

The herpetofauna of Honaz Mountain National Park (Denizli Province, Turkey) and threatening factors

^{1,*}Müge Gidiş and ²Eyup Başkale

¹Kütahya Dumlupınar University, Faculty of Arts and Science, Department of Biochemistry, Kütahya, TURKEY ²Pamukkale University, Faculty of Arts and Science, Department of Biology, Denizli, TURKEY

Abstract.—The aim of this study was to catalog the species of amphibians and reptiles in Honaz District, in the province of Denizli, Turkey, based on field surveys carried out during March–October of 2015–2018. The species found include five amphibians (*Bufo bufo*, *Bufo variabilis*, *Pelophylax bedriagae*, *Hyla orientalis*, *Rana macrocnemis*) and 22 reptiles (two turtles (*Mauremys rivulata*, *Testudo graeca*), nine lizards (*Stellagama stellio*, *Mediodactylus kotschy*, *Anatololacerta danfordi*, *Lacerta trilineata*, *Ophisops elegans*, *Ablepharus kitaibelii*, *Pseudopodus apodus*, *Blanus strauchi*, *Heremites auratus*), and 11 snakes (*Xerotyphlops vermicularis*, *Dolichophis jugularis*, *D. caspius*, *Hemorrhhois numnifer*, *Eirenis modestus*, *Telescopus fallax*, *Elaphe sauromates*, *Natrix natrix*, *N. tessellata*, *Eryx jaculus*, *Montivipera xanthina*). In addition, the various factors threatening these species in this area were determined and proposals for the conservation of these species are presented.

Keywords. Amphibians, Anura, distribution, habitat destruction, pollution, reptiles, Squamata, Testudines

Citation: Gidiş M, Başkale E. 2020. The herpetofauna of Honaz Mountain National Park (Denizli Province, Turkey) and threatening factors. *Amphibian & Reptile Conservation* 14(1) [General Section]: 147–155 (e228).

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Received: 19 April 2019; **Accepted:** 5 October 2019; **Published:** 3 April 2020

Introduction

Amphibians and reptiles are an important component of most ecosystems. In particular, their importance is incontrovertible for the maintenance of food networks. Their prey includes a variety of insects and their larvae, fish, shellfish, other reptiles, other amphibians, birds, and small mammals. They are also a source of food for fish, birds, reptiles, and mammals. From this point of view, amphibians and reptiles play an important role in ensuring the balance within ecosystems (Böhm et al. 2013; Heatwole and Wilkinson 2015). In addition, because they are poikilotherms and as they are in close contact with the air, water, and soil according to the characteristics of the habitats in which they are located, they have good characteristics as indicators for food networks (Duellman and Trueb 1994) and environmental changes (Demirsoy 1996; Baran and Atatür 1998; Budak and Göçmen 2008; Baran et al. 2012). In recent years, studies focusing on the assessment of species diversity among ecological communities have been instrumental in developing protection strategies, as well as helping to clarify the structure and dynamics of biological communities (Baldwin et al. 2006; Shaney and Marshall 2013; Berriozabal-Islas et al. 2017; Ćurić et al. 2018).

Amphibians and reptiles are two of the most endangered groups compared to other vertebrates (Hoffmann et al. 2010). The herpetofauna of Turkey has been studied intensively in the last 50 years, providing information about the distribution of the many amphibian and reptile species in Turkey (Sillero et al. 2014; Yıldız and İğci 2015; Bülbül et al. 2016; Göçmen and Karış 2017; Sarıkaya et al. 2017; Gül et al. 2018; Yıldız et al. 2019). However, due to technological and methodological developments the taxonomy of reptiles and amphibians has remained dynamic and unstable. For example, in 2008, only 8,734 reptile species were reported for the world, but as of July 2018 this figure had increased to 10,793 (Reptile Database: <http://www.reptile-database.org>). Amphibian species are represented by about 7,950 species globally (AmphibiaWeb: <http://www.amphibiaweb.org>), and from 2004 through November 2018, a total of 2,318 new amphibian species were described, including 139 from January 2018 until 14 November 2018. A similar situation is found in Turkey, where the number of known amphibian and reptile species was 141 in 2013, and with the latest developments, the number of species has grown to 170 (Sindaco et al. 2000; Yıldız and İğci 2015; Bülbül et al. 2016; Yıldız et al. 2019).

Correspondence. *mugegidis@gmail.com

The history of studies on the Turkish herpetofauna traces back to the 19th century (Boettger 1889), and in recent years many new species have been identified and new records have been published (Sillero et al. 2014; Yıldız and İgci 2015; Bülbül et al. 2016; Wielstra and Arntzen 2016; Göçmen and Karış 2017; Sarıkaya et al. 2017; Gül et al. 2018; Yıldız et al. 2019). Faunistic inventory studies in Denizli province were conducted in 2013 by the Ministry of Forestry and Water Affairs, General Directorate of GDMP, and the Pamukkale University Biology Department. However, that study did not provide much information about the species and the factors that threaten them in the province of Denizli. The current survey (conducted from 2015–2018) focused on the herpetological species of the Honaz Mountain National Park-Denizli, which is one of Turkey's most important protected areas, and elucidating the threatening factors for amphibian and reptile species living in this national park. The results provide a new opportunity for revising the conservation status of the Honaz Mountain National Park-Denizli herpetofauna and a new reference for distributional data.

Materials and Methods

Honaz Mountain National Park-Denizli, which is located within the borders of the Honaz district of Denizli province, was declared a National Park on 21 April 1995 and approved by the General Directorate of Nature Conservation National Parks on 9 March 2009. The area of the national park is 9,616 ha and the highest point has an altitude of 2,571 m. The climate is dominated by the Mediterranean climate and the park is mostly covered with Red Pine (*Pinus brutia*) forest. A map of the Honaz Mountain National Park and the survey sites is given in Fig. 1.

Field surveys were conducted between March and October in each year from 2015 to 2018. Amphibians and reptiles in this area are active during spring and summer, which is the best time to study them. Early autumn can also be considered suitable for observing reptiles before hibernation. The Visual Encounter Survey (VES, Crump and Scott 1994) method was used in the field studies to assess the amphibian and reptile species. In this study, two teams conducted the field studies along linear paths according to the habitat characteristics, such as forest land, stony areas, and bush. The specimens captured during the surveys were diagnosed, and assessed at the species or family levels. According to the size of the habitat, 0.5–1.5 h of fieldwork was performed at each station. Specimens which could not be identified in the field were transported to the laboratory, and species were diagnosed by using an identification key or the current literature for the relevant species (Baran and Atatür 1998; Özeti and Yılmaz 1994; Baran et al. 2012; Budak and Göçmen 2008).

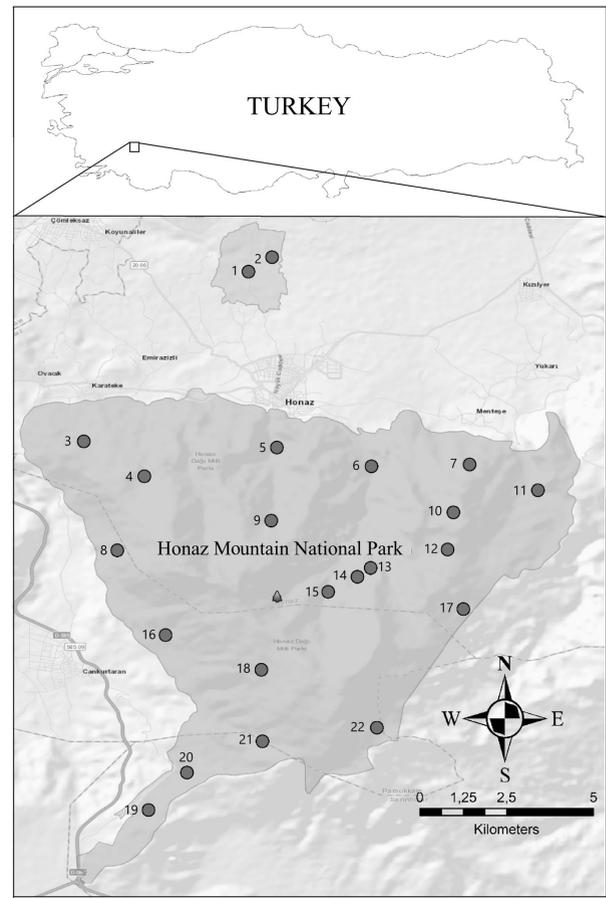


Fig. 1. Study area and locations of field surveys in Honaz Mountain National Park, Turkey. The coordinates and elevations of the numbered sites are given in Appendix 1.

After the species were identified, their population status was further determined using the following resources: 1) Convention on the Conservation of European Wildlife and Natural Habitats = BERN (Bern 1982), 2) Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1975), and 3) The International Union for Conservation of Nature's Red List of Threatened Species = IUCN Red List (<http://www.redlist.org>). Additional information was gathered on the factors that threaten the populations in the survey areas.

Results

In this study, a total of 27 amphibian and reptile species belonging to 13 families were observed in Honaz Mountain National Park (Fig. 2). The species of amphibians and reptiles found in the research area, and their associated habitat types, are given in Tables 1 and 2. According to the Bern Convention, 12 of the amphibian and reptile species are listed in Appendix 2, and 15 species are on the Annex 3 list. According to the IUCN Red List criteria, one species is listed as VU (Vulnerable), 21 as LC (Least Concern), and one as DD (Data Deficient) [Fig. 3A]. Four species have not been evaluated yet (NE),

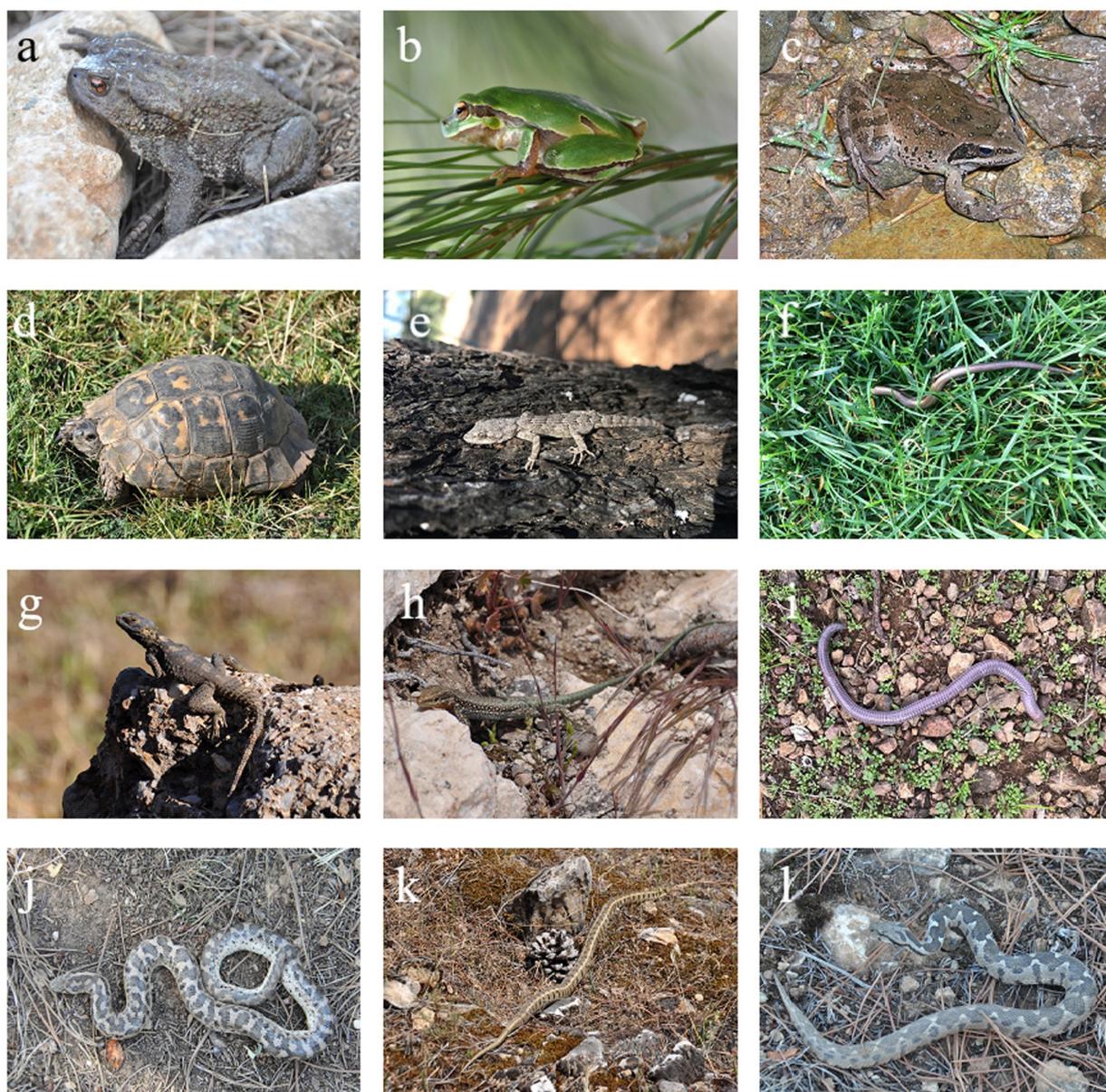


Fig. 2. Some of the amphibian and reptilian species in the study area: (a) *Bufo bufo*, (b) *Hyla orientalis*, (c) *Rana macrocnemis*, (d) *Testudo graeca*, (e) *Mediodactylus kotschyi*, (f) *Ablepharus kitaibellii*, (g) *Stellagama stellio*, (h) *Anatololacerta danfordi*, (i) *Blanus strauchi*, (j) *Eryx jaculus*, (k) *Natrix natrix*, and (l) *Montivipera xanthina*.

so they are not listed. In addition, according to CITES, two species are included in the Appendix 2 list and 25 are excluded from the list. The chorotype distributions of the species indicated that the amphibian and reptile species of Honaz Mountain National Park mostly belonged to the Turanian-Mediterranean and Eastern Mediterranean chorotypes (Vigna Taglianti et al. 1999; Sindaco et al. 2000) [Fig. 3B]. This study will inform the conservation of amphibian and reptile species in this area and contributes to the broader knowledge of Turkey's herpetofauna.

Discussion

Turkey has a rich flora and fauna due to its geological, topographical, and climatic characteristics. Herpetological

studies conducted for more than a century show that there is not enough information available on the herpetofauna of Turkey. On the one hand, in the last 20 years, new species and subspecies have been uncovered in Turkey and new localities have been recorded for the existing species (Ayaz et al. 2011; Göçmen et al. 2013; Avcı et al. 2015; Üzümlü et al. 2015; Bülbül et al. 2016). On the other hand, herpetology research has been limited to certain areas in Turkey despite the high number of divergent areas with differences in geographic isolation elements, and different ecosystems and ecological conditions. As a result, in the last 20 years, studies determining the amphibian and reptile species and their ecological preferences in the previously understudied regions have accelerated (Özdemir and Baran 2002; Afşar and Tok 2012; Özcan and Üzümlü 2013; Cihan and Tok 2014; Ege

Table 1. Amphibian species found in Honaz Mountain National Park and their characteristics.

Family	Species	Habitat	IUCN	Population status	Chorotype	BERN	CITES	Localities
Bufonidae	<i>Bufo bufo</i> (Linnaeus, 1758)	Forestlands, waysides, waterfronts, rocky terrains, meadowlands, croplands, gardens	LC	Stable	European	III	-	3, 15
Bufonidae	<i>Bufotes variabilis</i> (Pallas, 1769)	Forestlands, waterfronts, meadowlands, croplands, gardens	DD	Undetermined/unknown	Turano-European-Mediterranean	II	-	1, 2, 8, 10, 17, 18, 19
Ranidae	<i>Pelophylax bedriagae</i> (Camerano, 1882)	Forestlands, waysides, waterfronts, croplands	LC	Declining	Turano-European-Mediterranean	III	-	2, 6, 12, 20
Ranidae	<i>Rana macrocnemis</i> (Boulenger, 1885)	Waterfronts, croplands	LC	Declining	SW-Asiatic	III	-	9
Hylidae	<i>Hyla orientalis</i> (Bedriaga, 1890)	Forestlands, maquis shrublands, shrubbery	LC	Declining	European	II	-	2, 7

et al. 2015; Eksilmez et al. 2017; Kumlutas et al. 2017; Sarıkaya et al. 2017).

Most studies on the herpetofauna of Denizli province were carried out in the individual districts. For example, 17 reptile and amphibian species were found in the Babadağ district (Urhan et al. 1999); 24 in Acıpayam-Denizli (Urhan et al. 2003); 26 in Hambat (Urhan et al. 2004); and 22 around the Çal, Bekilli, and Baklan Districts (Urhan et al. 2006). Ünal et al. (2012) identified 25 amphibian and reptile species belonging to 15 families in Kale district. In this study, five anurans, two turtles, nine lizards, and 11 snakes (for a total of five amphibian and 22 reptile species) were observed in Honaz Mountain National Park. There are no current taxonomic controversies among these species. A previous study conducted about 20 years ago reported 21 amphibian and reptile species from Honaz Mountain National Park (Katılmış et al. 2002). In this study, *Hyla orientalis*, *Rana macrocnemis*, *Mauremys rivulata*, *Heremites auratus*, *Pseudopodus apodus*, and *Telescopus fallax* were recorded for the first time in Honaz Mountain National Park. In addition, seven amphibian and 26 reptile species have been identified in Denizli province during 2002–2009 (Urhan et al. 2009). In this respect, the Honaz Mountain National Park includes 71.4% of the amphibian diversity and 80.8% of the reptile diversity in Denizli province.

Of the ~18,000 amphibian and reptile species distributed around the world, about 35% are on the IUCN Red List. According to IUCN criteria, among the total of 27 amphibian and reptile species found in the study area: one (4.76%) is Vulnerable (VU), 21 (66.7%) are Least Concern (LC), one (4.76%) is Data Deficient (DD), and 4 (28.57%) are not evaluated yet (IUCN 2018). According to the IUCN Red List, the populations of 10 of these

species are stable (37.04%), while the populations of four species are decreasing (14.81%), and there is no information on the population status of the remaining 13 species (48.15%). Therefore, it is necessary to determine the roles of various threats to the ecosystem and the current population status of the species of amphibians and reptiles that were found.

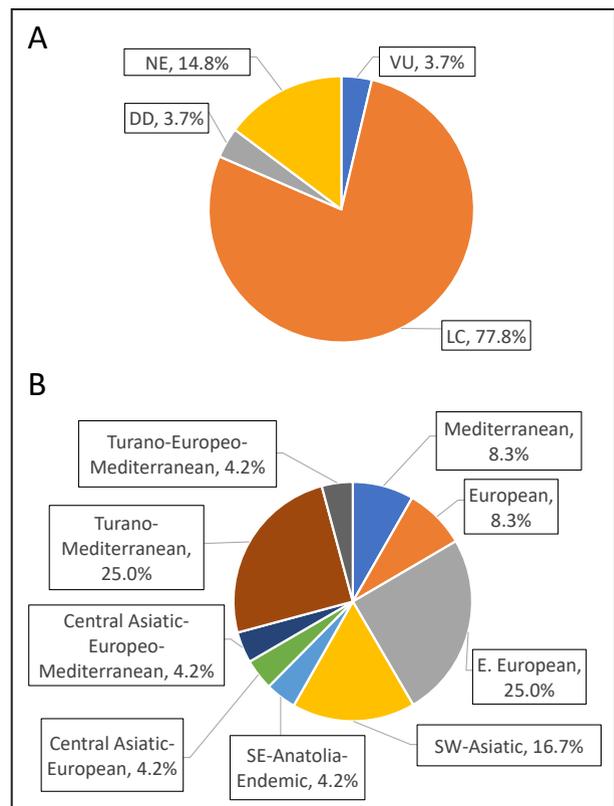


Fig. 3. Distribution of species according to IUCN categories (A) and their chorotypes (B).

Table 2. Reptile species found in Honaz Mountain National Park and their characteristics.

Family	Species	Habitat	IUCN	Population status	Chorotype	BERN	CITES	Localities
Testudinidae	<i>Testudo graeca</i> (Linnaeus, 1758)	Forestland, waterfronts, rocky terrain, meadowland, maquis shrubland, cropland, gardens, moorland	VU	Stable	Turano-Mediterranean	II	II	1, 3, 6, 8, 15, 16, 17, 19
Anguidae	<i>Pseudopus apodus</i> (Pallas, 1775)	Forestland, maquis shrubland, cropland, gardens	LC	Undetermined/Unknown	Turano-Mediterranean	II	-	4, 6, 10, 16
Geoemydidae	<i>Mauremys rivulata</i> (Valenciennes in Bory de Saint-Vincent, 1833)	Waterfronts, creeks	LC ₁	Undetermined/Unknown	Turano-Mediterranean	III	-	2
Agamidae	<i>Stellagama stellio</i> (Linnaeus, 1758)	Wayside, rocky terrain	LC	Stable	E. Mediterranean	II	-	3, 5, 18, 21
Gekkonidae	<i>Mediodactylus kotschy</i> (Steindachner, 1870)	Forestlands, waysides, open slopes, valley slopes, rocky terrains, maquis shrublands, croplands, gardens, residential areas	LC	Undetermined/Unknown	E. Mediterranean	II	-	1, 8, 10, 17, 19
Lacertidae	<i>Anatololacerta danfordi</i> (Günther, 1876)	Forestlands, waterfronts, open slopes, valley slopes, rocky terrains, meadowlands, maquis shrublands, croplands	LC	Stable	SE-Anatolia-Endemic	III	-	2, 12
Lacertidae	<i>Lacerta trilineata</i> (Bedriaga, 1886)	Forestlands, rocky terrains, croplands, bushlands, moorlands, semi-desert areas	LC	Stable	E. Mediterranean	II	-	2, 7, 12
Lacertidae	<i>Ophisops elegans</i> (Ménétries, 1832)	Forestland, rocky terrains, croplands, bushlands, moorlands, semi-desert areas	-	Undetermined/Unknown	E. Mediterranean	II	-	1, 3, 9, 10, 14, 18, 22
Scincidae	<i>Ablepharus kitaibelii</i> (Bibron and Bory St-Vincent, 1833)	Forestlands, rocky terrains, meadowlands	LC	Stable	E. Mediterranean	II	-	4, 5, 13
Scincidae	<i>Heremites auratus</i> (Linnaeus, 1758)	Rocky terrains	LC	Stable	SW-Asiatic	III	-	1, 11
Amphisbaenidae	<i>Blanus strauchi</i> (Bedriaga, 1884)	Forestlands, rocky terrains, croplands	LC	Undetermined/Unknown	Mediterranean	III	-	3, 11, 17, 21
Typhlopidae	<i>Xerotyphlops vermicularis</i> (Merrem, 1820)	Forestlands, waterfronts, rocky terrains, meadowlands	LC	Undetermined/Unknown	Turano-Mediterranean	III	-	4, 11, 17,
Colubridae	<i>Dolichophis jugularis</i> (Linnaeus, 1758)	Waterfronts, open slopes, valley slopes, rocky terrains, cropland, gardens	LC	Stable	SW-Asiatic	II	-	2, 12
Colubridae	<i>Dolichophis caspius</i> (Gmelin, 1789)	Open slopes, rocky terrains, meadowlands, croplands, gardens	LC	Undetermined/Unknown	Turano-Mediterranean	III	-	3, 17, 21
Colubridae	<i>Hemorrhois nummifer</i> (Reuss, 1834)	Open slopes, rocky terrains	LC	Undetermined/Unknown	Turano-Mediterranean	III	-	12
Colubridae	<i>Eirenis modestus</i> (Martin, 1838)	Rocky terrains	LC	Stable	SW-Asiatic	III	-	3, 21

Table 2 (continued). Reptile species found in Honaz Mountain National Park and their characteristics.

Family	Species	Habitat	IUCN	Population status	Chorotype	BERN	CITES	Localities
Colubridae	<i>Telescopus fallax</i> (Fleischmann, 1831)	Forestlands, bushlands, rocky terrains	LC	Undetermined/Unknown	Turano-Mediterranean	III	-	5, 8
Colubridae	<i>Elaphe sauromates</i> (Pallas, 1811)	Forestlands, waysides, open slopes, rocky terrains, meadowlands, croplands, gardens, bushlands, moorlands	LC	Undetermined/Unknown	Turano-European-Mediterranean	III	-	3
Colubridae	<i>Natrix natrix</i> (Linnaeus, 1758)	Forestlands, waterfronts, meadowlands	LC	Undetermined/Unknown	Central Asiatic-European-Mediterranean	III	-	2
Colubridae	<i>Natrix tessellata</i> (Laurenti, 1768)	Waterfronts	LC	Declining	Central Asiatic-European	II	-	12
Boidae	<i>Eryx jaculus</i> (Linnaeus, 1758)	Forestlands, open slopes, valley slopes, rocky terrains	LC	Undetermined/Unknown	Mediterranean	III	II	13
Viperidae	<i>Montivipera xanthina</i> (Gray, 1849)	Open slopes, valley slopes, rocky terrains	LC	Stable	E. Mediterranean	II	-	4

As indicated by field studies, all of the threats to amphibian and reptile diversity are found to originate from anthropogenic degradation of the environment (Curic et al. 2018; Hosseinzadeh et al. 2018). Destruction of habitat is the major threat for many species. Considering that the terrestrial frog and reptile species are mainly distributed in mountain slopes, as well as rocky and stony areas, mining activities pose a significant threat to biodiversity. Destruction and restriction of the habitats of amphibian and reptile species may cause them to become trapped in certain areas over the long term. The competition of species having a common niche will cause stress in terms of food resources and reproduction, and species that are trapped in certain areas will be more sensitive to changes in the ecosystem. Two other problems are the agricultural activities and domestic pollution which affect the species that are dependent on aquatic habitats. The species living in irrigation channels in agricultural lands are directly exposed to pesticides. During our field studies, packages of agricultural pesticides were found in many habitats, such as irrigation channels and streams. Another important threat for the reptiles is that local people do not recognize the non-venomous reptile species and kill reptiles indiscriminately due to mis-information. Most snake species encountered in the field or in different environments are killed despite being harmless. Even the European Glass Lizard (*Pseudopodus apodus*) is known by the local people as the “iron snake” and it is often killed due to the belief that it is venomous. As reptiles do not have mimic muscles and they have scaly structures, people often consider them to be “cold-faced animals.” Another problem observed in the survey area is that amphibians and reptiles are often crushed by road traffic.

Several recommendations for the conservation of species are given here.

- Information and training activities should be initiated in the habitat areas which are intensively used by people, such as recreational areas. In addition, Natural Life Protection Schools, supported by various institutions and associations, should be expanded and brought to a level that will appeal to more people.
- Modification or destruction of habitats should be prevented. If a study on habitat is conducted, at a minimum it should be carried out under the supervision of a commission of biologists and should be done outside of the breeding season.
- Most specimen mortalities occur during the migration to wetland ecosystems during the reproductive season. During migration, many adult individuals are destroyed on the roads due to heavy traffic. For this reason, barriers should be built around the main arteries in the wetland ecosystems and their channels; and similar structures should be built to ensure that individuals migrating to the wetland can pass from safe areas to the wetlands.
- Predator species not found in the natural environment should not be released to the wetland ecosystems. Numerous studies have shown that species added to the environment for biological control are harmful to the ecosystem over time, and often a struggle ensues to remove these species from the environment. For this reason, steps should be taken to ensure that these predators are removed as soon as possible.
- Due to the agricultural activities around the wetlands, many chemical pollutants are introduced into the water bodies. Therefore, when controlling harmful plants and insects, only herbicides and insecticides approved by the Republic of Turkey Ministry of Agriculture and Forestry should be used, and disposal of

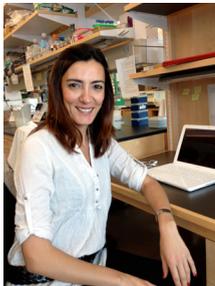
their waste materials should be in an isolated environment away from the water bodies.

- The environment is continuously being loaded with chemical substances released by anthropogenic activities that may directly or indirectly affect herpetofaunal populations. The geno- and ecotoxicological effects of these substances on living things should be further investigated.

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Müge Gidiş is an Assistant Professor in the Department of Biochemistry at the University of Dumlupınar (Kütahya, Turkey). Müge is interested in the molecular ecology and conservation biology of reptiles and amphibians. Her recent research projects focus on the comparative phylogeography of amphibians and reptiles.



Eyup Başkale is a Professor in the Department of Biology at the University of Pamukkale (Denizli, Turkey). His current research seeks to understand animal ecology and distribution, with special focus on the conservation of amphibians and reptiles living in Turkey. Eyup currently coordinates several research projects focusing on threatened species in Turkey.

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Appendix 1. Coordinates and altitudes of the study locations at Honaz Mountain National Park, Turkey.

Locality no.	Longitude	Latitude	Altitude (m)
1	29°15.646'E	37°47.216'N	376
2	29°19.080'E	37°44.227'N	1,101
3	29°15.999'E	37°43.358'N	1,345
4	29°14.361'E	37°41.585'N	1,156
5	29°17.545'E	37°42.625'N	1,427
6	29°14.031'E	37°44.044'N	1,138
7	29°14.692'E	37°39.455'N	1,200
8	29°18.739'E	37°42.911'N	1,645
9	29°18.828'E	37°43.486'N	1,622
10	29°17.338'E	37°42.487'N	1,402
11	29°16.884'E	37°42.254'N	1,405
12	29°17.556'E	37°44.199'N	785
13	29°15.847'E	37°41.047'N	1,909
14	29°15.865'E	37°39.939'N	1,592
15	29°13.089'E	37°44.586'N	902
16	29°18.984'E	37°41.988'N	1,742
17	29°17.642'E	37°40.152'N	2,025
18	29°13.609'E	37°42.896'N	1,070
19	29°16.014'E	37°47.440'N	362
20	29°20.141'E	37°43.829'N	1,109
21	29°16.090'E	37°44.489'N	808
22	29°14.095'E	37°38.874'N	1,272