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Arboreal behaviours of the nose-horned viper *Vipera ammodytes*, with links to video evidence

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ABSTRACT – *Vipera ammodytes* is considered to be a predominantly terrestrial species although we report eight individual episodes of arboreal behaviour that include 1) copulation, 2) active hunting and feeding, 3) thermoregulation and/or waiting in ambush for prey, and 4) escape after capture and handling. To our knowledge, this is the first report of arboreal copulation in any *Vipera* spp., and the first report of active arboreal hunting by *V. ammodytes*. Arboreal thermoregulation and waiting in ambush for prey are difficult to distinguish from one another and vipers may combine these two types of behaviours. Arboreal escape after capture and handling is most likely the result of stress and it seems that it is rarely exhibited. It is clear that *V. ammodytes* can use arboreal habitats to its advantage and it is suggested that further study may demonstrate that arboreal activity is a more important component of the behavioural ecology of *V. ammodytes* than previously reported.

INTRODUCTION

European *Vipera* spp. have similar morphologies as well as many similarities in their behavioural ecology, e.g. upper thermal set points, activity patterns, food habits etc. (Saint Girons, 1978; 1980; Luiselli, 2006). Their diet consists mainly of small mammals and reptiles, although birds, arthropods and even amphibians are also occasionally preyed upon (Speybroeck et al., 2016). Even though *Vipera* spp. are considered as mainly terrestrial (Phelps, 2010), some arboreal behaviours and activities have been reported: 1) active hunting and feeding (Groen et al., 2020); 2) thermoregulation (Saint Girons, 1975; Marx, 2022); 3) escaping from predators (Marx, 2022).

The nose-horned viper *Vipera ammodytes* (Linnaeus, 1758) is a medium-sized viper, distributed in the southern parts of Central and Eastern Europe and parts of Asia Minor to the Lesser Caucasus (Speybroeck et al., 2016). In Bulgaria, it is distributed throughout most of the country, except in the high mountains, intensively cultivated agricultural, and urbanised land (Stojanov et al., 2011). It is considered that *V. ammodytes* is mainly a sit-and-wait ambush predator whose diet depends on individuals' age and size. Juveniles prey mainly on small lizards and centipedes and as they grow in size their diet becomes more diverse, including also small mammals and more rarely frogs, snakes and birds (Beshkov, 1977; Luiselli, 1996; Anđelković et al., 2021). The species is considered predominantly terrestrial (Phelps, 2010), although some arboreal activity has been documented (Schweiger, 2013). In the current report, we document several aspects of arboreal activity and behaviour of *V. ammodytes* in Bulgaria.

MATERIALS & METHODS

Most of the data were collected during a long-term study (2013–2024) in various parts of Bulgaria. Vipers were located by active search along with inspection of potential hideouts during March–November when the species is active (Dyugmedzhiev et al., 2022). Co-ordinates for detected vipers were taken with a hand-held GPS device (Garmin eTrex 20; precision: 5 m). The temperature of the substrate on which the vipers were found (Ts) as well as the air temperature at 15 cm (T15) above the ground were measured with a quick-reading thermometer (TOPELEK TECP022AH; precision: 0.3 °C). The average between the values of Ts and T15 were used to estimate the temperature of the microhabitat (Dyugmedzhiev et al., 2021). The hour of the day in which each viper was found as well as the meteorological conditions (wind, cloudiness and rain) were recorded. When possible, vipers were captured, measured (precision: 0.5 mm), weighed (precision: 0.01 g), photo documented for individual identification (Dyugmedzhiev et al., 2018) and then released at the site of capture. The process of handling the snakes usually lasted less than 30 mins. Age group of the vipers was estimated based on individual total length (SVL + TL) as follows: neonates/juveniles – up to 28 cm; subadults – 28–46 cm for females and up to 49 cm for males; adults – over 46/49 cm for females and males, respectively (Dyugmedzhiev et al., 2020). The sex of vipers was determined by the body colour pattern, the length and width of the tail and SVL/TL ratio (Tomović et al., 2002).

Data on the predation of nestling birds (see below) were collected in 2015 during the course of filming the documentary 'Vrachanski Karst Reserve', which is dedicated to the biodiversity of this protected area.

OBSERVATIONS & DISCUSSION

Eight individual observations on arboreal activity and behaviour of *V. ammodytes* were made during the course of the study, categorised as 1) copulation; 2) active hunting and feeding; 3) thermoregulation and/or waiting in ambush for prey; and 4) escape after capture and handling. The specifics of each observation are presented below.

Copulation

On 12 May 2024, AD and MS found two adult *V. ammodytes* copulating on the branch of a Jerusalem thorn *Paliurus spina-christi* at 18:28 h, near Slivnitsa Village (41° 41'10" N, 23° 9'53" E; 183 m a.s.l.), south-western Bulgaria. The shrub was situated next to a path and above a stone wall, marking the yard boundary of a property with beehives. We recorded a quick video from approximately 1.5 m distance from the vipers, after which we retreated about 5 m away, hiding behind a bush, from where we continued to observe and film the vipers. The weather was strongly windy, cloud cover was 70%, and the microhabitat temperature was 19.1 °C. The vipers were situated proximately 100 cm above the ground. On the initial moment of observation, the male (SVL = 56.9 cm, TL = 8.2 cm, W = 140.22 g), was laying vertically on an upper branch, with its head positioned up and left, and the hind part of its body slightly coiled around that of the female, and its tail entangled around the females' tail with one of the hemipenes inserted in the female's cloaca (Fig. 1; BHS video 2025a, Part 1). The female was lying horizontally, with its head and first half of the body positioned below and to the left on the lower branch, and the hind part of its body was positioned on same branch as the male (Fig. 1; BHS video 2025a, Part 1). Throughout the period of copulation, the female did not stay still and altered its position many times. These alterations included 1) remaining in the same overall position as in the initial period of observation, but with its head positioned to the right (BHS video 2025a, Part 2), 2) climbing down and up many times, between its initial position, the lower branches and the upper branch on which the male was positioned (BHS video 2025a, Part 3), and 3) returning to its initial position. In contrast, the male stayed relatively still during the entire copulation, only slightly adjusting the back of its body and its tail, keeping its position around the female's body, and adjusting its head to balance for stability (BHS video 2025a, Parts 2&3). The copulation continued for 21 minutes from first observation after which the two snakes started to disentangle themselves with the male making spiral movements on the same branch (BHS video 2025a, Part 4) but with its head and front body positioned to the right, and the female climbing down from the bush and disappearing in the grass and stones on the ground beneath it. Once completely disentangled from the female, the male also started climbing down towards the ground and was then captured for measurement. After it was released, it disappeared in the grass and stones, as did the female.

Figure 1. A pair of *Vipera ammodytes* copulating in a Jerusalem thorn tree *Paliurus spina-christi* about 100 cm above the ground. Red dashed arrow indicates the female snake (F); blue continuous arrow indicates the male snake (M). Note that the lower blue arrow appears to be pointing at the female's body but actually this is part of the male's body lying in front of the female, this is more easily seen in the accompanying video (BHS video, 2025a).

Even though *V. ammodytes* is a species that is relatively easily found and observed in-situ, observations on its copulation are not very common and in the few reported cases, it occurred on the ground (Beshkov, 1977; Čubrić & Crnobrnja-Isailović, 2023). To the authors' knowledge, this is the first reported case on arboreal copulation in the species, as well as in the *Vipera* spp.generally. There was no obvious reason for why this copulation took place on the branches of the shrub. Indeed, there were possible disadvantages in this position since the vipers appeared much more exposed to avian predators on the branches and due to strong wind the branches were shaking making the shrub an unstable surface for copulation.

Active hunting and feeding

On 5 May 2015, BN and IHN used a pre-set action camera (GoPro 3+) to film an adult female *V. ammodytes* that was predating long-tailed tit *Aegithalos caudatus* nestlings between 17:59 h and 18:17 h in Vrachanski Balkan Nature Park (43° 11'24.66" N, 23° 31'16.59" E; 514 m a.s.l.), close to Zgorigrad village, north-western Bulgaria. The weather was mostly sunny, warm (air temperature about 25 °C) and calm, without wind. The nest was situated at 140 cm above the ground, comparatively well concealed in the interior of a hawthorn bush *Crataegus monogyna*. The viper climbed to the nest while the parents were not present, placed its

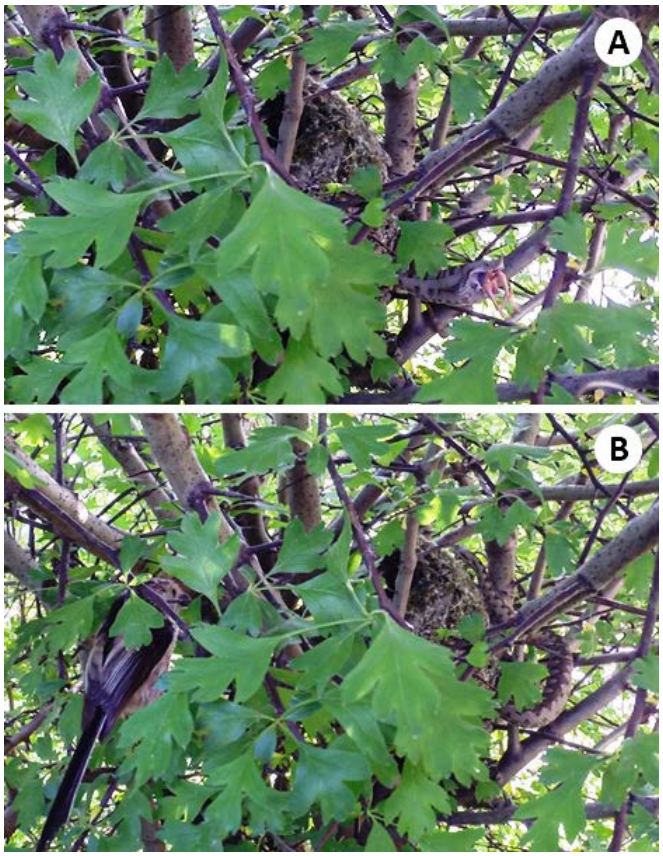

Figure 2. Predation of nestlings long tailed tits by an adult female *Vipera ammodytes* – **A.** The viper ingesting the first nestling, after dragging it out of the nest, **B.** The viper is crawling on top of the nest in front of one of the parents, before entering it a second time to capture the second nestling. More detail of this behaviour is shown in BHS video (2025b).

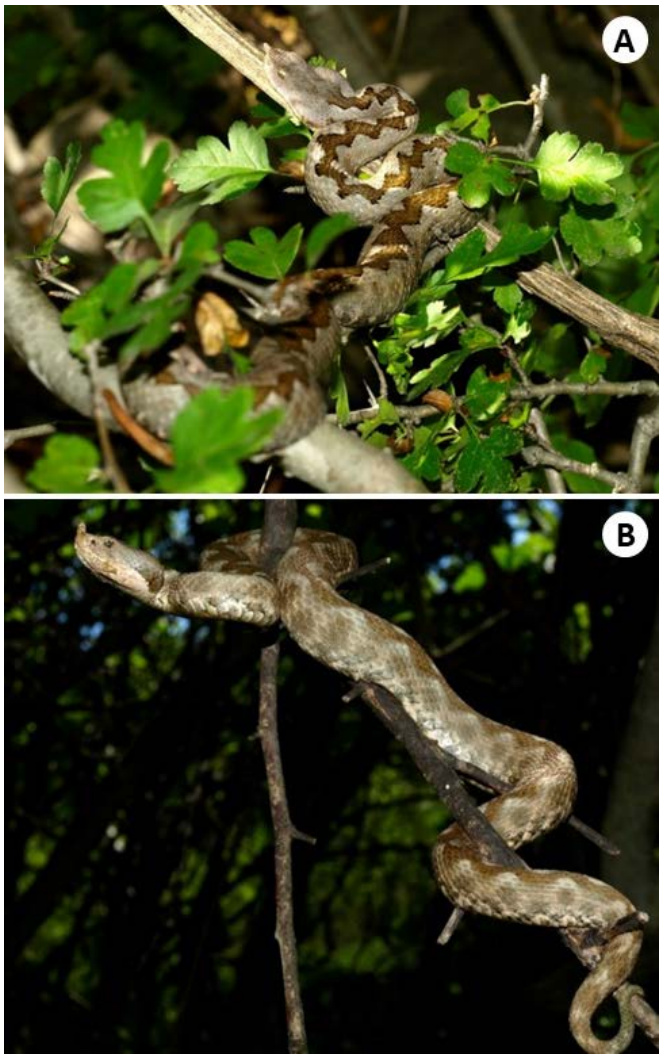

Figure 3. Two adult female *Vipera ammodytes* demonstrating – **A.** Probably waiting in ambush for prey, **B.** Escaping after capture and handling which resulted in it climbing up a tree

head inside it, bit and dragged out one of the nestlings and then started to swallow it (Fig. 2; BHS video, 2025b). While swallowing, one of the parents returned with food in its beak. The parent panicked, jumping from branch to branch around the nest, while the viper continued to swallow its nestling (BHS video, 2025b); this process took about 11 minutes. After devouring it, the viper captured another one, while the parent was still moving around the nest, after which, the snake climbed down from the nest whilst still holding the second nestling in its mouth; the viper went out of sight 2.5 minutes after capturing it. The long-tailed tit nestlings appeared to be about 4 days old. After the viper left, the parents approached the nest and continued feeding the remaining nestlings, which were left unharmed (BHS video, 2025b). The total number of nestlings in the nest remained unclear, at least two were left after the snake retreated.

It is well documented that birds make up a small part of the diet of *V. ammodytes* (Beshkov, 1977; Luiselli, 1996; Cattaneo, 2010; Anđelković et al., 2021; Tomović et al., 2022), however, to the best of our knowledge direct observations on bird predation until now have been lacking. Other European *Vipera* spp.are considered as mainly terrestrial sit-and-wait ambush predators but there have been similar observations of them as arboreal predators. For example, the northern viper *Vipera berus* has been reported in Britain preying on goldfinch *Carduelis carduelis* (Springwatch, 2014) and reed bunting *Emberiza schoeniclus* (Springwatch, 2024) and in the Netherlands preying on the Eurasian blue tit *Cyanistes caeruleus* (Groen et al., 2020); this species also occasionally preys on the nestlings of ground-nesting birds (Pielowski, 1962; Luiselli & Anibaldi, 1991; Groen et al., 2020). *Vipera ursinii* is also known to occasionally prey on fledgling birds in Italy, especially on those species that nest in dwarf juniper bushes (Agrimi & Luiselli, 1992).

Thermoregulation and/or waiting in ambush for prey

We report three different cases of this type of behaviour. On 29 September 2019 at 11:56 h near Gara Lakatnik Village (43° 5'20" N, 23° 23'2" E; 450 m a.s.l.), north-western Bulgaria, an adult female viper (SVL = 50.6 cm, TL = 5.8 cm, W = 69.15 g) was found by AD, NS and Kostadin Andonov in a light, sparse deciduous forest with shrub undergrowth, growing on a rocky/stony area. The weather was calm with light wind, cloud cover about 20% and microhabitat temperature 26 °C. The viper was positioned approximately 60 cm above the ground, stretched out between a thin tree, a shrub and a vine, with its body

being in partial shade. The back of its body was coiled on the stem of young cherry plum tree *Prunus cerasifera*, the middle part of the body was positioned horizontally on a thin branch of a hawthorn shrub and the front part and head of the viper were positioned in an upward position on a thin Traveler's joy vine *Clematis vitalba* (Fig. 3A). The viper was photographed in-situ and then captured for measurement. After its release, it hid beneath the rocks and stones.

On 31 May 2013 at 14:50 h in the Kresna Gorge (41° 45'53" N, 23° 9'20" E; 210 m a.s.l.), south-western Bulgaria, a juvenile female (SVL = 21.4 cm, TL = 2.5 cm, W = 8.56 g) was found by AD on a branch of a Jerusalem thorn in a stony area, overgrown with shrubs, situated between a dirt road and a railway. The weather was calm with light wind, cloud cover 50% and microhabitat temperature 30.5 °C. The viper was coiled on itself and positioned on a small branch in shade, approximately 20 cm above the ground. Following the sighting, the viper was captured for measurement and released back on site where it hid beneath some stones.

On 30 September 2024 at 12:54 h near Cherni Vit Village (42° 50'22" N, 24° 11'40" E; 606 m a.s.l.), northern Bulgaria, an adult female (SVL = 53.1 cm, TL = 6.1 cm, W = 31.82 g) together with four neonate vipers (as well as the shed skins of the latter) were found by AD. They were around a small hole between the roots of a shrub-sized hornbeam *Carpinus* sp. on a rocky/stony hill with scattered shrubs and trees. The weather was calm with light wind, cloud cover was 20% and microhabitat temperature 27 °C. While all neonates were laying on the ground (three of them basking and one hiding under a small stone), the female was stretched on the branches of the shrub approximately 30 cm above the ground, with its body exposed to the sunlight. Immediately after the sighting, the female as well as three of the neonates were captured for measurement, while the fourth neonate escaped into the hole. The second half of the female's body was thinner than the first half and had a long furrow, indicating that it was post-parturition and that the four neonates were most likely her offspring. After their release, all individuals hid in the hole, where the first neonate had escaped.

It is very difficult to distinguish between arboreal thermoregulation and/or waiting in ambush, therefore, we have presented them together. Furthermore, vipers might often combine these two types of arboreal behaviours. For instance, during colder days the ground warms up more slowly than the air above it, resulting in the temperatures of the ground often being lower than those of the air (Dyugmedzhiev et al., 2021). Therefore, on cold days vipers may climb onto branches where they can bask in a more favourable thermal environment, as already reported for *Vipera aspis* (Saint Girons, 1975; Marx, 2022), and wait in ambush for birds. During hot days, on the other hand, vipers escape from the high temperatures either by retreating to shelters (i.e. under stones, in holes, etc.), or to microhabitats that are in the shade, where they could hunt for prey (Dyugmedzhiev et al., 2021; 2022). In these sites, vipers might climb on the branches of trees or shrubs to wait for birds, or lay on the ground to hunt for small mammals or lizards that are also trying to escape from the heat. We speculate that this is precisely the case with the adult female observed around Gara Lakatnik Village. The day of the observation was hot, with microhabitat temperatures in the sun exceeding 28–29 °C, however, temperatures in the shade, where the viper was found were lower and much more tolerable (about 26 °C). The height at which the viper was resting, together with its peculiar position and placement, indicates that most likely it was waiting in ambush for birds. Furthermore, ambient temperatures in sunny places above the ground might often be more tolerable than those on the ground during warm and hot days, because of the cooling effect of the wind. Thus, vipers that stay in sunlight may find more suitable thermal conditions on the branches of shrubs where they can wait for birds or lizards. Such may have been the case with the observation of the adult female around Cherni Vit Village.

In the case of the juvenile female viper, observed in the Kresna Gorge, it seems more plausible that the viper was thermoregulating, instead of waiting for prey. This observation was made in a particularly hot day (i.e. microhabitat temperature of 30 °C in the shade). As suggested above, the thermal conditions 20 cm above the ground may have been more tolerable than those on the ground. While it seems unlikely that such a small viper was waiting to predate a bird, it may well have been waiting for lizards that may also climb on those lower branches to escape from the heat of the ground.

Escaping after capture and handling

We report three different cases on this type of behaviour.

On 19 July 2014 at 13:55 h near Balsha Village (42° 51'20" N, 23° 15'8" E; 713 m a.s.l.), central-western Bulgaria, a gravid adult female viper (SVL = 48.4 cm, TL = 5.7 cm, W = 149.8 g) was found by AD in an abandoned quarry overgrown with a mixture of grasses, shrubs and scattered trees. The weather was calm without wind, cloud cover was about 80% and microhabitat temperature was 20.7 °C. The viper was hidden beneath a stone under a shrub-sized hornbeam. The snake was captured, measured, colour-marked and photo-documented, with the entire process lasting around 20 minutes, after which it was released at the same spot. Right after its release, however, the viper did not hide under the stones, but instead started climbing on the inner branches of the shrub. It climbed until it reached approximately 60 cm above the ground after which it stopped and remained there. The viper was then left alone. At 16:04 h AD checked the area again and found the viper still on the shrub, only slightly moved so that its body would be exposed to sunlight. The viper was not disturbed. At 18:00 h, AD checked the area one last time and observed (without disturbing it) that the viper had now descended to the ground and was basking in front of the same shrub.

On 11 May 2017 at 11:25 h in the Kresna Gorge (41° 45'58" N, 23° 9'8" E; 213 m a.s.l.), south-western Bulgaria, an adult female (SVL = 53.4 cm, TL = 6.7 cm, W = 95.35 g) was found by AD on a stone pile overgrown with a mixture of tree- and shrub-sized hornbeam trees. The weather was calm with light wind, cloud cover of 20%, and microhabitat temperature was 18.5 °C. The viper was on the stones with most of its body positioned in the shade under a shrub. Similarly to the previous case, on its release following the measurement procedures, the viper started climbing on the inner branches of the shrub. It climbed until it reached a vertical part of the

branch, approximately 75 cm above the ground, after which it stopped and remained there, partially coiled around it (Fig. 3B). The viper stayed in this position for about 1 minute after which it moved the front part of its body downwards, to the part of the branch where its tail was. During this period the viper was photographed quickly and was then left alone. No further observations were made.

On 12 April 2024 at 14:50 h (local time) near Banichan Village (41° 37'34" N, 23° 43'40" E; 563 m a.s.l.), south-western Bulgaria, a pre-shedding adult male (SVL = 59.2 cm, TL = 8.1 cm, W = 151.44 g) was found by AD in a shrubbery area overgrown with Jerusalem thorn. The weather was calm with light wind, cloud cover of about 50%, and microhabitat temperature was 25.3 °C. The viper was on the ground, in partial shade under one of the shrubs. On release post-measurement, the viper climbed on the inner branches of the shrub until it reached approximately 100 cm above the ground after which it stopped and remained there. The viper was left alone. On the way back, at 17:20 h, AD checked again the area, however the viper could not be found.

The arboreal behaviour shown after capture and handling is most likely a result of stress. Usually, vipers are well aware of the characteristics of their habitat, and the most common ways of getting away from their enemies is either by escaping through the vegetation and/or hiding in various protective shelters in close proximity, such as under stones, in rock crevices, holes, etc. It appears that when under stress, they might choose alternative escape routes, such as climbing on branches of shrubs. This behaviour, however appears to be very rare in *V. ammodytes*, since it was exhibited in only 3 cases from out of more than 1,000 captured and handled vipers during the course of the study. Arboreal escape has already been reported for *V. aspis*, where several individuals were reported to climb on trees at heights of 70–190 cm while escaping from the observer, without being previously captured (Marx, 2022). The author speculated that this escape tactic is a result of behavioural plasticity in the species allowing it to adapt to changing environmental conditions caused by the predation pressure of wild boar's abundant population.

Vipera ammodytes is generally considered to be a terrestrial species (Phelps, 2010) but arboreal activity of *V. ammodytes* and other *Vipera* spp.is difficult to observe. Consequently, further study may well demonstrate that arboreal activity is a more important component of the behavioural ecology of *V. ammodytes* than previously reported.

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