

Finding *Vipera pontica*: morphological evidence of a possible hybrid between *V. kaznakovi* Nikolsky, 1909 and *V. ammodytes transcaucasiana* Boulenger, 1913 from central Georgia

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Abstract. *Vipera pontica* was originally described from two juvenile specimens from northeastern Turkey and has long been considered taxonomically enigmatic. Recent genomic studies suggest that these snakes represent a sporadic hybrid between *V. kaznakovi* and *V. ammodytes transcaucasiana*. We here report on an adult viper with an intermediate phenotype, part *V. kaznakovi* and part *V. ammodytes transcaucasiana*, observed in the Kura Valley of central Georgia within a known contact zone between the two other taxa. This snake combined diagnostic traits of both *V. kaznakovi* and *V. ammodytes transcaucasiana*, including an upturned but hornless snout, fragmented head scalation, intermediate ventral and subcaudal counts, a mixed dorsal zigzag pattern, and a bicoloured tail tip. This observation is the first documented adult resembling *V. pontica* and the first such record from Georgia, extending the known occurrence of this putative hybrid form approximately 150 km to the east of the type locality. Our findings support the interpretation of *V. pontica* as a rare hybrid arising in narrow parapatric overlap zones rather than a distinct evolutionary lineage, and this taxon therefore belongs in the synonymy of both *V. kaznakovi* and *V. ammodytes transcaucasiana*.

Keywords. Contact zone, Caucasus, Turkey, taxonomy, scalation, hybrid zone, ecotone, parapatry.

Introduction

Billing et al. (1990) proposed *Vipera pontica* as a new viper species from northeastern Türkiye, based on a description featuring only two juvenile specimens. The species was subsequently placed into the synonymy of *V. barani* Böhme & Joger, 1983 by Baran et al. (2001) before it was determined that the snakes used to establish the species *pontica* actually represented occasional hybrids between *V. kaznakovi* and *V. ammodytes transcaucasiana* (Mebert et al., 2015; Freitas et al., 2020). This was confirmed by Dufresnes et al. (2024), with the result that the species name *pontica* is a junior synonym of both *V. kaznakovi* and *V. ammodytes transcaucasiana*⁵. After 35 years, the observation of an adult individual in central Georgia adds new morphological context to this historically misinterpreted type of snake and its hybrid origin.

The description of *V. pontica* by Billing et al. (1990) featured two specimens collected in the Çoruh Valley, Artvin Province, northeastern Türkiye. These two vipers were characterized by a hornless, upturned snout, heavily fragmented scalation, and a sharply contrasting dorsal pattern. According to Billing et al. (1990), these individuals were considered morphologically distinct from both *V. kaznakovi* and *V. a. transcaucasiana* and were thought to be endemic to the Pontic region, the Black Sea coastal mountain range of northeastern Türkiye. These authors also mentioned a specimen from Gori, Georgia, that was first reported by Biella (1983), who described it as an atavistic and unusually built, genuine *V. a. transcaucasiana*, noting that no other viper species were known from the immediate surroundings. This specimen is now housed in the collection of the Naturmuseum Senckenberg (SMF 60870; Billing et al., 1990). This snake shows a combination of characters,

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⁵ We follow the conservative taxonomy advocated by Krecsák et al. (2025) and Wüster et al. (2025), who treated *transcaucasiana* as a subspecies of *V. ammodytes*. Although some authors (e.g., Thanou et al., 2023) have suggested that the species name *V. meridionalis* should be applied to southern Balkan, Anatolian, and Georgian viper populations, this arrangement is not widely accepted. For clarity and stability, we retain *V. a. transcaucasiana* as this arrangement is not widely accepted. For clarity and stability, we retain *V. a. transcaucasiana*.

including a slightly raised snout, a relatively high count of ventral scales, and several intermediate traits that do not fit well within either *V. kaznakovi* or *V. a. transcaucasiana*. Billing et al. (1990) later proposed that this specimen could belong to their newly described *V. pontica*. Schweiger (2009) followed Biella's interpretation and considered it an atypical *V. a. transcaucasiana*. However, according to K. Mebert (pers. comm.), this specimen warrants renewed attention, as it may represent one of the earliest indications of a possible *V. a. transcaucasiana* × *V. kaznakovi* hybrid.

An additional record originates from the Turkish side of the Chorokhi (Çoruh) Valley, close to the Georgian border. This is the same specimen originally illustrated by Baran et al. (2001) and later mentioned by Göçmen et al. (2015). The coordinates near Düzenli (41.4700°N, 41.8979°E) were first reported by Gül (2015), who listed the specimen as *V. berus barani* and not *V. pontica*. Later, Gül (2020) noted that it had been suggested that this record might represent *V. pontica*. The specimen, deposited in the collection of the Hessisches Landesmuseum, Darmstadt, Germany, as HLM RA-2891, has not been examined using molecular techniques. Photographs of this individual were obtained, and these clearly show that it represents *V. berus barani*. Its morphology does not correspond to either *V. kaznakovi* or *V. a. transcaucasiana*, and the previously reported locality information is therefore likely unreliable. Further analysis required to clarify its identity. Following its original description, *V. pontica* was met with scepticism. Baran and Atatür (1998) and Baran et al. (2001) suggested that the type specimens might actually be members of *Vipera berus barani*, citing overlapping morphological traits and the close geographic proximity of the two taxa. However, this proposed synonymy has been challenged because, *V. pontica* displays clear differences in scalation, snout morphology, and tail colouration (Kutrup, 2003).

Recent genetic studies have helped clarify the taxonomic uncertainty surrounding *V. pontica*. Freitas et al. (2020) showed that *V. pontica* carries a mixture of genes consistent with hybridization between *V. kaznakovi* and *V. a. transcaucasiana* in areas where the two species come into contact. This result was later corroborated and refined by Dufresnes et al. (2024), whose ddRADseq analyses confirmed that *V. pontica* does not represent an independent evolutionary lineage but a sporadic hybrid between *V. kaznakovi* and

V. a. transcaucasiana. In their clustering analyses, the *pontica* specimen fell precisely between two parental genetic clusters, a pattern consistent with a direct first-generation hybrid rather than with ongoing gene flow, representing this case as a rare mis-mating between two valid species.

In Georgia, the ranges of *V. kaznakovi* and *V. a. transcaucasiana* show a small overlap (Iankoshvili et al., 2021) with long-term sympatry and microhabitat-based divergence, including occasional syntopy. This overlap is particularly evident in the upper Kura (Ananjeva et al., 2021). *Vipera kaznakovi* primarily inhabits the humid Colchic foothills of southwestern Georgia and northeastern Türkiye (Yaşar et al., 2021), whereas *V. a. transcaucasiana* occupies more arid, montane and submontane habitats further east (Fig 1). Throughout their range from Georgia to northeastern Türkiye, the two taxa occur in long-term sympatry characterized by pronounced microhabitat divergence and only occasional syntopy (K. Mebert, pers. comm.), a pattern that is also evident within the Borjomi Valley. Here *V. kaznakovi* (referred to as *Pelias tuniyevi* by Ananjeva et al., 2021) is found in meadows with low shrubs and herbaceous vegetation (Fig 2), small forest glades, shrub dominated clearings and rocky outcrops within woodland dominated by oak trees and Oriental Hornbeams (*Carpinus orientalis*), while *V. a. transcaucasiana* replaces it on talus slopes and blocky rock areas (Fig 2). This fine-scale habitat segregation within a transitional climatic zone forms a mosaic of microhabitats, with dry and warm sections predominantly occupied by *V. a. transcaucasiana* and moist, cooler areas by *V. kaznakovi*, while the extensive intermediate zone contains patches suitable for both. Such a microhabitat-structured sympatry allows occasional contact and potential interbreeding where these habitats overlap.

Although *V. berus barani* is not expected to occur in Georgia and its presence in the Borjomi region is highly unlikely, the locality lies roughly 200 km from the nearest confirmed *V. berus barani* records (Gül., 2020). Given this geographic proximity, and the fact that the original Billing et al. (1990) individuals were found close to the *V. berus barani* range, we included comparative material of the *V. berus barani* to exclude any potential involvement.

Observation. On 7 May 2025 at 10:45 h a possible adult male hybrid between *V. kaznakovi* and *V. a. transcaucasiana* was observed in the upper Kura Valley, central Georgia (ca. 41.87°N, 43.42°E; elevation > 800 m).

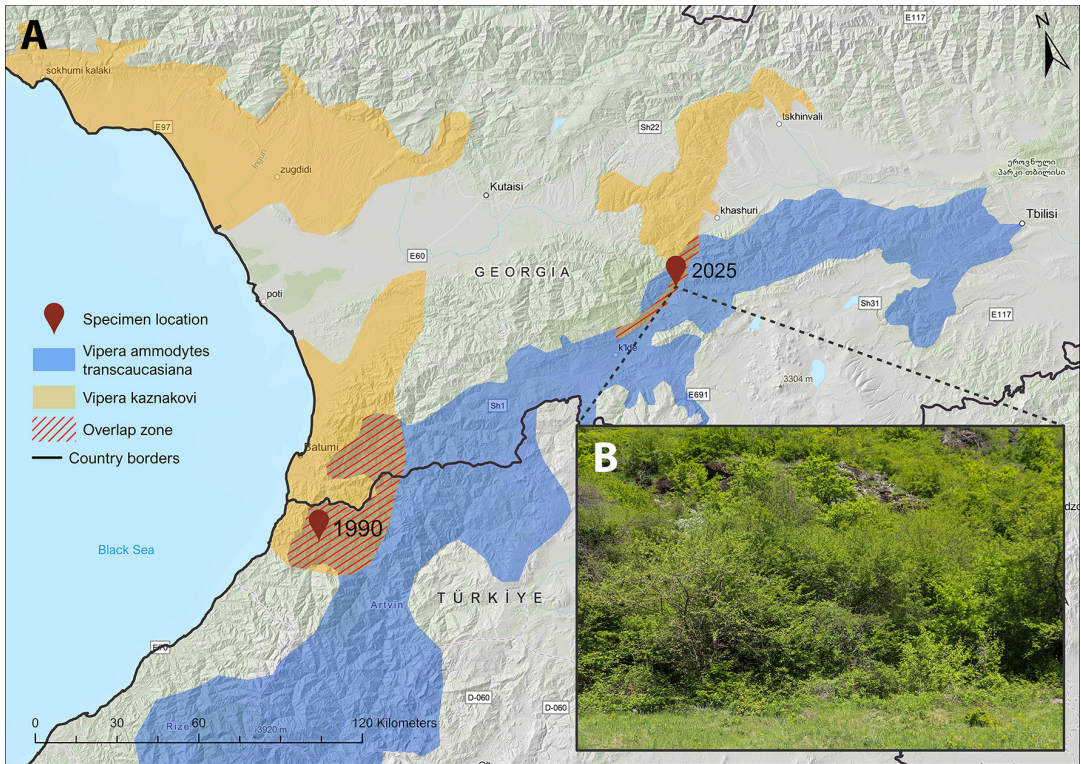


Figure 1. (A) Approximate ranges of *Vipera kaznakovi* and *V. ammodytes transcaucasiana* in the Caucasus, based on published records, highlighting the area where both taxa are known to come into contact. The map does not represent precise range boundaries. (B) Showing the observation site; a woodland edge with brambles and shrubs transitioning into a rocky slope, forming a small-scale habitat mosaic suitable for both parental taxa. Photo by Bas van Blitterswijk.

Air temperature was approximately 20°C with a UV index of 7. Earlier that morning, five adult *V. a. transcaucasiana* (four females and one male) were found basking at the same location. The presumed hybrid was first encountered basking at a forest edge at around 10:30 h and was seen basking again at 10:45 h in close proximity to a *V. a. transcaucasiana* individual. The presumed hybrid was morphologically distinct from the nearby *V. a. transcaucasiana* (see Morphological Description below).

The observation site was located at the base of a deciduous forest slope with scattered rocky outcrops (Fig 1). The microhabitat comprised a structurally diverse woodland edge dominated brambles (*Rubus*), roses (*Rosa*), stonecrops (*Sedum*), and hellebores (*Helleborus*), with scattered patches of ferns (*Pteridium tauricum*). Adjacent mesotrophic grasslands, grazed by local Brown Caucasian cattle, supported a diverse assemblage of herbaceous species typical of semi-natural meadows.

Evaluation. To assess whether the Borjomi individual represented a hybrid, we evaluated all diagnostic morphological traits (scalation and other external morphology) following a Mendelian character framework *sensu* Mebert (2008, 2010) and Gonzalez de la Vega et al. (2022). Each trait was treated analogously to segregating locus and classified as parental *V. a. transcaucasiana*-like, parental *V. kaznakovi*-like, intermediate, or mosaic. Dominance relationships were not inferred, and traits were classified solely by morphological similarity to parental phenotypes. Scalation characters are summarized in Table 1, whereas other traits (e.g., head shape, eye size, dorsal pattern, tail colouration) are described in the text. Because hybrids typically express a coordinated mixture of parental traits across multiple unlinked characters, comparisons were made primarily with local phenotypic variation of both parental taxa. The two specimens described by Billing et al. (1990) were used only to infer potential dominant versus codominant character expression.



Figure 2. Representative habitats of *V. kaznakovi* (A) and *V. a. transcaucasiana* (B) in the Borjomi Valley, Georgia. These images illustrate the characteristic habitats of both taxa but are not taken at the exact locality where the putative hybrid animal was found. The *V. kaznakovi* habitat consists of a mesic meadow with low shrubs adjacent to a deciduous forest edge, whereas the *V. a. transcaucasiana* habitat comprises an open rocky slope with scattered shrubs and low xeric vegetation, illustrating the fine-scale separation between the two taxa. Both photographs were taken on the same slope in close proximity to one another, not far from the site where we found the snake we discuss herein. At the locality, both habitat types occur in close proximity and form a fine-scale mosaic that enables contact between the taxa (see Fig. 1). Photos by Bas Raaijmakers (A) and Sten Gijbels (B).

Comparative material consisted of photographs of *V. a. transcaucasiana* and *V. kaznakovi* from local sources in Georgia (Kura Valley), including field observations, iNaturalist records, social media posts, personal archives and images provided by colleagues, resulting in sample of $n = 20$ for *V. a. transcaucasiana* and $n = 30$ for *V. kaznakovi*. For *V. berus barani*, which does not occur in Georgia, comparative photographs ($n = 5$) were used. These images were used to assess qualitative morphological traits (e.g., dorsal pattern, head shape, tail colouration) in addition to the scalation data summarized in Table 1.

Morphological description. The observed individual measured 447 mm in snout-vent length and 61 mm in tail length, resulting in a total length of 508 mm. It had a slender body, a slightly flattened head, and a distinctly upturned snout without an apical horn. The eyes were proportionally larger and wider in comparison to the nearby observed *V. a. transcaucasiana*.

The dorsal ground colour was pale to medium grey, contrasted by a sharply defined almost black dorsal band. This band was highly irregular and discontinuous: in the anterior 10–20 cm of the body, it consisted of diamond-shaped blotches separated by narrow interspaces. Along the midbody, it merged into a continuous zigzag, and more posteriorly it became fragmented again. Due to this irregularity, the number of windings was difficult to determine. Along both flanks, rows of small dark spots were present.

The head displayed heavily fragmented parietal and frontal shields, with diffuse markings in the temporal region. The canthus rostralis was clearly defined and raised but lacked an apical horn. A wide posterior black bordered band extended from the eye to the corner of the mouth and towards the neck. The tail tip was bicolored: dorsally dark, with remnants of the dorsal pattern becoming progressively darker towards the tip, and ventrally yellowish to light green (Fig. 3). The ventral surface was slightly marbled.

Table 1. Morphological data for the two *Vipera pontica* specimens described by Billing et al. (1990), the newly observed individual from Borjomi, Georgia, *V. ammodytes transcaucasiana*, *V. kaznakovi*, and *V. berus barani*. Asterisks indicate characters that could not be assessed from photographs. Dashes indicate data not reported in the literature and not assessable from available photographs. Abbreviations include SVL (snout–vent length), TL (tail length), TTL (total length) V (ventrals), SC (subcaudals), DSR (dorsal scale rows, counted at the neck/midbody/posterior body), AP (apicals), CAN (canthals), SupL (supralabials), SubL (sublabials), SubO (subocular rows), CircO (circumoculars), Lor (lorealis); Gen (genials), IntC/IntSO (intercanthals/intersupraoculars), ZZ turns total (number of turns in the zig-zag band), ZZ turns body (number of turns in the zig-zag band along the body, L/R (left/right).

Character	<i>V. pontica</i>	Borjomi	<i>V. a. transcaucasiana</i>	<i>V. kaznakovi</i>	<i>Vipera berus barani</i>
Sex	Males	Male	Male & female	Male & female	Male & female
SVL (mm)	224–246	447	350–548	330–401 (365.3 ± 20.5)	269–556
TL (mm)	30–31	61	45	–	81–99
TTL (mm)	254–277	508	395	382–471 (421.3 ± 26.2)	
Preventrals	2	2	–	2–3 (2.7 ± 0.3)	–
V	142–147	146	144–162	128–131 (129.7 ± 0.9)	142–147
SC	32/36	32/32	32–40	24–36	33–43
DSR	23/21/17	23/21/17	25–27/20–21/17	–/16–21/–	–/21–22/–
AP	2	2	8–12	1–2 (1.3 ± 0.3)	2
CAN	1/1	1/1	2/2	5–7 (6 ± 0.6)	
SupL	9/9	9/8	8/12	16–19 (17.7 ± 0.9)	9–10
SubL	12/11	11/11	9/11	19–21 (19.7 ± 0.7)	10–2
SubO	2/1.5	1.5/2	2/2	2/2	1/1
CircO	9/10	11/13	9–12	18–26 (21.7 ± 0.7)	9–13
Lor	7/6	6/6	7/7	7–12 (9.3 ± 1.5)	4–5
Gen	4	4	–	–	–
IntC/IntSO	26–34	35	44–49	16–22	25–32
ZZ turns total	65/69	63/67	50–64	55–69	63–66
ZZ turns body	51/58	58/60	47–59	42–61	52–59

The individual showed the following scalation (left/right values provided as needed): two preventrals, 146 ventrals, 32/32 paired subcaudals. Head scalation includes two apicals, one canthal, 9/8 supralabials, 1.5/2 subocular rows, 11/13 circumoculars, six loreals, and four secondary genials. The number of intercanthals and intersupraoculars was 35, and the midbody region had 21 dorsal scale rows. Comparative data for *V. pontica* were taken from Billing et al. (1990), for *V. a. transcaucasiana* from Kutrup (1999), Varol Tok (1996), Mallow et al. (2003), and Mebert et al. (2025),

representing both males and females; for *V. kaznakovi* from, Orlov et al. (1990) Ananjeva et al. (2021) and Gül et al. (2016); and for *V. berus barani* from Göçmen et al. (2015). For *V. kaznakovi*, *V. a. transcaucasiana*, and *V. berus barani* additional photographs (16, ten, and five, respectively) were examined to determine the number of turns in the zigzag band. Dorsal neck and posterior dorsal scale counts for *V. kaznakovi* could not be obtained because available photographs did not allow for a sufficiently detailed assessment. A full comparison with these taxa is provided in Table 1.



Figure 3. A viper from Borjomi Valley, Georgia, showing overall habitus (A). This individual shows intermediate characteristics of *V. kaznakovi* and *V. ammodytes transcaucasiana*, including the zigzag configuration, head shape, lateral facial band, snout morphology, and partially white supralabials. It also exhibits parental specific traits, such as the pronounced dark lateral blotches typical of *V. kaznakovi* and the coloured tail tip (B) characteristic of *V. a. transcaucasiana*. This individual is likely a hybrid between these two taxa. This type of hybrid has also been called *Vipera pontica*. Photos by Bas Raaijmakers (A) and Sten Gijbels (B).

Our identification of the hybrid is based on detailed field observations and photographic documentation, and we did not collect specimens.

Comparative morphology. A comparative overview of *V. kaznakovi*, *V. a. transcaucasiana*, and the Borjomi individual is shown in Fig. 4. The Borjomi snake shares several key traits with the two *V. pontica* specimens described by Billing et al. (1990), including an upturned but hornless snout, fragmented parietals, and similar ventral (146) and subcaudal (32/32) counts. However, a number of features set it apart: the eyes are proportionally larger and more laterally positioned (as in *V. kaznakovi*) and the tail tip is yellow with a darker ventral surface (similar to juvenile *V. a. transcaucasiana*). A fully yellowish tail tip is common in juvenile *V. a. transcaucasiana*, which perform caudal luring, whereas the tail tip is not brightly coloured in *V. kaznakovi*. The yellow to light-green tail tip of *V. pontica* as described by Billing et al. (1990) likely reflects their juvenile status rather than the pattern seen in the present adult individual.

The dorsal pattern is intermediate between the local *V. kaznakovi* and *V. a. transcaucasiana* populations, consisting of paired, parallel-sided lateral bars some pointed dorsally without connections between the pairs. The number of zigzag turns in the dorsal banding (63–67) falls between the ranges of both putative parental taxa (55–59 in *V. kaznakovi*, 50–64 in *V. a. transcaucasiana*), reinforcing the intermediate nature of the dorsal pattern. Scale morphology of the intercanthals and intersupraoculars also shows mixed affinities: the degree of fragmentation resembles traits typical of the ammodytes complex, whereas overall scale size aligns more closely with the *kaznakovi* complex.

Additional characters further support an intermediate condition. The number of dorsal scale rows at midbody (21) falls within the range of both parental taxa. Ventral scale counts (146) correspond more closely to *V. a. transcaucasiana* (144–162) than to *V. kaznakovi* (128–131). The ventral surface was black with white speckling; in *V. a. transcaucasiana* the ventrals are typically black



Figure 4. Comparative overview of three vipers found in the Borjomi Valley, Georgia. Shown are images of *Vipera kaznakovi* (A–C), a putative hybrid individual (D–F), and *V. ammodytes transcaucasiana* (G–I). The snake depicted in the middle row is clearly morphologically intermediate between the other two. The *V. a. transcaucasiana* individual was photographed at the same locality as the hybrid individual, whereas the *V. kaznakovi* individual was photographed in the same valley not far away from the observation site. These images were chosen to illustrate key differences in head morphology, dorsal patterning, and overall appearance of the two putative parental taxa and the hybrid-like individual. Photos by Sten Gijbels (A, D, G, I) and Bas Raaijmakers (B, C, E, F, H).

or dark brown with pale speckles, whereas *V. kaznakovi* usually has a uniformly black venter. Subcaudal counts are likewise intermediate.

The number of apicals strongly resembles *V. kaznakovi*. This is expected, as *V. a. transcaucasiana* typically has more apicals (8–12) associated with its pronounced rostral horn, whereas *V. kaznakovi* usually has only two, matching the Borjomi individual, despite

its raised snout. Snout morphology itself is intermediate: the canthus rostralis is clearly defined and elevated but lacks an apical horn, producing a raised rather than sharply horned or bluntly rounded profile.

Head shape is moderately broad and slightly angular, falling between the broader, rounded head of *V. kaznakovi* and the narrower, more angular head typical of *V. a. transcaucasiana*. The facial lateral band is

also intermediate: strongly expressed posteriorly (over the venom gland) and fading anteriorly, reaching the eye only weakly. In *V. kaznakovi* the band is thick, black, and extends strongly to the eye, whereas in *V. a. transcaucasiana* it is thinner, weaker, and often fades away halfway along the head. Supralabials in the Borjomi individual are white posteriorly but fade anteriorly, again intermediate between the mostly white supralabials of *V. kaznakovi* and the partially white condition in *V. a. transcaucasiana*. Lateral blotches are well developed, typically at least one scale in size and often extending into adjacent scales, which become partially darkened, resembling *V. kaznakovi*, which typically shows prominent lateral blotches, though the species is highly variable: darker and more contrasting individuals tend to exhibit larger blotches, whereas paler, less contrasting individuals show smaller and less distinct ones. Unlike *V. a. transcaucasiana*, which lacks this feature generally. The coloured tail tip is also noteworthy: *V. kaznakovi* usually has a uniformly coloured tail, whereas *V. a. transcaucasiana* generally shows a coloured one.

Discussion

The Borjomi snake represents the first clearly documented adult viper with this combination of morphological traits in the Lesser Caucasus. Although Biella (1983) described an unusual *Vipera* specimen from Gori, its taxonomic status and interpretation remain uncertain. Our record adds an additional locality to the previously known material from the Çoruh Valley in northeastern Türkiye.

Using the Mendelian character framework outlined by Mebert (2008, 2010), the combination of characters observed in the Borjomi individual cannot be explained by a single developmental anomaly or by local phenotypic variation. Single-gene mutations typically affect only one trait, whereas this individual shows a coordinated mixture of multiple independent characters. Instead, it displays a mosaic of traits typical of *V. kaznakovi* and *V. a. transcaucasiana*, together with several clearly intermediate features. Such a mixture of unlinked characters strongly argues against an atypical morph of either species. Although individual traits cannot be assigned unambiguously to dominant or codominant inheritance based on a single individual, the presence of both parental and intermediate character states is consistent with the expected combination of dominant and intermediate expression in F1 hybrids. This pattern is also consistent with diploid recombination in a

hybrid, where traits may express dominant, recessive, or intermediate phenotypes (Mebert et al., 2020). The coordinated mixture of parental and intermediate characters across many traits fits expectations for an F1 hybrid, although a later generation backcross cannot be excluded without genetic data.

The comparison with the two *V. pontica* specimens from Billing et al. (1990) helps identify which traits may reflect dominant versus intermediate expression, but geographic distance and local variation limit direct comparability. Local parental taxa therefore provide the most reliable baseline for interpreting the Borjomi individual. Potential involvement of *V. berus barani* is highly unlikely. The species is not known from Georgia, and the nearest confirmed records are approximately 200 km away in northeastern Türkiye (Gül, 2020). The Borjomi individual lacks the diagnostic traits of *V. berus barani*, including the characteristic *berus*-like head proportions, and it exhibits clearly defined lateral blotches, a feature not associated with *V. berus barani* but more typical of *V. kaznakovi*. Moreover, if *V. a. transcaucasiana* were to hybridize with *V. berus barani*, the dorsal pattern would be expected to show far greater fragmentation, as this is characteristic of both parental species. Instead, its morphology consistently reflects a mixture of characters from *V. kaznakovi* and *V. a. transcaucasiana*, with no indication of affinity to *V. berus barani*.

Cases of hybridization among species of the genus *Vipera* have been documented across Europe and the Caucasus, typically in ecological overlap zones where species ranges and habitat preferences overlap. Examples include *V. aspis* x *V. berus* in western France (Guiller et al., 2016), *V. aspis* x *V. latastei* in the Iberian Peninsula (Tarroso et al., 2014), and *V. ammodytes* x *V. aspis* or *V. berus* in southern and central Europe (Schweiger, 2009; Bagnoli et al., 2014; Mebert et al., 2015). In the Caucasus, *V. magnifica* and *V. orlovi* are considered to originate from an admixture of *V. kaznakovi* and *V. renardi* genotypes (Zinenko et al., 2016). These cases suggest that hybridization in *Vipera* is not exceptional and may occur under suitable ecological conditions, as observed in the Borjomi Valley.

The observed ecotonal habitat, combining rocky forest slopes, shrub-fern undergrowth, stone piles and adjacent grassland, provides a microclimatic gradient suitable for both *V. a. transcaucasiana* and *V. kaznakovi*. Such overlap zones allow the shaded, humid microhabitats favoured by *V. kaznakovi* to occur

alongside the open, rocky structures typical of *V. a. transcaucasiana*, thereby facilitating secondary contact and, apparently occasional hybridization. Overlapping habitats may also be a factor in the rare hybridization of other *Vipera* species, for example between *V. berus* and *V. aspis* in western France (Guiller et al., 2016) and among *V. ammodytes*, *V. aspis*, and *V. berus* (Mebert et al., 2015).

Interestingly, differences between the Borjomi individual and the *V. pontica* individuals described by Billing et al. (1990) may reflect variation in parental lineages. The holotype came from a region where *V. a. transcaucasiana* meets the southern coastal *V. kaznakovi* clade, whereas the Borjomi individual occurs in contact with populations more closely linked to the Greater Caucasus lineage (Freitas et al., 2020). Parental sexes may also have differed, potentially producing a different phenotypic outcome.

Both parental species occur in close proximity within the Kura Valley, and the mosaic microhabitat based at the observation site provides opportunities for occasional contact. The Borjomi individual fits this ecological context and shows a coordinated mixture of parental and intermediate traits that cannot be explained by local variation or developmental anomalies. Rather than representing an independent lineage, it most plausibly reflects a rare hybrid between *V. kaznakovi* and *V. a. transcaucasiana*. Further fieldwork and genetic analyses will be essential to clarify the frequency, parental origin, and spatial extent of such hybridization within the region.

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