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Body-bending behaviour in three snake species in the Russian Far East

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ABSTRACT – - Body-bending behaviour or kinking is a cryptic form of immobility, believed to be used by snakes to avoid predation. Originally, this defensive strategy was thought to be used only by arboreal species in the Neotropics but recent reports suggest that it may be more widespread than previously thought. For the first time, data is presented on this type of behaviour for three snake species of east Asia - *Elaphe dione, Elaphe schrenckii* and *Gloydius ussuriensis*.

INTRODUCTION

Effective antipredator strategies are vital to the survival of all living beings, including reptiles. Snakes, in particular, demonstrate a wide variety of antipredator tactics ranging from immobility such as death-feigning to fleeing or to biting, and the choice of a particular antipredator response is determined by a combination of both intrinsic and extrinsic factors (Passek & Gillingham, 1997; Durso & Mullin, 2014; Fuentes et al., 2021). Immobility is a common defensive pattern, which can manifest itself not only in death-feigning but also in a more cryptic form known as body-bending behaviour or kinking.

Body-bending behaviour (BBB) is a poorly understood defensive mechanism in which a snake contorts its body into small curves resembling a zigzag. Due to such shape, a kinking snake resembles a liana or a stick, which makes it harder for a potential predator to see. This cryptic behaviour was originally described exclusively for arboreal tropical snakes (Beebe, 1946; Abuys, 1986), and to date there are reports for less than thirty snake species using this defensive strategy. Recent publications have described first cases of BBB from Asia and Europe (Kathe & Deshmukh, 2020; Hauser et al., 2022), while the bulk of the existing records still refer to the Neotropics.

To the best of our knowledge, there have been no records of such behaviour from Russia. Therefore, we report here the first BBB cases for several snake species inhabiting the Russian Far East, namely the Amur rat snake *Elaphe schrenckii* (Strauch, 1873), the steppe rat snake *Elaphe dione* (Pallas, 1773) and the Ussuri pit viper *Gloydius ussuriensis* (Emelianov, 1929) (Uetz et al., 2024).

All our records were made during field studies in the period 2015–2024 in the southern and western parts of Primorsky Krai, Russia. The cases presented in our study refer to Khankaysky, Pogranichny, Nadezhdinsky and Partizansk Districts. We took pictures of all the snakes mentioned in our study and usually made brief notes on the surroundings and weather conditions. We have observed a total of twelve cases of BBB for three snake species; these cases are separated into groups by species and given in chronological order.

OBSERVATIONS

Elaphe dione

Case 1
On 30 June 2020 at 14:29 h, an adult *E. dione* was found by N.E. Pokhilyuk in the middle of an unpaved road. The observation occurred on the road to Dvoryanka (Khankaysky District) approximately 12 km north-east of the village. It was a warm cloudy day (20 ˚C) with a light wind. Since it had rained the previous night, the road was still moist. The snake lay stretched out in the middle of the road displaying a distinct BBB (Fig. 1A). It did not try to escape or curl up in a defensive posture when the author approached and touched it. When handled, the specimen stopped expressing BBB and returned to its normal body posture.

Case 2
On 18 September 2021 at 13:46 h, a snake was found by N.E. Pokhilyuk on an unpaved road in the Studenaya River valley ca. 3–7 km west of the village of Dukhovskoe in Pogranichny District. It was a warm day (25 ˚C) with few clouds and almost no wind. The snake was an adult steppe rat snake *E. dione* (ca. 70 cm in total length) vividly expressing BBB (Fig. 1B). Even when picked up and handled, the snake did not abandon this behaviour completely, it remained tense with a couple of small bends and a nearly square loop at the anterior part of its body. After taking several photographs, the rat snake was put on the roadside, where it quickly escaped into dense vegetation.

Case 3
On 24 April 2022 at 12:54 h, an adult *E. dione* was found by N.E. Pokhilyuk on an unpaved found road in the vicinity

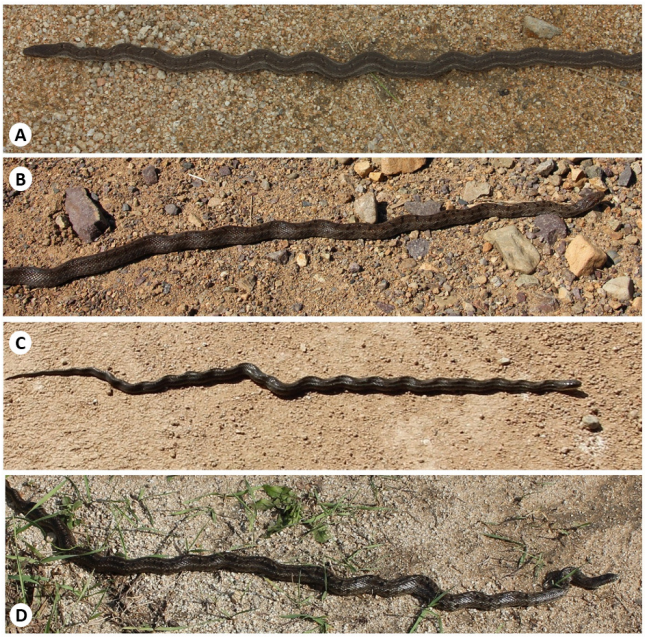

Figure 1. *Elaphe dione* displaying BBB

of Dvoryanka, Khankaysky District. It was a cool cloudy day (16 ˚C) with a light wind. The snake was crossing the road. When approached, the specimen stopped moving and started displaying BBB (Fig. 1C). The snake lost all its bends immediately after it was picked up. The snake moved rather slowly and did not try to provide any aggressive, defensive response.

Case 4

On the afternoon of 11 September 2022, the authors found an adult *E. dione* on an unpaved road between the villages of Zharikovo and Komissarovo (the Ilyinka-Komissarovo route) in the vicinity of Ilyinka, Khankaysky District. It was a warm cloudy day (25 ˚C) with a light wind. The snake expressed BBB and curled the anterior part of its body into a typical defensive S-posture. When picked up and handled, the snake lost its bends and actively tried to escape.

Case 5

On a warm and sunny afternoon on 25 September 2022 at 14:37 h, a steppe rat snake was observed by N.E. Pokhilyuk on the roadside approximately 3.5 km north-east of Dvoryanka, Khankaysky District. The snake was lying stretched out on the road with its tail still in the grass with multiple small bends along its whole body (Fig. 1D). It was an adult rat snake of at least 70 cm in total length. It did not try to escape when the author approached it. When picked up, the snake lost its bends and demonstrated no tendency to bite or take up a defensive posture. After being photographed, it was released into the wild.

Elaphe schrenckii

Case 6

On 13 September 2015, I.V. Maslova found a subadult *E. schrenckii* in the lower course of the Litovka River, Partizansk

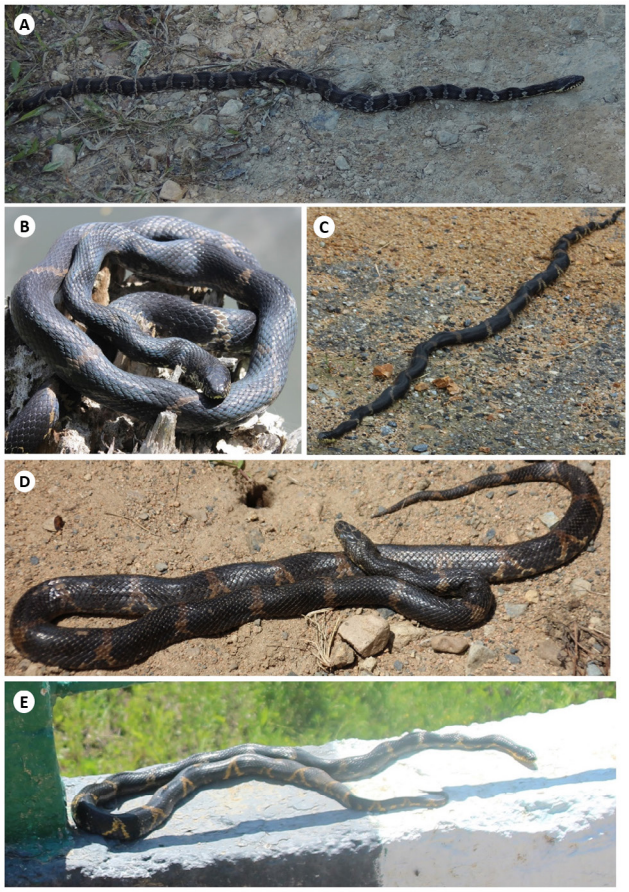

Figure 2. *Elaphe schrenckii* displaying BBB

District. The specimen was seen on an unpaved road located in the hills covered with oak forests. It was a relatively warm afternoon (19 ˚C) with some clouds. The snake lay stretched out with clearly visible small bends along its whole body (Fig. 2A).

Case 7

On 16 June 2019 at 16:10 h, N.E. Pokhilyuk collected two adult steppe rat snakes *E. dione* and an adult Amur rat snake *E. schrenckii* at the bank of the Komissarovka River in the vicinity of Dvoryanka, a remote village in Khankaysky District, Primorsky Krai. After taking pictures of the animals, all the snakes were released into the grass. The Amur rat snake slowly made its way through the grass and then started climbing up a dead tree stump (ca. 1 m tall) by the river. Next, it curled up on the top of the stump demonstrating BBB (Fig. 2B). The snake did not react to the author approaching it. When the author stepped back by ca. 8–10 m, it remained in the same position and continued to display BBB. In this case, it is difficult to tell whether such behaviour was solely a defence mechanism or the snake used it for effective basking. It should be noted that the weather on that day was relatively cool (17 ˚C) and moderately cloudy, and the tree stump was exposed to direct sunlight.

Case 8

On the afternoon of 14 July 2019, N.E. Pokhilyuk observed an adult *E. schrenckii* (over 130 cm in total length) on a small

bridge on the Zharikovo-Komissarovo route at the border between Khankaysky and Pogranichny Districts. It was a warm day (23 ˚C) with storm clouds and rain showers; therefore, both the unpaved road and the asphalt surface of the bridge were damp. The Amur rat snake lay motionless, distinctly displaying BBB (Fig. 2C), but when we approached it, the snake attempted to flee into vegetation along the roadside. When picked it up, the snake was very agitated and tried to escape. A few minutes later, it became significantly calmer and was released into the grass.

Case 9

On 22nd June 2021, N.E. Pokhilyuk saw a snake curled up on the roadside about 2 km south-west of Barabash-Levada, a small village in Pogranichny District. It was an adult *E. schrenckii*, most likely a gravid female over 130 cm in total length. The day was warm (22 ˚C) and cloudy. The snake lay about a metre from the grass edge, in a location between the foot of a mountain and the Komissarovka River. It was preparing to shed its skin which could be told by the blue colour of its eyes (Fig. 2D). The snake demonstrated BBB, however it's hard to tell whether it was a part of the basking process on a warm day or a defensive reaction to our car passing by.

Case 10

On 12 June 2022 at 13:52 h, while examining a bridge over a small creek for snakes, 3.5 km south-west of Barabash-Levada (Pogranichny District), N.E. Pokhilyuk recorded one *E. schrenckii* displaying BBB. It was a hot sunny afternoon (27 ˚C), and the snake was lying on the edge of the bridge basking (Fig. 2E). It was an adult of at least 140 cm total length. More than a half of snake's body lay on a black-painted section of the bridge, which seemed unusual, given the heat. The snake's head was slightly lifted indicating that it was awake and obviously had seen both our car and the author approaching it. When handled, the snake expressed neither BBB nor any aggressive defence mechanisms. It did not make any attempts to bite but actively tried to escape.

Gloydius ussuriensis

Case 11

On the evening of 17 September 2016, a subadult Ussuri pit viper *G. ussuriensis* displaying BBB was found by I.V. Maslova in the lower course of the Vtoraya Rechka River. It was lying on a track across a flood meadow in the vicinity of Senokosnaya, an abandoned village in Nadezhdinsky District. The snake was stretched out with the anterior part of its body having several slight bends (Fig. 3A). When approached, it initially tried to flee but when followed the pit viper soon resorted to aggressive defence coiling up and striking at the potential threat.

Case 12

On 9 September 2021, at 19:34 h, N.E. Pokhilyuk encountered an adult *G. ussuriensis* crossing the road approximately 3 km north-east of Dvoryanka, a small remote village in Khankaysky District, Primorsky Krai. It was a sunny evening, shortly before sunset. The snake was lying on the roadside

Figure 3. *Gloydius ussuriensis* displaying BBB

less than 0.5 m from the grass. It remained motionless with its head slightly turned towards the first author who approached it and started taking pictures (Fig. 3B). The body of the snake displayed several small bends that seemed an unusual posture for a pit viper. The snake did not react to the camera but when our automobile was passing by it, it turned its snout towards the car and jerked the head back further in a defensive S-shaped posture.

DISCUSSION

Given the number of cases presented in this study, we can suggest that BBB is common among at least some of the snake species of the Russian Far East. The previously known accounts of such behaviour would refer almost exclusively to tropical and subtropical species. All previous records referenced the Neotropics, south and south-east Asia, Spain and the USA (Marques et al., 2006; Doherty-Bone, 2009; Duarte, 2012; Torres et al., 2015; França et al., 2020; Kathe & Deshmukh, 2020; Hauser et al., 2022). The latter account refers to the grey rat snake *Pantherophis alleghaniensis* (Holbrook, 1836) (Doherty-Bone, 2009) which is, to the best of our knowledge, the only account of kinking in the temperate climate zone. Thus, the cases we have provided are the first published records of BBB in north-east Asia.

It was suggested by Marques et al. (2006) that BBB is most common among arboreal snakes dwelling in forest habitats which is consistent with the fact that all early publications referenced either arboreal or semiarboreal species. Subsequently, kinking was described for a number of non-arboreal snakes, e.g. *Coniophanes fissidens* or *Psomophis joberti* (Maddock et al., 2011; Miranda et al., 2012). Maddock et al. (2011) conjectured that this kind of defence mechanism is typical among not only arboreal but also terrestrial species which dwell on the forest floor littered with lianas and different branches. This suggestion seems reasonable, and most of our cases refer to *E. schrenckii* and *E. dione*, which are known for their tendency to climb (Table 1; Dunaev & Orlova, 2014). Nevertheless, the study by Hauser et al. (2022) mentions two cases of BBB in *Fowlea piscator* (Schneider, 1799), which is a semiaquatic species. This leads us to suggest that kinking may be a convergent defensive mechanism typical of most land snakes, their lifestyle notwithstanding.

Table 1. Natural history traits of the three snake species displaying body-bending behaviour

Traits / Species	*E. dione*	*E. schrenckii*	*G. ussuriensis*
Family	Colubridae	Colubridae	Viperidae
Adult body length	100–120 cm	160–180 cm	60–65 cm
Venom	Non-venomous	Non-venomous	Venomous
Reproductive mode	Oviparous	Oviparous	Ovoviviparous
Diet	Rodents, birds, amphibians	Rodents, birds	Frogs, fish, small mammals
Foraging mode	Active forager	Active forager	Ambush forager
Lifestyle	Semiarboreal	Semiarboreal	Terrestrial
Habitats	Eurytopic species	River valleys, montane forests	Eurytopic species (prefers wet habitats)
Activity pattern	Diurnal	Diurnal	Diurnal, crepuscular, nocturnal

It should be noted, we have also observed this behavioural trait in the Ussuri pit viper *G. ussuriensis* (Cases 11 & 12), which, as far as we know, is the first record of BBB in the family Viperidae. All previously documented records refer to different genera within the family Colubridae.

Hauser et al. (2022) noted that BBB is closely connected with diurnal species and open spaces. Our observations partially correspond to these criteria as nearly all snakes described in this study are diurnal (Table 1) and have been found in open spaces. The only exception is *G. ussuriensis* whose foraging behaviour is after sunset. It should be noted that we also cannot correlate BBB displays with a foraging mode as, unlike rat snakes, *G. ussuriensis* are ambush predators that do not actively search for potential prey.

All three species share similar types of habitats with *E. schrenckii* preferring montane areas while *E. dione* and *G. ussuriensis* can reside in both forested and open habitats. In all of our cases, snakes were found on flat open surfaces, usually a road. Such position might make a snake feel exposed to potential predators, but, at the same time, it provides better visibility of the surroundings with a chance of spotting a threat much earlier. Since the snakes we recorded had had a better opportunity to see us approaching from a distance, we have failed to observe the initial moment when they began exhibiting BBB.

Based on our observations and those already published, BBB cannot be correlated with the size of a snake. We observed this behaviour in *G. ussuriensis*, which did not exceed 60 cm in total length, and in *E. schrenckii* of more than 140 cm. Although most of our cases refer to adult snakes, we have recorded BBB in one subadult *E. schrenckii*, while other researchers have reported juvenile snakes with this defensive display (França et al., 2020; Hauser et al., 2022). Thus, this type of behaviour does not appear to be age-dependent. According to Hauser et al. (2022), this type of behaviour may also be connected with thermoregulation. Snakes are known to turn to more aggressive defensive strategies at high temperatures (Keogh & DeSerto, 1994). Therefore, BBB should have been a common passive antipredator display in snakes whose body temperature is suboptimal. Hauser et al. (2022) suppose that BBB serves as a warming up for further aggressive defence or fleeing. Nevertheless, we are more inclined to agree with França et al. (2020) who mention that some individuals were ready to attack a possible threat or flee rapidly, thus nothing hindered their mobility. We have observed similar traits in some *E. dione* and *E. schrenckii* that were actively trying to escape when handled. Those individuals exhibited no signs of suboptimal temperature; their movements were rapid, and the snakes immediately escaped into the vegetation when given a chance.

Apparently, BBB has rarely been observed in captive snakes, although BBB was displayed by *Elaphe taeniura* while both basking and just lying in its shelter (M.V. Akulenko, pers. comm.).

We presume that body-bending behaviour is a common defensive mechanism for many species, regardless of the climate zone they inhabit. Unfortunately, there have still been relatively few reports on this behaviour in the wild. We hope that our observations will encourage further studies that will contribute to understanding this phenomenon.

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