Winter activity of the Caspian whipsnake (*Dolichophis caspius*, Gmelin, 1789) in Belgrade, Serbia

The Caspian whipsnake, *Dolichophis caspius* (Gmelin 1789), is one of the largest European snake species, growing up to more than 2 m in length and has a large distribution range from Eastern Europe and the Balkan Peninsula to the Caucasus, southern Russia, and Kazakhstan in the east (Sahlean et al. 2014). This species is generally associated with open steppe and forest-steppe habitats, Mediterranean shrub, rocky slopes, and deciduous forest edges at low and medium elevations (Speybroeck et al. 2016) but may also occur in habitats caused by alteration of the original steppe and forest-steppe habitats (e.g., agricultural landscapes; Tomović et al. 2015). In general, knowledge on the ecology of *D. caspius* is scarce and mostly limited to some notes on diet (Doronin 2019, Plettenberg-Laing & Mee 2020, Dudás & Frank 2021), seasonal condition (Frank & Dudás 2018), activity reports (Pulev et al. 2019, Dyugmedzhiev 2021) and spatial ecology (Teffo et al. 2023). However trivial, activity pattern is one of the most fundamental characteristics of any species and is especially important for understanding its ecological role (Whitaker & Shine 2002).

D. caspius is considered a xerophilous species (Sahlean et al. 2014), which is diurnally active (Speybroeck et al. 2016), but there are reports indicating crepuscular and nocturnal activity as well (Dyugmedzhiev 2021). This species is usually active from March/April to late November (Stojanov et al. 2011, Dyugmedzhiev et al. 2019). The Caspian whipsnake is most active during the hottest months and times of the day (Pulev et al. 2019). Considering this, it is quite unusual to report observations of this species during the colder months of the year when it should be hibernating. In this paper, we report Caspian whipsnake activity in Serbia in mid-January and February.

Our studied population is located on the banks of the Danube River in Belgrade, Serbia (44°49' N, 20° 30' E 73 m a.s.l., Figure 1). The marshy embankment around the bridge, with bare concrete flood walls and occasional dense vegetation patches, is proving to be a suitable habitat for these snakes, probably because of the abundant food supply and places for basking, oviposition and hibernation (Bjelica & Anđelković 2021). However, the proximity of city roads and local settlements causes extremely high anthropogenic pressure on this population, such as road kills, intentional kills, and habitat destruction through illegal construction. As part of an ongoing capture-mark-recapture study at this locality, we performed field surveys of a 2.5 km stretch of the embankment and waited for the first signs of snake activity.

During a check of the known hibernacula in this area (Figure 1A) on January 22nd, 2023, at 12:55 a.m. (local time), we observed two adult individuals (based on approximate size) out in the open, apparently basking. On approach, one individual immediately retreated into a nearby burrow, but we managed to capture the other. This individual was lethargic but nonetheless postured and attempted to strike and hissed before being caught (Figure 1B). At the moment of capture, the air temperature was 6°C (1 m above the ground, measured with TP101 Digital Thermometer), the ground temperature at the capture site was 6.4°C, and the cloacal temperature of the individual was 10°C. The snake was a male (determined by shape and length of the tail), with a total length of 1444 mm (1045 mm snout—vent length and 399 mm tail length) and a weight of 313 g and had no palpable intact or digested food in its stomach. After measurements, the snake was released at the capture site and returned to its hibernaculum. On February 1st, 2023, at 11:15 a.m. (local time), we caught the same specimen again (identified by its marking, made by ventral scale notching, which was placed as a part of the ongoing capture-mark-recapture study), this time basking on a tree (Figure 1C). At the moment of capture, the air temperature was 7°C (1 m above the ground), the ground temperature at the capture site was 6.4°C, and the cloacal temperature of the individual was 11°C. On both occasions, prior to the day of observation, there was a period of several days with relatively low air temperatures and high precipitation (Table 1).

Figure 1. a) The hibernacula (two outgrowths visible in the photo) and the hibernaculum entrance (indicated by the red arrow) where the two individuals were found; b) The male individual at the capture site on January 22nd, photographed posturing; c) The same individual at the capture site on February 1st, photographed basking in the tree.

Considering that the Caspian whipsnake is a thermophilic species, these observations of winter activity are very unusual. Although there are previous documented observations of winter activity of the Caspian whipsnake in Bulgaria (in December (Buresch & Zonkov 1934) and February (Beshkov 1964)), Pulev et al. (2019) performed sporadic searches from 1991 to 2019 around known hibernacula in December, January and February but did not find any signs of snake activity. Besides our observations, we found several instances of winter activity of *D. caspius* in Serbia via social media in December (adult near Novi Sad; entry ID 92365; Serbian Biologer Community 2018), January (adult, near Vladičin Han; OKRadio, 2019; juvenile, near Leskovac; Marinković 2021) and February (several adults, near Vladičin Han; Telegraf 2021). A plausible explanation for the increased observations of active *D. caspius* in the colder months of the year could be that the higher

environmental temperatures in recent years tempt these warmth-loving snakes to emerge in winter (Table 2, Figure 2). A documented rise in annual mean temperatures across Serbia (from 1949-2008, Milovanović 2015), with December of 2022 and January 2023 having the least amount of frost days being the warmest winter months in Serbia since 1949 (Bulletin of the Republic Hydrometeorological Service of Serbia 2023) and Belgrade acting as a "heat island" (Milovanović 2015) are among the possible reasons for why such a behavior change is occurring.

Table 1. Mean, maximum, and minimum temperatures with average precipitation from January 15th to January 31st, 2023, in Belgrade, Serbia. Data obtained from: https://www.hidmet.gov.rs/

Date	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Precipitation (mm)
15.01.2023	11	3.1	6	2
16.01.2023	9.2	5.4	6.9	0
17.01.2023	13.7	8.1	9.9	8
18.01.2023	15.6	12	13.5	4
19.01.2023	16	5	10.9	10
20.01.2023	5	0.2	1.7	20
21.01.2023	3.8	0.5	1.5	18
22.01.2023	4.4	1.5	2.7	4
23.01.2023	8.7	3.8	6.1	0
24.01.2023	4.9	2	3.2	5
25.01.2023	2.9	1.4	2	0
26.01.2023	1.9	0.4	1.1	0
27.01.2023	0.8	0	0.3	10
28.01.2023	1.2	0.1	0.6	12
29.01.2023	2.1	0.6	1.2	5
30.01.2023	4.6	-0.1	1.3	2
31.01.2023	6.5	1.3	3.2	0

Table 2. Mean and standard deviation of average daily temperature in °C for January in the last 5 years in Belgrade. Data obtained from: https://www.hidmet.gov.rs/; http://www.pogodaiklimat.ru/

Year	Average temperature	SD of average temperature	Average maximum temperature	SD of average maximum temperature	Average minimum temperature	SD of average minimum temperature
2019	0.75	2.88	3.26	3.75	-1.24	2.85
2020	2.00	3.14	5.90	4.23	-1.03	2.14
2021	4.27	4.56	7.36	5.56	2.00	4.09
2022	2.35	4.28	6.39	5.69	-0.34	4.05
2023	5.84	3.72	8.96	5.18	3.76	2.91

Climate change is considered an important threat that increases the risk of extinction of many ectotherm species (Reading et al. 2010). As the biology of ectotherms, and therefore reptiles, largely depends on environmental temperature, many species exhibit changes in their phenology, distribution, morphology, and population dynamics in response to global warming (Weatherhead & Madsen 2009). Snakes have a particularly sensitive thermal ecology (Herczeg et al. 2007), and increased exposure to cold temperatures certainly presents a fitness cost. While some snake species are freeze-tolerant (e.g., *Vipera berus* (Linnaeus, 1758), see Turner & Maclean 2022), frequent exposure to sub-optimal temperatures and reduced body condition at emergence still likely reduce survival. Having this in mind, there is potential that these shifts in annual emergence from hibernation could have detrimental effects on many snake species (Bauwens & Claus 2019).

Of course, we cannot firmly state that temperature is the only reason for this unusual behavior. As this hibernaculum is found in proximity to human settlements, it is also possible that these observations of winter activity are the results of disturbance. Human activities dramatically change natural environments, and they do so at significant rates (i.e., human-induced rapid environmental change – HIREC, Sih 2013). As many animals use environmental cues to select habitats that maximize their fitness, HIREC can cause these cues to become uninformative of habitat quality (Hale & Swearer 2016). This leads to a phenomenon called ecological traps - animals prefer habitats where their fitness is lower than in other available habitats because of environmental change (Robertson & Hutto 2006).

A study by Sahlean et al. (2014) noted that the distribution of *D. caspius* is largely dependent on temperature-related variables. Although this study mainly showed positive outcomes for the future distribution of *D. caspius*, it also concluded that we simply do not have enough ecological data to be assured in model predictions. Undoubtedly, further monitoring studies, such as telemetric

studies of temperature-dependent activity, are needed to uncover the habits of this relatively secretive snake.

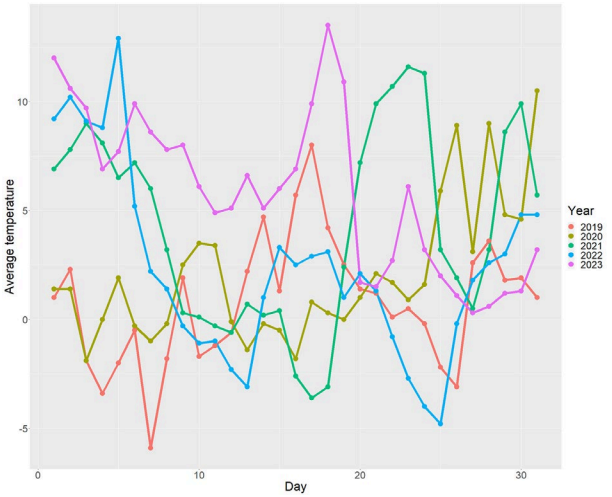

Figure 2. Daily average temperature in °C for January in the last 5 years in Belgrade. Data obtained from: https://www.hidmet.gov.rs/; http://www.pogodaiklimat.ru/

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References

Bauwens, D., Claus, K. (2019): Seasonal variation of mortality, detectability, and body condition in a population of the adder (*Vipera berus*). Ecology and Evolution 9 (10): 5821–5834.

Beshkov, V. (1964): Colubrid snakes in Bulgaria. Priroda i Znanie 9: 16-18. (in Bulgarian).

Bjelica, V., Anđelković, M. (2021): Different shades of snake: Peculiar coloration in an urban population of Grass Snakes *Natrix natrix* (Linnaeus 1758). Ecologica Montenegrina 39: 81-85.

Bulletin of the Republic Hydrometeorological Service of Serbia (2023): https://www.hidmet.gov.rs/data/klimatologija/latin/Januar.pdf, accessed on 05.02.2023. (in Serbian).

Buresch, I., Zonkov, J. (1934): Untersuchungen über die Verbreitung der Reptilien und Amphibien in Bulgarien und auf der Balkanhalbinsel. II Teil: Schlangen (Serpentes). Mitteilungen aus den Königlichen naturwissenschaftlichen Instituten in Sofia. (in Bulgarian, German summary)

Doronin, I.V. (2019): *Hierophis caspius* (Caspian Whip Snake) Diet. Herpetological Review 50: 159.

Dudás, G., Frank, K. (2021): *Dolichophis caspius* (Caspian Whip Snakes). Diet. Herpetological Review 52: 664.

Dyugmedzhiev, A. (2021): First ever records of crepuscular and nocturnal activity of the Caspian Whip Snake *Dolichophis caspius* (Gmelin, 1789). North-Western Journal of Zoology 17: 153-154.

Dyugmedzhiev, A., Slavchev, M., Naumov, B. (2019): Emergence and dispersal of snakes after syntopic hibernation. Herpetozoa 32: 149-157.

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

Hale, R., Swearer, S.E. (2016): Ecological traps: current evidence and future directions. Proceedings of the Royal Society B 283: 2015-2647.

Herczeg, G., Saarikivi, J., Gonda, A., Perälä, J., Tuomola, A., Merilä, J. (2007): Suboptimal thermoregulation in male adders (*Vipera berus*) after hibernation imposed by spermiogenesis. Biological Journal of the Linnean Society 92(1): 19–27.

Marinković, D. JuGmedia.rs (2021): <https://jugmedia.rs/zmija-izmilela-usred-zime-kad-joj-vreme-nije/, accessed on 05.02.2023>. (in Serbian).

Milovanović, B. (2015): Air temperature changes in Serbia and the Belgrade heat island. Journal of the Geographical Institute Jovan Cvijić SASA 65(1): 33-42.

OKradio.rs. (2019): https://www.okradio.rs/m/vesti/specijali/djipanje/nezapamceno-zmija-izmilela-usred-zime-video_72424.html, accessed on 05.02.2023. (in Serbian).

Plettenberg-Laing, A., Mee, G. (2020): Remarks on the diet of *Dolichophis caspius* (Gmelin, 1789) from Greece. Herpetology Notes 13: 989-991

Pulev, A., Naumov, B., Domozetski, L., Sakelarieva, L., Manolev, G. (2019): Distribution and activity of Caspian Whip Snake *Dolichophis caspius* (Gmelin, 1789) (Reptilia: Colubridae) in South-Western Bulgaria. Ecologia Balkanica 2: 116-137.

Reading, C., Luiselli, L., Akani, G.C., Bonnet, X., Amori, G., Ballouard, J.M., Filippi, E., Naulleau, G., Pearson, D., Rugiero, L. (2010): Are snake populations in widespread decline? Biology Letters 6: 777-780.

Robertson, B.A., Hutto, R.L. (2006): A framework for understanding ecological traps and an evaluation of existing evidence. Ecology 87: 1075–1085.

Sahlean, T., Gherghel, I., Papes, M., Strugariu, A., Zamfirescu, Ş. (2014): Refining climate change projections for organisms with low dispersal abilities: a case study of the Caspian Whip Snake. PloS ONE 9: e91994.

Serbian Biologer Community (2018): Biologer data on biological diversity. <https://biologer.rs/groups/4/species/59, accessed on 05.02.2023>.

Sih, A. (2013): Understanding variation in behavioural responses to human-induced rapid environmental change: a conceptual overview. Animal Behaviour 85: 1077–1088.

Speybroeck, J., Beukema, W., Bok, B., Van der Vort, J. (2016): Field guide to the amphibians and Reptiles of Britain and Europe. Bloomsbury Publishing, London, UK.

Stojanov, A., Tzankov, N., Naumov, B. (2011): Die Amphibien Und Reptilien Bulgariens. Frankfurt Am Main, Chimaira.

Teffo, T.R., Katona, K., Babocsay, G., Sós, E., Halpern, B. (2023): Home range of the Caspian Whipsnake Dolichophis caspius (Gmelin, 1789) in a threatened peri-urban population. Animals 13: 447.

Telegraf (2021): <https://www.telegraf.tv/vesti/19160-zmije-u-sred-zime-pa-sta-je-ovo-sa-vremenom, accessed on 05.02.2023>. (in Serbian).

Tomović, Lj., Urošević, A., Ajtić, R., Krizmanić, I., Simović, A., Labus, N., Jović, D., Krstić, M., Nikolić, S., Andjelković, M., Golubović, A., Džukić, G. (2015): Contribution to the knowledge of distribution of Colubrid snakes in Serbia. Ecologica Montenegrina 2: 162-186.

Turner, K.R., Maclean, M.D.I. (2022): Microclimate-driven trends in spring-emergence phenology in a temperate reptile (*Vipera berus*): Evidence for a potential "climate trap"? Ecology and Evolution 12(2): e8623.

Weatherhead, P.J., Madsen, T. (2009): Linking behavioral ecology to conservation objectives. pp. 149-171. In: Mullin, S.J., Seigel, R.A. (eds.), Snakes: Ecology and conservation. Comstock Publishing Associates, Cornell University Press, Ithaca, New York.

Whitaker, P., Shine, R. (2002): Thermal biology and activity patterns of the eastern brownsnake (*Pseudonaja textilis*): A radiotelemetric study. Herpetologica 58: 436-452.

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