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Conservation Activities for Mountain Viper, Montivipera albizona (Nilson, Andrén and Flärdh, 1990) in Anatolia, Turkey

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Abstract. The Mountain viper, *Montivipera albizona*, is an endemic to Anatolia and distributes in Anatolian Diagonal, Anti-Taurus Mountains and Amanos Mountains. Unfortunately, the species faced serious threats within narrow distribution range. Here, we evaluated the present status and main threats of the Mountain viper by 60-days intensive fieldwork and interviews with locals. According to our data, the Mountain viper prefers the rocky and those mountainous and rugged areas covered with less vegetation and they are active from the beginning of April to end of November. In spring, it is possible to observe 1 to 5 individuals in the suitable habitats depending on its density. We prepared 5-year Action Plan for Turkish General Directorate of Nature Conservation and National Parks and planned the roadmap for sustainability of the species with participation of regional administration, NGOs, and locals. We found that agricultural activities, overgrazing, road constructions, quarries, pet trade, sportive hunting, deliberate or accidental killing, and climatic change are the main threats on the Mountain viper in Anatolia. The main conservation measures include: creating some protected habitats in the high viper density regions, long-term monitoring survey to obtain data on its ecology and population trends, education and awareness raising activities among locals to prevent illegal collection/killing of the vipers.

Key words: Mountain viper, biology, conservation, reptiles, research, Anatolia.

Introduction

Reptiles contain more than 10,000 species (UETZ *et al.*, 2018) and are an important part of natural ecosystems and as the indicator of environmental quality. The group is threatened by habitat loss and destruction, introduced invasive species, environmental pollution, disease, unsustainable use, and global climate change (ALFORD & RICHARDS, 1999; GIBBONS *et al.*, 2000). Especially human-induced habitat loss and harvesting are the predominant threats to reptiles (BÖHM *et al.*, 2013).

Anatolia hosts approximately 15 viper species which belong to three genera (*Vipera*,

Macrovipera, *Montivipera*) (MALLOW *et al.*, 2003; BARAN *et al.*, 2012; UETZ *et al.*, 2018). The mountain viper genus *Montivipera* (NILSON *et al.*, 1990) contains eight valid species (*Montivipera albizona, M. bornmuelleri, M. bulgardaghica, M. kuhrangica, M. latifii, M. raddei, M. wagneri*, and *M. xanthina*, STÜMPEL *et al.*, 2016; UETZ *et al.*, 2018) and adapted to the high mountain ecosystems in Near and Middle East. The genus hosts some rare and narrow distributed species (*M. albizona, M. raddei, M. wagneri*, and *M. xanthina*) in Anatolia.

Among them the mountain viper, *Montivipera albizona* (NILSON *et al.*, 1990) was first described in Kulmaç Mountains which is formed by southeastern Sivas Province located in Tecer Mountains' arc towards north east through Sivas and Kangal (NILSON *et al.*, 1990). The species are only known from mountain ranges Anatolian Diagonal and cities of Sivas, Kayseri, Tunceli, Erzincan, Kahramanmaraş and Hatay, classified as Endangered (EN) according to the IUCN Red List, and its population tends to decrease (TOK *et al.*, 2009) and listed in the Bern Convention (Appendix III - Protected fauna species). In this study, we evaluated the distribution, population status, phenology and potential threats of Mountain viper in province of Sivas (Anatolia, Turkey). Furthermore, during the field work interviews with locals were conducted in order to learn their thoughts regarding the species. In order to conserve the species population and its habitats, we prepared 5 years conservation action plan according to literature data, field observations and interviews with the locals.

Material and Methods

Study Area. Sivas Province is geographically located at the intersection of Central Anatolia, Eastern Anatolia and Black Sea regions. It has a total surface area of 28.488 km² and divided into 17 districts (Akıncılar, Altınyayla, Divriği, Doğanşar, Gemerek, Gölova, Gürün, Hafik, İmranlı, Kangal, Koyulhisar, Merkez, Suşehri, Şarkışla, Ulaş, Yıldızeli, Zara).

The climate is a dry-summer continental climate (Köppen climate classification: Dsb), with warm and dry summers and cold and snowy winters (PEEL *et al.*, 2007). However, the north of the city (the districts of Suşehri, Akıncılar, Gölova, Koyulhisar, Doğanşar, and in the northern part of Zara) is similar to Black Sea and has oceanic climate with high and evenly distributed rainfall the year round (SK, 2018).

Fieldwork. In order to obtain information regarding the distribution, habitat preference, behavior, life cycle and population condition of the species in Sivas Province, we conducted field work in May-September for total 60 days by a 1 or 2 people teams.

Location information (coordinates and altitudes) of the places that species were observed is recorded by using Garmin GPSMAP 62s and a detailed distribution map is formed. We calculated relative density of *M. albizona* by using catch-per-unit-effort (CPUE) indices (RODDA, 2012) [dividing the number of the vipers captured by the effort expended] in three locations [(1) Gürün, (1) Kangal, (1) Ulaş] and searched for the snakes on 20 m x 2 km length routes. Each route was sampled four times by a team of two people between 09:00 and 18:00 hrs. in May - June 2017. We avoided indicating exact location due to illegal trade activities. The method may overestimate true abundance and reduce the capacity to detect both presence and severity of a population decline. However, the obtained data could provide a preliminary basis for detecting relative trends in the Mountain viper.

Ecological Niche Modelling. We compiled occurrence localities from available literature (NILSON *et al.*, 1990; TYNIE, 1991; MULDER, 1994; 1995; GÖÇMEN *et al.*, 2009; 2014, STÜMPEL *et al.*, 2016) and our own field data. Many authors did not indicate an exact locality data in case of avoiding international pet trade. The locality information with no coordinate data was obtained by using Google Earth ver. 7.1.2 (Google Inc.).

All records were georeferenced into WGS-84 coordinate system and checked with ArcGIS (v10, ESRI). To minimize sampling bias which could otherwise result in inaccurate projections and overestimated predictive power (MEROW *et al.*, 2013) and reduce spatial autocorrelation (BORIA *et al.*, 2014; FOURCADE *et al.*, 2014) we draw a 25 km buffer area each occurrence record and thinned a total of 34 records to 22 localities for ecological niche modelling.

We used 19 bioclimatic variables as predictor variables for the current distribution. The bioclimatic variables were obtained from the WorldClim data base (HIJMANS *et al.*, 2005, worldclim.org) at the spatial resolution of 30 arc seconds (approx. 1 km), which derived from monthly temperature and rainfall data as averages of the period 1950–2000. The bioclimatic variables for 2050 (average for 2041-2060) and 2070 (average for 2061-2080) at a spatial resolution of 30 arc-seconds (WorldClim 1.4, worldclim.org), which are projected according to intermediate (the representative concentration pathways, RCP4.5) and the worst (RCP8.5) emission scenario, used for predicting future distribution pattern of the species. The data set of "Hadley Global Environment Model 2 – Earth System", developed within the scope of the 5th Coupled Model Intercomparison Project (CMIP5) by the Met Office Hadley Centre (UK, metoffice.gov.uk), is preferred. We buffered the climatic variables by 0.5 degrees using minimum convex polygon representing the study area.

To reduce the negative effect that might result from multicollinearity among the bioclimatic variables (HEIKKINEN *et al.*, 2006; DORMANN *et al.*, 2013), we removed some highly intercorrelated ($r > 0.9$ or < -0.9) variables with a pairwise Pearson correlation and selected a subset of the bioclimatic variables based on the ecological requirements of the species. We chose 4 environmental variables [BIO1 - Annual Mean Temperature, BIO15 - Precipitation Seasonality (Coefficient of Variation), BIO17 - Precipitation of Driest Quarter, BIO19 - Precipitation of Coldest Quarter] that underlay the current distribution model for the species.

We modelled the geographic distribution of the Mountain viper under present (1950-2000) and future (2050, 2070) bioclimatic conditions using maximum entropy modelling with MAXENT 3.4.1 (PHILLIPS *et al.*, 2018). The MAXENT algorithm, which is among the most effective methods of ecological niche modelling (ELITH *et al.*, 2006), estimates the potential distributions of species from occurrence data by finding the probability distribution of the maximum entropy (i.e. closest to uniform) subject to the constraint that the expected value of each of a set of features (environmental variables or functions thereof) under this estimated distribution closely matches its empirical average (PHILLIPS *et al.*, 2006; PHILLIPS & DUDÍK, 2008).

We performed ENMeval (MUSCARELLA *et al.*, 2014) for optimizing model complexity to balance goodness-of-fit and predictive ability. We chose randomly selected background (pseudo-absences) approach (PHILLIPS *et al.*, 2006), and k-1 jackknife method when working with relatively small data sets (PEARSON *et al.*, 2007; SHCHEGLOVITOVA & ANDERSON, 2013). We built models with regularization multiplier values ranging from 0.5 to 10 (increments of 0.5) and with six different feature classes combinations (L, LQ, H, LQH, LQHP; where L - linear, Q - quadratic, H - hinge, P - product and T - threshold) and this resulted in 100 individual model runs. We applied the 10-percentile training presence logistic threshold approach as recommended by LIU *et al.* (2005), and the clog-log output was transformed into a continuous map of the presence-absence distribution. The clog-log outputs represent the habitat suitability between from 0 (unsuitable) to 1 (suitable).

Model accuracy was evaluated from four evaluation metrics by ENMeval (MUSCARELLA *et al.*, 2014) in R vers. 3.5.2: the area under the curve of the receiver–

operating characteristic plot for test localities (AUC_{TEST}) (HANLEY & MCNEIL, 1982; PETERSON *et al.*, 2011), the difference between training and testing AUC (AUC_{DIFF}) (WARREN & SEIFERT, 2011), OR_{10} (10% training omission rate) for test localities (FIELDING & BELL, 1997; PETERSON *et al.*, 2011) and the Akaike information criterion corrected for small sample sizes (AICc) (BURNHAM & ANDERSON, 2004; WARREN & SEIFERT, 2011). We used Wallace v1.0.6.1 modular platform (KASS *et al.*, 2018) in R vers. 3.5.2 for preparing and analyzing of species distributions. The results were imported and visualized with ArcGIS v10.0.

Conservation Action Plan. Throughout our fieldwork, we conducted interviews with hunters, shepherds, beekeepers, farmers and officers. We obtained knowledge (life cycle, phenology) and opinions of locals about the species and we tried to confirm their validity during fieldwork. Fieldwork, interview with the locals and literature data on species were used to form a draft of conservation action plan (CAP). We followed Open Standards methodology (2013, cmp-openstandards.org), used threats classification (ver. 2.0) for threats and actions classification (ver. 2.0) keys. CAP draft was finalized in a workshop at 27-28 September 2017 after obtaining feedbacks from stakeholders.

Results

Field studies showed that species live in various habitats in seven districts of Sivas Province: Divriği, Gemerek, Gürün, Kangal, Ulaş, Yıldızeli and Zara (Fig. 1). Interview with the locals also indicated the presence of species in Altınyayla, İmranlı and Şarkışla. The mountain vipers were observed especially in areas with lesser vegetation and rocky hillsides with higher sun penetration. The species mostly prefer sloped valleys at higher altitude and its vertical distribution ranges between 1300 – 2200 m a.s.l. In the regions that species were observed (Fig. 1B, C, D), specimens mostly found in dry rugged hillsides that also inhabits thorny *Astragalus sp.* communities and pile of rocks and the grass and tragacanth on the valley plains (Fig. 1). Possibly, vertical migrations into *Astragalus* sp. communities, rock piles and humid vegetations at lower altitudes provides optimization of body temperature for long durations in the active period and even helps survival in the harsh weather conditions.

During our field studies, it was noted that temperature changes throughout the day makes individual of species take advantage of the shadows of tragacanths that are present in the rocky areas with high steppe vegetation and the grassy fields which is formed by the water accumulated in valley plains (Fig. 1A). It was observed that grasshoppers, lizards (*Ophisops elegans, Parvilacerta parva, Trachylepis vittata*) and small mammalian species (*Spermophilus xanthoprymnus*, *Microtus* sp.) also densely inhabit these areas. Also, *Eirenis modestus*, *Dolichophis schmidti*, *Macrovipera lebetina* and *Vipera transcaucasiana* shares the same habitat. In the regions where the species occurs, farming and husbandry activities are present and also some predatory birds and wild animals might have some influence on the mountain vipers in between rock piles and tragacanth communities. Depending the climate conditions, the mountain vipers are active from April to end of November in Sivas Province. More active periods are mating period in spring and the end of hibernation. They are more frequently observed in mornings and the evenings, especially between July and September. Its relative abundance ranged 1-5 snakes in suitable habitats.

The niche model indicates the primary factors affecting the distribution of the species are annual mean temperature (BIO1, 35.3%), precipitation of coldest quarter (BIO19, 27.2%), precipitation seasonality (BIO15, 23%), precipitation of driest quarter (BIO17, 14.5%). In the future projected models for 2050 and 2070, the suitable habitats of the vipers in the distributional range will decrease and that there will be a decrease in the southern and eastern distributional boundaries in particular (Fig. 2).

Threats and conservation actions. Sheep and goat herds in the species' habitat is are highly frequent. The situation creates high levels of grazing pressure in the environment. Hunting sports are practiced frequently in Sivas Province. Hunters from neighboring districts come to Sivas Province for partridge, quail and rabbit hunting. Flashlight hunting in the nights puts all the animals in the habitat under stress.

Especially in the spring months, contact between species and local people (farmers, beekeepers and shepherds) occurs in the species' habitat. Locals kill the species intentionally or accidentally because they think species is poisonous or they are afraid. During the interviews, it was found that shepherds kill 3-10 individuals in a year. Furthermore, species' habitat is destroyed and segregated because of the road constructions and stone pit activities. Construction activities affect the species directly by habitat loss and indirectly by habitat segregation. The species attracts herpers, pet traders and scientist since they have spellbinding patterns and are endemic to Anatolia. Collecting the species from their habitats also cause the individual loss in the population.

The mountain viper is mainly threatened by agricultural activities, overgrazing, road constructions and quarries, pet trade, sportive hunting, deliberate or accidental killing by locals, and climate change (Table 1, Fig. 3).

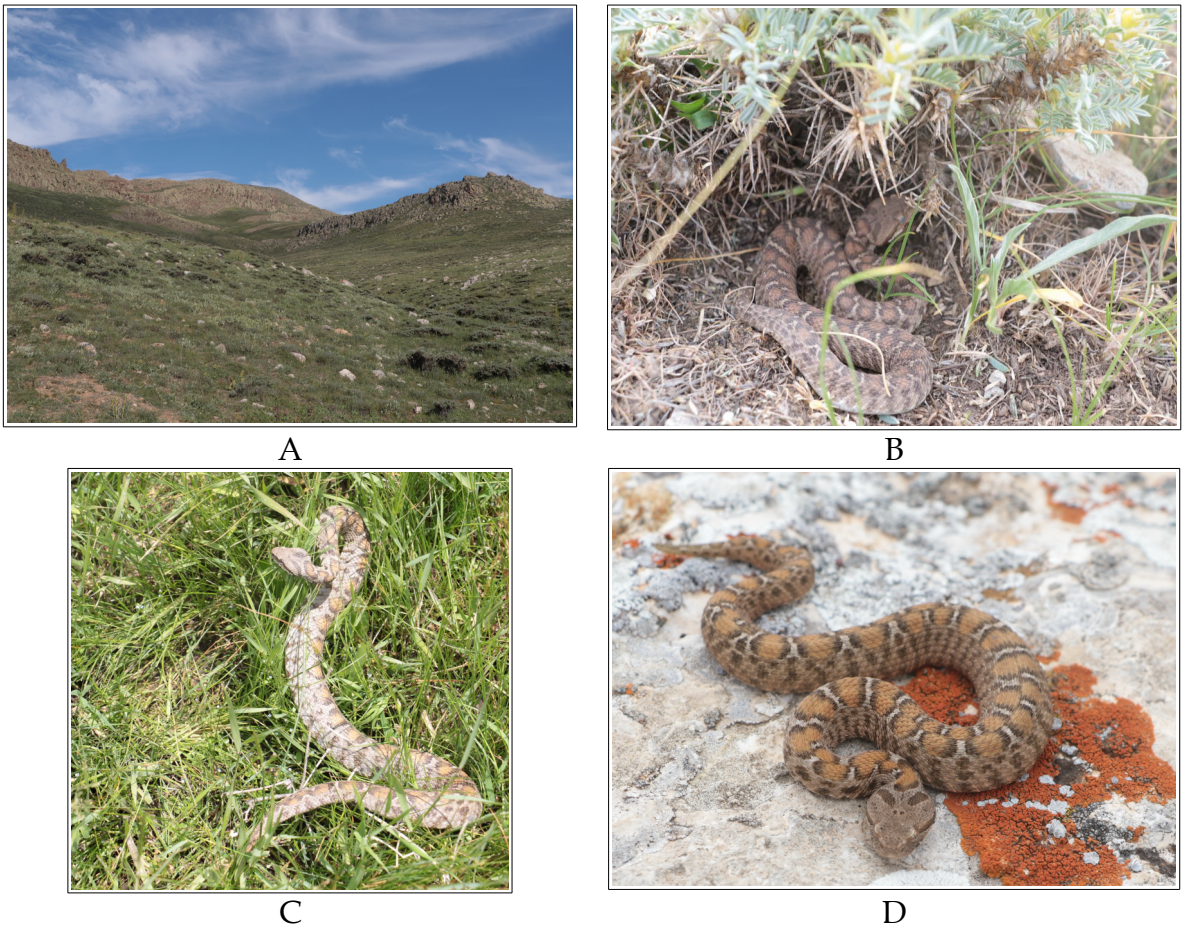

Fig. 1. The general view of habitat (A) and detected individuals (B,C,D) in Sivas Province.

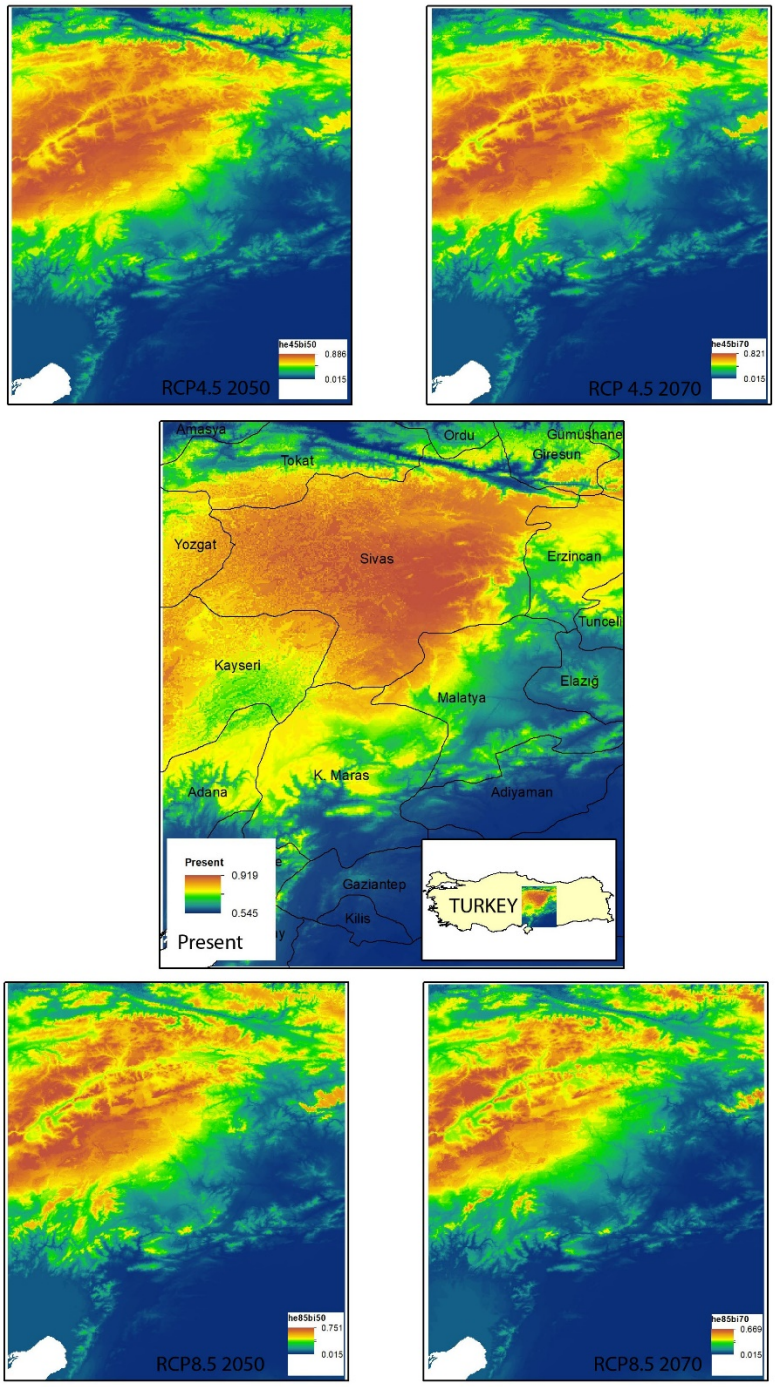

Fig. 2. Current and potential distribution of the Mountain viper (*Montivipera albizona*) in Anatolia. The current and future (2050, 2070) potential distribution model of the Mountain viper in Anatolia. Probability of presences increases from blue to red..

We planned some activities about land/water protection, species management, awareness raising, law enforcement and prosecution, conservation designation and planning, research and monitoring, education and training, and institutional development.

We determined that creating some protected habitats in the high viper density regions, long-term monitoring survey to obtain data on its ecology and population trends, education and awareness raising activities among locals to prevent illegal collection/killing of the vipers are main conservation measures for sustainability of the Mountain viper (Table 2).

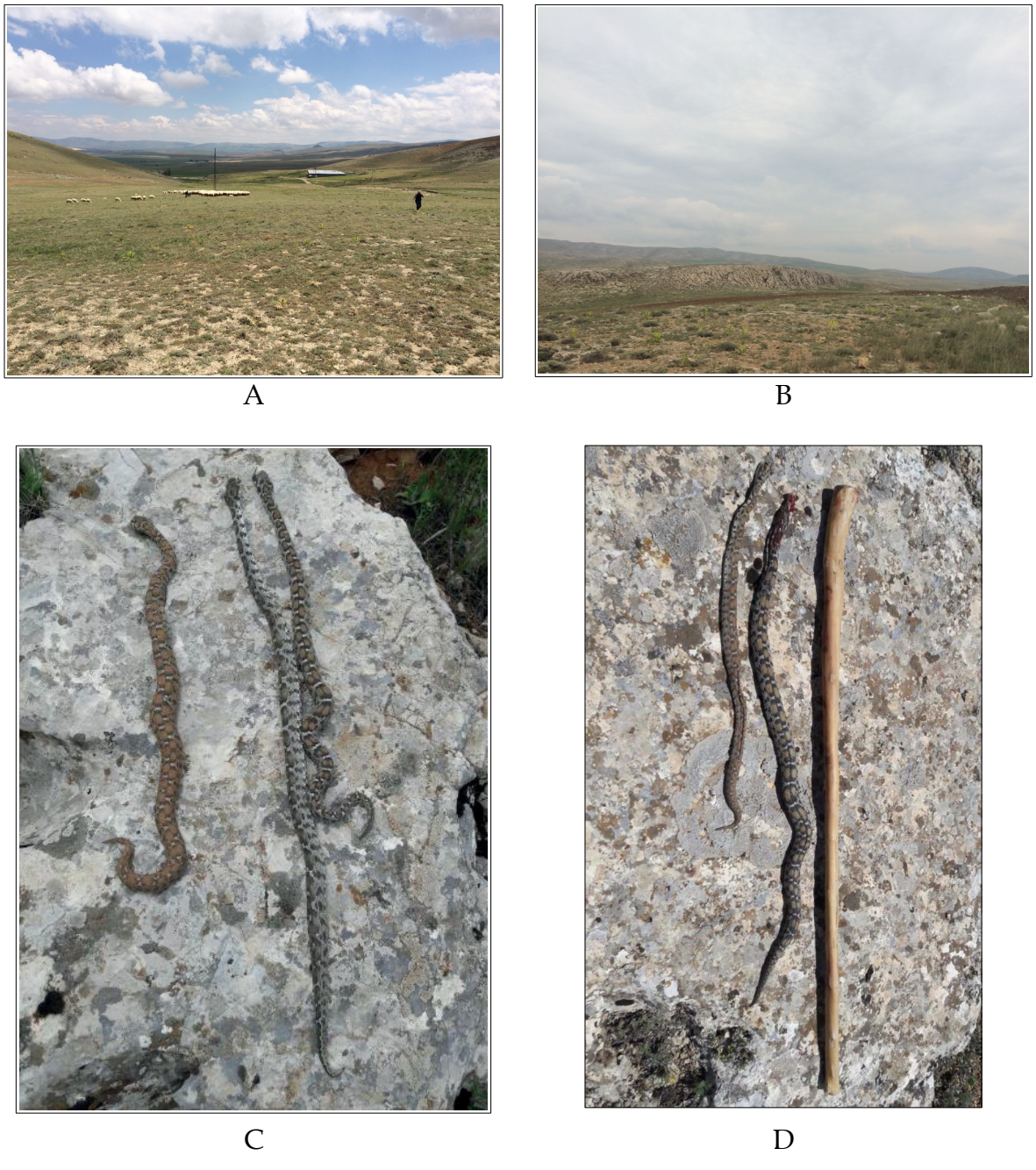

Fig. 3. Some potential threats of the Mountain viper from Sivas.
A: Overgrazing activities, B: Agricultural activities,
C, D: Deliberate or accidental killed vipers.

Table 1. The major threats for the Mountain viper (*Montivipera albizona*) in Sivas Province.

Major Threat	Reasons	Level
Agriculture and Aquaculture		
Annual and Perennial Non-Timber Crops	Intensive agricultural activities	High
Livestock Farming and Ranching	Overgrazing	High
Energy Production and Mining		
Mining and Quarrying	Road constructions, quarrying	High
Biological Resource Use		
Hunting and Collecting Terrestrial Animals	Poaching for pet, and hobbyist, scientific collection, Deliberate or accidental killing by locals	High
Climate Change		
Changes in Temperature Regimes	Changing phenology	Unknown
Changes in Precipitation and Hydrological Regimes	Changing phenology	Unknown

Table 2. The implementation of the conservation action plan for the Mountain viper (*Montivipera albizona*) in Sivas Province.

Actions	Priority	Responsible Agencies, Organizations and Individuals
Land/water protection		
Site/area protection Controlling some key viper habitats and not allowed grazing and hunting activities in these areas.	Critical	Forestry, Agricultural, Governorship offices, law enforcers, mukhtars.
Species Management		
Species Stewardship • The distribution maps of the species should be shared with the relevant governmental organizations for use in planning in road, quarry and infrastructure works due to reducing damage of the viper habitats. • Taking to consider the viper conservation in other the wildlife management plans.	High	Forestry, Agricultural, Water affairs, Governorship offices.
Ex-Situ Conservation • Providing two couple of vipers to some national zoos that can provide the necessary conditions of the species	High	Zoos, Universities.
Awareness Raising		
Outreach & Communications • Prevention of illegal agricultural land opening activities in the viper habitats. • Carry out awareness studies on the use of incorrect pesticides and fertilizers. • Opening of exhibitions and stand at the festivals in Sivas Province.	High	Forestry, Agricultural, Governorship, Education offices, schools.
Law Enforcement and Prosecution		
Detection and Arrest • Reducing illegal collection of the vipers and boosting of inspections for bio-smuggling.	Critical	Ministry of Foreign Affairs, Customs Office, Governorship.
Non-Criminal Legal Action • Unless the justification is well explained, the viper collection is not allowed in the natural environment for scientific purpose.	High	GDNCNP, Universities.

• Encouraging in-situ scientific studies in the ecology and biology of the species.		
Conservation Designation and Planning		
Protected Area Designation and/or Acquisition		
• Establishing protected areas in key habitats for the viper after evaluating the viper monitoring study results.	High	GDNCNP, Universities.
Site Infrastructure		
• With the help of rangers, mukhtars, shepherds, beekeepers and expert personnel, the creation of inventory by recording the deaths of the vipers for the road or other reasons within the year. • With the help of rangers, mukhtars, NGOs and locals, the creation of information sharing network on the detection of points where species are observed.	Medium	GDNCNP, Universities.
Research and Monitoring		
Basic Research and Status Monitoring		
• Conducting research or analysis on ecology and biology of the vipers. • Monitoring the population trend of the species over the years.	Critical	GDNCNP, Universities.
Education and Training		
Formal Education		
• In order to promote the viper and to increase the awareness of protection; preparing educational material for primary and secondary schools in Sivas Province, providing information about the subject and raising awareness. • Education and information about of officers, gendarmes, customshouse guards, forestry rangers against bio-smuggling.	High	GDNCNP, Forestry, Agricultural, Governorship. Education offices, universities, schools.
Training and Individual Capacity Development		
• Information the locals in the region, especially the mukhtars, the shepherds and the beekeepers on criminal penalties, prohibition of killing of species. • Providing information about the importance of the species to the locals and carrying out information activities against bio-smuggling (posters, brochures, one-to-one training etc.).	High	GDNCNP, Universities.
Institutional Development		
Internal Organizational Management and Administration		
• Kayseri, Tunceli, Erzincan, Kahramanmaraş and Hatay where species are distributed should be informed and encouraged to implement the plan activities • Organizing a workshop with all stakeholders in 2022 for the revision of the conservation action plan	High	GDNCNP

Discussion

The Mountain viper, *Montivipera albizona*, is distributed in suitable habitats of mountain range in south east of Anatolian diagonal and lives higher altitudes of north arm of the Middle Toros Mountains, Anti Toros Mountains, and Amanos Mountains in the south (NILSON *et al.*, 1990; TYNIE, 1991; MULDER, 1994; 1995; GÖÇMEN *et al.*, 2009; 2014).

The species especially prefer rocky regions enclosed by grass and bushes and is active in Sivas Region from April to November in suitable weather conditions. Researchers that study the species detect it in various region in the Anadolu diagonal mountain chains in Sivas Province. However, exact localities are not present in the literature in order to prevent harms that might be caused by snake collectors (NILSON *et al.*, 1990; TYNIE, 1991; MULDER, 1994; 1995).

It is already known that climate changes in glacial and inter glacial periods affected the geographical distribution of species. Thus, like many species, mountain vipers also experienced enlarging and narrowing of

suitable habitats for their ecological niche in parallel with climate changes. It is highly possible that the species in the same group, *Montivipera wagneri* lived in northeastern end of Anatolian diagonal, *Montivipera bulgardaghica* lived in southeast Mediterranean end and *Montivipera albizona* lived in the region between Anti-Taurus Mountains and northeastern Anatolia Mountains. Then, increase in the disadvantageous conditions might have narrowed down their habitat areas to the distribution areas of today. Some of the main threats against the mountain vipers are collection for scientific purposes and intentional/unintentional killing by the local population (TOK *et al.*, 2009)

Vipers are among snakes the most misunderstood and persecuted groups, while they are threatened by extinction due to their low fecundity and slow growth rate (MARTIZ *et al.*, 2016). The most important threats for vipers are habitat loss, degradation, and fragmentation (GIBBONS *et al.*, 2000; DIRZO & RAVEN, 2003; WALDRON *et al.*, 2006; FISCHER & LINDENMAYER, 2007; TUNIEV & TUNIEV, 2009; MADSEN & UJVARI, 2011; MARTIZ *et al.*, 2016).

International trade of viper species is a global phenomenon and its effects on the wild population still not known (IUCN, 2015; MARTIZ *et al.*, 2016). Furthermore, climate changes cause some viper species under extinction risk (MARTIZ *et al.*, 2016). Change in the climate might affect immune system functionality (KOBOLKUTI *et al.*, 2012), alter life-history traits (e.g. ALTWEGG *et al.*, 2005), trigger phenological changes (RUGIERO *et al.*, 2013), negatively impact the populations (BRITO *et al.*, 2011; LE GALLIARD *et al.*, 2012), and narrow their geographical ranges (e.g., BOMBI *et al.*, 2011; DAVIS *et al.*, 2015). The distribution of the Mountain viper could be narrowed from southern direction in particular. Besides, its life-history traits, phenology and population structure and fluctuation might be dependent on climate changes.

There have been few efforts to conserve endangered viper species worldwide (MARTIZ *et al.*, 2016). Fortunately, Turkish National Parks have been prepared conservation action plans for three endangered viper species in Anatolia up to now: *Vipera kaznakovi*, *V. anatolia*, and *M. albizona*. The Mountain viper is suffering from habitat loss and destruction, persecution, international pet trade, and climatic change. The creating some protected habitats in the high viper density regions, long-term monitoring survey to obtain data on its ecology and population trends, education and awareness raising activities among locals to prevent illegal collection/killing of the vipers are main possible mitigation measures for sustainability of the vipers.

Acknowledgements

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