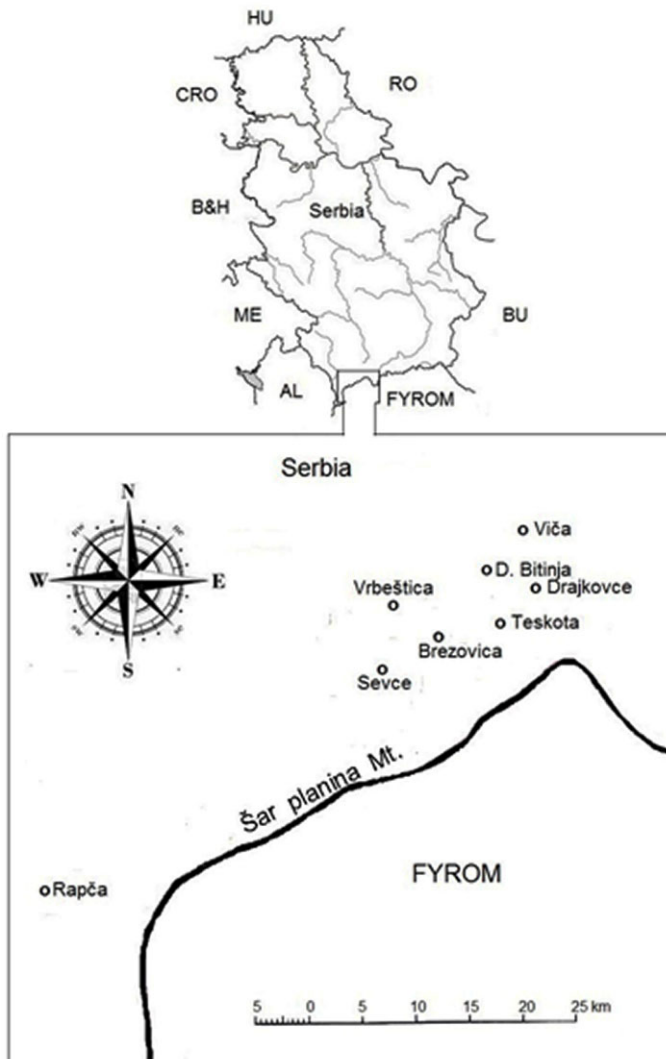
Up to now, some of the Balkan populations of the fire salamander have been included in genetic and phylogenetic studies (Joger & Steinfartz, 1995; Steinfartz et al., 2000), morphological studies (Beškov & Cončev, 1963; Grillitsch & Grillitsch, 1991; Veith, 1994; Labus et al., 2012) and sexual size and shape dimorphism studies (Labus et al., 2013).

Although specimens from the Šar planina Mountain population were included in some of these studies, complete descriptive data on morphological characters have not been published until now.

## MATERIAL AND METHODS

We examined the specimens of the fire salamander deposited in the herpetological collections of the University of Priština, temporarily seated in Kosovska Mitrovica, Faculty of Science and Mathematics, Biology Department. The specimens were previously collected from 8 localities (Sevce = 42°12'35" N, 20°57'24" E; Vrbeštica = 42°14'12" N, 20°58'44" E; Teskota = 42°13'37" N,

21°02'15" E; Brezovica = 42°13'19" N, 21°00'17" E; Viča = 42°15'57" N, 21°04'50" E; Donja Bitinja = 42°15'11" N, 21°2'35" E; Drajkovce = 42°15'10" N, 21°05'3" E and Rapča = 42°04' 59" N, 20°37'06" E) in the Šar planina Mountain (Serbia) (Fig. 1) in different times and therefore, no animals were sacrificed for this study.



**Figure 1:**  
Location of *Salamandra salamandra* populations used in this study.

In total, 68 ethanol-preserved specimens were analyzed: 22 sexually mature males, 38 sexually mature females, 6 immature males and 2 immature females.

Morphometric analysis has been done on 17 traits which determine size and shape of the body and head of the fire salamanders. Measurements were taken only on sexually mature individuals. Reproductively mature males and females were identified on the dissection and gonads survey basis. Measured traits were: L – total length, Lsd – length from the snout to the anterior edge of cloaca basis, Lsv – snout-vent length (from the snout to the posterior edge of the cloaca basis), TI - tail

length, Lc – head length, Ltc – head width, Ac – head height, D – interlimb distance, Lpa – forelimb length, Lpp – hindlimb length, Dn – distance between exterior nostrils, Do – eye diameter, Spp – minimal distance between orbits, Lpr – parotid gland length, A – forefoot length (measured from the base of foot to the end of 3rd toe), P – hindfoot length (measured from the base of foot to the end of the 4th toe), Lm – jaw length (measured from the snout to the corner of the mouth). All measurements were taken with a digital caliper to a precision of 0.01 mm by the same person (N.L.).

Qualitative analysis included three qualitative traits with several states. Qualitative traits were: (I) pattern of dorsal blotches: a - diffuse, b - medio-dorsally fused, c - symmetrical; (II) ventral side color: a - black, b - with yellow dots; (III) position of ventral blotches: a - only on throat, b - small number on throat, abdomen and tail, c - large number on throat, abdomen and tail.

Preliminary analysis revealed no significant age related variations in the frequencies of qualitative traits. Therefore, qualitative analysis was performed on the whole sample which includes except sexually mature and sexually immature individuals.

Programme package STATISTICA (version 7.0) has been used for statistical analysis of data. For morphometric characters basic parameters of descriptive statistics have been separately calculated by genders: mean ( $\bar{x}$ ), standard error (SE) and range. Analysis of variance (ANOVA) has been used to establish the significance of differences in respect of morphometric characters between the gender. Also, percentages of states for each qualitative trait were calculated.

## RESULTS AND DISCUSSION

### MORPHOMETRIC CHARACTERS

Descriptive statistics of morphometric characters of adult males and females are presented in Table 1.

The smallest male of the sample of the population from Šar planina Mountain was 153.5 mm, and the largest one 197.6 mm. The smallest female was 152.2 mm, and the largest one 199.9 mm. These values were in accordance with literature data (Beškov & Cončev, 1963; Grillitsch & Grillitsch, 1991; Džukić, 1993; Griffiths, 1996; Kalezić et al., 2000), but they were smaller than those in Radovanović (1951). Our measurements showed that snout-vent length (Lsv) values for males were between 92.8 – 114.9 mm ( $\bar{x} = 106.59 \text{ mm} \pm 1.30$ ), and for females between 89.5 – 121.8 mm ( $\bar{x} = 104.61 \text{ mm} \pm 1.18$ ). These values were in accordance with literature data (Obst, 1981; Joger & Steinfartz, 1994; Kalezić et al., 2000), too. Values of other morphometric characters for both gender were also in accordance with literature data for fire salamander from Serbia (Kalezić et al., 2000).

**Table 1. Descriptive statistics of 17 morphometric characters for adult male and female *Salamandra salamandra* from the Šar planina Mountain population studied. Sample size (N), mean value (in mm), range, standard error (SE). Abbreviations of characters are given in “Material and Methods”.**

character	males					females				
	N	mean	min	max	SE	N	mean	min	max	SE
<b>L</b>	22	177.35	153.50	197.60	2.71	38	175.81	152.20	199.90	1.89
<b>Lsd</b>	22	94.25	83.10	101.30	1.16	38	94.72	80.20	112.60	1.05
<b>Lsv</b>	22	106.59	92.80	114.90	1.30	38	104.61	89.50	121.80	1.18
<b>TI</b>	22	78.10	56.90	99.20	2.73	38	76.60	59.10	96.30	1.48
<b>Lc</b>	22	22.60	18.50	27.10	0.44	38	22.46	18.80	31.10	0.38
<b>Ltc</b>	22	18.89	16.10	22.30	0.26	38	19.57	17.30	22.40	0.19
<b>Ac</b>	22	12.97	11.10	15.50	0.27	38	13.73	10.40	18.80	0.32
<b>D</b>	22	51.29	41.70	58.10	1.06	38	52.87	35.60	65.60	1.01
<b>Lpa</b>	22	31.84	27.70	36.50	0.46	38	29.67	26.20	33.10	0.30
<b>Lpp</b>	22	36.65	31.30	38.90	1.13	38	34.05	30.70	39.70	0.36
<b>Dn</b>	22	6.10	4.90	7.30	0.11	38	6.37	5.10	7.80	0.10
<b>Do</b>	22	6.92	5.80	8.50	0.16	38	7.03	5.80	7.80	0.09
<b>Spp</b>	22	9.13	7.80	10.40	0.13	38	11.54	7.60	109.00	2.64
<b>Lpr</b>	22	13.68	12.10	15.40	0.21	38	13.81	11.20	16.40	0.18
<b>A</b>	22	14.63	12.20	16.70	0.29	38	13.72	11.40	17.30	0.21
<b>P</b>	22	17.10	14.80	18.70	0.23	38	17.04	14.30	19.70	0.20
<b>Lm</b>	22	16.80	12.40	22.30	0.41	38	16.99	14.20	21.80	0.25

The analysis of variance (ANOVA) showed that sexes significantly differed in 4 of 17 characters: head width (Ltc), forelimb length (Lpa), hindlimb length (Lpp) and forefoot length (A) (Tab. 2). For forelimb length, hindlimb length and forefoot length males were statistically larger than females, while females had greater head width. This is in accordance with literature data for central Balkans (Labus et al., 2013). Longer legs in males could be beneficial in courtship performance, where individuals with longer legs have larger reproductive success. Difference in head shape between males and females of the fire salamander could be consequence of different feeding strategies along a niche divergence process (Andersson, 1994).

No statistically significant differences between males and females were found in most traits which determine body size, even males were larger than females (L, Lsv, D). This is in accordance with existing study for two populations of the fire salamander in Serbia that showed bigger males than females individuals (Kalezić et al., 2000). On the other hand, females have larger interlimb distance. This is consistent with assumption that larger interlimb distance in females is an adaptation to provide larger space for eggs (Shine, 1979).

**Table 2. Gender size differences of *Salamandra salamandra* from the Šar planina Mountain population studied. Abbreviations of characters are given in „Material and Methods“. Bold statistically significant p values ( $p < 0.05$ ).**

character	F	P
L	0.227	0.636
Lsd	0.193	0.662
Lsv	0.862	0.357
TI	0.283	0.597
Lc	0.106	0.745
Ltc	4.939	<b>0.030</b>
Ac	2.008	0.162
D	1.365	0.248
Lpa	16.447	<b>0.000</b>
Lpp	5.968	<b>0.018</b>
Dn	2.639	0.110
Do	0.244	0.624
Spp	0.470	0.496
Lpr	0.113	0.738
A	6.346	<b>0.015</b>
P	0.033	0.857
Lm	0.078	0.782

#### QUALITATIVE TRAITS

Percentages of states for qualitative traits of the entire sample are presented in Tab. 3.

No differences in qualitative traits between males and females were found in the populations of the fire salamander. It is impossible to determine the sex based on the type and arrangement of spots on the dorsal or ventral side of the body (Džukić, 1993). Therefore, no analyses were performed separately for males and females.

In general, in the population of *S. salamandra* from the Šar planina Mountain there is predominance of specimens with symmetrical type of dorsal blotches (Ic) and the presence of ventral blotches only on throat (IIIa). Symmetrical type of dorsal blotches is present in 56.92 %, while the diffuse type of pattern (Ia) is the least represented (15.38 %). On the ventral side of the body black coloration of individuals is dominated (56.92 %). Individuals with yellow dots only on throat were dominant (55.38 %), while individuals with large number on throat, abdomen and tail (IIIc) and individuals with small number on throat, abdomen and tail (IIIb) represented by 21.53 % and 23.07 %, respectively. This established coloring pattern

of fire salamanders from Šar planina Mountain is in accordance with literature data for central Balkans (Džukić, 1993).

	whole sample (N = 68)
character	%
Ia	15.38
Ib	27.69
Ic	56.92
IIa	56.92
IIb	43.07
IIIa	55.38
IIIb	23.07
IIIc	21.53

**Table 3.**  
Percentages of states of qualitative traits (in %) in *Salamandra salamandra* from the Šar planina Mountain population studied. Abbreviations of traits are given in "Material and Methods".

## CONCLUSION

Complete analysis of morphological characteristics of *Salamandra salamandra* population from Šar planina Mountain, had not been published until now. Morphometric analysis showed that males were larger and had longer limbs than females, while females had a wider head. Analysis of qualitative traits showed that greatest number of animals had symmetrical type of dorsal blotches and dominant black coloration of ventral side of the body. The results of our analysis of external morphology of the fire salamander are in accordance with previous studies of this species for Serbia and central Balkans.

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