New records and search for contact zones among parapatric vipers in the genus *Vipera* (*barani*, *kaznakovi*, *darevskii*, *eriwanensis*), *Montivipera* (*wagneri*, *raddei*), and *Macrovipera* (*lebetina*) in northeastern Anatolia

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ABSTRACT - North-eastern Anatolia harbours a high diversity of viperid snakes with only a limited knowledge about their distribution and with relationships among these vipers not yet fully resolved. Moreover, information on habitat attributes for most of these vipers is scarce. We initiated a multi-year project to improve our knowledge on their distribution and habitat preferences, especially by searching contact zones of closely related and ecologically similar species and evaluate potential gene flow and species integrity. In this context and as an intermittent step, we report new localities nearby putative contact zones. Thus, herein we present new information on the distribution of *Vipera barani*, *V. kaznakovi*, *V. darevskii*, *V. eriwanensis*, *Montivipera wagneri*, *M. raddei* and *Macrovipera lebetina* based on our field work and third sources provided to us. With these data, we were able to reduce the distribution gaps between three pairs of "parapatric", related or ecologically similar, viper species (genus *Vipera*) by mostly 50%, and detected a putative contact zone in a fourth species pair (genus *Montivipera*). All putative contact zones are discussed in an ecological context. In addition, we add new sites of *M. lebetina* in the Province Artvin and discuss its northern limit in Turkey.

INTRODUCTION

The Anatolian Peninsula, the Asian part of Turkey, is a melting pot for palearctic species originating from Europe, Asia, and northern Africa. For example, its north-eastern quarter is considered as a global diversity hotspot for vipers with at least 10 species occurring within a radius of 200 km from the city of Erzurum (Nilson & Andren, 1986; Joger et al., 1997, 2005, 2007; Avci et al., 2010; pers. data), thus rivalling the species richness of most tropical sites in viperids. The diversity is resulting from a great variety of habitats, including zones of subtropical climate along the Black Sea coast, mixed deciduous forests, alpine meadows, and semi-arid steppes on the Central Anatolian plateau. Unfortunately, flooding of valleys associated to dam constructions, intensive agronomic practices, such as tea plantations along the Black Sea coast, and overgrazing by domestic livestock (goats, sheep, cattle) have drastically reduced the habitat quality for many animal species including vipers. Furthermore, illegal collecting of these rather attractively coloured vipers for the commercial trade, as well as intentional and accidental killing by locals, are considered to harm populations as well (IUCN Red List of Threatened Species, 2014.3; Ettling et al., 2014). However, the impact of illegal collecting appears to be reduced today and current threats relate rather to increased habitat destruction, and thus, conservation statuses need to be reassessed accordingly (Mebert, 2014).

Nonetheless, the lack of knowledge on Turkish vipers, from simple distribution data to taxon and population biology, is preventing any reasonable assessment of species statuses. It is therefore paramount to identify not only the environmental key factors that are relevant for their habitat, but also to elucidate which species really represent valid taxa (independent evolutionary entities) and deserve further conservation efforts, as well as the role of interspecific relationship among them. This can be achieved most efficiently through a multi-faceted approach by studying characters of habitat selection, genetics, and morphology in contact zones or contiguous populations of two or more viper species (e.g., Mebert et al., 2015). Finally all these elements will provide relevant tools for their conservation management.

Consequently, we outlined an ambitious project to search for contact zones, contiguous, and proximate populations of pairs of closely related or ecologically similar viper species in an area of approximately 200 km diameter in north-eastern Turkey (Ardeşen-Hopa-Camili-Posof-Çildir-Tuzluca-Kağizman-Horasan-Uzundere-Çamlihemşin). Eight confirmed species occur in this area, excluding the dubious *Vipera pontica*, which is known from only three specimens, all from one valley (Mebert et al., 2014), but represents a hybrid between *V. kaznakovi* and *V. (ammodytes) transcaucasiana* (Zinenko et al., 2013). The results of range extensions from the 2013 season including new records of *V. (ammodytes) transcaucasiana* have already been published (Göçmen et al., 2014; Mebert et al., 2014). The following reports focuses on new locality findings during the 2014 season of the other seven viper species from north-eastern Turkey, supplemented by previously unpublished records from third party sources. We update information on range distances between "parapatric" vipers of the genus *Vipera* and take a critical look at a possible contact zone between two rock viper species (*Montivipera* spp.) and its habitat-linked position.

Six out of seven viper species were assigned a conservation status according to the International Union for Conservation of Nature (IUCN Red List of Threatened Species, 2013.1). Their threat level and current population assessments with a focus on Turkey are listed below. The seventh species, *Macrovipera lebetina*, is not threatened and receives no conservation status by IUCN standards, but is added here due to its rarity in our study area and our new information on its range limit. In parentheses are recent suggestions for taxonomic name changes or affinities, that require more research or peer-reviews before the new taxonomy can be approved or disproved (see Stümpel, 2012; Joger & Zinenko 2013, Joger et al., 2010; Zinenko et al., 2013, 2015; Mebert et al. 2014; Göçmen et al., 2014):

1. *Vipera (berus) barani* (Baran's adder): Near Threatened; Turkish endemite, significant decline due pet-trade-harvesting, probably will qualify for Vulnerable status, known by ca. 25 specimens
2. *Vipera (olguni) darevskii* (Darevsky's viper): Critically Endangered; known in Turkey by approximately 20 adult wild specimens and a range < 100km^2 with all sites > 2000 m asl. and a similar situation in Armenia
3. *Vipera eriwanensis* (Armenian steppe viper): Vulnerable; known by approximately 25 sites in Turkey alone, few more sites in Armenia, Azerbaijan (Nachitschewan), extent of distribution < 20,000 km^2
4. *Vipera kaznakovi* (Caucasian viper): Endangered; populations severely fragmented, coastal range < 500km^2, in Turkey known from < 10 sites, exposed to the international pet trade and severe habitat degradation
5. *Montivipera raddei* (Radde's rock viper): Near Threatened; threat by pet-trade-overcollection, known from at least 10 sites in Turkey alone, few more in Armenia and Azerbaijan (Nachitschewan)
6. *Montivipera wagneri* (Wagner's rock viper): Critically Endangered Turkish endemite; very restricted range, known by approximately 15 sites, heavily collected for pet trade
7. *Macrovipera lebetina* (Levantine or Blunt-nosed biper): no IUCN status as it is not threatened, but appears to be very rare in Province Artvin

APPLIED FIELD METHODS

Three field expeditions, in May and July 2013 and June 2014, were conducted to sample vipers in north-eastern Turkey. We selected five geographic regions, four related to potential contact zones and one to a northern range limit. The five regions and the reasoning for their selection are:

1. A potential contact zone of *Vipera (berus) barani* and *V. kaznakovi* between Ardeşen and Findikli, Rize Province. These are two medium-sized and possibly parapatric species that both inhabit open patches of deciduous forest along the subtropical Black Sea coast.
2. A potential contact zone of *V. kaznakovi* and *V. darevskii* north of the Karçal Mountains between Camili and Maden, Artvin Province; these two viper taxa are ecologically and morphologically extremely different, as *V. darevskii* is a dwarf form of rock slides in alpine grassland, whereas *V. kaznakovi* is a medium-sized viper of subtropical light forest. But recent research found confounding results of mixed genotypes among several Caucasian vipers, including some closely related haplotypes between *V. darevskii* and *V. kaznakovi* (Zinenko et al., 2013), possibly indicating introgression. *V. kaznakovi* is known from the Camili area (Afsar & Afasr, 2009), and apparently suitable alpine habitat exists only a few km south in the Karçal Mountains from where no vipers have been confirmed, though.
3. Both vipers, *V. darevskii* and *V. eriwanensis*, occur in eastern Hanak District, Ardahan Province. These vipers are small forms that similarly inhabit rocky areas in alpine grassland. However, no contact zone or proximate populations have been reported so far, but can be expected in eastern Ardahan Province.
4. Both rock vipers, *Montivipera wagneri* and *M. raddei*, occur in Aras Valley, Kars Province. These two similar species inhabit rocky slopes in a montane environment west and east of Kağizman, respectively. As their preferred habitat is abound near Kağizman, a contact zone could be expected in that area.
5. The Coruh Valley in Artvin Province, as the north-eastern range limit of *Macrovipera lebetina* in Turkey, is based on a single record only (Basoglu & Baran, 1980). We add several unpublished records from various sources.

We accessed the different regions by all means possible, such as cars, tractors and on foot. Each region was searched for contact zones and/or proximate populations of pairs of viper species during about 40 days (4 weeks in 2013 and 2 weeks in 2014). Vipers have been located by visual encounter survey of suitable microstructures, usually with one area well exposed to solar radiation (rock slides, dry stone walls, edges of forest and bushes, river borders) that provides shelter, basking sites, and hunting ground. Our sampling effort focused on south-facing slopes, the preferred exposition for reptiles in the northern hemisphere, followed by east- and west-faced slopes, but eventually complemented by a few north-facing slopes. Furthermore, to accelerate the finding of new viper sites, we interrogated local residents about the regional viper species by showing them comparative photographs of various viper species from north-eastern Turkey, but without indicating them, which species is supposed to occur in their region. The locals mostly pointed to the photograph of the viper species, we expected to occur at their site, and thus encouraging our search efforts.

For each found viper, we recorded a few structural habitat factors (25 m radius around the exact capture point) for future analyses. Exact locality coordinates were taken with a GPS device for subsequent landscape and GIS analyses. Each specimen was sexed, photographed to assess colour pattern variation, a few body proportions measured, and some pholidosis characters recorded. Vipers aimed for release were scale-clipped (cutting off a dead part of the projecting outer edge of 1-2 ventral scales) and mouth-swabbed for future DNA analysis. Most specimens were released back to their habitat/capture site, while a few others were maintained for other projects or deposited as vouchers in the Zoology Museum of Adiyaman University (ZMADYU) in Adiyaman, Turkey.

RESULTS AND DISCUSSION

We successfully sampled all 7 focus-species within a radius of 100 km around the point where three provinces meet (Ardahan, Erzurum, Artvin). Information on habitat and distribution for each region and its viper species considered herein is summarised and discussed sequentially to facilitate reading and comprehension. In the following, we applied the current taxonomic affiliations of Turkish vipers as utilised by the IUCN in the remainder of this report.

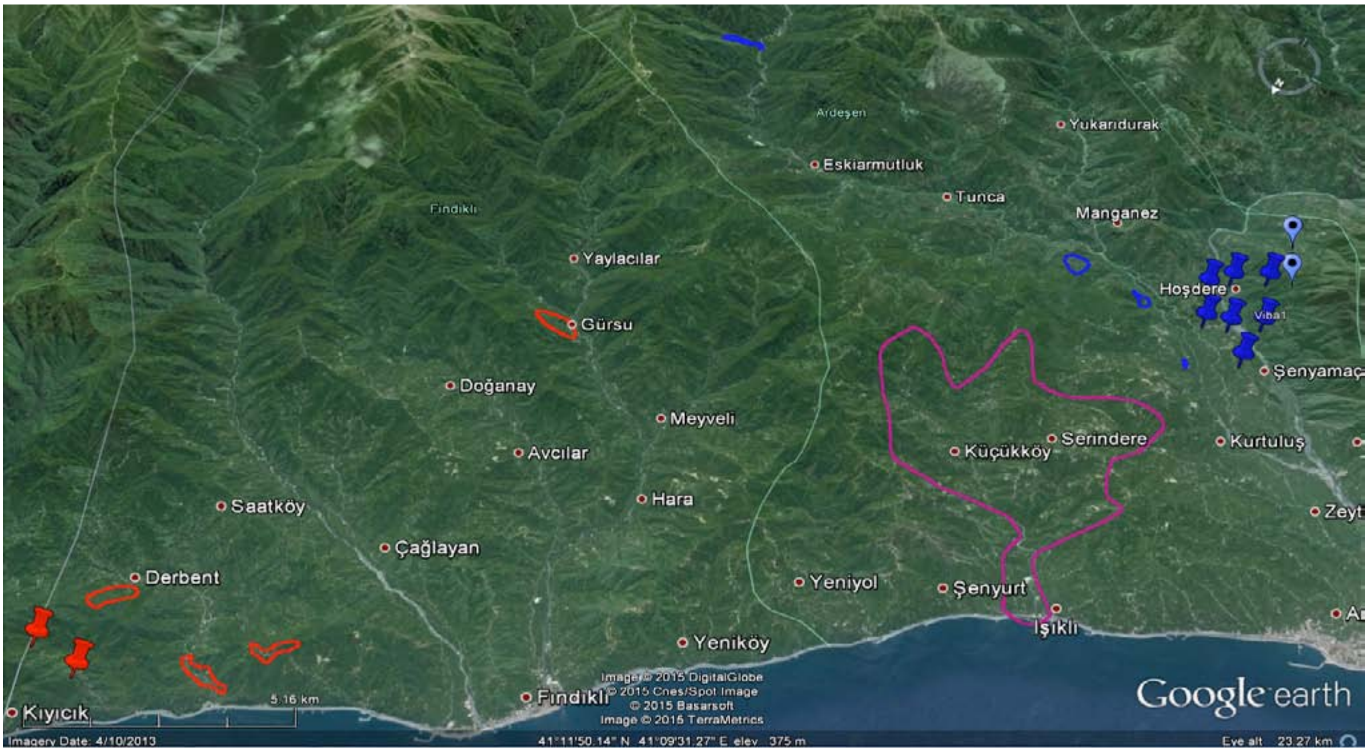
Region 1: *Vipera barani-V. kaznakovi* transition zone (Fig. 1)
For these species, our field inspections were focused along the coastal versant of the Black Sea Mountains from the environs of Hopa, Province Artvin, to Ardeşen, Province Rize, in particular within the districts of Arhavi, Findikli and Ardeşen. These districts lie between the previously known westernmost records of *V. kaznakovi* near Hopa (e.g., Nilson et al., 1988) and the easternmost coastal records of *V. barani* in Firtina Valley near Çamlihemşin (Franzen & Heckes, 2000; Baran et al., 2001, 2005a).

In all, we acquired information on eight *V. kaznakovi* (sampled n=7, observed n=1) and six *V. barani* (sampled n=5, unpublished record n=1 by J. Mulder pers. comm.). Six *V. kaznakovi* were sampled at known sites east of Hopa (Nilson et al., 1988; Afsar & Afsar, 2009), whereas two *V. kaznakovi* were found above Güzelyali near Kiyicik, Findikli District (one sampled, one observed; see Fig. 1). Latter two vipers represent currently the westernmost site and the first documentation for this species from Rize Province (Fig. 2C and D). *V. barani* were sampled in Firtina Valley mostly within five kilometres south of its confluence with Zigem River (Figs. 1, 2A and B). They represent minor extensions of up to 2.5 km north from a previously reported site (Franzen & Heckes, 2000).

With the new findings, the known distance between *V. barani* and *V. kaznakovi* vipers was reduced from 40 to 25 km, and even to 14 km when considering local reports. We presume that Işikli Valley constitutes the most likely area for a contact between *V. kaznakovi* and *V. barani*, but we only reached that valley during one rainy day without any sampling success. Future excursions should focus on the Işikli Valley and the area around Findikli and Zigem Valley south-east of Ardeşen.

We perceive that the Black Sea costal belt is the most threatened bio zone in north-eastern Turkey in regard to the survival of its indigenous viper populations. The habitat for

Figure 1. Approximate sampling area for Region 1, a *Vipera barani-V. kaznakovi* transition zone with the centre of the map at 41°11'50.14"N, 41°09'31.27"E. The pin markers/area-circles in red (*V. kaznakovi*) and blue (*V. barani)* represent new records/verbal reports from this study (see text). The new *V. barani* records have been displaced relative to each other to visibly fit into the map. The two "blue drop-markers with black centres" to the right refer to previous records of *V. barani* from Firtina Valley (Baran et al. 2001; Franzen & Heckes 2000). Purplish area-circle designates the potential contact zone between these viper species in Işikli Valley.



V. kaznakovi and *V. barani* is extremely degraded, as the once lightly-wooded hazelnut plantations, that were rich in rodent prey for vipers, have been cut and concomitantly replaced with structure-poor and canopy-closed tea plantations. Natural stretches of the coastal region consists mostly of densely shading forests, leaving suitable semi-open areas for vipers only along the margins of agricultural fields, tea plantations, and forests, as well as in meadows and along river-and roadside structures. Furthermore, future dam building will lead to the disappearance of many suitable valley habitats. Consequently, the survival of any viper populations in this region is uncertain. Action plans for both viper species, as well as studies to investigate the extend of their ranges, ecological niches, and the impact of tea plantations are urgently needed.

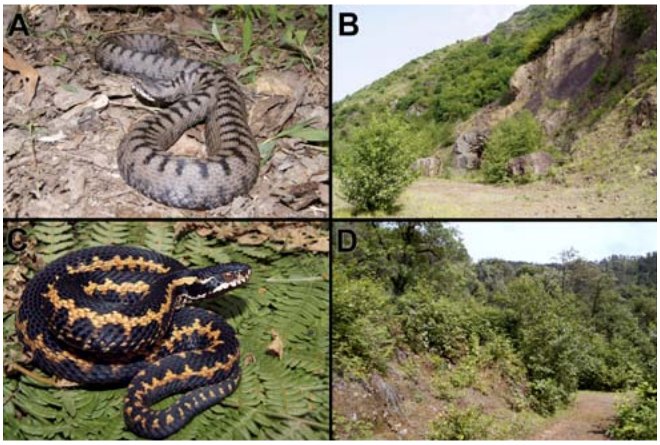


Figure 2. Region 1, transition zone between *Vipera barani* and *V. kaznakovi* in Province Rize, Turkey, along the Black Sea coast: (A) *V. barani* and (B) its habitat south of Ardeşen; (C) *V. kaznakovi* and (D) its habitat from Güzelyali, District Findikli. Habitat sites B and D are 27 km straight line apart.

Region 2: *Vipera kaznakovi-V. darevskii* transition zone (Fig. 3)
The currently known gap between *V. kaznakovi* from Borçka to *V. darevskii* near Zekeriyaköy is at least 60 km straight distance (Baran et al., 2005b; Geniez & Teynié, 2005), or approximately 90 km distance between *V. kaznakovi* from Maral Valley, Camili, Artvin Province, to *V. darevskii* near Posof, Ardahan Province (Afsar & Afsar, 2009; Avci et al., 2010). These stretches are accompanied by a significant change of elevation and vegetation cover, reflecting a corresponding change from temperate-humid to montane-arid climate. In the search for a high-alpine zone (> 2000 m asl.) suitable for *V. darevskii* but closer to *V. kaznakovi*, we located the Karçal Mountains just south of the Maral Valley. Both areas, the Maral Valley and Karçal Mountains, were visited each on single days in 2013 and 2014.

We sampled, and thus confirmed, *V. kaznakovi* around Düzenli, Maral Valley, at 600 m asl. (n=4, Mebert et al., 2014; Fig. 4A and B) in 2013. For *V. darevskii*, we briefly searched vipers in the high mountain valleys, the Lekoban and Çikunet Plateaus (Fig. 4D). We could not confirm the occurrence of *V. darevskii* in the Karçal Mountains, but locals on the Çikunet Plateau have shown us two sites (slopes), where small light greyish venomous snakes (vipers!) with a blackish dorsal

Figure 3. Sampling area for Region 2, a potential *Vipera kaznakovi*-*V. darevskii* transition zone in the Province Artvin, Turkey, with the centre of the map at 41°23'8.52"N, 42°0'21.25"E. Red pin-markers represent our sampled *V. kaznakovi* individuals and the red drop-markers with black centres refer to previously published individuals (Afsar & Afsar 2009). The new records of *V. kaznakovi* have been displaced relative to each other to visibly fit into the map. The black area-circles indicate where small grey-black vipers have been observed by locals or were anticipated by us, suggesting the potential occurrence of *V. darevskii*, albeit this requires verification (see text for explanation).

pattern occur. These sites are only 10-15 km distance from the nearest *V. kaznakovi* site at Baltacik, Maral Valley, around 1050 m asl. (Afsar & Afsar, 2009).

Even though the description of vipers by locals from the Çikunet Plateau would fit *V. darevskii* (or *V. eriwanensis*), it might also be related to the locally common Smooth Snake (*Coronella austriaca* in Fig. 4C). If no *V. darevskii* can be located in the Karçal Mountains, we suggest to expand the search to the next high mountain range east along the Turkish-Georgian border, which is closer to known populations of *V. darevskii* (Tuniyev et al., 2012, 2014). Any find of *V. darevskii* in either mountain range would greatly expand the known distribution for this critically endangered and geographically limited species. While the lightly wooded habitat for *V. kaznakovi* in the forest belt of the Maral Valley is protected, heavy cattle grazing of alpine meadows might pose a threat to potential viper populations in the Karçal Mountains (see also Region 3).

Region 3: *Vipera eriwanensis*-*V. darevskii* transition zone (Fig. 5).

V. eriwanensis and *V. darevskii* are externally similar small viper species that both inhabit high altitude rocky grassland (Fig. 6B), but are phylogenetically not close relatives (Joger et al., 2010; Zinenko et al., 2013). Recent publications show that *V. darevskii* occurs at two sites around Posof in the eastern Province Ardahan, Turkey (Avci et al., 2010; Tuniyev et al., 2012), whereas we reported new sites of *V. darevskii* 20 km farther south-east at Sulakçayir, Hanak District, Ardahan Province (n=4, Göçmen et al., 2014). The *V. darevskii*-site south of Posof is ca. 30-35 km distant to the nearest known site of *V. eriwanensis* south of Çamlibel, Ardahan District (Baran et al., 2005b) or Ölçek, Hanak District (Geniez & Teynié, 2005).

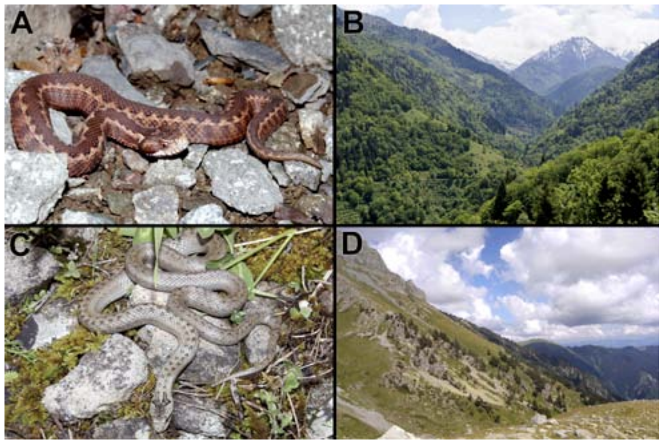


Figure 4. Region 2, with the potential (not confirmed) transition zone between *Vipera kaznakovi* and *V. darevskii* in the Province Artvin, Turkey: (A) juvenile *V. kaznakovi* and (B) its habitat in the Camili area, Artvin, with the Karçal Mountains visible in the background; (D) the Smooth Snake (*Coronella austriaca* from Province Ardahan), inhabiting high altitude site up to 2000 m asl., as the Çikunet Plateau in Artvin Province where small vipers were reported by locals, but which might be confused with the Smooth Snake.

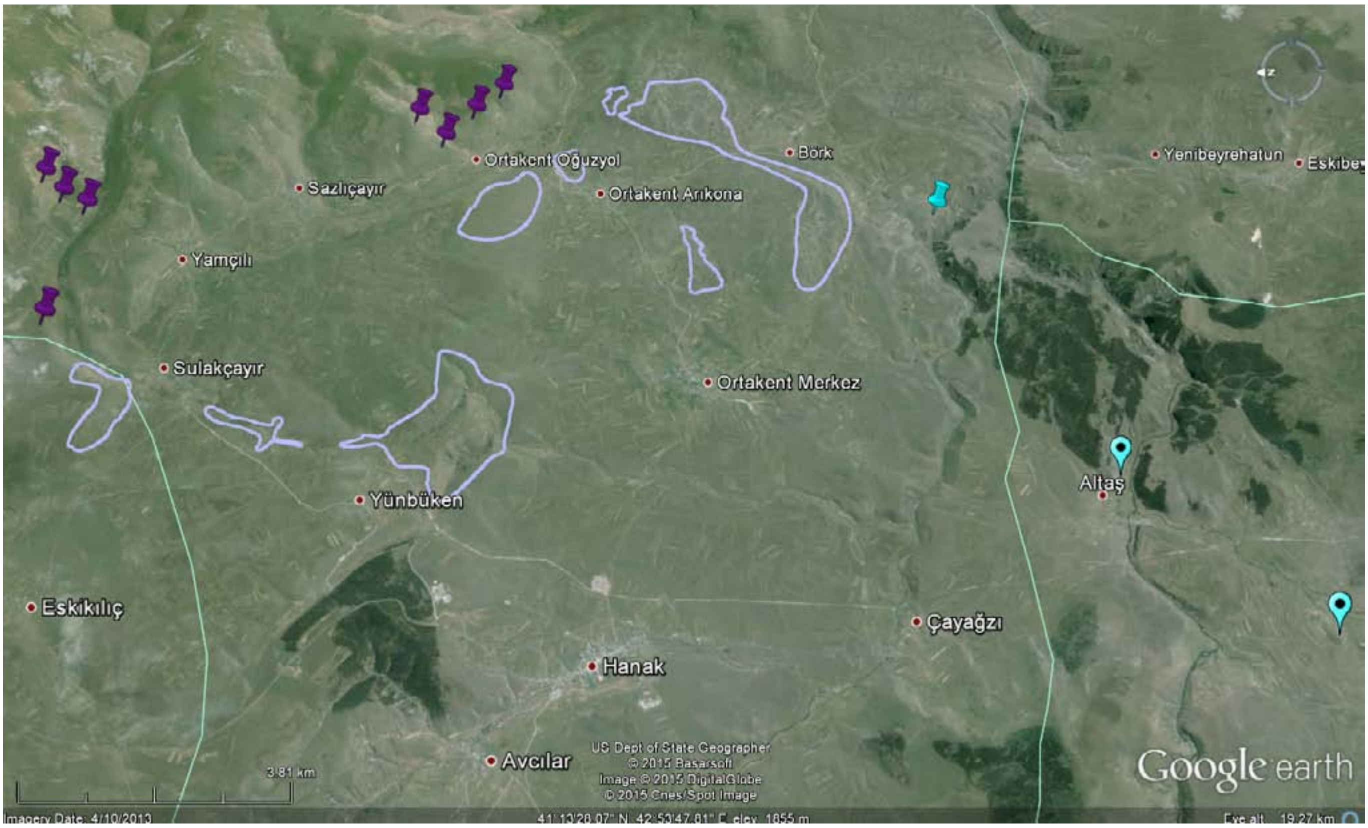


Figure 5. Sampling area for Region 3, the *Vipera darevskii*-*V. eriwanensis* transition zone with the centre of the map at 41°13'28.07"N, 42°53'47.81"E. Violet pin-markers on the left represent our *V. darevskii* records, the light blue one represents the new *V. eriwanensis* from Dilekdere. The new records of *V. darevskii* have been displaced relative to each other to visibly fit into the map. The two light blue drop-markers with black centres refer to published records; the upper one from Geniez & Teynié (2005) and the lower one by Mulder (1995). The exact positions of the latter two records were personally confirmed by the respective authors. The light purplish area-circles designate potential contact zones between these two viper species.

In 2014, we detected four *V. darevskii* near Oğuzyolu, approximately 7 km south of the Sulakçayir site (Fig. 5). Individuals were found in rockslides and natural stone piles in alpine grassland > 2000 m asl. Recently reported sites of *V. darevskii* in Georgia (Tuniyev et al., 2014), along its border with Turkey, are only 10-15 km distant from our sites. A look at the topography in north-eastern Ardahan Province suggests that all currently known sites of *V. darevskii* in that region, from Posof along the Turkish-Georgian border to Oğuzyolu and Dirsekkaya, are connected via mountains and slopes with sufficient rock slides and piles to provide an almost continuous habitat at an elevation > 2000 m over more than 40 km in this province alone. In regards to *V. eriwanensis*, we found only two specimens outside of Region 3 near Kağizman in Kars Province. But we were able to confirm its presence in eastern Hanak District via a photo-ID from Dilekdere (Fig. 6C). This record substantially shortens the distance between *V. eriwanensis* and *V. darevskii* from ca. 30 km to 8 km (Dilekdere to Oğuzyolu).

During two days in the field, we have unsuccessfully searched a putative contact zone in the area between the two viper species, which lies around 2000 m asl. and appears superficially suitable for either species, as it provides plenty of rocks/stones on alpine meadows. We recognised that the visibly heavy grazing by cattle and horses drastically reduced the diversity of dry meadow plants, and thus, the abundance of grasshoppers and crickets, an important food source for both species (Höggren et al., 1993; Aghasyan et al., 2009). Furthermore, the grazing reduces herbaceous cover, which is important for safe thermoregulation, as the cover obstructs against visual predators and provides increased humidity and moderate temperatures in hot summer days. Nonetheless, the few kilometres of rocky/grassy habitat between these

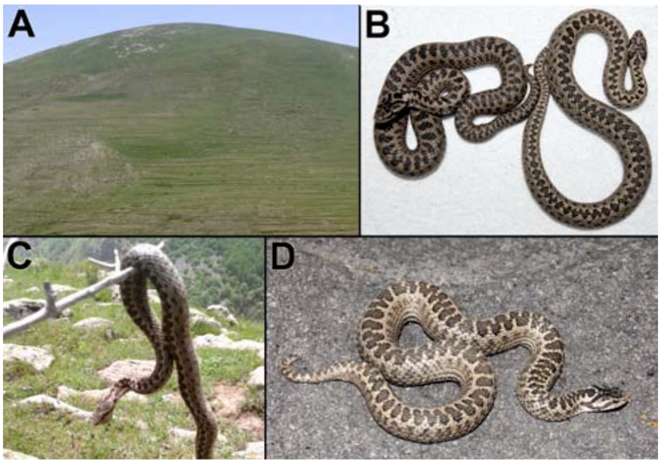


Figure 6. Region 3, transition zone between *Vipera eriwanensis* and *V. darevskii* in Province Ardahan, Turkey: (A) habitat of *V. darevskii* in eastern Hanak district with a cattle herd on the upper left slope; (B) two highland meadow vipers, with *V. darevskii* from the Province Ardahan on the left and *V. eriwanensis* from the Province Kars on the right; (C) *V. eriwanensis* from Dilekdere, Ardahan (photo by Uygun Akpinar); (D) a female *V. darevskii* from eastern Hanak at a distance of ca. 8 km from the *V. eriwanensis* depicted on the left image.

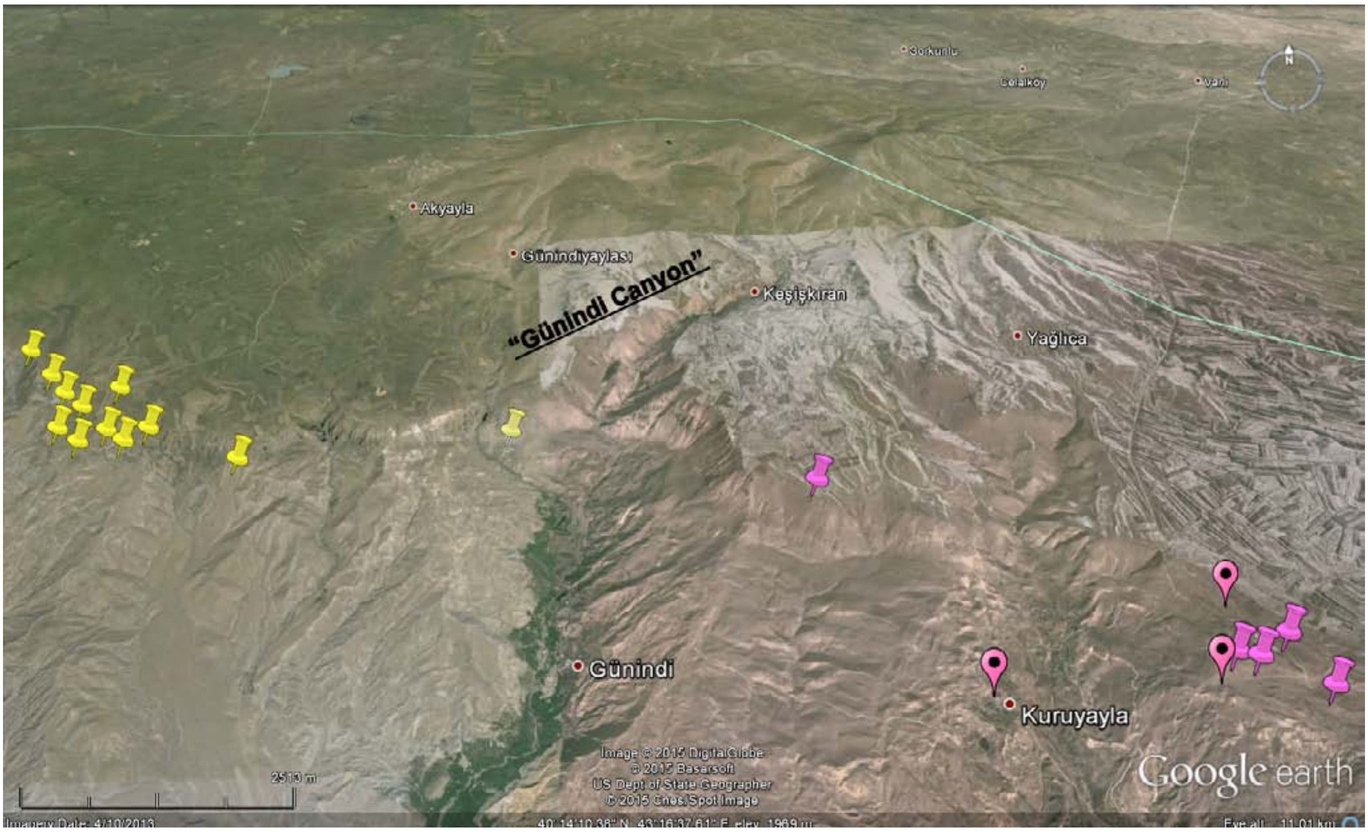


Figure 7. Sampling area for Region 4, the *Montivipera wagneri-M. raddei* transition zone with the centre of the map at 40°14'10.38"N, 43°16'37.61"E. Yellow pin-markers represent *M. wagneri* (the single pale yellow marker on the right is a unverified sighting of *M. wagneri* by a local, all saturated yellow markers were sampled by us), and the pink pin-markers is for *M. raddei.* Pink drop-markers with black centres represent *raddei*-markers from literature records (lower right composite for Nilson et al. 1988; Schätti 1991) and pers. comm. (drop-marker at Kuruyayla by M. Schweiger; upper right drop marker by M. Corboz and V. Ruffieux). The new records of *M. wagneri* to the left have been displaced relative to each other to visibly fit into the map.

two vipers will need to be searched more intensively to eventually find the zone of contact and evaluate differences in microhabitat. The impact of heavy grazing by cows, goats, sheep, and horses, should urgently be evaluated for its potentially detrimental effects to most small, alpine, and insectivorous vipers.

Region 4: *Montivipera wagneri-M. raddei* transition zone (Fig. 7)

The Aras Valley is home to both rock vipers (Fig. 8A and B). *M. wagneri* occurs predominantly west of Kağizman and *M. raddei* east of it with about 40 km distance between their closest officially known populations (Nilson et al., 1988; Schätti et al., 1991; Mulder, 1995; Baran et al., 2004; Stümpel, 2012). However, no proximate populations or area of contact have ever been published, and the occurrence of these taxa around Kağizman is not documented to our knowledge.

We searched and found vipers (*M. wagneri*: n=20, *M. raddei*: n=5) along the cliffs and their stone slides, as well as in patches of rock/alpine grass, near Karakurt and within 20 km of Kağizman. Both species were detected virtually in the same habitat along the south-exposed slopes north-east of Kağizman, but separated by a 6.7 km straight-line distance at Günindi (Fig. 7). The gap declined to only 3.5 km with the inclusion of one reliable observation of *M. wagneri* by a local shepherd (positive photo identification on our questionnaire sheet). This area constitutes the potential contact zone between these rock vipers on the northern side of the Aras Valley. The upper stretch of Günindi Valley contains a small stream, which divides the 40 km long continuous slope/cliff between the village Şabanköy and the Armenian border into an eastern (*raddei*) and western (*wagneri*) segment. Locals on either side of the "Günindi Stream" have corroborated this division by pointing on our questionnaire sheet only to the rock viper species occurring on their side of the stream. The eastern (*raddei*) and western (*wagneri*) cliffs come close to each other near Günindi, where the interjacent valley and both cliffs deviate north, forming a 3 km long canyon as far as to the village Keşişkiran (Fig. 7). At that village, the large cliffs/slopes end and change into less steep slopes and a plateau > 2200 m asl., a habitat less suitable for either *Montivipera* species. Already the cliffs/slopes in "Günindi canyon" are rarely south-exposed, and thus, will receive less direct solar radiation compared to the principal slopes of the Aras Valley, where both *Montivipera* spp. yield strong populations in essentially the same habitat. In particular the *raddei*-cliff in "Günindi canyon" is mostly north-exposed, and thus, maintains a cooler climate for a longer period in the winter through spring, which is well visible by the snow covered slopes on GE-satellite images taken on 21 December 2010 and 17 March 2009, whereas the *wagneri*-side in Günindi canyon is mostly snow free.

Even though, the "Günindi canyon" may lack optimal habitat for *Montivipera* spp., there are sufficient rock slides and piles to provide at least temporarily (e.g., during summer and fall months) some habitat. The shallow stream at the entrance of the canyon is only 1-5 m wide, and thus, unlikely poses a barrier for any exchange between these taxa. On the contrary, the confirmed distance down to a few kilometres between both *Montivipera* spp. is likely within the reach of moving/migrating specimens during the period of a single generation. However, other landscape factors possibly decrease the habitat quality in this area. For example, the slopes below the cliffs consist predominantly of finely eroded mineral soil (e.g., sand and gravel) across a straight distance of approximately 8.7 km between Kuruyayla and Günindi, and thus includes the potential contact zone. In addition, important rockslides are less frequent in that zone than in adjacent areas (Fig. 8C). The finding of the boid *Eryx jaculus* (Fig. 8D), a sand specialist, in this habitat corroborates the significant mineral soil component. The sandy slopes provide less stability to important subterranean burrow systems (for daily shelter, hibernation, prey) and decreases vegetation growth than the more stable organic soil, which can be found adjacent to this putative contact zone at Günindi-Kuruyayla, and where the two viper species are common.

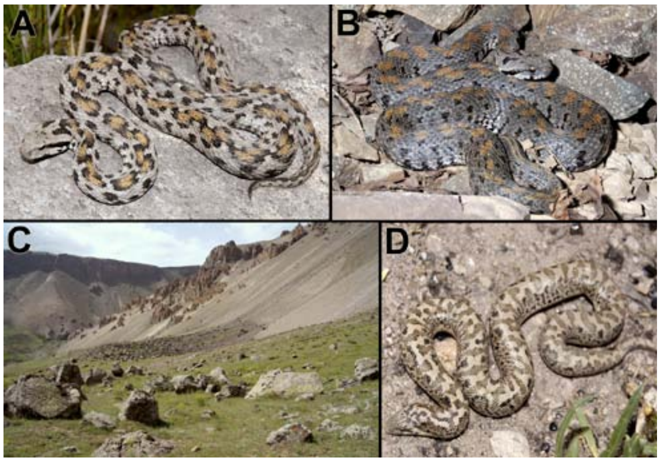


Figure 8. Rock vipers from sites near the putative *Montivipera* contact zone at Günindi, Kars Province; (A) *M. wagneri* and (B) *M. raddei*, (C) habitat at the contact zone with sandy slopes (see text), and (D) Sand Boa *Eryx jaculus* from this site, an indicator species for loose, sandy soil.

It needs further on-site investigations to evaluate how significant the perceived correlation "soil type-viper presence" is, and whether the mineral (sandy) soil poses an incomplete barrier for individuals of both species to migrate between their respective populations. Even though the putative contact zone may not be impossible to inhabit by either species, the entire zone of mineral soil of 8–9 km length may represents a density trough, i.e., that specimens of either species may migrate into that zone and live in sympatry and syntopy, but density is so low that neither species can build up a large population that would promote individuals to migrate into adjacent areas where only the other *Montivipera* species is present (on opposite sides of the potential contact zone). Hence, migration of any *Montivipera* species into the range/population of its related species would be countered by the neighbouring species' dominance (higher number of individuals), and provoke a competitive scenario or genetic swamping, if hybridization occurs.

Region 5: *Macrovipera lebetina* from its northern periphery in Turkey (Fig. 9)

The Blunt-nosed Viper is known only from a single record in Artvin Province, the most north-eastern province in Turkey (Ardanuç; Basoglu & Baran, 1980, see approximate location C in Fig. 9). We have compiled information on four new observations of *M. lebetina* in Artvin Province, which are:

1. We collected one exuvia of *M. lebetina* and observed one specimen (escaped) at 270 m asl. across Serender Tatil Köyü on the right hand slope downstream of Coruh River on 4. July 2013 (location B in Fig. 9; 41°14'33.96"N, 41°47'8.97"E).
2. Approximately 4 km north of our record, a video document by Ömer Altuntas (http://www.youtube.com/watch?v=uYkEmWQWKRo) clearly shows a *M. lebetina*. This observation was recorded in 2009 above the Coruh River near Irsa (Erenler) according to the author. We provisionally set the location at ca. 340 m asl. along a paved curve 11 km north of the city Artvin, fitting the scenes in the video clip. This record currently represents the most northern for this species in Turkey (approximate location A in Fig. 9).
3. An independent Dutch team found a killed *M. lebetina* on 30.05.2013 along Berta River ca. 12 km north of the town Ardanuç (location D in Fig. 9; 41°13'50.17"N, 42° 5'35.10"E).
4. One previously unpublished record of *M. lebetina* (DOR) at Yusufeli, Artvin by Göran Nilson, on 28.05.1989 (pers. comm. and location E in Fig. 9; 40°48'37.50"N, 41°34'9.90"E)

These observations indicate, that *M. lebetina* likely expanded via the Coruh Valley to its current northern limit near Borçka. The most northern extent of *M. lebetina* in Turkey is not known precisely, but they are likely to be found along the slopes of the Coruh Valley within 10 km south of Borçka. Whereas the construction of the hydropower plant at Borçka and the subsequent flooding of the Coruh River presumably has killed a large number of specimens of *M. lebetina*, the subsequent construction of the shore road generated new rock slides and large dry walls supporting the road. These structures probably produced new habitat along the river and so provide a potential corridor for *M. lebetina* to expand north toward Borçka. According to satellite images, the small ridge villages Ibrikil and Adagül south of Borçka appear to provide the last arid patches and south-exposed rocky outcrops, viewed as a suitable habitat for local *M. lebetina*. The area around Borçka is in the midst of a habitat transition with a humidity gradient across a few km only, and correspondingly, different viper species associated with it, ranging from dry (*M. lebetina*) to moderate humid (*V. ammodytes*) to humid (*V. kaznakovi*).

CONCLUSIONS

During three field expeditions, we have substantially reduced the distances between closely related viper species by mostly more than 50%, and in the case of *M. raddei* and *M. wagneri* determined one putative contact zone. However, in order to verify contact and mixed populations between closely related

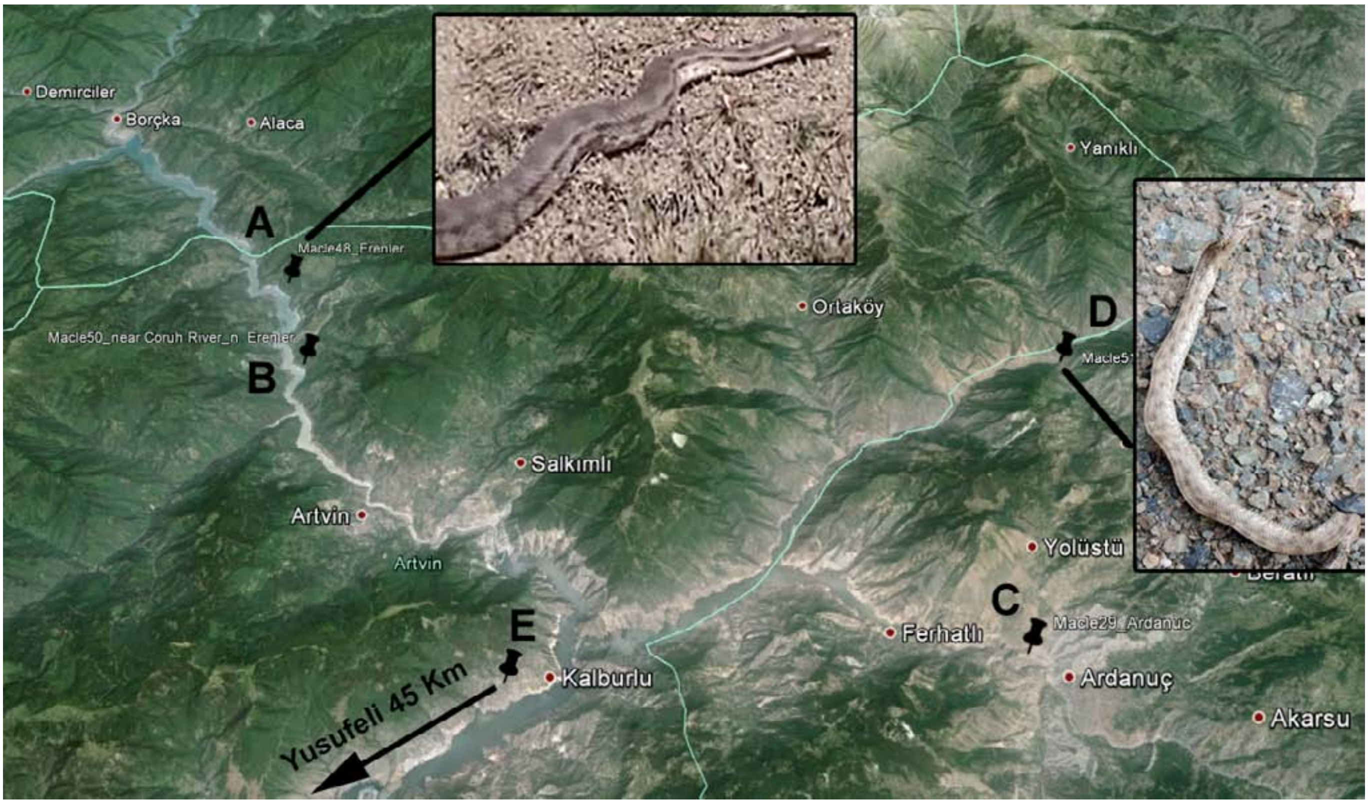


Figure 9. *Macrovipera lebetina* records from Province Artvin (see text for available coordinates and more information on the sources): (A) with an image of a specimen crossing a road near Eneler, District Artvin, by Ömer Altuntas; (B) our observations above Coruh River, District Artvin; (C) Ardanuç (Basoglu & Baran 1980); (D) killed specimen, Berta River, District Ardanuç, coordinate and photo provided by Ronald Laan, Klooiplek; (E) DOR from Yusufeli (not on map) by Göran Nilson (pers. comm.).

taxa, all defined regions should be visited again, possibly partitioned into regional and local study sites of a few square kilometres, in order to evaluate habitat segregation and/or potential hybridization.

Moreover, tissues from all sampled vipers are currently stored and await further additions before a genetic analysis will be conducted. Based on the new observations and further sampling, habitat distribution models could be considered in order to improve the distribution knowledge and ecological divergence of the different viper species. Although we are not at this level yet, we have steadily worked to approach this goal by sampling distributional, genetic, morphological, and ecological data. We have planed to continue this research and hope to acquire sufficient data in the near future to provide ample means for concrete and effective conservation purposes and specific action plans, i.e., such as the range limits of threatened taxa, their population densities, a clarification which taxa do constitute clear independent species (and deserve preferred conservation assessment), and which are their relevant environmental correlates. Finally, we look forward to further collaborative research with Turkish and international researchers. Once accomplished, the results will be available to conservation entities, including Turkish national park authorities, NGOs, academics, to generate public awareness and improve tools for the conservation of these valuable species.

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Statement on Conservation Issues: Publishing new viper locations in Turkey has been a contentious issue, as such information could facilitate the search for vipers by potential animal smugglers and dealers in order to supply the illegal pet trade. Furthermore, wildlife tourism for trophies (mainly photographs) has been increasing for years, but with negligible impact on local populations. However, the recent discussion held during the "The 4th Biology of the Vipers" conference in Athens on Oct. 2014 organised by the VSG (Viper Specialist Group of the SSC-IUCN) suggested that the threat status for Turkish vipers, as stated in the current IUCN Red Lists, is exaggerated and not justified and thus requires a complete update. Indeed, our expanded data set shows that most viper species are significantly more common and widespread in Turkey than stated in the Red Lists. After several years of research on vipers in Turkey by us, combined with our extensive field experience and knowledge of the biology of vipers from other countries, we have no grounds to consider densities of Turkish vipers being any different from other "healthy" viper populations in comparable mountain ranges (e.g., Alps, Balkan Peninsula). Numerous requests among persons with extended knowledge on Turkish vipers in the pet trade have not uncovered any explicit and recent commercial offers of wild caught vipers from Turkey, and by far most, if not all Turkish vipers in the market originated from the breeding of captive specimens. The occasional report of viper smuggling out of Turkey is either erroneous or relates to very few specimens, irrelevant for the conservation of Turkish viper populations. Nonetheless, we would like to promote the respect of Turkey's natural assets and state that collecting Turkish vipers is strictly forbidden and such illegal action will be prosecuted. In the context of publishing new locations, we perceive this as not problematic, as sampling at sites with low viper densities is non-profitable (large search effort for little success), a sufficient deterrent for illegal collectors, whereas sites with extensive habitats and large populations of vipers are robust enough to sustain limited impact by man. Yet we encourage projects to prevent biosmuggling with the participation of authorities and local people wherever such actions are required.

Based on our experience and studies with vipers in Western and Central Europe, we conclude that the biggest threat for Turkish vipers results mainly from man-made habitat degradation, including dam construction, overgrazing, plantation and intensive agriculture. We therefore suggest to conduct, publish and promote studies of wild Turkish viper populations after taking necessary permissions from The General Directorate of Nature Conservation and Natural Parks of Turkey. Such studies should result in relevant information on the species habitat requirements. By so, we hope to provide with our studies essential knowledge for the development of specific conservation plans for Turkish vipers and public education.

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