

**A herpetological hotspot in peril:
Anthropogenic impact upon the amphibian and reptile populations
from the Băile Herculane tourist resort, Romania**

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Abstract. Baile Herculane is a popular attraction for both tourists and zoologists, for its beautiful landscape, its thermal springs, a diversity of habitats which hosts a wide variety of animal species and, nonetheless, "Domogled-Valea Cernei" National Park that delimits this balneal resort on both sides. Still scarce data is available on the distribution and composition of herpetofauna in the area and there is even less information on the threat posed by human activity. In this paper the authors aimed to investigate the amphibian and reptile species populations in the area and determine which human activities pose the greatest threat to their survival. Since the beginning of the study, in 2003, 4 species of amphibians (*Bombina variegata*, *Bufo bufo*, *Bufo viridis*, *Rana dalmatina*) and 10 species of reptiles (*Testudo hermanni*, *Lacerta viridis*, *Podarcis muralis*, *Darevskia praticola*, *Anguis fragilis*, *Natrix tessellata*, *Dolichophis caspius*, *Zamenis longissimus*, *Coronella austriaca*, *Vipera ammodytes*) were identified in the urban and peri-urban habitats of Baile Herculane. *Vipera ammodytes* appears to be most threatened by human activities, misconceptions and beliefs, registering massive populations loss in the study area during the last few decades.

Keywords: urban and peri-urban environments, herpetofauna, protected species, conservation

Introduction

The herpetofauna of Romania has scarcely been investigated, up until recently the only notable publications being the two volumes about the "Fauna of the People's Republic of Romania" published by Fuhn (1960) and Fuhn & Vancea (1961). Related data can be found in publications by Șova (1970, 1972) and Ionescu et al. (1968). A preliminary report on amphibians was published by Cogălniceanu (1991), followed by a more comprehensive volume in 2000. Recently, more precise papers have been published, some focusing on the distribution and composition of the Romanian herpetofauna (e.g. Ghira et al. 2002, Covaciu-Marcov et al. 2000, 2002, 2003 a, b, c, 2004, 2005a, 2006 a, b, c, Strugariu et al. 2006 a, b, c, 2007

a, b, Gherghel & Ile 2006, Gherghel & Strugariu, 2007), some on the feeding biology and ecology of different amphibian species (Covaciu-Marcov et al. 2005b, Nicoară et al. 2005 a, b, Sas et al. 2005). Ghira et al. (2002) consider that the data gathered until 2000 only shows 5% of the real distribution and composition of the herpetofauna. Data regarding the anthropogenic impact on the Romanian amphibian and reptile species is also limited, the only literature available being in the form of scientific papers, some of them from the past decades (Fuhn 1964) and most of them published in recent years (Cogălniceanu & Andrei 1992, Andrei & Torok, 1997, Strugariu et al. 2007 a, b, Gherghel & Strugariu 2007).

The county of Caraș-Severin, in which Băile Herculane is situated, and, in fact, the whole Cerna

river basin is considered a real hot spot for Romanian flora and fauna diversity and several vulnerable or endangered species have been found in the area (Iftime 2005b). Despite this fact and the fact that the borders of “Domogled-Valea Cernei” National Park are, in some points, this resort’s city limits, few references regarding the herpetofauna of this area exist, some of them being a few decades old (Fuhn 1960, 1969, 1975, Fuhn & Vancea 1961). Some of the more recent publications in the area include the work of Covaciu-Marcov et al. 2005, but this paper focused on the North-Western area of Caraş-Severin County, Popescu et al. 2003, describing *Vipera ammodyes* habitats from the “Iron Gates” National Park and Rozyłowicz et al. 2003, who focused on the distribution of *Testudo hermanni*, also in the “Iron Gates” National Park. Iftime (2005b) publishes an article on the distribution of the herpetofauna from the Cerna Valley, and some actual data regarding Baile Herculane resort can be found here.

Taking these aspect into consideration, the authors of the present paper aimed to investigate the distribution and composition of the herpetofauna in urban and peri-urban environments in Baile Herculane, determine the most serious threats related to human presence in the area and determine which species are most threatened by anthropogenic activity in the area.

Material and methods

Study area

The study area is represented by the town/balneal resort of Baile Herculane (Fig.1). It is situated in the south-western sector of Romania, in the county of Caraş-Severin, inside the Cerna river basin, whose valley the resort follows. The valley of Cerna is cut threw the calcareous Cerna Mountains. On the eastern side of the resort the distinctive Domogled Peak is clearly visible, covered in banatic black pine (*Pinus nigra banatica*) forests, endemic to this section of the Romanian territory. Cerna’s river basin is cut deep threw the Cerna Mountains and this allows for the submediteranean climate in the area, as warm currents are funneled up inside the steppe valley. The mild climate, along with the variety of habitats offered by the calcareous mountains, is responsible for a great herpetological diversity.

For this study we have divided the town in 4 sites with distinct types of habitats and anthropogenic activity.

Site A. The resort of Baile Herculane along with all urban areas and the Cerna River, with aquatic habitats, running threw the middle of the study site. We decided to consider the sector of Cerna that runs threw the resort of Baile Herculane as an urban habitat because, although it is not highly modified, it is subject to great anthropogenic impact and activity.

Site B. The road following the base of Domogled Mountain, from its entrance in Baile Herculane up to 7 Springs. This is a peri-urban habitat, characterized mostly by the forest margin of the massive deciduous forest covering Domogled Mountain on the right, and Cerna’s river basin on the right.

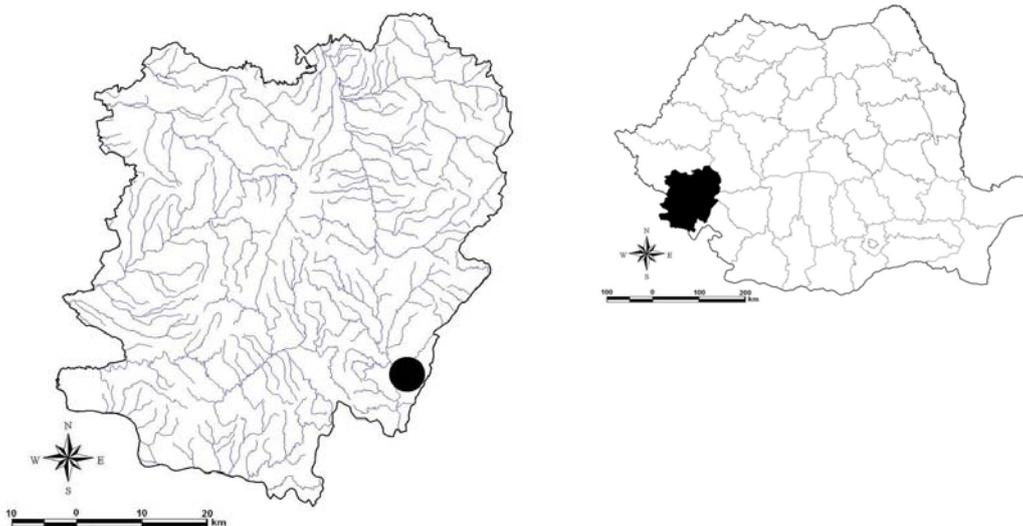


Figure 1. Geographic position of Caraş-Severin County in Romania and of Băile Herculane in Caraş-Severin County.

Site C. The steppe south-western slopes above Baile Herculane, close to the railway station. This area was selected as it is not covered in dense forest, hosting a variety of habitats: areas with grass vegetation and some bush vegetation, forest margins and calcareous rocky terrain covered in grass and scattered bushes from place to place.

Site D. The steppe slopes above Baile Herculane, close to Roman Hotel. We included this area in a particular site of its own for the habitat present here, unlike any in the other areas. It is covered in rare deciduous forest with fragmented rocky terrain and low thorny vegetation from place to place, bordered in some places by vertical calcareous walls. This habitat is quite inaccessible and would not typically be considered a peri-urban area but for one cave present here – “Grotă Haiducilor” which makes it an area with a high degree of anthropogenic impact. Also, climbers come here to practice cliff climbing on these vertical walls.

Study Methods

The study was conducted during 2003 – 2008. Several field trips were made (3 – 10 days long) by the authors during the following periods: August 2003, August 2005, June and August 2006, May 2008. The method used for mapping the herpetofauna was that of visual and auditory transects (Cogălniceanu 1997). Searches were performed throughout the day and some at dusk or at night, but the latter were shorter both in duration and distance covered.

Identification of animals was performed directly, animals being captured only if necessary. This operation was performed by hand and, in the case of venomous species (vipers) using snake hooks. All captured animals were photographed and released into their natural habitat. Information from local people was used, in some cases, but only for guidance purposes. Road kills and animals killed by locals also played a very important role in the present research.

Results and Discussions

During our study we observed 14 species belonging to the local herpetofauna, of which 4 species were amphibians: *Bombina variegata*, *Bufo bufo*, *Bufo viridis*, *Rana dalmatina*, and 10 species of reptiles: *Testudo hermanni*, *Lacerta viridis*, *Podarcis muralis*, *Darevskia praticola*, *Anguis fragilis*, *Natrix tessellata*, *Dolichophis caspius*, *Zamenis longissimus*, *Coronella austriaca*, *Vipera ammodytes* in the research area.

Site A. This area is represented by the town/resort of Baile Herculane itself and by the Cerna River. As can be seen from above (Tables 1, 2, Fig. 2), although highly urbanized and with intense anthropogenic activity, this area houses a significant number of amphibians and reptiles (7 species). Of these, some are known to be highly adaptable and have also been found in other cities in Romania, as with *Bufo viridis*, found in urban habitats in Oradea (Covaciu-Marcov et al. 2000, Sas et al. 2005), *Lacerta viridis*, found in different urbanized habitats around the country (Fuhn & Vancea 1961, Iftime 2005b) and *Podarcis muralis* reported from Baile Herculane as being adapted to areas with anthropogenic activity (Iftime 2005b). *Anguis fragilis* has been recorded to live in orchards, but we have found it at the edges of the forests bordering Baile Herculane resort and even on the sidewalks bordered by small to medium-sized trees, bushes or grass and leaf litter. It does not seem to be bothered by human activity too much and it thrives if given the right conditions.

Other species have entered the urbanized habitat of Baile Herculane as a result of habitat loss or habitat remodeling and integration as a part of the resort. *Natrix tessellata* can be found along the Cerna River even in its urban sector. This is because, in spite of intense human activity, the habitat has not been destroyed, only remodeled in some areas and in others it is intact and still suitable for this species in both cases. The dice snake seems to be highly adaptable and can live in all areas where it can find aquatic habitat, even in artificial pools (Sahlean & Strugariu, personal observations), although it is highly unlikely it will remain or survive there for a long period of time. From observations, this species seems to be in steady numbers all along the urban sector of the Cerna River.

Vipera ammodytes can be observed at the edges of Baile Herculane balneal resort as a result of habitat loss and continuous habitat destruction. The observed specimens were large males, probably both in search of food. These individuals probably appeared in such atypical habitats because their habitat had earlier been destroyed and completely leveled to make room for different tourist

attractions or houses. This species does not seem to be comfortable or adaptable in urban regions and has previously been cited as declining in the vicinity of human settlements due to misconceptions,

persecution and illegal trade (Iftime 2005a, b). Of the genus *Vipera*, only *Vipera berus* has been recorded as appearing sporadically in urban habitat from the city of Cluj-Napoca (Ghira et al. 2002).

Table 1. Distribution of the amphibian and reptile species in each of the studied areas.

Species	Site A	Site B	Site C	Site D
<i>Bombina variegata</i>	-	X	-	-
<i>Bufo bufo</i>	-	X	-	-
<i>Bufo viridis</i>	X	X	X	-
<i>Rana dalmatina</i>	-	X	-	-
<i>Testudo hermanni</i>	X	-	X	-
<i>Lacerta viridis</i>	X	X	X	X
<i>Podarcis muralis</i>	X	X	X	X
<i>Darevskia praticola</i>	-	X	-	-
<i>Anguis fragilis</i>	X	X	X	X
<i>Natrix tessellata</i>	X	X	-	-
<i>Dolichophis caspius</i>	-	-	X	-
<i>Zamenis longissimus</i>	-	X	-	-
<i>Coronella austriaca</i>	-	X	-	-
<i>Vipera ammodytes</i>	X	X	X	X
Total	14	Total 7	Total 12	Total 7
			Total 4	

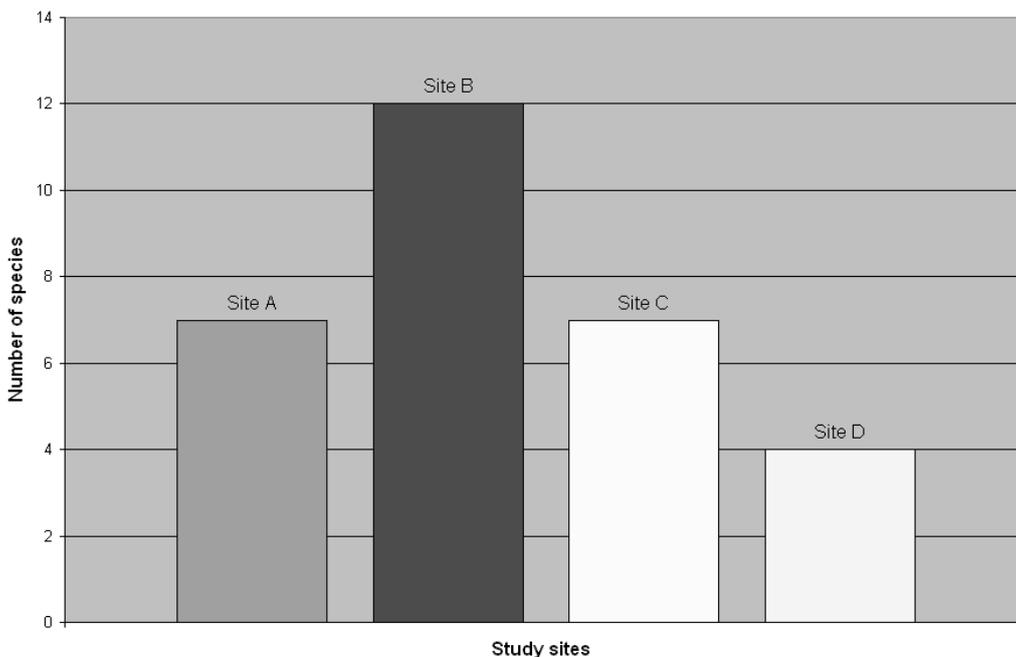


Figure 2. The number of species belonging to the local herpetofauna in each of the study sites.

Table 2. Habitat preferences of the amphibian and reptile species in the study area.

Species	Habitat type					
	Natural					Artificial
	Forest edge	Rocky terrain with covering vegetation	Meadows	Water edge or aquatic habitats	Forrest bodies	Man-made structures
<i>Bombina variegata</i>	-	-	-	X	-	X
<i>Bufo bufo</i>	X	-	-	-	-	-
<i>Pseudepidelea viridis</i>	X	X	X	-	-	X
<i>Rana dalmatina</i>	X	-	X	-	X	-
<i>Testudo hermanni</i>	X	X	X	-	-	X
<i>Lacerta viridis</i>	X	X	X	-	-	X
<i>Podarcis muralis</i>	X	X	-	X	-	X
<i>Darevskia praticola</i>	X	X	-	-	X	-
<i>Anguis fragilis</i>	X	X	X	-	X	X
<i>Natrix tessellata</i>	X	X	-	X	-	X
<i>Dolichophis caspius</i>	X	X	-	-	-	-
<i>Zamenis longissimus</i>	X	-	-	-	X	X
<i>Coronella austriaca</i>	X	X	-	-	-	X
<i>Vipera ammodytes</i>	X	X	-	-	-	X

Testudo hermanni has not been observed as appearing naturally in urban habitats from Baile Herculane. It was observed in one occasion roaming freely in the backyard of a hotel. This could be the result of collecting for tourist attraction purposes of the individuals or the species naturally occurred in the area and its habitat was destroyed when the hotel was built and the individuals were saved and reintroduced to the meadow that was designed here. But for this observation, no other individuals were identified in the rest of the urban area in *Site A*.

Site B. This area is represented by the peripheral road following the base of Domogled Mountain and, most of its way, the Cerna river basin from its entrance in Baile Herculane and up to 7 Springs. The main characteristic of this area is the drainage canal on the right protected by a concrete wall with forest margins, fragmented rocks and shrubs above it. This seems to compile a suitable habitat for a lot

of the herpetofauna seen in urban and peri-urban habitats of Baile Herculane, with a total of 12 species observed. The drainage holes at the base of the concrete wall offer good hiding places both for amphibians and reptiles and the water present in the drainage canal as a result of spring rain offer temporary breeding pools for some amphibian species.

Still, roads are considered one of the most significant anthropogenic modifications of terrestrial habitats in the past century (Trombulack & Frissell, 2000). As amphibians and reptiles are confined to moving through terrestrial habitats, they are likely to encounter considerable challenges and risks associated with this activity, especially in areas heavily modified by humans (Roe et al. 2006).

The first visible consequences of road networks and of traffic in the area are road kills. In *Site B* we have identified road kills among both amphibian and reptiles species (*Bufo bufo*, *Bufo viridis*, *Lacerta viridis*, *Natrix tessellata*, *Zamenis longissimus*, *Coronella*

austriaca), but most species of reptiles, probably because the number of reptiles in the area is greater and they tend to be much more active overall than amphibians.

Some of the reptiles found killed in the area were not a result of traffic, but a result of deliberate action, which in term is a result of certain myths, religious beliefs or poor education from family members or school. The road is frequently circulated by tourists following different paths to certain attractions or just having a walk. Although the concrete wall offers a good habitat and good basking spots for the local hereptofauna, it also makes it more visible for humans, some of which will not just settle to avoiding them. Of all species, snakes seem to be most vulnerable as they are considered all dangerous and are usually killed on sight, either venomous or not.

Another popular activity among local people or tourist is the collection of different amphibian and reptiles species for the illegal pet trade or for keeping at home as pets (Iftime 2001, 2005a, b, Strugariu et al. 2007).

Another way in which traffic is indirectly destructive to populations is by causing habitat fragmentation (Mader 1984, Lodé 2000). Habitat fragmentation may result in loss of genetic variation and an increased degree of population differentiation due to genetic drift (Fahrig & Merriam 1985, Hedrick 2000). Also, habitat fragmentation will reduce the re-introduction of lost alleles into the gene pool via immigration (Slatking 1987). In fact, loss and reduction in habitat size as well as interruption of gene flow among populations are recognized as some of the major threats to animal populations (Primack 2006, Vos & Chardon 1998).

Road kills may also affect populations by the fact that not enough individual make it to the other side of the road to supplement the loss of genetic diversity.

These aspects have been evidenced in various studies from North (Roe et al. 2006) and South America (Vega et al. 2000) and Europe (Lesbarrères

et al. 2006) and future studies in the area may evidence the same case for the road network here.

Site C. The south-western slopes above Baile Herculane, near the railway station host a variety of habitats and a significant number of species of amphibians and reptiles (7 species). Interestingly, this is the only site in our study area where *Testudo hermanni* was observed, probably because of the scattered trees with large openings that allow the presence of grass covering on which the turtles feed.

Still, this area has less reptile and amphibian species than *Site B*, although it hosts a wider variety of habitats. Amphibian species which are more affined to water are probably not well represented in the area because of the steppe configuration of slopes that do not allow for temporary pools to be formed, the only amphibian species observed in the area being *Bufo viridis*, a species known for its adaptability.

Another possible explanation for the small number of species in the area is the isolation of the area. From the amphibians and reptiles point of view this area is completely isolated, as it is surrounded by roads and massive deciduous forests, so few individuals can colonize the available habitats.

The main threat identified in the area is habitat destruction and fragmentation, as new areas are cleared to make room for different tourist attractions, houses or other constructions. More, the road at the base of these slopes may be responsible for poor habitat occupation by species belonging to the local herpetofauna by road kills and, possibly, population extinction, as the presence of the traffic in the area might have prevented gene flow and the re-introduction of alleles.

Site D. The steep slopes above Roman Hotel host no amphibian species and only 4 species of reptile. The possible explanation for the absence of amphibians in the area is the same as for *Site C*, and the small number of species is probably the result of habitat isolation and the occurrence of only one type of habitat.



Figure 3. Habitat destruction in Băile Herculane. An adult male *Vipera ammodytes* was found on the edge of this "ruine". (Photo by Al. Strugariu 2008)



Figure 4. Adult male *Vipera ammodytes* captured in the place depicted in Fig. 3 and relocated further from the human dwellings and the road. (Photo by Al. Strugariu 2008)



Figure 5. Dead *Vipera ammodytes*. Probably killed by road traffic. (Photo by Al. Strugariu 2006)



Figure 6. The injured tail of an adult male *Zamenis longissimus*. The animal died some hours after capture. (Photo by Al. Strugariu 2006)



Figure 7. Adult *Anguis fragilis* dead on road (photo by Al. Strugariu 2006).

Although isolated, this area is subject to intensive anthropogenic pressure throughout the year, numerous tourists coming to see "Grotta Haiducilor", a popular tourist attraction and other training to climb on the vertical walls towering above Roman Hotel.

The main threats detected here are deliberate killing of animals, as in the case of site B and collecting of animals for the illegal animals' trade or for keeping at home as pets. Another extremely destructive practice is the collection of numerous nose-horned vipers (*Vipera ammodytes*) sold every year to people misled by the promises of easy-made fortunes (Iftime 2005 a). Individuals are never brought back and most of them do not survive the first year of captivity.

Collecting for the pet trade or other means of unsustainable use of amphibians and reptiles has been documented in other areas of the world, the most noticeable case being of the ocellated mountain viper (*Vipera wagneri*), which was removed from the wild in large numbers, posing a serious threat to the survival of the species (Nilson et al. 1990). A similar situation can be observed with the populations of *Vipera ammodytes*, a species reported as common in the area a few decades ago (Fuhn & Vancea 1961, Fuhn 1969) and whose numbers are lower every year, being declared as endangered (EN) at a national level (Iftime 2005 a).

Conclusions

During our study 4 major types of anthropogenic threats were detected in the urban and per-urban habitats of Baile Herculane:

1.) Habitat deterioration in all of its forms: destruction, fragmentation and degradation which lead to losses in population numbers and, possibly, population differentiation by means of direct killings, genetic flow interruption and genetic drift.

2.) Unsustainable use is a major cause of many amphibians and reptiles' species decline. Most affected species in the area are *Testudo hermanni*,

collected and sold in various pet shops in Romania or other countries and *Vipera ammodytes*, collected both for illegal pet trade and for attempts of overnight profits.

3.) Environmental pollution – both reptiles and amphibians are highly sensitive to changes in habitat (Iftime 2001), and are heavily affected by various contaminants (Hall 1980, Fontenot et al. 1994), although the mechanisms through which these elements can lead to population-level effects are mostly unknown.

4.) Deliberate killing of animals – is the result of various popular or religious beliefs, preconceptions and various myths that are present at a local level or even on a national scale (Fuhn 1969, Nicoara 2003) or poor education received in family or school environment. This is a threat both to amphibians and reptiles, numerous individuals being killed annually. Of all herpetofauna, snakes are most threatened by these actions, because, independent of species, they are all considered dangerous and are, most often, killed on sight. Amongst the victims is *Anguis fragilis*, almost always mistaken for a snake and, obviously, treated in the same manner. This situation has also been reported in other areas of the country (Strugariu et al. 2007 a, b).

Generally, populations decline and loss is rarely the result of one threat, but mostly the cumulative effect of 2 or more factors (Gibbons et al. 2000).

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