Sexual size dimorphism in the tail length of the Caspian Whip Snakes, Dolichophis caspius (Serpentes, Colubridae), in south-western Hungary

GYÖRGY DUDÁS¹, KRISZTIÁN FRANK²,*

¹ Danube-Dráva National Park Directorate, Tettye tér 9, 7625 Pécs, Hungary
² Szekszárd District Office of the Government Office of Tolna County, Dr. Szentgáli Gyula u. 2, 7100 Szekszárd, Hungary
*Corresponding author. E-mail: krisz.frank.biol@gmail.com

Submitted on: 2021, 3rd January; Revised on: 2021, 5th May; Accepted on: 2021, 11th May
Editor: Marco Sannolo

Abstract. Sexual size dimorphism is widespread among snakes and has also been observed in lengths of body appendages such as in tails. Males typically possess longer tails than females and this dimorphism in tail length has generally been attributed to the importance of the tail in mating and reproduction. We used body size measurements, snout-vent length (SVL) and tail length (TL) as well as a body condition index (BCI) as a measure of quality in Caspian Whip Snakes from Hungary, in order to shed light on sexual dimorphism patterns. The SVL of males (1061 ± 133 mm, n = 25) were significantly longer than that of females (887 ± 208 mm, n = 41). However, the proportion of TL to total length was lower in males than in females (0.257 ± 0.018 and 0.274 ± 0.017, respectively). The BCI of females (386 ± 10) was significantly higher than that of males (343 ± 15). Females having proportionally longer tails compared to males seems to be the reverse of the usual trend. Selective pressures on the tails of female snakes are less obvious, as tail length may be linked to more than one function, and hence be simultaneously subjected to more than one type of selective force.

Keywords. Colubridae, Hungary, sexual size dimorphism, tail length.
the tail is an index signal by choosing mating partners (Sivan et al., 2020).

The Caspian Whip Snake, *Dolichophis caspius*, is a large-sized colubrid with a distribution area ranging from the Carpathian Basin to the west side of the Caspian Sea and covering most of the Balkan Peninsula and several neighbouring Near East countries (Puky et al., 2005). At the north-western edge of its distribution, populations tend to be fragmented and isolated (Tóth, 2002; Puky et al., 2005). A major part of scientific literature concerning the species deals with its geographic distribution and occurrence data. Life-history traits have been studied in the main distributional range in Frontier Asia and Balkans, studies conducted on north-western populations were less prominent.

We analysed body size measurements of Caspian Whip Snakes from Hungary, in order to shed light on sexual dimorphism patterns. At the north-western edge of its distribution, in south-western Hungary, the largest remnant Caspian Whip Snake population is harbouring Szársomlyó Hill, a strictly protected nature reserve (Tóth, 2002; Frank et al., 2012). During the period 1998-2003 road surveys were carried out from April to September. Snakes were captured by hand, weighed to the nearest 1 g by a digital balance and measured for snout-vent length (SVL) and tail length (TL) to the nearest 1 mm by stretching the animal out along a measuring tape. Snakes were probed to determine the sex of the animal. After measuring, snakes were released at the location of capture. Recaptures were not included in the statistical analyses. Two snakes had damaged tails and were omitted from the analyses.

Differences in body measurements (SVL and TL) and BCI between sexes were compared using t-tests. To examine the difference between the two regression estimates of TL on SVL in males and females an ANCOVA was used. Measurements are presented as means ± SE and P < 0.05 was accepted as the level of significance. All statistical analyses were performed with the software PAST (Hammer et al., 2001).

Average SVL of males (n = 25), 1061 ± 133 mm, was significantly longer than that of females (n = 41), 887 ± 208 mm (t = -4.091, P = 0.0001). However, average TL in males, 367 ± 54 mm, and females, 333 ± 72 mm was only marginally different (t = -1.997, P = 0.0501). The regression of TL on SVL (Fig. 1) was calculated in males as $\ln(\text{TL}) = 1.1734 \times \ln(\text{SVL}) - 2.2721$, ($R^2 = 0.597$, $F = 5.840$, $P = 0.0002$); and in females as $\ln(\text{TL}) = 0.9503 \times \ln(\text{SVL}) - 0.6407$ ($R^2 = 0.896$, $F = 18.339$, $P = 0.0001$). The proportion of TL to total length was lower in males than in females (0.257 ± 0.018 and 0.274 ± 0.017, respectively). Both size (as SVL) and sex affected TL ($F_{1,64} = 8.129$, $P = 0.0059$).

Size dimorphism between sexes is widespread among snakes; in a list of 129 species of the family Colubridae compiled by Shine (1994), males were the larger sex in 24% of species. Within the group of longer males, SSD ranged between -0.01 and -0.50 (Shine, 1994), the calculated SSD of *D. caspius* (Frank and Dudás, 2018) lies in the middle of this range. All 31 colubrids with longer males than females were oviparous (Shine, 1994), as is *Dolichophis*.

Difference in relative tail length between sexes is very widespread in snakes, and relative tail length might be a biologically relevant trait that affects reproduction (King, 1989; Shine, 1994; Shine et al., 1999; Sivan et al., 2020). Dimorphism in TL is usually male-biased, i.e. male snakes typically possess longer tails than females. This has generally been attributed to the importance of the tail in mating and reproduction (King, 1989; Luiselli, 1996; Shine et al., 1999; Shine and Shatty, 2001; Sivan et al., 2020). As pointed out by King (1989), males might benefit from a longer tail because it may provide space for larger hemipenes ("morphological constraint hypothesis") or because it confers an advantage in mating success ("male mating ability hypothesis"). Additionally, females might increase reproductive output due to an increase in body capacity and a secondary reduction of TL ("female reproductive output hypothesis").

Females having proportionally longer tails compared to males seems to be the reverse of the usual trend (King, 1989; Shine et al., 1999); thus, has been reported substantially less. In a list of 103 colubrid species compiled by King (1989), females had relatively longer tails than males in seven cases (King, 1989). Selective pressures on the tails of female snakes are less obvious (Shine and Shetty, 2001), as tail length may be linked to more than one function, and hence be simultaneously
subjected to more than one type of selective force. Sexual selection of longer tails in females would imply that individuals with longer tails have a higher reproductive output than females with shorter tails. Unfortunately, there are no data to confirm this hypothesis in *D. caspius*, and no finding of selective forces acting on the tails of female snakes has been published in any other species.

Relative tail length may also be influenced by ecological factors when, for example, males and females use different microhabitats, or have different defensive tactics. Arboreal snakes have been shown, in general, to have relatively longer tails than non-climbing species (Sheehy et al. 2015), but this trend was not investigated intraspecifically before. Besides, it is not likely that female *D. caspius* are more arboreal than males. However, this is the first study in which the sexual dimorphism in tail length in Caspian Whip Snakes was investigated and as for now the influence of tail length on female reproductive output or any other life-history trait remains unexplained.

**ACKNOWLEDGEMENTS**

We are grateful to all volunteers who participated in the fieldwork. This work was supported by Birdlife Hungary. Collecting and measuring the animals was done with permissions from the Danube-Dráva National Park Directorate.

**REFERENCES**

Frank, K., Dudás, Gy. (2018): Body size and seasonal condition of Caspian Whip Snakes, *Dolichophis caspius* (Gmelin, 1789), in southwestern Hungary. Herpetozoa 30: 131-138.

Frank, K., Majer, J., Dudás, Gy. (2012): Capture-recapture data of large Whip Snakes *Dolichophis caspius* (Gmelin, 1789), in southern Transdanubia, Hungary. Herpetozoa 25: 68-71.

Hammer, Ø., Harper, D. A. T., Ryan P. D. (2001): PAST: Paleontological statistics software package for education and data analysis. Palaeontol. Electron. 4: 9.

Heatwole, H., Davison, E. (1976): A review of caudal luring in snakes with notes on its occurrence in the Saharan sand viper, *Cerastes vipera*. Herpetologica 32: 332-336.

Jayne, B. C., Bennett, A. F. (1989): The effect of tail morphology on locomotor performance of snakes: a comparison of experimental and correlative methods. J. Exp. Zool. 252: 126-133.

King, R. B. (1989): Sexual dimorphism in snake tail length: sexual selection, natural selection, or morphological constraint? Biol. J. Linn. Soc. 38: 133-154.

Klauber, L. M. (1943): Tail-length differences in snakes with notes on sexual dimorphism and the coefficient of divergence. Bull. Zool. Soc. San. Diego. 18: 1-60.

Luiselli, L. (1996): Individual success in mating balls of the grass snake, *Natrix natrix*: size is important. J. Zool. 239: 731-740.

Puky, M., Schád, P., Szövényi, G. (2005): Magyarország herpetológiai atlasza / Herpetological Atlas of Hungary. Varangy Akciócsopor. Budapest.

Sheehy, C. M. III, Albert, J. S., Lillywhite, H. B. (2016): The evolution of tail length in snakes associated with different gravitational environments. Funct. Ecol. 30: 244-254.

Shine, R. (1978): Sexual size dimorphism and male combat in snakes. Oecologia 33: 269-278.

Shine, R. (1994): Sexual size dimorphism in snakes revisited. Copeia 1994: 326-346.

Shine, R., Olsson, M. M., Moore, I. T., LeMaster, M. P., Mason, R. T. (1999): Why do male snakes have longer tails than females? Proc. Roy. Soc. B 266: 2147-2151.

Shine, R., Shetty, S. (2001): The influence of natural selection and sexual selection on the tails of sea-snakes (*Laticauda colubrina*). Biol. J. Linnean Soc. 74: 121-129.

Sivan, J., Hadad, S., Tesler, L., Rosenstrauch, A., Degen, A.A., Kam, M. (2020): Relative tail length correlates with body condition in male but not in female crowned leaffnose snakes (*Lytorhynchus diadema*). Sci. Rep. 10: 4130.

Tóth, T. (2002): Data on the north Hungarian records of the Large Whip Snake *Coluber caspius*. Herpetozoa 14: 163-167.