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EXPLORING THE BATRACHO- AND HERPETOFAUNA RICHNESS OF MOJSTIRSKO-DRAŠKE MOUNTAINS

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ABSTRACT. The amphibian and reptile species inhabiting the Mojstirsko-Draške Mountains have not been thoroughly studied yet. From 2013 to 2018, a comprehensive field study effort documented a total of 20 species, comprising eight amphibian species and 12 reptile species. Based on Sorensen's coefficient of similarity, this area closely resembles other locations in the Republic of Serbia. The presence of species was determined through direct observation of adult or larval forms, identification of distinctive markings, and the detection of clusters of deposited eggs or larvae. The majority of documented amphibian and reptile species are subject to severe protection under national laws, mostly due to various anthropogenic influences that contribute to their declining populations. The results given are preliminary, although they make a substantial contribution to the understanding of the local fauna. Additional field research must be conducted, and a system of active monitoring should be implemented.

Keywords: Mojstirsko-Draške Mountains, amphibians, reptiles, similarity coefficient

INTRODUCTION

Amphibians and reptiles play a crucial role in indicating the overall health of an ecosystem because of their distinctive lifestyles and positions in food chains. Amphibians are primarily semiaquatic animals that have evolved to thrive in diverse environments, encompassing both water and land. They utilize their skin as a respiratory surface, and due to its permeability, it can readily absorb contaminants. Amphibians initiate their life cycle by depositing eggs, which undergo development into larvae in water and subsequently transform into adult organisms that inhabit the land, thereby establishing a link between aquatic and terrestrial environments (DUELLMAN and TRUEB, 1986; WELLS, 2007; CRUMP, 2010). The vulnerability of amphibians to changes in environmental conditions, stemming from their permeable skin and complex life history, is the primary factor contributing to their status as the most endangered group of animals worldwide (BISHOP *et al*., 2012). Furthermore, their

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significance in food chains means that their endangerment also has repercussions on the structure and dynamics of other ecosystems (RANVESTEL *et al*., 2004).

Recent estimates by the International Union for Conservation of Nature (IUCN, 2018) are that almost 41% of all amphibian species are endangered.

According to UROŠEVIĆ *et al*. (2022) in the Republic of Serbia, there are 22 species of amphibians, among which 14 species are anurans (order Anura) and eight species are tailed amphibians (order Caudata). Various factors that affect the populations of amphibians, both globally and in our country, are alteration, destruction, fragmentation, or degradation of habitats, also drying of wet habitats, deforestation, urbanization, and agricultural development in protected and unprotected areas (COLLINS and STORFER, 2003; KRIZMANIĆ *et al*., 2015).

In terms of conservation, reptiles are very important, both because of their role in ecosystems (as predators or prey), and because of their sensitivity to even the smallest changes in the environment (AJTIĆ *et al*., 2015). Populations of some reptiles (snakes) can indicate e.g. fluctuations in populations of small rodents and, to some extent, reflect the state of entire ecosystems. Also, snakes that consume fish and amphibians can be a good indicator of the condition of aquatic ecosystems (CAMPBELL and CAMPBELL, 2001). The specific biology and ecology of reptiles are the reason why these animals have narrower areas of diversity compared to other vertebrates. The result of the combination of narrow areas and the specific ecological requirements of this group is their exceptional susceptibility to various anthropogenic influences (AJTIĆ *et al*., 2015). According to data from the IUCN (2018) 21% of reptile species are at risk of extinction and have the status of endangered or vulnerable species.

UROŠEVIĆ *et al*. (2022) noted that in the Republic of Serbia, there are 26 autochthonous reptile species: three species of chelonians (order Testudines), 13 species of lizards (suborder Lacertilia) and 10 snake species (suborder Serpentes). Even though reptiles are found throughout its territory, Serbia is one of the least researched European countries. Serbia is home to close to 35% of all Balkan reptile species. Even though, comprehensive studies of distribution patterns, species diversity, and zoogeographic analysis of the herpetofauna of our country have been rarely done before (TOMOVIĆ *et al*., 2014).

The most significant factors threatening reptiles in Serbia are habitat loss and degradation, disturbance by humans, natural disasters, and biological (internal) factors (AJTIĆ *et al*., 2015).

The mountain terrain of Mojstirsko-Draške Mountains is inherently valuable due to its combination of elevated surfaces at watersheds, deeply incised river valleys, open grassy areas, and fertile pastures (Fig. 1). Tectonic processes can be inferred from geological characteristics that can be dated back to the conclusion of the Jurassic period. Given its topography and geographical location, it undeniably qualifies as a significant hub of biodiversity in Serbia as a whole (BELIJ, 1999; BELIJ, 2003; ANTONOVIĆ, 2003; ŠEHOVAC, 2003).

Figure 1. Typical landscape of Mojstirsko-Draške Mountains (photo by R. Ajtić, 2015).

The broader region of the Mojstirsko-Draške Mt. has been subject to limited research. The majority of the research conducted, particularly in recent years, has been fragmented and lacking a systematic approach.

The primary objective of this paper is to provide comprehensive data on the diversity of amphibians and reptiles in the understudied area. Additionally, we aim to present a list of the primary factors that pose a threat to their populations in the expansive mountain region. The data presented in this paper was collected over the past decade.

Also, one of the objectives of this article is to assess the resemblance between the richness of batracho- and herpetofauna in this region and that of other comparable regions within our country.

MATERIALS AND METHODS

Investigated area

The Nature Park "Mojstirsko-Draške Mountains" encompasses a portion of the mountainous region in the southwest of Serbia, situated between the Ibar River and the Metohija Basin. It extends further to the south and southeast, reaching the Prokletije massif (Fig. 2).

From an orographic perspective, these mountains are located in the far northeastern region of Prokletije. Geotectonically, they are part of the inner Dinarides. The Mojstirsko-Draške Mt. consists of an elevated block of limestone situated above the Metohija basin (BELIJ, 1999; ŠEHOVAC, 2003).

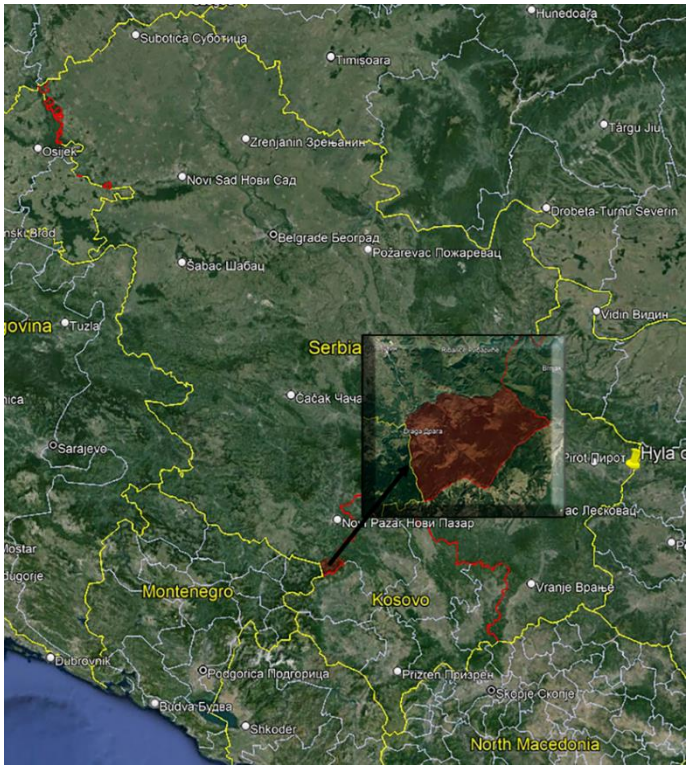

Figure 2. Research area of Mojstirsko-Draške Mountains (https://earth.google.com/).

Data collection

The majority of data was gathered from field surveys conducted from 2013 to 2018. Every species was recorded by directly observing them or catching them. Aside from directly observing adult and/or juvenile animals, including their larval forms, and recording their distinct vocalizations (in the case of anuran amphibians), indirect methods were also employed. These methods included identifying groupings of laid eggs (for anurans) and tracking molts (for

snakes). To maximize species observation, a comprehensive search was conducted across various habitat types over the whole activity period of amphibians and reptiles (from early spring to late fall) using the transect method.

Specimens were identified using standard literature (ARNOLD and OVENDEN, 2002; SPYBROECK *et al*., 2016). Taxonomy and current nomenclature were given according to UROŠEVIĆ *et al*. (2022).

Similarity index

Sorensen's index of similarity (SØRENSEN, 1948) was employed to assess the resemblance between the batracho- and herpetofauna in the Mojstirsko-Draške Mountains and other regions. This index is quite prevalent in ecological studies and provides a straightforward tool for comparing the species composition of two communities. The calculation is determined by the number of shared species between two communities and the number of species that are unique to each community.

Sorensen's Index of similarity can be calculated with formula:

$$s_s = \frac{2a}{2a+b+c} \quad (1)$$

where s_s is Sorensen's similarity coefficient; a is the number of species in sample A and sample B (joint occurrences); b is the number of species in sample B, but not in sample A; and c is the number of species in sample A, but not in sample B.

The comparison was made with five other areas in Serbia, including Rudnik and Golija Mountains, Sićevačko-Jelašnička George, Avala, and Radan Mountains, for the batracho- and herpetofauna separately. These five areas were selected because there is existing data on the fauna of amphibians and reptiles (SIMOVIĆ *et al*., 2013; ĆIRKOVIĆ *et al*., 2022; and authors unpublished data).

RESULTS AND DISCUSSION

List of amphibians and reptiles detected in the investigated area.

Class **Amphibia** Linnaeus, 1758
Order **Caudata** Scopoli, 1777 or **Urodela** Duméril, 1805
Family Salamandridae Goldfuss, 1820
Genus *Ichthyosaura* Sonnini and Latreille, 1801
1. *Ichthyosaura alpestris* (Laurenti, 1768) – Alpine Newt
Genus *Salamandra* Garsault, 1764
2. *Salamandra salamandra* (Linnaeus, 1758) – Fire Salamander

Order **Anura** Duméril, 1805
Family Bombinatoridae Gray, 1825
Genus *Bombina* Oken, 1816
3. *Bombina variegata* (Linnaeus, 1758) – Yellow-bellied Toad

Family Bufonidae Gray, 1825
Genus *Bufo* Garsault, 1764
4. *Bufo bufo* (Linnaeus, 1758) – Common Toad
Genus *Bufotes* Rafinesque, 1815
5. *Bufotes viridis* (Laurenti, 1768) – Green Toad

Family Ranidae Batsch, 1796
Genus *Pelophylax* Fitzinger, 1843
6. *Pelophylax ridibundus* (Pallas, 1771) – Marsh Frog

Genus *Rana* Linnaeus, 1758
7. *Rana dalmatina* (Fitzinger in Bonaparte, 1838) – Agile Frog
8. *Rana temporaria* (Linnaeus, 1758) – Common Frog

Class **Reptilia** Laurenti, 1768
Order **Squamata** Oppel, 1811
Family Lacertidae Batsch, 1788
Genus *Lacerta* Linnaeus, 1758
1. *Lacerta agilis* (Linnaeus, 1758) – Sand Lizard
2. *Lacerta viridis* (Laurenti, 1768) – Eastern Green Lizard
Genus *Podarcis* Wagler, 1830
3. *Podarcis muralis* (Laurenti, 1768) – Common Wall Lizard
Genus *Zootoca* Wagler, 1830
4. *Zootoca vivipara* (Jacquin, 1787) – Viviparous Lizard

Family Anguidae Gray, 1825
Genus *Anguis* Linnaeus, 1758
5. *Anguis fragilis* (Linnaeus, 1758) – Slow Worm

Family Natricidae Bonaparte, 1840
Genus *Natrix* Laurenti, 1768
6. *Natrix natrix* (Linnaeus, 1758) – Grass Snake
7. *Natrix tessellata* (Laurenti, 1768) – Dice Snake

Family Colubridae Oppel, 1811
Genus *Coronella* Laurenti, 1768
8. *Coronella austriaca* (Laurenti, 1768) – Smooth Snake
Genus *Zamenis* Wagler, 1830
9. *Zamenis longissimus* (Laurenti, 1768) – Aesculapian Snake

Family Viperidae Oppel, 1811
Genus *Vipera* Garsault, 1764
10. *Vipera ammodytes* (Linnaeus, 1758) – Nose-horned Viper
11. *Vipera berus* (Linnaeus, 1758) – Adder
12. *Vipera ursinii* (Bonaparte, 1835) – Meadow Viper

Out of all the listed batracho and herpetofauna species, only three species (*P. muralis*, *L. viridis* and *A. fragilis*) are not covered by the national legislation on species protection. Species *V. ammodytes* and *P. ridibundus* are protected by national legislation, and all others are strictly protected.

According to the obtained results, 20 amphibian and reptile species were recorded in the study area, which comprises 46.67% of amphibian and reptile fauna known in the Republic of Serbia. One characteristic related to these two groups of animals is that some species can only be found in a very small area and nowhere else in Serbia. Such is the case with one species of snake (*V. ursinii*) (Fig. 3). This species used to have a much larger distribution, but now it can only be found on the slopes of the Šar Mountains and the Mojstirsko-Draške Mt. The condition of many species of amphibians and reptiles in the Mojstirsko-Draške Mt. is not favorable today. The most pronounced threatening factors for these species are habitat destruction by construction, poaching, harassment, and careless and uncontrolled use of chemical agents in agriculture, which causes the death of animals.

The most frequently recorded reptile species were *P. muralis* and *L. viridis* in lower, and *L. agilis* in higher altitudes. The rarest recorded species was *V. ammodytes*.

Figure 3. *Vipera ursinii* detected on the Mojstirsko-Draške Mountains (photo by R. Ajtić, 2015).

Sorensen's similarity coefficient has shown high values between Mojstirsko-Draške Mt., and all compared areas (Tab. 1), both for amphibian and reptile fauna, although the biggest similarity of batracho- and herpetofauna of Mojstirsko-Draške Mt. is with Golija Mountain (Sorensen's coefficient value 0.84 for amphibians, and 0.87 for reptiles). The reason for this can be that Golija Mountain is geographically close to the investigated area, and there is a resemblance in ecosystems in these two mountain regions. Also, the ecological and environmental conditions are similar.

Table 1. Sorensen's similarity coefficient.

		RK	**GO**	**SJ**	**AV**	**RD**
Amphibians	MD	0.80	0.84	0.75	0.75	0.71
Reptiles	MD	0.67	0.87	0.72	0.64	0.60

MD – Mojstirsko-Draške Mountains, RK – Rudnik Mountain, GO – Golija Mountain, SJ george – Sićevačko-Jelašnička george, AV – Avala Mountain, RD – Radan Mountain.

Despite its natural beauty and biodiversity, Mojstirsko-Draške Mt. face various conservation challenges. Habitat loss due to human activities such as logging and agriculture poses a significant threat to the region's wildlife, including its batracho- and herpetofauna populations. Additionally, pollution and climate change further exacerbate these challenges, putting pressure on fragile ecosystems and pushing vulnerable species to the brink.

Efforts to conserve and protect Mojstirsko-Draške Mt. are underway, with initiatives focusing on habitat restoration, wildlife monitoring, and community engagement. By raising awareness and implementing sustainable conservation practices, there is hope that this unique mountain range and its diverse inhabitants will continue to thrive for generations to come.

Our data provide a valuable contribution to the understanding of the amphibian and reptile fauna in this area, although they do not fully capture the complete picture. In order to determine the location and layout of the wintering habitats of amphibians and reptiles, evaluate the population size and health, and identify the breeding sites of amphibians, it is essential to conduct further field investigations and implement a comprehensive system of active monitoring.

CONCLUSION

The area of Mojstirsko-Draške Mountains is very important for biodiversity, due to its complex combination of ecosystems. Batracho- and herpetofauna of the Mojstirsko-Draške

Mountains encompasses 20 species: two species of tailed amphibians (order Caudata), six species of anurans (order Anura), five species of lizards (suborder Lacertilia) and seven species of snakes (suborder Serpentes). Recorded species of amphibians and reptiles during the research period on this mountain are just a confirmation and initial step in exploring the fauna richness in this area. To gather detailed information and to acquire the right picture of biodiversity on Mojstirsko-Draške Mt. it is important to conduct long-term research at several levels.

One of the most important steps suggested to protect the populations of amphibians and reptiles in Serbia is the implementation of legal rules, ensuring their accurate, timely, and deliberate enforcement. Despite Serbia's relatively comprehensive nature conservation legislation, non-compliance with legal regulations and provisions remains one of the fundamental problems in implementing conservation measures. The realization of the provisions in the mentioned laws has not yet fully materialized.

We identify education and communication as fundamental measures in conjunction with the modification and improvement of legal frameworks for the protection of amphibians and reptiles. The primary objective of education within the context of reptile conservation is to enhance knowledge and awareness regarding the necessity of preserving these two groups of animals.

The fundamentals of protecting amphibian and reptile populations in Serbia are inseparable from the preservation or revitalization of disturbed and destroyed habitats. They are based on measures that primarily involve planned and active protection of endangered habitats, as well as the revitalization of destroyed habitats, especially those that represent centers of diversity for these two groups.

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