

Sensitivity assessment and extinction risk of amphibians (Chordata: Vertebrata: Amphibia) in Bosnia and Herzegovina

ADNAN ZIMIĆ^{1*,2} & EMINA ŠUNJE^{2,3}

¹ National Museum of Bosnia and Herzegovina,
Zmaja od Bosne 3, 71000 Sarajevo, Bosnia and Herzegovina

*Corresponding author e-mail: adnan.zimic@gmail.com

² Herpetological Association in Bosnia and Herzegovina – ATRA,
Urijan Dedina 137, 71000 Sarajevo, Bosnia and Herzegovina

³ Faculty of Natural Sciences and Mathematics,
Zmaja od Bosne 33-35, 71000 Sarajevo, Bosnia and Herzegovina

Scientific paper
UDK: 597.6 (497.6) "20"

Abstract: In this paper, we present the sensitivity assessment of amphibians of Bosnia and Herzegovina according to DELH (Distributional, Ecological, Life History) data based on 17 parameters. Most sensitive species of amphibians in Bosnia and Herzegovina are: *Proteus anguinus*, *Salamandra atra*, and *Triturus dobrogicus*, due the specific ecology and small habitat range. Nine amphibian taxa are considered to be moderately sensitive, while nine species probably belong to the low sensitivity group. Results indicate that Caudata are a much more threatened taxonomic group when compared to Anurans.

Keywords: conservation, DELH, Caudata, Anura, Life History, Distribution, Ecology

INTRODUCTION

Amphibians are undoubtedly the world's most endangered class of vertebrates. One-third of them (up to ca. 2000 species) are under direct threat of global extinction (Stuart et al., 2004), and the extinction rate is 25–45 times larger than normal (Malcolm, 2007). Due to their skin sensitivity, amphibians cannot endure many anthropogenic factors (often in combined functioning): habitat devastation, pollution, infectious diseases, climate change, invasive species, and excessive feeding exploitation or pet trade (e.g., Alford et al., 2001; Halliday, 2001; Collins & Strofer, 2003; Malcolm, 2007; Foden et al., 2013). Although these factors are identifiable in Bosnia and Herzegovina, the situation is further hampered by the lack of statutory protection of species, the inefficient exercise of existing law regulations and difficult political divisions in the country, which finally result in a small number of protected areas (0,67% Bosnia and Herzegovina territory: BH-CHM, 2010). Bosnia and Herzegovina with its 23 amphibian species (≈65% of total batrachofauna in the Balkans) is an important area in Southern Europe regarding amphibian diversity (Lelo et al., 2015; Lelo & Zimić, 2020) and proper evaluation of the sensitivity of those species at the national level is required.

In addition to the IUCN concept, species sensitivity assessment can be done based on ecological, biological, geographical, and anthropological parameters – so-called DELH (en. Distribution, Ecology, Life History) variables (Filippi & Luiselli, 2000). They elaborated DELH methodology and applied it for the first time in the sensitivity assessment of snakes in Italy. Soon afterwards, Andreone and Luiselli (2000) applied the same concept to the sensitivity assessment of Italian batrachofauna. So far, DELH assessments in Balkans were carried out on vipers (Jelić et al., 2013), and soon afterwards on the assessment of the reptiles (Tomović et al., 2015) and amphibians (Vukov et al., 2015) in Serbia. It was also applied in Vujanović & Jelić (2015), where the overall fauna of Croatia and Bosnia and Herzegovina was presented as a unique entity.

So far, some of the extinction risk assessments (according to IUCN) for amphibian species in Bosnia and Herzegovina were provided in Škrijelj et al. (2013) for the Federation of B&H, and in Anonymous (2012) for the Republic of Srpska, where a simple catalogue of species is listed without specific details. Therefore, the goal of this study was to determine the sensitivity index of all amphibian taxa within the territory of Bosnia and Herzegovina by using DELH methodology.

MATERIAL AND METHODS

The sensitivity assessment methodology applied here used a combination of parameters described in: Andreone & Luiselli (2000), Vujanović et al. (2015), and Vukov et al. (2015), with minimal modifications (Tab. 1). All variables were divided into three to four categories: 0 (min. risk) to 2 or 3 (max. risk). If data was not found or was unknown, this data was analysed by subjective assessment of the author. We used decimals in specific cases: (a) if a taxon showed traits of two parameters and/or (b) if data was unknown – the average value of existing data was used. By using the described approach, every taxon of interest showed its own sensitivity index by considering the average value of indices of all tested parameters (n=17) (Tab. 1). Based on the acquired sensitivity index, all taxa were divided into four categories: very sensitive (1.5–2.0: VS), sensitive (1–1.5: SE), near sensitive (0.9–1.00: NS), and low sensitivity (0–0.9: LS). Geographic parameters were determined based on the latest data on amphibian species distribution in Bosnia and Herzegovina (Lelo et al., 2015; Lelo & Zimić, 2020) compared to global distribution charts (Arntzen & Sparreboom, 1989; Gasc et al., 1997; Wielstra et al., 2013; IUCN, 2015). Used anthropogenic, ecological, and biological data parameters were adopted from: Fachbach (1990), Arnold et al. (1992), Greven (1998), Arnold & Ovenden (2002), Slavens (2003), Cogalniceanu & Miaud (2004), Pisanets et al. (2005), Vukov et al. (2006), Lelo (2007), Arntzen et al. (2009a, 2009b), Vitt & Caldwell (2009), Jelić et al. (2012), Zimić (2013, 2014, 2015), and Šunje et al. (2015).

Pelophylax kurtmuelleri and *P. shqipericus* were treated as not applicable for this study due to a recent discovery of species (Zimić et al., 2020) and their unresolved origin (Tab. 2).

RESULTS

Average values of sensitivity indices of amphibians in Bosnia and Herzegovina varied from 1.82 (*Proteus anguinus*) to 0.53 (*Bufo bufo* and *Rana dalmatina*). Three species (14%) were considered as very sensitive, six species (29%) as sensitive, three (14%) as near sensitive, whereas nine (43%) were considered to be of low sensitivity (Tab. 2).

Table 1. Sensitivity assessment indices for each set of examined parameters: geographical (■), biological (■) and ecological (■)

VARIABLES		RISK	ELABORATION
DB	Distribution Breadth	0	present in 50-100% area of Bosnia and Herzegovina
		1	present in 10-50% area of Bosnia and Herzegovina
		2	present in 5-10% area of Bosnia and Herzegovina
		3	present in <5% area of Bosnia and Herzegovina
ED	Elevational Distribution	0	present 0-2000 m asl
		1	present above 1000 m asl (high altitudes)
		2	present to 1000 m asl (hills)
		3	present to 200 m asl (restricted to plains)
E	Endemicity	0	0-10% of global distribution is in Bosnia and Herzegovina
		1	10-50% of global distribution is in Bosnia and Herzegovina
		2	50-80% of global distribution is in Bosnia and Herzegovina
		3	80-100% of global distribution is in Bosnia and Herzegovina
HF	Habitat Fragmentation	0	fragmentation 0-20%
		1	fragmentation 20-50%
		2	fragmentation 51-75%
		3	fragmentation >75%
PP	Peripheral Populations	0	peripheral populations non-existent
		1	global distribution boundary in BiH
		2	two peripheral boundaries (parallel)*
		3	completely isolated population(s)*
BD	Body Dimensions; SVL (Snout-to-Vent Length) measuring used	0	< 5cm of max. Size
		1	6-10 cm of max. size
		2	10-15 cm of max. Size
		3	> 16 cm of max size
RM	Reproductive mode	0	ovuliparity*
		1	oviparity*
		2	ovoviviparity*
		3	viviparity
EN	Eggs/Offspring Number	0	>200
		1	50-200
		2	10-50
		3	1-10
MA	Maximum Age	0	>15 years of lifespan
		1	11-15 years of lifespan
		2	6-10 years of lifespan
		3	>5 years of lifespan
LC	Life Cycle	0	finishes with complete metamorphosis
		1	finishes with facultative neoteny
		2	finishes with obligatory neoteny
FR	Frequency of Reproduction	0	more than 3 times a year
		1	2-3 times a year
		2	once a year
		3	once every few years
HB	Habitat Breadth: (sub)Mediterranean, montane, continental, pannonic	0	found in all four regions
		1	found in three regions
		2	found in two regions
		3	found in one region

AHR	Aquatic Habitat for Reproduction	0	aquatic habitat not required
		1	temporary or permanent water habitats
		2	only temporary water habitats
		3	water habitats rich in oxygen or slow streams
AI	Anthropogenic Impact: exploitation/harvesting, mortality on roads, purposeful killing, pet commerce	0	non existent
		1	one factor exists
		2	two or more factors exist*
AH	Adaptability to altered Habitats	0	very adaptable (found in urban areas)
		1	adaptable (found in suburban areas)
		2	ill-adaptable (mildly altered habitat)
		3	inadaptable taxon (only found in natural habitats)
HT	Habits	0	underground activity
		1	aquatic activity
		2	terrestrial/aquatic activity
		3	terrestrial activity
A	*Activity	0	nocturnal
		1	nocturnal and diurnal
		2	just diurnal

Table 2. Sensitivity assessment index results according to DELH: ■ very sensitive (>1.5), ■ sensitive (1.2-1.5), ■ near sensitive (1.00-1.20), ■ low sensitivity (<1.00), and not applicable (NA); data categories are elaborated in Table 1.

TAXON	DB	E	ED	HF	PP	BD	RM	EN	MA	LC	FR	HB	AHR	AI	AH	HT	A	DELH index
<i>Proteus anguinus</i>	2	2	3	3	1	3	1.5	2	0	2	1.5	3	3	1	3	0	0	1.82
<i>Salamandra atra</i>	3	0	1	0	3	1	3	3	1	0	3	3	0	0	3	3	1	1.65
<i>Triturus dobrogicus</i>	3	0	3	3	1	1	1	1	2	1	2	3	1	1	2	2	1	1.65
<i>Lissotriton graecus</i>	1	0	3	2	1	0	1	1	2	1	2	3	2	1	2	0.5	1.5	1.50
<i>Bombina bombina</i>	2	0	3	3	1	0	0	1	0	0	1	3	1	1	1	3	2	1.29
<i>Rana graeca</i>	0	1	0	2	2	1	0	0	3	0	2	2	3	1	3	0	2	1.29
<i>Triturus macedonicus</i>	0	1	2	3	1	1	1	1	1	1	2	1	2	1	2	1	1	1.29
<i>Triturus carnifex</i>	3	0	2	1.5	1	1	1	1	1	1	2	1.5	1	1	1	1	1	1.24
<i>Pelobates fuscus</i>	2	0	3	3	1	1	0	0	2	0	2	3	2	1	2	0	0	1.29
<i>Pelophylax lessonae</i>	2	0	2	0	1	1	0	0	2	0	2	3	2	1	1	1	1	1.12
<i>Ichthyosaura alpestris</i>	0	1	0	1	2	0	1	1	0	1	2	2	2	1	2	0.5	1	1.03
<i>Lissotriton vulgaris</i>	0	0	2	2	1	0	1	1	2	1	2	2	2	1	2	1	0	1.00
<i>Pelophylax kl. esculentus</i>	1	0	1.5	0	1	2	0	0	1	0	2	2	2	1	1	0	2	0.97
<i>Salamandra salamandra</i>	0	0	0	1	0	2	2	1	0	0	2	0	2	1	2	1	1	0.88
<i>Bombina variegata</i>	0	1	0	1	1	0	0	1	0	0	1	1	1	1	1	3	2	0.82
<i>Rana temporaria</i>	0	0	2	1	1	1	0	0	1	0	0	1	2	1	1	1	0	0.71
<i>Hyla arborea</i>	0	0	2	0	0	0	0	0	2	0	2	0	2	0	1	1	1	0.65
<i>Bufo viridis</i>	0	0	0	0	0	3	0	0	0	0	2	0	1	1	1	1	1	0.59
<i>Pelophylax ridibundus</i>	0	0	0	0	0	2	0	0	1	0	2	0	2	1	0	0	2	0.59
<i>Rana dalmatina</i>	0	0	0	0	0	1	0	0	2	0	2	0	2	0	1	1	0	0.53
<i>Bufo bufo</i>	0	0	0	0	0	3	0	0	0	0	2	0	1	1	1	1	0	0.53
<i>Pelophylax kurtmuelleri</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA
<i>Pelophylax shqipericus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA

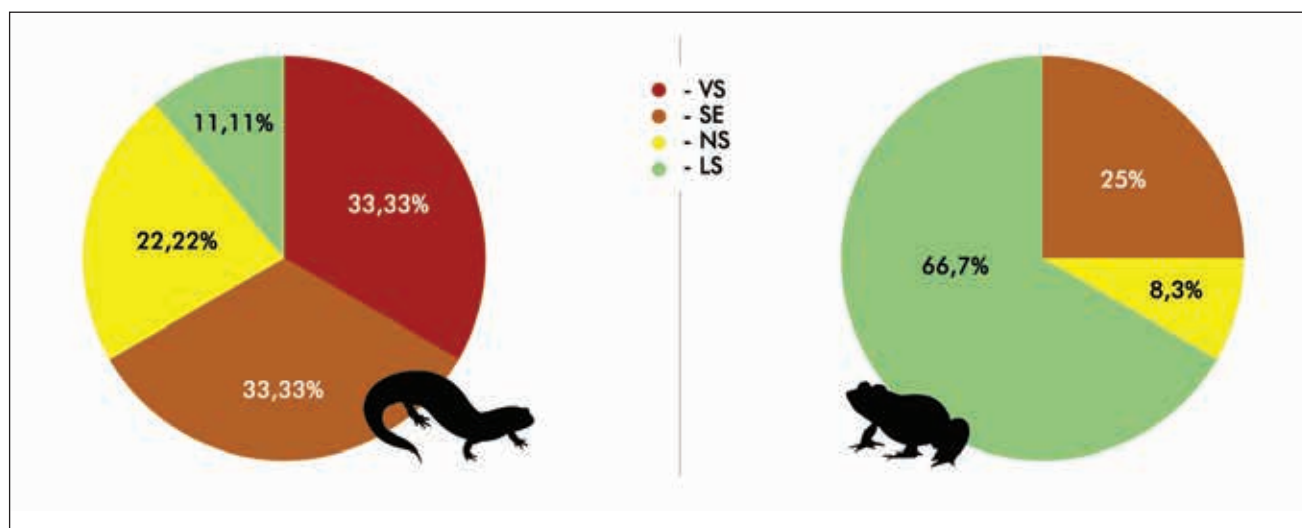


Figure 1. Sensitivity of Caudata (left) and Anura (right) in Bosnia and Herzegovina

DISCUSSION

Results have shown that Caudata in Bosnia and Herzegovina are far more sensitive than Anura. Just one species within Caudata was assigned as not threatened (*S. salamandra*) while all other tailed amphibians were part of a group of sensible taxa suggesting the need for specific conservation attention. On the other hand, there were no Anuran species categorized in the category of very sensitive ones (VS). Eight species of Anura were considered as not threatened (LS), while four taxa were marked as sensitive (SE) or near sensitive (NS) and thus also in need of conservation actions: *B. bombina*, *R. graeca*, *P. fuscus*, and *P. lessonae* (Fig. 1).

A comparison of sensitivity assessment performed for the overall territory of Bosnia and Herzegovina and Croatia (Vujanović & Jelić, 2015), to this one, performed only in Bosnia and Herzegovina territory, revealed minor differences between the two areas and, generally, slightly higher conservation status of amphibians in Bosnia and Herzegovina. For *P. anguinus*, the degree of sensitivity was nearly the same in both areas. Minor differences (0.1 for the total territory of BiH and Croatia versus 0.2 only for Bosnia and Herzegovina territory) were mainly noted for the species that have marginal distribution in Bosnia and Herzegovina: *T. dobrogicus*, *T. carnifex*, *P. fuscus*, *B. bombina*, *P. lessonae*, and *L. vulgaris*. Slightly larger differences were noted for *S. atra* (1.36 vs. 1.62). The reason lies in the fact that ecologically, populations in Bosnia and Herzegovina are very different from populations in Croatia (Šunje et al., 2015) and have very restricted horizontal-vertical distribution (Šunje et al., 2015). The largest difference was noted for *L. vulgaris* (0.57 – 1.00), and it can be explained through the use of a different approach: the amphibian sensitivity assessment of Bosnia and Herzegovina and Croatia (Vujanović et al., 2015) also included *L.*

graecus, which has somewhat different biology and ecology (see Frost, 2015). *Lissotriton graecus* was not a part of the sensitivity assessment of *L. vulgaris* in Bosnia and Herzegovina (this study). The most sensitive amphibians in Serbia according to DELH are *S. atra* and *T. dobrogicus* (Vukov et al., 2015) – which coincides with the results of this research. The only significant irregularity was also noted with *L. vulgaris* probably due to its larger range in Serbia.

CONCLUSIONS

Amphibian sensitivity assessment according to DELH can provide an accurate assessment of the vulnerability level of taxa.

Three amphibian species in Bosnia and Herzegovina are very sensitive (*P. anguinus*, *S. atra* and *T. dobrogicus*) (VS). Six taxa (29%) were marked as sensitive (SE), three (14%) as near sensitive (NS), while nine species (43%) showed low sensitivity (LS).

Tailed amphibians were much more sensitive than anurans. Only one species had low sensitivity index: *Salamandra salamandra*. All other tailed amphibians were considered sensitive taxa (very sensitive, sensitive, or near sensitive). In anurans, there were no highly sensitive taxa; eight species were assigned as having low sensitivity, while four taxa were considered sensitive or near sensitive.

Regionally, DELH statuses of amphibian species in Bosnia and Herzegovina largely coincided with Croatia and Serbia, with a difference in categorization of *L. vulgaris*.

All sensitive species with an index over 0.99 should be subjected to protection measures and special conservation actions as being assigned very sensitive (VS) according to DELH criteria.

REFERENCES

- Alford, R. A., Richards, S. J. & McDonald, K. R. 2001. *Biodiversity of Amphibians. Encyclopedia of Biodiversity*. Volume 1 AC. Academic Press.
- Andreone, F. & Luiselli, L. M. 2000. The Italian batrachofauna and its conservation status: a statistical assessment. *Biological Conservation*, 96: 197-208.
- Anonymous, 2012. Crvena lista zaštićenih vrsta flore i faune Republike Srpske (Црвена листа заштићених врста флоре и фауне Републике Српске). Lista vodozemaca. Pristupljeno: 15.11.2015. Dostupno na: http://www.nasljedje.org/docs/crvenalista/Lista_vodozemaca.pdf
- Arnold, E. N., Barton, J. A. & Oviden, D. W. 1992. *Reptiles and Amphibians of Britain and Europe – Field Guide*. Harper Collins, Glasgow.
- Arntzen, J. W. & Sparreboom, M. 1989. A phylogeny for the Old World newts, genus *Triturus*: biochemical and behavioural data. *Journal of Zoology*, 219: 645-664.
- Arntzen, J. W., Denoël, M., Miaud, C., Andreone, F., Vogrin, M., Edgar, P., Crnobrnja-Isailović, J., Ajtic, R. & Corti, C. 2009a. *Proteus anguinus*. The IUCN Red List of Threatened Species 2009: e.T18377A8173419. http://dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T18377_A8173419.en. Downloaded on 08 November 2015.
- Arntzen, J. W., Kuzmin, S., Jehle, R., Denoël, M., Anthony, B., Miaud, C., Babik, W., Vogrin, M., Tarkhnishvili, D., Ishchenko, V., Ananjeva, N., Orlov, N., Tuniyev, B., Cogalniceanu, D., Kovács, T. & Kiss, I. 2009b. *Triturus dobrogicus*. The IUCN Red List of Threatened Species 2009: e.T22216A9366668. Downloaded on 08 November 2015.
- BH-CHM, 2010. Nacrt Prvog nacionalnog izvještaja Bosne i Hercegovine za Konvenciju o biološkoj raznolikosti. Federalno ministarstvo okoliša i turizma. Dostupno na: www.fmoit.gov.ba/ba/page/63/bh-chm.
- Cogalniceanu, D. & Miaud, C. 2004. Variation in life history traits in *Bombina orientalis* from the lower Danube floodplain. *Amphibia-Reptilia*, 25: 115-119.
- Collins, J. P. & Storer, A. 2003. Global amphibian declines: sorting the hypothesis. *Diversity and Distribution*, 9: 89-98.
- Fachbach, G. 1990. Der Alpensalamander (*Salmandra atra* LAUR.) Biologie und Fortpflanzung. Österreichisches Bundesinstitut für den wissenschaftlichen Film.
- Filippi, E. & Luiselli, L. M. 2000. Status of the Italian snake fauna and assessment of conservation threats. *Biological Conservation*, 93: 219-225.
- Foden, W. B., Butchart, S. H. M., Stuart, S. N., Vie, J.-C., Akcakaya, H. R., Angulo, A., DeVantier, L. M., Gutsche, A., Turak, E., Cao, L., Donner, S. D., Katariya, V., Bernard, R., Holland, R. A., Hughes, A. F., O'Hanlon, S. E., Garnett, S. T., Sekercioglu, C. H. & Mace, G. M. 2013. Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals. *Plos One*, 8(6): 1-13.
- Gasc, J. P., Cabela, A., Crnobrnja-Isailović, J., Dolmen, D., Grossenbacher, K., Haffner, P., Lescure, J., Martens, H., Martínez Rica, J. P., Maurin, H., Oliveira, M. E., Sofianidou, T. S. Veith, M., & Zuiderwijk, A. (eds.) 1997. *Atlas of amphibians and reptiles in Europe*. Collection Patrimoines Naturels, 29, Societas Europaea Herpetologica, Muséum National d'Histoire Naturelle and Service du Patrimoine Naturel, Paris.
- Greven, H. 1998. Survey of the Oviduct of Salamanders With Special Reference to the Viviparous Species. *The Journal of Experimental Zoology*, 282: 507-525.
- Halliday, T. 2001. *Endangered reptiles and amphibians*. Encyclopedia of Biodiversity, Volume 2. Academic Press.
- IUCN, 2015. The IUCN Red List of Threatened Species. Version 2015-3. <<http://www.iucnredlist.org>>. Downloaded on 9 September 2015.
- Jelić, D., Ajtić, R., Sterijovski, B., Crnobrnja-Isailović, J., Lelo, S. & Tomović, Lj. 2013. Vipers (Reptilia: Squamata: Viperidae) of the Western and Central Balkans – legal status and assessment of conservation threats. *Herpetological Conservation and Biology* 8(3):764-770.
- Jelić, D., Kuljerić, M., Koren, T., Treer, D., Šalamon, D., Lončar, M., Podnar-Lešić, M., Janev-Hutinec, B., Bogdanović T. & Mekinić, S. 2012. *Crvena knjiga vodozemaca i gmazova Hrvatske* (Red Book of Amphibians and Reptiles of Croatia). Ministarstvo Kulture, Državni Zavod za Zaštitu Prirode, Zagreb.
- Lelo, S. & Zimić, A. 2020. *Biosistematika vertebrata: Biodiverzitet vodozemaca i gmizavaca sa posebnim osvrtom na faunu Bosne i Hercegovine*. Udruženje za inventarizaciju i zaštitu životinja, Ilijaš, Sarajevo.
- Lelo, S. 2007. *Priručnik za identifikaciju bosansko hercegovačkih vodozemaca*. Udruženje za inventarizaciju i zaštitu životinja, Ilijaš, Kanton Sarajevo.
- Lelo, S., Zimić, A., Čengić, M. & Jelić, D. 2015. *Biodiverzitet vodozemaca (Chordata: Vertebrata: Amphibia) Bosne i Hercegovine: Biosistematski prijedlog podataka sa preliminarnim kartama rasprostranjenja*. Udruženje za inventarizaciju i zaštitu životinja, Ilijaš, Sarajevo.
- Malcolm, L. M. 2007. Amphibian Decline or Extinction? Current Declines Dwarf Background Extinction Rate. *Journal of Herpetology*, 41(3): 483-491.
- Pisanets, E. M., Litvinchuk, S., Kurtyak, F. & Radchenko, V. I. 2005. *The amphibians of Ukrainian Red Book* (Handbook – Cadastre). Kiev, Zoomuseum NMNH NAS of Ukraine, p. 230.
- Škrijelj, R., Lelo, S., Drešković, N., Sofradžija, A., Trožić – Borovac, S., Korjenić, E., Lukić – Bilela, L., Mitrašinović – Brulić, M., Kotrošan, D., Šljuka, S., Gajević, M. & Karačić, J. 2013. Crvena lista Federacije Bosna i Hercegovine. Knjiga 3. Nacrt izvještaja – prijedlog. Greenway Sarajevo i Prirodno-matematički fakultet Univerziteta u Sarajevu (dostupno online: www.fmoit.gov.ba/download/Crvena%20lista%20Faune%20FBiH.pdf).
- Slavens, F. 2003. Frank and Kate Slavens's Reptile and Amphibian Longevity Project: Reptiles and Amphibians in captivity – longevity. Available at: www.pondturtle.com/longev.html. Pristupljeno: 9.11.2015.
- Stuart, S. N., Chanson, J. S., Cox, N. A., Young, B. E., Rodrigues, S. L., Fichman, D. L. & Waller, R. W. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science*, 306: 1783-1786.
- Šunje, E., Jelić, D., Müller, M., Škrijelj, R. & Helfer, V. 2015. Comparative morphology of *Salmandra atra prenensis* (Bosnia and Herzegovina) with its nominotypic subspecies *Salmandra atra atra* (Austria). Oral presentation. 1st Balkan Herpetological Symposium within the 12th Croatian Biological Congress with international participation. Sveti Martin na Muri, 18. – 23. IX 2015. Book of Abstracts, p. 77.

- Tomović, Lj., Urošević, A., Vukov, T. D., Ajtić, R., Ljubisavljević, K., Krizmanić, I., Jović, D., Labus, N., Đorđević, S., Kalezić, M. L., Džukić, G. & Luiselli, L. 2015. Threatening levels and extinction risks based on distributional, ecological and life-history datasets (DELH) versus IUCN criteria – example of Serbian reptiles. *Biodiversity and Conservation* 24(12): 2913-2934.
- Vitt, L. J. & Caldwell, J. P. 2009. *Herpetology: An Introductory Biology of Amphibians and Reptiles*. Third Edition. Burlington, Massachusetts, U.S.A.
- Vujanović, M. & Jelić, D. 2015. Procjena osjetljivosti faune vodozemaca i gmazova u Hrvatskoj i Bosni i Hercegovini uz definiranje važnih herpetoloških područja. 1st Balkan Herpetological Symposium within the 12th Croatian Biological Congress with international participation. Sveti Martin na Muri, 18. – 23. IX 2015. Book of Abstracts, p. 65.
- Vukov, T., Džukić, D. G., Lelo, S., Borkin, L. J., Litvinchuk, S. N. & Kalezić, M. L. 2006. Morphometrics of the yellow-bellied toad (*Bombina variegata*) in Central Balkans: implications for taxonomy and zoogeography. *Zoological Studies*, 45(2): 213-222.
- Wielstra, B., Litvinchuk, S. N., Naumov, B., Tzankov, N. & Arntzen, J. W. 2013. A revised taxonomy of crested newts in the *Triturus karelinii* group (Amphibia: Caudata: Salamandridae), with the description of a new species. *Zootaxa*, 3682(3): 441.
- Zimić, A. 2013. Observation of basic behavioral and zoopsychological characteristics of the European Tree Frog adult individuals, *Hyla arborea* (Linnaeus, 1758) (Amphibia: Anura: Hylidae). *Supplements to Fauna of Bosnia and Herzegovina*, 9: 21-36.
- Zimić, A. 2014. New findings of the Smooth Newt, *Lissotriton vulgaris* (Linnaeus, 1758) (Amphibia: Salamandridae: Pleurodelinae), in the valley of Sarajevo. *Supplements to Fauna of Bosnia and Herzegovina*, 10: 39-47.
- Zimić, A. 2015. Distribution (horizontal and vertical) and conservation status of herpetofauna of Sarajevo Canton and its wider area (Bosnia and Herzegovina). Oral presentation. 1st Balkan Herpetological Symposium within the 12th Croatian Biological Congress with international participation. Sveti Martin na Muri, 18. – 23. IX 2015. Book of Abstracts, p. 63.
- Zimić, A. 2016. Assessment of the status of endangerment of The Danube newt, *Triturus dobrogicus* (Kiritzencu, 1903), in Bosnia and Herzegovina. 9th Scientific Conference "Students Encountering Science" With International Participation. At: Banja Luka. Book of abstracts, pp. 40.
- Zimić, A., Vrhovac, B., Šunje, E., Ćurić, A. & Kalamujić Stroil, B. 2020. Molecular identification of Green frogs (Anura: Ranidae: *Pelophylax*) of Western Balkans (Bosnia & Herzegovina and Montenegro). IV Symposium of biologist and ecologist of Republic of Srpska with international participation – SBERS2020. At: Faculty of Natural Sciences and Mathematics, University of Banja Luka, 12-14.11, 2020.

SAŽETAK

Vodozemci su nedvojbeno najugroženija klasa kičmenjaka na svijetu, a trećina vrsta je pod izravnom prijetnjom globalnog izumiranja. Zbog osjetljivog kožnog sistema, vodozemci ne podnose mnoge antropogene pritiske poput: konverzije staništa, zagađenja, zaraznih bolesti, klimatskih promjena, invazivnih vrsta i dr. Iako se ovi čimbenici mogu identificirati u Bosni i Hercegovini, situacija je dodatno otežana nedostatkom zakonske zaštite vrsta, neučinkovito provođenje postojećih zakonskih propisa, teške političke podjele u zemlji, koje u konačnici rezultiraju malim brojem zaštićenih područja. Danas je poznato da u Bosni i Hercegovini (BiH) trenutno živi 23 vrste (i 24 podvrste) vodozemaca, a procjene osjetljivosti/ugroženosti su slabo rađene. U ovom radu data je procjena osjetljivosti i rizika izumiranja vodozemaca BiH na bazi ekoloških, bioloških, geografskih i antropoloških varijabli (DELH procjena) na temelju 17 različitih parametara. Rezultati ukazuju da su najranjivije i najugroženije vrste *Proteus anguinus* (čovječija ribica), *Salamandra atra* (alpski daždevnjak) i *Triturus dobrogicus* (dunavski krestasti vodenjak), zbog specifične ekologije i malog areala rasprostranjenosti. Devet taksona vodozemaca smatra se ranjivim, a 10 vrsta vjerojatno nije ugroženo. Rezultati ujedno ukazuju na to, da su repati vodozemci znatno senzibilnija skupina u odnosu na bezrepate vodozemce. Svi taksoni koji imaju indeks osjetljivosti preko 0.99 (60% bosanskohercegovačkih vodozemaca) trebaju se smatrati veoma senzitivnima, te zahtijevaju adekvatnu zaštitu i posebne konzervacijske programe.

Ključne riječi: očuvanje, DELH, Caudata, Anura, životna istorija, distribucija, ekologija