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REPTILES IN SERBIA
- DISTRIBUTION AND DIVERSITY PATTERNS -

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In this paper we present confirmed and potential distribution ranges of all native Serbian reptile species. The information provided herein presents the combination of the newly collected faunistic data and previously published records. The centres of reptilian diversity in Serbia were evaluated, in order to focus future conservation efforts on the regions of particular importance for the protection of

this understudied group of animals. We found four main centres of species richness: three in Metohija and one in Šumadija, with 17–21 species per 50 × 50 km square. Analysis of the similarity of species composition in different regions of Serbia showed that South-eastern Serbia is the most distinct from other regions of Serbia, due to high number of Mediterranean species, with two being found exclusively in that region (*E. quatuorlineata* and *P. najadum*). Metohija is also very distinct, due to the highest number of species and significant number of specific (Mediterranean) faunal elements. The remaining geographic regions are grouped into three clusters, with Kosovo-Southern Serbia cluster being especially distinct in the terms of species richness and the presence of Mediterranean species. We also compared Serbian herpetofauna with those in other Balkan countries, considering species' numbers and zoogeographic herpetofaunistic elements. Serbian herpetofauna is closest to the Romanian. Zoogeographic analysis showed that reptilian fauna of Serbia consists of eight chorotypes, with the Eastern-Mediterranean (nine species) and Southern-European (five species) as the most dominant ones.

Key words: reptile diversity, distribution, zoogeography

INTRODUCTION

There are more and more evidences that reptiles are globally declining (e.g. Gibbons *et al.* 2000, Ihlow *et al.* 2012, Reading *et al.* 2010, Sinervo *et al.* 2010). Reptilian declines is in a focus of conservation studies, *inter alia* because this vertebrates are acknowledged as good indicators of the "health" of terrestrial and freshwater ecosystems (Bauerle *et al.* 1975, Nagle *et al.* 2001, Lambert 2005).

Generaly, data about the distribution of species are fundamental for studies of their ecology and population biology, evolutionary biology, biogeography, and systematics, but especially in conservation biology (e. g. Zachos & Habel 2011). Insufficient distributional data of reptilian (or amphibian) faunas in certain countries preclude the prescription of effective conservation measures, not only at the national level, but also at the regional scales. Currently, it is widely acknowledged that the identification and conservation of specific important areas, especially those featuring exceptional concentrations of species ("hot-spots"), is of principal importance in efforts to reduce the loss of biological diversity (e.g. Buse & Griebeler 2012). Therefore, an important challenge in conservation biology is to identify those areas, on both large and small geographic scales.

Being situated in the central part of the Balkan Peninsula, Serbia is very important for the diversity of reptiles, owing to various biogeographical specificities: presence of endemic and relict species, different faunal elements, marginality of certain species' ranges, as well as range fragmentation (Matvejev 1961, Džukić 1974, 1980, 1995, Džukić & Kalezić 2004). In addition to species diversity *per se*, Serbia is of particular interest in terms of reptilian conservation, due to: 1) high taxonomical (i.e. number of subspecies) and morphological diversity; 2) pronounced genetic diversity, resulting from the presence of multiple glacial refugia during the Pliocene and Pleistocene, when various micro-evolutionary processes led to differentiation within numerous taxa (e.g. *Anguis fragilis* complex – Gvoždík *et al.* 2010, *Vipera ammodytes* – Ursenbacher *et al.* 2008); 3) presence of ancient and/or ancestral phylogenetic lineages, revealed by mtDNA analyses (e.g. *Vipera ammodytes* – Ursenbacher *et al.* 2008); 4) occurrence of peripheral populations of several species (e.g. *Testudo graeca* – Tomović *et al.* 2004, Ralev *et al.* 2012, *Mediodactylus kotschyi* – Ajtić & Tomović 2001, *Algyroides nigropunctatus* – Džukić & Pasuljević 1979, *Darevskia praticola* – Ljubisavljević *et al*. 2006, *Platyceps najadum* – Crnobrnja-Isailović & Aleksić 1999, *Elaphe quatuorlineata* – Ristić *et al.* 2006); 5) existence of relict populations in certain parts of Serbia (e.g. *Algyroides nigropunctatus* – Džukić & Pasuljević 1979, *Zootoca vivipara* – Ljubisavljević *et al.* 2010a, *Vipera berus* – Džukić & Purger 1988).

Despite the fact that its entire territory (both latitudinal and altitudinal gradients) is occupied by reptiles, Serbia is one of the least explored European countries. Comprehensive studies of distribution patterns, species diversity and zoogeographic analyses of Serbian herpetofauna have never been undertaken before, in spite of the fact that nearly 35% (24 of 69) of all Balkan reptile species occur in Serbia.

Due to historical and political reasons, in the majority of the previous faunistic studies Serbia was considered within the territory of ex-Yugoslavia (Karaman 1921, 1939, Radovanović 1941, 1951, 1964, Pavletić 1964, Džukić 1970, 1972, 1995, Džukić & Pasuljević 1979, Džukić & Kalezić 2004, Jelić *et al.* 2013). Nevertheless, these old faunistic publications (Mehély 1903, Karaman 1921, 1939, Radovanović 1941, 1951, 1964, Džukić 1972, 1975, Kattinger 1972) provided more or less precise distributional data for all reptile species which occur in Serbia. Many data on species distribution were provided in the papers oriented at systematic research of particular, restricted regions or peculiar habitats in Serbia (Mehély 1903, Karaman 1948, Ham *et al.* 1981, Tadijan & Mikeš 1984, Crnobrnja & Rohalj 1988, Jović *et al.* 1997, Stanković 2004, 2005, Perić & Stanković 2005, Ivančević *et al.* 2007, Crnobrnja-Isailović *et al.* 2012,

Ralev *et al.* 2012), while the largest part of the territory has never been a subject of targeted faunistic research. The most recent studies of this type were primarily focused on several rare (or uncommon) species with peripheral or disjunct occurrence in Serbia: *Testudo graeca* (Tomović *et al.* 2004, Ralev *et al.* 2012), *Algyroides nigropunctatus* (Džukić 1970, Džukić & Pasuljević 1979), *Darevskia praticola* (Džukić 1974, Pasuljević & Džukić 1979, Ljubisavljević *et al.* 2006), *Podarcis erhardii* (Džukić 1980, Crnobrnja-Isailović & Aleksić 1999), *Podarcis tauricus* (Džukić 1970, 1974, Crnobrnja-Isailović & Aleksić 1999, Ljubisavljević *et al.* 2010b), *Zootoca vivipara* (Džukić 1974, Ivančević *et al.* 2007, Ljubisavljević *et al.* 2010a), *Platyceps najadum* (Crnobrnja-Isailović & Aleksić 1999), *Elaphe quatuorlineata* (Ristić *et al.* 2006), *Vipera berus* (Jelić *et al.* 2013) and *Vipera ursinii* (Jelić *et al.* 2013). Complete distribution data were provided only for a few widespread species: *Testudo hermanni* (Ljubisavljević *et al.* 2014a) and *Vipera ammodytes* (Jelić *et al.* 2013). Surprisingly, information concerning the distribution of the most common, well-known and generally widespread species (*Anguis fragilis*, *Lacerta agilis*, *Lacerta viridis*, *Podarcis muralis*, *Natrix natrix*, *Natrix tessellata*, *Coronella austriaca* and *Zamenis longissimus*) are poor and scattered (Karaman 1939, 1948, Radovanović 1941, 1964, Džukić 1972, 1987, Jović *et al.* 1997). As a result of such circumstances, the general herpetological literature provides only broad distributional patterns of reptiles in Serbia, without the precise presence data (Arnold & Ovenden 2002), or with wide distribution gaps for the majority of species (Gasc *et al.* 1997, Sillero *et al.* 2014). This precludes meta-analyses of wide-range distributional patterns and, consequently, assessments of low-level taxonomic diversity, and conservation units.

Bearing in mind all these drawbacks, with this study we intended to: (1) present the complete and annotated checklist of reptile species in Serbia; (2) provide maps of confirmed and potential distribution of all species, including the characteristics of distribution patterns (in terms of marginality and fragmentation); (3) analyse species richness at different spatial scales and along elevation gradients; (4) provide zoogeographic analysis of Serbian reptiles.

MATERIAL AND METHODS

The identification of species was done according to the standard herpetological literature (e.g. Arnold & Ovenden, 2002). The presented distribution of Serbian reptiles is based on approximately 7,000 pieces of unpublished georeferenced distributional data, collected from several

sources: (1) the Herpetological Collection of the Institute for Biological Research "Siniša Stanković" (University of Belgrade), (2) Naturhistorisches Museum Wien (NHMW), (3) Museum of Natural History in Budapest (NHMB), (4) Students' research organization "Josif Pančić" in Belgrade, (5) the Petnica Science Center, (5) authors' field observations, and (6) field data kindly donated by our colleagues (see the Acknowledgements). In addition, we used more than 600 published records from the available literature. Because we still lack faunistic data from several regions (see Discussion), reptile distributions in Serbia were shown as global maps of species' ranges rather than as maps with point locality data.

In order to reduce probable biases in sampling effort, as well as to better visualize regional patterns (see Graham & Hijmans 2006), the species richness was assessed at three coarser levels: (1) at 50 × 50 km squares of the UTM National Grid Reference, (2) according to biogeographic regions (Marković 1970, Stevanović 1992, see below), and (3) altitudinal and latitudinal divisions of Serbia (Marković 1970).

The biogeographic regions (Marković 1970, Stevanović 1992) of Serbia are: Bačka (Ba), Banat (Bt), Srem (Sr), Pomoravlje (Po), Šumadija (Š), central Serbia (C), north-eastern Serbia (NE), eastern Serbia (E), north-western Serbia (NW), south-eastern Serbia (SE), western Serbia (W), south-western Serbia (SW), southern Serbia (S), Kosovo (K), and Metohija (M) (see Fig. 10). There are three altitudinal regions, distinctive in geographic and ecological aspects (Stevanović & Vasić 1995): (1) the Pannonian region (low-lying area north of the Sava and Danube Rivers, up to 200 m above sea level), (2) the Peripannonian region (the low-lying region and hills south of the Sava and Danube, from 200 to 600 m a.s.l.), and (3) the Mountain-valley region (the central and southern parts of Serbia, from 600 up to 2 650 m a.s.l.) (see Fig. 10). Pannonian and Peripannonian areas encompass similar surfaces (22 200 km^2 and 23 300 km^2, respectively), while the mountainous region covers almost the area of these two combined (42 800 km^2).

For the analyses and designation of centres of herpetofaunal diversity in Serbia, we used an application created in Visual Basic 6.1 in the program WinWord 2003 (Niketić 1999), using the method described by Walter & Straka (1970), at National Grid UTM Reference for Serbia 50 × 50 km.

Similarities among the regions of Serbia and with other Balkan countries were assessed according to the Bray-Curtis similarity index (Ludwig & Reynolds 1988). Data on the presence of reptilian taxa in Croatia, Bosnia and Herzegovina, Greece, Bulgaria, Montenegro and Romania were obtained from Gasc *et al.* (1997), Haxhiu (1998), Valakos *et al.* (2008), Polović & Ljubisavljević (2010), Stojanov *et al.* (2011), Jablon-

ski *et al.* (2012), Jelić *et al.* (2012), Cogălniceanu *et al*. (2013) and Podnar *et al*. (2014).

For zoogeographic analyses, chorotypes were identified according to the classification of Vigna Taglianti *et al.* (1999). As the taxonomy is concerned, we followed suggestions of Speybroeck *et al.* (2010).

RESULTS

Species distribution and richness

The list of native reptiles in Serbia includes 24 species: three chelonians, 11 lizards and 10 snakes (Table 1).

In the Figs. 1–8, four types of species' distribution patterns of reptiles in Serbia are given: 1) confirmed distribution range (orange), which is based on exact distributional data, 2) potential distribution range (yellow), which is based on our knowledge of the suitable aquatic and terrestrial habitats where the species occurrence has not been confirmed yet, 3) alochtonous distribution range (red), which is based on confirmed or hypothesized spread of the species outside of its suitable native range (including the cases of synanthropy), 4) extinct (suspected or confirmed) populations. It should be noted that only exact distribution data (including allochthonous populations) was included in the analyses of diversity centres and regional diversity, while potential distribution ranges were omitted.

The most widely distributed species, which occupy suitable habitats in the entire territory of Serbia are: one turtle (*Emys orbicularis*), two lizards (*Lacerta viridis* and *Podarcis muralis*), and three snake species (*Coronella austriaca*, *Natrix natrix* and *Natrix tessellata*). Species which inhabit more than 50% of Serbia are: one tortoise (*Testudo hermanni*), three lizards (*Anguis fragilis*, *Ablepharus kitaibelii* and *Lacerta agilis*) and two snakes (*Zamenis longissimus* and *Vipera ammodytes*). Rare species, inhabiting 10–50% of the country, are two lizards (*Darevskia praticola* and *Podarcis tauricus*) and one snake (*Dolichophis caspius*). Species with extremely limited distribution in Serbia (less than 10% of the territory) are one tortoise (*Testudo graeca*), four lizards (*Algyroides nigropunctatus*, *Mediodactylus kotschyi*, *Podarcis erhardii* and *Zootoca vivipara*), and four snakes (*Elaphe quatuorlineata*, *Platyceps najadum*, *Vipera berus* and *Vipera ursinii*) (Figs. 1-8).

Among the widespread or relatively common reptiles in Serbia, three species show fragmented ranges (*Emys orbicularis*, *Ablepharus kitaibelii* and *Lacerta agilis*) (see Table 1, Figs. 1-8). Not surprisingly, nine reptile

species regarded as rare or extremely rare display highly fragmented distribution: *Testudo graeca*, *Mediodactylus kotschyi*, *Algyroides nigropunctatus*, *Darevskia praticola*, *Podarcis tauricus*, *Zootoca vivipara*, *Dolichophis caspius*, *Vipera berus*, and *Vipera ursinii*.

Half of the Serbian reptiles (12 species) occur at the margins of their overall distributional ranges (see Table 1): two chelonians (*Testudo graeca* and *Testudo hermanni*), six lizards (*Mediodacylus kotschyi*, *Ablepharus kitaibelii*, *Algyroides nigropunctatus*, *Darevskia praticola*, *Podarcis erhardii*, and *Podarcis tauricus*) and four snakes (*Dolichophis caspius*, *Elaphe quatuorlineata*, *Platyceps najadum*, and *Vipera ursinii*).

It is noteworthy to mention that distribution ranges of one tortoise, six lizards and one snake in Serbia are fragmented and marginal at the same time (see Table 1).

One chelonian (*Testudo hermanni*, Fig. 1) and two lizards (*Mediodactylus kotschyi,* Fig. 2 and *Podarcis muralis,* Fig. 4) have been introduced outside of their suitable native ranges by various human activities.

Species hot-spots

Analysis of reptile biodiversity in Serbia revealed the highest numbers of species (17–21) in four 50 × 50 km UTM squares: DM3, DN3 and DN4 (all in Metohija), and DQ4 in Šumadija. In contrast, low species diversity was recorded in 11 UTM squares (less than 10 species per 50 × 50 km square), predominantly in the northern part of the country (the Vojvodina province), as well as in the bordering areas with neighbouring countries (Fig. 9).

Results of the analysis of reptile diversity along the altitudinal gradient showed that the Mountain-valley part of Serbia is characterized by much higher number of reptile species compared to Pannonian and Peripannonian parts (Fig. 10).

According to the analysis of reptile diversity among the regions of Serbia, the highest number of species (21, 19 and 19, respectively) were found in Metohija, Kosovo and South-eastern part of the country. On the contrary, north-western Serbia (13) and Bačka (14) are the regions with the lowest diversity of reptilian species (Fig. 10). However, this might be a consequence of insufficient field studies (see below).

Zoogeographic analysis

Zoogeographic analysis classified Serbian reptiles into eight chorotypes (Table 2). The most dominant were the Eastern-Mediterranean and South-European chorotypes, with nine and five species, respectively.

Table 1: - List of reptile species in Serbia.

Ordo	Familia	Species	Marginal zone	Fragmented range
Testudines	Emydidae	*Emys orbicularis*		+
	Testudinidae	*Testudo hermanni*	+	
		Testudo graeca	+	+
Lacertilia	Anguidae	*Anguis fragilis*		
	Gekkonidae	*Mediodactylus kotschyi*	+	+
	Scincidae	*Ablepharus kitaibelii*	+	+
	Lacertidae	*Algyroides nigropunctatus*	+	+
		Darevskia praticola	+	+
		Lacerta agilis		+
		Lacerta viridis		
		Podarcis erhardii	+	
		Podarcis muralis		
		Podarcis tauricus	+	+
		Zootoca vivipara		+
Serpentes	Colubridae	*Coronella austriaca*		
		Dolichophis caspius	+	+
		Elaphe quatuorlineata	+	
		Natrix natrix		
		Natrix tessellata		
		Platyceps najadum	+	
		Zamenis longissimus		
	Viperidae	*Vipera ammodytes*		
		Vipera berus		+
		Vipera ursinii	+	+

Table 2: - Classification of reptiles in Serbia according to chorotypes.

Chorotype	No. of species	Species
Eastern-Mediterranean	9	*Mediodactylus kotschyi* *Ablepharus kitaibelii* *Algyroides nigropunctatus* *Darevskia praticola* *Podarcis erhardii* *Podarcis tauricus* *Dolichophis caspius* *Elaphe quatuorlineata* *Vipera ammodytes*
Southern-European	5	*Testudo hermanni* *Lacerta viridis* *Podarcis muralis* *Zamenis longissimus* *Vipera ursinii*
Euro-Siberian	3	*Lacerta agilis* *Zootoca vivipara* *Vipera berus*
European	2	*Anguis fragilis* *Coronella austriaca*
Turano-Mediterranean	2	*Testudo graeca* *Platyceps najadum*
Centralasiatic-Europeo-Mediterranean	1	*Natrix natrix*
Turano-European	1	*Natrix tessellata*
Turano-Europeo-Mediterranean	1	*Emys orbicularis*

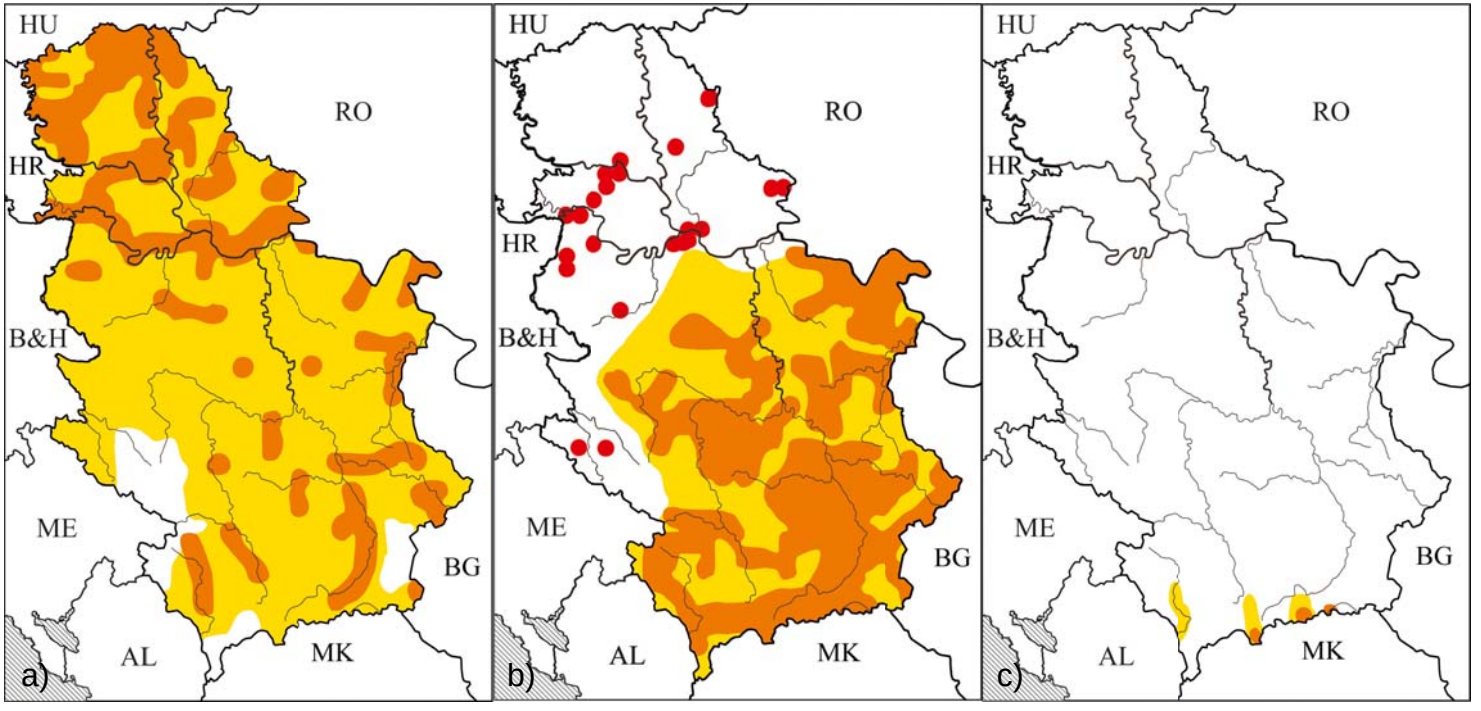

Fig. 1. - Distribution range of a) *Emys orbicularis*, b) *Testudo hermanni*, c) *Testudo graeca* in Serbia. (orange – – confirmed distribution range; yellow – potential distribution range; red – alochtonous distribution range).

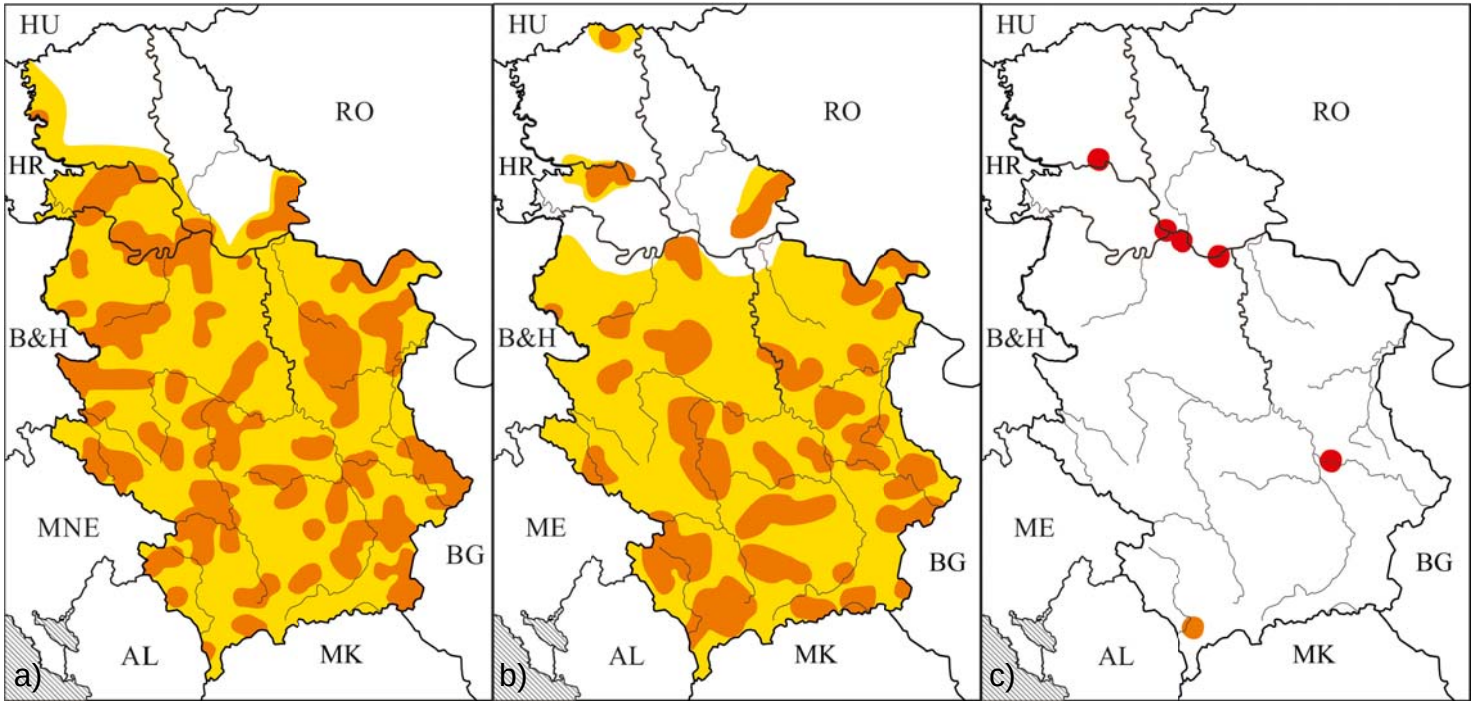

Fig. 2. - Distribution range of a) *Anguis fragilis*, b) *Ablepharus kitaibelii*, c) *Mediodactylus kotschyi* in Serbia. (orange – confirmed distribution range; yellow – potential distribution range; red – alochtonous distribution range).

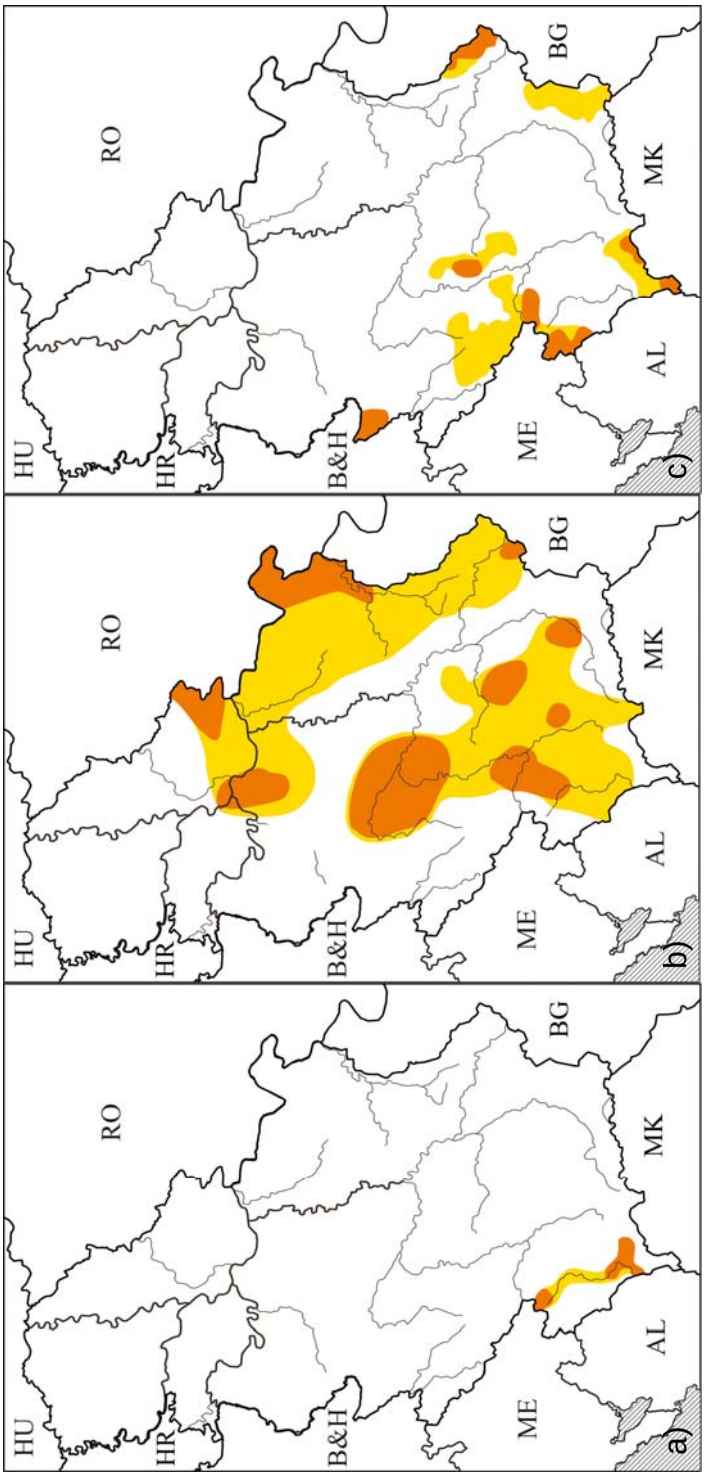

Fig. 3. - Distribution range of a) *Algyroides nigropunctatus*, b) *Darevskia praticola*, c) *Zootoca vivipara* in Serbia. (orange – confirmed distribution range; yellow – potential distribution range).

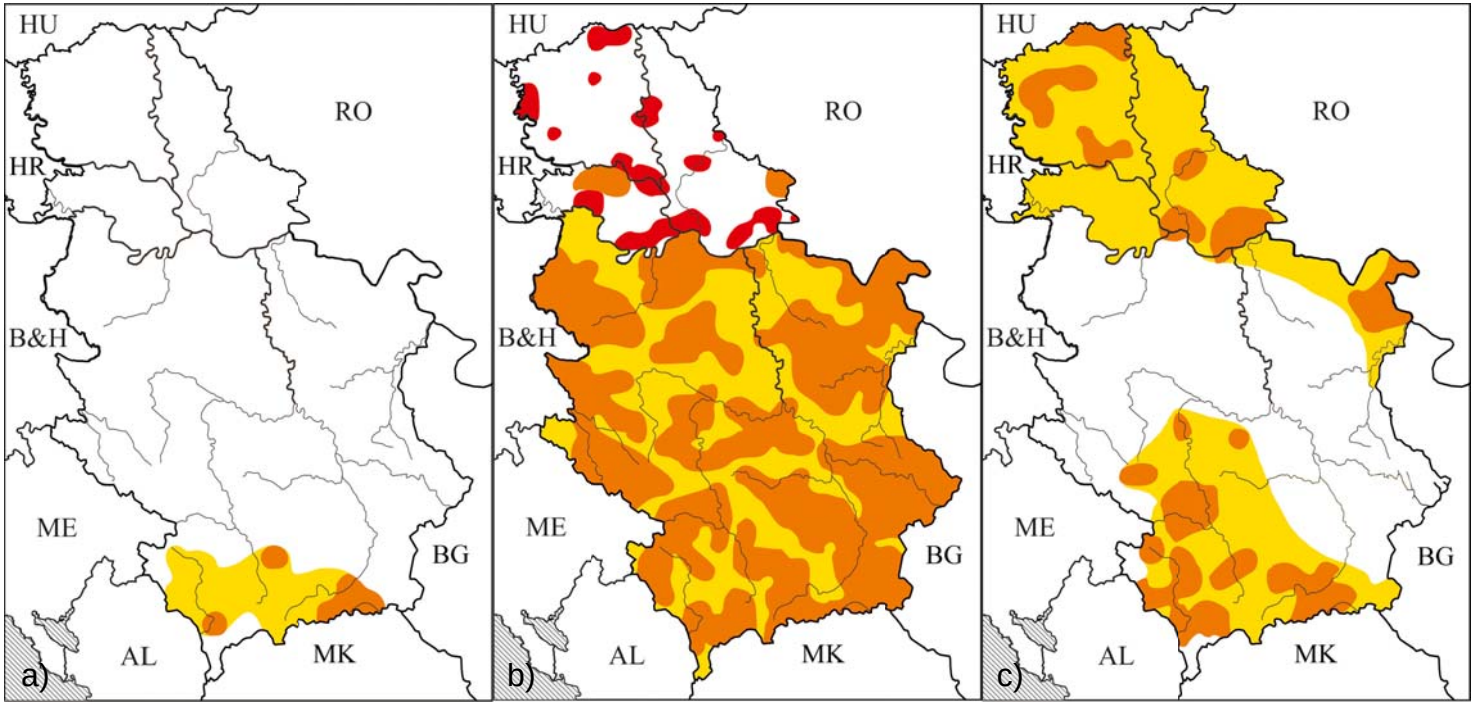

Fig. 4. - Distribution range of a) *Podarcis erhardii*, b) *Podarcis muralis*, c) *Podarcis tauricus* in Serbia. (orange – – confirmed distribution range; yellow – potential distribution range; red – alochtonous distribution range)

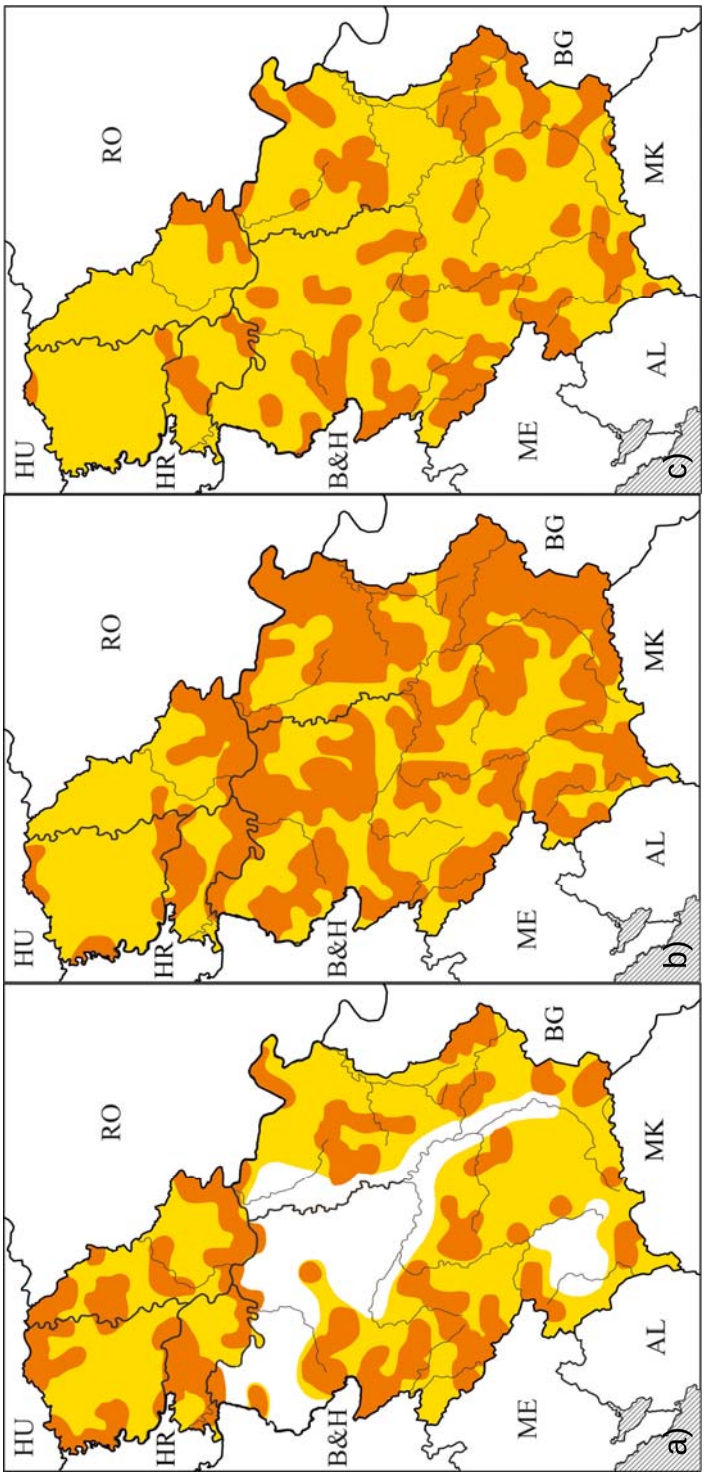

Fig. 5. - Distribution range of a) *Lacerta agilis*, b) *Lacerta viridis*, c) *Coronella austriaca* in Serbia. (orange – confirmed distribution range; yellow – potential distribution range).

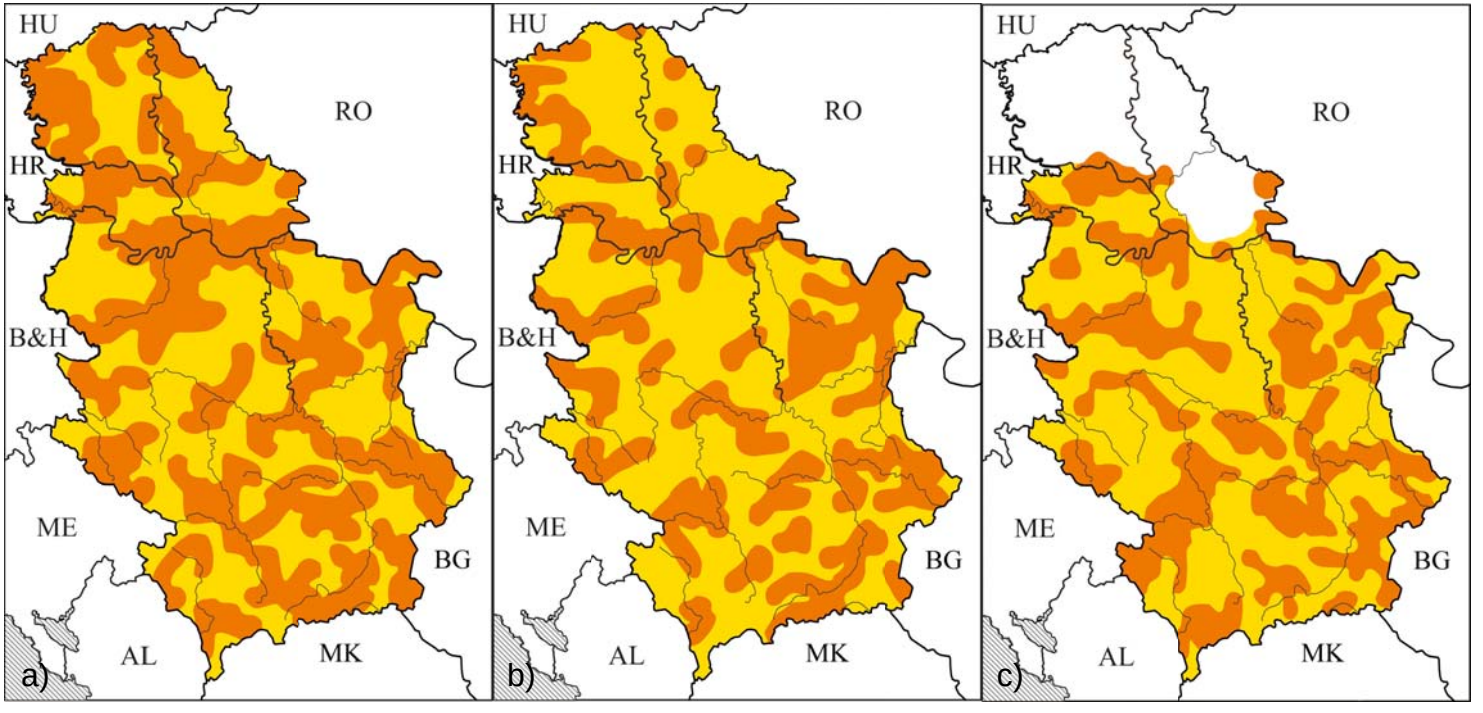

Fig. 6. - Distribution range of a) *Natrix natrix*, b) *Natrix tessellata*, c) *Zamenis longissimus* in Serbia.
(orange – confirmed distribution range; yellow – potential distribution range).

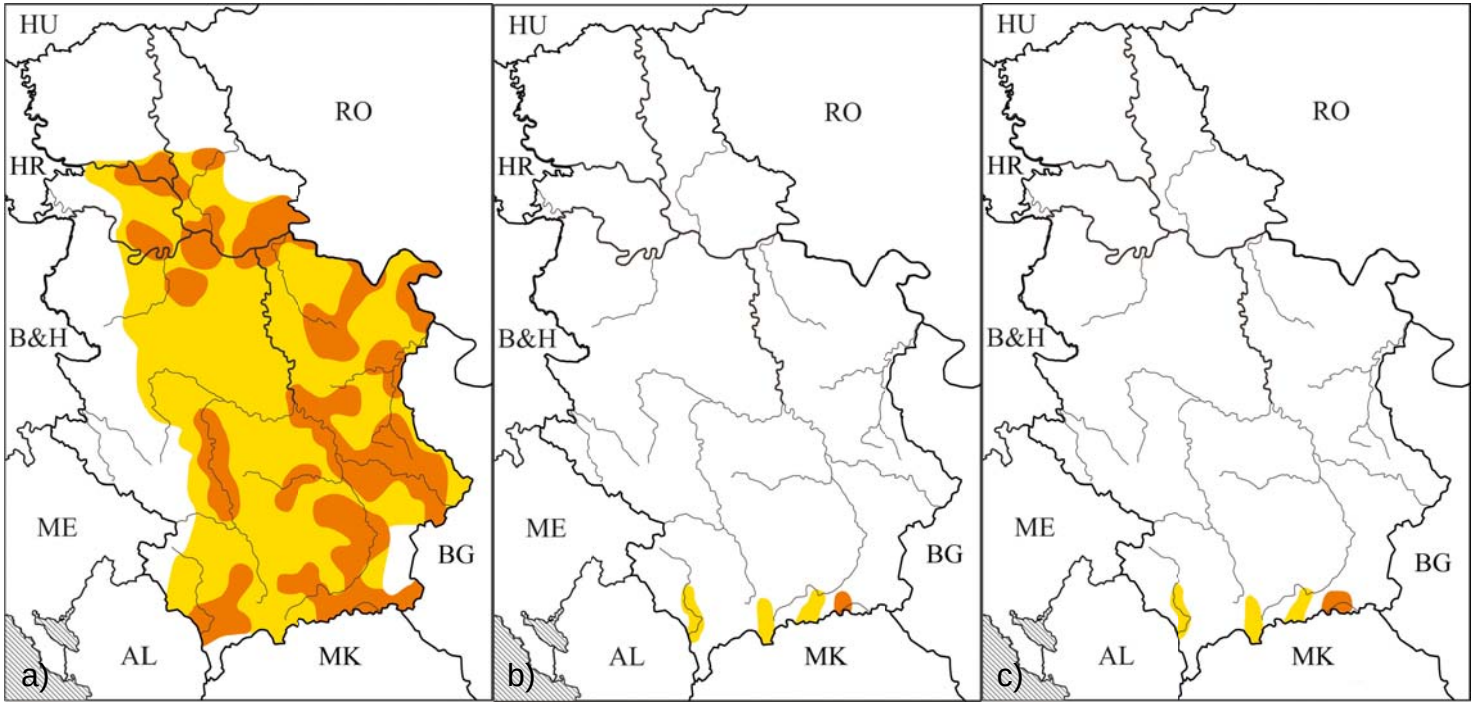

Fig. 7. - Distribution range of a) *Dolichophis caspius*, b) *Elaphe quatuorlineata*, c) *Platyceps najadum* in Serbia. (orange – confirmed distribution range; yellow – potential distribution range).

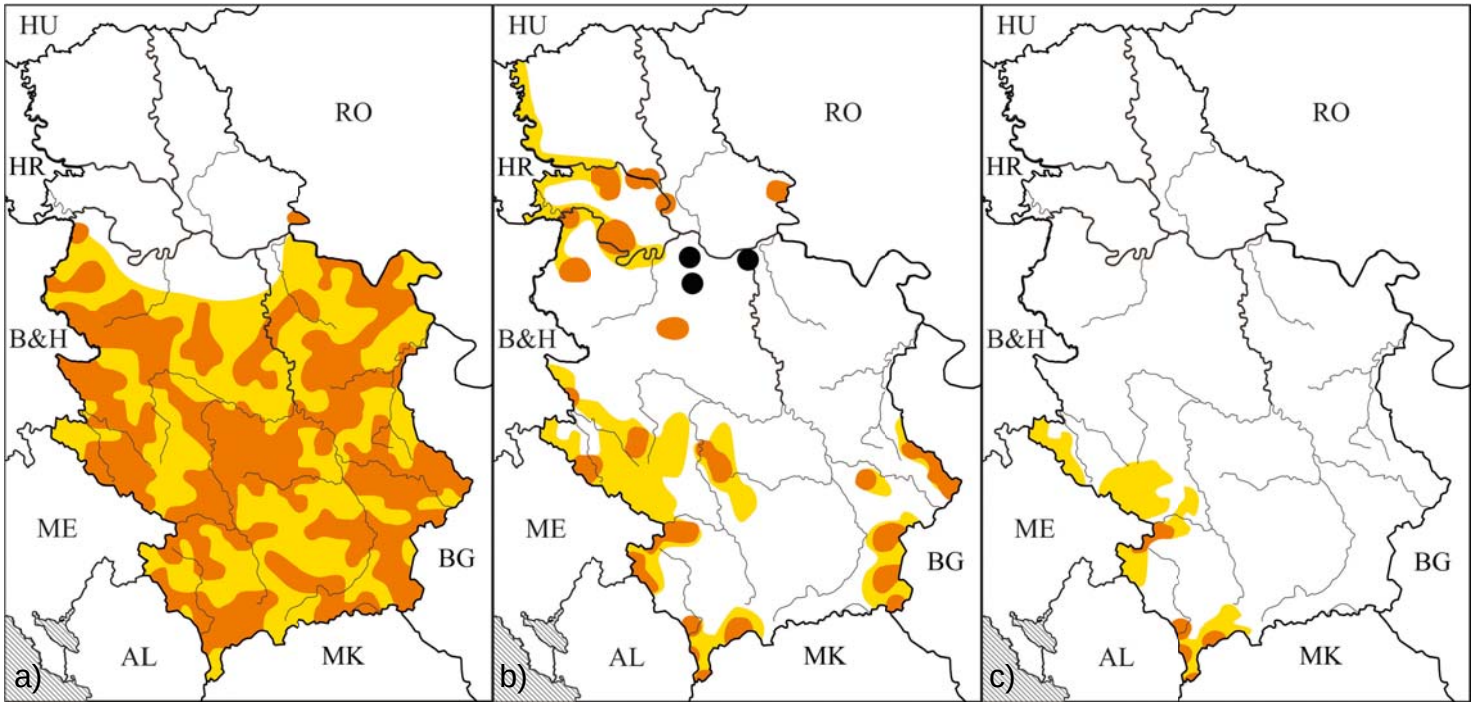

Fig. 8. - Distribution range of a) *Vipera ammodytes*, b) *Vipera berus*, c) *Vipera ursinii* in Serbia. (orange – confirmed distribution range; yellow – potential distribution range, black – extinct (suspected or confirmed) populations).

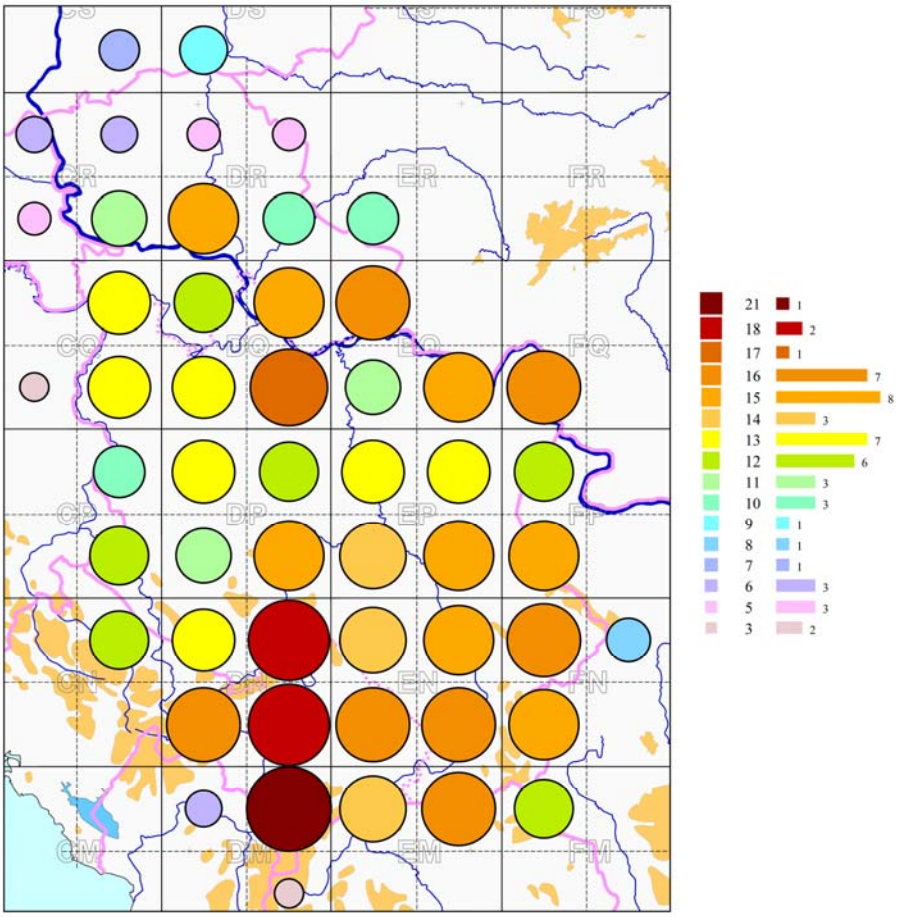

Fig. 9. - Species richness of Reptiles in Serbia at National Grid UTM 50 x 50 km Reference.

Faunal similarities

The Bray-Curtis similarity index showed that South-eastern Serbia is the most distinct from other regions of Serbia, due to high number of Mediterranean species, with two being found exclusively in that region (*E. quatuorlineata* and *P. najadum*). Metohija is also very distinct, due to the highest number of species and significant number of specific (Mediterranean) faunal elements. The remaining geographic regions are grouped into three clusters, with Kosovo-Southern Serbia cluster being especially distinct in the terms of species richness and the presence of Mediterranean species (Fig. 11).

The same similarity index was used for comparative analysis of the reptilian fauna of Serbia with those from other Balkan countries. These results

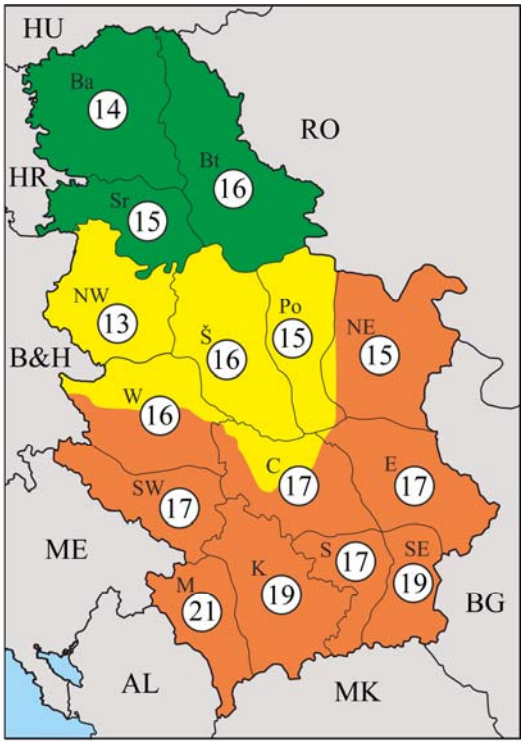

Fig 10. - Species diversity of Reptiles in Serbia at regional level according to biogeographic (see Material and methods section for abbreviations) and altitudinal and latitudinal division (green: Pannonian, yellow: Peripannonian, orange: Mountain-valley part) of Serbia.

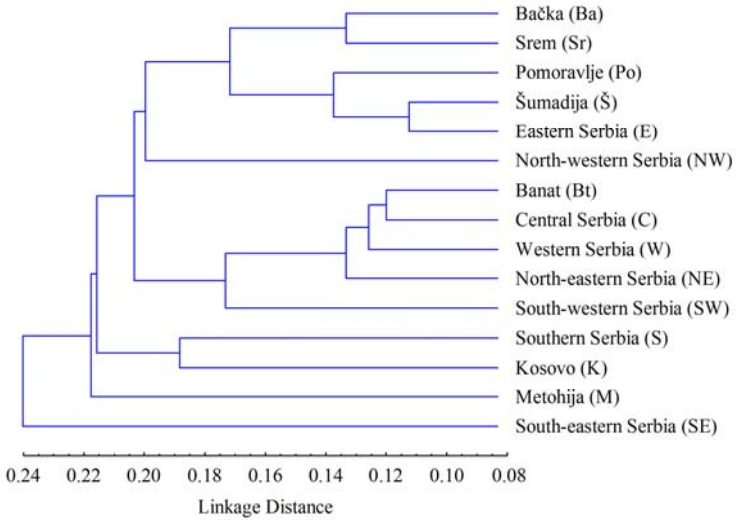

Fig. 11. - Cluster diagram of Bray Curtis similarity Index of biogeographic regions in Serbia.

showed that Serbian herpetofauna is the most similar to that of Romania. This cluster adjoins the cluster of two groups of faunas: the first from the western part of the Balkans (Croatia, Bosnia and Montenegro) and the second from the south-eastern part of the Balkans (Macedonia, Albania and Bulgaria). Herpetofauna of Serbia is the most distant from the reptile faunas of Slovenia (characterized by the lowest number of species, and the presence of western Mediterranean species) and Greece (characterized by the highest number of species coupled with high reptile endemicity) (Fig. 12).

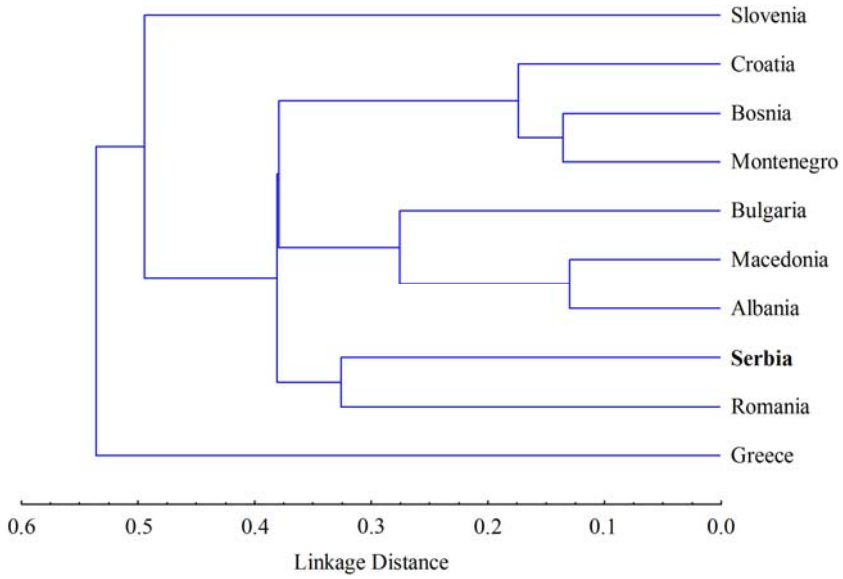

Fig. 12. - Cluster diagram of Bray Curtis similarity Index of the Balkan countries.

DISCUSSION

Research of Serbian herpetofauna showed that for almost all species huge discrepancies exist between the confirmed and potential distribution ranges (see Figs. 1–8). Large gaps in the known distribution of common or/and widespread reptiles (*Emys orbicularis*, *Anguis fragilis*, *Lacerta viridis*, *Podarcis muralis*, *Coronella austriaca*, *Natrix natrix*, *Natrix tessellata*, *Zamenis longissimus*) most probably reflect the lack of faunistic research in the respective regions rather than the actual absence of these species. The exceptions are *Vipera ammodytes* and *Testudo hermanni*, since their distribution was comprehensively investigated (Jelić *et al.* 2013, Ljubisavljević *et al.* 2014a).

The confirmed distribution of relatively rare species (*Ablepharus kitaibelii*, *Darevskia praticola*, *Lacerta agilis*, *Podarcis tauricus* and *Doli-*

chophis caspius) also does not fit the potential. This pattern may also be related to insufficient faunistic research, but can also reflect strong anthropogenic influences. Notably, three of the species mentioned above (*Ablepharus kitaibelii*, *Podarcis tauricus* and *Dolichophis caspius*) are predominantly associated with open steppe and forest-steppe habitats (Arnold & Ovenden 2002). The most probable determinant of their present-day distribution pattern is the lack of suitable habitats, resulting from land-use changes in vast areas, i.e. the transformation of original steppes and forest-steppes into agricultural fields in the largest part of the Vojvodina province and, to a lesser extent, in the Peripannonian parts of Serbia. Although preferable habitats (termophilous oak forests) of *Darevskia praticola* are also under anthropogenic pressures due to deforestation in large parts of Serbia, we suppose that scattered distribution of this species is more probably a result of sketchy faunistic research than of its genuine absence in numerous parts of the country.

Reptile species with very limited distribution in Serbia are of special interest, for several reasons. Firstly, many of these species demand specific, restricted and usually highly fragile habitats, such as those under (Sub)Mediterranean influences (*Testudo graeca*, *Algyroides nigropunctatus*, *Podarcis erhardii*, *Elaphe qautuorlineata*, *Platyceps najadum*), high-mountainous habitats (*Zootoca vivipara*, *Vipera berus*, *Vipera ursinii*), or specific lowland habitats (*Vipera berus*). The lowland habitats of *Vipera berus* are considered especially vulnerable. Those habitats had been under intensive anthropogenic pressures for centuries, and the severe habitat alteration led to suspected or confirmed local extinction at some localities (Crnobrnja-Isailović *et al.* 2012). Some populations in lowland or hilly regions have not been confirmed for several decades (e. g. Avala Mt., Kosmaj Mt., Velika Morava River mouth), so they should be considered as extinct (see Fig. 8b). Secondly, majority of these peculiar habitats lie within the marginal zones of the species' distributional ranges (see Table 1). Marginal populations are usually of prime conservation interest, due to their potentially unique genetic characteristics and/or because they are highly vulnerable to loss of genetic diversity (Vucetich & Waite 2003). Five extremely rare species display strongly fragmented distribution in Serbia (see Table 1). And finally, one tortoise (*Testudo graeca*), two lizards (*Mediodactylus kotschyi* and *Algyroides nigropunctatus*) and one snake (*Vipera ursinii*), are of the foremost conservation concern, because they are extremely rare, with small, marginal populations and fragmented distribution at the same time. Area fragmentation and the resulting isolation of sub-populations prevent biotic exchanges and affect the population survivorship and diversity; this can eventually lead to extinctions of local populations (Andreone & Luiselli 2000).

The analyses of herpetofaunal diversity and hot-spots in Serbia performed in this study identified regions which deserve prime conservation attention, and should be considered in the future designation of the Important Herpetological Areas at the national level. Within three of four herpetofaunal hot-spots in Metohija, several areas are protected in the national legislation (e. g. Šar Planina Mt. and Kopaonik Mt. as National Parks, Prizrenska Bistrica Gorge as Memorial Natural Monument, Beli Drim Canyon and Miruša River as Natural Monuments – Amidžić *et al.* 2007). In these regions, reptile communities are most probably under strong anthropogenic pressures due to habitat destruction and direct human disturbance, which are identified as one of the most important factors causing reptile population decline and reduction of species ranges (Gibbons *et al.* 2000). The remaining hot-spot of reptile diversity in Serbia lies in Šumadija: the foothills of the Avala Mt., which is protected as the Landscape of Outstanding Features (Amidžić *et al.* 2007). High reptile diversity in the four regions mentioned above classifies them as the most important areas for the reptile conservation plans in Serbia. Implicitly, protected areas (i.e. Important Herpetological Areas at the national level) should serve as a good "shelter" for the reptile species, which are otherwise threatened with anthropogenic pressures and potential extinction in non-protected regions.

Zoogeographic analyses showed that chorotype diversity of reptiles in Serbia is very high: the recorded 24 species belong to eight chorotypes (Table 2). The most dominant chorotypes are the Eastern-Mediterranean and South-European, with nine and five species, respectively. This would imply that Serbian heropetofauna has predominantly Eastern-Mediterranean-South-European characteristics. The predominance of Eastern-Mediterranean chorotypes was proved in most Balkan countries (Jablonski *et al.* 2012). High chorotype diversity, presence of marginal reptile populations and occurrence of the Balkan endemic species (*Algyroides nigropunctatus*) in Serbia, suggest its high biogeographic and refugial importance for reptile diversity of the Balkan Peninsula (Džukić & Kalezić 2004).

Results of the analysis of reptile diversity among the regions of Serbia showed that South-eastern Serbia, Metohija, Kosovo and Southern Serbia are the most distinct considering richness in the reptilian species. Considering that in southern Serbia climatic conditions are similar to these in the southernmost parts of the country, we suppose that this region contains even more reptile species than recorded to date, as much as the given neighbouring regions (Kosovo, Metohija and south-eastern Serbia). Thus, parts of the southern Serbia (e.g. Južna Morava River valley), should be the priority for future faunistic and conservation studies.

Generally, north-western Serbia and Bačka have the lowest numbers of reptile species recorded, either due to insufficient research or because of the lack of suitable habitats. In order to identify which of the two is the cause of low herpetological diversity, systematic faunistic research in the above-mentioned regions are also necessary in the future.

Results of this study showed that, in comparison to other Balkan countries, Serbian herpetofauna is among the poorest in number of species, together with Romania and Slovenia (Gasc *et al.* 1997, Sillero *et al.* 2014). Nevertheless, Serbia is by no means insignificant concerning the diversity of reptiles in the Balkans, due to the presence of phenomena of biogeographical and evolutionary significance – chorotype diversity, peripheral populations and range fragmentation (Džukić 1995, Džukić & Kalezić 2004).

In terms of species presence in Serbia, there are possibilities of finding previously unrecorded reptile species, especially in the south-eastern and southern regions, as well as in Kosovo and Metohija. Species *Lacerta trilineata*, *Malpolon insignitus*, *Telescopus fallax* and *Zamenis situla* reach their distribution limits in Macedonia, very close to the Serbian border (Sterijovski *et al.* 2014). The occurrence of several other Eastern-Mediterranean reptile species has recently been confirmed in the valleys of the Pčinja and Južna Morava rivers (Džukić 1980, Crnobrnja-Isailović & Aleksić 1999, Tomović *et al.* 2004, Ristić *et al.* 2006, Ralev *et al.* 2012). Therefore, we suppose that it is only a matter of time until the confirmation of the presence of at least some of the abovementioned species in the south-eastern or southern parts of Serbia. *Hierophis gemonensis* reaches its distribution limit in north-eastern Albania, very close to the Serbian border (Haxhiu 1998). Because the Eastern-Mediterranean reptiles, such as *Algyroides nigropunctatus* and *Mediodactylus kotschyi*, also occur in the Metohija region (along the Drim River valley and close to the border with Albania – Džukić & Pasuljević 1979, Ajtić & Tomović 2001), we suppose that *Hierophis gemonensis* could also be found in this region. And finally, *Dinarolacerta montenegrina* (endemic to the Prokletije Mountain Massif) has been recorded at two localities in Montenegro (Ljubisavljević *et al.* 2007, 2014b), as well as at one locality in Albania (Petrov 2006, Podnar *et al.* 2014). Large portion of the Prokletije Massif lies in the bordering area of the western Metohija, hence this species could also be expected in the suitable habitats at this massif (Džukić *et al.* 1997).

Considering that this is the first comprehensive overview of the distribution and diversity of the entire Serbian herpetofauna, gaps in distribution of many species are no surprise. They highlight the need for detailed faunistic and zoogeographic studies: the absence of certain species in the maps may illustrate the fact that the inventories have not been

systematically conducted in previous times. Precise data about distribution and especially about diversity of reptiles in Serbia are essential for conservation measures, i.e. the designation of protected areas (Important Herpetological Areas) in our country.

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ГМИЗАВЦИ СРБИЈЕ - РАСПРОСТРАЊЕЊЕ И ДИВЕРЗИТЕТ

РЕЗИМЕ

ЉИЉАНА ТОМОВИЋ, РАСТКО АЈТИЋ, КАТАРИНА ЉУБИСАВЉЕВИЋ, АЛЕКСАНДАР УРОШЕВИЋ, ДАНКО ЈОВИЋ, ИМРЕ КРИЗМАНИЋ, НЕНАД ЛАБУС, СОЊА ЂОРЂЕВИЋ, МИЛОШ КАЛЕЗИЋ, ТАЊА ВУКОВ, ГЕОРГ ЏУКИЋ

У овом раду представљени су потврђени и потенцијални ареали свих аутохтоних гмизаваца Србије. Коришћени су до сада необјављени подаци теренских истраживања, као и информације објављене у литератури. Оцењени су претпостављени центри диверзитета гмизаваца у Србији, са циљем да се скрене пажња на конзервационе мере неопходне за заштиту појединих региона од значаја за диверзитет гмизаваца у нашој земљи. Утврђено је постојање четири центра диверзитета: три у Метохији и једног у Шумадији, са присуством од 17 до 21 врсте на површини од 50 × 50 км. Анализа региона Србије по питању сличности састава фауне гмизаваца показала је да се регион југоисточне Србије највише одваја од свих осталих због ексклузивног присуства две медитеранске врсте гмизаваца (*Elaphe quatuorlineata* и *Platyceps najadum*). Метохија се одваја по највећем диверзитету као и присуству великог броја медитеранских врста гмизаваца. Остали региони формирају три групе, при чему се кластер кога чине Косово и јужна Србија одваја по присуству медитеранских врста гмизаваца. Када су на сличан начин упоређене фауне гмизаваца свих држава Балканског полуострва испоставило се да је фауна гмизаваца Србије најсличнија оној у Румунији. Зоогеографска анализа је показала да гмизавци Србије спадају у осам хоротипова, при чему су по броју врста најзаступљенији источномедитерански (са девет врста) и јужноевропски (са пет врста) хоротипови.