

First ever records of crepuscular and nocturnal activity of the Caspian Whip Snake *Dolichophis caspius* (Gmelin, 1789)

The Caspian Whip Snake *Dolichophis caspius* (Gmelin, 1789) is distributed from south-eastern Europe (Hungary and the majority of the Balkan Peninsula), through western and north-eastern Turkey, Moldavia, south Ukraine, south-western Russia (Dagestan), north-western Georgia and north-eastern Azerbaijan (Wallach et al. 2014). In Bulgaria the species is widespread throughout the country with the exception of the high-altitude areas of western Bulgaria, with altitudinal distribution extending up to 800-1100 m a.s.l., and as an exception up to 1580 m a.s.l. in Maleshevska Mountains (Stojanov et al. 2011). Throughout its range, the species is considered as diurnally active (Stojanov et al. 2011, Speybroeck et al. 2016, Geniez 2018). In south-western Bulgaria the species was found active only during the day, from 7:55 a.m to 7:05 p.m. (Pulev et al. 2019). The authors did not record any nocturnal activity of the species, while other snake species were found active at night during the course of their study.

The author considers an activity as crepuscular when time of its observation is in late crepuscular hours, approximately 30 minutes before dark, when seeing is still possible without the use of an artificial light and as nocturnal when time of observation is after dark, when seeing is impossible without an artificial light. Microhabitat temperature was estimated by the average of the temperature of the substrate on which a snake was found and the temperature of the air at 15-20 cm above the ground, measured with quick-reading thermometer (TOPELEK TECP022AH; precision: 0.3° C) (see Dyugmedzhiev et al. 2020a). Time of moonrise, moon phase and % illumination were obtained with Virtual Moon Atlas (v. 7.0). The site where the observations were made is a karst valley with steep rocks and terraces, covered with grasses, shrubs and patches of deciduous forests.

On 07 July 2017, during an ongoing ecological study of snakes in Bulgaria, a subadult *Dolichophis caspius*, with approximate total length of 35-40 cm, was found active on the surface by the author at 8:44 p.m. (local time), near Gara Lakatnik Village (N43°5'; E23°23'; 503 m a.s.l.) in north-western Bulgaria. On approach, the snake rapidly escaped and could not be captured. Microhabitat temperature was 24.3°C. Weather was calm with light wind and clouds covering about 20% of the sky. Moonrise was approximately one hour before the time of observation (at 7:37 p.m.). The moon was at one day before the full-moon phase and lunar illumination at the time of observation was 98%. During the day, the weather was warm with maximal daily temperatures below 28°C. Time of observation was around 15-30 minutes before dark, and seeing was still possible without the use of an artificial light. Two freshly regurgitated lizards (*Ablepharus kitaibelii* (Bibron & Bory ST-Vincent, 1833) and *Podarcis muralis* (Laurenti, 1768), both adults) were found right next to the place of observation of the snake.

A month later, on 08 August 2017, a subadult of the same species, with similar approximate total length, was found active on the surface (with the help of an artificial light) at 9:40 p.m. (local time), approximately 55 m from the site of the above observation (449 m a.s.l.). As in the previous case, the snake rapidly escaped on attempt of capture by the author.

Microhabitat temperature was 27°C. Weather was calm with light wind and clouds covering about 30% of the sky. Moonrise was approximately one hour before the time of observation (at 8:30 p.m.). The moon was at the full-moon phase and lunar illumination at the time of observation was 100 %. During the day, the weather was hot with maximal daily temperatures above 28°C. On time of observation, it was dark, and seeing was impossible without the use of an artificial light.

To the author's knowledge, these are the first observations of both crepuscular and nocturnal activity of *Dolichophis caspius*. Crepuscular and nocturnal activity in the summer have been reported for the closely related species *D. jugularis* (Linnaeus, 1758) (Speybroeck et al. 2016) and *D. schmidtii* (Nikolsky, 1909) (Geniez 2018). The latter two species, however, have more southern distribution, occurring in warmer and drier areas than *D. caspius* (Wallach et al. 2014). It seems that these types of activity are very rare for *D. caspius*, since these are the only two observations of crepuscular and nocturnal active individuals during the numerous night searches in different parts of Bulgaria between 2013 and 2019 (see Dyugmedzhiev et al. 2020 a, b). In fact, having in mind that both observations were within the period of one month, within the short distance of 55 m and the individuals observed were of the same approximate size, it is very plausible that both observations were of the same individual. In contrast, both crepuscular and nocturnal activity seems to be common for *Vipera ammodytes* (Linnaeus, 1758) in Bulgaria, with numerous individuals from all age groups being found during the night searches (Dyugmedzhiev et al. 2020a). Other snake species with well-known crepuscular and nocturnal activity (see Stojanov et al. 2011, Speybroeck et al. 2016), such as *Natrix natrix* (Linnaeus, 1758), *N. tessellata* (Laurenti, 1768), *Zamenis longissimus* (Laurenti, 1768), *Z. situla* (Linnaeus, 1758) and *Telescopus fallax* Fleischmann, 1831 were also found often during the night searches in different parts of Bulgaria (A. Dyugmedzhiev, unpublished data). By shifting towards nocturnal activity snakes usually need to function at lower body temperatures than their "preferred" range, which may lead to suboptimal performance and risk of predation (Vitt & Caldwell 2014, Dyugmedzhiev et al. 2020a). The benefits of such shift of activity may be increased feeding opportunities, as well as avoidance of some diurnally active predators or extreme daily temperatures (Vitt & Caldwell 2014, Dyugmedzhiev et al. 2020a). The presence of the two freshly regurgitated lizards after the escape of the crepuscular active *D. caspius* shows that this specimen was feeding during or shortly prior to time of observation. It is possible that the author's presence forced the snake to regurgitate its freshly ingested food in order to increase its chances to escape. Since the only two observations were on small subadult individuals, it could be speculated that adult *D. caspius* do not tend to be active at such late hours. The plausible reason for the lack of crepuscular and nocturnal activity in adult *D. caspius* may be their larger size, which makes them more visible and vulnerable to predators, while acting at lower temperatures makes their chances of escape smaller. It is interesting that the observations of crepuscular and nocturnal activity of *D. caspius* were not only after a hot, but also after a warm day. Similarly, crepuscular and nocturnal activity of *V. ammodytes* was detected in both warm

and hot days, with most observations being either in close-to-full moon phases or no moonlight at all (Beshkov 1993, Dyugmedzhiev et al. 2020a). Moonlight probably also affects the crepuscular and nocturnal activity of *D. caspius*, since both observations were in close-to-full-moon or complete full-moon stage. Ecological niche models predict that as a result of global warming, the range of *D. caspius* will expand to the north, with minor range decrease at its southern limits (Sahlean et al. 2014). Therefore, the observed first ever cases of crepuscular and nocturnal activity of the species might be as a result of the increase of temperatures in the last decades. It could be assumed that with future increase in temperatures due to climate change, the crepuscular and nocturnal activity of *D. caspius* may become more frequent, as in closely related species such as *D. jugularis* and *D. schmidtii*. Further studies are needed to understand whether crepuscular and nocturnal activity of *D. caspius* are, or will become more common, or are they only isolated cases of one or two particular individuals.

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