

**Distribution and conservation of *Dalmatolacerta oxycephala* (Duméril & Bibron, 1839)  
in Croatia and Bosnia and Herzegovina**

**Distribucija i zaštita *Dalmatolacerta oxycephala* (Duméril & Bibron, 1839) u Hrvatskoj i  
Bosni i Hercegovini**

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**Abstract**

The sharp snouted rock lizard, *Dalmatolacerta oxycephala*, is an endemic lizard of the Balkan Peninsula with 70% of its range found in Croatia and Bosnia and Herzegovina (B&H). The herpetological literature surprisingly yields scarce localized data. In this paper we summarize most, if not all, records found in literature, data from museum collections, our own field surveys and records of field researchers with reliable knowledge of *D. oxycephala*. All literature and new data are plotted and an updated distribution map for Croatia and B&H is given. The sharp snouted rock lizard occurs continuously over the southern areas of the region with new records increasing the known distribution towards the north and into the high mountainous regions. The species occupies a very wide set of habitats, from rocky shrubs at sea level (on islands) up to rocky mountain cliffs and gorges at 1400 m a.s.l. Overall seasonal activity was highest from April to June with strong affiliation to warm and dry habitats. The species has a large range, it is still very abundant and there is no direct evidence of population decline, therefore its IUCN regional status for Croatia should remain least concerned (LC) and near threatened (NT) for B&H.

**Key words:** endemic, Croatia, Bosnia and Herzegovina, distribution, conservation, Red List

**Sažetak**

Oštroglava gušterica, *Dalmatolacerta oxycephala*, je endemska vrsta gušterice Balkanskog poluotoka. Preko 70 % njezina areala rasprostranjenosti pada unutar nacionalnih granica Hrvatske i Bosne i Hercegovine. Unatoč tako velikom postotku, pregledom herpetološke literature moguće je pronaći samo pojedinačne i lokalizirane podatke o njezinoj pojavnosti. U ovom radu prikupili smo većinu, ako ne i sve, podatke dostupne u literaturi i muzejskim zbirkama, te podatke prikupljene terenskim istraživanjima autora i drugih pouzdanih istraživača. Svi literaturni i novi nalazi okupljeni su u zajedničku bazu podataka te je izrađena precizna nova karta rasprostranjenosti oštroglave gušterice u Hrvatskoj i Bosni i Hercegovini. Oštroglava gušterica kontinuirano nastanjuje južne dijelove istraživane regije dok novi nalazi doprinose poznavanju njezina areala u najsjevernijim

i planinskim područjima. Vrsta nastanjuje vrlo širok spektar staništa, od stjenovitih staništa s makijom uz samu morsku obalu (npr. na otocima), do stjenovitih kanjona visokih planina iznad 1400 m nadmorske visine. Općenita sezonska aktivnost oštroglave gušterice najviša je od travnja do lipnja, a vidljiva je i vrlo jaka sklonost ka toplim i suhim staništima. Vrsta još uvijek ima vrlo velik areal rasprostranjenosti, vrlo je česta na pogodnim staništima i nema izravnih dokaza o opadanju brojnosti njene populacije, te na temelju toga možemo zaključiti da bi njen IUCN status u Hrvatskoj trebao ostati najmanje zabrinjavajuća (LC) te gotovo ugrožena svojta (NT) u Bosni i Hercegovini.

**Ključne riječi:** endemske vrste, Hrvatska, Bosna i Hercegovina, distribucija, zaštita, Crveni popis

## Introduction

Individuals of sharp snouted rock lizard originating from Dalmatia were described for the first time by Duméril & Bibron (1839) under the name *Lacerta oxycephala*. According to its specific morphology and phylogenetics, Arnold et al. (2007) suggest a reclassification of the species allocating it to a newly described genus: *Dalmatolacerta* - a feminine name derived from *Dalmatia* - the Croatian region bordering the east coast of the Adriatic Sea where the species occurs, and *lacerta*, a lizard. Another synonym of the species is also *Archaeolacerta oxycephala*, Arribas (1999). Bedriaga (1886) gives the first distribution data for the species in Croatia when investigating the Krka River. Three years later the species was also confirmed in Bosnia and Herzegovina – B&H (Tomassini 1889). Steindachner (1892) describes the presence of the species in areas not exceeding 1200 m above sea level in south-west Herzegovina. Bolkay (1924) published additional distributional notes for the area and gave special attention to almost fully black individuals described by Schreiber (1891) as *Lacerta oxycephala* var. *tomasini* which he registered in the area of Herzegovina (Fig. 1). Bolkay (1924) was the first to address the distribution of the sharp snouted rock lizard in Montenegro.

Later historic publications found the sharp snouted black lizard to be abundant in south-east areas of Croatia bordering the sea, and on its islands (Rössler 1920, Pavletić 1964, Gorman et al. 1970, De Luca et al. 1990, Schmidtler and Bischoff 1999, Cafuta 2004, Podnar-Lešić 2005). Distribution data for B&H is rare and refers to information provided by Werner (1898, 1899), Bolkay (1924), Radovanović, (1941, 1951) and Lazar and Balent (2000). Even in recent times, there is a lack of systematic research on the distribution of the sharp snouted black lizard especially in B&H.

*D. oxycephala* is unanimously regarded as monotypic (Bischoff 1984, Mayer and Podnar 2003) however, recent phylogeographic study based on two mitochondrial molecular markers revealed two deeply separated clades (“island” and “mainland clade”) that diverged some five MY ago (Podnar et al. 2014).

Our aim was to gather all records from literature data (references and reports) and from museum collections as well as data from our field surveys and records of field researchers with reliable knowledge of *D. oxycephala*. Remarks on the current conservation status of *D. oxycephala* are also provided and an updated distribution map is drawn.



**Figure 1.** *D. oxycephala*: A) dark morph from Baba planina, B&H (19.06.2011). B) light morph from location on the way from Boračko lake to Kašići village, B&H (08.08.2012; Photo: M. Radaković, B. Jusić)

**Slika 1.** *D. oxycephala* A) crna forma s Baba planine, BiH 19.06.2011). B) uobičajna forma s lokaliteta na putu od Boračkog jezera prema selu Kašići (08.08.2012; Fotografije: M. Radaković, B. Jusić)

### Material and Methods

New data was collected onwards from 1994, coming from observations of known field researchers and the authors. None of these observations are the result of a planned sampling scheme and therefore an absence in a particular area might be the consequence of a lack of surveying, possibly yielding a „false absence“. Interpretation of the map should consider such a shortcoming. Part of the data was received from museum collections of the Hungarian National History Museum, Budapest (HNHM), Museo Civico di Storia Naturale di Milano (MSNM), Muséum national d'Histoire naturelle, Paris (MNHN), and the Naturhistorisches Museum Wien (NHMW).

The following publications were used for a data overview and production of a distribution map (Fig. 3): Duméril & Bibron 1839 (description, *terrae typicae*: Dalmatia, Croatia), Kolombatović 1886a,b,c, Kolombatović 1888, Tomassini 1889, Steindacher 1892, Boettger 1893, Werner 1897, Depoli 1898, Werner 1898, Werner 1899, Galvagni 1902, Werner 1902, Gugler 1903, Kammerer 1903, Kolombatović 1904, Méhely 1904, Werner 1905,

Brusina 1908, Rogenhofer 1908a,b, Werner 1908a,b,c, Rössler 1919, Rössler 1920, Karaman 1921, Bolkay 1924, Kammerer and Wettstein 1926, Koch 1926, Bolkay 1928a,b, Mertens 1934, Cyren 1941, Radovanović 1941, Radovanović 1951, Radovanović 1954., Radovanović 1957a,b, Radovanović 1960, Krpan 1962, Frommhold 1963a,b, Pavletić 1964, Radovanović 1964, Diesner 1966, Pozzi 1966, Cvitanić 1968, Džukić 1972, Brelih and Džukić 1974, Gorman et al. 1975, Böhme 1984, Lapini 1984, Arnold 1987, Pracht 1987, Raynor 1989, De Luca et al. 1990, Tvrtković and Kletečki 1993b, Bressi 1995, Vogrin 1997, Grbac et al. 1998b, Bressi 1999, Schmidtler 1999, Škvarč 1999a,b, Planinc 2000, Janev-Hutinec 2001, Pistotnik 2001, Scheers and Van Damme 2002, Mayer and Podnar 2002a,b,c, Cafuta 2003, Mayer and Podnar 2003, Cafuta 2005, Lončar 2005, Podnar and Mayer 2006, Šalamon et al. 2005, Janev-Hutinec et al. 2006, Konte et al. 2006, Tóth et al. 2006, Tvrtković and Veen 2006, Huyghe et al. 2007, Kryštufek and Kletečki 2007, Lucić 2007, Lucić et al. 2008, Vervust et al. 2009, Barun et al. 2010, Jelić et al. 2012a,b,c, Jelić 2014.

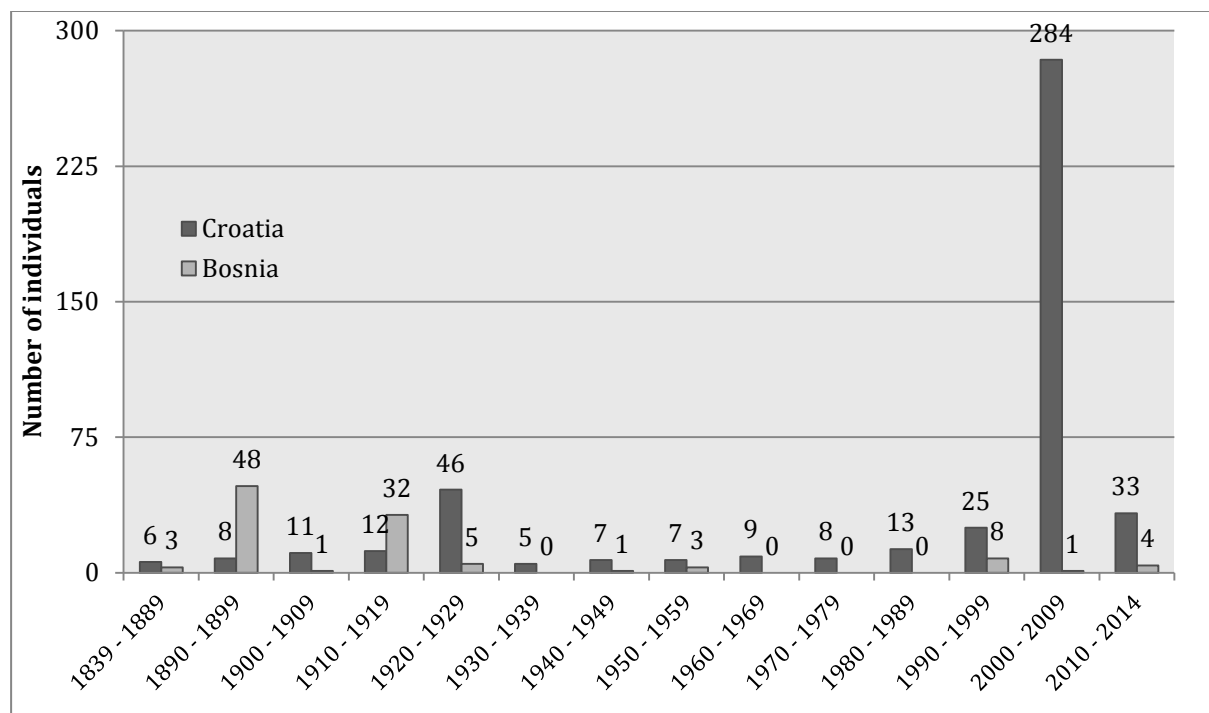
All maps were prepared in the WGS84 coordinate system. Some records correspond to larger areas and are plotted here as a single record at the centre of the indicated area (literature data only). Records were divided in two categories: 1) literature data, and 2) new unpublished data (Fig. 3).

Annual mean temperatures and Digital elevation model were downloaded from WorldClim - Global Climate Data version 1.4 (Free climate data for ecological modeling and GIS; <http://www.worldclim.org/>) web service which is based on weather conditions recorded from 1950 to 2000. The spatial resolution is approximately 900 m x 900 m. These maps were created from downscaled global climate model (GCM) data from

CMIP5 (IPPC Fifth Assessment). We intersected all of our literature and new data, with precise coordinates, with these two models to get annual mean temperatures and altitude for all areas of interest (Hijmans et al. 2005).

## Results

The collected data comprise 264 records from Croatia and 81 records from B&H. For Croatia, 70% of the data refer to published records and 30% correspond to new observations; for B&H, 95% of the data originate from literature records and 5% correspond to new observations.



**Figure 2.** Number of *D. oxycephala* records over a period of 175 years in Croatia and Bosnia and Herzegovina.

Remark: Some authors in their references referred that they observed “several individuals” per specific year, which was presented as five (5) individuals in the chart above.

**Slika 2.** Broj nalaza *D. oxycephala* kroz period od 175 godina istraživanja u Hrvatskoj i Bosni i Hercegovini.

Napomena: neki autori u svojim zapisima navode da je zabilježeno “nekoliko jedinki” u određenoj godini, te su takvi zapisi na grafu prikazani kao pet (5) jedinki.

According to the data presented, the sharp snouted rock lizard is distributed continuously across the south region of both countries and a large number of Croatian islands (Fig. 3). The time table of records (Fig. 2) shows that 32% of the total observed number of individuals are older than 60 years and should be interpreted with caution.

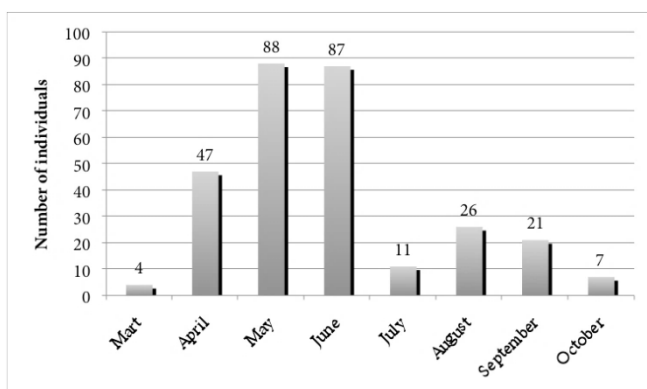
Almost 56% of the records were collected in the past ten years, reflecting the recently increased interest for this species, and herpetological research in general.

However, these results were not collected uniformly and the data analyses presented here should be viewed bearing this in mind.



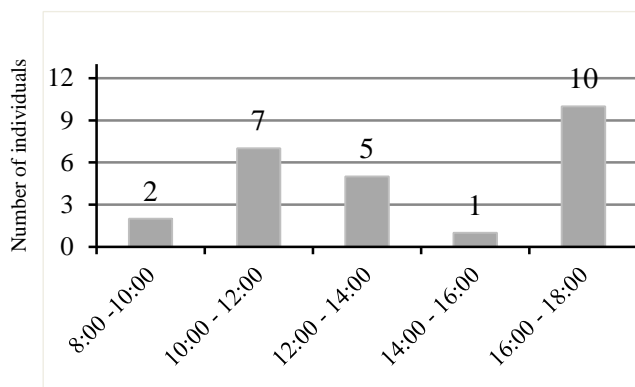
**Figure 3.** Distribution of *D. oxycephala* in Croatia and Bosnia and Herzegovina.

**Slika 3.** Distribucija vrste *D. oxycephala* u Hrvatskoj i Bosni i Hercegovini



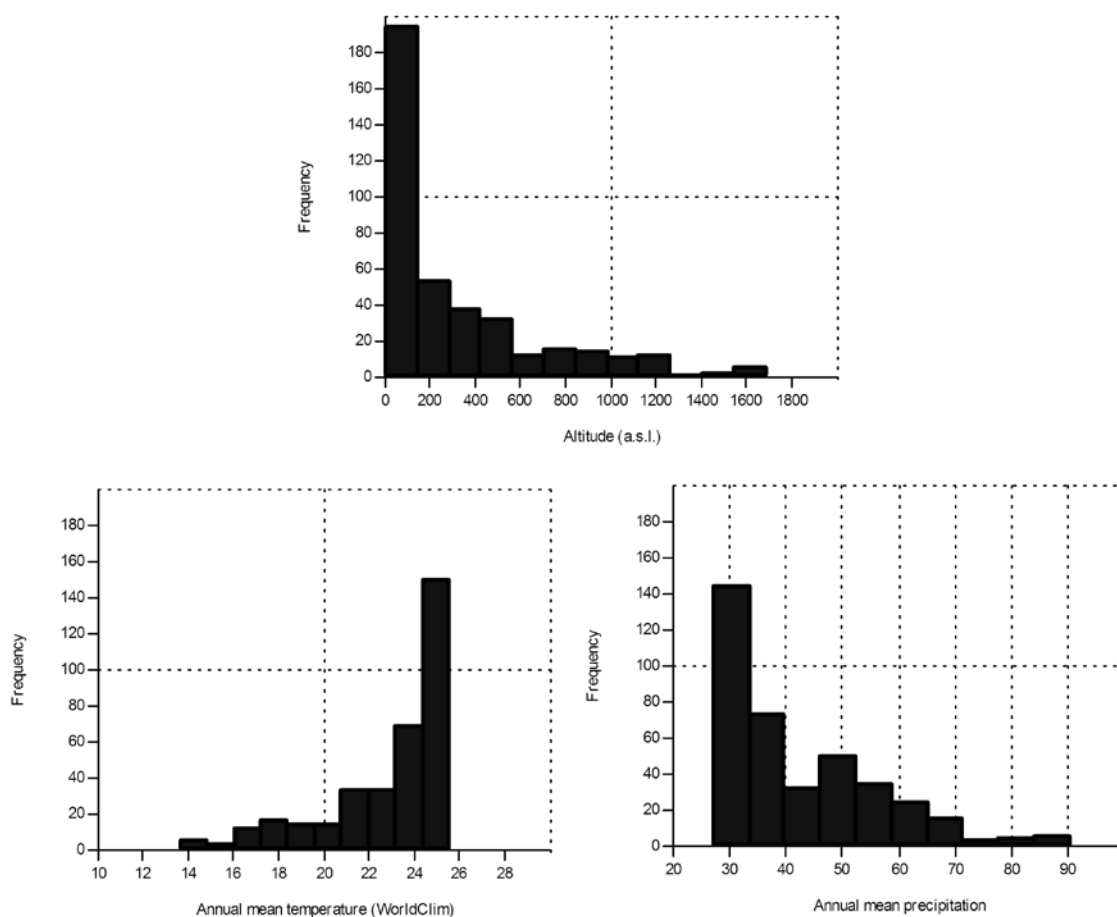
**Figure 4.** Seasonal activity of *D. oxycephala*: number of individuals observed per month (n = 291)

**Slika 4.** Sezonska aktivnost vrste *D. oxycephala*: broj zabilježenih jedinki po mjesecima (n = 291)



**Figure 5.** Daily activity of *D. oxycephala*: number of individuals observed per 2 hour intervals (n=25)

**Slika 5.** Dnevna aktivnost *D. oxycephala*: broj zabilježenih jedinki tijekom aktivnog dijela dana s intervalom od 2 sata (n = 25)



**Figure 6.** *D. oxycephala* record distribution (n = 385) over altitudinal, annual mean temperature, and annual mean precipitation gradients (data interpolated from WorldClim  $\approx 1 \text{ km}^2$  grid)

**Slika 6.** Pregled nalaza vrste *D. oxycephala* (n = 385) u odnosu na visinski gradijent, gradijent srednje godišnje temperature i gradijent srednjih godišnjih padalina (podatci su preuzeti iz WorldClim mreže preciznosti  $\approx 1 \text{ km}^2$ ).

*D. oxycephala* is distributed continuously across the southern parts of B&H and the region of Dalmatia (Croatia) representing the south-east coast of the Adriatic Sea with most of its accompanying Croatian islands (Biševo, Vis, Brač, Hvar, Mljet, Lastovo, Korčula, and most of the smaller island around them) (Fig. 3). Its distribution range was significantly expanded to the north, to the island of Cres (town of Osor), through anthropogenic influence. This recent introduction resulted in the establishment of a small, but stable population. The island of Lošinj is connected with Cres by an 11 m long bridge and the chance of further expansion is also possible. Recent visits to Osor revealed that *D. oxycephala* is currently present only on the old town walls without any indication of further dispersal (Martina Podnar Lešić, Zagreb, pers. comm. 2014).

According to data collected in the field, the peak of *D. oxycephala* activity is reached in the months of April, May and June (Fig. 4) during late afternoon or morning before the sun is high on the horizon and the temperature reaches the daily maximum. Recent data collected in this study shows that *D. oxycephala* individuals were found active throughout the day between 08:00 and 18:00 hours without any special preference (Fig. 5).

*D. oxycephala* inhabits a wide range of habitats and can be found from sea level ( $\approx 1$  m a.s.l. on rocky sea beaches) up to more than 1600 m a.s.l. in Mountains like Biokovo (Croatia) and Baba planina (B&H). However the largest proportion of records were found under 400 m a.s.l. (Fig. 6). We found an opposite trend in frequency of records along annual mean temperature gradient (interpolated from WorldClim; Fig. 6) where most of the records were made in areas where annual mean temperature was between 21°C and 26°C. Total annual temperature span of this species was 13.6-25.5°C (average = 22.8°C; median = 24.2°C). The species mostly

occupies dry areas with low annual mean precipitation between 25 and 50 mm. This corresponds to dry Mediterranean-type habitats in Dalmatia and Herzegovina, but the species was also recorded in high mountainous region in B&H (Korita) with annual mean precipitation of 90 mm.

## Discussion

The sharp snouted rock lizard is an endemic species of Croatia, B&H and Montenegro. The species probably reaches the southernmost point in northern Albanian territory (Hill 2009, Polović 2011) but it still has to be officially confirmed (Crnobrnja-Isailović 2009).

Very old data by Depoli (1898) suggest that the northernmost locality of the species is the city of Rijeka and its surroundings. Since this record has never been reconfirmed in recent times, we consider it not valid and as a possible misidentification. Boulenger (1916, 1920) claims that its northernmost point of distribution is in the vicinity of the city of Zadar, while Bischoff (1984) claims this has not been recently reconfirmed. We believe that the northernmost distribution area actually extends up to the river Krka as Bedriaga (1886) and Schreiber (1912) already suggested. The northernmost island in Croatia inhabited by the species is Cres. As already indicated, the species has been introduced there probably on boats and ships (Toth et al. 2006, Sämman and Zauner 2010). The small island of Biševo near Vis is the westernmost known population. The southernmost locality in Croatia is the peninsula of Molunat near the border with Montenegro. In the east of the range, it occupies a continental area of B&H, reaching the easternmost point in Korita ( $\approx 1200$  m a.s.l.). The Dinaric mountain chain lays parallel to the Adriatic shoreline and presents a high

altitudinal barrier that prevents the spread of warm adapted Mediterranean species further inland. As we move further to the north from the Adriatic coast the climate becomes colder and with more precipitation. The northernmost point of distribution in relevance from the Adriatic Sea is again in B&H, in the canyon of the river Ljuta under Mt. Treskavica ( $\approx 100$  km from the shoreline). This is also the northernmost confirmed record in B&H and in the whole species native range. According to old literature data, there are records from Jablanica-Rama (Bolkay 1924) and Konjic (Werner 1897), but these sightings still need confirmation. From Fig 2. it is clear that Croatia had a higher rate of recent research on *D. oxycephala* and that there is a continuous lack of herpetological investigations in B&H. It is estimated that for 48 % of the entire B&H territory, there is no herpetological distribution data (Čengić, 2013 unpublished).

Roughly more than 70 % of the entire species range (estimation inferred according to IUCN), falls within Croatia and B&H and therefore the largest responsibility for species protection falls to these two countries. Most of the remaining 30% falls within Montenegro and the exact distribution in Albania still remains unclear.

Daily activity is clearly dependant on the month in which the species was observed and was the highest when the temperature was around 22°C which is complementary to the data presented by Bischoff (1981) who correlates the activity of the species with external temperature, between 19 and 27.5°C. These results are mainly a consequence of random daily activity of the researchers and should be considered as such.

The sharp snouted rock lizard is a species highly adapted to rocky habitats. It occurs on warm, sparsely vegetated, sunny rocky areas. Often it is the only lizard in these habitats, although it

occasionally occurs syntopically with *Podarcis muralis*, *Dinarolacerta mosorensis* (Hill 2009) and *Alygroides nigropunctatus* (Džukić and Pasuljević 1979). Our observations confirm these relationships in many areas, but we also discovered that population in Korita (B&H) appears in syntopy with *Lacerta agilis* and *V. ursinii macrops*). These are the first confirmation of coexistence with cold adapted mountainous species. This is not an isolated example as Jelić et al. (2012a) confirmed a similarly surprising syntopic coexistence of cold adapted *V. ursinii* and warm adapted *Zamenis situla* on Velebit mountain (1200 m a.s.l.). On the other side of the scale on the Adriatic coast *D. oxycephala* coexists with some of the most thermophilic Balkan species like *Hemidactylus turcicus*, *Telescopus fallax* and *Platyceps najadum*. Vervust et al. (2009) also reported sympatry with an introduced population of *Podarcis siculus* and *Podarcis melisellensis* from the Lastovo archipelago. *P. melisellensis* and especially *P. siculus* specimens are ecologically similar species and competitively superior over *D. oxycephala*: on small islands where the species co-occur, *D. oxycephala* often retreats to the peripheral zone of almost barren rocks to avoid competition (Vervust et al. 2009). Competitive exclusion could prevent *D. oxycephala* to co-exist with ecologically similar species (i.e. *P. siculus* which is partly an invasive species in Croatia) in smaller areas and islands (Radovanović 1956, Nevo et al. 1972) and it might be an answer to the discontinuous distribution range on Croatian islands presented in this paper. Vervust et al. (2009) conclude that on more flat and vegetated islands, without significant areas of bare rock, the habitat is more favorable for *Podarcis sp.* and *D. oxycephala* is rare or absent. This is another contribution to explain the discontinuous distribution range. The species' appearance in coastal zones is highly reflected in results of



temperature preference visible in Figure 6 where it is obvious that *D. oxycephala* prefers warmer habitats in general. This result is partly biased by the larger amount of data collected in lowland and coastal areas, but still gives a valuable insight into species' wide niche breadth. Large differences in niche selection (altitude, temperature, precipitation) would support the theory of Podnar et al. (2014), of the existence of two deeply separated clades within *D. oxycephala*. On the other hand, the previous study of genetic diversity performed on *D. oxycephala* populations on the small islands of Skadar lake (Montenegro) showed maintenance of high levels of genetic variability and absence of strong isolation effects that would be expected in island populations (Crnobrnja-Isailović 1995). The ability to maintain high genetic variation, combined with high levels of morphological variation, contributes to the species' high adaptive capacity and ability to easily occupy new niches when it doesn't come in competition with other species. *D. oxycephala* exhibit at least 16 anatomical characters that display interspecific variability and such levels of morphological differentiation and genetic divergence often exceed those between Lacertidae taxa that are already treated as full genera (Arnold et al. 2007). Within the species, two basic colour morphs exist: the dark morph (var. *tomasini* Schreiber 1891) usually encountered in higher altitudes and the light morph, which inhabits mostly lower altitudes and the islands (Hill 2009) (Fig. 1). A dark body absorbs radiant energy more efficiently than a light body, and melanism is thus often considered an advantage in a cool environments. Partial melanism (with visible pattern) was also observed in some of the Adriatic islands and theory of its correlation with colder environments is therefore not well supported. Previous studies on two species of snakes (*Vipera berus*, and *Thamnophis sirtalis*) and heliothermic

lizards (Clusella-Trullas 2008) have shown that in those species, melanism increases the efficiency of heat absorption, thus allowing a longer active season and higher reproductive success (Gibson and Falls 1979, Andren and Nilson 1981, Capula and Luiselli 1994, Forsman and As 1987), particularly in high-latitude or high-altitude environments (Monney et al. 1995).

Currently *D. oxycephala* is labelled in the Red List of Amphibians and Reptiles of Croatia as Least Concerned (LC). In B&H, due to lack of data, in the preliminary version of the red list document (Škrijelj et al. 2013) it is listed as Near Threatened (NT). Based on the current knowledge, data collected by this research, and the IUCN Red List Categories and Criteria version 3.1 (IUCN 2012), we feel confident that *D. oxycephala* should keep the status of Least Concern (LC), in Croatia and Near threatened (NT) in B&H until more research is conducted since most of the habitat is under high anthropogenic pressure.

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