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Contribution to the knowledge of the Reptile fauna and diversity in FYR of Macedonia

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Abstract. Although reptile fauna of FYR of Macedonia (FYROM) was the matter of interest since more than a century, detailed distributions of most of the species are still missing. According to published data, 32 reptile species inhabit FYROM. In this paper, detailed distribution data of reptile species in FYROM are presented. Research of herpetofauna of FYROM was conducted from 1999 until 2012 and included 393 localities. For 32 recorded reptile species, exact localities and altitudes, as well as published records are given. Analyses of the reptile diversity of the FYROM showed that the regions with the highest species diversity are: the Prespa and Ohrid Lake Region, Skopje region, Veles region and the Dojran Lake Region, with 18-21 reptile species per UTM 10 x 10 squares. These regions should be considered for the future designation of important herpetological areas at national level. Results of comparative analysis of reptile faunas from all Balkan countries showed that Macedonian fauna is the most similar with Albanian (92.537) and Bulgarian (90.909) reptile faunas. Zoogeographic analysis showed that reptile fauna of FYROM consists of eight chorotypes in total, the most dominant chorotype being the Eastern-Mediterranean with 13 species, followed by the Turano-Mediterranean with six and Southern-European with five species. Detailed distribution data of this study could be basis for future action plans, protection and conservation measures of reptiles in FYROM, and should be implemented in the national legislation and acts. In addition, this data are imperative for the Red Data Book of reptilians and designation of the Important Herpetological Areas in the country.

Key words: reptile species, faunistic, biodiversity, zoogeography, FYR of Macedonia.

Introduction

Although more than 9,000 species of reptiles have been described worldwide (Uetz 2010), taxonomic, geographical and biological knowledge of this group is still incomplete, particularly in the species-rich countries of the developing world (Measey 2006). Habitat loss and degradation are the principal threats affecting reptile populations in these regions (Cox & Temple 2009), followed by unsustainable trade, invasive species, pollution, disease and climate change (Gibbons et al. 2000). Regional faunistic studies are the starting point for threatened reptile research, and reveal regions, taxa and anthropogenic threat processes on which future research and conservation efforts should be targeted, to effectively maintain the local reptile diversity as well as world's reptile diversity.

The Balkan Peninsula, as a part of the Mediterranean basin, is generally recognized as one of the hot-spots of European biodiversity (Médail & Quézel 1999, Džukić & Kalezić 2004). FYR of Macedonia (FYROM), situated in the central part of the Balkan Peninsula, is characterized by high biological diversity of many plant and animal groups (Anonymous 2010). Published data about distribution of reptiles in the FYROM are mainly from two periods of the 20th century. The first one falls between the two world wars (Doflein 1921, Buresch & Zonkow 1932, 1934, Karaman 1928, 1931, 1937, 1938-39, 1939) and the second one is between the years 1950 and 2000 (Radovanović 1951, Dimovski 1959a,b, 1963, 1964, 1966a,b, 1971, 1981, Džukić & Grubač 1988, Petrušev et al. 1990, Petkovski et al. 2000/2001). Only recently, the number of distribution records for Macedonian reptile fauna started to increase in the published literature (Sterijovski & Stamatoski 2002, Sterijovski et al. 2002, 2010a,b, Sterijovski 2005, Jelić et al., 2012). In some of the recent general literature of European herpetofauna (Gasc et al. 1997), the distribution of the reptile species in FYROM are given, but precise distribution data are still lacking.

The aims of this paper were to: a) use both literature and field data, in order to complete up-to-date knowledge about distribution of herpetofauna in FYROM, b) asses regions with the highest reptile diversity in the country, c) propose the zo-

ogeographic classification of the reptile species in FYROM, d) analyze the similarity of Macedonian reptile fauna with the neighboring countries of the Balkan Peninsula.

Materials and methods

Two types of records became part of the study: (i) records previously published in the literature and (ii) unpublished (new) records. They are as such, distinguished in the grid maps. Faunistic records (both literature and new ones) were mapped in the 10 km x 10 km UTM (universal Transverse Mercator) geographic coordinate grid system.

During fourteen consecutive years (from 1999 to 2012) numerous field trips were conducted in different regions of FYROM. Most field trips were done in July and August, and some were carried out from April to September. Most specimens were collected, examined for identification, photographed and released in original habitats. For identification, field guides of Radovanović (1951), Arnold & Ovenden (2002) were used, and taxonomy and nomenclature was adopted from Speybroeck et al. (2010). Some samples (e. g. road kills) were collected for more detailed studies and were deposited at the Herpetological collection of Macedonian Ecological Society or the private collection of Bogoljub Sterijovski in Skopje.

The majority of literature data are given with exact localities. However, in several old references given by Dimovski (1960, 1963, 1966b) and Karaman (1922, 1931), only general distribution of certain species is given (e.g. mountains or regions) without precise localities. Due to imprecision of those data, we did not include them in the distribution maps and further analyses.

For analyses of reptile's diversity and the designation of centres of herpetological diversity in FYROM, we used an application created in Visual Basic 6.1 in the program WinWord 2003 (Niketić, 1999), using the method by Walter & Straka (1970), at National Grid UTM Reference for FYROM 10 x 10 km.

Similarities with all Balkan's countries were calculated according to the Sorensen Similarity Index. Data on the presence of the taxa follow Gasc et al. (1997); for Bosnia & Herzegovina, Greece (excluding Crete and Eastern Aegean Islands) and Bulgaria with respect to recent publications (Jablonski et al. 2012, Valakos et al. 2008, Stojanov et al. 2011).

For zoogeographic analyses, chorotypes were identified according to the classification of Vigna Taglianti et al. (1999). Chorotype structure of the reptile fauna of FYROM was compared with that of two neighbouring countries of the central part of the Balkan Peninsula: Serbia and Montenegro.

Results

According to relevant herpetological literature (Doflein 1921, Buresch & Zonkow 1932, 1934, Karaman 1928, 1931, 1937, 1938-39, 1939, Radovanović 1951, Dimovski 1959a,b, 1963, 1964, 1966a,b, 1971, 1981, Džukić & Grubač 1988, Petrušev et al. 1990, Petkovski et al. 2000/2001, Džukić et al. 2001, Sterijovski 2005), 32 reptile species are present in FYROM. Field research conducted during fourteen years, confirmed the presence of all 32 species in this territory. Approximately 65% of the territory was covered (393 localities – 188 of 294 totals UTM 10 x 10 squares). Unfortunately, intensive searches were not completed in the all parts of FYROM equally, thus some parts are not covered well enough with the data.

For every reptile species distribution in FYROM, field data (with region, locality, altitude and date of finding) are given in Appendix I, and literature data (with localities and references) are presented in Appendix II. Records of all species in FYROM are given in Figure 1(A-C) (National Grid UTM 10 x 10 km Reference).

Results of this study and published records show that the most common representatives (recorded in more than 20% of the country – 60 or more of total 294 UTM squares) of Macedonian herpetofauna are: *T. hermanni, A. fragilis*, *L. viridis, L. trilineata, P. erhardii, P. muralis, N. natrix, C. austriaca, D. caspius, Z. longissimus* and *V. ammodytes* (Table 1).

Species that were moderately distributed (recorded in 5 – 20% of the territory – 15-60 of total 294 UTM squares) in our results and/or in literature, data are: *T. graeca*, *A. kitaibellii*, *L. agilis*, *P. tauricus, T. vermicularis, N. tessellata*, *P. najadum*, *E. quatuorlineata*, *M. monspessulanus* and *V. berus* (Table 1).

According to current data, extremely rare reptilian species (recorded in less then 5% of the country – up to 15 of total 294 UTM squares) in FYROM are: *E. orbicularis*, *M. rivulata*, *C. kotschyi*, *P. apodus*, *A. nigropunctatus*, *Z. vivipara*, *E. jaculus*, *H. gemonensis*, *T. fallax*, *Z. situla* and *V. ursinii* (Table 1).

Analyses of the reptile diversity of the FYROM showed that the regions with the highest species diversity are: the Prespa and Ohrid Lake Region (DL 83, DL 93), Skopje region (EM 25), Veles region (EM 61, EM 70) and the Dojran Lake Region (FL 46), with 18-21 reptile species per UTM 10 x 10 squares (Figure 2).

Sorensen's similarity index was used for comparative analysis of reptile faunas from all the Balkan countries. Results showed that Macedonian

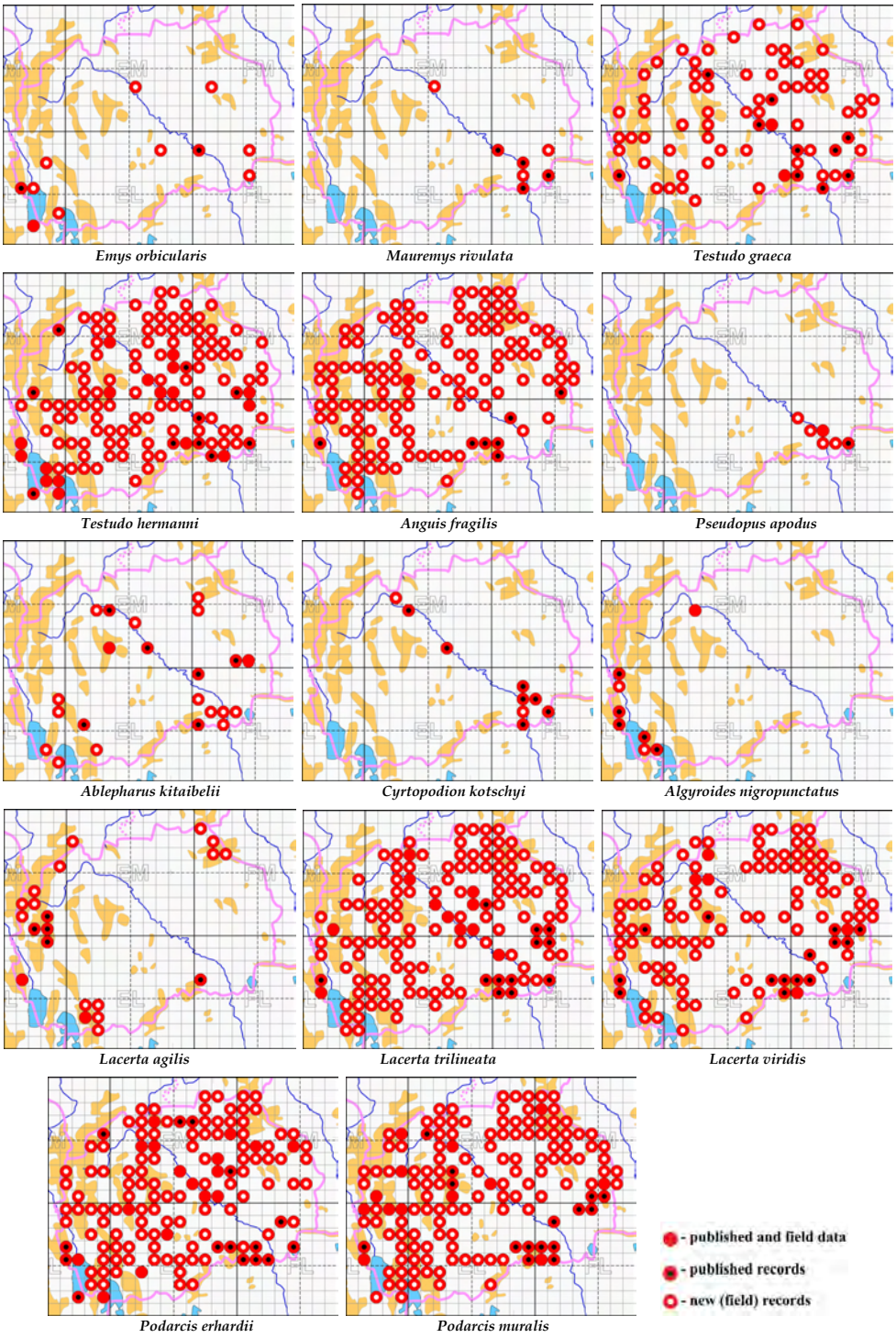

Figure 1/A. Records of reptile species in FYROM. (National Grid UTM 10 x 10 km Reference).

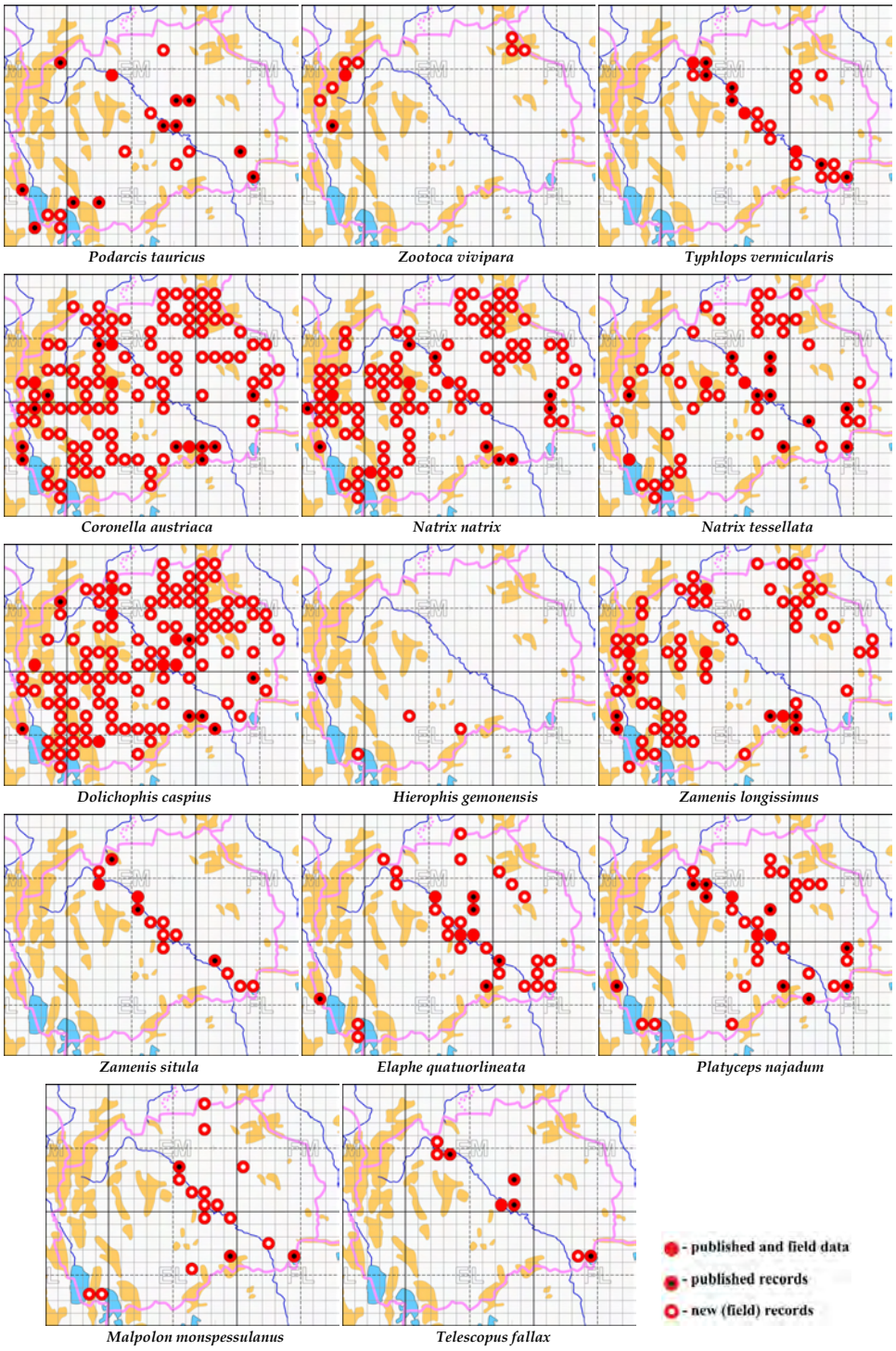

Figure 1/B. Records of reptile species in FYROM. (National Grid UTM 10 x 10 km Reference).

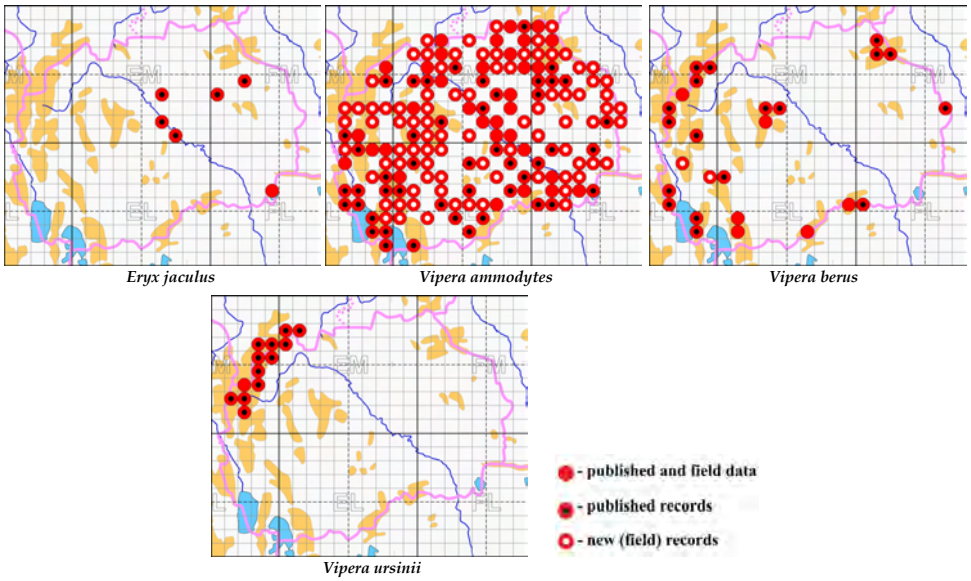

Figure 1/C. Records of reptile species in FYROM. (National Grid UTM 10 x 10 km Reference).

Table 1. Species list and number of UTM 10 x 10 km grids with their records (field and literature data) in FYR of Macedonia.

Species	No. of UTM records
Emys orbicularis	11
Mauremys rivulata	7
Testudo graeca	71
Testudo hermanni	126
Anguis fragilis	128
Pseudopus apodus	6
Ablepharus kitaibelii	22
Cyrtopodion kotschyi	9
Algyroides nigropunctatus	8
Lacerta agilis	21
Lacerta trilineata	134
Lacerta viridis	106
Podarcis erhardii	136
Podarcis muralis	143
Podarcis tauricus	20
Zootoca vivipara	9
Typhlops vermicularis	21
Coronella austriaca	109
Natrix natrix	94
Natrix tessellata	50
Dolichophis caspius	118
Hierophis gemonensis	4
Zamenis longissimus	68
Zamenis situla	14
Elaphe quatuorlineata	31
Platyceps najadum	33
Malpolon monspessulanus	17
Telescopus fallax	8
Eryx jaculus	6
Vipera ammodytes	165
Vipera berus	26
Vipera ursinii	13

fauna is most similar with the Albanian (92.537) and Bulgarian (90.909) reptile faunas (Table 2).

Zoogeographic analysis showed that reptile fauna of FYROM consists of eight chorotypes in total (Table 3, Figure 3). The most dominant chorotype is the Eastern-Mediterranean one with 13 species, followed by the Turano-Mediterranean with 6 and Southern-European with 5 species. Two endemic Balkan species (*Algyroides nigropunctatus* and *Hierophis gemonensis*) occur in the country, but none of them is endemic for FYROM. Comparison with two neighbouring countries of the central Balkans (Serbia and Montenegro) showed that representation of the reptile chorotypes are generally very similar, with the exception of an extra chorotype in Montenegro (Mediterranean chorotype due to the presence of *Hemidactylus turcicus*). Comparatively, Macedonian reptile fauna is characterized by the highest number of Turano-Mediterranean chorotype, with the exclusive presence of *Eryx jaculus*.

Discussion

Since the first published data by Doflein in 1921 and until present day, there has been no detailed comprehensive study about distribution of reptiles that covers the complete territory of the FYROM. Several papers published in the 20th century pre-

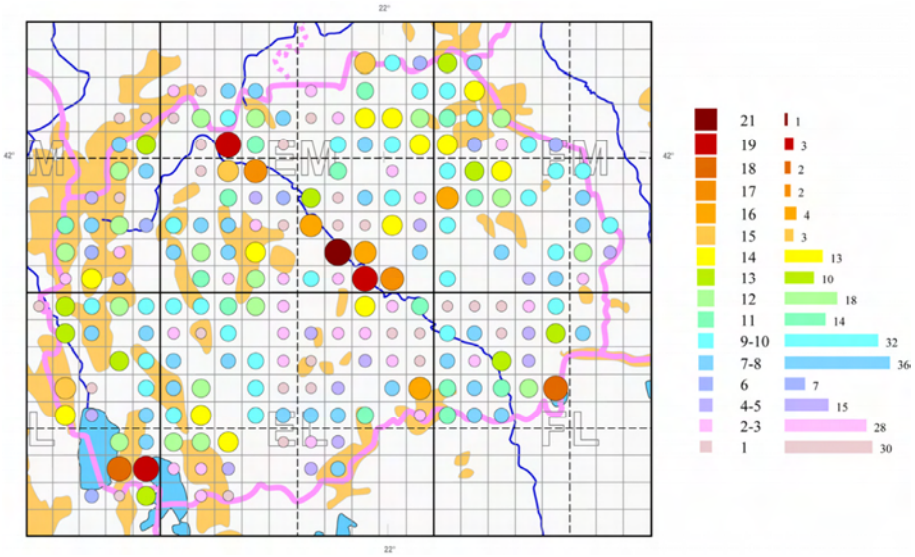

Figure 2. Species diversity of Reptiles in FYROM at National Grid UTM 10 x 10 km Reference.

Table 2. Sorensen similarity index of reptile fauna of the Balkans countries.

SSI	FYR of Macedonia	Serbia	Montenegro	Bulgaria	Albania	Greece	Bosnia	Croatia
FYR of Macedonia	100.000	82.143	81.250	90.909	92.537	75.610	78.689	77.612
Serbia	82.143	100.000	64.286	79.310	74.576	62.162	64.151	64.407
Montenegro	81.250	64.286	100.000	72.727	80.597	63.415	91.803	89.552
Bulgaria	90.909	79.310	72.727	100.000	84.058	76.190	69.841	69.565
Albania	92.537	74.576	80.597	84.058	100.000	77.647	78.125	77.143
Greece	75.610	62.162	63.415	76.190	77.647	100.000	60.759	63.529
Bosnia	78.689	64.151	91.803	69.841	78.125	60.759	100.000	90.625
Croatia	77.612	64.407	89.552	69.565	77.143	63.529	90.625	100.000

Table 3. Chorotype classification of reptiles in FYROM (NSp – number of species).

Chorotype	NSp	Species
Centralasiatic-Europeo-Mediterranean	1	*Natrix natrix*
Turano-European	1	*Natrix tessellata*
Turano-Europeo-Mediterranean	1	*Emys orbicularis*
European	2	*Anguis fragilis, Coronella austriaca*
Euro-Siberian	3	*Lacerta agilis, Zootoca vivipara, Vipera berus*
Southern-European	5	*Testudo hermanni, Lacerta viridis, Podarcis muralis, Zamenis longissimus, Vipera ursinii*
Turano-Mediterranean	6	*Testudo graeca, Pseudopus apodus, Typhlops vermicularis, Eryx jaculus, Platyceps najadum, Telescopus fallax*
Eastern-Mediterranean	13	*Mauremys rivulata, Cyrtopodion kotschyi, Algyroides nigropunctatus, Lacerta trilineata, Podarcis erhardii, Podarcis tauricus, Ablepharus kitaibelii, Malpolon monspessulanus, Dolichophis caspius, Elaphe quatuorlineata, Hierophis gemonensis, Zamenis situla, Vipera ammodytes*

sented the distribution of reptiles in particular (but limited to) parts of the country (Buresch & Zonkow 1932, 1934, Karaman 1928, 1931, 1937, 1938-39, 1939, Radovanović 1951, Dimovski 1959a,b, 1963, 1964, 1966a,b, 1971, 1981, Džukić & Grubač 1988, Petrušev et al. 1990, Petkovski et al. 2000/2001, Sterijovski & Stamatoski 2002, Sterijovski et al. 2002, Sterijovski 2005, Sterijovski et al. 2010a,b) or for specific taxonomic groups (e. g. Vipers – Jelić et al. 2012).

Recent records of some Mediterranean species in the southernmost part of Serbia (the Pčinja

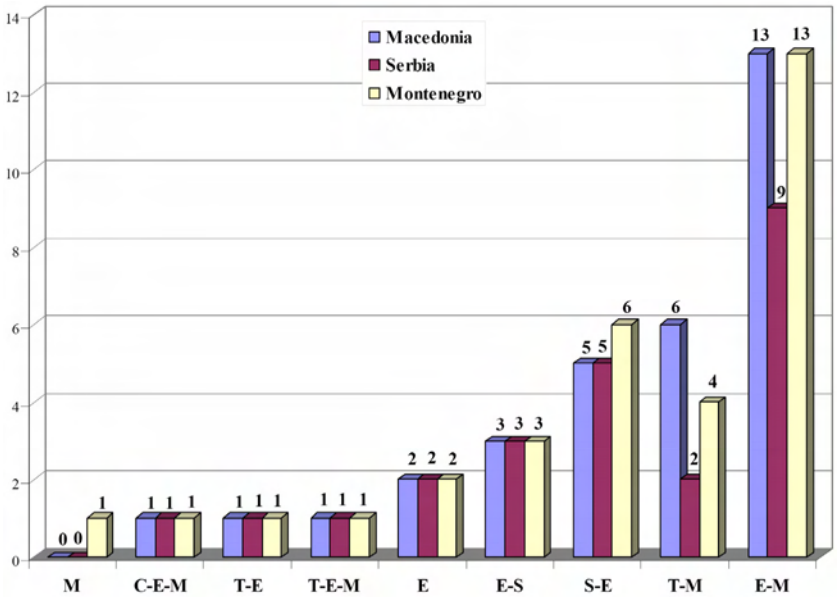

Figure 3. Comparison of numbers of identified chorotypes of reptiles of FYROM and two neighbouring countries of the central Balkans (Serbia and Montenegro). M – Mediterranean, C-E-M – Centralasiatic-Europeo-Mediterranean, T-E – Turano-European, T-E-M – Turano-Europeo-Mediterranean, E – European, E-S – Euro-Siberian, S-E – Southern-European, T-M – Turano-Mediterranean, E-M – Eastern-Mediterranean.

River valley and Prizren) – *P. najadum* (Crnobrnja-Isailović & Aleksić, 1999), *C. kotschyi* (Ajtić & Tomović, 2001), *T. graeca* (Tomović et al., 2004) and *E. quatuorlineata* (Ristić et al., 2006) are further support to the assumption that lack of data for the northern and north eastern parts of FYROM could be the result of incomplete research. Few novel records of the (sub)species of international importance (*Vipera ursinii graeca*) in the southern parts of Albania, may enlarge the possibility that this taxon could be distributed in the southern parts of FYROM too (Korsós et al. 2008). Future studies should also focus on bordering areas with neighbouring countries (Greece, Bulgaria, Albania, Serbia) for the comparative studies of the species diversity (e. g. Asimakopoulos 1994, Ioannidis & Bousbouras 1997, Haxhiu 1998, Crnobrnja-Isailović & Aleksić 1999, Ajtić & Tomović 2001, Petrov & Beshkov 2001, Ristić et al. 2006, Petrov et al. 2006).

More comprehensive faunistic studies may show that some of the species currently treated as "extremely rare" in FYROM (e.g. *P. apodus* and *C. kotschyi*) could be distributed more widely, having in mind their general distribution and ecological preferences. According to the results of faunistic studies, reptile species that we consider to have the highest conservation value and that should have the highest priority in assessment of the conservation status and legal protections at the national level in FYROM are the following:

(i) species that are extremely rare – e. g. *P. apodus, A. nigropunctatus*, *H. gemonensis*

(ii) species which are restricted to very small (isolated) areas and/or specific habitats – *E. orbicularis*, *M. rivulata*, *Z. vivipara*, *E. jaculus, T. vermicularis, V. berus*

(iii) species considered as important at the international level (e.g. Habitats directive, Bern convention, IUCN Red List and CITES) – e. g. *T. graeca*, *T. hermanni*, *E. quatuorlineata*, *V. ursinii*.

The analyses of species diversity performed in this study identified regions that should be considered in the future designation of the Important Herpetological Areas at the national level. Among them are the Prespa Lake and the Ohrid Lake regions. They are already included in the NP Galičica, which makes this National Park one of the most important areas for the reptile conservation plans in FYROM. An imperative for adequate management of protected areas is detailed knowledge of the area's biodiversity. Herpetological studies on diversity, distribution, and ecology of the species in protected areas are amongst the pri-

orities at the European community level (Kati et al. 2007). Implicitly, protected areas should serve as a good "shelter" for the reptile species, otherwise subject to anthropogenic influences and potential extinction in non-protected regions. However, it has been recently proved that this may not be the true – substantial population decline of several snake species was recorded in protected areas worldwide (Reading et al. 2010). Long-term population studies are essential for the assessment of the conservation status of reptile species as well as environmental protection programs at the local or regional level (Gibbons et al. 2000). Only recently, the only long-term population study in FYROM was set at Golem Grad Island at the Prespa Lake (Sterijovski et al. 2011, Ajtić et al. 2013).

Unfortunately, other regions with the highest reptile diversity are not included in the national legislation as protected areas. Further more, Skopje and Veles regions include some of the biggest cities in the country (Skopje and Veles). Reptile communities thus probably suffer from strong anthropogenic pressure as concerned to habitat destruction and human disturbance, which are designated as one of the most important factors affecting reptile population decline and reduction of species range (Gibbons et al. 2000).

Zoogeographic analyses showed that chorotype reptile diversity of FYROM is very high – 32 species belong to nine chorotypes, and the most dominant is the Eastern-Mediterranean, followed by the Turano-Mediterranean. Predominance of Eastern-Mediterranean chorotypes was proved for most of the Balkan countries (Jablonski et al. 2012). However, dominance of the Turano-Mediterranean chorotype is particularly important for FYROM, as it distinguishes the reptile fauna of this country from other countries of the western Balkans (this study – Table 3, and Jablonski et al. 2012). FYROM also presents an area where two species of this chorotype (*Testudo graeca* and *Eryx jaculus*) have western and/or northern distribution limit in Europe (Gasc et al. 1997).

High chorotype diversity, presence of marginal reptile populations and occurrence of the two endemic species in FYROM (*Algyroides nigropunctatus* and *Hierophis gemonensis*) suggest high biogeographic and refugial importance for reptile diversity in the Balkan Peninsula (Hewitt 1999, Džukić & Kalezić 2004).

Detailed distribution data of this study that cover more than 60% of the territory of FYROM could be basis for future action plans, protection and conservation measures of reptile species and should be implemented in the national legislation and acts. In addition, this data are imperative for the Red Data Book of reptilians and the designation of the important herpetological areas in FYROM.

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-Appendix I – Field data – 10 pages
-Appendix II – Literature data – 4 pages