

DIVERSITY OF THE BATRACHO- AND HERPETOFAUNA OF THE VRMAC HILL (MONTENEGRO)

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Diversity of amphibians and reptiles, as well as threat factors were investigated during last decade in the wide area of the Vrmac hill. Field methodology included active searching and visual observation of species along defined transects. In total, 29 species were recorded, what comprises about 54% of amphibian and reptile fauna known for Montenegro. Main threat factors for amphibians and reptiles in the area of Vrmac hill are: urbanization, habitat fragmentation and destruction, fires, illegal landfills, waste waters, direct killing by locals and road killing.

Key words: amphibians, reptiles, threat factors, coast, Montenegro

INTRODUCTION

Vrmac hill is situated in the inner part of the Boka Kotorska Bay on the border of two coastal municipalities, Tivat and Kotor. It has the shape of a

peninsula and extends in the NW-SE direction, about 8 km long and about 5 km wide, and consists of two elongated ridges that are broadly connected to the slopes of the Lovćen massif via the Trojica pass. The highest peak of the hill is Sveti Ilija (768 m a.s.l.). The coast of the peninsula is slightly indented and oval. The northern and eastern sides rise steeply directly above the sea, while the southern and western slopes are separated from the sea by the Tivat valley (Baština – pokretač razvoja, 2015).

Vrmac hill is characterized by specific geomorphological and hydrological forms. A typical Mediterranean climate is presented on the southern slopes up to an altitude of 400 m, while at higher altitudes, as well as on the northern side of the hill, a modified Mediterranean or sub-Mediterranean perhumid climate is present (Baština – pokretač razvoja, 2015).

The vegetation of the Vrmac hill consists of typical Mediterranean and sub-Mediterranean vegetation. The main types of Mediterranean vegetation on the Vrmac hill are: maquis, gariga, dry grasslands, pastures, chestnut forests and vegetation near the sea. The sub-Mediterranean vegetation mainly consists of the association *Rusco-Carpinetum orientalis*, which was created by the degradation of oak forests (Baština – pokretač razvoja, 2015). Anthropogenic habitats such as orchards, olive groves and vineyards are also present. All these habitats are very important from the perspective of amphibians and reptiles diversity.

While on the Tivat side of the Vrmac hill, atmospheric waters are collected through several natural watercourses – streams that flow into the Tivat Bay, on the Kotor side of hill only smaller springs (wells) with poor water capacity and old bisterias from the Austro-Hungarian era are registered (Baština – pokretač razvoja, 2015). Therefore, the Tivat part of the Vrmac hill is a very significant area in terms of the diversity of aquatic and semi-aquatic amphibian and reptile species.

The part of the Vrmac hill that belongs to the Municipality of Kotor is on the UNESCO World Heritage list. Due to natural, historical and cultural values, Municipalities of Kotor and Tivat in cooperation with Environmental Protection Agency have started with process to protect Vrmac hill as Nature Park.

The main goal of this paper is to present data about amphibians and reptiles diversity, as well as list of main threat factors to their populations in the wide area of the Vrmac hill which we collected in last decade. We also prepared literature review of published data about amphibians and reptiles diversity in area of Vrmac hill.

MATERIAL AND METHODS

Data about diversity of amphibians and reptiles on the Vrmac hill were collected during field survey in the last decade. Study area covered 37.3 km² (Fig. 1). Methodology included active searching and visual observation of species along defined transects as well as observation of road killed specimens. For aquatic turtles, traps – *hoop-nets* were used (Mali *et al.* 2014). Traps were baited with hot dogs, and checked on the end of each day. With bait, plastic bottles were placed inside the traps to ensure that they are on the surface of water body, so turtles caught in traps can breathe. For newts, hand nets and fisheries pots were used.

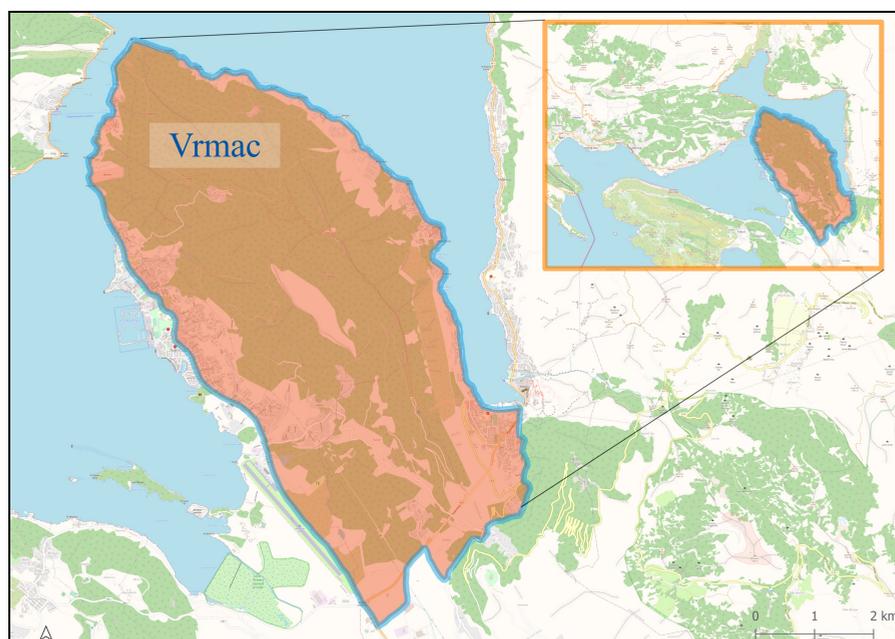


Fig. 1. – Investigated area, Vrmac hill.

Species identification was done according to standard herpetological literature (Arnold & Ovenden 2002, Speybroeck *et al.* 2016). Taxonomy and nomenclature were given according to Speybroeck *et al.* (2020). *Lacerta viridis-bilineata* complex which occur in the Western Balkans including Montenegro was threatened as *Lacerta viridis* complex because further taxonomy evaluation is required (Marzahn *et al.* 2016).

Literature review included published data in national and international papers as well as data from available studies and reports.

RESULTS AND DISCUSSION

Class **Amphibia** Linnaeus, 1758

Order **Caudata** Scopoli, 1777

Family **Salamandridae** Goldfuss, 1820

1. **Lissotriton graecus** (Wolterstorff, 1906)

In total, 21 individuals were recorded in freshwater habitats, e.g. channels, ponds, streams and even in bisteria near Fort Vrmac.

Order **Anura** Duméril, 1805

Family **Bombinatoridae** Gray, 1825

Genus **Bombina** Oken, 1816

2. **Bombina variegata** (Linnaeus, 1758)

In total, seven individuals were recorded in river Gradiošnica, in Lješkovački stream and in stream in Pasiglav.

Family **Bufo** Gray, 1825

Genus **Bufo** Garsault, 1764

3. **Bufo bufo** (Linnaeus, 1758)

In total, 35 individuals were identified from which 31 were road killed. All individuals were identified in the vicinity of freshwater habitats. Numerous tadpoles were identified in Lješkovački stream. Some individuals, all road killed, were recorded even during the winter (30.12.2018; 20.03.2019; 12.02-27.02.2020; 12.12.2020; 30.01.2021).

Genus **Bufo** Rafinesque, 1815

4. **Bufo viridis** (Laurenti, 1768)

Just one individual was recorded on wet meadow as well as one road killed individual in human settlement.

Family **Hylidae** Rafinesque, 1815

Genus **Hyla** Laurenti, 1768

5. **Hyla arborea** (Linnaeus, 1758)

A large population was recorded in canals in Tivat valley just near airport.

Family **Ranidae** Batsch, 1796

Genus **Pelophylax** Fitzinger, 1843

6. **Pelophylax ridibundus** (Pallas, 1771)

A huge number of individuals were recorded in freshwater habitats in Tivat valley, e.g. Tivat lake, river Gradiošnica, streams, canals and ponds.

Genus *Rana* Linnaeus, 1758

7. *Rana graeca* Boulenger, 1891

In total, eight individuals were recorded in streams.

Class **Reptilia** Laurenti, 1768

Order **Testudines** Linnaeus, 1758

Family **Emydidae** Rafinesque, 1815

Genus *Emys* Duméril, 1805

1. *Emys orbicularis* (Linnaeus, 1758)

In total, 35 individuals were recorded in freshwater habitats in Tivat valley: lake Tivat, river Gradiošnica, streams, canals and ponds, mainly on lower altitudes.

Family **Geoemydidae** Theobald, 1868

Genus *Mauremys* Gray, 1869

2. *Mauremys rivulata* (Valenciennes, 1833)

In total, 25 individuals were identified in freshwater habitats in Tivat valley: lake Tivat, river Gradiošnica, streams, canals and ponds, mainly on lower altitudes.

Family **Testudinidae** Batsch, 1788

Genus *Testudo* Linnaeus, 1758

3. *Testudo hermanni* Gmelin 1789

In total, 36 individuals were recorded in all terrestrial habitats: bushes, meadows, human settlements, road edges and degraded forests, mainly up to 500–600 m a.s.l. Also three road killed individuals were recorded.

Order **Squamata** Opperl, 1811

Family **Anguidae** Gray, 1825

Genus *Anguis* Linnaeus, 1758

4. *Anguis fragilis* complex

In total, eight individuals were recorded bellow stones and in gardens, as well as two road killed individuals.

Genus *Pseudopus* Pallas, 1775

5. *Pseudopus apodus* (Pallas, 1755)

In total, 17 individuals were recorded in all terrestrial habitats: bushes, rocky walls, meadows, human settlements, road edges and degraded forests, mainly up to 500–600 m a.s.l. Also seven road killed and one individual killed by locals were recorded.

Family **Gekkonidae** Oppel, 1811

Genus *Hemidactylus* Oken, 1817

6. *Hemidactylus turcicus* (Linnaeus, 1758)

Only three individuals were recorded in human settlements on house walls.

Family **Lacertidae** Batsch, 1788

Genus *Algyroides* Bibron & Bory, 1833

7. *Algyroides nigropunctatus* (Duméril and Bibron, 1839)

In total, eight individuals were recorded on rocky habitats covered with dense bushes and in open woods, mainly above 200 m a.s.l.

Genus *Dalmatolacerta* Arnold, Arribas, & Carranza, 2007

8. *Dalmatolacerta oxycephala* Duméril and Bibron, 1839

In total, seven individuals were recorded on karst rocks near old road Škaljari-Trojica which is just on border between the Vrmac hill and Lovćen massif. Two individuals were recorded even during the winter, on 13.03.2020 and 24.02.2022, basking on the sun.

Genus *Lacerta* Linnaeus, 1758

9. *Lacerta trilineata* Bedriaga, 1886

In total, 19 individuals were recorded in all terrestrial habitats: bushes, rocky walls, meadows, human settlements, road edges and degraded forests, mainly up to 600 m a.s.l. Also two road killed individuals were identified.

10. *Lacerta viridis* complex

Only one individual was recorded on wood edge at about 500 m a.s.l.

Genus *Podarcis* Wagler, 1830

11. *Podarcis muralis* (Laurenti, 1768)

Only two individuals were recorded near road edges on Kotor side of the hill.

12. *Podarcis melisellensis* (Braun, 1877)

In total, 33 individuals were recorded near road edges and on meadows in Tivat valley.

13. *Podarcis siculus* (Rafinesque-Schmaltz, 1810)

Only three individuals were recorded on the rock wall in human settlement Škaljari – Muo.

Family **Colubridae** Oppel, 1811Genus *Elaphe* Wagler, 183314. *Elaphe quatuorlineata* (Bonnaterre, 1790)

In total, six individuals were recorded, but five were road killed on local roads. One alive individual was recorded in open wood near stream.

Genus *Hierophis* Fitzinger, 183415. *Hierophis gemonensis* (Laurenti, 1768)

In total 11 individuals were recorded among all investigated area in all terrestrial habitats: stones, rocks, bushes, human settlements, road edges. Also three road killed, one individual killed by locals and one shedded skin were recorded. One alive individual was recorded even during the winter, on 30.01.2021, basking on the sun.

Genus *Platyceps* Blyth, 186016. *Platyceps najadum* (Eichwald, 1831)

In total, four individuals were recorded mainly on rocky habitats with low vegetation, as well as two road killed individuals.

Genus *Telescopus* Wagler, 183017. *Telescopus fallax* (Fleischmann, 1831)

Only two individuals were recorded in human settlements, as well as one road killed individual. One live individual was found by locals in their house during the night.

Genus *Zamenis* Wagler, 183018. *Zamenis longissimus* (Laurenti, 1768)

Only two individuals were recorded on wood edges just near human settlements.

19. *Zamenis situla* (Linnaeus, 1758)

In total three individuals were recorded mainly on rocky dry habitats with dense vegetation near human settlements, as well as two road killed individuals. Individuals with both morphs were recorded, *leopardinus* and *situla* morph.

Family **Natricidae** Bonaparte, 1840Genus *Natrix* Laurenti, 176820. *Natrix natrix* (Linnaeus, 1758)

In total, five individuals were recorded in freshwater habitats (e.g. canals, rivers, ponds, streams), as well as one road killed individual. Individuals with *natrix* and *persa* morf were recorded.

21. *Natrix tessellata* (Laurenti, 1768)

In total, five individuals were recorded in freshwater habitats (e.g. rivers and streams).

Family **Viperidae** Opperl, 1811

Genus *Vipera* Garsault, 1764

22. *Vipera ammodytes* (Linnaeus, 1758)

Only two individuals were recorded on rocky habitats covered with dense vegetation, as well as one individual killed by locals.

According to obtained results, 29 amphibian and reptile species were recorded in the study area, what comprises about 54% of amphibian and reptile fauna known for Montenegro. Upon literature sources, 54 amphibian and reptile species are officially confirmed for Montenegro (Jablonski *et al.* 2021, Gvozdrenović & Ikočić 2022, Ljubisavljević 2022, Čadenović *et al.* 2022). In this list, three potentially present species (*Proteus anguinus*, *Mediodactylus kotschy* and *Podarcis tauricus*) are not included (Polović & Ljubisavljević 2010, Gorički *et al.* 2017, Ljubisavljević *et al.* 2018). High species diversity which is obtained on Vrmac hill not surprising, as the karstic limestone mountains and coastal lowlands that line the eastern coast of the Adriatic Sea, including Montenegrin coast, represent a herpetologically diverse region (Speybroeck *et al.* 2016).

All recorded species belong to four orders (Anura, Caudata, Testudines and Squamata) and 14 families. In total, 337 specimens were recorded (without *Hyla arborea* and *Pelophylax ridibundus* individuals, as those species have numerous population in this area and observed individuals in some cases could not be counted). The highest number of recorded specimens belong to nine species: *Bufo bufo*, *Hyla arborea*, *Pelophylax ridibundus*, *Emys orbicularis*, *Mauremys rivulata*, *Testudo hermanni*, *Pseudopus apodus*, *Lacerta trilineata* and *Podarcis melisellensis*.

In total, 60 specimens were found road killed, while three more specimens were killed by locals (one *Pseudopus apodus*, one *Hierophis gemonensis*, one *Vipera ammodytes*). The highest number of road killed specimens belong to *Bufo bufo* (31 specimens). It is known that road traffic cause habitat fragmentation and leads to decrease of amphibian and reptile populations (Ikočić *et al.* 2022), as a large number of specimens are run over by a vehicles during their migrations. *Bufo bufo* is also known as one of the species which populations are the most affected by road traffic in central part of Montenegro (Ikočić *et al.* 2022), as well as the most killed species on European roads (Elzanowski *et al.* 2009).

During our investigation we observed three species active during the winter (December – March): *Bufo bufo* (12 individuals), *Dalmatolacerta oxycephala* (two individuals) and *Hierophis gemonensis* (one individual)

(Fig. 2) (see Appendices for more details). All *Bufo bufo* individuals were found road killed in vicinity of freshwater habitats. *Dalmatolacerta oxycephala* individuals were basking on karst stones during sunny and quite warm weather, while *Hierophis gemonensis* was basking on road edge also during sunny and warm weather conditions. It is known that most of ectothermic animals, including amphibians and reptiles, go into hibernation during the winter in order to overcome cold weather and low temperatures, but activity even during the winter is not surprising in recent years (e.g. Sas *et al.* 2012, Kaczmarek 2018, Koç *et al.* 2018, Altunişik 2019, Bülbül *et al.* 2019, Altunişik & Kara 2021, Özkan & Bülbül 2021). In recent years, reports about winter activity of amphibians and reptiles increased, what is very likely linked to the global warming. According to Altunişik & Kara (2021), documentation of these unusual winter events not only adds to the biological knowledge of the species, but also provides valuable preliminary evidence for analysing climate change patterns.



Fig. 2. – Winter activity of *Bufo bufo* 30.01.2021 (left), *Hierophis gemonensis* 30.01.2021 (middle) and *Dalmatolacerta oxycephala* 24.02.2022 (right) (photos: Slađana Gvozdenović Nikolić).

Literature review

Although Vrmac hill is situated on the coast with quite developed road infrastructure and numerous hiking trails, it has been poorly and partially herpetologically explored. Up to our knowledge, there are just several literature sources with very scattered data about amphibians and reptiles diversity.

Tomassini (1905) and Fritz (1995) reported presence of *Mauremys rivulata* along Tivat valley, while preliminary population characteristics of the same species for Tivat valley is given by Iković & Gvozdenović (2018). Džukić *et al.* (2017) described presence of several species in area of Vrmac hill: *Anguis fragilis* complex, *Hemidactylus turcicus*, *Algyroides nigropunctatus* and *Podarcis melisellensis*, while Ljubisavljević *et al.* (2018) reported several lizard species: *Hemidactylus turcicus*, *Algyroides nigro-*

punctatus, *Lacerta trilineata*, *Podarcis melisellensis*, *Podarcis siculus*, *Anguis fragilis* complex and *Pseudopus apodus*.

Molecular identification of green frogs in Tivat valley was done by Zimić *et al.* (2020), who underlined that those populations belonged to *Pelophylax kurtmuelleri*. As the validity of this species has not been accepted by the batrachologists (e.g. Crnobrnja-Isalović *et al.* 2018, Speybroeck *et al.* 2016, 2020) due to small genetic distance and the lack of clear morphology characteristics on the basis of which the *Pelophylax kurtmuelleri* could be distinguished from the *Pelophylax ridibundus* (Ljubisavljević & Ikočić 2020), we consider it as *Pelophylax ridibundus* in this paper.

In the study Baština – pokretač razvoja (2015) in total 15 amphibian and reptile species were provided for Vrmac hill: *Lissotriton graecus* (in the study it was given as *Lissotriton vulgaris*), *Pelophylax ridibundus*, *Bufotes viridis* (in the study it was given as *Pseudepidalea viridis*), *Hemidactylus turcicus*, *Podarcis muralis*, *Podarcis melisellensis*, *Dalmatolacerta oxycephala*, *Lacerta viridis*, *Dinarolacerta mosorensis*, *Pseudopus apodus*, *Zamenis longissimus*, *Zamenis situla*, *Elaphe quatuorlineata*, *Testudo hermanni* and *Vipera ammodytes*. Presence of the *Dinarolacerta mosorensis* on the Vrmac hill is doubtful. In addition to this is also a fact regarding species distribution in Montenegro (e.g. Ljubisavljević *et al.* 2018), as well as a photo from the mentioned study, which clearly shows other lizard species – *Algyroides nigropunctatus*. Also, in the study among photos, photo of juvenile *Pseudopus apodus* is wrongly given as *Elaphe quatuorlineata*.

Ljubisavljević (2022) reported presence of allochtone *Trachemys scripta scripta* in a pond at Lovanja (Tivat valley), as well as native *Mauremys rivulata*, while Mićanović *et al.* (2022) gave preliminary data about population size of *Emys orbicularis* and *Mauremys rivulata* in Tivat valley.

Threat factors

During field survey in the area of Vrmac hill different threat factors for amphibian and reptile populations were identified: urbanization, habitat fragmentation and destruction, fires, illegal landfills, waste waters, direct killing by locals and road killing.

Habitat loss and fragmentation were suggested to have reduced biodiversity by up to 75% around the world in last 30 years (Haddad *et al.* 2015). Urbanisation, habitat fragmentation and road killing are very closely related factors, which today more than ever, lead to decrease of amphibian and reptile populations and diversity loss (Elzanowski *et al.* 2009, French *et al.* 2018, Vujović *et al.* 2015, Anđelković & Bogdanović 2022, Ikočić *et al.*

2022). Although Vrmac hill is still quite preserved area, in last 10 years urbanisation has been gaining momentum, so urgent protection of this area is required. It is known that some species, e.g. *Bufo bufo* and *Testudo hermanni*, are highly impacted by urbanisation. *Bufo bufo* is the most common road killed species on Vrmac hill in this study. The intensity of the urbanisation on Vrmac hill can be rated as medium to high. Some road killed amphibian and reptile species recorded during field work on Vrmac hill are presented on Fig. 3.



Fig. 3. – Some road killed species identified during field work on Vrmac hill; up left – *Zamenis situla*; down left – *Elaphe quatuorlineata* juvenile; up middle – *Bufo bufo*; down middle – *Testudo hermanni* juvenile; up right – *Telescopus fallax*; down right – *Lacerta trilineata* (photo: Slađana Gvozdrenović-Nikolić).

Fires are second common trait factor on Vrmac hill, especially during warm period of the year. Fires can be devastating for slow moving species such as *Testudo hermanni* (Vujović *et al.* 2015). Climate changes can be addressed as one cause of fires, but also intentional burning. Almost every summer season, small or large fires break out on the Vrmac. One of the biggest fire appeared ten years ago, when huge south-west part of the hill was devastated. The effects of that fire are still visible on the vegetation that is in the recovery phase. The intensity of the fires on Vrmac hill can be rated as medium to high. On Fig. 4 fires on Vrmac hill are presented.



Fig. 4. – Fires on Vrmac hill (left photo: Slađana Gvozdrenović-Nikolić; right photo: <https://google.com>).

Illegal landfills as well as waste waters are third threat factor on Vrmac hill. In Montenegro, illegal landfills and waste waters are result of negligent behaviour of humans, and lack of legislations which address this issue. Landfills can cause degradation and habitat loss, especially when we have in mind freshwater habitats, while waste waters cause changes of physical, chemical and biological characteristics of freshwaters, where amphibians are under huge negative impact, especially their eggs and larvae (Zeitler *et al.* 2021). Intensity of the waste on Vrmac hill can be rated as low to medium. Waste on Vrmac hill identified during field work is presented on Fig. 5.



Fig. 5. – Waste on Vrmac hill (photo: Slađana Gvozdenović-Nikolić).

Some recommendations in order to reduce above mentioned pressures are:

1. Urbanization – it is necessary to prevent or mitigate the possible devastation of important habitats with certain measures, and to clearly define the areas/regions where it is possible to build and where not;
2. Fires – greater responsibility of local government, better institutional cooperation and greater budgetary resources are necessary in order to reduce the consequences of fires to the lowest possible level. Although climate changes are a global problem, measures to mitigate it should be adopted and implemented;
3. Waste – national regulations are necessary, which includes a ban, enhanced controls and punishment for illegal disposal of solid waste. For wastewaters, national regulations are necessary for the

regulation and adequate treatment of wastewaters that primarily comes from households and business entities.

Acknowledgement

This work was supported by the several projects: “Natura 2000 in Montenegro” implemented by Environmental Protection Agency of Montenegro; “Protection study for Vrmac hill” implemented by Environmental Protection Agency of Montenegro; “Promoting protected areas management through integrated marine and coastal ecosystems protection in coastal area of Montenegro” implemented by Ministry of Ecology, Spatial Planning and Urbanism of Montenegro; “Checking the distribution and populations’ status of the highly endangered Balkan Terrapin (*Mauremys rivulata*) in Montenegro”; “Determination of the degree of vulnerability and distribution Balkan Terrapin in Montenegro” and “Assessment of demographic structure and protection measures of the Balkan Terrapin (*Mauremys rivulata*) in Montenegro” implemented by NGO Montenegrin Ecologists Society. Many thanks to Jelena Popović who provided the map of the study area in GIS program. The author also thanks to reviewers who improved the paper with constructive comments.

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SUPPORTING INFORMATION

Online Appendices:

Appendix 1. – Batracho- and Herpetofauna, Vrmac.

ДИВЕРЗИТЕТ БАТРАХО- И ХЕРПЕТОФАУНЕ БРДА ВРМАЦ (ЦРНА ГОРА)

СЛАЂАНА ГВОЗДЕНОВИЋ-НИКОЛИЋ, ВУК ИКОВИЋ

Р Е З И М Е

Диверзитет водоземаца и гмизаваца, као и фактори угрожавања истраживани су током последње деценије на ширем подручју брда Врмац. Методологија је била заснована на активном тражењу и визуелном бележењу врста дуж дефинисаних трансеката. Укупно је забележено 29 врста, што представља удио од 54% у укупном броју до сада забележених врста водоземаца и гмизаваца у Црној Гори. Главни фактори угрожавања популација водоземаца и гмизаваца на подручју брда Врмац су: урбанизација, фрагментација и уништавање станишта, пожари, дивље депоније, отпадне воде, директно убијање од стране локалног становништва, као и страдање на путевима.