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Diversity and Conservation Status of Batrachofauna and Herpetofauna in the Lake Skadar Region

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Abstract The basin of Lake Skadar with its drainage area represents one of the Balkan Peninsula's hotspots regarding amphibian and reptile fauna. The value of the batracho- and herpetofauna of the Lake Skadar region is reflected in a rich and diverse composition of species. This is undoubtedly the result of the basin's specific geographic position and complex geological history. Recent studies revealed that Lake Skadar's watershed is inhabited by 15 amphibian and 36 reptile species. Among these, one amphibian (*Pelophylax shqipericus* – EN) and two reptile species (*Dinarolacerta mosorensis* and *Vipera ursinii*, both VU) are considered to be globally threatened according to IUCN criteria. An additional three reptile species (*Emys orbicularis*, *Testudo hermanni*, and *Elaphe quatuorlineata*) could become threatened in the future. As an attractive tourist area, a significant part of the Lake Skadar region could be impacted by fast and intense anthropogenic changes. Therefore, preserving the network of suitable habitats, maintaining continuous monitoring, and investing in additional research are essential for maintaining this rich local amphibian and reptile diversity.

Keywords Albania, Amphibians, Biodiversity hotspot, Montenegro, Reptiles, The Lake Skadar region

1 Introduction

The Balkan Peninsula is designated as one of the biodiversity hotspots in Europe [1] and one of the three southern refugia of European biodiversity [2, 3]. This applies equally to batrachofauna (amphibians, e.g., salamanders, newts, toads, and frogs) and herpetofauna (tortoises, terrapins, lizards, and snakes) of this area [4].

The basin of Lake Skadar together with its drainage area represents one of the hotspots for amphibian and reptile fauna on the Balkan Peninsula [4–7]. Local amphibian or reptile species diversity refers to the trans-boundary water ecosystem between two countries – Montenegro and Albania [8], also named as the Lake Skadar region [5] (Fig. 1). The entire area could be described as a big pot consisting of a natural depression maintaining a large, shallow lake and the surrounding lowlands bound by the slopes of Dinaric Alp mountain belt.

In Montenegro (stretching in the clockwise direction from the Bojana/Buna river to the northeast), these mountains include Taraboš, Rumija, Sutorman, Sozina, Lovćen, Stavor, Garač, Prekornica, Žijevo, and through Grbaja and Plav valleys into the Prokletije massif to Bogićevica [5]. Unique elements of Lake Skadar's natural treasure are two groups of small lacustric islands: the first group of permanent and temporary islands is located in the area of "Fučko blato" in the shallower, northwestern part of the lake and includes Velja Čakovica, Mala Čakovica, Kamenik, Liponjak, Kosmač, Prevlaka,

Fig. 1 Lake Skadar region

Odrinska gora, Kom, and Žabljak islands. The second group, situated in the area of "Veliko blato," includes Vranjina and Lesendro plus a group more than 30 small karstic islands named "southwestern archipelago" [7] (Figs. 2 and 3).

The Albanian part of the Lake Skadar region could be defined as the lowland area of the Shkodra district plus the surrounding mountain slopes of Prokletije massif exposed to the Adriatic Sea (Fig. 4). The eastern and southern parts of the lake are composed of lowlands and wetlands, due to the presence of the Bojana, Drini, and Kiri rivers. The southwestern part of the lake is limited by the Taraboshi mountain with a lesser presence of the water. Moving north from Bojana Bridge to the Montenegrin part of the lake, the coastline is rocky and amphibians are less predominant. Amphibians having higher ecological valence, such as *P. kurtmuelleri*, are mainly found there. This area (26.535 km^2) is a "Managed Nature Reserve" (Category IV as per IUCN). Since 2005 the area between the Albanian part of the Lake Skadar, Delta, and the island of Franz Josef, all along the Buna rivers, Domni wetland, Viluni lagoon, and surrounding areas, has been designated a "Protected Landscape" (Category V as per IUCN).

The value of the batracho- and herpetofauna of the Lake Skadar region is reflected in a composition of species occurring and coexisting within a relatively small area. This is undoubtedly the result of its geographic position plus complex geological history, where

Fig. 2 Southwestern Lake Skadar Archipelago. View from Rumija Mountain (Photo: J. Crnobrnja-Isailović)

Fig. 3 Bisag island. Southwestern Lake Skadar Archipelago (Photo: Natural History Museum Podgorica Photo Archive)

Fig. 4 Surroundings of Koplik, Shkodër District (Photo: J. Crnobrnja-Isailović)

orography and the climate have shaped the composition of vegetation [9], resulting in Mediterranean, oro-Mediterranean, Mediterranean-middle-European, boreal, arcto-alpine, and steppic elements [5]. Local herpetofauna is predominantly Mediterranean, with typical elements comprising the most common species, not only on the islands and coastal area of the lake but in the entire lowland, spreading toward the north of the Lake Skadar region via the canyons and gorges of the Rijeka Crnojevića, Zeta, Morača, Cijevna, and Drin/Drini rivers [7]. Elements of pontic herpetofauna are more common in the lowlands of northwestern Albania in the Drin/Drini river valley [7]. The representatives of Middle-European batracho- and herpetofauna are distributed throughout the region, depending on their ecological requirements, while species typical for the boreal and arcto-Alpine fauna of amphibians and reptiles inhabit higher elevations and mountain peaks, mostly on the eastern part of the mountain ridges that surround the Lake Skadar depression [7].

According to [10], the Lake Skadar region harbors representatives of three out of nine (33.3%) and seven out of thirteen (54%) distribution types, identified as class Amphibia and Reptilia, respectively. Although the results of this analysis are somewhat inflated by the quality of donated input data (and therefore must be interpreted with caution), general distribution patterns obtained could help to highlight conservation priorities.

The amphibians in the Lake Skadar region mostly belong to western European (CA2: five species or 33% of total number of amphibian species within the area) or a widespread European (CA3: five species or 33%) distribution type, plus one representative of Alpine and Dinaric distribution types (CA9: one species or 7%). This could mean that 73% of amphibians of the Lake Skadar region are neither specifically endemic to the area of the Lake Skadar and the Balkan Peninsula nor to Southeastern Europe. For various reasons, four amphibian species (*Triturus macedonicus*, *P. kurtmuelleri*, *P. shqipericus*, and *Rana graeca*), or 27% of the total number of amphibian species in the area, were not incorporated into that classification, despite all of them being endemic to the entire or southeastern part of the Balkan Peninsula (Fig. 5).

As expected, the highest number of reptile species in the Lake Skadar region belongs to the Balkan Peninsula and Southeastern Europe distribution type (CR4: 11 species or 31% of total number of reptile species occurring in the area), while the group belonging to widespread European distribution type is the second highest in number (CR6: seven species or 19%). Additionally, 50% of the reptile species in the area fit into the following three groups: the Italian/Balkan Peninsulas and Southeastern Europe distribution type (CR1: six species or 17%), Western-Central European distribution type (CR7: five species or 14%), or eastern Adriatic coast distribution type (CR5: five species or 14%). The remaining 5% of the total number of reptile species in the Lake Skadar region belong to western-southern Mediterranean distribution type (CR2: one species or 2.5%) or Southeastern Europe distribution type (CR11: one species or 2.5%). In summary and by distribution type, 64.5% of total number of reptile species recorded within the Lake Skadar region belongs to an entire or specific part of Southeastern Europe. Therefore, the reptile fauna of the region is much more diverse and specific than local amphibian fauna. This could be explained by the higher diversity of local habitats and ecosystems utilized by reptiles. Shaped by complex orography, climate, and history, those habitats and ecosystems provide suitable conditions for relatively similar numbers of reptile species belonging to different distribution types (Fig. 6).

2 Species Richness

2.1 Amphibians

The first comprehensive list of batrachofauna of the Lake Skadar region contained 15 amphibian species: *Salamandra atra*, *S. salamandra*, *T. alpestris* (now *Ichthyosaura alpestris*), *T. vulgaris* (now *Lissotriton vulgaris*), *T. carnifex* (now *T. macedonicus*), *Bombina variegata*, *Bufo bufo*, *B. viridis* (now *Bufotes viridis*), *Hyla arborea*, *R. balcanica* (now *P. kurtmuelleri*), *R. dalmatina*, *R. graeca*, *R. ridibunda* (now *P. ridibundus*), *R. shqiperica* (now *P. shqipericus*), and *R. temporaria*) [5, 11]. *Pelophylax kurtmuelleri* was recorded only on the Albanian part of the Lake Skadar region [11]. In addition to the two green frog species (*P. kurtmuelleri* and *P. shqipericus*), in this area their hybrid is found. Taxonomic and bioacoustics' studies conducted in the area [12, 13]

Species Distribution type*	English Common Name	Albanian Common Name	Montenegrin Common Name	Presence in Albanian part	Presence in Montenegrin part
Urodela					
Salamandridae					
Salamandra atra CA9	Alpine salamander	Salamandra e zezë	Crni daždevnjak	+	+
Salamandra salamandra CA2	Fire salamander	E bukura e dheut, Picrrak, Pisrenge, Picnok	Šareni daždevnjak	+	+
Ichthyosaura alpestris CA2	Alpine newt	Tritoni i alpeve	Planinski mrmoljak	+	+
Lissotriton vulgaris CA3	Smooth newt	Triton i zakonshëm	Mali mrmoljak	+	+
Triturus macedonicus **	Macedonian crested newt	Tritoni me kreshtë	Makedonski mrmoljak	+	+
Anura					
Bombinatoridae					
Bombina variegata CA2	Yellow-bellied toad	Bretkosa barkverdhë	Žutotrbi mukač	+	+
Bufonidae					
Bufo bufo CA3	Common toad	Thithlopa, Shapulicë	Krastača, Smeđa krastava žaba, Velika krastača	+	+
Bufotes viridis CA3	Green toad	Thithlopa e gjelbër	Zelena krastača, Zelena krastava žaba	+	+
Hylidae					
Hyla arborea CA2	Common tree frog	Verore, Bretku, Gargaliq, Bretkosa e drurëve	Gatalinka	+	+
Ranidae					
Pelophylax kurtmuelleri **	Balkan water frog	Bretkosa e gjelbër e zakonshme,	Balkanska zelena žaba	+	

Fig. 5 Amphibian species occurring in the Lake Skadar region. For abbreviations see Introduction. Cell in *black* color: species presence not confirmed in respective country. *According to [10]. **Not classified there. ***The bioacoustic studies conducted by Prof. Haxhiu and Prof.

		Zhaba			
Pelophylax ridibundus CA3	Marsh frog		Zelena žaba, Velika zelena žaba		+
Pelophylax shqipericus **; ***	Albanian water frog	Bretkosa e Shqipërisë, Bretkosa e leshterikut	Skadarska žaba, Skadarska zelena žaba	+	+
Rana dalmatina CA2	Agile frog	Bretkosa kër-cimtare	Šumska smeđa žaba, Šumska žaba	+	+
Rana graeca **	Greek stream frog	Bretkosa e përrenjeve	Grčka žaba	+	+
Rana temporaria CA3	Grass frog	Bretkosa e malit, Bretkosa e kuqërremtë e pyllit	Travnjača, Žaba travnjača, Livadska smeđa žaba	+	+

Fig. 5 (continued)

confirmed the presence of this hybrid (about 2%) in the areas with a high presence of vegetation.

Recent studies also suggest that the Lake Skadar watershed is inhabited by 15 amphibian species ([14], Fig. 5). However, Haxhiu [15] listed 13 amphibian species in the Shkodra district of Albania, excluding *R. graeca* and commenting that in some contemporary fauna studies on the batrachofauna of Albania, the authors synonymized *P. kurtmuelleri* with *P. ridibundus*. The newest list [16] confirms the presence of *R. graeca* in a wider area of the Albanian part of the region. They did not refer in details to the presence of particular *Pelophylax* species, summarizing records as "*Pelophylax* sp." In the Montenegrin part, the number of amphibian species reaches 13 (Fig. 5). However, a relatively recent analysis of the Montenegrin part of the Lake Skadar (northeastern part and vicinity of Vranjina) suggested the occurrence of *P. kurtmuelleri* and *P. shqipericus* [17], which highlights the importance of additionally clarifying water frog species richness in this area.

Fig. 5 (continued) Schneider have shown the sonograms and oscillograms of the frog found at Lake Skadar to be the same as those recorded in the Central EU. In their opinion the frog named *P. shqipericus* is indeed *P. lessonae*. However, as this chapter follows Frost as amphibian taxonomic authority, we kept the name *P. shqipericus*. Taxonomy followed [68]. English common names followed [10]. Albanian names followed Red List of Wild Flora and Fauna of Albania (Ministerial Order No. 1280 of 20.11.2013) and [69]. Montenegrin common names are given according to resolution on placing certain plant and animal species under protection (Official Gazette of the Republic of Montenegro, No. 76/06) [70] and author's modifications of common names according to the work in progress

Species Distribution type*	English Common Name	Albanian Common Name	Montenegrin Common Name	Presence in Albanian part	Presence in Montenegrin part
Chelonia					
Emydidae					
Emys orbicularis CR6	European pond terrapin	Breshkujza	Barska kornjača	+	+
Geoemydidae					
Mauremys rivulata CR4	Balkan terrapin	Breshkujza	Rječna kornjača	+	+
Testudinidae					
Testudo hermanni CR7	Hermann's tortoise	Breshka tokës, Breshka e zakonshme, Breshka e ugareve	Kopnena kornjača, Šumska kornjača	+	+
Sauria					
Anguidae					
Anguis fragilis/graeca CR6	Slow worm	Kakzogëza	Sljepić	+	+
Pseudopus apodus CR4	Glass lizard	Bullari	Blavor	+	+
Gekkonidae					
Hemydactilus turcicus CR2	Turkish gecko	Hardhuca me venduza e mureve	Kućni macaklin, Kućna gubavica	+	+
Mediodactylus kotchyi CR4	Kotchy's gecko	Hardhuca me kthetra e mureve		+	

Fig. 6 Reptile species in the Lake Skadar region. For abbreviations see Sect. 1. Cell in *black* color: species presence not confirmed in respective country. *According to [10]. Taxonomy followed [71]. English common names followed [10]. Albanian names followed Red List of Wild Flora and Fauna of Albania (Ministerial Order No. 1280 of 20.11.2013) and [72]. Montenegrin common names followed resolution on placing certain plant and animal species under protection (Official Gazette of the Republic of Montenegro, No. 76/06) for protected species. For other species the Montenegrin common names followed authors' work in progress and particular references on national herpetofauna (for *H. turcicus* [6], for *D. montenegrina* [27], for three viper species [73]). For unprotected species that do not have common names in literature on Montenegrin herpetofauna (*P. tauricus*, *A. kitaibelii*, and *D. caspius*), the authors followed Serbian regulation on the designation and protection of the strictly protected and protected wild species of plants, animals, and fungi (Official Gazette of the Republic of Serbia, No. 5/2010), as linguistically the most similar

Lacertidae					
Algyroides nigropunctatus CR5	Dalmatian Algyroides	Hardhuca me luspa të më mëdha	Mediteranski gušter, Mrki gušter, Ljuskavi gušter	+	+
Dalmatolacerta oxycephala CR5	Sharp-snouted rock lizard	/	Oštroglavi gušter, Plavi gušter	+	+
Dinarolacerta montenegrina CR5	Prokletije rock lizard	/	Prokletijski gušter, Crnogorski gušter	+	+
Dinarolacerta mosorensis CR5	Mosor rock lizard		Mosorski gušter		+
Lacerta agilis CR6	Sand lizard	Zhapiu i ngathët	Sivi gušter, Livadski gušter	+	+
Lacerta trilineata CR4	Balkan green lizard	Zhapiu me tre vija	Veliki zelembać	+	+
Lacerta viridis complex CR1	Eastern green lizard	Zhapiu i gjelbër	Zelembać	+	+
Podarcis erhardii CR4	Erhard's wall lizard	Hardhuce e vogel muri		+	
Podarcis muralis CR7	Common wall lizard	Hardhuca e mureve	Zidni gušter	+	+
Podarcis melisellensis CR5	Dalmatian wall lizard	Hardhuca bishtgjatë	Kraški gušter	+	+
Podarcis siculus CR7	Italian wall lizard	Hardhuca Italiane e mureve	Primorski gušter	+	-
Podarcis tauricus CR1	Balkan wall lizard	Hardhuca e barit	Stepski gušter	+	+
Zootoca vivipara CR6	Viviparous lizard	Zhapiu që lind këlysh	Planinski gušter	+	+

Fig. 6 (continued)

2.2 Reptiles

According to the distribution data available in 1997 [11], the Lake Skadar region harbored 33 reptile species: *Emys orbicularis*, *Mauremys caspica* (now *M. rivulata*), *Testudo hermanni*, *Anguis fragilis*, *Ophisaurus apodus* (now *Pseudopus apodus*),

Scincidae					
Ablepharus kitaibelii CR1	Snake-eyed skink	Zhapi këmbëvogël	Kratkonogi gušter	+	–
Ophidia					
Typhlophidae					
Xerotyphlops vermicularis CR4	Worm snake	Gjarpri i verbër	Slijepa zmija	–	+
Colubridae					
Coronella austriaca CR6	Smooth snake	Gjarpri i zi	Smukulja	+	+
Dolichophis caspius CR1	Caspian whip snake	Shigjeta e gjatë	Stepski smuk	+	+
Elaphe quatuorlineata CR7	(Western) Four-lined snake	Bolla me katër vija, Rrëshaja	Prugasti smuk	+	+
Hierophis gemonensis CR4	Balkan whip snake	Shigjeta e shkurtër	Primorski smuk	+	+
Malpolon insignitus CR4	Eastern Montpellier snake	Biroja	Mrki smuk	+	+
Natrix natrix CR6	Grass snake	Gjarpri i madh i ujit	Barska bjelouška	+	+
Natrix tessellata CR1	Dice snake	Gjarpri i vogel i ujit	Riječna bjelouška	+	+
Platyceps najadum CR4	Dahl's whip snake	Shigjeta e hollë	Zmija šilac	+	+
Telescopus fallax CR4	Cat snake	Gjarpri me lara	Mačja zmija	+	+
Zamenis longissimus CR7	Aesculapian snake	Bolla e shtëpisë	Obični smuk	+	+
Zamenis situla CR4	Leopard snake	Bolla laramane	Šareni smuk	+	+

Fig. 6 (continued)

Cyrtodactylus kotschyi (now *Mediodactylus kotschyi*), *Hemidactylus turcicus*, *Algyroides nigropunctatus*, *Lacerta agilis*, *L. mosorensis* (now *Dinarolacerta mosorensis*), *L. oxycephala* (now *Dalmatolacerta oxycephala*), *L. trilineata*, *L. viridis*, *L. vivipara* (now *Zootoca vivipara*), *Podarcis melisellensis*, *P. muralis*, *P. taurica* (now *P. tauricus*), *Ablepharus kitaibelii*, *Coluber caspius* (now

Viperidae					
Vipera ammodytes CR1	Nose-horned viper	Nëpërka, Gjarpri me bri, Gjarpri i bokës, Gjarpër shullani, Gjarpri me nuska (hajmali), Gjarpri me xhepa, Bishtcung, Gjarpri me hundë, Gjarpri me kycylyt	Poskok	+	+
Vipera berus CR6	Adder	Nëpërka me lara e malit, Nëpërka e malit me lara të ndërprera	Šarka	+	+
Vipera ursinii CR11	Meadow viper	Nëpërka e vogel e malit	Krški šargan	+	+

Fig. 6 (continued)

Dolichophis caspius), *C. gemonensis* (now *Hierophis gemonensis*), *C. najadum* (now *Platyceps najadum*), *Coronella austriaca*, *Elaphe longissima* (now *Zamenis longissimus*), *E. quatuorlineata*, *E. situla* (now *Z. situla*), *Malpolon monspessulanus* (now *M. insignitus*), *Natrix natrix*, *N. tessellata*, *Telescopus fallax*, *Typhlops vermicularis* (now *Xerotyphlops vermicularis*), *Vipera ammodytes*, *V. berus*, and *V. ursinii*. The most recent list includes 36 species (Fig. 6), where *M. kotschyi*, *P. erhardii*, *P. siculus*, and *A. kitaibelii* are recorded only in the southwesternmost part of the region (Albanian part), while *D. mosorensis* and *X. vermicularis* are recorded only in the Montenegrin part of the region [18, 19].

A study published in 1995 showed that 28 species were recorded in the Montenegrin part of the area (*M. rivulata*, *D. montenegrina*, *P. tauricus*, *A. kitaibelii*, and *D. caspius* were not registered) [5]. Recently, the list has been significantly updated, resulting in 32 species on the Montenegrin side, including *M. rivulata*, *D. montenegrina*, *P. tauricus*, and *D. caspius* [18]. For comparison, in 1997, 29 species were recorded on the Albanian side of the region [11, 20]. Later, 30 species were reported [14], but the recent fauna study suggests that the total number of species could increase to 34, if *P. erhardii* is added to the list [19].

3 Species Conservation Status

3.1 IUCN Global

The International Union for the Conservation of Nature (IUCN) is the oldest and largest global environmental organization, with a central mission to conserve biodiversity worldwide [21]. IUCN regularly updates Red Lists of threatened species and produces publications relating to the status of endangered species (for European amphibians and reptiles; see [22, 23]).

Only one amphibian species in the Lake Skadar region is globally threatened (*P. shqipericus*) (Fig. 7). It is categorized as Endangered (EN) because its distribution area is less than 5,000 km^2 and severely fragmented, with a reported continuous decline in the extent and the quality of its habitat [24]. *Triturus macedonicus* has still not been evaluated for Red List, but there are indications that it could be threatened.

Two reptile species in the region are globally threatened (*D. mosorensis* [25] and *V. ursinii* [26]) (Fig. 7). Both are Vulnerable (VU), having an overall area less than 2,000 km^2, severely fragmented, and they require specific habitats, discontinuously distributed throughout the range [25, 26]. *Dinarolacerta montenegrina* [27] was proclaimed to be of Least Concern (LC) in the absence of evidence of threats [28].

Emys orbicularis, *T. hermanni*, and *E. quatuorlineata* could be threatened in the future (Fig. 7). Those Near Threaten (NT) species should be carefully monitored as the size of their overall distribution range and/or the quality of their habitats are already recognized as impacted by threatening factors. Continuation or intensification of those threats could easily shift the species into one of the threatened IUCN categories [29–31].

3.2 CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora establishes and regulates conditions that govern the transfer of wild species or their parts or derivatives across the countries' administrative borders [21].

Two of the reptile species listed here are covered by CITES annexes – *T. hermanni* and *V. ursinii* (Fig. 7). The level of their international transport control differs: the transport of Hermann's tortoise across borders requires an export permit from the country of origin, issued by the governmental authority, while for the meadow viper, both export and import permits (issued by the relevant government authority of the country of import) must be provided.

Species	IUCN[1]	CITES[2]	BERN[3]	HABITATS[4]	Albania[5]	Montenegro[6]
Amphibia						
Urodela						
Salamandra atra	LC	_	**II**	**II, IV**	+ (LRnt)	+
Salamandra salamandra	LC	_	**III**	_	+ (DD)	+
Ichthyosaura alpestris	LC	_	**III**	_	+ (DD)	+
Lissotriton vulgaris	LC	_	**III**	_	+ (LRlc)	+
*Triturus macedonicus**	NE	_	**II**	**IV**	+ (LRlc)	+
Anura						
Bombina variegata	LC	_	**II**	**II, IV**	+ (LRcd)	_
Bufo bufo	LC	_	**III**	_	+ (LRnt)	+
Bufotes viridis	LC	_	**II**	**IV**	+ (LRnt)	+
Hyla arborea	LC	_	**II**	**IV**	+ (LRlc)	+
Pelophylax kurtmuelleri	LC	_	**III**	_	+ (VU)	
Pelophylax ridibundus	LC	_	**III**	**V**		+
Pelophylax shqipericus	**EN**	_	**III**	_	+ (VU)	+
Rana dalmatina	LC	_	**II**	**IV**	+ (LRlc)	_
Rana graeca	LC	_	**III**	**IV**	+ (LRnt)	+
Rana temporaria	LC	_	**III**	**V**	+ (LRcd)	_

Fig. 7 Global conservation status and international/national levels of legal protection of amphibians and reptiles that inhabit ecosystems of the Lake Skadar region and their degree of legal protection on the international and local level. Cell in *black* color: species presence not confirmed in respective country. [1]IUCN (*International Union for Conservation of Nature*) – Listed categories of threat according to IUCN categorization: LC, species is not threatened (*Least Concern*); NT, species is almost threatened (*Near Threatened*); VU, species is considered to be facing a high risk of extinction in the wild (*Vulnerable*). [2]CITES (*Convention on International Trade of Endangered Species*) – (Appendix I, species that face extinction; Appendix II, species that should be under the control of trade to avoid the threat of extinction; Appendix III, species that are protected on the territory of at least one country. [3]BERN (*Bern Convention on the Conservation of European Wildlife and Natural Habitats*) – (II, strictly protected animal species; III, protected animal species). [4] HABITATS (*European directive on conservation of natural habitats and of wild fauna and flora*) – (Annex II, Vulnerable/sensitive species which could become endangered in the near future if the factors of threat continue to act, and * means priority species; Annex IV, species that require strict protection;

Reptilia						
Chelonia						
Emys orbicularis	**NT**	_	**II**	**II, IV**	+ (LRnt)	+
Mauremys rivulata	LC	_	**II**	**II, IV**	+ (VU)	+
Testudo hermanni	**NT**	**+(II)**	**II**	**II, IV**	+ (LRnt)	+
Sauria						
Anguis fragilis/graeca	LC	_	**III**	_	+(NE)	+
Pseudopus apodus	LC	_	**II**	**IV**	+ (LRnt)	+
Hemydactilus turcicus	LC	_	**III**	_	+ (LRcd)	_
Mediodactylus kotschyi	LC	_	**II**	**IV**	+ (LRcd)	
Algyroides nigropunctatus	LC	_	**II**	**IV**	+ (LRcd)	+
Dalmatolacerta oxycephala	LC	_	**III**	**IV**	_	+
Dinarolacerta montenegrina	LC	_	**III**	_	_	_
Dinarolacerta mosorensis	**VU**	_	**III**	**II, IV**		+
Lacerta agilis	LC	_	**II**	**IV**	+ (LRnt)	+
Lacerta trilineata	LC	_	**II**	**IV**	+ (LRcd)	+
Lacerta viridis	LC	_	**II**	**IV**	+ (LRcd)	+
Podarcis erhardii	LC	_	**II**	**IV**	+ (LRcd)	
Podarcis melisellensis	LC	_	**II**	**IV**	+ (LRcd)	+
Podarcis muralis	LC	_	**II**	**IV**	+ (NE)	+

Fig. 7 (continued)

Fig. 7 (continued) Annex V, species which breeding in the wild and exploitation could be a matter of management). [5]Red List of Wild Flora and Fauna of Albania (approved by Ministerial Order No. 1280, 20.11.2013). [6]Resolution on placing certain plant and animal species under protection (Official Gazette of the Republic of Montenegro, No. 76/06). *Named as *T. carnifex* in [6]. **Named as *M. monspessulana* in [6]

Podarcis siculus	LC	_	**II**	**IV**	_	+
Podarcis tauricus	LC	_	**II**	**IV**	+ (LRnt)	_
Zootoca vivipara	LC	_	**III**	_	+ (LRnt)	+
Ablepharus kitaibelii	LC	_	**II**	**IV**	+ (LRnt)	_
Serpentes						
Xerotyphlops vermicularis	LC	_	**III**	_	+ (CR)	_
Coronella austriaca	LC	_	**II**	**IV**	+ (LRnt)	+
Dolichophis caspius	LC	_	**II**	**IV**	+ (LRlc)	_
Elaphe quatuorlineata	**NT**	_	**II**	**II, IV**	+ (CR)	+
Hierophis gemonensis	LC	_	**II**	**IV**	+ (CR)	+
*Malpolon insignitus***	LC	_	**III**	_	+ (LRlc)	+
Natrix natrix	LC	_	**III**	_	+ (NE)	+
Natrix tessellata	LC	_	**II**	**IV**	+ (NE)	+
Platyceps najadum	LC	_	**II**	**IV**	+ (LRcd)	+
Telescopus fallax	LC	_	**II**	**IV**	+ (LRlc)	_
Zamenis longissimus	LC	_	**II**	**IV**	+ (EN)	+
Zamenis situla	LC	_	**II**	**II, IV**	+ (CR)	+
Vipera ammodytes	LC	_	**II**	**IV**	+ (LRnt)	_
Vipera berus	LC	_	**III**	_	+ (LRnt)	_
Vipera ursinii	**VU**	**+ (I)**	**II**	***II, IV**	+ (LRnt)	_

Fig. 7 (continued)

3.3 BERN Convention

The main goal of the Bern Convention on the Conservation of European Wildlife and Natural Habitats is to conserve wild flora and fauna and their natural habitats and to promote European cooperation in this field [21]. Species and habitats of conservation concern are listed under several appendices. However, it is obvious that some species have not been properly evaluated, despite having a very restricted distribution range. These are occurring exclusively in the Balkans and/or in Eastern Europe.

All European amphibian and reptile species, and therefore also those occurring in the Lake Skadar region, are included in the annexes of the Bern Convention (Fig. 7). Regarding scientific names of species in the annexes, it is obvious that there is a certain time lag in adopting recent taxonomic changes, so we took the liberty of adding the same status to new species that have appeared by splitting species already listed in the Convention or to those whose species status is still being debated.

3.4 Habitats Directive

Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, known as the Habitats Directive, combines the idea of maintaining a network of protected sites with a strict system of species protection on a European level [21].

Six out of fifteen amphibian species from our study (or 40%) are not listed in annexes of the Habitats Directive (*S. salamandra*, *I. alpestris*, *L. vulgaris*, *B. bufo*, *P. kurtmuelleri*, *P. shqipericus*) (Fig. 7). Although they inhabit European countries outside EU, the last two species could hardly be considered to be widespread throughout member states of the European Union (EU), so they have not been taken into consideration for the annexes of the Habitats Directive yet. In fact, 8 out of 36 reptile species occurring in the Lake Skadar region (or 22%) are not included in the annexes (*A. fragilis/graeca*, *H. turcicus*, *D. montenegrina*, *Z. vivipara*, *X. vermicularis*, *M. insignitus*, *N. natrix*, *V. berus*) (Fig. 7). Some of these species do belong to the category of "widely widespread" throughout EU, while some others are probably considered as stable. The reasons above could also explain the absence of *D. montenegrina* [27] in the annexes.

3.5 National Legislatives

3.5.1 Albania

Fifteen amphibian and 37 reptile species are listed under the Red List of Wild Flora and Fauna in Albania. Two out of three amphibians listed as Vulnerable are found in the Lake Skadar region. Meanwhile, one EN, three CR, and one VU reptile species

found in this region were reported in the last evaluation adopted in 2013 by the Law on Biodiversity Protection (Order No. 1280, dated 20.11.2013 on the Approval of the Red List of Wild Flora and Fauna). The collection of amphibians and reptiles is regulated by the Law on Transboundary Lakes (Law No. 9103, dated 10.7.2003), while these species are not included in the list of wild species subject to hunting (Decision No. 546, dated 07.07.2010). It is necessary during the next evaluation to update the recent status of some species, as well as the nomenclature used.

3.5.2 Montenegro

Thirteen amphibian and 26 reptile species are protected by law in Montenegro (Law on Nature Protection – Official Gazette of the Republic of Montenegro, No. 54/16) according to the latest resolution on placing certain plant and animal species under protection (Official Gazette of the Republic of Montenegro, No 76/06, 12 December, 2006). Of that number, 11 species of amphibians and 23 species of reptiles that inhabit the Montenegrin part of the Lake Skadar region are protected, which represents approximately 79 and 72% of the total number of amphibian and reptile species recorded in this area (Fig. 7).

The list of protected species was adopted in 2006 and needs revision for consistency with current nomenclature, eventual inclusion of newly established species for Montenegro (*D. montenegrina*, *A. kitaibelii*), and correction of some initial shortcomings. For example, the list includes species not officially confirmed on the territory of Montenegro (*Proteus anguinus*, *Pelobates fuscus*) yet excludes complete families (e.g., Viperidae). Such errors and discrepancies clearly need to be amended in accordance with international conventions (e.g., status of *V. ursinii*), which is one step included in the harmonization of Montenegrin legislation with the EU legislation and standards in the environmental sector in the process of EU accession.

4 Main Threats

The main drivers of contemporary extinction of wildlife are often briefly described as “evil quartet” [32]. They refer to the negative human impact on biodiversity and include habitat fragmentation and degradation, overexploitation of the species, successful colonization of allochthonous species (“invasive species”), and the chain effects of species extinctions. Human persecution, road kills, and pathogens are sometimes considered as separate threat factors. Climate change has also had visible impact on biodiversity: the majority of models in simulation studies suggest alarming consequences for life at all scales [33].

Although most of the Lake Skadar region is legally protected, negative anthropogenic impacts have not been excluded: demographic movements have intensified since 1990, leading to increased exploitation of local natural resources [8]. Intensification of industry and agriculture in the lowland parts of the region has resulted in deforestation, drainage of wetlands beside Lake Skadar, and chemical pollution [5]. Economic improvement in the

mountainous part of the region has been made through the development of ski-tourism and tourism in general (involving transformation of Vulnerable local amphibian breeding sites into fisheries), as well as deforestation and change of landscape, all of which have a negative impact on local batracho- and herpetofauna.

4.1 Amphibians

Amphibians are currently the most threatened group of vertebrates [34]. They are declining in numbers rapidly due to intensive habitat fragmentation, degradation, alteration, or entire loss of their breeding sites [35]. The apparent sensitivity of amphibians to environmental and/or anthropogenic changes is a consequence of their complex life history, where both aquatic and terrestrial environments are required for the successful completion of their life cycle.

Ćirović [36] listed several global threats that also disturb amphibians in Montenegro. Habitat fragmentation and degradation in Montenegro and therefore in the Lake Skadar region as well could be a particularly sensitive issue for newts: their breeding sites show decreasing trends due to demographic changes in the area [37]. In the karst, most suitable spawning sites for newts are actually of anthropogenic origin, made and maintained for water collection. When abandoned (due to mass migration of local people to the cities), those aquatic habitats undergo degradation and became unsuitable for newts and other amphibians.

A variety of anthropogenic influences have affected the populations of amphibians in Albania: reduction of lowland aquatic habitats; construction of large drainage channels to gain land for agriculture; pollution by sewage, detergents, and other chemicals, especially over the last 25 years; usage of the riverbeds for construction materials [15, 38]; etc.

Over exploitation (i.e., collection and harvesting) of water frogs on the territory of Montenegro has certainly occurred recently [39], although it is not easy to evaluate its consequences in the absence of the quantitative population data before overexploitation. In Albania, exploitation of *P. epeiroticus* (water frog species not present in the Lake Skadar region) was so big that regulations and laws were needed to prohibit collection [15]. Over-collection for commercial purposes is specifically mentioned as a threat for *P. kurtmuelleri* [40].

Allochthonous species that can jeopardize local amphibians are mainly fish species accidentally or intentionally introduced by people to fishless, stagnant waters where they usually cause lower breeding success, decline, or even extinction of local amphibians [41]. In the Montenegrin karstic environment particularly, newts prefer aquatic environment without fish [42]. Moreover, the deliberate introduction of allochthonous water frogs (e.g., for economic reasons) could negatively impact at least endemic and globally threatened Albanian water frogs [39]. Additionally, new invasive pathogens such as chytrid fungus (*Batrachochytrium dendrobatidis*) are specifically alarming [43]. This was first detected in the western part of Europe, while the Balkan Peninsula was only recently checked for the presence of chytrid fungus. A study conducted in the

Montenegrin part of the Lake Skadar region detected *B. dendrobatidis* mostly in samples of water frogs (*Pelophylax* sp.), but there were sporadic cases of infested yellow-bellied toads (*B. variegata*), tree frogs (*H. arborea*), and even smooth newts (*L. vulgaris*) and Macedonian crested newts (*T. macedonicus*) [44].

4.2 Reptiles

Reptiles have been recently recognized as a vertebrate group of conservation concern, being prone primarily to anthropogenic threats [45]. Mediterranean and sub-Mediterranean areas of Montenegro provide apparently high diversity of suitable habitats for a number of reptile species, but this richness could be severely decreased by intensive habitat degradation, fragmentation, and destruction due to aggressive development of tourism and consequent urbanization in the area. Species utilizing specific habitats whose natural history may not be well known could be especially affected (e.g., *X. vermicularis*, *A. nigropunctatus*, *D. montenegrina*, *V. ursinii*). Wildfires strongly affect local herpetofauna, particularly slow-moving species such as tortoises [46], and that issue is increasing in the study area [47].

Overexploitation (overharvesting) particularly impacted *T. hermanni* in former Yugoslavia. In a recent review study [48], Lake Skadar region was indicated as a possibly Vulnerable area. The illegal trade in tortoises could still be a current issue there despite CITES initiatives and the recent efforts of local ecologically oriented NGOs. Moreover, the flagrant illegal export of 800 *T. hermanni* to Italy by Albanians was reported two decades ago. Overkilling by vehicles produces an outcome similar to that of overexploitation, and Hermann's tortoises are again among the most targeted reptiles in the area [47]. *Vipera ammodytes* is another reptile species that could be locally devastated, traditionally collected for venom supplies [49], and harvested in this area [50].

Transition, intensification of communications, tourism, and the increasing influence of general trends in western society inevitably brings new threats to local wildlife. One of them is keeping allochthonous species as pets followed by their deliberate release into local ecosystems, as happened with the spectacled caiman near the town of Budva on the nearby Adriatic coast [51]. Another attractive allochthonous pet species, the common slider (*Trachemys scripta*), poses a great threat to autochthonous terrapins: neglected common sliders are being released into the local aquatic ecosystems, where they can easily establish viable populations [52]. This species has already been recorded in the freshwater ecosystem near the Adriatic coast of Montenegro [53] and may form part of the local aquatic fauna in the Lake Skadar region. The small Indian mongoose (*Herpestes auropunctatus*) is an allochthonous predator that already has a reputation for exterminating reptile fauna in Southern Europe. It has been detected along the entire Montenegrin coastal zone but could also spread to the Lake Skadar region by the valley of Bojana/Buna river [54].

5 Species of Special Conservation Concern

5.1 Amphibians

Although all amphibian species in Albania and most in Montenegro are protected [15, 36], the threats listed above warn us of the necessity to continuously monitor local amphibian populations. The high species richness in Lake Skadar region almost reflects the total amphibian diversity in those two countries. However, some species are rather specific to Lake Skadar, such as *P. shqipericus* [24] (Fig. 8). *Salamandra atra* (Fig. 9) has a very restricted distribution in this area and apparently contributes to its conservation value. Although not threatened by IUCN criteria, these southernmost populations could be quite fragile and susceptible to the negative effects of recent climate change, particularly if combined with intensive human alterations of species habitats [55].

Fig. 8 *Pelophylax shqipericus* (Photo: B. Prakljačić)

Fig. 9 *Salamandra atra* (Photo: Natural History Museum Podgorica Photo Archive)

Ichthyosaura alpestris (Fig. 10) has a broader ecological niche than the Alpine salamander, but it has become generally exposed to a threat of local extinction by the introduction of fish to the primarily fishless mountainous lakes and the destruction of breeding sites due to the establishment of ski resorts [56]. There is still a possibility to maintain viable local populations of Alpine newts in the region if nature conservation authorities actively participate in the projects of sustainable development. *Triturus macedonicus* (Fig. 11) is the only crested newt species in Montenegro and

Fig. 10 *Ichthyosaura alpestris* (Photo: N. Čađenović)

Fig. 11 *Triturus macedonicus* (Photo: J. Crnobrnja-Isailović)

Albania [57] and, according to evidence, has become quite Vulnerable throughout Montenegro with regard to breeding site stability (see in [36, 37, 41]).

5.2 Reptiles

The reptile species of special conservation concern in the Lake Skadar region were chosen applying the same criteria as for amphibians: global conservation status by IUCN, local rareness, and/or fragility of local populations.

Globally threatened reptile species by the IUCN criteria are *D. mosorensis* [25] (Fig. 12) and *V. ursinii* [26] (Fig. 13). Both species have rather specific habitat requirements [58, 59] and therefore restricted distribution within the region [59, 60]. Also, local meadow viper populations belong to *macrops* subclade, as do those from Bosnia and Herzegovina [61]. Three species with Near Threatened (NT) global status – *T. hermanni* (Fig. 14), *E. orbicularis* (Fig. 15), and *E. quatuorlineata* (Fig. 16) – must also be included in the list of local reptile conservation priorities, for reasons already presented in Sect. 4. The apparent intentional killing of a four-lined snake in the Montenegrin part of the Lake Skadar coastal area has been the consequence of local human attitude, probably because of the size and robustness of this snake (Crnobrnja-Isailović, pers. obs.), while the specific coloration of juveniles resembles that of vipers (Ljubisavljević, pers. obs.). Therefore, this species should be checked for population size and abundance. Further education and awareness-raising activities would also be welcomed.

Mauremys rivulata (Fig. 17) should be a conservation priority because of its suspected vulnerability to the invasive common slider and to destruction and alteration of its habitats along the Montenegrin coast due to excessive urbanization [62]. Additionally, *D. montenegrina* (Fig. 18) must be a conservation priority in the region because of its endemic status and information on likely occurring

Fig. 12 *Dinarolacerta mosorensis* (Photo: L. Polović)

Fig. 13 *Vipera ursinii macrops* (Photo: J. Crnobrnja-Isailović)

Fig. 14 *Testudo hermanni* (Photo: L. Polović)

threats [63]. There are additional two lizard species, of which special care should be taken, due to its very restricted area of occupancy in the region or Vulnerable habitats: *P. erhardii* has so far been detected in a very small part of the

Fig. 15 *Emys orbicularis* (Photo: L. Polović)

Fig. 16 *Elaphe quatuorlineata* (Photo: Natural History Museum Podgorica Photo Archive)

northeasternmost Lake Skadar region (Albanian part) [19], while *Z. vivipara* occurs here at the southern edge of the species range and occupies specific boreal and Alpine meadow habitats which could be degraded by climate change (generally explained in [64]) and ski-tourism.

Fig. 17 *Mauremys rivulata* (Photo: L. Polović)

Fig. 18 *Dinarolacerta montenegrina* (Photo: K. Ljubisavljević)

Vipera ammodytes (Fig. 19) and *V. berus* (Fig. 20) should be carefully monitored within the region as recent publications indicate some global contemporary issues relating to snakes [65] and particularly vipers [66]. The nose-horned viper is

Fig. 19 *Vipera ammodytes* (Photo: J. Crnobrnja-Isailović)

Fig. 20 *Vipera berus* (Photo: O. Isailović)

specifically threatened, being a quite visible snake that often inhabits sites in close vicinity to human settlements, where local people have a strong negative attitude toward vipers [49]. Therefore, permanent education of inhabitants about the

importance of vipers and the ecosystem services they provide should follow. Moreover, populations of nose-horned viper from Montenegro and adjacent parts of Albania form a separate genetic clade and are therefore additionally valuable for conservation as a specific evolutionary significant unit [67].

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