

Contribution to the Knowledge on Amphibians and Reptiles of North-western Croatia

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Abstract: The amphibian and reptile fauna of North-western Croatia was never systematically surveyed and knowledge of it is incomplete. In 2008–2015, we conducted a detailed survey of the region and recorded 17 amphibian species (85% of all species in Croatia) and 13 reptile species (33% of all reptile species in Croatia). We recorded all typical and widespread species of amphibians and reptiles expected to occur the relatively well-preserved habitats in this area. Further, we also present data on some rare species such as *Vipera berus* and *Zootoca vivipara* as well as on species included in the Natura 2000 network: *Triturus carnifex*, *T. dobrogicus*, *Bombina bombina*, *B. variegata* and *Emys orbicularis*. The surprising species richness of the studied area, which is under high anthropogenic pressure, establishes a good foundations for further protection and management of amphibians and reptiles.

Key words: Amphibia, Reptilia, species inventory, Natura 2000

Introduction

Croatia is a member of the South East European (SEE) region and has a very important biogeographical position. Situated between the Pannonian Plain in the north-east, bordered by the Alps in the north-west, and connecting the Dinaric Arc with the Mediterranean, its biodiversity represents a mixture of the aforementioned regions. Its surface area is only 56 590 km² and, with 39 species of reptiles and 20 species of amphibians, it is among the European countries with a high diversity of the herpetofauna (JELIĆ *et al.* 2009). Despite this, there are still huge gaps in the knowledge of distribution of amphibians and reptiles in Croatia. One of the poorly known areas, with very few published records, is North-western Croatia, from the Slovenian border north-west from Zagreb, up to the town of Koprivnica including the confluence of the Mura and Drava Rivers.

This is the most densely populated area in Croatia. According to the last census (ANONYMOUS

2015), the average population density for Croatia was 75.71 individuals per km². From our study area, only the Koprivnica-Križevci County has a lower-than-average population density of 66.12 individuals per km²; the remaining three counties have above average densities (Krapina-Zagorje County with 108.13, Varaždin County with 139.42 and Međimurje County with 156.11 individuals per km²; ANONYMOUS 2015). Hence, rare natural habitats and the knowledge on species' distribution are of great importance.

Studies

According to the Red Book of Amphibians and Reptiles of Croatia (JELIĆ *et al.* 2012), there are 58 native, one introduced and two potentially present species but, since the latter have never been confirmed, they are not included in the present article.

According to the data compiled by JELIĆ (2014), there are several published records of amphibians

and reptiles in this area. They mention the smooth snake *Coronella austriaca* Laurenti, 1768; sand lizard *Lacerta agilis* Linnaeus, 1758; agile frog *Rana dalmatina* Fitzinger in Bonaparte, 1838 (PAVLETIĆ 1964); moor frog *Rana arvalis* Nilsson, 1842 (KARAMAN 1921); nose-horned viper *Vipera ammodytes* Linnaeus, 1758; grass snake *Natrix natrix* (Linnaeus, 1758) (PAVLETIĆ 1964, RÖSSLER, 1904); adder *Vipera berus* (Linnaeus, 1758) (KARAMAN 1921, VILAJ & DVORSKI 2014, WERNER 1897). JANEV HUTINEC *et al.* (2013) published a popular handbook on herpetofauna in Međimurje but the data presented there have no scientific value. In the present work, we give a comprehensive overview of herpetofauna in North-western Croatia, which is based on extensive fieldwork carried out over a period of eight years.

Materials and Methods

Study area

This survey was carried out on the territory of four counties in North-west Croatia (Fig. 1). A great number of habitat types were examined. North-western Croatia was a territorial unit that included six counties: Krapina-Zagorje, Varaždin, Međimurje, Koprivnica-Križevci, Zagreb County and the City of Zagreb as a separate entity till 2012 (ANONYMOUS 2007). The name was taken over because it best describes the research area. Due to the specificity of the City of Zagreb and Zagreb County, they were excluded from further analyses in this paper. Thus, when referring to North-western Croatia, it will only include the remaining four counties.

Geographically, the research area can be divided into a highland part and a lowland part. The highland area is characterised by many hills and a several mountains (such as Ivanščica, Strahinjščica, Macelj, Ravna gora and Kalnik), with the highest peak of 1060 m a.s.l. on Ivanščica Mt. The area is covered with mesophyllic forests, meadows, mosaic habitats and agricultural land (from lower to higher intensity of maintenance). Hills are criss-crossed with numerous smaller streams flowing from the southern slopes into the Krapina River basin, reaching the Sava River next to Zagreb City. From the northern slopes streams flow to the Bednja and Drava Rivers. Forest pools and ponds are also relatively abundant there, while wetlands are relatively rare compared to floodplains of the Drava and Mura Rivers. The lowlands are a part of the Pannonian plain, which incorporates the alluvial plains of Drava and Mura and is rich in rare and endangered habitats, such as flooded forests, oxbow lakes, meanders and escarpments. The major element for this habitat diversity

is the river dynamics, constantly shaping the environment by continuously creating new habitats and bringing regular floods that fill depressions where stagnant water stays for weeks. A narrow strip very close to the river is still in its natural state, without significant human impact (ŠAFAREK 2011).

Protection status

In the surveyed region, there are two main protected areas. These are: Nature Park Medvednica, founded in 1981 (ANONYMOUS 1981), which was only partially included in our study area, and Regional Park Mura-Drava, founded in 2011, which incorporates the area of Drava and Mura Rivers (ANONYMOUS 2011). In 2012, the whole area of the Mura, Drava and Danube Rivers in Croatia and Hungary was declared as a transboundary biosphere reserve (MAB), raising the importance of the region. Additionally, in 2013, 36 sites from our study area were added to the National ecological network, which is a part of the Natura 2000 ecological network (ANONYMOUS 2013a). Thus, many diverse habitats and species within our study area gained legal protection.

Sampling methods

Fieldwork was carried out from 2008 till 2015. In order to obtain the best results, several sampling methods were combined. Most of the data was obtained by visual observation, which consisted of examining the area in a certain period of time and searching for different species. In all stagnant freshwater habitats, hand-nets (eye size 1 mm) were used in order to investigate aquatic stages of amphibians, i.e. adults and larvae of frogs and newts. In the ponds, lakes and other stagnant freshwater habitats, traps for newts and for terrapins were set. Near the same habitats, pit-fall traps and nylon fences were set for a shorter period and checked on a daily basis.

All caught and identified animals were photographed and released unharmed afterwards back into the wild at the same spot where they were found. Coordinates for each individual were recorded using a GPS device.

While identifying species of the *Pelophylax* complex, authors were guided by previously known data that included three species: marsh frog *Pelophylax ridibundus* (Pallas, 1771), pool frog *Pelophylax lessonae* (Camerano, 1882) and edible frog *Pelophylax kl. esculentus* (Linnaeus, 1758). However, in light of recent data based on DNA analysis (JELIĆ *et al.* 2015), we know today that this species complex is much more perplexing, with an unexpected presence of the Balkan water frog *Pelophylax kurtmuelleri* (Gayda, 1940), as well as a new hybrid complex in Croatia. Therefore, results on green frogs reported

Table 1. List of recorded species in the study area with IUCN categories, legal status, and number of records. *SP – strictly protected

| Family | Latin name | Red Book category | Habitats Directive (Annex) | Nature protection law (Croatia)* | Number of records |
|-------------------|----------------------------------|-------------------|----------------------------|----------------------------------|-------------------|
| Class: Amphibia | | | | | |
| Order: Caudata | | | | | |
| Salamandridae | <i>Ichthyosaura alpestris</i> | LC | / | / | 31 |
| | <i>Lissotriton vulgaris</i> | LC | / | / | 16 |
| | <i>Salamandra salamandra</i> | LC | / | / | 61 |
| | <i>Triturus carnifex</i> | NT | II, IV | SP | 3 |
| | <i>Triturus dobrogicus</i> | NT | II, IV | SP | 2 |
| Order: Anura | | | | | |
| Bombinatoridae | <i>Bombina bombina</i> | NT | II, IV | SP | 23 |
| | <i>Bombina variegata</i> | LC | II, IV | SP | 75 |
| Pelobatidae | <i>Pelobates fuscus</i> | DD | IV | SP | 6 |
| Bufonidae | <i>Bufo viridis</i> | LC | IV | SP | 12 |
| | <i>Bufo bufo</i> | LC | / | / | 151 |
| Hylidae | <i>Hyla arborea</i> | LC | IV | SP | 20 |
| Ranidae | <i>Pelophylax kl. esculentus</i> | LC | V | | 100 |
| | <i>Pelophylax lessonae</i> | LC | IV | SP | 17 |
| | <i>Pelophylax ridibundus</i> | LC | V | | 76 |
| | <i>Rana arvalis</i> | LC | IV | SP | 11 |
| | <i>Rana dalmatina</i> | LC | IV | SP | 183 |
| | <i>Rana temporaria</i> | LC | V | | 31 |
| Class: Reptilia | | | | | |
| Order: Testudines | | | | | |
| Emyidae | <i>Emys orbicularis</i> | NT | II, IV | SP | 30 |
| | <i>Trachemys scripta</i> | NA | / | / | 7 |
| Order: Squamata | | | | | |
| Lacertidae | <i>Lacerta agilis</i> | LC | IV | SP | 130 |
| | <i>Lacerta viridis</i> | LC | IV | SP | 144 |
| | <i>Zootoca vivipara</i> | DD | / | SP | 2 |
| | <i>Podarcis muralis</i> | LC | IV | SP | 67 |
| Anguidae | <i>Anguis fragilis</i> | LC | IV | / | 36 |
| Colubridae | <i>Coronella austriaca</i> | LC | IV | SP | 16 |
| | <i>Natrix natrix</i> | LC | / | / | 122 |
| | <i>Natrix tessellata</i> | LC | IV | SP | 56 |
| | <i>Zamenis longissimus</i> | LC | IV | SP | 21 |
| Viperidae | <i>Vipera ammodytes</i> | LC | IV | SP | 29 |
| | <i>Vipera berus</i> | NT | / | / | 1 |

here should be regarded with caution, since there is a high probability that more species from the green frog complex are present in this area, which should be tested with further DNA analysis.

Results

Here we present data including c. 1500 records of amphibians and reptiles in North-western Croatia. The majority of these records present new distributional data.

During our survey, we recorded 30 species of amphibians and reptiles (Table 1) which represented 51% of all reptile and amphibian species currently known from Croatia. The high number of 17 amphibian and a somewhat lower number of 13 reptile species made up 85% and 33% of the total number of Croatian herpetofauna species, respectively. Apart from that, our data give us an insight into the species richness of herpetofauna of the study area (see Total species distribution, Fig. 2).

Four recorded species of amphibians, the Italian crested newt *Triturus carnifex* (Laurenti,

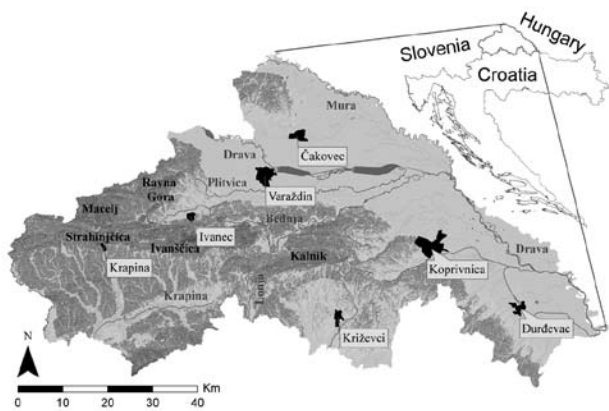


Fig. 1. Map of the study area comprised of four counties located in North-western Croatia

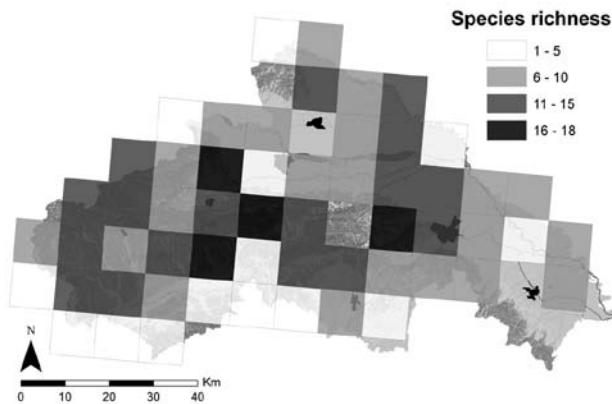


Fig. 2. Species richness of the surveyed area

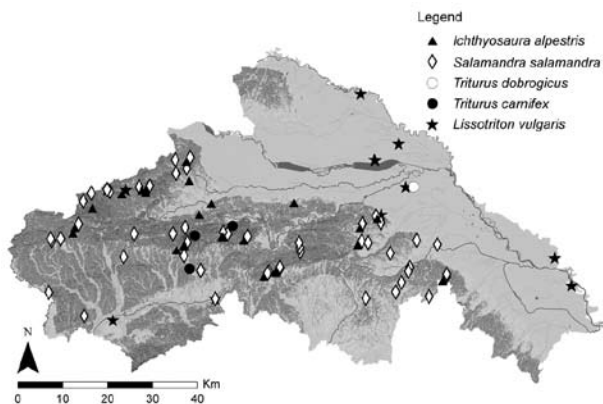


Fig. 3. Distribution of species of the order Caudata

1768), Danube crested newt *Triturus dobrogicus* (Kiritzescu, 1903), fire-bellied toad *Bombina bombina* (Linnaeus, 1761), yellow-bellied toad *Bombina variegata* (Linnaeus, 1758), and one species of reptiles, European pond terrapin *Emys orbicularis* (Linnaeus, 1758) are protected through the Natura 2000 network and listed in Annexes II and IV of the Habitats Directive 92/43/EEC.

Amphibians

Five recorded amphibian species belong to the order Caudata, accounting for 71% of the total species of this order present in Croatia. Most of the recorded species of Caudata, i.e. the Alpine newt *Ichthyosaura alpestris* (Laurenti, 1768), smooth newt *Lissotriton vulgaris* (Linnaeus, 1758) and fire salamander *Salamandra salamandra* (Linnaeus, 1758), were evenly distributed in most or all of the surveyed area, while some species had a more local distribution. For example, *T. carnifex* was present only at the higher elevations, mostly the area of Ivanščica Mt., while its sister species, *T. dobrogicus*, was rather a lowland species, recorded mainly in the alluvial plain of the Drava River.

Species richness of the order Anura was also high; out of 13 species present in Croatia, 12 of them were recorded in the study area (92%).

Three brown frog species were found during this survey (Fig. 4). *Rana arvalis* was closely associated with the lowland part with flooded meadows and forests in the alluvial plains of the Drava and Mura Rivers. The common frog *Rana temporaria* Linnaeus, 1758 preferred highland areas covered with forests such as Macelj and Ivanščica Mts., and *R. dalmatina*, a habitat generalist, was present in the whole study area.

The *Pelophylax* complex was represented with all three species known from Croatia: *P. ridibundus*, *P. lessonae* and *P. kl. esculentus*. They were the most numerous amphibian species recorded in this area (Fig. 5). While *P. lessonae* was recorded only in the lowland region, in the alluvial plains of Drava and Mura Rivers, the other two species were found in the entire area, except from high elevations on mountainous parts.

Both Croatian species of the genus *Bombina* were recorded in the study area: *B. variegata* in highlands, where it was found mostly in smaller ponds throughout the forests on Macelj, Ravna gora, Ivanščica and Strahinjščica Mts., while *B. bombina* was only found in the lowland region of the alluvial plains of Drava and Mura. Similarly, the common spadefoot *Pelobates fuscus* (Laurenti, 1768) was recorded only at six localities in the north-eastern part of the study area, near the border with Hungary. The common tree frog *Hyla arborea* (Linnaeus, 1758) was usually recorded in stagnant water bodies at both highland and lowland locations (Fig. 6).

While the common toad *Bufo bufo* (Linnaeus, 1758) was present across the entire survey area, the green toad *Bufo viridis* (Laurenti, 1768) was recorded only in the lowland parts of Drava, Mura and Lonja Rivers (Fig. 7).

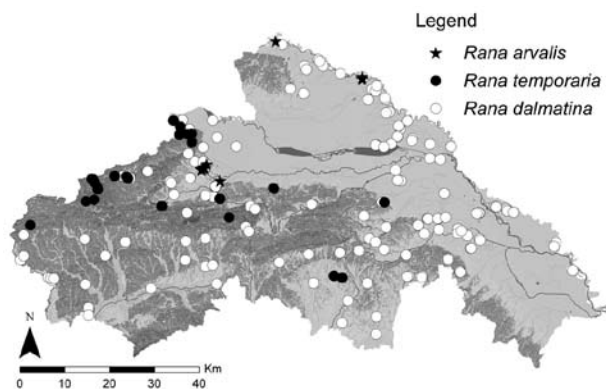


Fig. 4. Distribution of species of the genus *Rana*

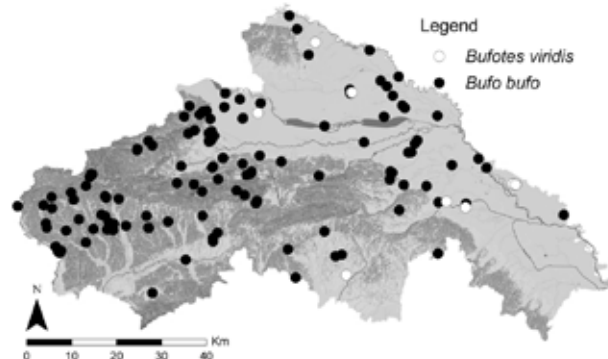


Fig. 7. Distribution of species of the family Bufonidae

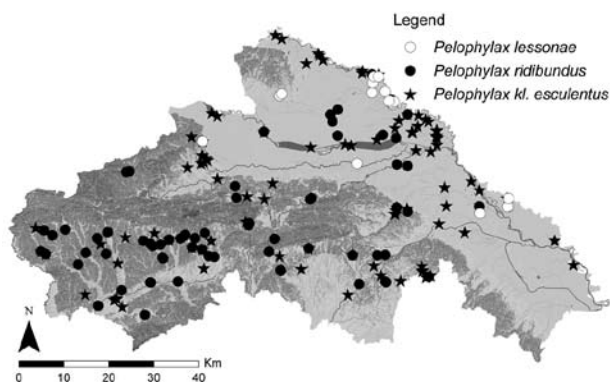


Fig. 5. Distribution of the species of the genus *Pelophylax*

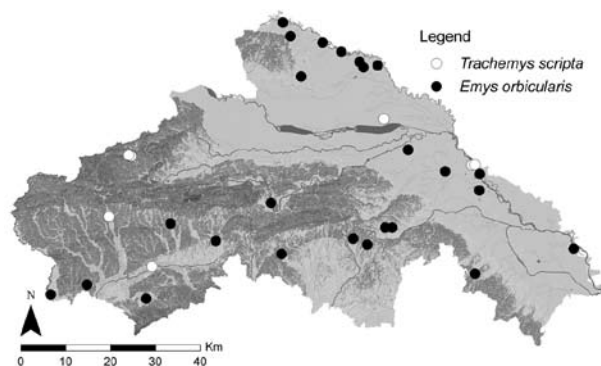


Fig. 8. Distribution of the genera *Emys* and *Trachemys*

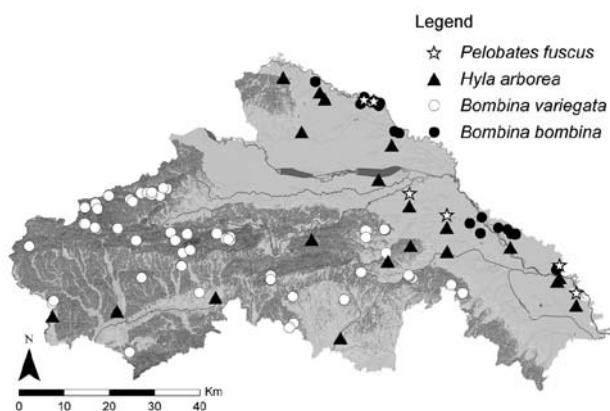


Fig. 6. Distribution of species of the genera *Bombina*, *Pelobates* and *Hyla*

Reptiles

The only freshwater turtle species native to this region is *E. orbicularis*, whose presence was confirmed in both the lowlands and highlands. An introduced species, the common slider *Trachemys scripta* (Thunberg in Schoepff, 1792), was also recorded at several localities across the entire study area (Fig. 8).

The order Squamata was represented with five species of lizards and six species of snakes in the surveyed area. Most of the records for lizards be-

longed to the genus *Lacerta*; the eastern green lizard *Lacerta viridis* (Laurenti, 1768) inhabited highland parts and *L. agilis* inhabited lowland part in the alluvial plains of Drava and Mura Rivers, but it also entered highlands along the river valleys of Bednja, Plitvica and Krapina. On the other hand, a lower number of records came from the viviparous lizard *Zootoca vivipara* (Jacquin, 1787) that only inhabited a small area of Macelj Mt. where it was discovered just recently (in 2011: LAUŠ 2016: Fig. 9).

Two more species of lizards occur in this area. While the slow worm *Anguis fragilis* Linnaeus, 1758 was common in both highland and lowland parts, the common wall lizard *Podarcis muralis* (Laurenti, 1768) preferred drier habitats in the highlands. There were also some records from the lowlands, but these were mostly connected to settlements (e.g. cities like Varaždin and Križevci) that had different habitat conditions from the surroundings (Fig. 10).

The most common non-venomous snake species were the grass snake *N. natrix* and dice snake, *Natrix tessellata* (Laurenti, 1768). The latter was always found in the close vicinity of water bodies, while the first did not depend exclusively on water, and was found from a much wider area (Fig. 11).

The Aesculapian snake *Zamenis longissimus*

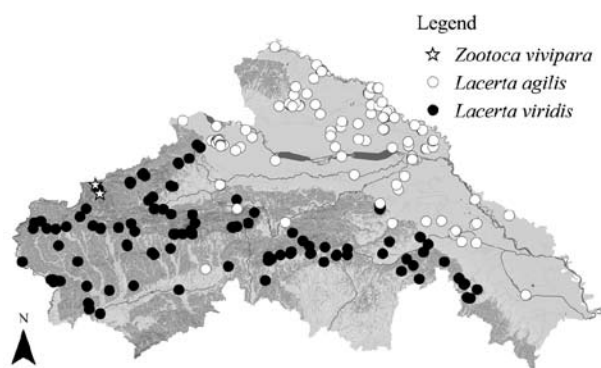


Fig. 9. Distribution of lizards of the genera *Lacerta* and *Zootoca*

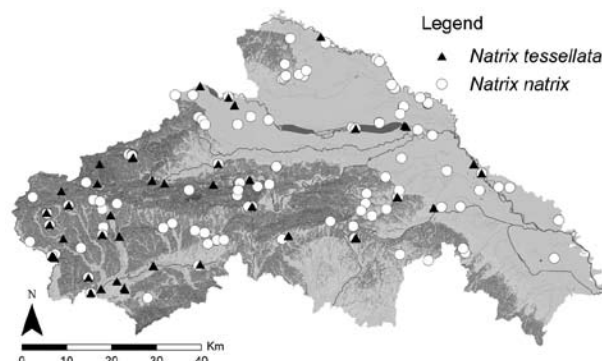


Fig. 11. Distribution of snakes of the genus *Natrix*

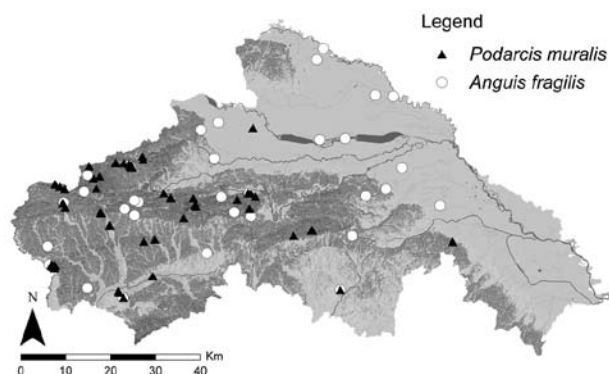


Fig. 10. Distribution of lizards of the genera *Podarcis* and *Anguis*

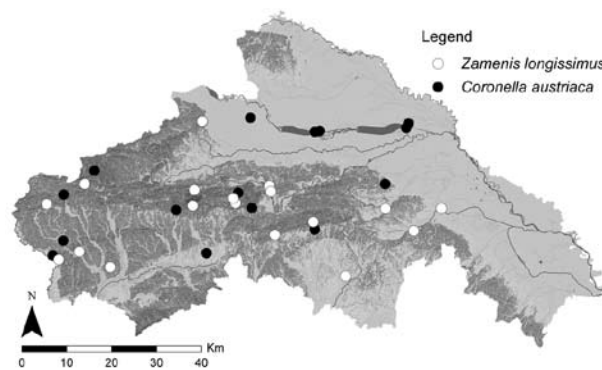


Fig. 12. Distribution of two non-venomous snakes of the genera *Zamenis* and *Coronella*

(Laurenti, 1768) was found mostly in the highland area, while *C. austriaca* in both areas (Fig. 12). Despite the wide general distribution of these species, their findings seem to be rare, compared to other colubrids that were recorded in the region.

Two venomous snake species were found in this region. The more frequent one was *V. ammodytes*, which inhabited highland parts with calcareous rocks on Strahinjščica, Ivanščica, Ravna Gora and Kalnik Mts. *Vipera berus* was very rare in the studied area, with just one record in 2015 at the same location as in 2014 (VILAJ, DVORSKI 2014). It was present in the eastern part of Varaždin County, in a floodplain oak forest in the surroundings of the Drava River (Fig. 13).

The areas with the highest species diversity included Ivanščica Mt. (Fig. 2) with surrounding areas that have a combination of highland habitats, as well as lowland habitats along rivers like Bednja, Plitvica and Krapina. The lowest diversity was found in highly modified habitats, such as larger settlements (Varaždin, Čakovec, Đurđevac Cities) and areas with big dams (hydropower plants Varaždin, Čakovec and Dubrava). The most frequent species of amphibians were *R. dalmatina* (183 records), *B. bufo* (151

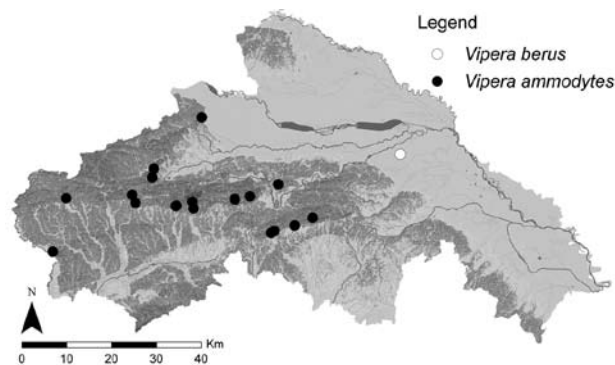


Fig. 13. Distribution of two venomous snakes of the genus *Vipera*

records) and *P. kl esculentus* (100 records) that were present in the whole surveyed area. The most frequent reptile species were *L. viridis* (144 records) in highland habitats and *L. agilis* (130 records) in lowland habitats, while *N. natrix* (122 records) was present in both regions. We recorded five Natura 2000 species, and their diversity was equal in both highland and lowland habitats. *Bombina variegata* was present in highland habitats and was recorded more frequently (75 records) than *B. bombina*, which was present in lowland alluvial habitats (23 records).

Records of *T. carnifex* in highland (three) and *T. dobrogicus* in lowland habitats (two) were rare. *Emys orbicularis* was evenly distributed in the whole surveyed area along different water bodies and was found frequently (30 records).

Discussion

Our data notably increased the knowledge of amphibians and reptiles of this region. Previously published data summarised by JELIĆ (2014) accounts for only a few dozen records, while our survey adds approximately 1500 new records for the region. Some species were common, with numerous records, but there were also important records of some rare or more elusive species.

Given the fact that this area is the most densely populated area in Croatia, habitats here are very fragmented and under pressure of urbanisation, but are still highly diversified and extremely important for the survival of the biodiversity in the region. As the survey area is in the continental part of the country, a lower number of reptile species was expected, since a large number of reptile species found in Croatia inhabit the Mediterranean Region. Although the studied area geographically belongs to Croatia, several of the recorded species are valuable not only on the national, but also on the international level. The high number of recorded species indicates the importance of the area for both groups. This region should be regarded as one of the most important areas for the order Anura in Croatia, as almost all the species present in the country have been recorded there. It would be of great importance to establish a regular monitoring scheme for the presence of the chytrid fungus *Batrachochytrium dendrobatidis* (Bd), which was not yet reported in Croatia but was confirmed for Hungary (GARNER *et al.* 2005, VÖRÖS & JELIĆ 2011). The presence of Bd in this area could have significant negative influence on the amphibian fauna, especially in highland habitats, which are the most suitable for the pathogen.

SILLERO *et al.* (2014a) list a total of 384,609 records of amphibians and reptiles for Europe, from which 2395 records are for Croatia. These data are accessible in the form of an online atlas, NA2RE interactive map, with records displayed in 50×50 km square grid (SILLERO *et al.* 2014b). However, since quadrants displaying the presence of some species cover border areas between Croatia, Slovenia and Hungary, we cannot know for certain that point records are indeed placed within the borders of our survey area. For species with no quadrants covering this area, our records represent an addition to this

atlas and should in the future be included in their database.

When examining each species separately, we can see that the number of records for some of them were quite small, e.g. both species of the genus *Triturus*. As these are important species in terms of conservation (both are Natura 2000 species), future research should focus on specific methods for mapping and monitoring of newts, in order to provide higher quality results for these species. Another reason for their low presence might be the degradation of available habitats. However, to confirm this, qualitative surveys of currently known and potential habitats should be carried out.

Bombina bombina and *P. fuscus* are present in the same geographic area but usually inhabit different habitats. *Bombina bombina* is an important Natura 2000 species in Croatia, and requires more focused research. *Pelobates fuscus* occurs in the alluvial plains, on habitats with less compact soil, as the adults usually bury themselves into the soil during daytime. This is one of the rarest and most secretive frog species in Croatia, and is not recorded often during field surveys. Additional research is needed in order to gain an insight into its distribution, as well as the conservation status of this species in Croatia. Currently it is categorised as Data Deficient in the Red Book of Amphibians and Reptiles of Croatia (JELIĆ *et al.* 2012). Both of these species can be easily overlooked in general surveys because they require special attention due to habitat preferences, the time of day or the season.

The most interesting reptile species present in the area are *Z. vivipara* and *V. berus*. *Zootoca vivipara* was recorded for this area for the first time in 2011 (LAUŠ 2016). The population of *Z. vivipara* occupies just a small area of the Macelj Mt. The closest known population is located 70 kilometres to the south-west, on Žumberak Mountain (JELIĆ *et al.* 2012). Even though it is extremely widespread, its territory ranging from Europe, across most of Northern Asia to China and Japan (AGASYAN *et al.* 2010), its distribution in Croatia is still unclear as the recent new findings on the Macelj Mountain or in the lowlands of Eastern Croatia (JELIĆ & BOGDANOVIĆ 2011) suggest. This is one of the reasons why it is listed as Data Deficient for Croatia (JELIĆ *et al.* 2012).

The first record of *V. berus* in the region is almost a century old (WERNER 1897, KARAMAN 1921). It was reconfirmed in the region only recently (VILAJ & DVORSKI 2014). In 2015 the presence of *V. berus* in the area was again reconfirmed, but the surveys of the neighbouring localities did not yield any new

records. Due to that, we assume that only a small population of *V. berus* still persists in the region, and that it is the most threatened reptile in the area. The habitats in the surroundings of the locality are highly modified and intensely used for agriculture. Only fragments of once abundant floodplain oak forests and grasslands, with specific microhabitats and vegetation components that are essential for this species remain. An additional problem is that, to the best of our knowledge, there are no known populations of the adder in the neighbouring areas, so there is a chance that this population is indeed isolated. The two closest population are located in Hungary, approximately 35 km from the study site (PUKY *et al.*, 2005), and near Mala Polana (Slovenia), 45 km from the study site (CAFUTA 2010). Therefore, it is critical to continue with the research on this species in order to assess potential and real threats, and to provide effective conservation measures for the future survival of the population. The presence of this species in the surveyed area is a valuable addition to the NA2RE atlas (SILLERO *et al.* 2014b).

According to the number of records (Table 1), another venomous species, *V. ammodytes*, appears to be more frequent than the two colubrid species, *C. austriaca* and *Z. longissimus*. However, *V. ammodytes* has a very local distribution, dependent on the presence of calcareous habitats in this area, which are under strong anthropogenic pressure. Furthermore, there is a negative perception about this species in the general public, and any interaction with humans is usually lethal for the snake, regardless of the fact that it is strictly protected by the Nature Protection Law (ANONYMOUS 2013b).

A single alien species, *T. scripta*, was recently recorded in the area (JELIĆ & JELIĆ 2015). The oc-

currence of this species in the surveyed area is also a valuable addition to the NA2RE atlas (SILLERO *et al.* 2014a).

The national database for herpetofauna of Croatia is still not available, and in that context, our data presented here are a valuable distribution resource.

Conclusion

Our study provides the first recent comprehensive data on herpetofauna in the area of North-western Croatia, which can be used as a baseline for studies and monitoring activities in the future. During our survey, we recorded a total of 17 species of amphibians and 13 species of reptiles, which represented 85% and 33% of all amphibian and reptile species recorded in Croatia, respectively. However, further research is needed in order to complete the data gaps. Some species were not found in all suitable habitats in this region, although they are expected to inhabit certain sites. In order to obtain more detailed and precise data, field visits in the early spring should be mandatory, during the intensive breeding period of amphibians. Special attention should be given to rare species or to species of special conservation interest.

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