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Morphological characteristics of the elusive blotched snake (*Elaphe sauromates*) at its northwestern range limit (Romania)

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Abstract: The blotched snake (*Elaphe sauromates*) is one of the most elusive species of snakes in Romania, and only a small number of individuals have ever been found, which is why morphological data are both scarce and over half a century old. The data gathered from the individuals captured during our field work confirmed the presence of sexual dimorphism (significant for SVL/TL ratios) and presented a greater morphological variation than recorded in the scientific literature. Individuals examined usually had more than 2 rows of temporal scales and displayed variation in subocular scales, as opposed to the information previously available, hinting at a possible environmental influence on meristic characteristics.

Key words: Reptiles, morphometrics, scalation, sexual dimorphism, Romanian Dobruja

The blotched snake, *Elaphe sauromates* (Pallas 1814), is one of the largest and more massive European snakes, growing up to 2.6 m in length (Fuhn and Vancea, 1961). The species is easily recognizable by the yellow dorsal coloration with four rows of dark brown, black, or reddish-brown blotches and the black oblique line from the eye to the corner of the mouth (Fuhn and Vancea, 1961; Schultz, 1996; Böhme and Shcherbak, 1999). Juveniles differ in coloration from the adults, the background color being gray or yellowish with four to five rows of dark brown or black blotches (Fuhn and Vancea, 1961; Böhme and Shcherbak, 1999).

Described in 1814 by Pallas, the species was demoted to a subspecies of the four-lined snake, *Elaphe quatuorlineata* (Lacepede, 1789), the type locality being restricted to Isthmus near Perekop, Tauria, Ukraine by Mertens and Müller (1928). Molecular analyses conducted by Lenk et al. (2001) and Utiger et al. (2002) indicated the existence of three clades within *E. quatuorlineata*, of which *E. sauromates* is the most genetically distinct.

The distribution range of the blotched snake partially covers two continents, Europe and Asia (Fuhn and Vancea, 1961; Schultz, 1996; Böhme and Shcherbak, 1999; Ananjeva et al., 2006). In Europe, the distribution range includes southern Romania, southern Moldova, southern Ukraine, Bulgaria, Greece, the European part of Turkey, and southern Russia (Fuhn and Vancea, 1961; Fuhn, 1969; Schultz, 1996; Borkin et al., 1997; Böhme and Shcherbak, 1999; Bozhansky, 2005; Ananjeva et al., 2006; Torok, 2006), while in Asia *E. sauromates* is distributed in western Kazakhstan, western Uzbekistan and Turkmenistan, Georgia, Azerbaijan, Armenia, Turkey, northwestern Iran, Lebanon, and southwestern Syria (Bodenheimer, 1944; Başoğlu and Baran, 1980; Böhme and Shcherbak, 1999; Ananjeva et al., 2006). The blotched snake inhabits arid landscapes, such as steppes or semideserts, but also rocky landscapes with forest-steppe in mountainous or flat regions (Baran and Atatür, 1998; Böhme and Shcherbak, 1999; Ananjeva et al., 2006).

The global conservation status of the species has not been evaluated by the IUCN (IUCN, 2015), but the taxon is featured in numerous Red Books across its range, including the Red Book of Ukraine (1994), Kazakhstan (1996), and Turkmenistan (1999) (Ananjeva et al., 2006).

In Romania, the blotched snake is known mostly from the southern part of the country, most of the distribution records being available from Dobruja (Fuhn and Vancea, 1961; Fuhn, 1969; Török, 2006), while the persistence of

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the species further north has been confirmed relatively recently through a record from the Muddy Volcanoes area (Buzău County) (Ţibu and Strugariu, 2007). The rest of the occurrence records from this region date back to before 1940 (Băcescu, 1937; Fuhn and Vancea, 1961; Török, 2006; Ţibu and Strugariu, 2007).

E. sauromates is very rare in Romania and is considered a critically endangered species according to the Red Book of Vertebrates in Romania (Iftime, 2005), the main factors responsible being habitat destruction and degradation, extension of agricultural and industrial areas, utilization of chemicals in agriculture, direct killing by locals, and motorized traffic (Iftime, 2005). Legally, the species is considered one of community interest, the protection of which requires the designation of special areas of conservation (European Union, 1992).

The scientific literature for Romania regarding the species features no more than 50 known individuals (Török, 2006; Ţibu and Strugariu, 2007), and the last morphological data come from the volume on reptiles published by Fuhn and Vancea (1961) as part of the Romanian Fauna series. In this sense, the aim of the current paper was to update and/or revise the morphological information available for *E. sauromates* in Romania, which is older than 50 years and features a small sample size.

Field work was conducted between 2011 and 2014 in the continental part (i.e. not including the Danube Delta) of Dobruja, Romania, where information available in the literature regarding occurrence and habitat was used to find blotched snakes in previously recorded and new localities. Snakes were captured by hand and morphometric data were collected either on-site or subsequently. Because juveniles differ in color from adults (Fuhn and Vancea, 1961; Böhme and Shcherbak, 1999), individuals with adult coloration were treated as sexually mature; sex was determined using ball tip sexing probes. Reproductive state for adult females was detected by careful palpation of the lower half of the body. All snakes were photographed and released afterwards in the same place where they were found.

Morphometric data were collected using a digital caliper to the nearest 0.1 mm (for head length (measured from the tip of the nose to the end of the mouth) – HL; head height (measured at the eyes) – HH; head width (same as previous measurement) – HW; body height (measured at the widest point) – BH; body width (same as previous measurement) – BW; tail width (measured at the widest point behind the cloaca) – TW; tail height (same as previous measurement) – TH) and by tape measurer to the nearest 1 mm (for snout-vent length – SVL; tail length – TL), while weight (W) was determined using a digital scale (to the nearest 0.1 g). Meristic data were subsequently collected using detailed photographs taken in the field (targeting head scalation and ventral scales), except for the number of dorsal scales rows, for which counting was done on-site; the definition of head scalation followed that of Lillywhite (2008).

Data analysis was performed using MS Office Excel and Past 3.01 (Hammer et al., 2001; http://folk.uio.no/ohammer/past/) to generate the descriptive statistics for morphometric and meristic characters and to carry out the Mann–Whitney U test to examine the differences between males and females for all morphometric characters investigated. Fulton's index (K) was used as a body condition index (BCI) and was calculated using the formula $K = \frac{W}{SVL^3} \times 10^5$ (Sztatecsny and Schabetsberger, 2005; Băncilă et al., 2010).

During the 3-year study period 9 blotched snakes were captured: 6 males and 3 females, all featuring the characteristic adult coloration and therefore considered sexually mature (Table 1). The sex ratio for captured individuals was 2:1. None of the females captured showed signs of gestation during inspection.

Descriptive statistics for 10 morphometric characteristics and body mass collected from the 9 blotched snake individuals captured are given in Table 2, along with the results of the Mann–Whitney U test. Females were, on average, larger than males, but the difference was not significant and very large individuals belonging to both sex categories were found. Males had longer tails than females, on average, but the difference was also not significant. By contrast, the ratio between SVL and TL was significantly higher for females (Table 2). As in the case of SVL, females were heavier than males, but the difference was not significant and males with considerable body mass were also found.

Fuhn (1969) mentioned that the species is sexually dimorphic, the difference being that males are larger, have a lower count of ventral scales, and a longer tail; our field results partially confirmed this, except that in our data females were on average larger than males (Table 2). Moreover, a strong dimorphic character seems to be the SVL/TL ratio, where no overlap between values for males and females was found (Table 2).

Head scalation had a large between-individuals variation and the only stable configuration was observed for the preocular scales, all individuals showing 1 preocular on each side of the head. Little variation was observed for postocular scales, where only the largest female captured had 3 postocular scales on the right side of the head (Table 3). The largest variation was observed for temporal scales where usually not only the number differed, but also the number of rows. The variation extended not only to individuals, but also to different sides of the body (Table 3). The total number of dorsal rows at mid-body was the same for all individuals, while the ventral scales ranged between

Table 1. Descriptive information for the 9 blotched snake individuals captured during the study period.

Sample no.	Date	Locality	Sex	Reproductive state	Color pattern	Ecological conditions*
ES-1	28.04.2013	Măcin	♂	Adult	Yellow color form	Steppe with rare oak trees, abandoned structures, and various garbage
ES-2	28.04.2013	Măcin	♂	Adult	Yellow color form	Steppe with rare oak trees, abandoned structures, and various garbage
ES-3	02.05.2013	Măcin	♂	Adult	Yellow color form	Steppe with rare oak trees, abandoned structures, and various garbage
ES-4	26.06.2013	Deniz Tepe Hill	♀	Adult	Yellow color form	Steppe with rare bushes
ES-5	30.05.2014	Agighiol	♂	Adult	Reddish color form	Road at the edge of an agricultural field
ES-6	30.04.2014	Măcin	♀	Adult	Yellow color form	Tall grass and bushes along a rock wall at the edge of a road
ES-7	30.05.2014	Agighiol	♂	Adult	Yellow color form	Steppe with rare bushes
ES-8	07.06.2014	Cerna	♂	Adult	Yellow color form	Steppe with rare bushes
ES-9	05.11.2014	Agighiol	♀	Adult	Reddish color form	Steppe with rare bushes

*: At the place of capture.

Table 2. Descriptive statistics for the morphometric characteristics and body mass collected from the blotched snakes captured, as well as the results of the Mann–Whitney U test for the two groups (significant values in bold).

	Males n = 6		Females n = 3		M vs. F
	Range	Mean ± SD	Range	Mean ± SD	
SVL (mm)	865–1460	1120.3 ± 224.7	1175–1525	1326.7 ± 179.6	U = 4, P = 0.245
TL (mm)	214–340	282.5 ± 50.8	210–326	262 ± 58.9	U = 7, P = 0.698
HL (mm)	26.39–40.36	33.06 ± 4.99	31.92–42.52	36.68 ± 5.38	U = 5, P = 0.366
HH (mm)	10.62–17.28	13.48 ± 2.54	12.93–16.44	15.07 ± 1.88	U = 5, P = 0.366
HW (mm)	16.05–25.57	20.92 ± 4.08	16.95–27.04	23.20 ± 5.46	U = 4.5, P = 0.299
BH (mm)	19.52–40.98	30.84 ± 9.14	30.93–42.49	35.61 ± 6.09	U = 5, P = 0.366
BW (mm)	18.20–38.71	28.14 ± 9.11	29.37–35.30	31.94 ± 3.04	U = 7, P = 0.698
TH (mm)	12.67–21.40	16.71 ± 3.57	16.44–17.80	17.18 ± 0.69	U = 9, P = 0.897
TW (mm)	11.82–19.17	14.97 ± 2.56	15.78–17.36	16.70 ± 0.82	U = 4, P = 0.245
W (g)	230.20–858.40	465.27 ± 248.51	572.90–920.00	691.27 ± 198.13	U = 4, P = 0.245
BCI (K)	25.94–35.81	29.69 ± 5.34	27.58–35.57	30.94 ± 2.99	U = 9, P = 0.594
SVL/TL	3.76–4.29	3.96 ± 0.19	4.68–5.60	5.13 ± 0.46	**U = 0, P = 0.02**

201 and 212 in males (mean ± SD: 205.83 ± 3.97) and 214 to 217 for females (215.67 ± 1.52). The anal scale was divided in all individuals. Subcaudal scales ranged from 75 to 79 in males (77 ± 1.67) and 63 to 70 in females (65.67 ± 3.78).

These preliminary data show clearly that *E. sauromates* exhibits a much greater morphological variation in Romania than presented in the limited literature available (Fuhn and Vancea, 1961), especially for the subocular, loreal, and temporal scales. The variation in loreal scales is in accordance with the data of Böhme and Shcherbak (1999), but some individuals also displayed variation in suboculars (Table 3). The individuals examined also seem to contradict the scientific literature, as the authors observed more than 2 rows (usually 3 or 4) of temporal scales (Figure), whereas the sources available (Fuhn and Vancea, 1961; Böhme and Shcherbak, 1999) only refer to

Table 3. Scale counts for the blotched snakes captured during the study period (n = 9; L-R – left-right sides of the body; for temporal scales, counting followed both Böhme and Shcherbak (1999) and the definition provided by Lillywhite (2008)).

No.	1	2	3	4	5	6	7	8	9
Sex	♂	♂	♂	♀	♂	♂	♂	♀	♀
Preoculars L-R	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-1
Postoculars L-R	2-2	2-2	2-2	2-2	2-2	2-2	2-2	2-3	2-2
Suboculars L-R	1-1	1-1	1-1	1-1	1-1	1-1	1-1	1-2	2-2
Loreals L-R	1-1	1-1	1-1	1-3	2-2	2-3	2-2	2-2	1-2
Upper labials L-R	8-8	8-8	8-8	9-9	8-8	9-8	8-8	8-9	9-8
Lower labials L-R	10-10	10-10	10-9	10-10	10-10	10-12	11-10	11-10	11-11
Temporals left	1+2 (1+2+4)	2+2 (2+2+3)	2+4 (2+4+5)	2+2 (2+2+3)	3+4 (3+4+5)	3+3 (3+3+4+4)	3+3 (3+3+4)	3+4 (3+4+5)	3+4 (3+4+4)
Temporals right	2+1 (2+1+4)	2+3 (2+3+4)	2+3 (2+3+5+4)	1+3 (1+3+3+5)	2+4 (2+4+3+4)	4+3 (4+3+4+4)	3+3 (3+3+4)	3+4 (3+4+4+5)	3+3 (3+3+4)
Gulars	6	5	5	5	7	7	6	6	7
Dorsal (mid-body)	25	25	25	25	25	25	25	25	25
Ventrals	204	212	201	214	207	203	208	217	216
Anal	-/-*	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Subcaudals	76	77	75	64	79	79	76	70	63

-/-: anal plate divided.

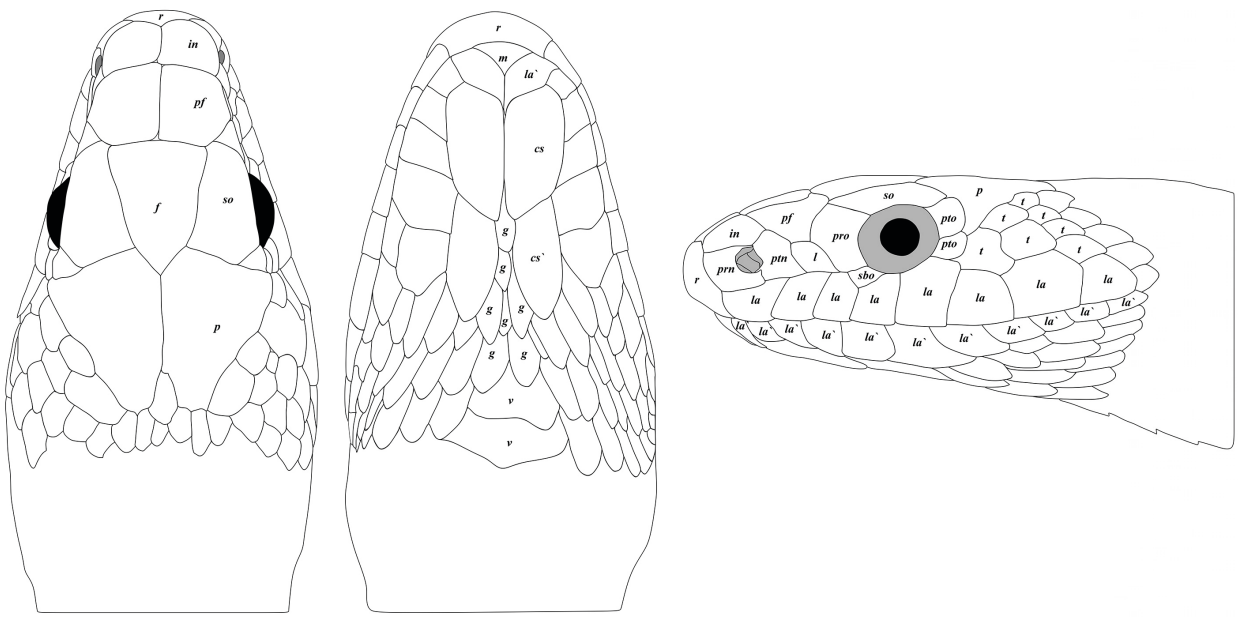

Figure. General head scalation pattern for *Elaphe sauromates* (cs – anterior chin shields; cs' – posterior chin shields; f – frontal; g – gulars; in – internasal; l – loreal; la – upper labials; la' – lower labials; m – mental; p – parietals; pf – prefrontal; prn – prenasal; ptn – postnasal; pto – postocular; pro – preocular; r – rostral; so – supraocular; sbo – subocular; t – temporals; v – ventral shields).

2 rows of temporal scales. The authors presume that this is related to the fact that, until recently, the species was classified as a subspecies of *Elaphe quatuorlineata*, and since the nominal subspecies (*E. q. quatuorlineata*) has 2 rows of temporal scales, it was automatically assumed that this was true for all subspecies.

The complex variation in some meristic characters exhibited by *E. sauromates* might be related to the fact that these results have been obtained at the northwestern limit of the species' range. Similar observations have been made in other colubrid species at their northern range limit (e.g., *Natrix tessellata*: Mebert, 2011) and are probably environmentally induced.

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