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New records and zoogeographic classification of amphibians and reptiles from Bosnia and Herzegovina

Daniel JABLONSKI[1,*], David JANDZIK[1,2] and Václav GVOŽDÍK[3,4]

1. Department of Zoology, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynska dolina B-1, 842 15 Bratislava, Slovakia.
2. Department of Ecology and Evolutionary Biology (EBIO), University of Colorado, Ramaley N122, Campus Box 334, 80309-0334 Boulder, CO, USA.
3. Department of Zoology, National Museum, Cirkusová 1740, 193 00 Prague, Czech Republic.
4. Laboratory of Molecular Ecology, Institute of Animal Physiology and Genetics, Academy of Sciences of the Czech Republic, 277 21 Liběchov, Czech Republic.
*Corresponding author, D. Jablonski, E-mail: daniel.jablonski@balcanica.cz

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Abstract. Bosnia and Herzegovina plays an important role for the diversity of herpetofauna of the Balkans. The composition of the amphibian and reptile fauna has been influenced by both continental and Mediterranean climate. So far, 18 species of amphibians and 29 species of reptiles have been found to inhabit the territory, but due to the overall neglected faunistic research of this region in the last decades, this is presumably not the final number. At 31 localities we observed 12 species of amphibians and 17 species of reptiles representing 66.7 and 58.6% of the total known diversity of amphibians and reptiles, respectively. We recorded new distribution data for 8 species of amphibians and 9 species of reptiles. A zoogeographic analysis showed that the herpetofauna of Bosnia and Herzegovina could be classified into at least 12 chorotypes. While the amphibian assemblages are predominantly influenced by the European temperate climatic conditions, the Mediterranean climate plays a key role for the composition of the reptile fauna.

Keywords: Amphibia, Reptilia, herpetofauna, faunistics, distribution, biogeography, zoogeography, Former Yugoslavia, Balkan Peninsula.

Introduction

Herpetofauna of Bosnia and Herzegovina (BaH), a country situated in the north-western Balkan Peninsula, is characterized by high amphibian and reptile species richness. So far 18 species of amphibians and 29 species of reptiles (excluding the marine turtles) have been reported from the country representing Mediterranean, central European, boreal and steppe elements (according to the maps in Gasc et al. 1997 and with respect to the current taxonomy sensu Speybroeck et al. 2010). Distribution patterns of the herpetofauna in BaH are mainly influenced by continental and Mediterranean climatic conditions and by diverse geography comprising the Pannonian Plain in the North-East and the North-West to the South-East oriented Dinarides, which form the western and southern boundaries of the country. The presence of the Pannonian Plain and the absence of longitudinally oriented mountain ranges enabled migration of the fauna and flora through the Balkan Peninsula in latitudinal direction and thus contributed to the general faunistic richness in the region (cf. Hewitt 1996, 1999). The parts of this region presumably served as microrefugia of amphibians (e.g. *Ichthyosaura alpestris*, Sotiropoulos et al. 2007) and reptiles (e.g. *Vipera ammodytes*, Ursenbacher et al. 2008) and speciation centres (e.g. *Dinarolacerta mosorensis*, Ljubisavljević et al. 2007). Similar pattern of refugia and speciation centres could be found in mammals (e.g. *Dinaromys bogdanovi*, Kryštufek et al. 2007), invertebrates (e.g. *Drusus croaticus*, Previšić et al. 2009) or plants (e.g. *Fraxinus* spp., Heuertz et al. 2006). It is noteworthy that faunistic and phylogeographic research of the Balkans has usually omitted the territory of BaH due to the recent civil war in the region, and the data on the amphibian and reptile fauna must be mostly deduced based on the patterns from neighboring countries.

With 29 species of amphibians and 62 species of reptiles (excluding the marine turtles and the herpetofauna of Crete and Eastern Aegean Islands), the Balkan Peninsula is considered a centre of species diversity and endemism for European herpetofauna (e.g. Džukić & Kalezić 2004 with respect to the current taxonomy sensu Speybroeck et al. 2010). The highest species diversity is concentrated in the southern parts of the Balkans, where the main speciation centers were situated (Lymberakis & Poulakakis 2010), nevertheless almost 52% of the Balkan amphibian and reptile species occur in BaH. Though no amphibian or reptile

species is strictly endemic to BaH, some subendemic taxa may be found here. In amphibians this is the case of the Dinaric endemic *Proteus anguinus* (Sket 1997), or of *Salamandra atra prenjensis* which is distributed in the southern Dinarides, geographically presumably isolated from the nominotypic subspecies from the Alps (Staniszewski 2011). Importance of the north-western part of the Balkan Peninsula for herpetofaunal diversity may be further demonstrated by several unique lizard taxa distributed only in this region such as *Dalmatolacerta oxycephala*, *Dinarolacerta mosorensis*, *Dinarolacerta montenegrina* or *Podarcis melisellensis* (Arnold & Ovenden 2002, Podnar et al. 2004, Arnold et al. 2007, Ljubisavljević et al. 2007).

Despite the importance of BaH for understanding the amphibian and reptile zoogeography in the Balkan Peninsula, the information on recent distribution of herpetofauna remains vastly incomplete. Few contributions were published at the end of the 19th century and during the 20th century (Tomasini 1894, Werner 1897, 1899, 1907, Bolkay 1919, 1924, 1929, Radovanović 1941, Frommhold 1963), while the only attempts to summarize all known information on reptiles of BaH are those of Veith (1925, published in 1991a,b). It is obvious that even the complex atlas of the distribution of European herpetofauna shows highly incomplete information on the distribution of many amphibian and reptile species in BaH (cf. Gasc et al. 1997). The aim of our study is thus to bring recent data on the distribution of amphibians and reptiles in BaH and classify the region of BaH zoogeographically.

Material and Methods

In late August, early September and late October 2010 we collected data on distribution of amphibians and reptiles at 31 localities representing most regions of Bosnia and Herzegovina (Table 1, Fig. 1). The species were identified according to Arnold & Ovenden (2002) and taxonomy and nomenclature was adopted from Speybroeck et al. (2010). The faunistic records were usually documented with photographs of both specimens and habitats. We took GPS coordinates (WGS 84) and altitude of all localities as well as all other relevant faunistic data. The distribution data of individual species or species complexes were recorded into 50 x 50 km Universal Transverse Mercator (UTM) maps to be comparable to those of Gasc et al. (1997) (see Fig. 2). Chorotypes were identified according to the classification of Vigna Taglianti et al. (1999) and in chelonians and lizards with respect to Sindaco & Jeremčenko (2008). Subsequently we compared the chorotype structure of the herpetofauna of BaH with that of three regions of the Balkan Peninsula: the North-Western (NW) Balkans (defined here as Croatia and Slovenia), the Eastern (E) Balkans (Bulgaria and Romania) and the Southern (S) Balkans (Albania and Greece, excluding Crete and Eastern Aegean Islands). Data on the presence of the taxa follow Gasc et al. (1997), for Greece and Bulgaria with respect to recent publications (Valakos et al. 2008, Stojanov et al. 2011).

Results

The list of all recorded species can be found in Table 1 (for locality position see Fig. 1). In total, we recorded 29 amphibian and reptile species representing 61.7% of the total number of known species of BaH (47 species), 12 of which were represented by amphibians (from 18 species in total, which is 66.7%) and 17 were represented by reptiles (29 species, 58.6%). The recorded species belonged to 12 families: Proteidae (1 species), Salamandridae (3), Bombinatoridae (1), Bufonidae (2), Hylidae (1), Ranidae (4), Lacertidae (6), Anguidae (2), Colubridae (4), Natricidae (2), Psammophiidae (1), Viperidae (2). In comparison with the distribution maps from Gasc et al. (1997), we found new 50 x 50 km UTM grid records in 8 amphibian species: *Triturus cristatus* complex, *Bombina variegata*, *Bufo bufo*, *Bufo viridis* complex, *Hyla arborea*, *Rana temporaria*, *Rana dalmatina*, *Pelophylax ridibundus* and 9 reptile species: *Lacerta agilis*, *Lacerta viridis* complex, *Podarcis muralis*, *Anguis fragilis* complex, *Coronella austriaca*, *Hierophis gemonensis*, *Natrix natrix*, *Natrix tessellata* and *Zamenis longissimus* (see Fig. 2). In total we recorded 84 faunistic items in 14 50 x 50 UTM quadrates (35.9% from 39 quadrates covering BaH). The most often recorded amphibian species was *B. bufo* (7 localities, 5 quadrates), *P. ridibundus* (4, 3) and *B. variegata* (3, 3). The most common reptile species was *P. muralis* (12, 8). The green lizards of the *L. viridis* complex (11, 8) and slow worms of the *A. fragilis* complex (9, 8) were also relatively common.

On the other hand we did not find some other species known to occur in areas within the mapping grids covering BaH (sensu Gasc et al. 1997): *S. atra*, *I. alpestris*, *Bombina bombina*, *Pelobates fuscus*, *Pelophylax* kl. *esculentus, Mauremys rivulata*, *Emys orbicularis*, *Testudo hermanni*, *Hemidactylus turcicus*, *Algyroides nigropunctatus*, *D. mosorensis*, *Podarcis siculus*, *Zootoca vivipara*, *Elaphe quatuorlineata*, *Zamenis situla*, *Telescopus fallax* and *Vipera ursinii*. However, many of these species probably inhabit BaH only marginally (cf. Gasc et al. 1997).

Table 1. List of surveyed localities, faunistic records and numbers of specimens of amphibians and reptiles encountered within this study in Bosnia and Herzegovina. Locality numbers are the same as in the map (Fig. 1). Nloc – total number of localities where the species was found, Nspec – total number of specimens found at all localities, Nquad – total number of new 50 x 50 km UTM quadrate records, * – new 50 x 50 km UTM quadrate record, + more nearby places were surveyed (coordinates are approximate).

Locality No.	Name of locality	Coordinates	Altitude (m a.s.l.)	*Proteus anguinus*	*Lissotriton vulgaris* complex	*Triturus cristatus* complex	*Salamandra salamandra*	*Bombina variegata*	*Bufo bufo*	*Bufo viridis* complex	*Hyla arborea*	*Rana dalmatina*	*Rana graeca*	*Rana temporaria*	*Pelophylax ridibundus*	*Dalmatolacerta oxycephala*	*Lacerta agilis*	*Lacerta viridis complex*	*Lacerta trilineata*	*Podarcis melisellensis*	*Podarcis muralis*	*Anguis fragilis complex*	*Pseudopus apodus*	*Coronella austriaca*	*Hierophis gemonensis*	*Platyceps najadum*	*Zamenis longissimus*	*Natrix natrix*	*Natrix tessellata*	*Malpolon insignitus*	*Vipera ammodytes*	*Vipera berus*
1	Kozara Mts.+	45.04N 16.91E	230-375	-	-	-	-	2*	2*	-	-	-	-	2*	-	-	-	1*	-	-	2*	1	-	-	-	-	1*	-	-	-	-	-
2	Oštrelj	44.47N 16.40E	1028	-	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
3	Titov Drvar	44.32N 16.33E	935	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	2*	-	-	-	-	-	-	-	-	-	-	-
4	Gorne Peulje	44.13N 16.50E	816	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Humac	43.99N 17.50E	610	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Graćanica	43.99N 17.47E	668	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Kordići	43.96N 17.46E	902	-	-	-	-	2*	1*	-	-	-	-	1*	-	-	-	1*	-	-	>10*	1	-	-	-	-	-	-	-	-	-	-
8	Prozor	43.84N 17.59E	1116	-	-	-	-	-	-	-	-	-	-	-	-	-	2*	2*	-	2	-	-	-	-	-	-	-	-	-	-	-	-
9	Graćac	43.74N 17.67E	335	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-	-	-	1*	-	-	-
10	Dolna Jablanica	43.61N 17.74E	171	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
11	Jasenica (Kravica waterfall)	43.15N 17.60E	80	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
12	Karaotok (Hutovo Blato)	43.07N 17.75E	1	-	-	-	-	-	2*	-	6*	1*	-	-	4	-	-	-	-	-	-	-	1	-	1*	-	-	4*	2	-	-	-
13	Neum	42.92N 17.61E	43	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
14	Hadžibegova Kula	42.95N 17.80E	420	-	4	-	-	-	-	2*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Zavala (Vjetrenica Cave)	42.84N 17.97E	267	2	-	-	-	-	-	1*	1*	-	-	-	-	-	-	-	4	-	-	-	-	-	1	-	-	-	-	1	-	-
16	Nevesinje	43.24N 18.09E	1160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2	1	1	-	3	-	-	-	-	-	-	-	-
17	Šume	43.20N 18.45E	959	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-
18	Sutjeska (loc. 1)	43.29N 18.64E	716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>10	-	-	-	-	-	-	-	-	-	-	-
19	Sutjeska (loc. 2)	43.30N 18.66E	773	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	>10	1	-	-	-	-	-	-	-	-	-	-
20	Sutjeska (loc. 3)	43.36N 18.70E	865	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
21	Sutjeska (loc. 4)	43.34N 18.70E	990	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Sutjeska (loc. 5)	43.28N 18.71E	1714	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	2
23	Tjentište (Sutjeska, loc. 6)	43.36N 18.70E	541	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Sarajevo	43.85N 18.43E	556	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>10	-	-	-	-	-	-	-	-	-	-	-
25	Visoko	43.97N 18.18E	671	-	-	-	2	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. (continued).

Locality No.	Name of locality	Coordinates	Altitude (m a.s.l.)	*Proteus anguinus*	*Lissotriton vulgaris* complex	*Triturus cristatus* complex	*Salamandra salamandra*	*Bombina variegata*	*Bufo bufo*	*Bufo viridis* complex	*Hyla arborea*	*Rana dalmatina*	*Rana graeca*	*Rana temporaria*	*Pelophyax ridibundus*	*Dalmatolacerta oxycephala*	*Lacerta agilis*	*Lacerta viridis complex*	*Lacerta trilineata*	*Podarcis melisellensis*	*Podarcis muralis*	*Anguis fragilis complex*	*Pseudopus apodus*	*Coronella austriaca*	*Hierophis gemonensis*	*Platyceps najadum*	*Zamenis longissimus*	*Natrix natrix*	*Natrix tessellata*	*Malpolon insignitus*	*Vipera ammodytes*	*Vipera berus*
26	Niśićі	44.05N 18.46E	1059	-	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	2	-	-	-	-	?	-	-	-	-	-
27	Požarnica	44.53N 18.77E	306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	1*	-	-	-	-	-	-	-	-
28	Jelah	44.65N 17.96E	175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Teśan	44.64N 17.88E	194	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Klupe (Hadjučke vode)	44.60N 17.61E	711	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	>10*	-	-	-	-	-	-	-	-	-	-
31	Bogdanićі	44.58N 17.56E	598	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>10*	-	-	-	-	-	-	-	-	-	-
	Nloc			1	1	1	2	3	7	2	2	2	1	2	4	1	3	11	2	3	12	9	1	2	2	1	1	2	2	1	1	1
	Nspec			2	4	3	5	6	9	3	7	2	1	3	7	1	4	>10	5	5	>10	>10	1	4	2	1	1	5	3	1	1	2
	Nquad			-	-	1	-	2	5	2	2	2	-	2	1	-	3	6	-	-	4	1	-	1	1	-	1	1	1	-	-	-

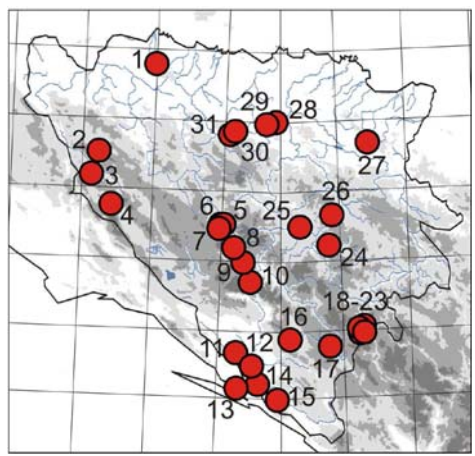

Figure 1. Map of Bosnia and Herzegovina with all localities of the amphibians and reptiles surveyed in this study with the 50 x 50 km UTM grid.

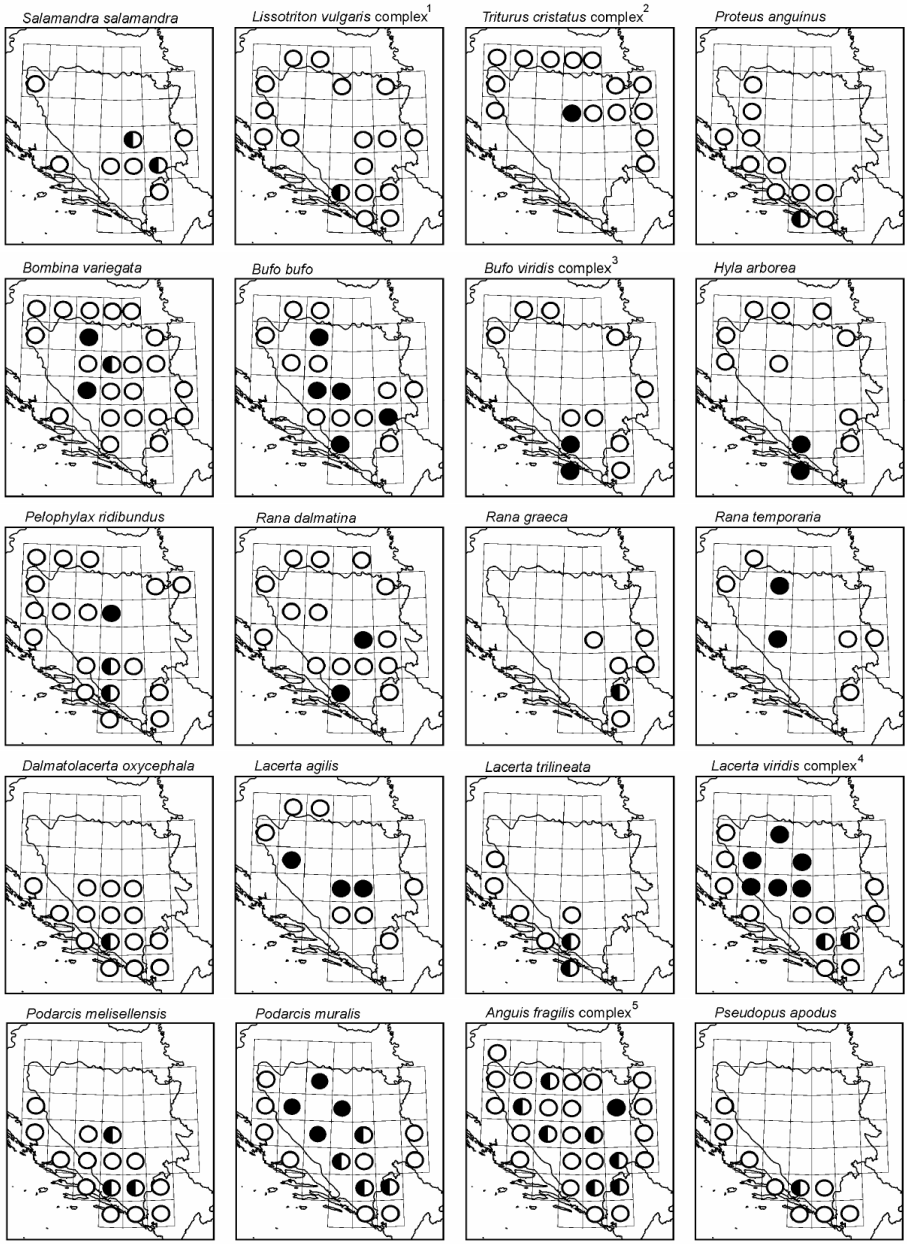

Figure 2. Maps of the known distribution of amphibian and reptile species encountered within this study in the context of the 50 x 50 km UTM mapping quadrates covering the territory of Bosnia and Herzegovina (sensu Gasc et al. 1997). Black circles – new occupied quadrates based on our new records; Empty circles – previously published records from Gasc et al. (1997) (before and after 1970 not distinguished); Half-filled circles – records from Gasc et al. (1997) and re-confirmed by new records of this study. For precise locality data see Table 1.

1.- *Lissotriton* (*v.*) *vulgaris* and *L.* (*v.*) *graecus* presumably occur in the region (cf. Babik et al. 2005).
2.- *Triturus macedonicus*, *T. carnifex*, and presumably also *T. dobrogicus* occur in the region (cf. Wielstra & Arntzen 2011).
3.- *Bufo viridis* and possibly also *B. variabilis* could occur in the region (cf. Stöck et al. 2006).
4.- *Lacerta viridis* and presumably also *L. bilineata* occur in the region (cf. Böhme et al. 2007).
5.- *Anguis fragilis* sensu stricto presumably occurs in the region (cf. Gvoždík et al. 2010).
6.- ? = record of shed skin of uncertain identification.

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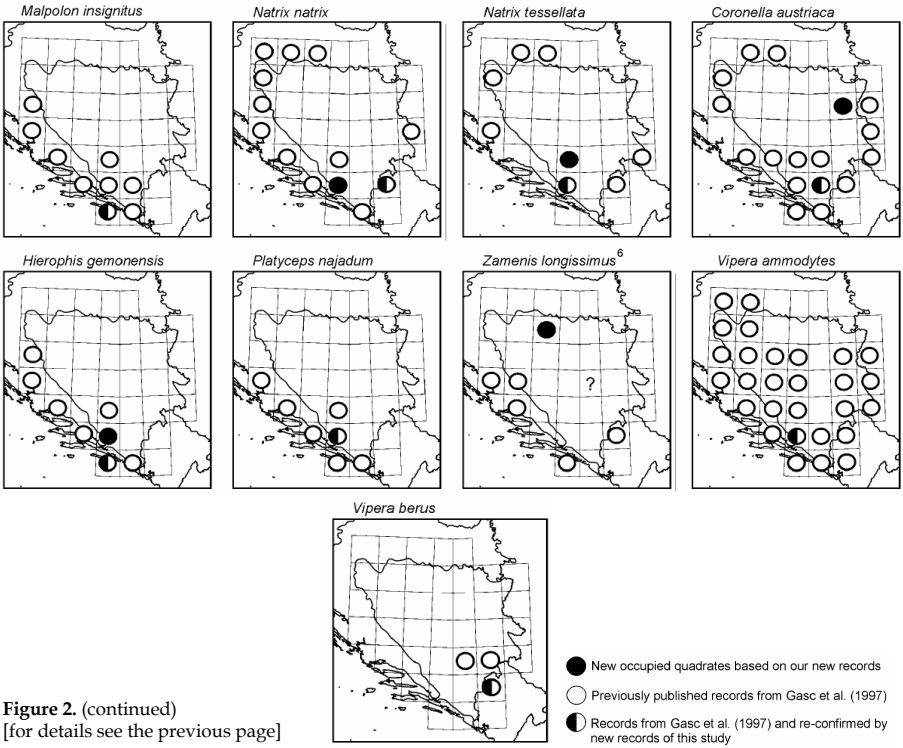

Figure 2. (continued)
[for details see the previous page]

The highest number of species at one locality was recorded in Karaotok (Hutovo Blato) – four amphibian species (*B. bufo*, *H. arborea*, *R. dalmatina*, *P. ridibundus*) and four reptile species (*Pseudopus apodus*, *H. gemonensis*, *N. natrix*, *N. tessellata*) from six families, and in the Sutjeska region where we found three amphibian species (*Salamandra salamandra*, *B. bufo*, *Rana graeca*) and five reptile species (*L. viridis* complex, *P. muralis*, *A. fragilis* complex, *N. natrix*, *Vipera berus*) from seven families (Table 1, Fig. 3).

We classified the herpetofauna of BaH into 12 chorotypes in total (Table 2, Fig. 4). In amphibians we identified eight chorotypes (the most dominant being the European with 27.8% of number of species), in reptiles we identified nine chorotypes (the most dominant being the Eastern-Mediterranean chorotype with 37.9% of number of species). None of the species is endemic for BaH, but eight Balkan endemics occur here accounting for 17.0% of all amphibian and reptile species of BaH (see Table 2).

Chorotype comparison of BaH with the three regions of the Balkan Peninsula (Fig. 4; species lists are in Table 2 and Appendix 1), showed that the number of amphibian chorotypes is the same in all regions with the exception of the Euro-Siberian chorotype which is only represented in the NW and E Balkans, but not in BaH and the S Balkans. Another significant difference is formed by the Eastern-Mediterranean chorotype which is dominant in the S Balkans (36.8%), while only weakly represented in the NW Balkans (5.0%) and moderately in BaH and the E Balkans (16.7% and 18.2%, respectively). Further, the Central-European chorotype is represented by lower relative number of species in BaH (5.6%) and the S Balkans (5.3%) than in the NW and E Balkans (15.0% and 13.6%, respectively). The European chorotype was the most dominant within amphibians in all Balkan regions with the exception of the S Balkans, where the Eastern-Mediterranean chorotype is dominant.

Representation of the reptile chorotypes in all Balkan regions is also very similar in general, with the exception of an extra chorotype in the NW Balkans (Western-Mediterranean chorotype; presence of *Lacerta bilineata*), and an extra chorotype in the E Balkans (Centralasiatic-European; presence of *Eremias arguta*). On the other hand, the Mediterranean chorotype represented by *H. turcicus* is missing in the E Balkans. Frequencies of the other

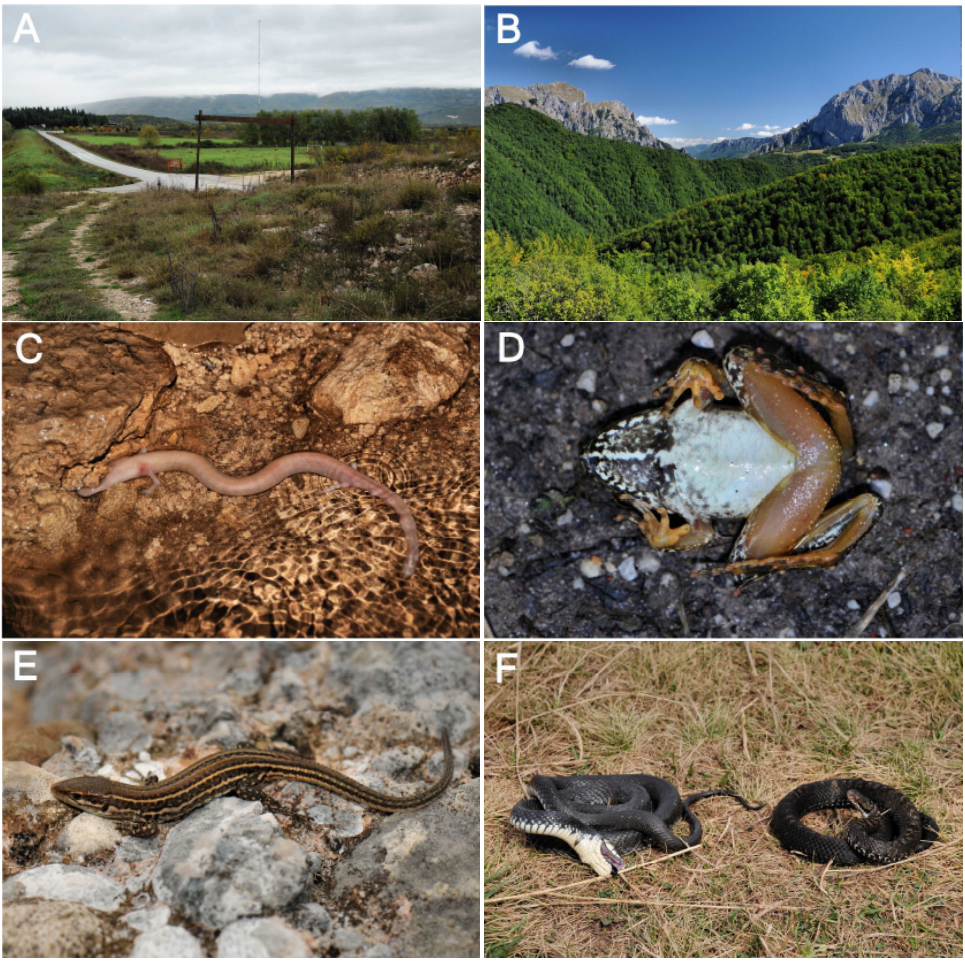

Figure 3. The most species-rich localities surveyed within this study in Bosnia and Herzegovina and representatives of herpetofauna. **A** – Mediterranean habitat in Karaotok (Hutovo Blato). **B** – Overall view on the region of Sutjeska. **C** – Adult *Proteus anguinus* from the Vjetrenica Cave. **D** – Subadult specimen of *Rana graeca* from Sutjeska. **E** – Juvenile specimen of *Podarcis melisellensis* from Nevesinje. **F** – *Natrix natrix* (displaying thanatosis) and *Vipera berus* found at the same locality and habitat in Sutjeska at ca. 1710 m a.s.l.

chorotypes within the Balkan regions are similar with the main deviation in the Eastern-Mediterranean chorotype dominating in all regions, but with much higher representation in the S Balkans (56.6%) than in the remaining three regions (38.6% in average).

Discussion

Bosnia and Herzegovina (BaH) lacks a detailed review of the herpetofauna. Studies published so far were mainly focused on the region of the former Austrian-Hungarian Monarchy or Yugoslavia (Tomasini 1894, Werner 1897, 1899, 1907, Bolkay 1924, Radovanović 1941, Henle 1985), on a particular subregion within BaH (Bolkay 1929), or the information on the distribution of amphibians and reptiles is only general, without presenting detailed faunistic data (Veith 1925, published in 1991a,b, Westrin 2003). As a main source of reference and comparison serves thus the Atlas of amphibians and reptiles in Europe (Gasc et al. 1997) according to which 18 species of amphibians (if we consider two species of the *Triturus cristatus* complex: *T. carnifex* and *T. macedonicus*; cf. Wielstra & Arntzen 2011) and 29 species of reptiles inhabit the country. However, several species are known from

Table 2. Chorotype classification of amphibians and reptiles of Bosnia and Herzegovina: bold – species recorded in this study (larval individuals of the *Triturus cristatus* complex could not be identified into the species), * – Balkan endemic species.

Chorotype	Number of species		Species
	Amphibians	Reptiles	
Centralasiatic-Europeo-Mediterranean	0	1	***Natrix natrix***
Central-European	1	0	*Salamandra atra*
Eastern-European	2	0	*Bombina bombina*, *Pelobates fuscus*
Eastern-Mediterranean	3	11	***Proteus anguinus****, *Triturus macedonicus**, ***Rana graeca****, *Mauremys rivulata*, *Algyroides nigropunctatus**, ***Dalmatolacerta oxycephala****, *Dinarolacerta mosorensis**, ***Lacerta trilineata***, ***Podarcis melisellensis****, *Elaphe quatuorlineata*, ***Hierophis gemonensis****, *Zamenis situla*, ***Malpolon insignitus***, ***Vipera ammodytes***
European	5	2	*Ichthyosaura alpestris*, ***Lissotriton vulgaris*** **complex**, ***Bufo bufo***, *Pelophylax* kl. *esculentus*, ***Rana temporaria***, ***Anguis fragilis*** **complex**, ***Coronella austriaca***
Europeo-Mediterranean	2	0	***Salamandra salamandra***, ***Hyla arborea***
Mediterranean	0	1	*Hemidactylus turcicus*
Southern-European	3	6	*Triturus carnifex*, ***Bombina variegata***, ***Rana dalmatina***, *Testudo hermanni*, ***Lacerta viridis*** **complex**, ***Podarcis muralis***, *Podarcis siculus*, ***Zamenis longissimus***, *Vipera ursinii*
Euro-Siberian	0	3	***Lacerta agilis***, *Zootoca vivipara*, ***Vipera berus***
Turano-European	1	1	***Pelophylax ridibundus***, ***Natrix tessellata***
Turano-Europeo-Mediterranean	1	1	***Bufo viridis*** **complex**, ***Emys orbicularis***
Turano-Mediterranean	0	3	***Pseudopus apodus***, ***Platyceps najadum***, *Telescopus fallax*

neighboring countries close to the political border of BaH [*Triturus dobrogicus*, *Rana arvalis* (cf. Tvrtković & Kletečki 2008), *Pelophylax lessonae*, *Ablepharus kitaibelii* (cf. Szövényi & Jelić 2011), *Iberolacerta horvathi*, *Tarentola mauritanica*]. Their assumed absence in BaH is presumably due to the lack of detailed faunistic data, rather than illustrating the real distribution of these species, thus it is highly probable that they will be found to be distributed more widely. Also recent advances in molecular phylogeny and phylogeography, enabling to delimit species and subspecies more precisely, revealed new taxa (or evolutionary lineages) existing in the Balkans (see e.g. Riberon et al. 2001, Babik et al. 2005, Stöck et al. 2006, Artzen et al. 2007, Böhme et al. 2007, Espregueira Themudo et al. 2009, Gvoždík et al. 2010, Fijarczyk et al. 2011, Garcia-Porta et al. 2012) and we may expect that some of them will also be found inhabiting BaH.

A detailed zoogeographic classification of herpetofauna of Bosnia and Herzegovina has not been carried out so far, although categorization of amphibians and reptiles was proposed based on species habitats (Veith 1925, published in 1991a,b). It distinguished four main groups: Alpine, Pannonian-Pontic, Mediterranean and Balkan fauna. This categorization is however not as detailed as the chorotype classification that we have adopted in this study (sensu Vigna Taglianti et al. 1999, Sindaco & Jeremčenko 2008). Our complex analysis distinguished eight chorotypes of amphibians in BaH with the European chorotype representing the continental fauna being the richest (with 27.8%). With respect to the species number, these chorotypes follow: the Eastern-Mediterranean and Southern-European chorotypes, Europeo-Mediterranean and Eastern-European. All other chorotypes are represented by only a single species. Amphibian fauna of BaH is thus mainly influenced by European elements, similarly to amphibian fauna of the NW and E Balkans. Conversely, in the S Balkans the influence of European elements is considerably weaker and the most dominant chorotype is the Eastern-Mediterranean. Amphibian endemics in the S Balkans confirm the evolutionary significance of this region (cf. Lymberakis & Poulakakis 2010). The high number of identified amphibian chorotypes of BaH with respect to the total number of species indicates that the region was colonized by amphibian fauna of different

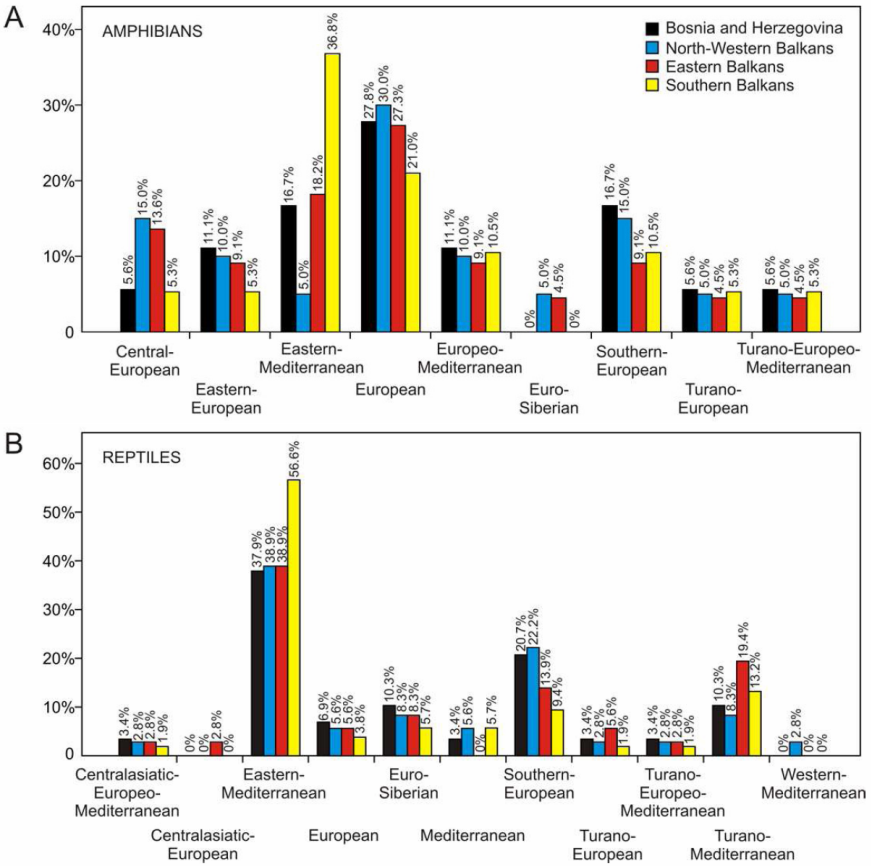

Figure 4. Comparison of frequencies of the identified chorotypes of amphibians and reptiles of Bosnia and Herzegovina and three regions within the Balkan Peninsula (North-Western Balkans – here defined as Croatia and Slovenia; Eastern Balkans – Bulgaria and Romania; Southern Balkans – Albania and Greece without Crete and the Eastern Aegean Islands). For species lists of each particular region see Table 2 and Appendix 2.

origin. There is a vast overlap in distribution ranges of species with different affinities, e.g. BaH forms the southern margin of the ranges of *P. fuscus* and *P.* kl. *esculentus*, the eastern distribution limit of the Balkan endemic *P. anguinus*, and is a part of the southern isolated distribution range of *S. atra* (sensu Gasc et al. 1997, Arnold & Ovenden 2002). *R. graeca*, and presumably *T. macedonicus* too (see Wielstra & Arntzen 2011), are Balkan endemics occurring in BaH and reaching their northern limits there.

Although more reptile species than amphibians occur in BaH, reptile chorotype diversity is about equally rich. Twenty-nine reptile species belong to nine chorotypes and the most numerous is the Eastern-Mediterranean chorotype, followed by the Southern-European chorotype. All other chorotypes are represented by only three or less species. Chorotype composition of the reptiles of BaH is very similar to the three Balkan regions. However, the E Balkans lack the Mediterranean chorotype represented by the gecko *H. turcicus*. On the other hand the E Balkans is the only region in which the Centralasiatic-European chorotype is present (*E. arguta* from Eastern Romania, e.g. Gherghel et al. 2007). Also the NW Balkans contains an additional chorotype, i.e. Western-Mediterranean due to the presence of *L. bilineata*, which might also occur in BaH, though this needs to be confirmed (cf. Böhme et al. 2007). Unlike in amphibians, the best represented reptile chorotype in BaH is the Eastern-Mediterranean which is dominant in other Balkan regions as well. Relatively high representation of this chorotype in BaH

is surprising given the small area of BaH belonging to the Mediterranean climatic zone and highlighting thus the importance of the southern regions for the biological diversity of the country. In the Balkan Peninsula, the NW and E regions form the marginal zones and in the past they were more influenced by fauna from farther regions outside the Balkans, e.g. by the Ponto-Caspian fauna in the case of the E Balkans [*Triturus* (*karelinii*) *arntzeni*, *Darevskia praticola*, *E. arguta*, *Dolichophis caspius*, *Elaphe sauromates*; cf. Radovanović 1964, Covaciu-Marcov et al. 2006, Gherghel et al. 2007, Strugariu & Gherghel 2007, Ţibu & Strugariu 2007], or the fauna with southern-European affinities in the NW Balkans (e.g. *Hierophis viridiflavus*; or *Vipera aspis*, cf. Kumar 2009).

This clearly shows that the eastern-Mediterranean fauna has had by far the strongest influence on the overall reptile species diversity of BaH, despite the fact that the Mediterranean ecoregion forms only a small portion of BaH. Ranges of many reptile species with mostly southern distribution have their partial margins here: chelonians *M. rivulata* (the northernmost distribution) and *T. hermanni*, lizards *H. turcicus*, *P. melisellensis*, *P. siculus*, *D. mosorensis*, *D. oxycephala*, *A. nigropunctatus*, *Lacerta trilineata*, and *P. apodus*, and snakes *E. quatuorlineata*, *Z. situla*, *H. gemonensis*, *Platyceps najadum*, *T. fallax*, and *Malpolon insignitus* (sensu Gasc et al. 1997, Arnold & Ovenden 2002). Additionally, five Balkan endemic reptile species occur in BaH: *A. nigropunctatus*, *D. mosorensis*, *D. oxycephala*, *P. melisellensis* and *H. gemonensis*.

Despite the continental geography and temperate climatic conditions of most of BaH, which influenced mainly the composition of the amphibian fauna, the composition of the reptilian fauna of BaH resembles more the Mediterranean zoogeographic subregion. Twelve amphibian and reptile chorotypes that we identified suggest high biogeographic importance of the BaH region for the Balkan herpetofaunal diversity, which is also in concordance with the refugial role of the Balkan Peninsula (e.g. Hewitt, 1999).

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+ Appendix 1 (3 pages)

Appendix 1. Chorotype assignments and overview of the presence of amphibians and reptiles in Bosnia and Herzegovina and the three regions within the Balkan Peninsula (for definitions and data sources see Material and Methods)..

Species	Bosnia and Herzegovina	North-Western Balkans		Eastern Balkans		Southern Balkans		Chorotype
		Croatia	Slovenia	Bulgaria	Romania	Albania	Greece	
Amphibia								
Ichthyosaura alpestris	+	+	+	+	+	+	+	European
Lissotriton montandoni					+			Central-European
Lissotriton vulgaris complex	+	+	+	+	+	+	+	European
Salamandra atra	+	+	+			+		Central-European
Salamandra salamandra	+	+	+	+	+	+	+	Europeo-Mediterranean
Triturus (*karelinii*) *arntzeni*				+	+		+	Eastern-Mediterranean
Triturus cristatus				+	+			Central-European
Triturus carnifex	+	+	+					Southern-European
Triturus dobrogicus		+		+	+			Central-European
Triturus macedonicus	+			+		+	+	Eastern-Mediterranean
Proteus anguinus	+	+	+					Eastern-Mediterranean
Bombina bombina	+	+	+	+	+		+	Easter-European
Bombina variegata	+	+	+	+	+	+	+	Southern-European
Pelobates fuscus	+	+	+	+	+			Eastern-European
Pelobates syriacus				+	+	+	+	Eastern-Mediterranean
Bufo bufo	+	+	+	+	+	+	+	European
Bufo viridis complex	+	+	+	+	+	+	+	Turano-Europeo-Mediterranean
Hyla arborea	+	+	+	+	+	+	+	Europeo-Mediterranean
Pelophylax bedriagae							+	Eastern-Mediterranean
Pelophylax epeiroticus						+	+	Eastern-Mediterranean
Pelophylax esculentus	+	+	+	+	+			European
Pelophylax lessonae		+	+		+			European
Pelophylax ridibundus	+	+	+	+	+	+	+	Turano-European
Pelophylax shqipericus						+		Eastern-Mediterranean
Rana arvalis		+	+		+			Euro-Siberia
Rana dalmatina	+	+	+	+	+	+	+	Southern-European
Rana latastei		+	+					Central-European
Rana graeca	+			+		+	+	Eastern-Mediterranean
Rana temporaria	+	+	+	+	+	+	+	European
Number of amphibian species	18	20	19	19	20	16	17	

Appendix 1. (continued)

Species	Bosnia and Herzegovina	North-Western Balkans		Eastern Balkans		Southern Balkans		Chorotype
		Croatia	Slovenia	Bulgaria	Romania	Albania	Greece	
Reptilia								
Testudo graeca				+	+	+	+	Turano-Mediterranean
Testudo hermanni	+	+	+	+	+	+	+	Southern-European
Testudo marginata						+	+	Eastern-Mediterranean
Mauremys rivulata	+	+		+		+	+	Eastern-Mediterranean
Emys orbicularis	+	+	+	+	+	+	+	Turano-Europeo-Mediterranean
Laudakia stellio							+	Eastern-Mediterranean
Hemidactylus turcicus	+	+				+	+	Mediterranean
Mediodactylus kotschyi				+		+	+	Eastern-Mediterranean
Tarentola mauritanica		+	+				+	Mediterranean
Algyroides moreoticus							+	Eastern-Mediterranean
Algyroides nigropunctatus	+	+	+			+	+	Eastern-Mediterranean
Dalmatolacerta oxycephala	+	+				+		Eastern-Mediterranean
Darevskia praticola				+	+		+	Eastern-Mediterranean
Dinarolacerta montenegrina								Eastern-Mediterranean
Dinarolacerta mosorensis	+	+						Eastern-Mediterranean
Eremias arguta					+			Centralasiatic-European
Hellenolacerta graeca							+	Eastern-Mediterranean
Iberolacerta horvathi		+	+					Eastern-Mediterranean
Lacerta agilis	+	+	+	+	+	+	+	Euro-Siberian
Lacerta bilineata		+	+					Western-Mediterranean
Lacerta trilineata	+	+		+	+	+	+	Eastern-Mediterranean
Lacerta viridis complex	+	+	+	+	+	+	+	Southern-European
Ophisops elegans				+			+	Eastern-Mediterranean
Podarcis erhardii				+		+	+	Eastern-Mediterranean
Podarcis gaigeae							+	Eastern-Mediterranean
Podarcis levendis							+	Eastern-Mediterranean
Podarcis melisellensis	+	+	+			+		Eastern-Mediterranean
Podarcis milensis							+	Eastern-Mediterranean
Podarcis muralis	+	+	+	+	+	+	+	Southern-European
Podarcis peloponnesiacus							+	Eastern-Mediterranean
Podarcis siculus	+	+	+					Southern-European
Podarcis tauricus				+	+	+	+	Eastern-Mediterranean

Appendix 1. (continued)

Species	Bosnia and Herzegovina	North-Western Balkans		Eastern Balkans		Southern Balkans		Chorotype
		Croatia	Slovenia	Bulgaria	Romania	Albania	Greece	
Zootoca vivipara	+	+	+	+	+	+		Euro-Siberian
Ablepharus kitaibelii		+		+	+	+	+	Eastern-Mediterranean
Chalcides ocellatus							+	Mediterranean
Ophiomorus punctatissimus							+	Eastern-Mediterranean
Anguis cephallonica							+	Eastern-Mediterranean
Anguis fragilis complex	+	+	+	+	+		+	European
Anguis graeca						+	+	Eastern-Mediterranean
Pseudopus apodus	+	+		+		+	+	Turano-Mediterranean
Typhlops vermicularis				+		+	+	Turano-Mediterranean
Eryx jaculus				+	+	+	+	Turano-Mediterranean
Malpolon insignitus	+	+	+	+		+	+	Eastern-Mediterranean
Natrix natrix	+	+	+	+	+	+	+	Centralasiatic-Europeo-Mediterranean
Natrix tessellata	+	+	+	+	+	+	+	Turano-European
Coronella austriaca	+	+	+	+	+	+	+	European
Dolichophis caspius		+		+	+	+	+	Eastern-Mediterranean
Elaphe quatuorlineata	+	+	+	+		+	+	Eastern-Mediterranean
Elaphe sauromates				+	+		+	Turano-Mediterranean
Hierophis gemonensis	+	+	+			+	+	Eastern-Mediterranean
Hierophis viridiflavus		+	+					Southern-European
Platyceps collaris				+				Eastern-Mediterranean
Platyceps najadum	+	+		+		+	+	Turano-Mediterranean
Telescopus fallax	+	+	+	+		+	+	Turano-Mediterranean
Zamenis longssimus	+	+	+	+	+	+	+	Southern-European
Zamenis situla	+	+		+		+	+	Eastern-Mediterranean
Macrovipera schweizeri							+	Eastern-Mediterranean
Montivipera xanthina							+	Eastern-Mediterranean
Vipera ammodytes	+	+	+	+	+	+	+	Eastern-Mediterranean
Vipera aspis			+					Southern-European
Vipera berus	+	+	+	+	+	+	+	Euro-Siberian
Vipera ursinii	+	+		+	+	+	+	Southern-European
Number of reptile species	29	35	25	34	23	36	50	