

Action Plan for the Conservation of Endemic Anatolian Meadow Viper, *Vipera anatolica* Eiselt & Baran, 1970 in Southwestern Anatolia

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ABSTRACT

The Anatolian viper, *Vipera anatolica* Eiselt & Baran, 1970, is the rarest, critically endangered, and endemic species in the western Taurus Mountains, Antalya, Turkey. Here, we evaluated the current status, potential threats, and recommended necessary conservation measures for Anatolian meadow viper. We created some activities during the 5-year species conservation action plan implemented by the General Directorate of Nature Conservation and National Parks. We conducted 70-days extensive fieldworks between May and October 2016–2017 for determining the distribution, habitat characteristics, phenology, and population status of the species in the province of Antalya. We also interviewed locals and surveyed potential threats of Anatolian meadow viper. We detected only 10 specimens in the territory of the Çıtlıkara cedar forest reserve at altitudes between 1800 and 2300 m and only two specimens in the territory of Geyik Mountains at altitudes between 1600 and 1900 m. We determined the potential threats like habitat loss and degradation, quarry (especially for senliki subspecies), global climate change, illegal collecting, and willingly or accidentally killing of vipers. Major precautions to protect the species were determined as: (1) to establish protected habitat patches in the species' known distribution and to prohibit entrance and grazing activities, (2) to create alternative new habitats for reintroduction, (3) to plan long-term monitoring survey to obtain data on its ecology and population trends, (4) to start a captive breeding program, (5) to educate and raise awareness among locals to prevent illegal collecting, willingly or/and accidentally killing of specimens for the sustainability of Anatolian meadow viper.

Keywords: Anatolia, ecology, species action plan, *Vipera anatolica*, viper conservation

Introduction

The Mediterranean basin is categorized as one of the global hotspots and considered affected by serious threats (Brooks et al., 2006; Çiçek & Cumhuriyet, 2017; Mittermeier et al., 1999; Myers et al., 2000). Mediterranean region of Turkey is positioned in the eastern part of the hotspot and exhibit one of the most irreplaceable biodiversity regions with many endemic species (Şekercioğlu et al., 2011), including that of amphibians and reptiles (Çiçek & Cumhuriyet, 2017). Anatolia is host to 19 endemic reptile species of which 10 of them are snakes (Ilgaz, 2019).

Apart from the original description of *Vipera anatolica* from Kohu Mountain in the western Taurus Mountains, Antalya province by Eiselt and Baran (1970), limited concrete records of the species have been encountered on an excursion from its type locality until 1987 (Billing, 1985; Eiselt & Baran, 1970; Sigg, 1987). Later, the species is listed as CR in the IUCN Red List due to its extent of occurrence is less than 100 km² (Tok et al., 2009). In the following period, no new localities were found from neighboring mountainous regions in western Antalya province by numerous herpetologists, and the specimens were encountered only by the known locality of this species till then (Franzen et al., 2008). Between 2013 and 2014, two groups of researchers were carried out field works to confirm the presence of *V. anatolica* in the vicinity of Kohu Mountain and rediscovered it in the type locality (Göçmen et al., 2014; Stümpel et al., 2015; Zinenko et al., 2016). The new population of *V. anatolica*

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was reported from the Geyik Mountain Range in eastern Antalya province and assigned as new subspecies, *V. a. senliki* (Göçmen et al., 2017). The locality is about 200 km east of the terra typica at Kohu Mountain in western Antalya Province, Turkey. Later, Mebert et al. (2017) also reported on a second population of the recently described *V. a. senliki* from Mühür Mountain, Geyik Mountains in eastern Antalya, and 10 km farther type locality of the subspecies. The results of these research were formed from the basic knowledge of population structure, dynamics, and main threats of the species. Stümpel et al. (2015) and Zinenko et al. (2016) also stressed the effect of human influence and recommended the establishment of a large enough protected area for it in Kohu Mountain. Moreover, Göçmen et al. (2017), which could for the firstly discovered specimens from the eastern Antalya range, proposed preparing an action plan for *V. anatolica*.

Here, we evaluated the current status, potential threats, and necessary conservation measures for Anatolian meadow viper and prepared the species conservation action plan implemented by the General Directorate of Nature Conservation and National Parks (GDNCNP).

Methods

Study Area

The province of Antalya is geographically located between 29° 20' – 32° 35' E longitudes and 36° 07'–37° 29' N latitudes at coast bordered by the Taurus Mountains, Antalya, southwest Anatolia. It is surrounded by the Taurus Mountains extending parallel to the Mediterranean Sea in the south and the north, neighboring Mersin, Konya, and Karaman provinces in the east, Isparta and Burdur provinces in the north, and Muğla province in the west. The area of the province has 77.8% mountainous, 10.2% plain, and 12% rugged structures (Kaman & Yavaş, 2014). The Taurus Mountains, which cover 3/4 of the province and are mostly composed of limestones, have many hills exceeding 2500–3000 m. Between 1.200 and 2.100 m elevation, there is a forest belt consisting of fir (*Abies cilicica*), scotch pine (*Pinus sylvestris*), beech (*Fagus sylvatica*), and various juniper (*Juniperus* spp.) species. Coniferous forests over 2000 m become sparse and stunted. This area ends at 2100–2300 m and passes to high grasslands that do not dry in the summer called alpine meadows. The province has a Mediterranean climate (Köppen: Csa) with hot and dry summers and mild and rainy winters (Peel et al., 2007). The annual average air temperature is 18.5°C, the average precipitation is 1074.6 mm, and the average relative humidity is around 64%. (Turkish Meteorology Station, 2020).

Fieldwork

We conducted 70-days extensive fieldworks by two or three crew people between May and October 2016–2017 for determining potential distribution, habitat characteristics, and phenology, and population status of species in the province of Antalya. We used a visual encounter survey (Guyer & Donnelly, 2012) for the detection of the vipers' recorded locality information

(coordinates and altitudes) by using Garmin GPSMAP 62s. We visited at least three times the previously known localities of Anatolian meadow viper and additional suitable habitats in other mountainous areas around Antalya where the species could be found (Figure 1). We mostly focused on suitable habitats of Kohu Mountain, Susuz Mountain, Alaca Mountain, Ak Mountains, Bey Mountains, Katrancık Mountain, Geyik Mountain ranges.

Conservation Action Plan

Throughout our fieldwork, we conducted interviews with rangers, farmers, beekeepers, shepherds, hunters, and officers. We obtained knowledge (life cycle, phenology) and opinions of locals on 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 the conservation action plan (CAP). We followed the Open Standards methodology (2013, www.cmp-openstandards.org), used threats classification (ver. 2.0) for threats and actions classification (ver. 2.0) keys. The 5-year action plan was discussed with the participation of GDNCNP, regional administration, and NGOs.

Result and Discussion

The reptiles are declining for many reasons especially due to human-induced habitat loss, fragmentation, harvesting, and climate change (Araújo et al., 2006; Gibbons et al., 2000). But in particular, reptiles can be a responsive indicator of human-induced possible threats caused by high grazing pressure (Read, 2002). Among them, vipers are the most misunderstood and persecuted animals. However, their low fecundity and slow growth rates have caused them to be disproportionately threatened by extinction (Maritz et al., 2016). The Anatolian meadow viper is an endemic and threatened species and needs special conservation measures and actions for the sustainability of its population. We detected only 10 vipers in the territory of the Çiğlikara cedar forest reserve at altitudes between 1800 m and 2300 m and only two vipers in the territory of Geyik Mountains at altitudes between 1600 m and 1900 m.

Habitat Characteristics

The exact locality information in the distribution areas of *V. anatolica* has not been clearly specified in the studies carried out so far (Billing, 1985; Eiselt & Baran, 1970; Göçmen et al., 2014; Nilson & Andrén, 2001; Sigg, 1987; Stümpel et al., 2015; Zinenko et al., 2016), for the purpose of protecting the species. Eiselt and Baran (1970) were reported that type species was found at altitudes between 1650 and 1750 m. In the subsequent studies (Göçmen et al., 2014, 2017; Mebert et al., 2017; Zinenko et al., 2016), it was stated that the species lives in suitable habitats on the subalpine Mediterranean mountain steppe vegetation starting with the upper limit of the tree line. In this study, in parallel with the previous researches, the specimens were found at the bottom, near or slope of the karstic dolines that show the characteristics of Mediterranean mountain steppe vegetation. Except for a captured subadult, other adult specimens were found at the bottom, near or slopes of the karstic dolines

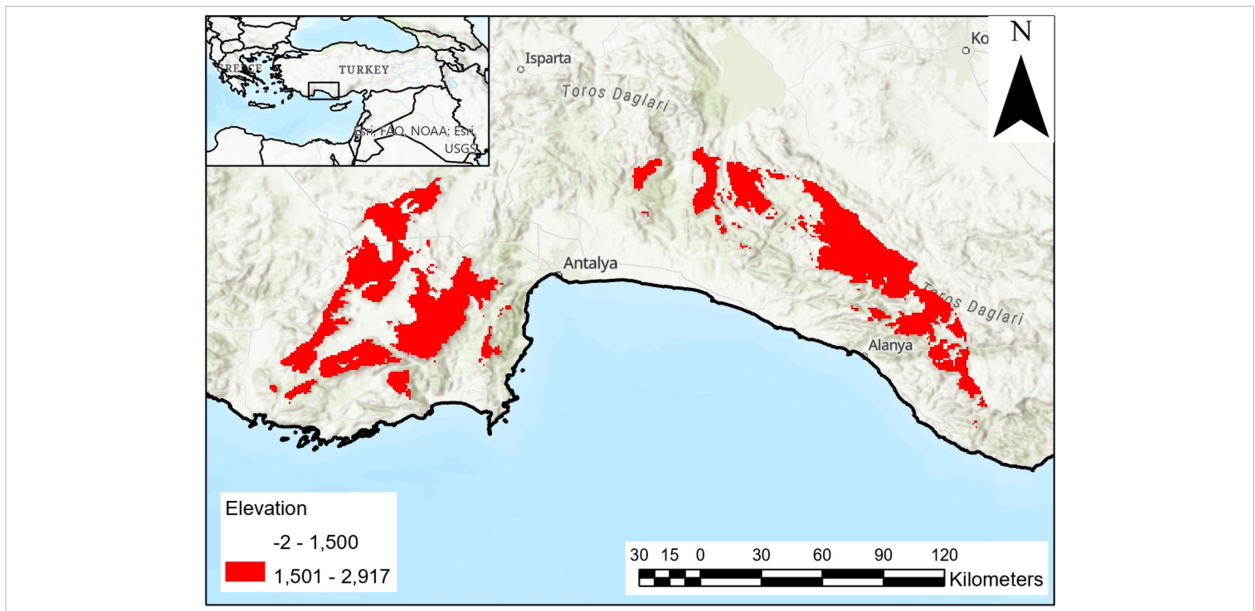


Figure 1. The Map Showing the Study Site the Province of Antalya (Southwestern Anatolia) and Major Fieldwork Area (1500 m and Above).

sized between 1 and 2.2 ha, and it has been observed that the adult specimens prefer the stony parts, grass, and vegetation covered with thorny *Astragalus* sp. (Figures 2 and 3). However, the subadult was found at an altitude of 2073 m near the top of a stony slope with little vegetation. It was observed that subadult, which was caught under stones in June, also preferred the suitable stony areas in the regions where strong winds were blowing and both took refuge under the rocks and used them for thermoregulation purposes. The area in question is located 50 m from the active goat trail. In the interviews, shepherds stated that the species is encountered in such habitats from May to October.

As stated in the previous study, two specimens of other subspecies from 1600 to 1800 m from the Geyik Mountains were detected in cloudy and occasionally rainy weather (Figures 4 and 5). Specimens have been identified in the herbaceous vegetation where *Euphorbia nicaeensis*, *Verbascum* sp. and *Juniperus oxycedrus* species are seen in the subalpine zone around Mühür Dağ, west of Geyik Mountains (Afsar et al., 2019).

Activity, Phenology, and Feeding

The observations of the specimens in Eiselt and Baran (1970), and Sigg (1987) were in June and July. Göçmen et al. (2014) reported that although the field studies were carried out from April to October, interestingly, most samples were encountered in October (four out of seven individuals), and one sample was recorded in May, June, and July each. Zinenko et al. (2016) reported that 19 specimens were caught in May (five individuals), July (seven individuals), and September (seven individuals). Among them, the month in which activity is observed the most is stated as July in the middle of summer.

In this study, the vipers were encountered between 7 a.m. and 10 a.m. in June, July, and the third and fourth quarters of August. Weather conditions in the region where the species live are highly variable, with air temperature measured between 17.9°C and 27°C. The unique movement behavior of the species between thorny *Astragalus* sp. communities and flat stones on high mountain slopes helps to optimize body temperature for long periods in the active period and even manage it in bad weather conditions. During the field studies, it was noted that at noon when the air temperature rises, the individuals made use of the shadows of grass and *Astragalus* communities concentrated in karstic dolines in regions where high Mediterranean steppe vegetation prevails. Shed skin of



Figure 2. The General View of *V. a. anatolica* Habitat from Kohu Mountain in Southwestern Anatolia.



Figure 3.
The General View of a Female Specimen of *V. a. anatolica* from Kohu Mountain in Southwestern Anatolia.



Figure 4.
The General View of *V. a. senliki* Habitat from Geyik Mountains in Southwestern Anatolia.



Figure 5.
The General View of a Female Specimen *V. a. senliki* from Geyik Mountains in Southwestern Anatolia.

an adult *V. anatolica* specimen was found on August 14th on an *Astragalus* sp. on Kohu Mountain. It has also been observed that these regions contain intensive grasshopper species in both subspecies habitats. and in this period of time, instead of foraging, the species set an immobile trap and waited for its prey to come to itself.

For nominate subspecies, Yakin et al. (2019) observed that during field studies on the nights following the days when *V. anatolica* specimens were found, *Anatololacerta pelasgiana* (Mertens, 1959) and *Ablepharus kitaibelii* Bibron & Bory St-Vincent, 1833 specimens were active between 9 p.m. and 11 p.m. It was observed that grasshopper species come first in the food spectrum of the species, and in addition, *A. kitaibelii* (Göçmen et al., 2014). Zinenko et al. (2016) stated that the species was specialized to feed on Orthoptera, and the lizards were consumed as prey in the spring and autumn months when the invertebrate population decreased. In this study, it was determined that the *V. anatolica* individuals were fed on *A. kitaibelii* specimens during short-term captivity. In addition, small mammal activity was noted around different localities where individuals were caught in July. Afsar et al. (2019) described a new subspecies of the Ottoman viper *Montivipera xanthina varoli* in the same habitat of *senliki* subspecies.

Threats and Conservation Actions

We determined the potential threats like habitat loss and degradation (grazing activities etc.), quarry, global climate change, illegal collecting, and willingly or accidentally killing of vipers (Table 1). Intensive ovine and goat breeding is carried out in the subalpine region, which is the range of the Anatolian meadow viper. Therefore, there is an overgrazing pressure in the area (Göçmen et al., 2014, 2017; Zinenko et al., 2016). Overgrazing is also destroying the habitat of both subspecies. The effect of overgrazing on the habitat of nominate subspecies was observed denser. In addition, the decrease in the amount of grass affects the grasshopper populations which are an important food source of the Anatolian meadow viper. Also, sheep/goat herds use a limited amount of water in the region. On the other hand, the quarry is the main threat for *senliki* subspecies. The activity of the quarry disturbs the vipers and destroys their habitat and their surroundings.

One of the major threats to the species is global climate change. *V. anatolica* is a viper that has adapted to high altitude environments like *Vipera graeca* Nilson & Andrén, 1988 (Mizsei et al., 2020; Zinenko et al., 2016). Mizsei et al. (2016) reported that high mountain habitats are under threat from overgrazing and soil erosion as well as the potential increase in tree line uplift due to climate change. While the geographical boundaries of the species are shifting, species living in high mountainous such as *V. anatolica* habitats can migrate upward only to a limited extent. In this case, it is clear that the natural habitats of the species will decrease. By evaluating the future climate scenarios made by Lieveld et al., (2012) Mizsei et al. (2020) stated that suitable

Table 1.
The Major Threats for the Anatolian Meadow Viper in Southwestern Anatolia

Major Threats	Reasons	Threat Level
Agriculture & Aquaculture		
Livestock Farming & Ranching	Grazed land has caused significant declines in populations of this species due to high grazing activity which leads to the degradation of vegetation and decrease of abundance of potential preys.	High
Biological Resource Use		
Hunting & Collecting Terrestrial Animals	Deliberate or accidental killing by locals, illegal collection of vipers for the pet trade, scientific collection.	High
Climate Change		
Changes in Temperature Regimes	Potentially affecting the phenology and distribution of species.	Unknown
Changes in Precipitation & Hydrological Regimes	Potentially affecting the phenology and distribution of species.	Unknown
Human Intrusions & Disturbance		
Quarry	The activity of the quarry threatens the habitat of the species (especially subspecies <i>senliki</i>).	High
Recreational Activities	Off-road vehicles, mountain bikes, hikers, birdwatchers, skiers, pets in recreational areas, temporary campsites, caving, rock-climbing.	Medium

habitats for a species that adapted to cold and high altitudes like *V. graeca* will not remain in the future which be possible for *V. anatolica*. Because according to the model stated in Lelieveld et al. (2012), it is estimated that the maximum temperatures of daytime will increase rapidly in the eastern Mediterranean in Balkan Peninsula and Turkey mostly; the annual rainfall will decrease in southern Europe, in Turkey and the eastern Mediterranean countries; the number of dry days will increase until 21st century.

The high peaks of the Taurus Mountains rising suddenly from the southern shores of the Mediterranean region exceeding 3500 m. There are semi-alpine and rarely alpine meadows above the forest border. The water retention potential of the region is low because the general rock structure of the region is limestone. The survivability of the species depends on the amount of snowfall during the winter months. It has also been found that individuals are observed in areas close to the snow pits, especially in the spring months. In the interviews with the locals, it was stated that the snowfall was gradually decreasing. Annual rainfall reduction in the future can trigger the regressive effect to the permanence of the region of *V. anatolica*, which has adapted to cold like *V. graeca* and occupies a narrow space.

Wildlife hunting is prohibited in Çiğlıkara National Park where the nominate subspecies lives. Thus, especially wild boars (*Sus scrofa*), owls (*Athene noctua*, *Otus scops*, etc.), and accipitres (*Buteo rufinus*, *Buteo buteo*, *Clanga clanga*, etc.) are the predators for the subspecies.

The habitat of the other subspecies has no protection status, and the most effective threat for *senliki* subspecies is the quarries. Thus, habitat destruction and fragmentation are the main threats which *senliki* subspecies will encounter/encountered.

In addition, the potential habitats, especially in Beydağ, Alacadağ, and Akdağ regions were observed. But during the interviews with the locals and field studies, Ottoman viper (*Montivipera xanthina*) was found in those regions. Probably, the Anatolian meadow viper came to the Taurus by following the Anatolian Diagonal and separated from its Caucasian relatives and was limited to certain regions of the western Taurus. Likely, it could not compete with the Ottoman viper in the past and disappeared in other areas.

The species is usually observed while basking on the pillow-shaped plants, and in contact with humans, they hide inside to the roots of the plants. Locals, shepherds, and beekeepers who make contact with the species kill the species intentionally or accidentally because the species is poisonous and they are scared. However, the venom of the Anatolian viper is as effective as the scorpion venom in the region and does not have a lethal effect.

Although the illegal collection of herptile species is seen as a major threat in Turkey (Baran & Atatür, 1998, IUCN, 2020) after the 2000s case on this issue is very limited. The major threat for reptiles is habitat loss and habitat fragmentation (Gibbons et al., 2000). Especially human-induced factors such as the expansion of urban areas, infrastructure and road constructions, agricultural activities, grazing, quarries, cause habitat loss or decreasing the habitat quality. Besides the biology of vipers in Turkey has been poorly studied, including studies on their distributions and population statuses with only fragmentary or misleading information (Mebert et al., 2020).

Conclusion and Recommendations

In summary, the potential threats of the Anatolian viper are habitat loss and degradation (grazing activities), quarry, global climate change, illegal collecting, and willingly or accidentally

Table 2.
The Implementation of the Conservation Action Plan for the Anatolian Meadow Viper in Southwestern Anatolia

Actions	Priority	Responsible Agencies, Organizations, and Individuals
A. Land / Water Management		
<p><i>A.1. Site/Area Stewardship</i></p> <p>In Çiğlikara Natural Reserve and the habitat of the subspecies <i>senliki</i>, determination of approximately 100 ha protected areas and prohibition of grazing activities in these areas</p> <p>In Çiğlikara Natural Reserve and the habitat of the subspecies <i>senliki</i>, continuous monitoring of the area and the technological monitoring equipment</p> <p>Availability of expert personnel for monitoring studies and coordination</p>	High	Law enforcers, Mukhtars. Local government officers, Forestry, Agricultural, Governorship offices.
B. Species Management		
<p><i>B.1. Species Stewardship</i></p> <p>To preclude the illegal collection by introducing the Anatolian viper to locals.</p> <p>To protect the regions that Anatolian viper lives, increasing the coordination with relevant corporations and organizations, and to prevent the sharing of official species data.</p> <p>To add awareness activities for protecting the Anatolian viper to the other studies in the viper habitats.</p> <p>Preventing the species from being harmed by guiding the expert personnel who have knowledge about the Anatolian Viper to the works to be carried out in the region.</p>	High	Law enforcers, Mukhtars. Local governments, Forestry, Agricultural, Governorship offices, Universities.
<p><i>B.2. Ex-Situ Conservation</i></p> <p>Giving enough viper specimens to the zoos in Turkey which can provide necessary conditions to support the sustainability of the species.</p> <p>Releasing the newborns acquired from the couples to their natural habitats.</p>	High	Zoos, Universities.
C. Awareness Raising		
<p><i>C.1. Outreach & Communications</i></p> <p>To introduce the Anatolian viper and to increase awareness of protection; Preparing posters and brochures etc. for its promotion and opening a stand and exhibition in festivals to be held in the province.</p>	High	Ministry of Foreign Affairs, Customs Office, Governorship
D. Law Enforcement and Prosecution		
<p><i>D.1. Detection and Arrest</i></p> <p>Raising the awareness of law enforcement officers and officials at border gates for the person(s)/(herp keepers) who attempt to collect or steal Anatolian viper specimens without permission.</p>	Critical	Ministry of Foreign Affairs, Customs Office, Governorship.
<p><i>D.2. Non-Criminal Legal Action</i></p> <p>Not permitting specimens to be taken in the natural environment for scientific research and allowing to work without removing the specimens from the field by taking expert opinion only if the reason is well explained.</p> <p>Supporting the studies and follow-up of the populations in the field to determine their reproduction, behavior, annual activity, and breeding periods.</p>	High	GDNCNP, Universities.
E. Conservation Designation and Planning		
<p><i>E.1. Protected Area Designation and/or Acquisition</i></p> <p>As a result of extensive studies on the species, creating new protected areas by revealing suitable/ important habitats for their populations.</p>	High	GDNCNP, Universities.
<p><i>E.2. Site Infrastructure</i></p> <p>Establishing an inventory by recording the deaths of Anatolian viper due to roadkills or other reasons with the help of forest guards, shepherds, and expert personnel, and taking protection infrastructure measures in these regions.</p>	Medium	GDNCNP, Universities.
F. Research and Monitoring		
<p><i>F.1. Basic Research and Status Monitoring</i></p> <p>Supporting or conducting research on the ecology and biology of the species.</p> <p>Monitoring the population trend of the species over several years.</p>	Critical	GDNCNP, Universities.
G. Education and Training		
<p><i>G.1. Formal Education</i></p> <p>Preparing educational materials for primary and secondary schools to attract attention to the viper and its protection.</p> <p>To inform and educate officers, gendarmes, customs house guards, and forestry rangers on the harm of smuggling the species.</p>	High	GDNCNP, Forestry, Agricultural, Governorship. Education offices, Universities, Schools.
<p><i>G.2. Training and Individual Capacity Development</i></p> <p>To inform locals and especially mukhtars, the shepherds, and the beekeepers who encounter the species most often, about the prohibition on killing the species and its criminal penalties.</p> <p>Increasing awareness of the importance of the species and the threat of bio-smuggling to locals via posters, brochures, one-on-one training, etc.</p>	High	GDNCNP, Universities.

killing of vipers. We recommend (1) to establish protected habitat patches in the species' known distribution, (2) to create alternative new habitats for reintroduction, (3) to plan long-term monitoring survey, (4) to start a captive breeding program, (5) educate and raise awareness among locals to prevent illegal collecting, willingly or/and accidentally killing of individuals for the sustainability of Anatolian meadow viper (Table 2).

Ethics Committee Approval: The study was carried out with the permission of the Directorate of Antalya Branch of the 6th Regional Directorate of the Department of Nature Protection and National Parks of the Republic of Turkey, Ministry of Forestry and Water Affairs.

Peer-review: Externally peer-reviewed.

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