CONTRIBUTION TO KNOWLEDGE OF BATRACHO- AND HERPETOFAUNA OF SOUTHERN AND SOUTH-EASTERN SERBIA

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We present the updated distribution of batracho- and herpetofauna in southern and south-eastern Serbia, based on literature and new field records for 16 amphibian and 22 reptile species. In these two biogeographic regions, already recognized as biodiversity hotspots, we discovered two new amphibian species with limited distribution: *Hyla orientalis* and *Pelobates balcanicus*. Also, one species (*Triturus ivanbureshi*) has restricted distribution, while one (*Bombina bombina*) is rare. Four reptile species have limited distributions and six are rare in these regions. The presence of hybrid zones and the influence of the Mediterranean climate make southern and south-eastern Serbia areas of great importance and the target for future ecological and conservation studies in Serbia.

**Key words:** Amphibians, Reptiles, biodiversity
INTRODUCTION

It is generally known that a comprehensive knowledge of the biodiversity of a certain region is the most important and mandatory step that precedes ecological, biogeographic and conservation studies. Therefore, systematic faunistic studies are of increasing importance, especially in the regions (or countries) with incomplete data on the species distribution (Margules et al. 2002). Detailed distribution data are crucial for identifying biodiversity “hotspots” i.e. areas with exceptional species compositions, high levels of endemism and/or areas under significant threats (Gaston et al. 2002).

The most recent publications of the complete batracho- and herpetofauna of Serbia provided broad overviews of distributions of amphibian and reptile species, without precise distribution records (Vukov et al. 2013, Tomović et al. 2014). The complete fauna was recently published for Kosovo & Metohija province only (Tomović et al. 2018), while for other biogeographic regions the precise data on batracho- and herpetofaunal diversity are generally missing.

According to our knowledge, the studies which focused on batracho- and herpetofauna of southern and south-eastern Serbia were published for particular areas: Vranje (Nedeljković 1958), Leskovac (Janjić 1969), Grdelička gorge (Stamenković 1970), Lebane (Stanković 2005) and for Bosilegrad (Sterijovski 2014).

Southern and south-eastern Serbia were already identified as regions with a relatively high diversity of amphibian and reptile species. Out of 21 amphibian species occurring in Serbia, 12 and 14 species were recorded in southern and south-eastern Serbia, respectively (Kalezić et al. 2015). Furthermore, a very high diversity of reptiles, with 17 and 19 species (out of a total of 24 species) in these two regions was recorded (Tomović et al. 2015a). New reptile species for Serbian fauna were discovered particularly in southern and south-eastern Serbia: Platyceps najadum (Crnobrnja-Isailović & Aleksić 1999), Elaphe quatuorlineata (Ristić et al. 2006), Testudo graeca (Tomović et al. 2004, Ralev et al. 2012) and Lacerta trilineata (Andelković et al. 2022).

Several species- or group-oriented papers provided complete distribution summaries and filled up the gap concerning the distribution of amphibians and reptiles in southern and south-eastern Serbia: Triturus spp. (Vučić et al. 2020), Hyla spp. (Urošević et al. 2022a), Rana spp. (Urošević et al. 2018), Emys orbicularis (Krizmanić et al. 2015, Golubović et al. 2017), Testudo graeca (Tomović et al. 2019a), Testudo hermanni (Ljubisavljević et al. 2014, Golubović et al. 2019), Ablepharus kitaibelii (Ljubisavljević et al. 2015), Anguis fragilis complex (Urošević et al. 2020),...
Lacertidae (Urošević et al. 2015), Colubridae (Tomović et al. 2015b) and Viperidae (Tomović et al. 2019b). However, data concerning the precise distribution of common and generally widespread amphibian species (e.g. Bombina variegata, Bufo bufo, Bufotes viridis, Pelophylax ridibundus,

Fig. 1. – Division of biogeographic regions of Serbia proposed by Stevanović (1992), and accepted by Kalezić et al. (2015) and Tomović et al. (2015b).
Ichthyosaura alpestris, Lissotriton vulgaris and Salamandra salamandra) are relatively poor and scattered.

Therefore, with this study we aim to: (i) publish a complete dataset of distribution records of amphibian and reptile species in southern and south-eastern Serbia, summarizing previously published and new distribution data, and (ii) provide standardized 10 × 10 km UTM maps of the summarized data.

MATERIALS AND METHODS

The data was collected from various sources and included: 785 distribution records (386 new and 399 published data) for 16 amphibian species and 916 distribution records (264 new and 652 published data) for 22 reptile species in southern and south-eastern Serbia.

For each species, the new distribution records (with broad locations, exact localities, toponyms, UTM's, geographic coordinates, altitudes, observer/legator names who provided data, dates and years of observation) are given in Appendix 1. Data from the literature (with broad locations, exact localities, toponyms, UTM's and literature/internet sources) are presented in Appendix 2.

The data was mapped on the standard 10 × 10 km UTM grid. For delineation of southern and south-eastern Serbia, we used the standard division of biogeographic regions of Serbia proposed by Stevanović (1992), and accepted by Kalezić et al. (2015) and Tomović et al. (2015b) (Figure 1).

RESULTS

In Figures 2–8, detailed distribution records of all amphibian and reptile species found in southern and south-eastern Serbia are provided.

According to our dataset, two new amphibian species were recorded in these two biogeographic regions: eastern tree frog (Hyla orientalis) in south-eastern Serbia and Balkan spadefoot toad (Pelobates balcanicus) in southern Serbia. The most widespread (i.e. more than 20 UTM's) amphibian species in southern and south-eastern Serbia are: fire salamander (Salamandra salamandra – 41), yellow-bellied toad (Bombina variegata – 38), marsh frog (Pelophylax ridibundus – 33), Greek stream frog (Rana graeca – 28), common toad (Bufo bufo – 26), agile frog (Rana dalmatina – 26), Macedonian crested newt (Triturus macedonicus – 25) and green toad (Bufotes viridis – 25). Relatively common species (i.e. between 10 and 20 UTM's) are:
Fig. 2. – Distribution records of amphibian species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
Fig. 3. – Distribution records of amphibian species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
Fig. 4. – Distribution records of amphibian species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
**Emys orbicularis**

**Ablepharus kitaibelii**

**Testudo graeca**

**Anguis fragilis**

**Testudo hermanni**

**Darevskia praticola**

Fig. 5. – Distribution records of reptile species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
Fig. 6. – Distribution records of reptile species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
Fig. 7. – Distribution records of reptile species in southern and south-eastern Serbia; red dots – confirmed published data; red-black dots – published data; red-white dots – new data.
smooth newt (*Lissotriton vulgaris* – 19), Alpine newt (*Ichthyosaura alpestris* – 18), common frog (*Rana temporaria* – 13) and tree frog (*Hyla arborea* – 10). Species with very limited distribution (i.e. less than 10 UTMs) are: eastern tree frog (*Hyla orientalis* – 5) and Balkan crested newt (*Triturus ivanbureschi* – 2). Amphibian species with only one record (UTM) in southern and south-eastern Serbia are: fire-bellied toad (*Bombina bombina*) and Balkan spadefoot toad (*Pelobates balcanicus*) (Figures 2–4).

Among reptiles, the most common (i.e. more than 20 UTMs) species in southern and south-eastern Serbia are: wall lizard (*Podarcis muralis* – 46), green lizard (*Lacerta viridis* – 44), Hermann’s tortoise (*Testudo hermanni* – 41), grass snake (*Natrix natrix* – 31), slow-worm (*Anguis fragilis* – 27), Caspian whip-snake (*Dolichophis caspius* – 25), Aesculapian snake (*Zame-
nis longissimus – 25), nose-horned viper (Vipera ammodytes – 23) and smooth snake (Coronella austriaca – 22). Relatively common species (i.e. between 10 and 20 UTM) are: dice snake (Natrix tessellata – 17), snake-eyed skink (Ablepharus kitaibelii – 15) and Balkan wall lizard (Podarcis tauricus – 11). Species with limited distribution (i.e. between 5 and 10 UTM) are: sand lizard (Lacerta agilis – 9), Erhard’s wall lizard (Podarcis erhardii – 9), adder (Vipera berus – 9) and European pond turtle (Emys orbicularis – 8). Rare reptile species (i.e. less than 5 UTM) are: Greek tortoise (Testudo graeca – 4), Dahl's whip snake (Platyceps najadum – 4), Balkan green lizard (Lacerta trilineata – 3), meadow lizard (Darevskia praticola – 2), viviparous lizard (Zootoca vivipara – 2) and four-lined snake (Elaphe quatuorlineata – 2) (Figures 5–8).

DISCUSSION

According to the latest update, the Serbian batracho- and herpetofauna consist of 48 autochthonous species, with 22 amphibians and 26 reptiles (Urošević et al. 2022b).

A review of the published data (Džukić et al. 2005, Vukov et al. 2013, Urošević et al. 2022a) revealed that there are two new species of batrachofauna of southern and south-eastern Serbia: Hyla orientalis and Pelobates balcanicus. Thus, in these regions, there are now 16 amphibian species, in comparison with 14 provided by Kalezić et al. (2015).

The new finding of the Balkan spadefoot toad in Levosoje (Bujanovac) significantly extends its distribution range to the south (app. 120 km) from the previously known locality (Bobovište, Aleksinac). Both findings are located in the Južna Morava valley; however, Džukić et al. (2005) hypothesized that the Grdelica canyon demarcates the border between two portions of the Balkan spadefoot toad’s range within the Balkans. Thus, we can assume that Pelobates balcanicus spreads from the south (through the Moravica river valley), as it is recorded in the northern part of North Macedonia, very close to the Serbian border (Džukić et al. 2008). Therefore, it is necessary to intensify research in southern Serbia where habitats are suitable for this species.

The only record of Bombina bombina in southern Serbia (Vukov et al. 2006, 2013), in addition to its discovery in central Serbia (Jović et al. 2016), represents the southernmost limit of the species distribution in our country.

The presence of peripheral populations and hybrid zones of crested newts (T. ivanburechi × T. macedonicus – Wielstra et al. 2017, Vučić et al. 2020) and tree frogs (H. arborea × H. orientalis – Dufresnes et al. 2015,
Urošević et al. 2022a) in south-eastern Serbia, makes this region particularly interesting. Future faunistic and genetic studies should provide more accurate data about the extent of the hybrid zones of these amphibian taxa in Serbia.

Concerning other, widespread amphibians for which detailed distribution data are lacking (e.g. Bombina variegata, Bufo bufo, Bufotes viridis, Pelophylax ridibundus, Ichthyosaura alpestris, Lissotriton vulgaris and Salamandra salamandra), results of this study showed that these species are quite common in southern and south-eastern Serbia.

Biogeographic regions of southern and south-eastern Serbia, with the presence of 22 (out of a total 26) reptile species, have already been recognized as herpetological “hotspots” in our country (Tomović et al. 2015a). This particularly stands for the Mediterranean reptile species (Testudo graeca, Lacerta trilineata, Podarcis erhardii, Elaphe quatuorlineata and Platyceps najadum), as distribution of these species is almost exclusively (besides Kosovo & Metohija province) restricted to southern and south-eastern Serbia. Furthermore, potential future findings of some other Mediterranean snakes (e.g. Malpolon insignitus, Telescopus fallax, Zamenis situla) in these regions could be expected (Tomović et al. 2014), as their distribution limits in North Macedonia are very close to the Serbian border (Sterijovski et al. 2014). Finally, there is a possibility for the presence of Anguis graeca or its contact zone with A. fragilis in southern or south-eastern Serbia (Jablonski et al. 2016, Urošević et al. 2020).

Of 38 species of amphibians and reptiles registered in southern and south-eastern Serbia, six are considered vulnerable/near threatened according to the IUCN Red Lists, eight are listed on the Annexes II of the Habitats Directive, and two are on the Appendices II of the CITES (see Urošević et al. 2022b, Table 1). At the national level, ten species are considered critically endangered, endangered or vulnerable according to the IUCN criteria (Kalezić et al. 2015, Tomović et al. 2015a); additionally, three species are protected and 29 are strictly protected by law (Official Gazette of the Republic of Serbia No. 5/2010) (see Urošević et al. 2022b, Table 1).

Considering the abovementioned, as a result of projects conducted during the last three years (see acknowledgements), we proposed two locations in southern Serbia for legal protection in the frame of the establishment of national ecological networks in Serbia: marsh near Levosoje (Bujanovac) and surroundings of Slavujevac (Preševo).

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**SUPPORTING INFORMATION**

**Online Appendices:**

Appendix 1. – Unpublished (field) records.

Appendix 2. – Previously published records.
ПРИЛОГ ПОЗНАВАЊУ БАТРАХО- И ХЕРПЕТОФАУНЕ ЈУГОИСТОЧНЕ И ЈУЖНЕ СРБИЈЕ

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РЕЗИМЕ

У овом раду дато је ажурирано и систематизовано распространење батрахо и херпетофауне јужне и југоисточне Србије, на основу публикованих литературних, као и нових теренских података за 16 врста водоземаца и 22 врсте гмизаваца. У ова два биогеографска региона, претходно препознатих као подручја високог специјског диверзитета, забележене су две нове врсте водоземаца са ограниченим распрострањењем: Hyla orientalis и Pelobates balcanicus. Такође, једна врста репатих водоземца (Triturus ivanbureshi) има ограничено распросстранење, док је Bombina bombina веома ретка. Четири врсте гмизаваца су са ограниченом дистрибуцијом, а још шест су веома ретке у ова два биогеографска региона.

Од укупно 38 врста водоземаца и гмизаваца потврђених у регионима јужне и југоисточне Србије, шест је рањиво/готово угрожено према критеријумима IUCN-а, осам су на анексу II Директиве о стаништима, а две су на апендиксу II CITES-а. На националном нивоу, 10 врста се сматра критично угроженим, угроженим или рањивим по критеријумима IUCN-а, три врсте су заштићене, а 29 строго заштитене законом.

Као резултат ових истраживања, две локације у јужној Србији: Левосоје (Бујановац) и Славујевац (Прешево), предложене су за заштиту у оквиру успостављања националних еколошких мрежа у Србији.

Присуство хибридних зона и утицаја Медитеранске климе чине региона јужне и југоисточне Србије подручјима од великог значаја за диверзитет наше земље, и фокусом за будуће еколошке и конзервације студије.