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When did *Buddleja davidii* become invasive in Slovenia?

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Abstract. Butterfly-bush (*Buddleja davidii*) is globally widespread invasive alien plant that originates in China. In Slovenia, a switch from benign naturalized plant to invasiveness occurred just recently, so in the last decade it has been spreading rapidly in the sense of geography and also forming viable competitively strong populations in (semi-)natural habitat types such as abandoned quarries, rocky slopes and river banks. In the article its spreading is presented with some older overlooked records and several new records that more than double our knowledge of the species' distribution in Slovenia. These data strongly confirm that it can be recognized as invasive alien species also in Slovenia, owing to its successful spread to natural habitat types in several parts of the country in the last decade.

Key words: *Buddleja davidii*, alien plant invasion, Slovenia

Izvleček. Kdaj je *Buddleja davidii* postala v Sloveniji invazivna? – Metuljnik (*Buddleja davidii*) je po vsem svetu razširjena invazivna rastlina, ki izvira s Kitajske. V Sloveniji je do prehoda iz neškodljive naturaliziranosti v invazivnost prišlo šele nedavno, tako da se v zadnjem desetletju vrsta intenzivno širi v geografskem smislu in na več mestih oblikuje konkurenčno močne populacije v (pol)naravnem okolju opuščenih kamnolomov, skalovja in obrečnih prodnatih bregov. V članku je predstavljeno njeno širjenje s starimi spregledanimi kot tudi številnimi novimi podatki, ki več kot podvojijo vednost o njen razširjenosti v Sloveniji. Podatki potrjujejo, da je tudi na območju Slovenije vrsta zanesljivo invazivna, saj se vsaj zadnje desetletje širi tudi na naravna rastišča na več koncih države.

Ključne besede: *Buddleja davidii*, širjenje tujerodnih invazivnih vrst, Slovenija

Introduction

Invasive alien species often develop their invasiveness in the newly occupied region after years of gradual adaptation. This is the so-called lag-phase (Kowarik 1995) and can last for years or even centuries. During this phase, populations of a new-comer are exposed to new environmental conditions that include abiotic (climatic and soil conditions, geological substrate structure, etc.) and biotic factors (competition, herbivory, parasitism, pollination biology, etc.). Among the latter, human interventions can also be listed, such as e.g. ruderalization of native habitat types, selective treatment of plant communities (e.g. logging, using selective herbicides), deliberate propagation of alien plant (e.g. for decoration, food, fiber production), etc. Quite few, perhaps even more than half of all invasive alien plant species, have been brought to new regions of the world intentionally, mostly for horticultural use as ornamental plants. For such introductions it is important that traditionally seed and other propagulae exchange had taken place between gardeners already in previous times, when spectrum of ornamental plants available in garden markets was not so diverse, as some of popular ornamentals spread quite quickly. And their speed had been definitely much quicker than their natural capacities of spread would allow and, on the other hand, with very irregular biogeographic pattern of spread.

As early as the 1950s it was documented in Slovenia that *Echinocystis lobata* became popular and that its seeds were exchanged by mail (Petkovšek 1952). Several late flowering melliferous alien species were spread by bee-keepers, *Helianthus tuberosus* by hunters as winter food for wild boar, etc. Of course, only ornamental plants that are easy to maintain and propagate spread by direct informal support of gardeners, but this means that those species were better adapted to the local ecological conditions and subsequently their sub-spontaneous meta-population quickly scatters over huge areas. So the propagule pressure on the environment grew extremely fast and, in such conditions, the probability that some types become better adapted to the local natural habitat types rose as well. Often it is not possible to trace the source of better adapted populations as the naturalization pattern is blurred by high number of populations ranging from ephemerophytes to already naturalized ones. On the other hand it is not possible to monitor all the plant species in a wider territory in real time and systematically, so the availability of field data is mostly a result of random floristic activity. But when a species really goes beyond the lag phase, it becomes »common« very quickly indeed. That is what obviously happened in Slovenia with American *Erigeron annuus* just recently; at the end of the 1990s we personally observed how it switched from only ruderal habitat types to semi-natural grasslands, and today it can be found literally everywhere up to the montane altitudinal belt. A similar switch was reported for *Ambrosia artemisiifolia* in the 1990s, when its populations became well adapted to dry ruderal habitat types, especially along main roads, and from scattered distribution pattern turned to linear pattern linked to the main road network (Jogan & Vreš 1998). On a local scale, similar happened with *Cornus sericea* in the area of Ljubljana where it switched from ornamental gardens to wetland shrub communities (Bačič et al. 2015). Lag-phase between introduction in a new region and species naturalization is often several dozens to several hundred years long. For the 45 studied invasive species in Brandenburg (S Germany), the shortest lag-phase between 30 and 60 years has been reported for *Prunus serotina* (29), *Mahonia aquifolium* (38), *Prunus mahaleb* (54) and *Buddleja davidii* (56 years) (Kowarik 1995).

Butterfly-bush (*B. davidii*) as a widespread plant in China was described quite late. The first known specimens were brought to Europe at the end of the 19th century and in 1887 it was described, but at approximately the same time became popular as ornamental plant and entered the intense horticultural trade (Tallent-Halsell & Watt 2009). First reports of its spontaneous spread are from the 1930s (Fritsch 1933, Tallent-Halsell & Watt 2009). In Central Europe, Hegi (1966) reported only a couple of escapes in NW Germany and S Switzerland. In all neighboring countries sub-spontaneous occurrence of *B. davidii* is reported and recognized as invasive in N Italy (Celesti-Grapow et al. 2010), potentially invasive in Austria (Walter et al. 2002), locally naturalized in N Croatia (Boršić 2018), and adventitious in some parts of W Hungary (Bartha & Kiraly 2015).

Butterfly-bush is still among very popular ornamental plants with dozens of cultivars especially admired for its attraction to butterflies. It can be found at every garden market and subsequently in Slovenia in several gardens all over the country. In the general Slovenian floristic literature *B. davidii* was first reported in 1999 (Martinčič 1999) as ornamental, locally escaped and naturalized with 4 mentioned localities. The first explicit mention of the species as invasive in Slovenia dates from 2009 (Kus Venvliet et al. 2009) and later reassessed in 2012 (Jogan et al. 2012). Today it is recognized also as a harmful species that needs local control and administrative prohibition of deliberate spread (Simončič 2011).

Comparable to many other invasive trees and shrubs, *B. davidii* has the smallest seeds that are easily dispersed by wind during winter and spring months, when ripe inflorescences from previous year are persisting on branches, with capsules gradually opening in dry weather. From just 10 collected ripe inflorescences with thousands of ripe capsules, about 1 g of seeds was gathered after drying (original data). But as the weight of 1 seed is only about 0.05 mg, here are c. 20,000 seeds in 1 g. So the whole well developed shrub with hundreds of inflorescences can produce several 100,000 to several millions of seeds every year.

Materials and methods

Stratified floristic sampling in Slovenia follows the Central-European method with grid divided into base fields 10' latitude × 6' geographical longitude, which are divided in 4 quarters, the so-called »quadrants« (Niklfeld 1971). Each quadrant covers approximately 35 km^2.

All available published records of *B. davidii* in the territory of Slovenia and all original records as a results of random floristic mapping were organized in a database with special emphasis on age of the record, type of occurrence of *B. davidii* in locality (ephemeral, individual, naturalized, invasive) and habitat type distinguishing between ruderal, semi-natural and natural. From the database, a distribution map with data structured by their age and another analysis of discrepancy between the known localities in certain period and those compiled in three previously published maps (Jogan et al. 2001, 2012, Mavrič & Strgulc Krajšek 2017) were prepared.

Special attention was paid to »grey« literature, e.g. project reports and internet publication of data, of course with checking the reliability of sources.

Results

In addition to already compiled and published data (Mavrič & Strgulc Krajšek 2017), more than 30 new quadrants were filled with new or overlooked records of *B. davidii* that gives us a much different picture of its presence and spreading in Slovenia. Obviously (Fig. 1) in eastern and central Slovenia, its distribution is scattered but frequent, mostly linked to ruderal places. In western Slovenia it is naturalized especially in the Soča valley but also with few scattered occurrences elsewhere.

In the recently published article, Mavrič & Strgulc Krajšek (2017) provided a negligible number of their own new records but tried to compile several older published (and unpublished) records organized in 4 groups, so that the first impression is completeness of the study. But this compilation of the same available sources just a year later resulted in more than twice as many quadrants with confirmed records of *B. davidii*, which is a substantial change in knowledge. In addition to several authors' original records and already mentioned »grey« sources, a study that resulted in more than 20 new records in 2012 and 2013 (Jogan et al. 2013) had been completely overlooked.

In such a quick spread it is impossible to trace the bio-geographic pattern of propagule pathways, and it is also a hard work to compile all the known records at certain period. So there is always a gap between the known occurrences and reported and compiled ones, and it is simply not sufficient to rely only on data available in some databases or even on the internet. In Fig. 1, three distribution maps of *B. davidii* in Slovenia are shown, published in 2001 (Jogan et al. 2001), 2012 (Jogan et al. 2012) and now (2018). These temporal borders are used also for a structured presentation of distribution data on the actual map, so we can compare the available knowledge of distribution in certain period with data more or less successfully compiled by certain author. These relations are better shown in Fig. 2, where another recently published distribution maps (Jogan et al. 2001, 2012, 2018 and Mavrič & Strgulc Krajšek 2017) are taken into consideration. Here we can clearly see discrepancies between the available and compiled records number, which is due not only to the author's willingness to prepare a complete compilation but to a certain extent also to complexity of network of sources where one can search for records. Among other sources for such easily recognizable shrub like butterfly-bush, it is important to check also some portals on the internet as e.g. iNaturalist (https://www.inaturalist.org), FotoNarava (http://www.foto-narava.com/) and Geopedia (http://www.geopedia.si). In each of the three mentioned sources, at least one reliable record in a new quadrant has been found.

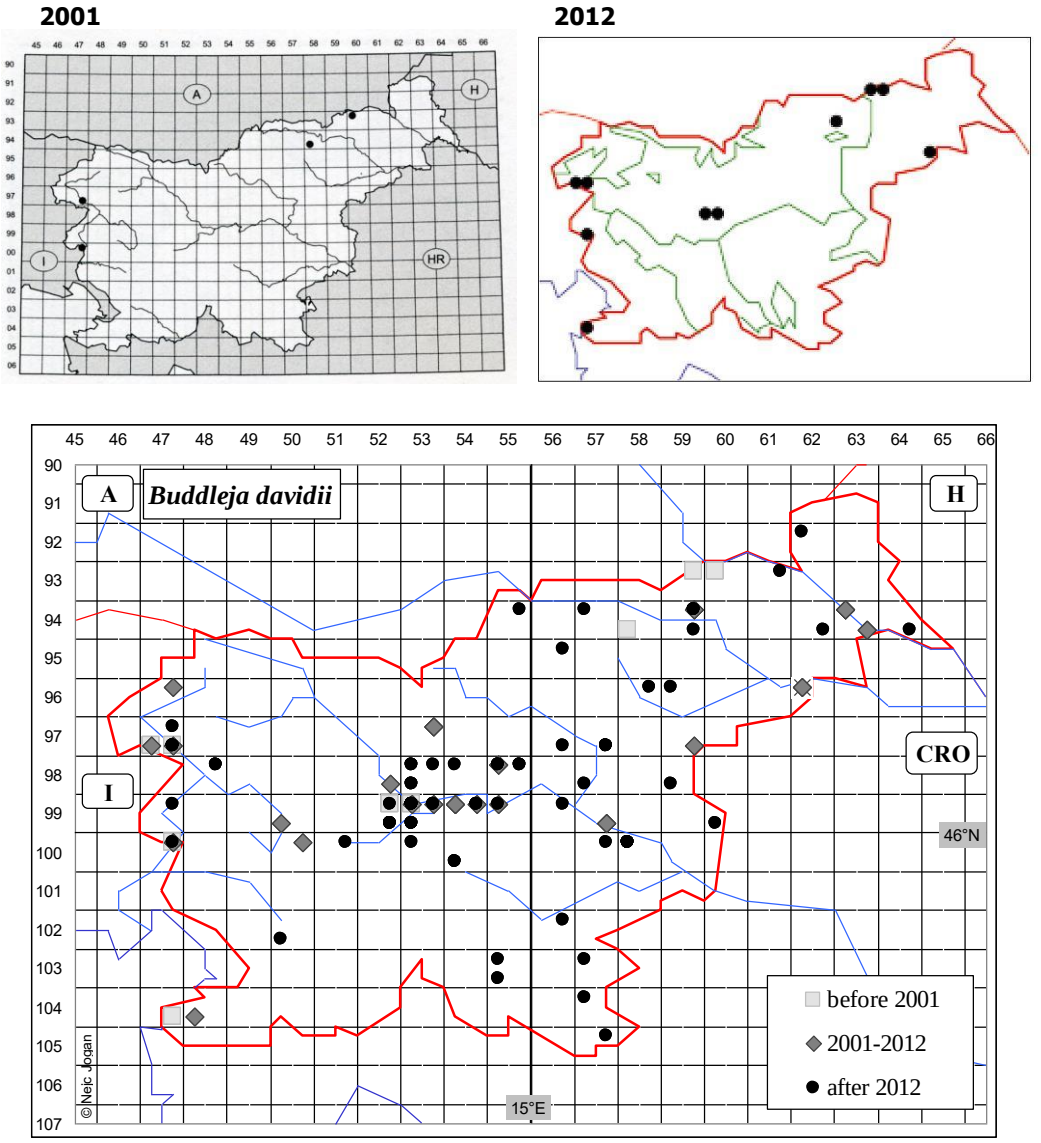

Figure 1. Three distribution maps of *B. davidii* in Slovenia as published in 2001, 2012 and now, with the same temporal boundaries used in the last map to compare the published patterns with available records at the same time.
Slika 1. Trije zemljevidi razširjenosti *B. davidii* v Sloveniji objavljeni 2001, 20012 in tukaj z enakimi starostnimi intervali prikazanih podatkov, da lahko primerjamo objavljene vzorce razširjenosti z realnimi znanimi vzorci na podlagi tedaj zbranih podatkov.

Here is a list of additional compiled (or published in rarely consulted places) records of *B. davidii* in Slovenia. In addition to the records cited in Mavrič & Strgulc Krajšek 2017, some records of the species kindly provided by the FloVegSi database manager Branko Vreš and some records published by other authors (Bakan 2011, Dakskobler et al. 2011, 2014) were taken into consideration:

0047/2 Primorska, Solkan, SE slopes of mount Sabotin, at Solkanski bridge, screes. 90 m s. m. 30. 6. 2006. Leg. Vreš B., Čelik T. (FloVegSi database)
0051/2 vicinity of Ljubljana, Vrhnika, E, individual shrubs in ruderal places. Det. D. Cenčič, 18. 9. 2012 (results of Thuja 2 project)
0053/1 vicinity of Ljubljana, Staje pri Igu, individual shrubs in ruderal places. Det. B. Dolinar, 5. 9. 2012 (results of Thuja 2 project)
0054/3 vicinity of Ljubljana, Grosuplje, Radensko polje (45,92171334°N, 14,67989451°E). Det. Jana Kus Venvliet, 8. 6. 2013 (results of Thuja 2 project)
0054/3 vicinity of Ljubljana, Zagradec pri Grosupljem, individual shrubs in ruderal places. Det. B. Dolinar, 8. 9. 2012 (results of Thuja 2 project)
0058/1 Posavje, at river Sava between Log and Blanca, many shrubs. Photo »tama«, 27. 7. 2011 [http://galerija.foto-narava.com/]
0058/1 Posavje, Leskovec pri Krškem, Nova pot, may be also cultivated, 2013 [data from publicly accessible application in Geopedia]
0250/3 Primorska, Senožeče, in the bushes. Det. S. Behrič, 24 8 2013 (results of Thuja 2 project)
0256/2 Dolenjska, Novo mesto, Brod. Det. J. Čuš, 3. 10. 2013 (results of Thuja 2 project)
0355/1 Dolenjska, Kočevje, Stara Cerkev, individual shrubs in ruderal places. Det. H. Lesar, 3. 9. 2013 (results of Thuja 2 project)
0355/3 Dolenjska, Kočevje, Mestni Log, individual shrubs in ruderal places. Det. T. Potočnik, 31. 7. 2013 (results of Thuja 2 project)
0357/1 Bela krajina, Semič, individual shrubs in ruderal places. 2013? (no author name, results of Thuja 2 project)
0457/1 Bela Krajina, Črnomelj, ulica pod Gozdom, may be only cultivated. 2013 [no author name, data from publicly accessible application in Geopedia]
0557/2 Zilje, individual shrubs in ruderal places, scattered, probably naturalized. Det. B. Dolinar, 1. 9. 2013 (results of Thuja 2 project)
9262/1 Prekmurje, Krašči, individual shrubs in ruderal places. Det. R. Šturm, 22. 9. 2012 (results of Thuja 2 project)
9361/2 Štajerska, Prlekija, Črešnjevci. Det. J. Čuš, 6. 9. 2013 (results of Thuja 2 project)
9455/2 Koroška, SW of Vič pri Dravogradu, individual shrubs in ruderal places. Det. H. Lesar, 27. 8. 2013 (results of Thuja 2 project)
9457/1 Štajerska, Vuhred, individual shrubs in ruderal places. Det. M. Cojzer, 14. 9. 2012 (results of Thuja 2 project)
9459/2 Štajerska, Maribor, Tabor, abandoned park area along railway. Det. N. Jogan, 2014 (46°33'5,73" N 15°38'40,28" E)
9459/4 Štajerska, Maribor, Tezno, dry ruderal places along Tržaška cesta. Det. N. Jogan, 2016 (46°31'58,63" N 15°38'44,24" E)
9462/4 Štajerska, Prlekija, Precetinci-Gajševsko lake. Det. J. Čuš, 7. 9. 2013 (results of Thuja 2 project)
9464/4 Prekmurje, Petišovci, individual shrubs in ruderal places. Det. J. Čuš, 5. 9. 2013 (results of Thuja 2 project)

9556/2 Koroška, Mislinjska Dobrava, individual shrubs in ruderal places. Det. I. Čede, 4. 9. 2013 (results of Thuja 2 project)
9647/2 Triglav National Park, rocky outcrops at Kluže fortress (46°21'26" N 13°35'16" E) 9. 9. 2010 (results of Thuja 2 project)
9659/1 Štajerska, Slovenska Bistrica, dry ruderal places at Žolgarjeva ulica. Det. N. Jogan, 8. 2017 (46°23'16" N 15°34'11" E)
9747/2 Posočje, rocky slopes above the road N of Kobarid. Det. N. Jogan, 26. 8. 2017 (46°14'59" N 13°35'7" E)
9747/4 Posočje, Kobarid, slopes at »Napoleonov bridge« [»...pri Kobaridu ... nad mostom, kjer cesta proti Ladri prečka Sočo ... kaže, da je prešla v proces naturalizacije ...«]. N. Jogan & A. Podobnik 1993 (Jogan & Podobnik 1995), locality previously mistakenly interpreted as Kobarid or Smast
9756/4 Štajerska, vicinity of Celje, Migojnice. Det. Jan Gojznikar, 18. 9. 2013 (46,23303748 °N, 15,16169261°E) (results of Thuja 2 project)
9757/4 Štajerska, Celje, ob Savinji. Det. J. Markovič, 20. 9. 2013 (46,22511036 °N, 15,26665992 °E) (results of Thuja 2 project)
9757/4 Štajerska, Celje, Oblakova ulica. Det. Jan Gojznikar, 19. 9. 2013 (46,23446908 °N, 15,26264733 °E) (results of Thuja 2 project)
9757/4 Štajerska, Celje, Trubarjeva ulica. Det. Jan Gojznikar, 16. 9. 2013 (46,23236177 °N, 15,25412234 °E) (results of Thuja 2 project)
9759/4 Štajerska, Rogaška Slatina, Zdraviliški trg, supporting wall behind hotel Strossmajer (46°14'12" N 15°38'23" E). Photo N. Jogan, 18. 2. 2006
9848/2 Posočje, Klavže, individual shrubs in ruderal places. Det. R. Šturm, 29. 8. 2013 (results of Thuja 2 project)
9848/2 Posočje, Most na Soči, few shrubs at the left bank of Soča lake. Det. N. Jogan, 14. 1. 2018 (46°9'17" N 13°44'47" E)
9853/2 Gorenjska, Prevoje pri Šentvidu, ruderal places at Hofer shop. 315 m s. m., 20. 9. 2013. Leg. Vreš B. (FloVegSi database).
9854/1 Gorenjska, Lukovica pri Domžalah, Podpeč, Lukovica quarry. 340 m s. m., 27. 8. 2014. Leg. Vreš B. (FloVegSi database).
9855/2 Štajerska, Podlipovica, individual shrubs in ruderal places. Det. D. Cenčič 3. 9. 2013 (results of Thuja 2 project)
9857/3 Štajerska, Rimske Toplice, Šmarjeta, individual shrubs in ruderal places. Det. I. Čede, 19. 8. 2013 (results of Thuja 2 project)
9859/3 Štajerska, Lesično, individual shrubs in ruderal places. Det. I. Čede, 30. 8. 2013 (results of Thuja 2 project)
9947/2 Posočje, Morsko pri Kanalu, individual shrubs in ruderal places. Det. T. Potočnik, 4. 10. 2013 (results of Thuja 2 project)
9950/3 between Idrija and Spodnja Idrija. 2010? (published in Dakskobler et al. 2011)
9953/2 vicinity of Ljubljana, Spodnji Kašelj, individual shrubs in ruderal places. Det. D. Cenčič, 9. 10. 2012 (results of Thuja 2 project)
9954/2 vicinity of Ljubljana, Litija, Gradec, young plants in asphalt cracks on Graška cesta. Det. N. Jogan, 2013 (46°3'48" N 14°49'2" E)
9954/2 vicinity of Ljubljana, Veliki vrh pri Litiji, individual shrubs in ruderal places. Det. B. Dolinar, 12. 10. 2012 (results of Thuja 2 project)
9956/2 Posavje, Radeče, Njivice, southern slopes of abandoned quarry. Det. N. Jogan, 2013 (46°3'57,14" N 15°8'44,14" E)

9960/3 Štajerska, Bizeljsko-Trnje, individual shrubs in ruderal places, one shrub in the bushes. Det. R. Šturm, 13. 9. 2013 (results of Thuja 2 project)

Comparison of three older published distribution maps with current database showed that all available data in certain period (2001, 2012 and 2017) were not taken into consideration and that discrepancy is as high as 1:2 (Fig. 2). The reasons for incompleteness of given distribution maps are different, quite often there is a temporal gap between record in the field and reporting information to any public interface (classical printed publication, public herbarium voucher, databasing, publishing on internet), but it is also not easy to bear in mind all the complex information network of potentially available records. And there is a sad situation particularly in Slovenia that some research results of projects financed from public financial mechanisms are simply not available to the public. Even more, after an explicit request to one of these public institutions, where they are in possession of more than 20 additional records of *B. davidii* especially from western Slovenia, only three records were provided. Fortunately, the overall distribution pattern published here would not change much by adding the mentioned unavailable records. So also our results will definitely prove incomplete in the following years.

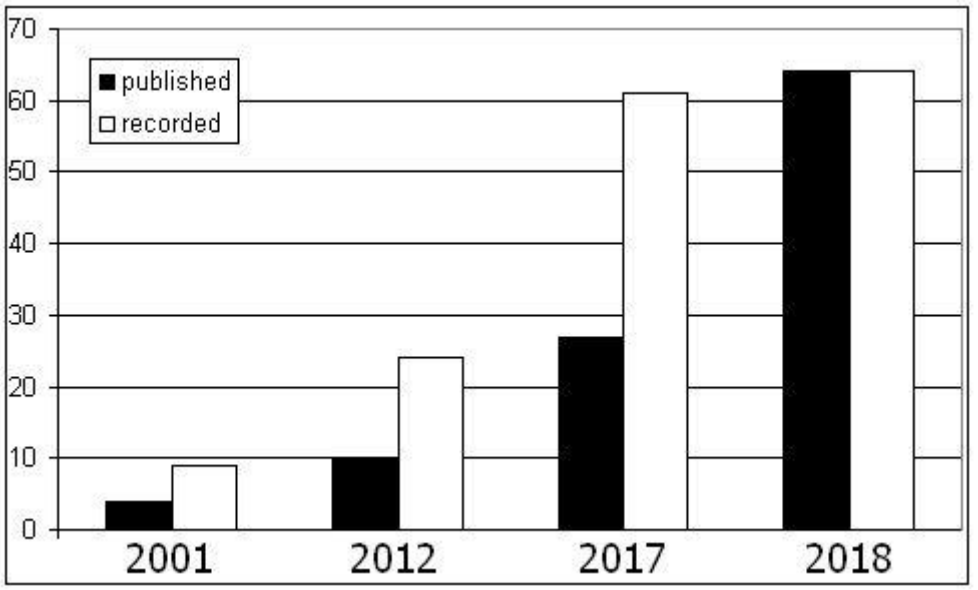

Figure 2. Comparison of compiled (in a map presented in Fig. 1; black columns) and available at the time of published compilation (white columns) records of *B. davidii* in certain period based on quadrant occurrences.
Slika 2. Primerjava zbranih (in predstavljenih z zemljevidom na Sl. 1) podatkov o razširjenosti *B. davidii* v posameznih predhodnih objavah s številom sočasno razpoložljivih podatkov. Podatki agregirani na nivoju kvadranta.

Discussion

It is hard to trace the first occurrence of *B. davidii* in horticulture in the territory of modern-day Slovenia, but definitely as early as 1930 it was reported as escaping from cultivation at Lovrenc na Pohorju (NE Slovenia) (Fritsch 1933). This is obviously one of the first records on *B. davidii* escape from cultivation in entire Europe. Also in a wider European garden practice, the species had not been introduced before 1890 (Tallent-Halsell & Watt 2009), since it was discovered and described as a new species only slightly earlier. It is reported that in the territory of the present-day Czech Republic it appeared as an ornamental in 1911 (Skalicka 2000), and we have to bear in mind that in those times it was part of the Austro-Hungarian Empire that also included the bigger part of modern-day Slovenia (Krain, Untersteiermark, partly Küstenland). Lovrenc na Pohorju was part of Steiermark with Graz as its capital and one of the most important towns in Austria, so we can assume that *B. davidii* appeared in garden practice at approximately the same time as in Czechia, i.e. in the last few years before WW I. So the reported escapes from Lovrenc in 1930 might have been a result of less than 2 decades (!) of cultivation. These reported escapes were as old as the first assumed escapes in Great Britain (Tallent-Halsell & Watt 2009). Further records of escapes in Austria were reported for the town area of Salzburg (Janchen 1956), later Wien and Deutsch Altenburg (Janchen 1966).

In Slovenia, the occurrence at Lovrenc has not been confirmed after its first report. The old graveyard, from the walls of which the first escaped population was reported in 1930 (Fritsch 1933), had been abandoned and the area around the church changed. The new graveyard is situated about 300 m away, and despite the quite intense floristic activity around Lovrenc in the last few decades, the occurrence of *B. davidii* has not been confirmed. It is interesting to mention that in horticultural handbook from 1974 (Strgar in Hay & Synge 1974) it is explicitly stated that *B. davidii* shrubs are not well adapted to continental Slovenia as their shoots are destroyed by winter frost. Obviously the situation changed at least in the 1990s, probably due to new and better adapted cultivars.

The situation comparable to Slovenia and Austria is also in the neighbouring Friuli Venezia Giulia region (Italy), where in 1991 the presence of butterfly-bush was reported in 12 mapping units and only a decade later in 39 units covering more than half of the regional territory (Poldini 1991, 2002). And most probably we share with Friuli Venezia Giulia the oldest regional record and source of later spread of *B. davidii* that escaped from cultivation in Gorizia. This record is important for understanding its spreading in W Slovenia along the Soča river. C. Zirnich collected a butterfly-bush in 1945 beyond a public garden above the Koren stream in Gorizia (Italy, Mezzena 1986), which is just about a km from the Slovenian border and about 2 km from the localities in Solkan above the river Soča. It is interesting that the oldest herbarium record for this part of Italy mentioned by Poldini (2009) is 20 years younger: Trieste, M. Valerio 1965. In Slovenia, the oldest records with confirmed continuous presence of *B. davidii* are exactly from the Soča valley and also from Ljubljana in the first half of the 1990s (Turk 1988, Jogan & Podobnik 1995). From the area along the Soča valley, the first records came from natural or semi-natural habitat types on rocky limestone outcrops above the river and the river banks. In this part of Slovenia, *B. davidii* has obviously been spreading since then (and most probably already after 1945) and today its occurrence is reported from

Kluže at about 500 m a.s.l. to Solkan 400 m lower and about 70 km further to the south. Here, *B. davidii* has larger populations in some abandoned limestone/dolomite quarries or similar rocky localities with little vegetation cover.

The species' occurrence in dry ruderal localities in Ljubljana is similar to the situation in the oldest Austrian records from towns. *B. davidii* has been spontaneously spreading for 3 decades, and today about 20 localities are known (15 of them recorded during the floristic mapping of the Ljubljana Municipality in 2015; Jogan et al. 2015). Its occurrence in Ljubljana is mostly linked to dry ruderal places, especially open gravelly or pebbly areas at the abandoned building sites; no population has been recorded in semi-natural habitat types. The oldest occurrence of cultivated butterfly-bush in Ljubljana is not known, but as early as 1933 instructions for its maintenance were given by the chief city gardener A. Lap (»Pomladanska dela na vrtu«, Slovenski narod, 18. 3. 1933, p. 7).

In the last two decades, the number of recorded localities of *B. davidii* in Slovenia has been growing almost exponentially, and today its presence in more than 60 quadrants is known in all parts of Slovenia below 500 m a.s.l. Especially alarming are the results of systematic mapping of invasive alien plants in 100 randomly (!) chosen 1 km^2 squares that took place in 2012 and 2013 within the framework of Thuja 2 project (Jogan et al. 2013). Specifically, *B. davidii* was recorded in more than 20% of the mapping units, mostly as individual plants in dry ruderal places, but these localities can function as a stepping stone to rocky/gravelly habitat types in the vicinity. Particularly so, if we bear in mind the extreme spreading potential of *B. davidii* with enormous production of tiny seeds dispersed by wind.

Invasion of *B. davidii* populations in semi-natural rocky habitat types similar to the already mentioned situation along the Soča valley has been recorded especially in some abandoned dolomite quarries in the vicinity of Radeče (9956/2), Litija (Sava, 9955/1) and Zreče (Brinjeva gora, 9658/2), as well as in gravelly or pebbly river banks of the Drava, Sava and Mura rivers.

So when did *B. davidii* become invasive in Slovenia? Definitely not in 1930, and it is definitely invasive today. If we analyze records per decades, the number of new records and the number of completely new localities has unquestionably risen in the last decade, hence the switch to invasiveness must have occurred in the first decade of this century. So butterfly-bush occurrence in Slovenia can be interpreted as probably ephemeral in the first decades after the 1930s, then undoubtedly locally naturalized since 1990s (Jogan & Podobnik 1995), whereas about 20 years later it definitely became an invasive alien species quickly spreading into semi-natural habitat types and changed their structure/function. Today we can confirm its already recognized invasive status (Jogan et al. 2012) based on results presented herewith.

Povzetek

Metuljnik (*Buddleja davidii*) je po vsem svetu razširjena invazivna rastlina, ki izvira s Kitajske. Opisana je bila šele konec 19. stoletja in kmalu zatem se je kot okrasna rastlina pojavila v hortikulturi. Na evropske razmere je bila očitno dobro prilagojena, tako da o prvem podivjanem uspevanju poročajo že v 1930. letih, ko je bila zabeležena v Lovrencu na Pohorju in ponekod v Z Evropi. Pojavljanje v Lovrencu kasneje ni bilo potrjeno, s konca druge svetovne vojne pa je podatek o podivjanem uspevanju v bližini kasnejše Nove Gorice, kjer so naturalizirane populacije metuljnika še danes in prvič zanesljivo zabeležene že pred skoraj tremi desetletji. Danes ima metuljnik več popolnoma naturaliziranih populacij vse od Gorice do gornje doline Soče (trdnjava Kluže), pojavljajo pa se predvsem po skalovju in v opuščenih kamnolomih. Drugod po Sloveniji spremljamo pojavljanje posameznih rastlin raztreseno vse od 1990. let, kontinuirano je vrsta razširjena v Ljubljani, vendar brez podatkov o popolni naturalizaciji v naravnih rastiščih, na več mestih v vzhodnejših predelih Slovenije pa se poleg številnih razpršenih podatkov o morda še efemernem uspevanju vrsta z naturaliziranimi populacijami širi na območjih opuščenih kamnolomov (npr. pri Radečah, Zrečah, Litiji). V Sloveniji je do prehoda iz neškodljive naturaliziranosti v invazivnost prišlo šele nedavno, na podlagi zbranih podatkov lahko sklepamo, da po letu 2000, medtem ko predhodne faze postopnega prilagajanja lahko časovno umestimo nekako takole: od 1930. let dalje pojavljanje efemerno, v 1990. letih že lokalno naturalizirano in v zadnjem desetletju zanesljivo invazivno z več smermi širjenja v geografskem in ekološkem smislu. Za širjenje v (pol)naravne rastiščne razmere so primerni predvsem opuščeni kamnolomi in prodišča ter skalnata obrežja rek. Novi podatki, predstavljeni v članku, več kot podvojijo vednost o razširjenosti metuljnika v Sloveniji, primerjava treh predhodno objavljenih kompilacij podatkov o razširjenosti vrste v Sloveniji pa je pokazala, da vedno obstaja razkorak med trenutno zbranim in na zemljevidih razširjenosti upoštevanim znanjem. Glede na to lahko ocenimo, da je naturaliziranih populacij tudi danes v Sloveniji že precej več, kot nam jih je uspelo zabeležiti, kar zahteva tudi odgovorno ukrepanje.

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Changes in butterfly species richness (Lepidoptera: Papilionoidea) over two decades in the Koroška region, Northern Slovenia

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Abstract. Changes in butterfly fauna in the Koroška region in northeastern Slovenia have been compared over a period of 22 years. Records from 12 sampling sites from late July 2016 are compared with the same sites from late July/early August 1994. On average, 30% of species richness was lost per site, with a maximum loss of 80% at one site with complete habitat degradation. Records from 35 sampling sites from July 2016 are presented, including records of several rare habitat specialist species, such as *Lycaena dispar*, *Plebejus optilete*, *Boloria titania*, and *Phengaris arion*, the latter being of particular importance for conservation. All in all, habitat degradation has been confirmed to be the main driver of the loss of butterfly richness in the Koroška region.

Key words: species distribution, species richness, threatened species, habitat degradation

Izvleček. Spremembe v favni dnevnih metuljev (Lepidoptera: Papilionoidea) v dveh desetletjih na Koroškem, severna Slovenija – V članku primerjava podatke terenskih raziskav dnevnih metuljev na Koroškem med letoma 1994 in 2016. Povprečno se je število vrst metuljev na lokacijo zmanjšalo za 30 %, z največjo izgubo 80 % vrst na lokaciji s povsem degradiranim habitatom. Objavljava tudi vse podatke o pojavljanju dnevnih metuljev, zbranih na 35 lokacijah v drugi polovici julija 2016. Med njimi so tudi vrste habitatnih specialistov *Boloria titania*, *Phengaris arion* ter *Plebejus optilete*, izmed katerih po naravovarstveni vrednosti izstopajo najdbe *P. arion*. Glavni razlog za izgubo vrstne pestrosti dnevnih metuljev na Koroškem je degradacija habitatov.

Ključne besede: razširjenost vrst, pestrost vrst, ogrožene vrste, degradacija habitata

Introduction

Historical records and scientific reports of local species diversity are extremely valuable because they provide baseline data that can be used for the evaluation and preservation of biodiversity, which is the main goal of the Biodiversity Convention (UNEP 1992). Only a few historic and recent scientific works have focused on the species diversity of the butterfly fauna in the Koroška region, therefore, every additional contribution is very important in providing information that can help to protect and preserve its butterfly fauna and the species' habitats.

The landscape of the Koroška region is characterized by predominantly extensively farmed meadows and a patchy landscape of forests, mountains, and valleys (Senegačnik 2012), which contribute to high butterfly diversity. The butterfly fauna of the region is relatively well studied given the data included in the Atlas of Butterflies of Slovenia and its supplement (Verovnik et al. 2012, Čelik 2014). However, very little published information is available. The only overview covering the Koroška region dates back to 1983, when the butterfly fauna of the Podravje region was reviewed (Jež 1983). Important species distribution information is also available for the neighbouring part of Koroška in Austria (Thurner 1948, Hassler & Tschinder 1998). Two reports based on field work at the student research camps in 1994 and 1995 also added important new information on species distribution of the Koroška region (Verovnik 1995a, b). Most recently, a rigorous study of butterfly diversity of Mt Košenjak was published (Kadiš 2016).

Apart from general surveys of the butterfly fauna of the Koroška region, two cases of species extirpation in the region have been reported. The first concerns *Coenonympha tullia*, which was found in the Koroška region in 1962 (Lesar 1998) and at several additional sites in the 1990s (Verovnik et al. 2012). The species was last recorded in Koroška in 2001 and is considered locally extinct due to habitat degradation, including the overgrowing of wet meadows and drainage of mires (Čelik et al. 2005, Čelik 2012, Verovnik et al. 2012). The second case concerns *Colias myrmidone* (Esper, 1781), which was reported from several sites in the Koroška region up to 1989 (Predovnik & Verovnik 2004), but is now considered extinct in Slovenia (Verovnik et al. 2012). Both cases are examples of extreme effects of land use change on butterfly habitats.

Koroška also includes several important areas designated as Natura 2000 sites aimed at conserving qualifying butterfly species (Ur.l. RS 2004). Four qualifying species of butterflies have been observed in the Koroška region, i.e. *Colias myrmidone*, *Lycaena dispar*, *Euphydryas aurinia* and *E. maturna*. Already at the time when these areas were designated, the problem of intensive overgrowing and habitat deterioration was recognized as the main threat to the habitats of *Lycaena dispar* and *Euphydryas aurinia* in the area of Gornji Dolič and Razbor due to changes in land use (Čelik et al. 2005).

The main goal of this study is to compare the change of species richness in the Koroška region over the past 22 years. The basis of our comparison is a field survey report on the species richness of butterflies in the Koroška region from 1994, when 14 localities were visited at the end of July and beginning of August (Verovnik 1995a). A total of 61 species were observed during the survey, including some rare species associated with wet grasslands like

Lycaena dispar, *Phengaris teleius*, and *P. nausithous*. In order to implement a comparable survey of butterfly fauna in the region, we revisited 13 of the 14 previously surveyed localities in the second half of July 2016 during the Biology Students Society's (DŠB) research camp. By comparing 12 of the revisited sites, we wished to elucidate particularly the changes in butterfly richness, the loss of butterfly diversity in the region, and to provide comments on the causes of the decline.

Materials and methods

Butterflies were surveyed in the second half of July 2016. In total, 35 localities were visited; among them, 13 localities were revisited after 22 years (Fig. 1). The 22 new localities were selected based on known distribution records of rare and endangered butterfly species (Verovnik et al. 2012) and Google Earth satellite images where potentially extensive or partially overgrown grasslands, which could host a large number of butterfly species, were identified. Adult butterflies were captured using entomological nets and released after identification. For identification purposes, the field guide Butterflies of Britain and Europe (Tolman & Lewington 2008) was used.

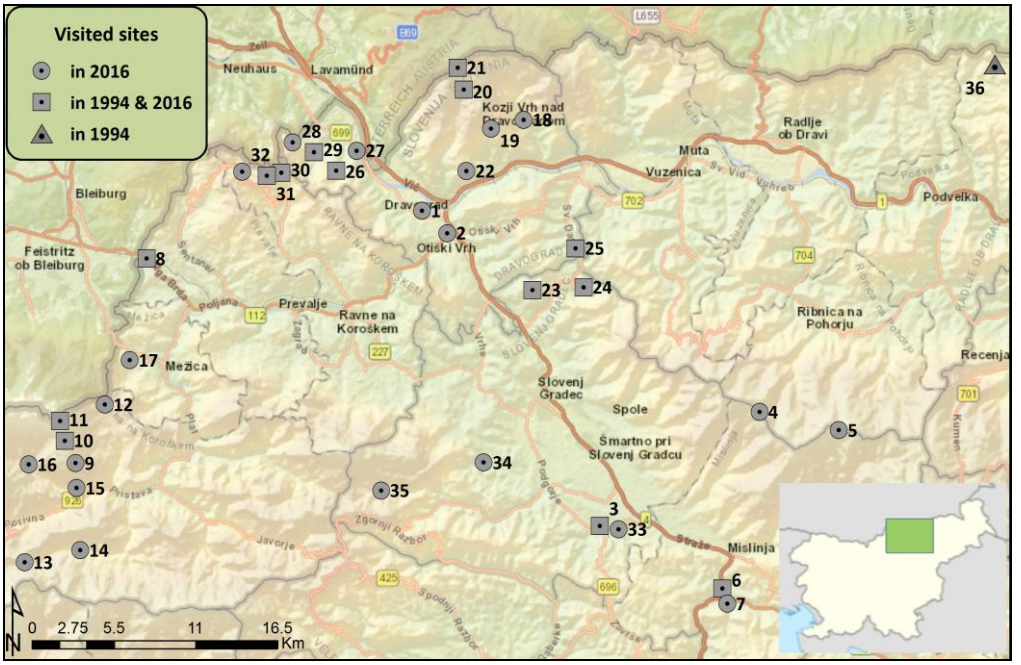

Figure 1. A map of locations in the Koroška region where butterflies were sampled. Circles indicate locations sampled exclusively in 2016, triangles in 1994, while squares denote locations sampled in 1994 and 2016.

Slika 1. Zemljevid prikazuje lokalitete, kjer smo vzorčili dnevne metulje na Koroškem. Krogi prikazujejo lokalitete, ki smo jih vzorčili samo v letu 2016, trikotniki v letu 1994, kvadrati pa lokalitete, ki smo jih vzorčili v obeh letih.

Sampling sites

The list of localities contains the relevant toponyms, a short description of the habitat, altitude, coordinates (WGS 1984), and dates of the visits. The locations in bold represent those that were also surveyed in 1994 and are included in the comparison herewith.

1. Dravograd, Dravski otok; bushes along the road, 350 m, 46°35'8.84"N 15°0'31.65"E, 18.7.2016, 22.7.2016.
2. Dravograd, at the roundabout in the direction of Ravne na Koroškem; intensively managed meadow, 340 m, 46°34'35.5"N 15°01'27.0"E, 18.7.2016.
3. **Podgorje, Šmiklavž**; wet meadow and intensive meadows, 470 m, 46°27'16.54"N 15°6'58.37"E, 18.7.2016.
4. Pohorje, at Grmovškov dom; extensively managed dry meadow, forest edge, 1370 m, 46°30'7.74"N 15°12'45.99"E, 18.7.2016.
5. Ribnica na Pohorju, Ribniški vrh and Ribniško jezero; extensively managed dry meadows, forest edge, and a bog, 1480 m, 46°29'40,41"N 15°15'38.38"E, 18.7.2016.
6. **Mislinja, Zgornji Dolič, west of the main Mislinja–Velenje road**; wet meadows and a fen, 540 m, 46°25'42.65"N 15°11'25.19"E, 18.7.2016.
7. Mislinja, Zgornji Dolič below the road to Zreče; overgrown fens, 540 m, 46°25'19.96"N 15°11'35.68"E, 18.7.2016.
8. Holmec, railway station; overgrowing meadow, intensively managed meadow, 510 m, 46°33'57.45"N 14°50'32.40"E, 19.7.2016.
9. Peca, below Planinski dom na Peci; path and clearings in coniferous forest, 1440 m, 46°28'50,87"N 14°47'58.32"E, 19.7.2016.
10. **Mala Peca, saddle**; partially abandoned pastures, forest edge, 1690 m, 46°29'24.61"N 14°47'34.54"E, 19.7.2016.
11. **Peca, trail to the Kordeževa glava peak**; alpine meadows mostly overgrown with Pinus mugo, 1880 m, 46°29'54.03"N 14°47'24.18"E, 19.7.2016.
12. Peca, Karavla; forest edge, 1030 m, 46°30'18.58"N 14°49'1.51"E, 19.7.2016.
13. Črna na Koroškem, Bistra, Kozja peč; rocky slopes in the gorge, 1080 m, 46°26'22.28"N 14°46'7.29"E, 20.7.2016
14. Črna na Koroškem, Bistra, Plaznik homestead; intensively managed meadow, 840 m, 46°26'40,45"N 14°48'8.57"E, 20.7.2016.
15. Črna na Koroškem, Topla, first part of the valley; rocky slopes, 750 m, 46°28'13.57"N 14°48'0,55"E, 20.7.2016.
16. Črna na Koroškem, Topla, Fajmut homestead; intensively managed meadow, 940 m, 46°28'49.04"N 14°46'15.99"E, 20.7.201626.
17. Mežica, at the Sušec stream; wet meadow, 640 m, 46°31'25.28"N 14°49'56.36"E, 20.7.2016.
18. Dravograd, upper part of the Velka stream valley; dirt road with stream and bushes in the forest, 600 m, 46°37'25.04"N 15° 4'12.97"E, 21.7.2016.
19. Dravograd, Sveti Duh, under homestead; extensive mesophilic meadow, 900 m, 46°37'11.97"N 15° 3'2.07"E, 21.7.2016.
20. **Dravograd, Košenjak, below the mountain hut**; extensive humid grasslands, pastures, 1190 m, 46°38'10,20"N 15° 2'2.31"E, 21.7.2016.
21. **Dravograd, Košenjak, top of the mountain**; extensive dry subalpine meadow, 1510 m, 46°38'42.83"N 15° 1'49.20"E, 21.7.2016.

22. Dravograd, Ojstrica; extensive dry meadow, rocky slope, 680 m, 46°36'8.29"N 15°2'8.54"E, 21.7.2016.
23. **Pameče, Anski vrh**; intensively managed meadow, 750 m, 46°33'10,24"N 15° 4'31.65"E, 21.7.2016.
24. **Pameče, Jesenk**; meadows overgrown by bushes and intensively managed meadows, 640 m, 46°33'14.25"N 15° 6'23.14"E, 21.7.2016.
25. **Trbonje, Reka stream valley**; intensively managed meadow, forest edge, 430 m, 46°34'12.78"N 15° 6'6.02"E, 21.7.2016.
26. **Črneče, Črneška gora**; intensively managed meadow, 690 m, 46°36'8.95"N 14°57'25.12"E, 22.7.2016.
27. Črneče, Rener homestead; extensive dry meadow, 360 m, 46°36'38.68"N 14°58'9.82"E, 22.7.2016.
28. Libeliče, Flori homestead; dry meadow, 770 m, 46°36'51.31"N 14°55'50,53"E, 22.7.2016.
29. **Libeliče, Libeliška gora**; dry meadow, forest edge, 560 m, 46°36'36.66"N 14°56'36.64"E, 22.7.2016.
30. **Prevalje, Strojna, Janeš homestead**; dry meadow, 960 m, 46°36'5.81"N 14°55'25.83"E, 22.7.2016.
31. **Prevalje, Strojna, at the school**; dry meadow and pastures, 1010 m, 46°36'1.25"N 14°54'54.33"E, 22.7.2016.
32. Prevalje, Strojna, Smrečnik homestead; wet meadow and forest edge, 880 m, 46°36'7.36"N 14°54'0.34"E, 22.7.2016.
33. Slovenj Gradec, Šmiklavž, Jenina; intensively managed wet meadow, 480 m, 46°27'11.86"N 15°7'39.57"E, 24.7.2016.
34. Raduše, valley under Smrčun homestead, west from the village; wet meadow and forest road, 500 m, 46°28'51.85"N 15°2'46.06"E, 24.7.2016.
35. Slovenj Gradec, Podgorje, Plešivčnikov mlin; partially overgrown wet meadows, 860 m, 46°28'9.91"N 14°59'3.01"E, 24.7.2016.
36. Remšnik, Potočnikov potok; wet meadows and thermophilic slope, 650 m, 46°38'47.6"N 15°21'17.8"E, 1.8.1994 (Verovnik 1995a).

The data distributions from the two years were tested for normality using Q-Q plot and Shapiro-Wilks test, and for homogeneity of variances with Levene's test. The data was then compared using the Student's Paired t-test. The mean values and standard errors were plotted. Comparisons were performed using R statistical software (R Core Team 2015).

Results

Species lists from 1994 and 2016

A total of 70 butterfly species were recorded at the 35 sampled locations in the Koroška region during the 2016 surveys (Tab. 1). In 1994, 61 species were observed at 14 sampled locations (Tab. 1). Overall, there are 11 species that were recorded during the first survey, but were not observed again in 2016 (Tab 1.). On the other hand, 21 species that were recorded in 2016 had not been observed in 1994 (Tab. 1).

Table 1. List of butterflies recorded during survey in the Koroška region in 2016 with a comparison to the 1994 survey. The nomenclature follows the European Red list of Butterflies (Van Swaay et al. 2010) with some modifications. The numbering of locations is the same as in the list of the locations. An »x« marks the species that were not found in the corresponding sampling session.

Tabela 1. Seznam dnevnih metuljev, opaženih med terenskim delom na Koroškem v letu 2016, ter primerjava s popisom iz leta 1994. Poimenovanje je povzeto po European Red List of Butterflies (Van Swaay et al. 2010) z nekaterimi modifikacijami. Številčenje lokacij je enako kot v seznamu lokacij. »x« označuje vrste, ki v posameznem letu vzorčenja niso bile najdene.

Taxon	No. of location in 2016	No. of location in 1994
Papilionidae		
Papilio machaon Linnaeus, 1758	9, **10**, **29**	6, 23, 30, 31
Iphiclides podalirius (Linnaeus, 1758)	**23**	6, 29, 30, 31
Pieridae		
Pieris brassicae (Linnaeus, 1758)	7, 18, 27, 28, **29**, **30**, 32	6, 10, 21, 26, 29
Pieris rapae (Linnaeus, 1758)	1, **6**, 8, **10**, **24**, 27, **30**	6, 10, 11, 20, 23, 24, 26, 29, 32
Pieris bryoniae (Hübner, 1805)	9, **11**	10, 11, 26
Pieris napi (Linnaeus, 1758)	8, 19, **20**, 22, **26**, 28, **30**, 32	3, 23, 24, 25, 26, 29, 36
Anthocharis cardamines (Linnaeus, 1758)	9	x
Colias crocea (Geoffroy, 1785)	1, **3**, 7, 8, **24**, **29**, **31**	3, 6, 10, 11, 20, 21, 23, 24, 25, 29, 30, 31
Colias hyale (Linnaeus, 1758)	7	x
Gonepteryx rhamni (Linnaeus, 1758)	5, 7, 9, **10**, **11**, 13, 16, 17, 18, **21**, **29**, **30**, **31**, 32, 33, 34	6, 10, 20, 23
Leptidea sinapis/juvernica	7, 15, 18, **23**, **24**, 27, **30**, 34	6, 10, 20, 24, 25, 26, 29
Lycaenidae		
Satyrium spini (Denis & Schiffermüller, 1775)	9, 13	x
Lycaena phleas (Linnaeus, 1761)	8, 16, 22, **29**, **31**, 32	29
Lycaena dispar (Haworth, 1802)	8	25
Lycaena virgaureae (Linnaeus, 1758)	13, 15, 16, 28, **29**, **30**, **31**	10, 20, 24, 26, 29, 30, 31
Lycaena tityrus (Poda, 1761)	8, 27, **29**	23, 29
Lycaena alciphron (Rottemburg, 1775)	**29**	x
Lycaena hippothoe (Linnaeus, 1761)	4, **10**	3, 10
Celastrina argiolus (Linnaeus, 1758)	1	26, 29
Cupido argiades (Pallas, 1771)	8, **29**	x
Cupido minimus (Fuessly, 1775)	7, **30**	6

Taxon	No. of location in 2016	No. of location in 1994
Glaucopsyche alexis (Poda, 1761)	x	10
Phengaris arion (Linnaeus, 1758)	19, 22, **29**, **31**	x
Phengaris nausithous (Bergsträsser, 1779)	x	8
Phengaris teleius (Bergsträsser, 1779)	x	8
Plebejus optilete (Knoch, 1781)	4, 5	x
Plebejus argus (Linnaeus, 1758)	8, **24**, **29**, 34	6, 29
Plebejus idas (Linnaeus, 1761)	22	x
Aricia agestis (Dennis & Schiffermüller, 1775)	x	29
Cyaniris semiargus (Rottemburg, 1775)	4, 9, **10**, **11**	x
Polyommatus dorylas (Dennis & Schiffermüller, 1775)	x	29
Polyommatus amandus (Schneider, 1792)	5	x
Polyommatus bellargus (Rottemburg, 1775)	35	x
Polyommatus icarus (Rottemburg, 1775)	1, **3**, **6**, 7, 14, **23**, **26**, 27, **30**	23, 25, 29, 30, 31
Nymphalidae		
Apatura iris (Linnaeus, 1758)	32	20, 25, 30, 31
Limenitis populi (Linnaeus, 1758)	1, 15, 16	x
Neptis rivularis (Scopoli, 1763)	13, 18, **24**, 32	x
Nymphalis polychloros (Linnaeus, 1758)	**20**	x
Nymphalis antiopa (Linnaeus, 1758)	**31**, **32**	10, 21, 29
Aglais io (Linnaeus, 1758)	**3**, 4, 5, 7, 9, **10**, **11**, 13, 17, **20**	6, 10, 11, 20, 21, 26
Aglais urticae (Linnaeus, 1758)	4, 5, 9, **10**, **11**, 13, 19, 28	10, 11, 20, 21, 25, 30, 31
Vanessa atalanta (Linnaeus, 1758)	**3**, 4, 5, 7, 9, **10**, 17, 18, **20**, **23**, **26**, **30**, 32, 35	3, 6, 10, 11, 20, 21, 26, 29
Vanessa cardui (Linnaeus, 1758)	4, 5, 8, 9, **10**, 14, 16, 17, **20**, **21**, **26**, 28	3, 10, 11, 20, 21, 23, 25, 30, 31
Araschnia levana (Linnaeus, 1758)	7, 8, 18, 19, **25**, **26**, **29**, 35	x
Polygonia c-album (Linnaeus, 1758)	9, 18, **20**	10, 20, 23, 24, 25, 26
Issoria lathonia (Linnaeus, 1758)	**21**	10, 20, 21, 23, 30, 31
Argynnis paphia (Linnaeus, 1758)	9, 13, 14, 15, 17, **20**, 34, 35	6, 10, 23, 24, 26, 29
Argynnis aglaja (Linnaeus, 1758)	4, **10**, **11**, 12, 16, **20**, **21**, 22, **25**, **30**, **31**, 32	10, 20, 21, 23, 25, 26, 29, 30, 31

Taxon	No. of location in 2016	No. of location in 1994
Argynnis niobe (Linnaeus, 1758)	**10**, 19	10, 29
Brenthis daphne (Bergsträsser, 1780)	**20**	x
Brenthis ino (Rottemburg, 1775)	3, 8, 17	x
Boloria titania (Esper, 1793)	9	10
Boloria euphrosyne (Linnaeus, 1758)	9	x
Boloria selene (Denis & Schiffermüller, 1775)	7	6
Boloria dia (Linnaeus, 1767)	x	20, 23
Melitaea diamina (Lang, 1789)	14	x
Melitaea didyma (Esper, 1778)	x	23, 25
Melitaea athalia (Rottemburg, 1775)	4, 5, **21**, 28, **30**, **31**, 32	10, 21, 29
Melitaea aurelia Nickerl, 1850	**21**	36
Melanargia galathea (Linnaeus, 1758)	7, 8, 9, 12, 17, 18, 19, **20**, 22, **23**, **26**, 27, 28, **29**, **30**, **31**, 32, 34, 35	6, 10, 20, 21, 23, 25, 26, 29, 30, 31
Minois dryas (Scopoli, 1763)	2, 34	23, 25
Brintesia circe (Fabricius, 1775)	x	24, 26
Erebia ligea (Linnaeus, 1758)	9, **20**	36
Erebia euryale (Esper, 1805)	4, 9, **20**, **21**, 35	10, 11, 20, 21
Erebia aethiops (Esper, 1777)	x	6, 11, 26
Erebia medusa (Denis & Schiffermüller, 1775)	**10**	x
Erebia stiria (Godart, 1824)	13	10
Maniola jurtina (Linnaeus, 1758)	**3**, 7, 8, 12, 13, 14, 16, 17, 18, 19, 22, **23**, **24**, **25**, **26**, 27, 28, **29**, **30**, **31**, 32, 33, 34, 35	3, 6, 10, 20, 21, 23, 24, 25, 26, 30, 31
Aphantopus hyperantus (Linnaeus, 1758)	**3**, 8, 18, **20**, **26**, **29**, **30**, **31**, 32, 33	20, 25, 26, 29
Coenonympha arcania (Linnaeus, 1761)	4, 9, 13, **20**	10,
Coenonympha glycerion (Borkhausen, 1788)	8	23
Coenonympha pamphilus (Linnaeus, 1758)	**3**, 7, 8, **24**, **26**, 28, **29**, **30**	3, 6, 30, 23, 24, 25, 26, 30, 31
Pararge aegeria (Linnaeus, 1758)	9	6, 25, 26
Lasiommata megera (Linnaeus, 1767)	x	21, 23, 29, 30, 31
Lassiommata petropolitana (Fabricius, 1787)	x	10
Lasiommata maera (Linnaeus, 1758)	9, **10**, **11**, 13, **20**, **21**	x

Taxon	No. of location in 2016	No. of location in 1994
Hesperiidae		
Erynnis tages (Linnaeus, 1758)	**6**, 8, 9, **29**	3, 6, 23, 25, 29
Thymelicus lineola (Ochsenheimer, 1808)	**3**, 4, 7, 12, 16, 17, 19, **20**, **21**, 22, **24**, **25**, 27, 28, **30**, **31**, 35	26, 29, 30, 31
Thymelicus sylvestris (Poda, 1761)	9, 16, **24**	6, 20, 24, 29, 31
*Hesperia comma (*Linnaeus, 1758)	8	6, 23, 24, 25, 29, 30, 31
Ochlodes sylvanus (Esper, 1777)	**6**, 9, 12, 13, 15, 16, 17, **29**, 32, 35	25, 26

Comparison of the two surveys

Twelve locations were sampled in both years, which enabled us to prepare a complete list of the species observed and to make their direct comparisons (excluding locations 8 and 36, which were only partially sampled in 1994). In 1994, 57 species had been observed at these locations and 48 in 2016. Therefore, in total, nine species fewer were observed in 2016, marking a 16% decline. Looking at the species, 18 of those observed in 1994 were not seen at these same locations in 2016. On the other hand, 10 new species were observed in 2016.

The mean value of the number of species per site was 18.3 in 1994 and 12.8 in 2016 (Tab. 2). Therefore, the calculated mean number of the species detected per site in 2016 is by 30% lower than in 1994. The difference between the means is significant when tested with the Student's Paired t-test (t=2.088; p=0.017), at a confidence interval of 95% (Fig. 2). When looking at the locations, nine out of 12 of the compared locations had lower species richness in 2016 (Tab. 2).

Table 2. Comparison of butterfly species richness in the Koroška region between 1994 and 2016 at 12 locations, with the change in species richness indicated by the colour code (green – increase, orange – minor decrease of up to 5 species, red – decrease by more than 5 species). The locations are numbered as in the list of sampling sites.
Tabela 2. Primerjava pestrosti vrst dnevnih metuljev na 12 lokacijah na Koroškem v letih 1994 in 2016 z navedenimi spremembami številčnosti, prikazanimi z barvno lestvico (zeleno – povečanje št. vrst, oranžno – manjše zmanjšanje št. vrst do 5, rdeče – zmanjšanje št. vrst za več kot 5). Lokacije so oštevilčene tako kot v seznamu lokacij.

Location	3	6	10	11	20	21	23	24	25	26	29	30, 31
No. 1994	8	20	27	9	19	14	22	12	20	21	29	18
No. 2016	9	18	28	7	17	10	6	9	4	9	17	20
Difference	**+1**	**-2**	**+1**	**-2**	**-2**	**-4**	**-16**	**-3**	**-16**	**-12**	**-12**	**+2**

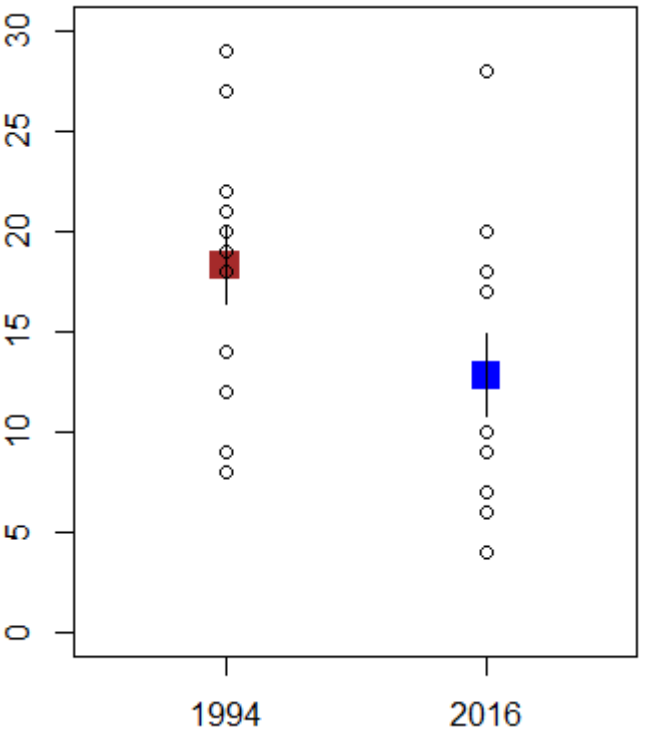

Figure 2. Comparison of butterfly species richness mean values per sampled location between 1994 and 2016. The squares indicate the mean value in each year. The lines denote standard error for the given mean value. The empty circles indicate the number of observed species at each location.

Slika 2. Primerjava srednjih vrednosti števila vrst dnevnih metuljev glede na lokacijo med letoma 1994 in 2016. Kvadrata prikazujeta srednjo vrednost vrst v posameznem letu. Liniji označujeta standardno napako vsake srednje vrednosti. Točke ponazarjajo število opaženih vrst na posamezni lokaciji.

Discussion

At first glance, the total number of species observed in 2016 (70) surpasses the number of species in 1994 (61). However, not all of the locations from the surveys can be directly compared as the 2016 survey involved more than twice as many sites and a larger area. When only the sites surveyed in both years are compared, a 16% decline in richness is evident in 2016. Additionally, several species not recorded in 1994 are the result of a partial mismatch in the timing of both surveys and potential seasonal differences as several species typically flying in spring, such as *Anthocharis cardamines*, *Brenthis ino*, *Boloria euphrosyne*, and *Erebia medusa*, were observed only in 2016. The absence of species not recorded in 2016 could, however, not be interpreted by their phenology. According to the implemented statistical test, the negative change in species richness is significant for the analyzed sites. The loss of more

than six species on average per site is alarming as it is equal to 30% fewer species observed (Fig. 2). The four sites with the most drastic declines (Tab. 2) have been transformed from flower rich meadows to intensive grasslands, supporting a much lower number of butterfly species, which are mostly habitat generalists (Dolek & Geyer 1997, Van Swaay et al. 2016).

The loss of wet meadows is evident in the entire Koroška region (authors' pers. observ.). None of the aforementioned wet grassland specialists, including *Phengaris teleius*, and *P. nausithous* were observed during the 2016 survey (Tab. 1). *P. alcon* was not found at a historically known location (location 33) (Verovnik et. al. 2012). Even their larval host plants were missing from those sites. These wet grassland specialist butterfly species disappeared from the Koroška region before 2010 (Verovnik et al. 2012, Verovnik pers. observ.). Another species associated to wet grasslands was observed after a long absence: *L. dispar* was found again at a new site close to the border crossing Holmec at location 8 in 2016 (Tab. 1). In remaining fragments of wet meadows and fens, we found only *Melitaea diamina*, *Brenthis ino*, and *Boloria selene*, which are generally not exclusively linked to wetland habitat types in Slovenia (Verovnik et al. 2012). All visited sites where the three mentioned species had been found in the past were in different stages of overgrowing with tall herbs, bushes, and trees, hence unsuitable for other specialist butterfly species.

The most encouraging finding of the surveys in 2016 is the observation of *Phengaris arion* at several sites on Mt Strojna and Mt Košenjak. The species is limited to extensively managed dry grasslands with an abundance of thyme (*Thymus* spp.) or origanum (*Origanum vulgare*) and is considered vulnerable (VU) in Slovenia (Ur. l. RS 2002). It has been historically recorded from only two locations in the Koroška region (Verovnik et al. 2012) until several colonies were discovered on Mt Košenjak in 2009 (Kadiš 2016). In 2016, we confirmed its presence on Mt Košenjak, and made new sightings on Mt Strojna. Only single specimens were observed at all sites, however, *P. arion* is generally known to occur in low densities (Mouquet et al 2005). Additional interesting records of specialists are: *Boloria titania*, which was observed on Mt Peca at 1440 m, within the main altitudinal belt of its distribution in Slovenia (Verovnik et al. 2012), *Plebejus optilete*, found again within its range in the western part of Pohorje Mts (Jež & Verovnik 2012), and *Erebia stiria*, which was found at Kozja peč in Bistra valley on screes and rocky slopes, a typical habitat of the species in Slovenia (Jutzeler et al. 2001).

Several locations visited during the 2016 survey are located within Natura 2000 sites (Ur.l. RS 2004): Grintovci (ID: SI5000024, locations 9, 10, 11, 15, 16), Huda luknja (ID: SI3000224, locations 6, 7), Peca (ID: SI3000132, locations 9, 10), Pohorje (ID: SI3000270, locations 4, 5), Razbor (ID: SI3000166, locations 34, 35), and Zahodni Kozjak (ID: SI3000337, locations 18, 19). Huda luknja and Razbor are listed as areas where *L. dispar* is present (Ur. l. RS 2004), however, the habitats formally suitable for *L. dispar* are currently almost completely overgrown with trees and bushes and the presence of the species could not be confirmed at either site. *Colias myrmidone* is a qualifying species in the Pohorje Natura 2000 area, but is considered extinct in Slovenia (Verovnik et al. 2012). The presence of both *Euphydryas* species could not be verified during our surveys, as they fly earlier in the season. The goal of the Natura 2000 sites, to preserve and, at best, improve the quality of the protected species' habitats (Ur. l. RS 2004), has not yet been met in the Koroška region.

Even more disappointingly, drastic negative habitat changes are evident in the last decades and are ongoing in many areas included in this study (authors' pers. observ.). Although there is sufficient legislative support for the conservation of threatened butterfly species and their habitats in Slovenia, the implementation is completely lacking and the negative processes of either abandonment or intensification continue. We fear that without the engagement of landowners, local communities, and authorities, coupled with regular monitoring, we will be faced with continuous erosion of butterfly species richness in the Koroška region. To halt this negative trend, the appropriate funding by the state and development of nature oriented tourism will be of great importance—the sooner the better!

Povzetek

V članku primerjamo podatke terenskih raziskav dnevnih metuljev na Koroškem med letoma 1994 in 2016. V letu 2016 smo ponovno vzorčili 13 lokalitet, katerih podatki so predstavljeni v poročilu terenskega dela iz leta 1994 (Sl. 1). Primerjali smo 12 lokalitet, za katere imamo kompletne podatke o favni metuljev v obeh letih. Dodatno smo obiskali še 22 drugih lokalitet (Sl. 1) in pripravili pregled razširjenosti vrst (Tab. 1) na Koroškem v drugi polovici julija.

Iz rezultatov je razviden upad skupne pestrosti vrst na primerjanih lokacijah za 16 %, ter kar za 30 % manjše povprečno število opaženih vrst, ko primerjamo stanje na posamezni lokaciji. Povprečno znižanje vrst med dvema letoma je tudi statistično značilno glede na Student's paired t-test.

Razlika v srednji vrednosti števila vrst glede na lokaliteto med obema letoma je več kot šest vrst (Sl. 2). Največje razlike so bile opažene med habitati, na katerih se je raba travnika intenzivirala oz. se habitat intenzivno zarašča. Na teh lokacijah se je število vrst znižalo tudi do 80 %. Poleg tega v letu 2016 nismo našli dveh vrst, vezanih na mokrotne travnike (*Phengaris teleius*, *P. nausithous*), kar je dodatni kazalec izgube mokrotnih travnikov na Koroškem. Nadaljnje uničenje travnikov in povirij po eni strani ter intenzivno zaraščanje po drugi, bosta v prihodnje privedla tudi do poslabšanja stanja drugih specializiranih vrst, ki nam jih je v letu 2016 še uspelo potrditi (*Melitaea diamina*, *Brethis ino*, *Boloria selene*).

Kljub vsemu je najdba 70 vrst dnevnih metuljev v drugi polovici julija na območju Koroške v letu 2016 spodbudna, še posebej pa dajejo upanje nove najdbe *Phengaris arion* na dveh lokalitetah na ovršju Strojne. Ekstenzivna raba travnikov na tem območju omogoča rast materine dušice (*Thymus* spp.), hranilne rastline tega metulja. Gledano v celoti je stanje predvsem mokrotnih travnikov na Koroškem kritično, saj kljub vzpostavitvi območij Natura 2000, ki naj bi ščitila kvalifikacijske vrste dnevnih metuljev (*Lycaena dispar*) in njihovih habitatov, ti pospešeno izginjajo, kar bo prispevalo k nadaljevanju erozije vrstne pestrosti metuljev na Koroškem.

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The current distribution of pond slider *Trachemys scripta* (Reptilia: Emydidae) in Croatia

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Abstract. The pond slider *Trachemy scripta* was one of the most commonly exported turtles until the last decade and often released into the wild outside its native range. It was introduced to Europe, Africa, South America and Asia and included on the EU list of 100 World's Worst Invasive Alien Species and the List of invasive alien species of Union concern. The import of the subspecies *Trachemys scripta elegans* into Europe and Croatia has been banned for some time, but the number of specimens recorded in nature is still increasing. In this paper we present 45 new localities were the species was observed in Croatia, which makes a total of 84 known localities. Most of the records, 58%, are in the Continental biogeographical region and the rest in the Mediterranean. It has not yet been recorded for the Alpine biogeographical region. Most records (42%) come from ponds. Three new sightings of females digging nests, laying eggs and sightings of hatchlings were recorded, suggesting successful reproduction of the species. Further surveys of this alien species in Croatia are needed.

Key words: invasive species, terrapin, Emydidae, Reptilia

Izvleček. Razširjenost gizdave želve *Trachemys scripta* (Reptilia: Emydidae) na Hrvaškem – Gizdava želva *Trachemy scripta* je bila v zadnjem desetletju ena izmed najpogosteje izvoženih želv iz Amerike in s strani lastnikov pogosto izpuščena v naravno okolje zunaj njene naravne razširjenosti. Vnesena je bila v Evropo, Afriko, Južno Ameriko in Azijo. Vključena je na Seznam 100 najinvazivnejših tujerodnih vrst sveta in Seznam invazivnih tujerodnih vrst Evropske unije. Uvoz podvrste rdečevratke *Trachemys scripta elegans* je bil v Evropo in Hrvaško prepovedan, vendar se kljub temu število zabeleženih primerkov v naravi povečuje. V prispevku predstavljamo 45 novih lokalitet, kjer je bila vrsta opažena. Skupno je tako za Hrvaško znanih 84 lokalitet o pojavljanju te vrste. Največ najdb (58 %) je iz kontinentalne geografske regije, preostanek pa iz mediteranske. V alpski geografski regiji vrsta še ni bila potrjena. Večina najdb oz. opazovanj (42 %) je z ribnikov. Poročamo tudi o treh novih opažanjih izvaljenih mladičev ter samic, ki kopljejo gnezdo in odlagajo jajca. Potrebne so nadaljnje raziskave o tej tujerodni invazivni vrsti na Hrvaškem.

Ključne besede: invazivne vrste, želve, Emydidae, Reptilia

Introduction

Invasive species threaten biodiversity and related ecosystem services (Kikillus et al. 2010) and can negatively affect native species through predation, competition and transmission of pathogens (Ficetola et al. 2009). One of the most common invasive species also included on the list of 100 of the World's Worst Invasive Alien Species (Lowe et al. 2000) is the pond slider turtle *Trachemys scripta* (Thunberg & Schoepff, 1792). It is native to Eastern, Northern and Central America (Ficetola et al. 2009). The three subspecies of pond sliders *T. scripta scripta* (Schoepff, 1792), *T. scripta elegans* (Wied, 1838) and *T. scripta troostii* (Holbrook, 1836) were probably the most commonly traded reptiles in the world up until the last decade (Ficetola et al. 2012). This species has been farmed in large quantities in the southern USA for the last several decades, partially for the global pet trade and partially as food for Asian markets (van Dijk et al. 2017). Pond sliders were very popular owing to their small size, low price and simple requirements (Teillac-Deschamps et al. 2008). Small turtles bought in the pet shops outgrow their enclosures after several years and are usually released into the wild by their owners (Cadi & Joly 2003). In 1975, turtle trade was banned in the USA due to salmonellosis (Williams 2016), after which the baby turtles were sent to markets in Europe and Asia (Cadi & Joly 2003). An estimated 52 million specimens of *T. s. elegans* were exported from the USA to international markets between 1989 and 1997 (Telecky 2001, Cadi et al. 2004, Scalera 2006). Today, the pond slider is introduced in Europe, Africa, South America and Asia (Cadi et al. 2004). The import of the subspecies *T. s. elegans* has been banned in the European Union from 1997 via the Protection of Species of Wild Fauna and Flora by Regulating Trade (Anonymous 1997) due to their invasive character and impact on native species (Anonymous 2014). In 2016, *T. scripta* was included on the list of invasive alien species that are of concern in the European Union (Anonymous 2016), which means that concrete action at the Union level is required to prevent their introduction, establishment or spread.

Trachemys scripta has been introduced into the Balkan Peninsula probably around the 1970's (Džukić & Kalezić 2004). It is known from several countries in the Balkans, e.g. Slovenia (Krofel et al. 2009, Vamberger et al. 2012), Bosnia and Herzegovina (Jelić & Jelić 2015), Serbia (Scalera 2006, Urošević et al. 2016), Montenegro (Žagar et al. 2013), Bulgaria (Tzankov et al. 2015), and Greece (Scalera 2006, van Dijk et al. 2011). Most records are from urban and peri-urban areas of larger cities (Scalera 2006, Tzankov et al. 2015), while illegal import is still a problem in some areas (Tzankov et al. 2015). Successful reproduction in the wild is known from Slovenia (Vamberger et al. 2012). Today, two subspecies are widely distributed in Croatia: *T. s. elegans* and *T. s. scripta*. According to Jelić & Jelić (2015), 39 recorded sites of *T. scripta* are reported for Croatia. The goal of this paper is to summarize all available knowledge about the current range and reproduction of *T. scripta* subspecies in Croatia.

Materials and methods

To assess the current range of the slider turtle in Croatia, all available knowledge about its occurrence, referring to the period between 1999 and 2017 was gathered, including data from published literature, field surveys, as well as the verified records from the public sent to us by social media. Recent field survey data includes both random findings and targeted surveys for the slider and general amphibians and reptiles inventories carried out through approximately 350 days in the field. Water bodies both in/nearby cities and those further away from urban areas were checked. All data refer to the period between 1999 and 2017. The distribution map based on the dataset was made in ArcMap (v. 10.2.2, ESRI), in the WGS84 coordinate system. Based on unique localities, the tentative habitat preference and the affiliation to a particular biogeographical region were calculated.

Results and discussion

During this survey, *T. scripta* was observed on 44 new localities (Appendix 1), which in addition to the previous knowledge about its distribution (Jelić & Jelić 2015, Schweiger 2015) amounts to a total of 84 localities within Croatia (Figs. 1, 2). In respect to the biogeographical regions, most localities belong to the Continental biogeographical region, i.e. 49 localities (58%), followed by the Mediterranean region, i.e. 35 (42%). No records of this species are known from the Alpine biogeographical region in Croatia. This is probably due to the much lower number of inhabitants per square kilometre (Nejašmić 2000), corresponding to a very limited number of pet shops both now and in the past few decades.

In the Continental biogeographical region, *T. scripta* is present in the lowlands, including lakes, streams and ponds. The highest altitude where it was observed is in a lake 350 meters above sea level. In the Mediterranean biogeographical region, it is present both on the mainland and the Adriatic islands. The highest record concerns the mainland in a pond 475 meters above sea level. While during the first overview of the species distribution in the country (Jelić & Jelić 2015) the species was recorded only on the islands of Krk, Pag and Vir, our records show that it is present also on Veli Brijun, Dugi Otok, Šolta and Korčula. It is hard to say whether these records represent new releases in the last few years or were overlooked during the previous surveys in the country. However, it is probable that the species is present also on other Adriatic islands containing suitable wetland habitats.

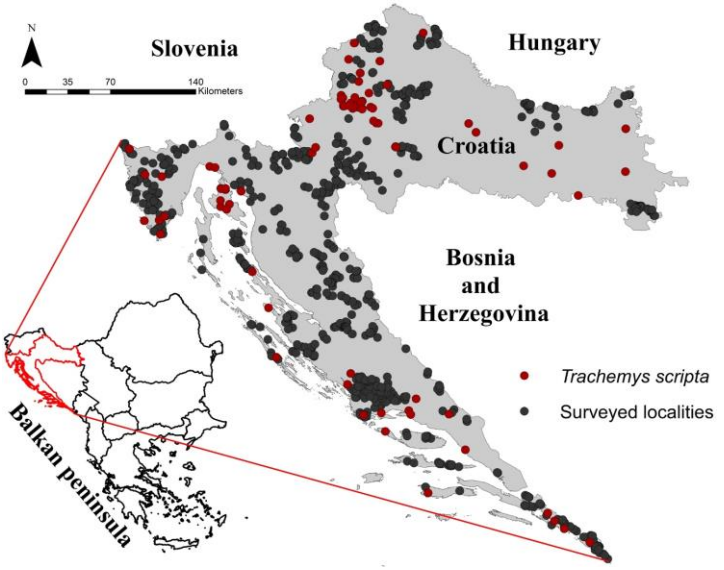

Figure 1. Map with all visited localities and those at which the presence of *Trachemys scripta* was confirmed.
Slika 1. Zemljevid z vsemi obiskanimi lokalitetami in tistimi, na katerih je vrsta *Trachemys scripta* potrjena.

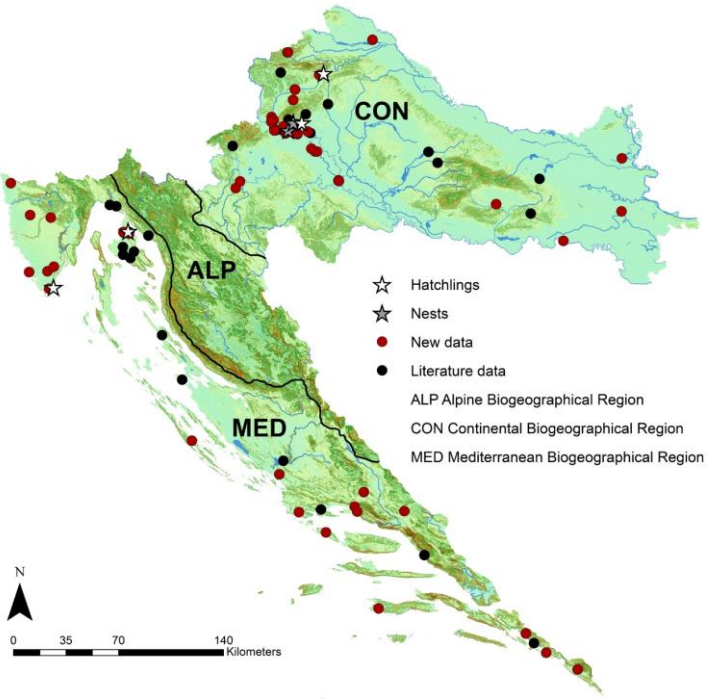

Figure 2. Map with new and previously published localities of *Trachemys scripta* in different biogeographical regions of Croatia.
Slika 2. Zemljevid z novimi in že objavljenimi lokalitetami vrste *Trachemys scripta* v različnih biogeografskih regijah Hrvaške.

Most specimens were observed in ponds, 35 (42%), followed by lakes, 23 (27%), streams, 12 (14%), rivers, 7 (8%), fountains, 5 (6%), and channels 2 (2%). Specimens are often visible in the ponds, floating and basking in the sun, or sometimes even actively swimming towards the observer, expecting to be fed. This corresponds to the data elsewhere from Europe, where *T. scripta* are generally released in freshwater areas, which are frequented by humans, such as public ponds and other natural habitats close to urban areas (Bringsøe 2006). 72% of the localities with pond sliders in Croatia and Bosnia and Herzegovina are 15 km or less away from the cities that have more than 10,000 inhabitants (Jelić & Jelić 2015). *Trachemys scripta* has a total range of about 2–3 km, therefore their presence in the isolated ponds, e.g. more than several kilometres apart, especially in the Mediterranean part of the country, somewhat limits their propagation potential, and the potential for spreading to different habitats (Ryan et al. 2008). On the other hand, specimens released in streams and rivers are most likely to be unnoticed during surveys and are expected to spread and colonize new habitats since their reproduction is predicted to be successful due to similar climate like in Slovenia (Zaninović 2008).

The aquatic habitats in which *T. scripta* was recorded during this study do not necessarily indicate the species' real habitat preference, but they may indicate the habitats on which the individuals can successfully overwinter, due to its adaptability (Cadi & Joly 2004), and as such, they are crucial for further surveys of this species in the country.

Not all *T. srcipta* populations are reproductively active. So far, successful reproduction in Europe has been reported from Spain (De Roa & Roig 1997, Martínez-Silvestre 1997, Pleguezuelos 2002, Perez-Santigosa 2008), France (Cadi et al. 2004), Italy (Sindaco et al. 2005), Slovenia (Vamberger et al. 2012, Standfuss et al. 2016) and Austria (Kleewein 2014). Egg-laying females and hatchlings were also observed from the Mediterranean region of Turkey (Çiçek & Ayaz 2015).

For Croatia, egg laying was for the first time reported in 2013 from the Continental biogeographical region, specifically from Maksimir Forest Park, Zagreb, while few years later, successful reproduction was confirmed on the same location by monitoring of few nests in nature and recording successful hatching (Jelić et. al 2016). Aside from Maksimir Forest Park, egg laying female was also observed on another location in Zagreb, on the shore of Bundek Lake in June 2017 (Dubravko Dender, personal communication).

The first indication of breeding in the Mediterranean biogeographical region was stated in Schweiger (2015) for the island of Krk. The author observed a single one year old hatchling. A couple of years earlier, one female was observed digging a hole (Boris Lauš, pers. obs. in 2012), but the location was never again checked to see if eggs were actually laid. In Medulin, Istria, small hatchlings of *T. s. elegans* were observed in 2015 by the first and second authors in the pond inhabited by more than ten adult specimens. It is most likely that the specimen was hatched in the area. Also, on Dugi Otok Island, near the pond where 6 adult specimens were found, the second author observed one female digging a hole, but no eggs were later found there. While the only evidence of the complete breeding success remains that from the lakes at Maksimir Forest Park (Jelić et al. 2016), it is highly probable that successful breeding can also occur in other parts of Croatia, and in different biogeographical regions. Recently, from a population genetics approach based on 14 highly polymorphic microsatellite loci, the

breeding of this species was confirmed at three localities in two different regions of Slovenia (Standfuss et al. 2016), which are similar to the climate conditions of Croatia.

Bringsøe (2001) suggested that in northern Europe the climate is too cold, while in the Mediterranean region summers are too dry for successful egg development. But the increasing number of the countries, where reproduction was confirmed, indicates that this is not the case (Jelić et al. 2016, Schweiger 2015, Vamberger et al. 2012, Standfuss et al. 2016).

The concerning fact in Croatia is that the number of new localities for this species increased by almost 100% in the last several years. Additionally, in some areas like the pond Sali on Dugi Otok Island or the pond in Medulin (Istria), many adult specimens were observed, and it is possible that they will indeed start to reproduce in the future, if they have not done so already, since this is already known from other Mediterranean regions (Standfuss et al. 2016). Due to the longevity of this species, which may be up to 30 years in the wild (van Dijk et al. 2017), even if for some reason reproduction does not occur, they have still been, and will be, present in the wild for many years. Adults are resistant and can survive long periods in suboptimal areas with low temperature or limited precipitation (Bringsøe 2001). Specimens kept in captivity quickly outgrow their small starter aquariums and become unruly for handling, especially in small apartments in the cities. Consequently, they are still being released into the wild even today. In Croatia, specimens of both *T. s. elegans* and *T. s. scripta* cannot be bought from pet stores any more, but they are available on the internet for sale, especially specimens older than ten years, or people just give them away for free on different internet portals.

In Croatia, two species of native freshwater turtles occur, *Emys orbicularis* (Linnaeus, 1758) and *Mauremys rivulata* (Valenciennes, 1833). Both species are listed in the Red Book of Amphibians and Reptiles of Croatia, *E. orbicularis* as NT (Near threatened) and *M. rivulata* as EN (Endangered) (Jelić et al. 2012). Pond sliders may compete with the native pond turtle *E. orbicularis* for food, egg-laying sites, or basking places (Bury & Wolfheim 1973, Rovero et al. 1999, Lindeman 1999, Cadi & Joly 2003), and can be infested with various pathogens, which have been shown to cause mass mortalities in native species (Iglesias et al. 2015). Some authors consider positive competition with the pond turtle in Europe (Luiselli et al. 1997, Cadi & Joly 2003). The competition with *M. rivulata* has still not been confirmed, but is probably similar as with *E. orbicularis*, given that in southernmost Croatia, for example, all three species are found in the same habitats.

In conclusion, the known distribution of the pond slider in Croatia has been greatly expanded. Additional breeding activities have also been observed. In light of that, it is necessary to continue the survey of this invasive species in Croatia and create a plan for the future removal of this species from the wild.

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Appendix 1. List of new records of Trachemys scripta in Croatia. T.s.e. – *Trachemys scripta elegans*, T.s.s. – *Trachemys scripta scripta*.
Priloga 1. Seznam novih najdb vrste Trachemys scripta na Hrvaškem. T.s.e. – *Trachemys scripta elegans*, T.s.s. – *Trachemys scripta scripta*.

	Locality name	N (WGS84)	E (WGS84)	Dates	Elevation (m)	No. of individuals	Observer	Subspecies
Continental biogeographical region								
1	Rakitje, Rakitje Lake	45.793196	15.829403	28.3.2010	115	1	Muhamed Kovačević, Ivan Špelić	*T.s.e.*
2	Ivanja Reka, Sava River	45.787931	16.116482	2017	95	1	Hrvoje Škrlin Vučina	*T.s.e.*
3	Zagreb, Bundek park, Bundek Lake*	45.785267	15.984014	1.8.2009, 28.7.2012	111	/	Željko Vasilik, Boris Lauš	*T.s.e.*
4	Zagreb, Staglišće, stream	45.785002	15.932071	29.6.2008	116	2	Boris Lauš	*T.s.e.*
5	Zagreb, Savica Lakes*	45.776765	16.026599	13.4.2013, 2017	109	2	Boris Lauš, Damir Plačko	*T.s.e.*
6	Zagreb, Jarun Lake*	45.776496	15.927268	1.8.2009, 2017	112	/	Boris Lauš, Bojan Šmid	*T.s.e.*
7	Zagreb, Turopolje, stream	45.685480	16.147839	8.4.2017	106	1	Jure Skejić	*T.s.e.*
8	Zagreb, Poljana Čička, Odra, Kosnica Stream	45.669200	16.177200	12.4.2017	100	1	Ivona Burić	*T.s.e.*
9	Zagreb, Turopolje, Sava-Odra Canal	45.668340	16.196176	9.4.2017	100	1	Mladen Zadravec	*T.s.e.*
10	Nature Park Kopački rit, channel »Čonakut«	45.605519	18.801251	6.3.2017	83	1	Katarina Koller Šarić, Hrvoje Domazetović	*T.s.s.*
11	Sisak, north pond	45.496579	16.381176	17.6.2015	96	/	Željko Vasilik	*T.s.e.*
12	Sisak, middle pond	45.495000	16.382000	12.4.2015	96	/	Željko Vasilik	*T.s.e.*
13	Sisak, former brickworks	45.494013	16.379434	29.5.2014	96	1	Željko Vasilik	*T.s.e.*
14	Sisak, south pond in Ciglarska Graba	45.492534	16.384019	11.4.2017	96	1	Željko Vasilik	*T.s.e.*
15	Karlovac, Novi centar, pond	45.486971	15.541010	2017	110	100	Željko Krpan	*T.s.e.*
16	Duga Resa, bridge across the Mrežnica River	45.445734	15.505172	17.6.2008	124	2	Boris Lauš	*T.s.e.*
17	Požega, fishpond Eminovci	45.347513	17.722460	28.6.2014	152	1	Frano Barišić	unknown
18	Vinkovci, Banja Lake	45.288317	18.785394	20.4.2012	77	1	Pavao Dragičević	*T.s.e.*
19	Slavonski Brod, Svilaj, pond	45.119985	18.286853	20.8.2015	80	1	Frano Barišić	unknown
20	Rakitje, Rakitje Lake	45.793196	15.829403	28.3.2010	115	1	Muhamed Kovačević, Ivan Špelić	*T.s.e.*

	Locality name	N (WGS84)	E (WGS84)	Dates	Elevation (m)	No. of individuals	Observer	Subspecies
21	Ivanja Reka, Sava River	45.787931	16.116482	2017	95	1	Hrvoje Škrlin Vučina	*T.s.e.*
22	Zagreb, Bundek park, Bundek Lake*	45.785267	15.984014	1.8.2009, 28.7.2012	111	/	Željko Vasilik, Boris Lauš	*T.s.e.*
23	Zagreb, Staglišće, stream	45.785002	15.932071	29.6.2008	116	2	Boris Lauš	*T.s.e.*
24	Zagreb, Savica Lakes*	45.776765	16.026599	13.4.2013, 2017	109	2	Boris Lauš, Damir Plačko	*T.s.e.*
25	Zagreb, Jarun Lake*	45.776496	15.927268	1.8.2009, 2017	112	/	Boris Lauš, Bojan Šmid	*T.s.e.*
26	Zagreb, Turopolje, stream	45.685480	16.147839	8.4.2017	106	1	Jure Skejić	*T.s.e.*
27	Zagreb, Poljana Čička, Odra, Kosnica Stream	45.669200	16.177200	12.4.2017	100	1	Ivona Burić	*T.s.e.*
28	Zagreb, Turopolje, Sava-Odra Canal	45.668340	16.196176	9.4.2017	100	1	Mladen Zadravec	*T.s.e.*
29	Nature Park Kopački rit, channel »Čonakut«	45.605519	18.801251	6.3.2017	83	1	Katarina Koller Šarić, Hrvoje Domazetović	*T.s.s.*
	Mediterranean biogeographical region							
30	Sisak, north pond	45.496579	16.381176	17.6.2015	96	/	Željko Vasilik	*T.s.e.*
31	Istra, Kmeti, south of village St. Lucija, pond	45.443020	13.588106	19.5.2014	50	1	Toni Koren	unknown
32	Istra, Anžići village, Korneda Pond	45.255762	13.762086	10.7.2014	273	1	Ana Štih	unknown
33	Istra, Pazin, Pazinčica Stream, near the water pump	45.245253	13.937681	10.4.2009	257	1	Toni Koren	unknown
34	Istra, Loborika, Gornji Radeki, pond	44.923264	13.924587	9.7.2014	136	1	Ana Štih	unknown
35	Istra, Mandalana pond, 1 km west of Cveki	44.952108	13.977462	21.6.2014	84	1	Toni Koren Ana Štih	unknown
36	Istra, Veli Brijun Island, Brijun Pond	44.914626	13.769662	3.5.2014	11	1	Željko Vasilik	*T.s.e.*
37	Istra, Pula, Medulin, pond	44.818990	13.942461	23.6.2014	9	10	Toni Koren, Ana Štih	*T.s.e.*
38	Krk Island, Omišalj, Njivice, lake near Njivice	45.170710	14.556338	2.6.2012	15	1	Boris Lauš	*T.s.e.*
39	Krk Island, two ponds near Mediterranean mussels farm in Čižići	45.161753	14.604901	2009	18	1	Berislav Horvatić, Mario Schweiger	*T.s.e.*

	Locality name	N (WGS84)	E (WGS84)	Dates	Elevation (m)	No. of individuals	Observer	Subspecies
40	Dugi Otok Island, Sali, Sali Pond	43.929614	15.165853	4.5.2015	43	6	Toni Koren, Ana Štih	*T.s.e., T.s.s.*
41	Šibenik, fountain near the »Gospe van Grada« church*	43.734048	15.894212	13.6.2015	15	8	Ivona Burić, Marko Blažić, Katarina Koller	*T.s.e.*
42	Dicmo, Dicmo Osoje, near St. Jakov church, pond	43.628917	16.592802	17.4.2009	346	1	unknown	*T.s.e.*
43	Split, Jadro, Jadro River	43.541800	16.519100	20.4.2016	17	1	Stjepan Mekinić	unknown
44	Cista Provo, Crljivica, pond	43.515190	16.927096	22.6.2014	476	1	Stjepan Mekinić	unknown
45	Stobreč, Žrnovnica, stream	43.513400	16.538600	5.6.2014	5	1	Stjepan Mekinić	unknown
46	Gornji Sevid, pond	43.509144	16.057949	1.5.2015	140	1	Stjepan Mekinić	unknown
47	Šolta Island, Srednje Selo, pond	43.388104	16.281494	19.8.2014, 28.04.2017	97	1	Ivona Burić, Mak Vujanović, Ana Štih	unknown
48	Korčula Island, Gornja Potirna, pond	42.932672	16.712419	9.6.2017	140	1	Ana Štih, Mak Vujanović	*T.s.s.*
49	Donji Majkovi, pond	42.773538	17.912024	19.8.2016	222	4	Ana Štih, Toni Koren	*T.s.e., T.s.s.*
50	Dubrovnik, city park, fountain	42.656262	18.074957	10.10.2017	18	1	Toni Koren	unknown
51	Rožat, Ombla river	42.672073	18.131111	13.08.2015.	0	1	Ana Štih	unknown
52	Konavle, Pridvorje, pond	42.552551	18.327373	27.5.2014	63	1	Toni Koren	*T.s.s.*

* already published localities (Jelić & Jelić 2015, Schweiger 2015, Štih & Koren 2014)

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Observations of amphibian, reptile and some mammal species in the area of Šaleška jezera near Velenje during the 2015–2017 period

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Abstract. In this contribution we present our observations of amphibians, reptiles and some mammals from the area of Šaleška jezera (lakes) near Velenje in northern Slovenia. This area refers to three lakes – Velenjsko jezero, Šoštanjsko jezero and Škalsko jezero, which were formed in the 20th century as a consequence of underground lignite mining. The landscape is still changing due to an ongoing subsidence of the valley caused by continuous mining, which constantly affects the surface water bodies and habitats. The changes are so apparent that they could be measured in weeks if not days. New records on the occurrence of 9 amphibian, 7 reptilian and 9 mammalian species were made in the region during our field work carried out from 2015 to 2017. Three of these species are listed on Annex II of the EU Habitats Directive – *Emys orbicularis, Bombina variegata* and *Triturus carnifex*, and additional eight on Annex IV of this directive – *Bombina variegata, Hyla arborea, Rana dalmatina, Triturus carnifex, Emys orbicularis, Lacerta viridis, Podarcis muralis* and *Natrix tessellata*. We also recorded two introduced species – *Dama dama* and *Trachemys scripta.*

Key words: amphibians, reptiles, mammals, coal-mine subsiding area, Šaleška jezera, Slovenia

Izvleček. Opazovanja dvoživk, plazilcev in določenih vrst sesalcev med letoma 2015 in 2017 v okolici Šaleških jezer, Slovenija – V prispevku navajamo lastna opazovanja dvoživk, plazilcev in sesalcev v obdobju 2015–2017 v okolici Šaleških jezer, severna Slovenija. Območje obsega tri jezera – Velenjsko, Šoštanjsko in Škalsko, ki so nastala v 20. stoletju kot posledica izkopavanja lignita. Pokrajina se še vedno nenehno spreminja zaradi ugrezanja doline, kjer je premogovništvo še aktivno, in vpliva na površinska vodna telesa in habitate. Spremembe površja so opazne iz tedna v teden, ponekod celo iz dneva v dan. Med terenskimi popisi smo na območju jezer zabeležili 9 vrst dvoživk, 6 vrst plazilcev in 9 vrst sesalcev. Tri najdene vrste so uvrščene v Prilogo II Habitatne direktive – *Emys orbicularis, Bombina variegata* in *Triturus carnifex*, osem pa jih je uvrščenih v Prilogo IV omenjene direktive – *Bombina variegata, Hyla arborea, Rana dalmatina, Triturus carnifex, Emys orbicularis, Lacerta viridis, Podarcis muralis* in *Natrix tessellata*. Opazili smo tudi dve tujerodni vrsti – *Dama dama* in *Trachemys scripta*.

Ključne besede: dvoživke, plazilci, sesalci, ugrezninsko območje premogovnika, Šaleška jezera, Slovenija

Introduction

Several amphibian, reptile and mammal species are known from the wider area of Šaleška jezera (near the town of Velenje) from various sources (Kryštufek 1991, Gregori 1995, Tome 1996, Poboljšaj & Kotarac 1997, Planinc 1999, Planinc 2001, Krofel et al. 2009, Žagar 2012), but often with unspecified or not very accurate localities. In the vicinity of the lakes, three species of amphibian and reptiles were noted – *Bombina variegata, Pelophylax* kl. *esculenta* complex and *Trachemys scripta* (Gregori 1995, Tome 1996, Poboljšaj & Kotarac 1997). Seven more were recorded in the wider surroundings of the town Velenje – *Natrix natrix* and *N. tessellate*, *Zamenis longissimus, Anguis fragilis, Lacerta viridis,* and *Podarcis muralis* (Planinc 1999, Krofel et al. 2009, Žagar 2012). The introduced mammal species *Dama dama* has been present in the region since 1973 (Krže 1975). For other mammals we found no data of specified localities for the surveyed area, even though they are generally present in this part of Slovenia (Kryštufek 1991).

Since the area and its lakes are fairly dynamic with constantly changing habitats, data about possible vertebrate distribution can be considered interesting. Distribution changes and succession had been noted in some former destroyed mining areas in other countries (e. g. Tischew et al. 2009). The most dynamic subsiding area, where the changes can be measured in days, is the landscape between lakes Velenjsko jezero and Šoštanjsko jezero due to still active underground mining and ash deposition from the nearest Šoštanj thermoelectric plant. Despite the records of endangered species at the European level, this landscape has currently no nature conservation status. On the other hand, the northeastern shore of Velenjsko jezero, including the patch between Velenjsko and Škalsko jezero, is designated as a valuable natural area (Ur. l. RS 2004a). Velenjsko and Škalsko jezero are also partly situated on the southwestern border of the Velenjsko-Konjiško gorovje area of ecological importance (»ekološko pomembno območje«; Ur. l. RS 2004b). The same area was also included in an initiative to establish a natural landscape park Škale, but all the attempts failed (Pokorny 1999).

In this contribution we present some amphibian, reptile and mammal species in the Šaleška jezera region, noted as chance findings between the years 2015 and 2017.

Materials and methods

Šaleška jezera (lakes) are very young, formed in the mid-20th century in Šaleška dolina, a basin in Slovenia near the town of Velenje. The valley has natural deposits of lignite and the mining of this coal started 130 years ago, causing the subsidence of the valley, which was gradually flooded with the water from passing brooks. The flooding resulted in three notable lakes (Fig. 1) - Velenjsko jezero, Šoštanjsko jezero in Škalsko jezero (Šterbenk 2011). Due to the still active mining, the shape of the lakes and their surrounding landscape is still changing. After several decades of activity, the subsidence of the grounds is currently most significant on the northwestern shores of Velenjsko jezero and northern and eastern shores of Šoštanjsko

jezero. The changes occur in short periods of time and are often accompanied by deforestation along with creation of new water bodies, marshland, reeds, shrubland and other surfaces (Šterbenk 2011). The southern, more stable shores of these two lakes are popular tourist destinations, with the smallest lake, Škalsko jezero, completely designated for human activities (Šterbenk et. al. 2017).

The fieldwork was carried out from May 2015 to October 2017 and was mainly focused on regular bird surveys (Gojznikar et al., in prep.), but we also recorded other vertebrate species encountered during our field work. The amphibian and reptile species were either caught, identified, photographed and released or only observed through binoculars or telescope and identified using some of the available literature (Veenvliet & Kus Veenvliet 2008, Speybroeck et al. 2016). Some amphibian species were also identified by sound recognition. Mammals were identified after being photographed or observed through binoculars or telescope with the aid of available literature (Kryštufek 1991, Kryštufek & Janžekovič 1999). We also identified several mammalian species via their footprints according to Krofel & Potočnik (2016). Apart from the obvious and easily determinable species, we excluded certain mammal groups from our survey, as no suitable methods for their identification were at hand. These were nearly all rodents (Rodentia) and all insectivores (Eulipotyphla) and bats (Chiroptera).

Results and discussion

In the surveyed area we noted 25 different species-level taxa from three vertebrate classes - Amphibia, Reptilia and Mammalia with 9, 7 and 9 species respectively (Tab. 2). Altogether, the animals were noted on 71 different localities (Tab. 1). We recorded three species found on Annex II of the EU's Habitats Directive: yellow-bellied toad (*Bombina variegata*), Italian crested newt (*Triturus carnifex*) and European pond terrapin (*Emys orbicularis*), and additional eight on Annex IV of this directive: yellow-bellied toad (*Bombina variegata*), European tree frog (*Hyla arborea*), agile frog (*Rana dalmatina*), Italian crested newt (*Triturus carnifex*), European pond terrapin (*Emys orbicularis*), European green lizard (*Lacerta viridis*), common wall lizard (*Podarcis muralis*) and dice snake (*Natrix tessellata*) (Official Journal of the EU 1992). The only noted species being considered endangered (E category) in Slovenia is *E. orbicularis* (Ur. l. RS 2002). Two introduced species for Slovenia were also observed: the pond slider (*Trachemys scripta*) and the fallow deer (*Dama dama*). We noted two subspecies of the former – *T. s. scripta* and *T. s. elegans* (Tab. 2).

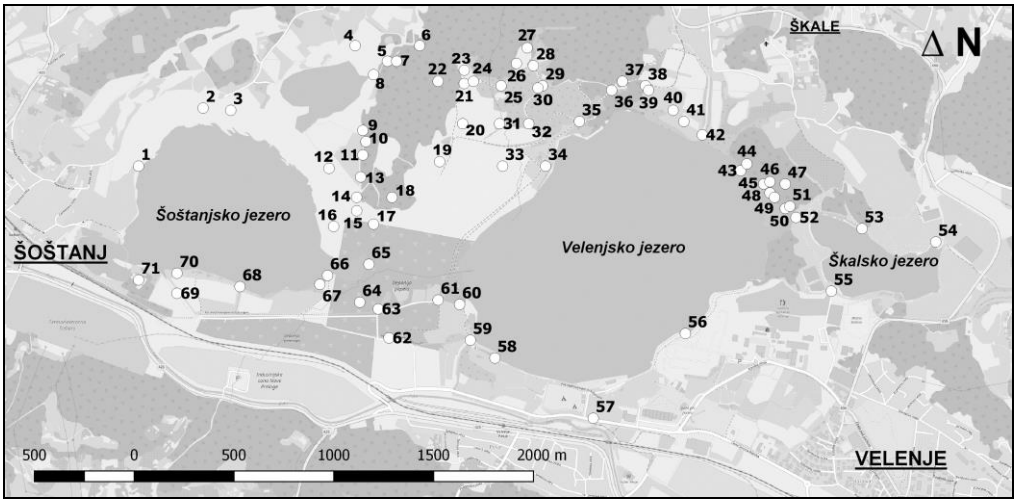

Figure 1. Localities of all species observed (see Tab. 1). The landscape may have changed significantly due to continuous subsidence since the last data were collected and was in fact not implicitly representative of the landscape during our research. The map was created in QGIS software using OpemStreetMap as a basemap (© OpenStreeMap contributors).

Slika 1. Lokalitete vseh opaženih vrst. Lokalitete so ošteviločene kot v Tab. 1. Površje v okolici jezer se je zaradi ugrezanja morda bistveno spremenilo od datuma zadnjega podatka in ni nujno primerljivo s stanjem med našo raziskavo. Zemljevid je bil izdelan v QGIS software z uporabo OpemStreetMap kot osnovo (© OpenStreeMap contributors).

Table 1. All localities of the species recorded at Šaleška jezera between 2015 and 2017; coordinates are in WGS84 decimals (lat. (°N)/ long. (°E)).

Tabela 1. Vse lokalitete vrst, zabeleženih v okolici Šaleških jezer med letoma 2015 in 2017 ; koordinate so v WGS84 decimalnem zapisu (lat. (°N)/ long. (°E)).

No. of locality / Št. lokalitete	Description / Opis	Habitat / Habitat	Coordinates / Koordinate	Elevation (m) / Nadmorska višina (m)
01	Western lake shore of Šoštanjsko jezero	lake shore	46.3798/15.0575	368
02	Northern lake shore of Šoštanjsko jezero	marshy lake shore	46.3824/15.0617	370
03	Northern lake shore of Šoštanjsko jezero	lake shore	46.3823/15.0635	368
04	Northeast from Šoštanjsko jezero, near the gravel road	shrubland	46.3852/15.0716	374
05	Gravel road near the outflow of the Velunja stream, northeast from Šoštanjsko jezero	wheel ruts and roadside puddles	46.3845/15.0737	382
06	Northeast from Šoštanjsko jezero, uphill on deforested ridge above Velunja	pools of a small stream	46.3852/15.0758	396
07	Northeast of Šoštanjsko jezero, near the outflow of the Velunja stream	vegetation	46.3845/15.0743	380

No. of locality / Št. lokalitete	Description / Opis	Habitat / Habitat	Coordinates / Koordinate	Elevation (m) / Nadmorska višina (m)
08	Northeastern lake shore of Šoštanjsko jezero	lake shore	46.3839/15.0728	376
09	Gravel road below deforested ridge, east from Šoštanjsko jezero	gravel road	46.3814/15.0721	374
10	Gravel road below deforested ridge, east from Šoštanjsko jezero	wheel ruts and roadside puddles	46.3809/15.0723	378
11	Waterhole by the gravel road below deforested ridge, east from Šoštanjsko jezero	waterhole	46.3803/15.0721	378
12	Gravel road near the eastern shore of Šoštanjsko jezero	pothole	46.3797/15.0699	371
13	Gravel road below deforested ridge, east from Šoštanjsko jezero	pothole	46.3793/15.0720	377
14	Waterhole near the crossroads of gravel roads, shrubland on the east of Šoštanjsko jezero	waterhole	46.3784/15.0717	372
15	Shrubland east of Šoštanjsko jezero	vegetation near the small pool	46.3778/15.0717	370
16	Shrubland east of Šoštanjsko jezero	vegetation	46.3771/15.0702	369
17	Shrubland east of Šoštanjsko jezero, near the gravel road	shrubland	46.3772/15.0728	369
18	Shrubland between Šoštanjsko and Velenjsko jezero	shrubland	46.3784/15.0740	381
19	Ash deposits between Velenjsko jezero and deforested ridge	ash deposits	46.3800/15.0771	389
20	Northwest from the water reservoir	vegetation	46.3817/15.0786	387
21	Ditch by the gravel road below deforested ridge, northwest from the water reservoir	roadside ditch	46.3835/15.0787	404
22	Deforested ridge, northeast from Šoštanjsko jezero	deforested ridge	46.3836/ 15.0770	416
23	Puddles by the gravel road below deforested ridge, northwest from the water reservoir	puddles	46.3841/15.0787	412
24	Gravel road below deforested ridge, northwest from the water reservoir	gravel road	46.3836/15.0793	394
25	Forest northwest of Velenjsko jezero, gravel road between deforested ridge and the forest pond	roadside ditch	46.3834/15.0811	402
26	Forest northwest of Velenjsko jezero, north from the water reservoir	forest pond	46.3844/15.0821	404
27	Forest northwest of Velenjsko jezero, north from the water reservoir	forest pond	46.3851/15.0828	409

No. of locality / Št. lokalitete	Description / Opis	Habitat / Habitat	Coordinates / Koordinate	Elevation (m) / Nadmorska višina (m)
28	Clearing by the gravel road near the forest pond, north from the water reservoir	forest edge	46.3843/15.0832	407
29	Forest northwest of Velenjsko jezero	forest road	46.3834/15.0838	391
30	Forest northwest of Velenjsko jezero	forest	46.3833/15.0835	390
31	Pond by the northern road around the water reservoir	pond	46.3817/15.0810	377
32	Waterhole by the northern road around the water reservoir, near the gravel road to the forest pond	overgrown waterhole	46.3817/15.0829	378
33	Waterhole between the water reservoir and artificial pool on ash deposits, northwest form Velenjsko jezero	waterhole	46.3798/15.0812	368
34	Northwestern lake shore of Velenjsko jezero	lake shore	46.3798/15.0840	374
35	Crossroads of gravel and forest roads, north from Velenjsko jezero	overgrown roadside ditch	46.3818/15.0862	413
36	Forest north of Velenjsko jezero	forest clearing	46.3832/15.0883	396
37	Forest north of Velenjsko jezero	wheel ruts on forest road	46.3836/15.0890	424
38	Forest north of Velenjsko jezero	forest edge	46.3834/15.0905	389
39	Fields near Škale, north from Velenjsko jezero	field near the forest	46.3832/15.0907	384
40	Grassland north of Velenjsko jezero	tent on the grassland	46.3823/15.0923	391
41	Grassland north of Velenjsko jezero	hunting observatory	46.3818/15.0930	375
42	Outflow of the Ljubela stream north of Velenjsko jezero	bank of the stream outflow	46.3812/15.0942	375
43	Northern lake shore of Velenjsko jezero	lake shore	46.3796/15.0967	384
44	Forest northeast of Velenjsko jezero	forest	46.3799/15.0971	376
45	Forest northeast of Velenjsko jezero	pothole in the forest	46.3790/15.0982	390
46	Forest northeast of Velenjsko jezero	forest	46.3791/15.0986	391
47	Forest northeast of Velenjsko jezero	forest	46.3790/15.0996	413
48	Northeastern lake shore of Velenjsko jezero	lake shore	46.3786/15.0986	387
49	Forest northeast of Velenjsko jezero	puddle in the forest	46.3784/15.0989	388
50	Northeastern lake shore of Velenjsko jezero	lake shore	46.3779/15.0996	387
51	Forest northeast of Velenjsko jezero	forest edge	46.3780/15.0999	368

No. of locality / Št. lokalitete	Description / Opis	Habitat / Habitat	Coordinates / Koordinate	Elevation (m) / Nadmorska višina (m)
52	Grassland between Velenjsko and Škalsko jezero	grassland near reeds	46.3775/15.1003	367
53	Northern lake shore of Škalsko jezero	regulated lake shore	46.3770/15.1046	377
54	Northeastern lake shore of Škalsko jezero, at the outflow of the Lepena stream	lake shallows	46.3764/15.1094	386
55	Stream connecting Škalsko and Velenjsko jezero	stream bank	46.3742/15.1026	377
56	Southeastern lake shore of Velenjsko jezero	regulated lake shore	46.3723/15.0931	368
57	Main road from Velenje to southern shore of Velenjsko jezero	roadside ditch	46.3685/15.0871	370
58	Southwestern lake shore of Velenjsko jezero	lake shore with reeds	46.3712/15.0807	367
59	Southwestern lake shore of Velenjsko jezero	lake shallows with reeds	46.3720/15.0791	368
60	Ash deposits southwest of Velenjsko jezero	grassland	46.3736/15.0784	376
61	Ash deposits southwest of Velenjsko jezero	artificial pool	46.3738/15.0770	377
62	Road between Velenjsko and Šoštanjsko jezero	asphalt road	46.3721/15.0738	367
63	Waterhole at the crossroads of roads to ash deposits and the road between Velenjsko and Šoštanjsko jezero	waterhole	46.3734/15.0731	364
64	Southeast from Šoštanjsko jezero, near the road between Velenjsko and Šoštanjsko jezero	marshy shrubland	46.3737/15.0719	367
65	Ash deposits between Velenjsko and Šoštanjsko jezero	small pool	46.3754/15.0725	375
66	Southeastern lake shore of Šoštanjsko jezero	lake shallows	46.3749/15.0698	360
67	Southeastern lake shore of Šoštanjsko jezero	vegetation	46.3745/15.0693	360
68	Southern lake shore of Šoštanjsko jezero	outflow of the ditch	46.3744/15.0641	360
69	Stream connecting the Paka river and Šoštanjsko jezero, south from Šoštanjsko jezero	stream bank vegetation	46.3741/15.0600	360
70	Southern lake shore of Šoštanjsko jezero	lake shore vegetation	46.3750/15.0600	360
71	Small island on the southwest of Šoštanjsko jezero	small island	46.3747/15.0575	362

Table 2. Amphibian, reptilian and some mammalian species recorded in the Šaleška jezera area between 2015 and 2017 (A – Amphibia, R – Reptilia, M –– Mammalia; I – introduced species; HD – Habitats Directive (Ur. l. EU 1992), RL – Slovenian Red List (Ur. l. RS 2002), IUCN – The IUCN List of Threatened Species, E – endangered, LC – least concern, NT – near threatened, O1 – species threathened in the past but currently not threatened, V - vulnerable ; few: 2–5, many: 6 or more).

Tabela 2. Vrste dvoživk, plazilcev in določenih sesalcev, zabeležene v okolici Šaleških jezer med letoma 2015 in 2017 (A – Amphibia, R – Reptilia, M – Mammalia; I – tujerodne vrste; HD – Habitatna direktiva (Ur. l. EU 1992), RL – Rdeči seznam Slovenije (Ur. l. RS 2002), IUCN – IUCN seznam ogroženih vrst, , E – prizadeta vrsta, LC – vrsta, ki trenutno ni smatrana za ogroženo, NT – potencialno ogrožena vrsta, O1 – vrsta zunaj nevarnosti, V – ranljiva vrsta; few: 2–5, many: 6 ali več).

Class / Razred	Species / Vrsta	Date [No. of locality - Number of specimens] / Datum [št. lokalitete - število osebkov]	Methods of identification / Metoda določitve	Conservation status / Varstvene kategorije		
				HD	RL	IUCN
A	*Bombina variegata*	10. 5. 2015 [Loc 35 - 2, Loc 45 - 2, Loc 49 - 2]; 12. 4. 2016 [Loc 35 - few, Loc 45 - 3]; 2. 4. 2017 [Loc 5 - 2]; 14. 4. 2017 [Loc 5 - many, Loc 10 - few, Loc 45 - 3, Loc 49 - few]; 7. 5. 2017 [Loc 5 - many, Loc 13 - few, Loc 49 - many]; 21. 5. 2017 [Loc 5 - few, Loc 10 - few, Loc 49 - few]; 10. 6. 2017 [Loc 5 - few, Loc 6 - few, Loc 21 - few, Loc 23 - few, Loc 35 - few, Loc 37 - few,]; 26. 6. 2017 [Loc 11 - 20, Loc 23 - 2, Loc 37 - few]; 17. 7. 2017 [Loc 10 - 5, Loc 12 - 2]; 5. 8. 2017 [Loc 5 - few, Loc 10 - few, Loc 11 - few, Loc 21 - few]; 8. 8. 2017 [Loc 25 - 2]; 19. 8. 2017 [Loc 5 - 5]; 20. 9. 2017 [Loc 5 - 1, Loc 10 - 2]; 1. 10. 2017 [Loc 11 - 2]; 15. 10. 2017 [Loc 9 - 1, Loc 10 - 1, Loc 34 - 1]	caught, observation, photographed, sound recognition	Annex II, Annex IV	V	LC
A	*Bufo bufo*	12. 4. 2016 [Loc 26 - 3]; 2. 4. 2017 [Loc 1 - 1]; 7. 8. 2017 [Loc 24 - 1, Loc 26 - 2]	caught, observation, cadaver		V	LC
A	*Hyla arborea*	14. 4. 2017 [Loc 8 - 1, Loc 30 - 1]; 7. 5. 2017 [Loc 8 - 2]; 1. 10. 2017 [Loc 11 - 2, Loc 60 - 2]	observation, sound recognition	Annex IV	V	LC
A	*Pelophylax* sp.	17. 10. 2015 [Loc 63 - 4]; 12. 4. 2016 [Loc 63 - few]; 14. 4. 2017 [Loc 14 - many, Loc 33 - many, Loc 65 - few]; 7. 5. 2017 [Loc 15 - few, Loc 31 - few, Loc 63 - many, Loc 58 - 1]; 21. 5. 2017 [Loc 2 - 1, Loc 14 - few, Loc 15 - 1, Loc 58 - 2, Loc 59 - few, Loc 63 - 2, Loc 66 - 3]; 10. 6. 2017 [Loc 3 - 1, Loc 8 - few, Loc 15 - 3, Loc 59 - few, Loc 70 - 3]; 26. 6. 2017 [Loc 8 - few, Loc 15 - 4, Loc 34 - few, Loc 59 - few, Loc 61 - few, Loc 64 - few]; 5. 8. 2017 [Loc 8 - few, Loc 72 - few]; 6. 8. 2017 [Loc 32 - 1] 19. 8. 2017 [Loc 2 - few, Loc 8 - few, Loc 63 - few, Loc 66 - 2]; 2. 9. 2017 [Loc 8 - 1, Loc 31 - 1, Loc 64 - 1]; 20. 9. 2017 [Loc 2 - 2]; 1. 10. 2017 [Loc 31 - many, Loc 33 - many]; 15. 10. 2017 [Loc 31 - 2]	caught, observation			
A	*Rana dalmatina*	2. 4. 2017 [Loc 8 -1]; 14. 4. 2017 [Loc 52 - 2]; 19. 8. 2017 [Loc 50 - 1]	caught	Annex IV	V	LC
A	*Rana temporaria*	19. 3. 2017 [Loc 44 -1]	caught	Annex V	V	LC
A	*Ichthyosaura alpestris*	6. 8. 2017 [Loc 32 - 4]	caught		V	LC

Class / Razred	Species / Vrsta	Date [No. of locality - Number of specimens] / Datum [št. lokalitete - število osebkov]	Methods of identification / Metoda določitve	Conservation status / Varstvene kategorije		
				HD	RL	IUCN
A	*Lissotriton vulgaris*	6. 8. 2017 [Loc 32 - 2]	caught		V	LC
A	*Triturus carnifex*	17. 10. 2015 [Loc 63 - 1]; 6. 8. 2017 [Loc 40 - 1]	caught, observation	Annex II, Annex IV	V	LC
R	*Anguis fragilis*	14. 4. 2017 [Loc 42 - 1]	observation		O1	LC
R	*Lacerta viridis/bilineata*	23. 7. 2016 [Loc 7- 1]; 14. 4. 2017 [Loc 38 - 1]; 7. 5. 2017 [Loc 35 - 2]; 21. 5. 2017 [Loc 41 - 1]; 5. 8. 2017 [Loc 38 - 1]; 19. 8. 2017 [Loc 32 - 1]	observation, photographed	Annex IV	V	LC
R	*Podarcis muralis*	21. 5. 2017 [Loc 69 - 1]; 10. 6. 2017 [Loc 36 - 5]; 26. 6. 2017 [Loc 62 - 1]; 15. 10. 2017 [Loc 69 - 2]	caught, observation	Annex IV	O1	LC
R	*Natrix natrix*	2. 4. 2017 [Loc 42 - 1]; 14. 4. 2017 [Loc 70 - 1]	observation		O1	Lower Risk/ LC
R	*Natrix tessellata*	2. 4. 2017 [Loc 53 - 1]; 7. 5. 2017 [Loc 56 - 1]; 10. 6. 2017 [Loc 55 - 1]	observation	Annex IV	V	LC
R	*Emys orbicularis*	14. 4. 2017 [Loc 26 - 5]; 7. 5. 2017 [Loc 26 - 8]; 21. 5. 2017 [Loc 26 - 5]; 10. 6. 2017 [Loc 26 - 1]; 7. 8. 2017 [Loc 26 - 1]; 2. 9. 2017 [Loc 26 - 1]	observation, photographed	Annex II, Annex IV	E	Lower Risk/ NT
R	*Trachemys scripta scripta*[I]	12. 4. 2016 [Loc 71 - 1]; 14. 4. 2017 [Loc 26 - 2]; 7. 5. 2017 [Loc 26 - 2, Loc 48 - 2, Loc 50 - 1]	observation, photographed			LC
R	*Trachemys scripta elegans*[I]	19. 3. 2017 [Loc 43 - 1]; 7. 5. 2017 [Loc 26 - 1, Loc 48 - 1]	observation, photographed			LC
R	*Trachemys scripta ssp.*[I]	19. 3. 2017 [Loc 48 - 1, Loc 54 - 1]; 2. 4. 2017 [Loc 48 - 2, Loc 50 - 2, Loc 71 - 1]; 14. 4. 2017 [Loc 26 - 3, Loc 43 - 1, Loc 48 - 4, Loc 50 - 2, Loc 71 - 2]; 21. 5. 2017 [Loc 26 - 2, Loc 27 - 1]; 10. 6. 2017 [Loc 50 - 1]; 26. 6. 2017 [Loc 59 - 1]	observation, photographed			LC
M	*Dama dama*[I]	17. 10. 2015 [Loc 28 - 1, Loc 44 - 1]; 14. 11. 2015 [Loc 47 - 3, Loc 67 - 2]; 28. 12. 2015 [Loc 44 - 2, Loc 46 - 1]; 12. 4. 2016 [Loc 36 - 1, Loc 47 - 1]; 22. 10. 2016 [Loc 46 - 1, Loc - 60]; 11. 12. 2016 [Loc 47 - 1]; 5. 3. 2017 [Loc 46 - 3]; 7. 5. 2017 [Loc 19 - 3]; 2. 9. 2017 [Loc 35 - 4]	observation, photographed, footprints			LC
M	*Capreolus capreolus*	17. 10. 2015 [Loc 28 - 3]; 28. 12. 2015 [Loc 35 - 2]; 12. 4. 2016 [Loc 38 - 2]; 15. 1. 2017 [Loc 19 - 1]; 19. 3. 2017 [Loc 18 - 1, Loc 39 - 1, Loc 60 - 2]; 2. 4. 2017 [Loc 67 - 1]; 14. 4. 2017 [Loc 29 - 1, Loc 17 - 1]; 17. 7. 2017 [Loc 39 - 2]; 2. 9. 2017 [Loc 17 - 2, Loc 18 - 2]	observation, photographed, footprints, feces			LC
M	*Rupicapra rupicapra*	28. 10. 2017 [Loc 20 - 1]	observation	Annex V		LC

Class / Razred	Species / Vrsta	Date [No. of locality - Number of specimens] / Datum [št. lokalitete - število osebkov]	Methods of identification / Metoda določitve	Conservation status / Varstvene kategorije		
				HD	RL	IUCN
M	*Lepus europaeus*	17. 2. 2017 [Loc 15 - 2]; 5. 3. 2017 [Loc 15 - 3, Loc 16 - 1]; 14. 4. 2017[Loc 4 - 1]; 21. 5. 2017 [Loc 2 - 1]; 10. 6. 2017 [Loc 14 - 1]; 5. 8. 2017 [Loc 12 - 1]; 15.10.2017 [Loc 20 - 1]; 28. 10. 2017 [Loc 17 - 1]	observation, photographed, footprints, feces			LC
M	*Sciurus vulgaris*	11. 12. 2016 [Loc 51 - 1]; 5. 8. 2017 [Loc 9 - 1]; 19. 8. 2017 [Loc 50 - 1]; 20. 9. 2017 [Loc 50 - 1]	observation			LC
M	*Meles meles*	14. 4. 2017 [Loc 9 - 1]; 10. 6. 2017 [Loc 24 - 1]	footprints		O1	LC
M	*Mustela erminea*	19. 8. 2017 [Loc 68 - 1]	observation			LC
M	*Mustela nivalis*	2. 4. 2017 [Loc 57 - 1]	observation		O1	LC
M	*Vulpes vulpes*	17. 10. 2015 [Loc 46 - 1]; 22. 10. 2016 [Loc 39 - 1]; 10. 6. 2017 [Loc 59 - 1]; 19. 8. 2017 [Loc 22 - 1]	observation, photographed		O1	LC

None of the observed amphibians are considered endangered (E), but all (see Tab. 1) are classified as vulnerable (V) on the Slovenian Red List (Ur. l. RS 2002). *Bombina variegata* is still considered widespread in Slovenia, but could locally be under negative impact. Its populations are, in general, under threat from urbanisation, intensive forestry, agriculture and disappearance of small water bodies, their preferred habitat (Poboljšaj & Lešnik 2003). In the research area, small water bodies are highly susceptible to geomorphological changes, which could exert pressure on the local population of the species. *Triturus carnifex*, on the other hand, was not seen as often as *B. variegata*. Although generally present throughout Slovenia, its populations are very small (Poboljšaj & Lešnik 2003) and the species is sometimes considered rare (Govedič et al. 2009). *T. carnifex* is threatened by multiple local negative influences, especially the devastation of suitable water bodies nationwide (Poboljšaj & Lešnik 2003), and therefore faces a similar problem in the lake area as *B. variegata*. Other interesting amphibian observations were *Ichthyosaura alpestris* and *Lissotriton vulgaris*, which were found only as juveniles together in the same pond, and *Hyla arborea*, found on four localities. All three are common and generally present in Slovenia (CKFF 2018).

Of the six noted indigenous reptile species, according to the Slovenian Red List (Ur. l. RS 2002), one is endangered (*E. orbicularis*), while two are considered vulnerable (*Lacerta viridis/bilineata* and *Natrix tessellata*). The others were threatened in the past, but are currently stable (O/O1). The only species not listed on the Slovenian Red List is the invasive *T. scripta. Emys orbicularis* is also listed on the Annex II and Annex IV of the Habitats Directive (Ur. l. EU 1992). It is known to have suffered population declines throughout its range, mainly due to habitat degradation, fragmentation and destruction (Tome 2003). In the research area, *E. orbicularis* was discovered only recently, for the first time recorded about two years ago (CKFF 2018, leg. M. Vranič). During the time of our survey, it was noted also by other researchers (CKFF 2017, leg. N. Kirbiš & M. Vamberger) on the same locality. Although there were at least 8 different individuals present in the aforementioned pond, we found no evidence of their reproduction. It is of crucial importance to ensure that the current state of

the pond remains undisturbed, which might be difficult to achieve due to the continuous subsidence in the area. Another issue for *E. orbicularis* is the presence of the possibly competitive *T. scripta* in the area. Cadi & Joly (2004) suggested in their experiment that the latter could have a negative impact on the former. During our research, *T. scripta* was found, among other localities, in the same pond as *E. orbicularis*. The former is known in the area for a much longer period than the latter, with the first recorded observation at Škalsko jezero in 1995 (Gregori 1995). The subspecies *T. s. elegans* is known to reproduce in the wild elsewhere in Slovenia (Lipovšek 2013); the question whether it reproduces in our study area, remains unanswered. Among other reptilians we could not distinguish between *L. viridis* and *L. bilineata* due to their almost identical morphological features. The species complex is still a partial mystery in Slovenia, even though it seems that *L. bilineata* is more likely to be found in the west and *L. viridis* in the east of the country (Tome 1999). Other noted reptilian species are quite common across Slovenia (Krofel et al. 2009).

Our list of amphibian and reptilian species is more or less in concordance with other publications (Poboljšaj 2001, Poboljšaj & Lešnik 2003, Krofel et al. 2009), even though we believe that some other common Slovenian species could also occur regularly in the area (e.g. the Fire Salamander (*Salamandra salamandra*)). The same, however, cannot be said of our observations of mammals. The actual number of mammalian species in the area is certainly much higher owing to the fact that we excluded bats, insectivores and nearly all rodents from our records. Out of nine species of the recorded mammals, only three (*Mustela erminea*, *M. nivalis and Sciurus vulgaris*) are listed on the Slovenian Red List and fall into the O1 category. We did, however, regularly note *D. dama*, which was introduced to the lake area in 1973 (Krže 1975). An interesting find was a lone chamois (*Rupicapra rupicapra*), a species usually restrained to higher altitudes (Kryštufek 1991).

Degraded areas can offer an interesting insight into succession processes, as demonstrated in Eastern Germany, where enormous tracts of land were destroyed by open-pit coal mining (Tischew et al. 2009). Lignite mining in our area of research is, however, subterranean, which is not common on a global scale (Šterbenk 2011). Therefore, the ever changing surface offers a unique window into succession processes and species reaction to quick environmental changes as indirect consequences of human activities. We believe that further research, focused on noting the impact of the changeable surface, could be interesting. The area is also interesting from the aspect of conservation – the species listed on the Annex II or the Annex IV co-appear in several conservationally important areas elsewhere in Slovenia (Govedič et al. 2009) and offer a possible comparison insight into the effect of the aforementioned human activities.

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First record of the moustached darter *Sympetrum vulgatum* (Linnaeus, 1758) (Odonata: Libellulidae) for the Bjelovar area, Croatia

Prva najdba navadnega kamenjaka *Sympetrum vulgatum* (Linnaeus, 1758) (Odonata: Libellulidae) na območju Bjelovarja, Hrvaška

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Sympetrum vulgatum is widely distributed from Western Europe through Central and Eastern Europe, eastwards across Russia to Japan (Kalkman et al. 2015, Hinojosa et al. 2017). This Palearctic species is common and widespread in continental western, central and eastern Europe, but is largely absent from the westernmost regions and southern Europe (Kalkman et al. 2015). It is listed as a species of least concern (LC) in the European Red List of Dragonflies (Kalkman et al. 2010).

The species is increasingly rare towards the south of the Balkan Peninsula and considered rare in Serbia (Jović et al. 2009), with only few known records from Bosnia and Herzegovina, Montenegro and Macedonia (Kalkman et al. 2015). In Croatia, the species is more often found in central part of Croatia and Slavonia rather than in the south, where a few records were reported from the region of Lika and from islands of Pag and Krk. In continental part of Croatia, *S. vulgatum* has been recorded in Podravina, Slavonia, Međimurje, Lonjsko polje and the surrounding area of Zagreb and Karlovac (Belančić et al. 2008). In the Red Data Book of Dragonflies of Croatia (Belančić et al. 2008), it is listed as near threatened (NT). Hitherto, there are no literature data on *S. vulgatum* for the surrounding area of Bjelovar and neither for the wider Bjelovar-Bilogora area.

The present note deals with two specimens of Moustached Darter *S. vulgatum,* photographed during field research of butterfly and moth fauna in Gornje Plavnice during 2017. A juvenile female of *S. vulgatum* was found on 18. 7. 2017 at 11:27 a.m. in a meadow at Gornje Plavnice, Bjelovar (45°56'49.8'' N, 16°51'50.0'' E, 190 m above sea level), while resting on *Sorghum halepense* (L.) Pers. (Fig. 1). A male specimen was found on 18.9. 2017 at 14:35 p.m., while resting on the ground in a backyard at Gornje Plavnice (45°56'32.3'' N, 16°51'24.6'' E, 230 m above sea level). Both records concur with the species' flight season which begins in June and ends in October, although most records originate from July (Belančić et al. 2008, Kalkman et al. 2015). *S. vulgatum* was identified on the basis of photographs taken using HUAWEI P9 Lite mobile phone and determined by Dijkstra & Lewington (2006). Both female and male specimen were photographed and identified, but not captured.

Figure 1. A juvenile female of Moustached Darter *Sympetrum vulgatum,* found at Gornje Plavnice, Bjelovar, Croatia (photo: Monika Veljković).
Slika 1. Juvenilna samica navadnega kamenjaka *Sympetrum vulgatum,* najdena v kraju Gornje Plavnice, Bjelovar, Hrvaška (foto: Monika Veljković).

The Bjelovar-Bilogora area is situated in continental and traditionally agricultural part of Croatia covered with fields, meadows and deciduous forests. The habitats in this area include wet and mesophilous meadows, forests, forest edges, glades, agricultural land, fallow land, backyards and gardens. One part of the meadow at Gornje Plavnice near Bjelovar, where *S. vulgatum* was found,

is mowed every year and characterized mostly by the plant association *Arrhenatheretum elatioris* Br. - Bl., but another part has now been overtaken by the invasive species Golden Rod (*Solidago virgaurea* L.).

S. vulgatum larvae develop in different lentic water bodies rich in littoral vegetation like puddles, lakes, marshes and streams with slow-flowing water even at higher altitudes (Belančić et al. 2008). It is possible that the specimens found in a backyard and in a meadow developed in a nearby pond at Gornje Plavnice, which is only 160 meters away from the location where male was found and 740 meters away from the meadow where female was found. According to Belančić et al. (2008), *S. vulgatum* larvae develop along the edges of standing water rich in shore vegetation, so the small stream connected to the pond and the pond at Gornje Plavnice itself, which are both rich in shore vegetation, could be a suitable habitat for the species' development. On the other hand, it is also possible that the presented records are based on observations of vagrant individuals originating from elsewhere in the wider region.

Present records encapsulate the first findings of *S. vulgatum* in the Bjelovar-Bilogora area of continental Croatia. More targeted fieldwork is needed to determine whether *S. vulgatum* has a permanent breeding population at Gornje Plavnice.

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Lubin Y.D., Eberhard W.G., Montgomery G.G. (1978): Webs of Miagrammopes (Araneae: Araneaidae) in the neotropics. Psyche 85: 1-13.

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Edmonds D.T. (1997): The contribution of atmospheric water vapour to the formation of a spider's capture web. In: Heimer S. (Ed.), Proceedings of the 17th European Colloquium of Arachnology. Oxford Press, London, pp. 35-46.

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Lubin Y.D., Eberhard W.G., Montgomery G.G. (1978): Webs of Miagrammopes (Araneae: Araneaidae) in the neotropics. Psyche 85: 1-13.
Lucas S. (1988a): Spiders in Brasil. Toxicon 26: 759-766.
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Nentwig W., Heimer S. (1987): Ecological aspects of spider webs. In: Nentwig W. (Ed.), Ecophysiology of Spiders. Springer Verlag, Berlin, 211 pp.
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