Univerza v Ljubljani
Biotehniška fakulteta

NACIONALNI INŠTITUT ZA BIOLOGIJO

NATURA SLOVENIAE

Revija za terensko biologijo • Journal of Field Biology

Letnik • Volume 22 Številka • Number 1

Ljubljana
2020

NATURA SLOVENIAE

Revija za terensko biologijo • Journal of Field Biology

Izdajata • Published jointly by

Biotehniška fakulteta, Univerza v Ljubljani
Jamnikarjeva 101, SI-1000 Ljubljana
Tel.: (0)1 320 30 00; Telefax: (0)1 256 57 82
http://www.bf.uni-lj.si

Nacionalni inštitut za biologijo
Večna pot 111, SI-1000 Ljubljana
Tel.: (0)59 232 700; Telefax: (0)1 2412 980
http://www.nib.si

http://www.bf.uni-lj.si/bi/NATURA-SLOVENIAE/index.php

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NATURA SLOVENIAE, Večna pot 111, SI-1111 Ljubljana, Slovenija

Izvlečki prispevkov so zavedeni v zbirkah **ASFA, AGRIS, Biological Abstracts, Biosis Previews, COBISS** in **Zoological Records**

ISSN: 1580-0814 **UDK: 57/59(051)=863=20**

Lektorji • Language Editors
za angleščino (for English): Henrik Ciglič
za slovenščino (for Slovene): Henrik Ciglič

Oblikovanje naslovnice • Layout
Daša Simčič akad. slikarka, Atelje T

Natisnjeno • Printed in
2020

Tisk • Print
Miha Košenina s.p., Brezovica pri Ljubljani

Naklada • Circulation
300 izvodov/copies

Sofinancira • Cofinanced by
Javna agencija za raziskovalno dejavnost RS/Slovenian Research Agency

Kazalo vsebine

NATURA SLOVENIAE 22(1): 5-17
SCIENTIFIC PAPER

Prejeto / Received: 14. 7. 2020
Sprejeto / Accepted: 13. 10. 2020

Newly discovered vital population of the European pond turtle *Emys orbicularis* in Prilipe oxbow lakes (SE Slovenia)

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Abstract. In this study we examined the population of the European pond turtle (*Emys orbicularis*) in the Prilipe oxbow lakes along the Sava River. The species' sex and age structure were estimated as well its population size. In the area of approximately 5.9 ha of water surface, 3 individuals were found in 2008 and 70 in 2019, when a more detailed survey was conducted. The population size was estimated at 125 individuals. According to the age structure and confirmed reproduction, the population is recognized as viable. The main threats to the survival of European pond turtles in this area are potential direct interventions into habitat as well as indirect changes such as alterations in flood regime or in groundwater level. Additionally it is threatened by the invasive red-eared slider (*Trachemys scripta elegans)*, the reproduction of which was also confirmed during our survey. Although the studied area meets all conditions for the establishment of the Natura 2000 site, it was not included in this network in 2003 due to lack of knowledge as far as this species was concerned.

Key words: *Emys orbicularis*, population size, age structure, invasive species

Izvleček. Novo odkrita vitalna populacija močvirske sklednice *Emys orbicularis* v mrtvicah Prilipe (JV Slovenija) – V članku predstavljamo izsledke raziskave populacije močvirske sklednice (*Emys orbicularis*) na območju mrtvic reke Save pri Prilipah. Ugotovili smo spolno in starostno strukturo populacije ter ocenili njeno velikost. Na približno 5,9 ha velikem območju mrtvic smo leta 2008 našli 3 osebke, leta 2019, ko smo območje podrobno raziskali, pa 70 osebkov. Populacijo smo ocenili na 125 osebkov. Starostna struktura in potrjeno razmnoževanje sta dokaz, da je populacija viabilna. Glavni dejavniki ogrožanja močvirske sklednice na tem območju so morebitni direktni posegi v habitat, prav tako pa tudi indirektni posegi, kot so spremembe v vodnem režimu in spremembe gladine podtalnice. Dodatno jo ogroža pojavljanje tujerodne invazivne želve rdečevratke (*Trachemys scripta elegans*), saj se, kot smo potrdili, na tem območju tudi uspešno razmnožuje. Čeprav so izpolnjeni vsi pogoji za uvrstitev območja v Natura 2000 omrežje, pa je to ostalo zunaj njega, saj leta 2003 ni bilo veliko znanega o močvirski sklednici na tem območju.

Ključne besede: močvirska sklednica, velikost populacije, starostna struktura, tujerodne vrste

Introduction

The knowledge on the distribution and conservation status of the European pond turtle *Emys orbicularis* (Linnaeus, 1758) in Slovenia has significantly increased in the last decade (Vamberger 2009, Krofel et al. 2009, Vamberger & Kos 2011, Grželj & Grželj 2012, Vamberger et al. 2013, 2015, 2017, Pekolj et al. 2015, Govedič et al. 2016). Interestingly, even though prior to 2008 almost nothing was known about this species in Slovenia, the European Commission within the Biogeographic Seminar concluded in 2006 that a sufficient percentage of the European pond turtle populations were included into the Natura 2000 network in Slovenia (Zagmajster & Skaberne 2006). Thus some very important and vital populations have remained outside of Natura 2000 sites (Govedič et al. 2016). The species is listed in Annex IV (strict protection regime) and Annex II (Sites of Community Importance) of the Habitats Directive and fully protected by the Slovenian national legislation (Ur. l. EU 1992, Ur. l. RS 2004a). Its habitat is protected as well, especially egg deposition sites that are subjects of environmental liability (Ur. l. RS 2009), irrespective of whether they are located within Natura 2000 sites or not. Before the authorities issue any environmental permit for new activities in all potential habitats of the European pond turtle, conservation status of the species needs to be evaluated. To make the right decisions regarding measures of nature conservation, good quality data on the natural history of the species are necessary. For each location, where the European pond turtle was observed, it is crucial to define the viability, reproduction success and the size of the population. In case of any interventions in the turtle's habitat, it is necessary to find egg deposition sites. Detailed studies on the present status, individual numbers and natural history of *E. orbicularis* are lacking in Slovenia and were undertaken only at Ljubljansko barje (Vamberger & Kos 2011, Vamberger et al. 2017) and in Bela krajina (Vamberger et al. 2013). No detailed study has been done along the Krka River and in the Posavje region, even though the European pond turtle was observed in the clay pit north of Brežice (Hudoklin 1995). In this region, only the preserved oxbow lakes along the Sava River (Prilipe is also called Cola or Topla struga) in the Posavje region with constant water are suitable for the European pond turtle (Ivanovič 1991). They are defined as hydrological, geological, botanical and ecosystem value of national importance (Ur. l. RS 2004b). Tome (2003) did not mention the European pond turtle for the Prilipe oxbow lakes or neighbouring areas, but this species does live downstream along the Sava River in Croatia (Šalamon et al. 2013) and thus they were expected also at Prilipe.

The aim of our study was to confirm the presence of the European pond turtle in the area of the Prilipe oxbow lakes and to determine the population size, age-structure and, therefore, the viability of the population.

Methods

Study area

The oxbow lakes along the Sava River situated near the village Prilipe are known by the locals as Cola or Topla struga. However, we decided to use the name Prilipe oxbow lakes in our paper. The study area is located in south eastern Slovenia near Čatež (45°53' N 15°37' E), bordered by the Čatež Spa to the north, by the Sava River to the east and by the highway to the south (Fig. 1). It covers 140 ha, while 5.9 ha of the area is covered by water. To the west of the Prilipe oxbow lakes stretches an open area with prevailing agricultural surfaces.

Climatic conditions in the study area are mainly continental, with a mean annual air temperature of 10–12°C and annual rainfall of 1100–1200 mm (ARSO 2006). Mean annual river water temperature in the region is 12°C (Jaklič & Vrezec 2011). However, this data doesn't reflect temperature of water in the oxbow lakes. There is an influx from the underground hot springs and outflow from the pools inside the Čatež Spa (section A, Fig. 1), which is the most distant part from the main river. Actually, section A is a man-made channel that connects hot springs with the oxbow lake. Therefore the water gradually cools down towards the outfall (section E, Fig. 1), in winter from 35 to 5°C (Jaklič & Vrezec 2011).

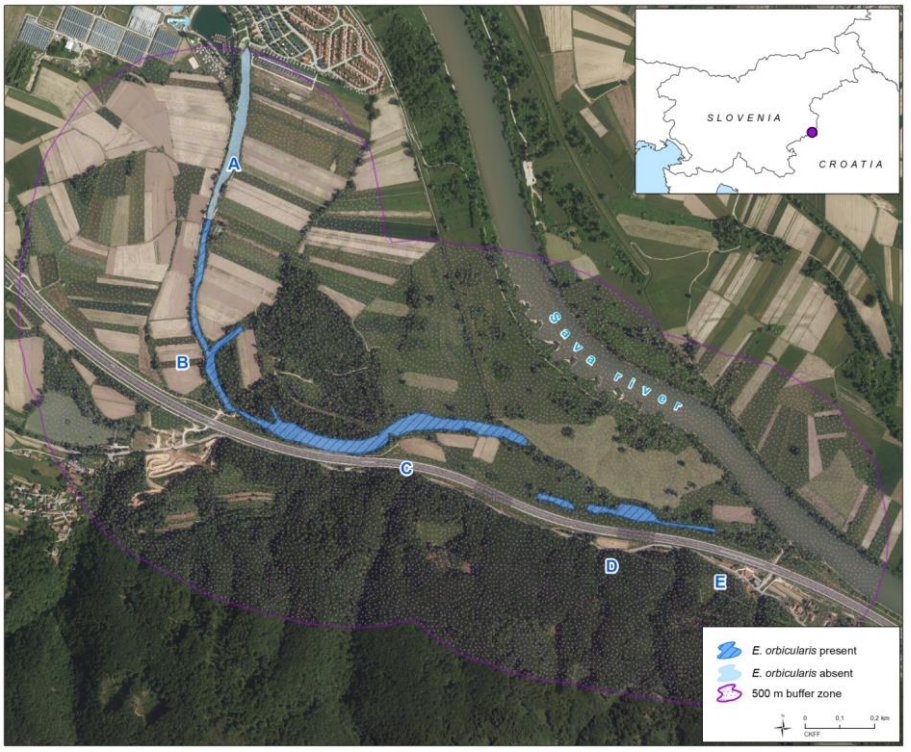

Figure 1. Area of the Prilipe oxbow lakes with 500 m buffer zone. Different sections are marked with capital letters A–E.
Slika 1. Območje mrtvic Prilipe s 500 m puferskim pasom. Posamezni odseki so označeni s črkami A–E.

In the oxbow lake, non-indigenous tropical species such as the tropical redclaw crayfish (*Cherax quadricarinatus*) and the fish Nile tilapia (*Oreochromis niloticus*) are present (Jaklič & Vrezec 2011). Water lettuce (*Pistia stratiotes*) spreads and fully covers sections B and C of the oxbow lake (Fig. 1). Section E (Fig. 1) represents the habitat type *Natural eutrophic lakes with Magnopotamion or Hydrocharition* (NATURA 2000 Code: 3150 (EC 2013)). The water chestnut (*Trapa natans*) and the common duckweed (*Lemna minor*) are dominant water plants in section E (Fig. 1). Otherwise, the oxbow banks are covered with sedges (*Carex* spp.), sweet flag (*Acorus calamus*) and the common cattail (*Typha latifolia*). Alder (*Alnus glutinosa*) and white willow (*Salix alba*) provide shadow for the water surface.

Field work

The survey was conducted in the years 2008 and 2019.

Due to lack of knowledge on the distribution of the European pond turtle near Sava River between Krško and the national border with Croatia, we set funnel traps in the Prilipe oxbow lakes between 12. 5. and 16. 5. 2008 to confirm the presence of the European pond turtle there. The effort invested corresponds to 46 trap days. A trap day was defined as 24-hour trapping with one trap. Turtles were also caught by hand or with a deep net.

In 2019, the survey was repeated and conducted in four periods: from 15. 4. to 19. 4., from 22. 4. to 26. 4., from 18. 7. to 22. 7., and from 16. 7. to 30. 7. The effort invested corresponds to 432 trap days. Four periods serve to estimate the population size using the capture-recapture approach. Since the European pond turtles begin with their sexual activities immediately after hibernation, we started with sampling in spring. Most females lay eggs in the first half of June (Fritz 2003) and do not feed during this time (Lukina 1966). This is why we carried out no sampling during this time.

Before setting the funnel traps, the area was thoroughly surveyed for potential individuals basking in the sun on tree trunks, dead wood, vegetation or sunny shores. Depending on the presence of turtles, the funnel traps were placed in different sections of the oxbow lake to increase the likelihood of catching them. To prevent the trapped turtles from drowning, one third of a funnel trap remained above the water surface. All traps were fixed to prevent sinking. Beef and pork liver were used for bait. Traps were controlled daily and rebaited on every second day.

We measured, weighed, photographed and individually marked turtles by marginal notching (Vamberger & Kos 2011). All captured individuals were released at the capture site immediately after processing. Sex was determined based on colour of their eyes and other sex specific morphometric characters (Vamberger & Kos 2011).

Age was estimated as a combination of the number of growth rings and shell abrasion. Age can be accurately determined by the number of growth rings only for animals of up to 10 years, where single growth rings are still clearly visible. Juveniles represent individuals of up to the age of 2 years, while 2–10 year olds represent subadults (Fritz 2003). Single growth rings are not visible any longer in old individuals, so the age cannot be determined accurately. Based on shell

abrasion, adults were divided into three classes: young adults, middle aged adults and old adults (Meeske 2006, Vamberger & Kos 2011).

Their abundance was defined as the relative measure (Krebs 1989) of the mean number of trapped turtles per 10 trap days. If turtles were trapped more than once, this was not taken into account in the calculation of relative densities.

The population size was calculated based on data from 2019 with the Schnabell method for closed population (Krebs 1989) using the formula: $N = \frac{\sum_t (Ct * Mt)}{\sum_t Rt}$, with *Ct* meaning the total number of individuals caught in sample t, *Rt* the number of individuals already marked when caught in sample t, and *Mt* the number of marked individuals in the population just before the *t*-th sample is taken.

In the short period, when the survey was conducted, we can assume there were no arrivals to the population and the mortality rate was zero. The population is geographically isolated, so there was no significant movement in or out from the area. Anglers from the local angling club confirmed one sighting of the turtle at mouth of the oxbow along the Sava River. Single movements of European pond turtles outside our area are expected in a longer period, which has no effect on our assumption of a closed population between April and August 2019.

Results

Distribution and relative density

In 2008, one European pond turtle was trapped into a funnel trap, while two additional turtles were caught by feeling them in mud (muddling technique). One individual was younger than 10 years. The indigenous red-eared sliders (*Trachemys scripta elegans*) were also observed.

In 2019, we had 99 captures of European pond turtles, which include 30 recaptures. Average abundance was 2.29 (number of trapped turtles per 10 trap days). It means that, on average, two European pond turtles were trapped in 10 traps which were set for one day or, in other words, two turtles were trapped in one trap set for 10 days. Abundance was the highest in C, D and E sections (Tab. 1, Fig. 1).

One hatchling was found in a headland furrow next to the oxbow lake on 23. 4. 2019, seeking for access to water. Additionally, mating of European pond turtles was observed on 18. 4. 2019. All the individuals from our survey belonged to the subspecies *Emys orbicularis orbicularis*. The subspecies was determined based on morphological characters (colour of their eyes and body size (Fritz 2003)).

Table 1. Relative densities of the European pond turtle (*Emys orbicularis*) in different sections (A–E) of the Prilipe oxbow lakes in 2019.
Tabela 1. Relativne gostote močvirskih sklednic (*Emys orbicularis*) v različnih odsekih (A-E) mrtvic Prilipe v letu 2019.

Sections of the oxbow lake/ Deli mrtvice	Number of hunting days/ Število lovnih dni	Number of individuals/ Število osebkov	Relative density (number of individual/10 trap days)/ Relativna gostota osebkov (število osebkov/10 lovnih dni)
A	48	0	0
B	56	2	0.36
C	192	56	2.92
D	48	22	4.58
E	88	19	2.16
Sum	**432**	**99**	**2.29**

At least 20 of indigenous red-eared sliders were observed and a one year old turtle was caught on 17. 4. 2019. In addition, the yellow-bellied terrapin (*Trachemys scripta scripta*) was observed.

Sex and age structure in 2019

A total of 70 different individuals were identified in 2019: 69 individuals were caught in traps, one juvenile was found outside the water, in the nearby field. There were 34 males and 33 females (M:F sex ratio 1.03:1) in total. Sex could not be determined for 3 young turtles. Out of 67 individuals, most (26 individuals; 38.8 %) were classified as subadults (2–10 years old), followed by 25.4 % young adults, 23.9 % middle aged adults and 11.9 % old adults.

Population size estimation

The population in the Prilipe oxbow lakes is estimated at 125 adult and subadult individuals (81–212 with 95 % confidence interval) in 2019. However, this prediction was made due to the recapture success of adult and subadult individuals. Individuals below 3 years were not caught in traps and are not considered in the estimation. We also observed movements between different parts of the oxbow lakes (Fig. 1) assuming that every turtle older than 3 years could possibly be caught. The density is calculated at 28 individuals per 1 ha of water, considering that the whole population is distributed only in the southern part of the area estimated to cover 4.5 ha in total.

Table 2. Input data for population size estimation in 2019. $\mathbf{C_t}$ – total number of individuals caught in sample *t*; $\mathbf{R_t}$ – number of individuals already marked when caught in sample *t*; $\mathbf{U_t}$ – number of individuals marked for the first time and released in sample *t*; $\mathbf{M_t}$ – number of marked individuals in the population just prior to *t* sampling.
Tabela 2. Vhodni podatki za oceno velikosti populacije v letu 2019. $\mathbf{C_t}$ – število ujetih želv v lovu *t*; $\mathbf{R_t}$ – število ujetih živali v lovu *t*, ki so predhodno že označene; $\mathbf{U_t}$ – število prvič ujetih, označenih in izpuščenih živali v lovu *t*; $\mathbf{M_t}$ – število označenih živali v populaciji pred vzorčenjem *t*.

Series number of sampling/ Številka vzorčenja	Number of captures (Ct)/ Število ulovov	Number of recaptures (Rt)/ Število ponovnih ulovov	Number of newly marked (Ut)/ Število novo označenih	Number of marked individuals in total (Mt)/ Število vseh označenih osebkov
1	16	0	16	0
2	11	4	7	16
3	33	5	28	23
4	28	10	18	51

Discussion

Distribution

Our study in the Prilipe oxbow lakes along the Sava River reveals a new vital population of the European pond turtle for Slovenia and the first one in the Posavje region. The proposal of Natura 2000 sites for the European pond turtle in the year 2003 (Tome 2003) as well as for many other species listed in Habitat Directive was made on the existing data of the time, without additional research. Consequently, the vital population of the Prilipe oxbow lakes was left out from Natura 2000 site. In the case of the European pond turtle, the proposal was based on the occurrence data or observation density. According to the methodology used for defining Natura 2000 network in 2003, we believe that the Prilipe oxbow lakes certainly fulfilled all conditions for establishment of a Natura 2000 site.

Spatial distribution of individuals in the area is not even. The lowest number of European pond turtles was caught in the western part of the oxbow lake (sections A, B; Fig. 1) and the highest in the eastern part of the oxbow lake (sections C, D, E; Fig. 1). Section C is almost completely covered with water lettuce during the summer, and most of section E is covered with water chestnut. The water surface of section D is small and is not covered with macrophytes. We can conclude that the invasive water lettuce has no negative impact on the European pond turtle. It seems that it has the same function as other indigenous macrophytes, although it is denser and produces higher biomass than other floating macrophytes. There are probably more reasons for the absence of the European pond turtle in the western part of the oxbow lake. In section A, the water is deep and shores are steep, the surrounding area is inappropriate for egg laying and the neighbouring area is inhabited, which consequently leads to interferences caused by visitors, anglers, dog walkers, etc. In section B, water is shallow and waste water from the treatment plant is discharged there.

Sex and age structure of the population

Our results with 38.8 % of subadults are similar to those in Bela krajina where 31 % of trapped individuals were subadults (Vamberger et al. 2013). Young individuals, considered to be 1-2 years old, are rarely trapped in funnel traps. Thus the population of the Prilipe oxbow lakes and Bela krajina seem to be at first glance healthier than the population from Ljubljansko barje (Vamberger & Kos 2011, Vamberger et al. 2017), where fewer subadults have been found. However, turtle habitats of the Prilipe oxbow lakes and Ljubljansko barje (with water channels) are different. The sex ratio in the Prilipe oxbow lakes is only slightly in favour of males (1.03:1), while in Bela krajina it is significantly higher with 1.72:1 (Vamberger et al. 2013). In general, the sex ratio is often in favour of males all over the distribution range (Fritz 2003).

A stable viable turtle population is defined as one having the reproductive capability to sustain itself without immigration of individuals from other populations (U.S. Fish and Wildlife 1993). The population in the Prilipe oxbow lakes seems to be viable according to this. The age structure is comparable to the viable population from Golek in Bela krajina (Vamberger et al. 2013) and we have a proof of successful reproduction. In addition to the one hatchling found during our survey in April 2019, we caught up to 8 years old subadults, indicating successful reproduction for at least the last 8 years.

Estimation of the population size

There are only few published studies on the population size estimation of the European pond turtle in Europe (Fritz 2003, Balázs & Györffy 2006), so comparisons are not so easy to make. However, the density in the Prilipe oxbow lakes is 100 times higher than at Ljubljansko barje (Vamberger et al. 2017), but the system of ditches in agriculture area of Ljubljansko barje is not comparable with the Prilipe oxbow lakes. Compared to the density in the oxbow lake along the Tisza River in Hungary, the density of the European pond turtle of the Prilipe oxbow lakes is 20 times lower (Balázs & Györffy 2006).

Nature conservation implications

Aquatic habitats are crucial for the existence of the European pond turtle in many ways. All individuals need water while feeding, since they cannot swallow food without it, especially if it was preyed upon on land (Wermuth 1952). It literally means that despite abundance of food, the European pond turtle can not survive without water (Wermuth 1952). However, for long term survival, terrestrial habitats are important for the species as well, as they lay eggs in dry sandy places (Fritz 2003). They are important also for daily and seasonal movements. In Slovenia, habitat loss and nest destruction by intensified agriculture is a real threat to the species (Vamberger et al. 2017). Consequently, it is of outstanding importance to find the egg-laying sites to preserve the species and its habitat. The egg-laying site(s) of the Prilipe oxbow lakes remain unknown, even though one hatchling was found next to the oxbow lake in the south-east (section C). With this single finding, it is impossible to conclude where other egg-laying sites are. It is well known that even small intervention in the terrestrial habitats around the water body can impact the species significantly and may even drive it to extinction.

Interventions are not only direct changes of habitat, but also changes in the flood regime or changes in the groundwater level. European pond turtles can lay eggs very close to the water body, up to 1 km away, up to 1.2 km away or even up to 5 km away (Fritz & Günther 1996, Jabłoński & Jabłońska 1998, Schneeweiss et al. 1998, Zuffi 2000). Therefore, Ficetola et al. (2004) suggested at least a 1–1.5 km wide buffer zone of terrestrial habitat around the water body to maintain favourable condition for the population and to protect the egg-laying sites. However, not even a protection of 500 m buffer zone is possible anymore for the Prilipe oxbow lakes due to human impact. The Prilipe oxbow lakes are trapped between the highway in the south, the river Sava in the east and the populated area Čatež health resort in the north. The management of the terrestrial habitats next to the oxbow lake is therefore of immense importance for this population and depends additionally on the time when hatchlings come out of the nests. For some parts of Slovenia, it is known that hatchlings overwinter in the nest and hatch in the next spring (Vamberger 2009, Vamberger & Kos 2011, Vamberger et al. 2017). Our results indicate the same for the Prilipe oxbow lakes. However, with a single observation we cannot conclude that this is true for significant proportion of hatchlings, so a more detailed study is necessary. Nevertheless, the single sighting of one hatchling is already enough to manage terrestrial habitat around the oxbow lakes very carefully and to ensure dry areas for egg-laying. Furthermore, to secure a viable population for the European pond turtle, the management of the area needs to consider that turtles need a peaceful environment, especially in the time of egg-laying (Wermuth 1952). The conditions around the south-eastern part of the Prilipe oxbow lakes (sections C, D, E) are probably the most favourable site for egg-laying from this perspective. There are no residential buildings and consequently no pets such as dogs and cats. Visitors or strollers from the Čatež Spa come mostly during the day to avoid mosquitos, so they don't disturb turtles in the evening, when turtles proceed from the water to the egg-laying sites. The banks of the oxbow lake are difficult to access, since they are overgrown with reeds and other vegetation, which is again in favour of the turtles. Predators, however, are another threat especially for hatchlings and nests. In general, most of the nests are damaged immediately after eggs are laid or during hatching (Lukina 1966) by predators like the wild boar (*Sus scrofa*) or red fox (*Vulpes vulpes*) (Fritz 2003). For the Prilipe oxbow lakes, at least the wild boar can be excluded as possible predator, since we did not find any sign of wild boars near the oxbow lake and there has been no resident population of this species confirmed by the local hunting association. But hatchlings are preyed on also in the water by predatory fish like pike (*Esox lucius*) or catfish (*Silurus glanis*) (Fritz & Günther 1996). The density of predatory fish species is similar in different parts of the Prilipe oxbow lakes (observations of the local Angling club). At the same time, there are many other fish species which are on the European pond turtle's daily menu.

Another threat for the European pond turtle are non-indigenous turtles (Vamberger et al. 2012, Standfuss et al. 2016). The overall impact of non-indigenous turtles at the Prilipe oxbow lakes is not known yet and a study should be conducted in the future. We observed at least two invasive subspecies of turtles; the red-eared terrapin and the yellow-bellied terrapin. This species is a serious threat to our indigenous turtles (Hidalgo-Vila 2009, Pérez-Santigosa et al. 2008, Standfuss et al. 2016) and in general to aquatic ecosystems worldwide (GISD 2019). Successful breeding of *Trachemys* could be confirmed in the Prilipe oxbow lakes by one hatchling of a red-eared pond slider. This is the fourth area in Slovenia (Vamberger et al. 2012, Standfuss et al. 2016), where breeding of red-eared terrapins in nature has been confirmed. Further studies are necessary to study the invasive potential of the species in this area.

For the long-term survival of the European pond turtle population in the Prilipe oxbow lakes it is of immense importance to find the egg-laying sites to minimize the potential threats like agriculture or other interventions into terrestrial habitats. The area is small and squeezed between the highway and the Sava River, but it hasn't changed much in the last 15 years. However, the north western part of the oxbow lake is not suitable for the turtles due to fishing, tourists and agriculture. The density of turtles in the Prilipe oxbow lakes is much lower than in other similar habitats in Europe (Fritz 2003, Balázs & Györffy 2006), but additional research could give more precise data on population characteristics. Improving the western part of the oxbow lake would increase the available and suitable habitat for the turtles and in the long term contribute to the growth of a stable and healthy population. In the past, the population of the Prilipe oxbow lakes was supposedly part of a big population established along the Sava River, distributed between the Jovsi, Sotla and Krka River with its tributaries. If genetic analysis would confirm that the Prilipe oxbow lakes population represents remains of the original population, individuals could be taken to repopulate SE parts of Slovenia in the future and to connect the remaining populations along the Sava River.

Povzetek

V zadnjem desetletju smo zaradi tarčnih raziskav dobili veliko novih podatkov o razširjenosti in ekologiji močvirske sklednice (*Emys orbicularis*) v Sloveniji (Vamberger 2009, Krofel et al. 2009, Vamberger & Kos 2011, Grželj & Grželj 2012, Vamberger et al. 2013, 2015, 2017, Pekolj et al. 2015, Govedič et al. 2016). Vrsta je uvrščena na Prilogi 2 in 4 Direktive o habitatih (OJ 1992). Zavarovane so živali in tudi njen habitat, ne glede na to, ali je v območju Natura 2000 ali ne (Ur. l. RS 2004a). Pred vsakim posegom v habitat bi bilo treba presoditi morebitne negativne vplive na populacijo močvirske sklednice. Povsod, kjer je bila opažena ali pa obstaja potencialen habitat, je treba najprej oceniti velikost populacije, preveriti razmnoževalni uspeh in na podlagi teh podatkov oceniti vitalnost populacije. Močvirsko sklednico so v glinokopu pri Brežicah opazili že pred dvajsetimi leti (Hudoklin 1995), vendar primerna območja vzdolž reke Krke in v Posavju vse do naše študije niso bila raziskana.

Prvič smo pojavljanje močvirske sklednice na območju mrtvic Prilipe potrdili leta 2008, ko smo našli tri osebke. Leta 2019 smo območje raziskali bolj natančno in sistematično. V štirih obdobjih od aprila do julija smo na območju celotne mrtvice nastavili vrše, v katere se je skupno ujelo 99 želv, od tega 70 različnih osebkov. Na podlagi zunanjih morfoloških znakov smo vsem osebkom določili spol in starost. Spolno razmerje je bilo z 1,03:1 le malenkost v prid samcem. V brazdi njive poleg mrtvice smo našli enega ravno izleženega mladiča, ki je iskal dostop do vode. Populacijo smo ocenili na 125 osebkov, gostoto pa na 28 osebkov na 1 ha vodne površine. Izsledki naše raziskave razkrivajo še eno vitalno populacijo močvirske sklednice v Sloveniji in prvo v Posavju. Zaradi pomanjkanja znanja leta 2003 območje ni bilo uvrščeno v Natura 2000 omrežje, čeprav bi po današnjih podatkih ustrezalo vsem predpisanim kriterijem.

V Sloveniji močvirsko sklednico najbolj ogrožata izguba habitatov in uničevanje gnezd (Vamberger et al. 2017). Za varovanje vrste je ključno, da poznamo mesta odlaganja jajc. Prav ta bi bilo treba najti tudi za populacijo želv v Prilipah, saj bomo lahko le tako še naprej ohranjali populacijo v ugodnem stanju. Glede na podatke iz literature bi morali okoli vodnega habitata v obzir varstva vključiti še vsaj 1-1,5 km širok puferskega pasa kopenskega habitata (Ficetola et al. 2004). V Prilipah ne moremo več zagotoviti niti 500 m širokega pasu, saj je območje že zdaj povsem stisnjeno med avtocesto, reko Savo in Čateškimi toplicami. Močvirsko sklednico v Prilipah ogrožajo tudi tujerodne želve rumenovratke (*Trachemys scripta scripta)* in rdečevratke (*Trachemys scripta elegans)*. Pri slednji smo potrdili tudi razmnoževanje.

Dolgoročno bo populacija močvirske sklednice na tem območju preživela le, če bomo zagotovili majhen vpliv kmetijstva in druge posege v kopenski habitat. Z izboljšanjem vodnega habitata v zahodnem delu mrtvice lahko dodatno spodbudimo rast populacije. V preteklosti je bila verjetno populacija močvirske sklednice iz Prilip del večje populacije vzdolž reke Save in njenih pritokov. Če bi to potrdili z genetsko analizo, bi lahko z osebki iz te populacije ponovno naselili območje jugovzhodne Slovenije in tako povezali med sabo druge, sedaj ločene, populacije vzdolž reke Save. Samo tako bomo zagotovili gensko raznolikost populacije oz. vrste, ki je nujna za njeno preživetje.

Acknowledgements

Turtles were surveyed and marked in accordance with licence (35601-32/2010-6) issued to the Centre for Cartography od Fauna and Flora by the Slovenian Environment Agency of the Ministry of the Environment and Spatial Planning of the Republic of Slovenia. Field work was done within the framework of the following two projects: »Pregled živalskih in rastlinskih vrst, njihovih habitatov ter kartiranje habitatnih tipov s posebnim ozirom na evropsko pomembne vrste, ekološko pomembna območja, posebna varstvena območja, zavarovana območja in naravne vrednote na vplivnem območju predvidenih HE Brežice in HE Mokrice« (project client: Hidroelektrarne na Spodnji Savi, d.o.o.) in 2008 and in 2019 the project »Inventarizacija in popis želv v mrtvici Prilipe« (project client: Savaprojekt d.d., Krško). Aleksandra Lešnik from CKFF prepared the Figure 1.

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NATURA SLOVENIAE 22(1): 19-27
KRATKA ZNANSTVENA VEST

Prejeto / Received: 31. 3. 2020
Sprejeto / Accepted: 13. 7. 2020

Ocena številčnosti populacije velikega/panonskega pupka (*Triturus carnifex/dobrogicus*) v mrtvici Zaton (Petanjci) ob Muri (SV Slovenija)

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Izvleček. Leta 2018 smo v mrtvici Zaton na Petanjcih (Natura 2000 »Mura«, SAC SI3000215 & SCI SI5000010) ocenjevali številčnost populacije velikega/panonskega pupka (*Triturus carnifex/dobrogicus*). Deset zaporednih dni v obdobju razmnoževanja dvoživk smo v mrtvici postavili Ortmannove pasti, potem pa fotografirali individualno specifični ventralni barvni vzorec vseh ujetih osebkov velikih/panonskih pupkov. Iz primerjav fotografij po dnevih in med pastmi smo po metodi ulova, označitve in ponovnega ulova ocenili velikost populacije na 2951 osebkov (95 % interval zaupanja: 2226–3977 osebkov).

Ključne besede: dvoživke, Amphibia, veliki pupek, panonski pupek, *Triturus carnifex/dobrogicus*, ocena velikosti populacije, mokrišča, mrtvica Zaton, Mura, Slovenija

Abstract. Estimation of the Italian crested/Danube crested newt (*Triturus carnifex/dobrogicus*) population size in the Zaton oxbow lake (Petanjci) along the Mura River (NE Slovenia) – In 2018 we estimated the population size of the hybrid population of Italian crested/Danube crested newt (*Triturus carnifex/dobrogicus*) in the Zaton oxbow lake, Petanjci (Natura 2000 »Mura«, SAC SI3000215 & SCI SI5000010). The Ortmann traps were set in the lake for ten consecutive days during the reproductive season. We used the mark-release-recapture method by comparing photographs of individually specific belly patterns of the trapped newts. The estimated Italian crested/Danube crested newt population size in the Zaton oxbow lake was 2,951 individuals (95 % confidence interval: 2,226–3,977 individuals).

Key words: amphibians, Amphibia, Italian crested newt, Danube crested newt, *Triturus carnifex/dobrogicus*, population size estimation, wetlands, Zaton oxbow lake, Mura River, Slovenia

Uvod

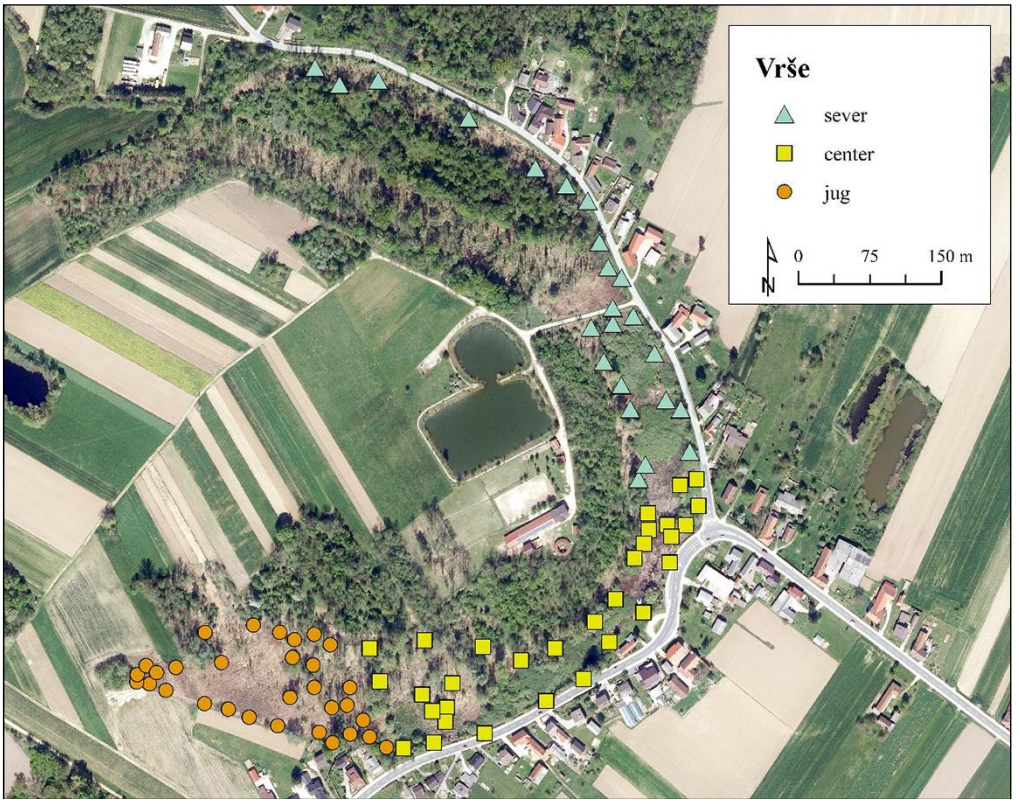
Mrtvica Zaton na Petanjcih (občina Tišina, WGS84 koordinate: 46,6554, 16,0567) leži v območju Natura 2000 »Mura« (SAC SI3000215 & SCI SI5000010). Gre za obsežen mrtvi rokav Mure v poznem sukcesijskem stadiju. Nekaj čez 22 ha veliko območje mrtvice z zunanjim obsegom blizu 3,5 km, ki leži zunaj visokovodnega nasipa, je botanična, zoološka in ekosistemska naravna vrednota državnega pomena (ZRSVN 2019). V pričujočem prispevku objavljamo rezultate ocene številčnosti populacije velikega/panonskega pupka (*Triturus carnifex/dobrogicus*) v mrtvici. Medtem ko je veliki pupek v Sloveniji splošno razširjen, je panonski pupek omejen na njen vzhodni del, vključno z obravnavano lokaliteto (Stanković & Delić 2012, Rašl 2017). Ker je za zanesljivo določitev obeh vrst in njunih hibridov potrebna genetska analiza, ju v tej raziskavi obravnavamo kot en takson. V večini evropskih držav je populacijski trend obeh vrst negativen (Arntzen et al. 2009, Romano et al. 2009). Obe vrsti sta ogroženi predvsem zaradi hitrega izgubljanja vodnih in kopenskih habitatov ter sta kvalifikacijski za ustanovitev posebnih varstvenih območij Natura 2000 (vrsti v Prilogi 2 Habitatne direktive).

Materiali in metode

V mrtvici smo spomladi leta 2018 postavili Ortmannove pasti (Drechsler et al. 2010, Cipot et al. 2011) za lov pupkov. Dovoljenje za lov št. 35601-58/2017–4 je Herpetološkemu društvu izdalo Ministrstvo za okolje in prostor, Agencija RS za okolje. Pasti (»vrše«) smo postavili na razdalji 10 do 20 m vsaksebi in v globinah vode od približno 30 cm do 1 m. Ker smo imeli na voljo 31 pasti, smo mrtvico vzorčili v treh delih (Sl. 1). Pasti smo imeli v vodi deset zaporednih dni: v skrajno južnem delu mrtvice od 25. 4. do 28. 4., v njenem osrednjem delu od 28. 4. do 1. 5. in v severnem delu (23 pasti) od 1. 5. do 4. 5. Za vabo smo uporabljali briketirano ribjo hrano, ki se raztaplja počasi. Pasti smo pregledovali vsak dan. Fotografirali smo trebušno stran vseh ujetih velikih/panonskih pupkov in jih tako na osnovi značilnega barvnega vzorca individualno »označili« (Heyer et al. 1994). Iz primerjav fotografij po dnevih in med pastmi smo po metodi ulova, označitve in ponovnega ulova spomladi leta 2018 ocenili velikost populacije v mrtvici. Fotografije smo med seboj primerjali brez posebne programske opreme, s primerjavo vseh možnih parov na dveh zaslonih. Karte točkovnih nahajališč oz. opažanj pupkov smo izrisali v programu ArcGis 10.4 (ESRI, 2016).

Glede na načrt vzorčenja (10 zaporednih dni vzorčenja) smo predvidevali, da mora biti populacija zaprta in panmiktična. Posamezen dan vzorčenja je ponazarjal en odlovni interval; skupaj jih je bilo devet. Ker je bila za samice ponovna ulovljivost nizka (le dva ponovna ulova), smo podatke za oba spola združili za nadaljnje analize. V programu MARK (White & Burham 1999) smo uporabili modul za zaprte populacije (*Closed captures*, opcijo *Huggins' p and c*), kjer smo testirali različne modele. Pri ocenjevanju številčnosti zaprtih populacij primerjamo modele, ki predpostavljajo različno odvisnost parametrov ulovljivosti (parameter p) oz. ponovne ulovljivosti (parameter c) med skupinami osebkov in med vzorčnimi intervali. Tako smo testirali štiri modele: M_t (časovna odvisnost ulovljivosti, pri čemer je $p = c$), M_b (vedenjski odziv na ujetje, »trap-happy« ali »trap-shy«, $p \neq c$), M_h (heterogenost v ulovljivosti v populaciji) in M_0 (ulovljivost je enaka med osebki in v času). Načrtna matrika vseh uporabljenih modelov je

prikazana v Prilogi 1. Najboljši model smo izbrali glede na kriterij AIC in po tem modelu izračunali predvidene parametre: ulovljivost v posameznem vzorčnem intervalu ter oceno velikosti populacije.



Slika 1. Lokacije Ortmanovih pasti v mrtvici Zaton leta 2018.
Figure 1. Locations of the Ortman traps in the Zaton lake in 2018.

Rezultati in diskusija

V nekaterih pasteh smo ujeli večje število odraslih osebkov, največ 24 v posamezni pasti v enem dnevu. Skupno število ujetih osebkov je bilo 489 (82 samic in 407 samcev), od teh smo jih 38 ujeli dvakrat (7,2 %). Le en samec se je ujel trikrat (29. 4., 30. 4. in 1. 5.). Tudi pri navadnem pupku (*Lissotriton vulgaris*) je bilo razmerje med spoloma pri osebkih, ki smo jih ujeli v pasti, podobno (6,7-krat več samcev kot samic). Zato domnevamo, da je večina samic pupkov med našim vzorčenjem odlagala jajčeca in so bile zato slabše ulovljive, tako da je njihovo dejansko število verjetno višje. Ravno tako je verjetno, da dela populacije zaradi globine vode in zaraščenosti mrtvice nismo odlovili.

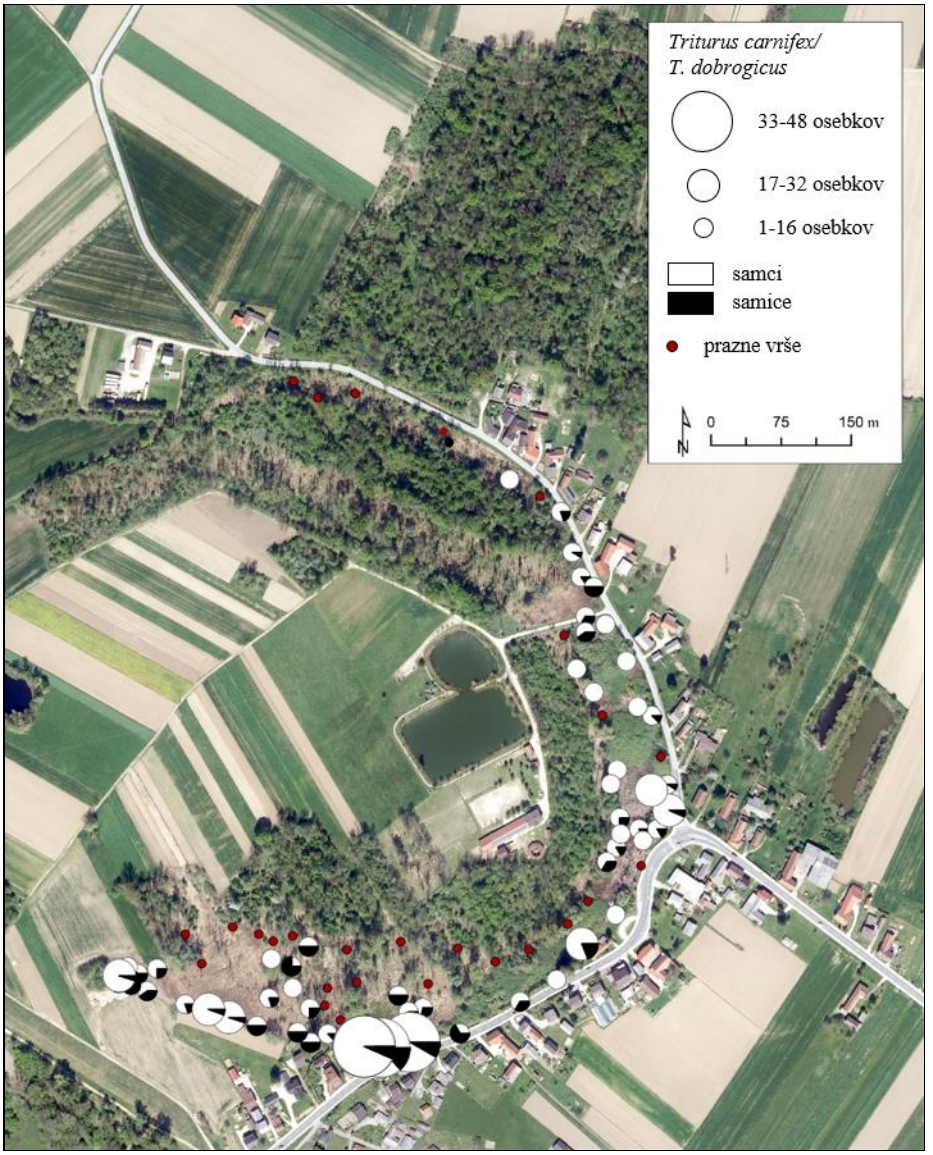
Po drugi strani je hitro upadanje vode terjalo razmeroma kratek časovni interval vzorčenja (mrtvica se je do ponovnega ogleda 8. 6. 2018 skrčila na manj kot polovico svojega spomladanskega obsega). Zaprtost in panmiktičnost populacije v času raziskave potrjujejo ponovni ulovi med jugom in centrom ter centrom in severom mrtvice, vendar ocenjujemo, da je severni del mrtvice nekoliko bolj izoliran. Morda bi bilo smiselno v prihodnje za primerjavo menjavati lokacijo vsak dan (npr. jug, center, sever, jug, center, sever ...).

Najnižjo vrednost kriterija AIC je imel model populacije M_t (časovna odvisnost ulovljivosti, pri čemer je $p = c$) in po tem modelu smo izračunali predvidene parametre: ulovljivost v posameznem dnevnem vzorčnem intervalu (Tab. 1) ter oceno velikosti populacije. Vsi preostali testirani modeli so imeli veliko slabšo oceno AIC oz. so se močno razlikovali od najboljšega modela (ΔAIC 97,9 za model M_b, 125,9 za M_0 in 129,9 za M_h), zato jih nismo upoštevali pri oceni številčnosti. Obstaja možnost, da nekatere predpostavke preostalih modelov ustrezajo preučevani populaciji (predvsem heterogenost v populaciji), vendar so bile ulovljivosti zelo majhne (0,5–3,6 %), kar onemogoča tovrstno modeliranje. Tako smo velikost populacije velikega/panonskega pupka ocenili na 2951 osebkov (95 % interval zaupanja: od 2226 do 3977 osebkov).

Tabela 1. Parametri modela M_t, po katerem smo ocenjevali velikost populacije.
Table 1. Parameters of the model M_t by which population size was estimated.

Ulovljivost (p) po modelu M(t)	Časovni interval	Ocena parametra	Standardna napaka	95 % interval zaupanja
p_1	25. 4.–26. 4.	0,0193	0,0038	0,0131–0,0285
p_2	26. 4.–27. 4.	0,0237	0,0045	0,0163–0,0344
p_3	27. 4.–28. 4.	0,0200	0,0039	0,0136–0,0294
p_4	28. 4.–29. 4.	0,0366	0,0065	0,0258–0,0516
p_5	29. 4.–30. 4.	0,0319	0,0058	0,0223–0,0453
p_6	30. 4.–1. 5.	0,0210	0,0041	0,0143–0,0308
p_7	1. 5.–2. 5.	0,0047	0,0015	0,0026–0,0086
p_8	2. 5.–3. 5.	0,0146	0,0031	0,0096–0,0221
p_9	3. 5.–4. 5.	0,0071	0,0019	0,0042–0,0119

Zanimiva je tudi gručasta prostorska razporeditev velikih/panonskih pupkov v mrtvici (Sl. 2). Skoraj vsi pupki, tako kot tudi druge vrste dvoživk, so se zadrževali ob južnem in vzhodnem robu mrtvice. To se kaže tudi v ulovljivosti, ki je bila v južnem (1,9–2,4 %) in osrednjem (2,1–3,7 %) delu višja, kot v severnem delu (0,5–1,5 %). Razlog za to bi lahko bil v različni stopnji osončenosti in posledično ugodnejši spomladanski temperaturi vode, večji količini hrane ali v izogibanju nevretenčarskim plenilcem ali morebitnim drugim pritiskom na nasprotni strani. Morda na odsotnost pupkov na severu mrtvice poleg nizke vode vplivajo tudi mineralni izviri. Vpliv mikroklimatskih razmer na pojavljanje bi bilo treba še podrobneje raziskati.



Slika 2. Gručasta prostorska razporeditev in neenakomerna zastopanost spolov ulovljenih osebkov velikega/panonskega pupka v mrtvici Zaton spomladi 2018. Velikost krogov je sorazmerna s celotnim številom ulovljenih osebkov v posameznih pasteh v treh dneh, ki smo ga zaradi boljše preglednosti razdelili v tri razrede.

Figure 2. Clustered spatial distribution and unequal sex representation of captured Italian crested/Danube crested newt individuals in the Zaton oxbow lake in spring 2018. The size of the pies is proportional to the total number of individuals caught in each trap over three days, for clarity divided into three groups.

Za populacijo velikega/panonskega pupka v mrtvici Zaton zanesljivih velikostnih trendov žal ne moremo podati, saj edina dosedanja sorodna raziskava iz let 2013 in 2014 (Cipot et al. 2015) zaradi majhnega števila ujetih osebkov ne daje ocen velikosti populacije. Kljub temu pa lahko povzamemo, da je populacija velikega pupka trenutno v ugodnem stanju in na videz v porastu. Iz naših podatkov je razviden pomen večletnega spremljanja stanja populacij dvoživk, saj so rezultati zelo odvisni od vremenskih razmer. Tovrstne raziskave je treba prilagoditi vremenskim razmeram in hidrološki periodiki lokalnega okolja, saj se zaključki lahko zelo razlikujejo celo med dvema vremensko ugodnima letoma (npr. Cipot et al. 2015). Le tako je mogoče sproti ugotavljati (potencialne) vzroke za nezaželene spremembe (npr. upad) populacije dvoživk in hitro ter primerno ukrepati. Ob tej priložnosti posebej opozarjamo na alarmantno hitrost izsuševanja in zaraščanja mrtvice, ki je domnevno v največji meri posledica regulacije potoka Kučnice (Baumann 2001, Triglav 2012), ter s tem potencialne izgube primernega razmnoževalnega habitata za nič manj kot 11 tu živečih vrst dvoživk.

Zahvala

Zahvaljujemo se dr. Andreju Pančurju za pomoč na terenu, Centru za kartografijo favne in flore (Marijan Govedič) za izposojo vrš in Geodetski upravi RS (Ida Rejc) za ortofoto podlago. Za raziskavo nismo bili deležni nobenega financiranja.

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Priloga 1. Načrtna matrika (design matrix) različnih modelov, ki smo jih primerjali pri analizi številčnosti populacije velikih/panonskih pupkov v mrtvici Zaton v programu MARK.
Appendix 1. Design matrix of different models, which were compared in the analysis of population size of Italian crested/Danube crested newts in the Zaton oxbow lake, using MARK programme.

Tabela/Table A. Model M_t : p(t) = c(t)

B1: p Int	Pam	B2: t1	B3: t2	B4: t3	B5: t4	B6: t5	B7: t6	B8: t7	B9: t8
1	1:p	1	0	0	0	0	0	0	0
1	2:p	0	1	0	0	0	0	0	0
1	3:p	0	0	1	0	0	0	0	0
1	4:p	0	0	0	1	0	0	0	0
1	5:p	0	0	0	0	1	0	0	0
1	6:p	0	0	0	0	0	1	0	0
1	7:p	0	0	0	0	0	0	1	0
1	8:p	0	0	0	0	0	0	0	1
1	9:p	0	0	0	0	0	0	0	0
1	10:c	0	1	0	0	0	0	0	0
1	11:c	0	0	1	0	0	0	0	0
1	12:c	0	0	0	1	0	0	0	0
1	13:c	0	0	0	0	1	0	0	0
1	14:c	0	0	0	0	0	1	0	0
1	15:c	0	0	0	0	0	0	1	0
1	16:c	0	0	0	0	0	0	0	1
1	17:c	0	0	0	0	0	0	0	0

Tabela/Table B. Model M_b : p(.) ≠ c(.)

B1: p Int	Pam	B2: t1
1	1:p	1
1	2:p	1
1	3:p	1
1	4:p	1
1	5:p	1
1	6:p	1
1	7:p	1
1	8:p	1
1	9:p	1
1	10:c	0
1	11:c	0
1	12:c	0
1	13:c	0
1	14:c	0
1	15:c	0
1	16:c	0
1	17:c	0

Tabela/Table C. Model M_0 : p(.) = c(.)

B1: p Int	Pam
1	1:p
1	2:p
1	3:p
1	4:p
1	5:p
1	6:p
1	7:p
1	8:p
1	9:p
1	10:c
1	11:c
1	12:c
1	13:c
1	14:c
1	15:c
1	16:c
1	17:c

Tabela/Table D. Model M_h : $p_a(.) = c_a(.)$, $p_b(.) = c_b(.)$, π

B1: pi Int	Pam	B2: p Int	B3: p Mixture
1	1:pi	0	0
0	2:p	1	1
0	3:p	1	1
0	4:p	1	1
0	5:p	1	1
0	6:p	1	1
0	7:p	1	1
0	8:p	1	1
0	9:p	1	1
0	10:p	1	1
0	11:p	1	0
0	12:p	1	0
0	13:p	1	0
0	14:p	1	0
0	15:p	1	0
0	16:p	1	0
0	17:p	1	0
0	18:p	1	0
0	19:p	1	0
0	20:c	1	1
0	21:c	1	1
0	22:c	1	1
0	23:c	1	1
0	24:c	1	1
0	25:c	1	1
0	26:c	1	1

NATURA SLOVENIAE 22(1): 29-32
FIELD NOTE

Prejeto / Received: 21. 6. 2020
Sprejeto / Accepted: 27. 7. 2020

Occurrence of fairy shrimp (*Chirocephalus croaticus*) in the lake Petelinjsko jezero during the 2008–2014 period

Pojavljanje kraškega škrgonožca *(Chirocephalus croaticus)* v Petelinjskem jezeru v obdobju 2008–2014

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The lake Petelinjsko jezero is the second largest, lowest lying and longest lasting of the Pivka intermittent lakes (SW Slovenia). In this particular lake, a small fairy shrimp crustacean *Chirocephalus croaticus* (Crustacea, Anostraca) lives, adapted to temporary wetlands. Although this species is declared endemic to the lake Petelinjsko jezero, it also occurs in large numbers in puddles of Jeredovce (Pipan 2005).

Brancelj & Gorjanc (1999) gave a detailed morphological description of the species in Slovenia, together with its ecology. The species does not survive in stagnant waters inhabited by fish. For its normal development it requires a certain period of time during which the thick-shelled eggs are exposed to drought and low temperatures (Brancelj & Gorjanc 2000).

Chirocephalus croaticus has the status of a vulnerable species (VU) in the IUCN Red list of Threatened Species (Sket 1996). It is also a rare species (R) in the Red List of lower crustaceans of Slovenia and is one of the protected species. It is included in the list of animal species listed in Annex 2, the habitats of which are protected under the Decree on protected wild animal species (Ur. l. RS 2002, Ur. l. RS 2004). Its population is potentially threatened by mechanical interventions and/or pollution (including fertilization of meadows) (Brancelj & Gorjanc 2000).

Based on multi-year sampling at different seasons (Tab. 1), the population appears to be stable. Under favourable conditions, the species occurs in large numbers (Brancelj & Gorjanc 2000). In addition to its occurrence, Jeklar (2019) studied the average size and sex ratio of *C. croaticus*, and how physical and chemical parameters of the water and air affect its population prevalence and size (Tab. 1).

During several years of our field observations of the lake Petelinjsko jezero (Kirn 2016), we occasionally noticed *C. croaticus*. It had never been observed in other Pivka intermittent lakes, while the lakes in Krajnikov dol and Jeredovce were not inspected. We observed fairy shrimps in the lake Petelinjsko jezero every year from 2008 to 2014 in ten periods when the lake was filled with water (Tab. 1). During our fieldtrips, we found fairy shrimps in all seasons; they were spotted throughout the spring until early summer, after which they were inspected only in late autumn and winter. Since fairy shrimps are difficult to spot during high water levels, our field data cover only the time when the lake water level was dropping. For example, in the December 2009–April 2010 period, when the lake basin was filled with water, fairy shrimps were spotted only in April, while their previous occurrences remain unknown. In general, the monthly occurrence of *C. croaticus* has changed over the years, depending on the lake dynamics.

The time when the lake basin is filled with water affects the occurrence of fairy shrimps. In the small lake, which was partially filled with water in June 2012 (Fig. 1), fairy shrimps appeared smaller and their density was lower than at the time when the lake was larger. In June 2010, however, fairy shrimp did not occur in the lake, reaching only the first filling phase and lasting for less than a week.

At high water levels, fairy shrimps are difficult to spot when individual specimens were observed in November 2010, specifically in the streambed leading from Jeglenk. Otherwise, fairy shrimps were observed in a puddle at the bottom of the Jeglenk sinkhole, which dries up before the main lake. Apparently, fairy shrimps at Jeglenk first separate from those in the main lake, and as this lake dries up, the population is divided further. Fairy shrimps appear longest at the bottom of the lowest parts of the lake Petelinjsko jezero, i.e. in the basin under estavelles in the southeastern part of the lake, as well as at the lowest section of the main cart track and in holes of the central basin. Their density increases with the water decrease.

Table 1. Time of occurrence of *Chirocephalus croaticus* (Crustacea, Anostraca) in the lake Petelinjsko jezero according to literature and our field data. Exact dates are given if available in the literature.
Tabela 1. Čas pojavljanja kraškega škrgonožca *Chirocephalus croaticus* (Crustacea, Anostraca) v Petelinjskem jezeru iz literature in naših terenskih podatkov. Natančni datumi so navedeni, če so na voljo v literaturi.

Month	**Brancelj & Gorjanc 1999*, Brancelj & Gorjanc 2000** (autumn 1999–spring 2000)	**Jeklar 2019** (spring 2018–spring 2019)	**Our observations in 2008–2014, when the lake was filled with water** (indicated in parentheses**)
Jan	2000: 20.1.		2013: 20. 1. (October 2012–January 2013)
Feb			2011: 12. 2., 19. 2. (September 2010–February 2011)
Mar			2009: 15. 3., 24. 3. (December 2008–March 2009)
Apr	1998: 17. 4., 23. 4., 30. 4. 2000: 19. 4.	2018: 11. 4., 13. 4., 17. 4., 20. 4., 23. 4., 25. 4.	2010: 13. 4., 21. 4., 24. 4. (December 2009–April 2010) 2011: 5. 4. (March–April 2011)
May	1998: 5. 5., 8. 5.	2018: 2. 5., 5. 5.	2008: 23.5. (March–May 2008) 2009: 2. 5., 3. 5., 5. 5., 6. 5. (March–May 2009) 2010: 28. 5., 30. 5. (May 2010) 2014: 4. 5., 17. 5. (till May 2014)
Jun		2019: 10. 6., 18. 6.	2012: 23. 6. (Jun 2012)
Jul			
Aug			
Sep			
Oct			
Nov		2018: 13. 11.	2010: 14. 11. (September 2010–February 2011)
Dec			

* Sampling was performed once or twice per year for a few years before 1998 and weekly in 1998, but the exact dates are given only for the late spring 1998. Colour scale: blue – winter, green – spring, yellow – summer, orange – autumn
** The time when the lake was filled with water is not given by exact dates – the period is defined monthly.
* Vzorčenje je bilo nekaj let pred letom 1998 opravljeno enkrat ali dvakrat na leto, leta 1998 pa tedensko. Datumi so navedeni le za pozno pomlad 1998. Barvna lestvica: modra – zima, zelena – pomlad, rumena – poletje, oranžna – jesen
** Trajanje pojavov jezera ni podano z natančnimi datumi – obdobje je opredeljeno mesečno.

Figure 1. The Petelinjsko jezero basin with smaller water surface (photo: Tina Kirn).
Slika 1. Kotanja Petelinjskega jezera ob nastanku manjšega jezera (foto: Tina Kirn).

The fairy shrimps were initially observed in the shallows of the flooded cart track (in the extent of the smaller lake) along the northern edge of the central basin. Some specimens were found dead on the dry cart track along the southern edge of this basin (May 2014). We believe that they were washed up on the lakeshore. As the water level dropped, only the lower part of the lake basin was flooded. During this time, the initially single lake splits into two smaller lakes. The fairy shrimps were found in the lake shallows of the flooded cart track at the bottom of the central basin, as well as in holes and small basins along the lake. Before the disappearance of the lake, we observed fairy shrimps only in the lowest parts of the lake bottom. Thus, after drying, the patches of dead fairy shrimps remained there. If there are filamentous algae in the lake, the dead fairy shrimps are pressed into the algae paper that remains at the dried up bottom (Fig. 2). We believe that based on the number and size of the patches we could check/track the state of the fairy shrimp population (stable, increasing, decreasing) in the lake.

To conclude, *C. croaticus* occurs in the lake Petelinjsko jezero regularly and in large numbers, as already stated by Brancelj & Gorjanc (2000) and Jeklar (2019). We observed fairy shrimps in all seasons, but were the commonest in spring.

Figure 2. Examples of finds of fairy shrimps (*Chirocephalus croaticus*) in the lake Petelinjsko jezero (photo: Tina Kirn).
Slika 2. Primeri najdb kraškega škrgonožca *(Chirocephalus croaticus*) v Petelinjskem jezeru (foto: Tina Kirn).

Acknowledgements

I would like to thank Tanja Pipan and Anton Brancelj, to whom we sent some photos of the found fairy shrimps for determination. I am also very grateful to the editor and anonymous reviewer for suggestions that significantly improved the manuscript.

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NATURA SLOVENIAE 22(1): 33-34
FIELD NOTE

Prejeto / Received: 23. 1. 2020
Sprejeto / Accepted: 30. 3. 2020

First record of the species *Mythimna andereggii* (Boisduval, 1840) (Lepidoptera: Noctuidae) in Croatia

Prva najdba vrste *Mythimna andereggii* (Boisduval, 1840) (Lepidoptera: Noctuidae) na Hrvaškem

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In Croatia, the genus *Mythimna* Ochsenheimer, 1816, is represented by 15 species (Kučinić 1997, Karsholt & Nieukerken 2020). Members of this genus occurring in Europe are very similar in appearance, with yellow-brownish wings with more or less black dots and/or markings on the wing. Most species can be distinguished by external wing morphology, while for some the examination of genitalia is necessary (e.g. *Mythimna alopecuri/Mythimna sicula*, see Stojanović & Glavendekić 2005).

While some species inhabit the whole country, some of them are related to a specific climate or habitat type (Macek et al. 2008, Leraut 2019). For example, *Mythimna alopecuri* (Boisduval, 1840) and *Mythimna sicula* (Treitschke, 1835) show a predominately Mediterranean distribution, *Mythimna conigera* (Denis & Schiffermüller, 1775) is usually found in the mountains, while *Mythimna straminea* (Treitschke, 1825) and *Mythimna turca* (Linnaeus, 1761) usually inhabit smaller or larger patches of wetlands.

Here we present the first record of *Mythimna andereggii* (Boisduval, 1840) (Fig. 1). This species was found during our short visit to Mt. Troglav in the Dinara mountain chain. The data of these records are: Croatia, Mt. Troglav, Pume chalet, Velika Divjakuša and Rosića glavica; 43.935822N, 16.572526E, 18.6.2016, 2 ex., leg. Boris Lauš.

It is a Holo-Mediterranean-Central Asian species (Nowacki 1998), in Europe mostly confined to the mountain ranges of the Pyrenees, Apennines, Alps and the mountains in the Balkan peninsula (Macek et al. 2008, Leraut 2019). According to Nowacki (1998), it occurs in open montane habitats like meadows and steppes, between 1,200 to 2,500 m a.s.l. Adults are present between May and August in a single generation (Macek et al. 2008). Its caterpillars feed on different grasses (Hacker et al. 2002). The Balkan populations belong to the subspecies *Mythimna andereggi pseudocomma* (Rebel, 1931).

The screening of all the available literature for the Lepidoptera of Croatia revealed that no record of this species exists in the country. The closest records out from Mt. Troglav are the ones from Bosnia & Herzegovina, from Rilji (Stauder 1926). Recently, the species was also recorded for the first time for the fauna of Serbia (Stojanović et al. 2014). It is found also in Northern Macedonia (Thurner 1964) and Slovenia (Carnelutti 1992).

With further explorations of the mountain habitats in Croatia, additional records of new species or the expansion of the known ranges for other mountain species are expected.

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Figure 1. *Mythimna andereggii* from Mt. Troglav, Croatia (photo T. Koren).
Slika 1. *Mythimna andereggii* z gore Troglav, Hrvaška (foto T. Koren).

NATURA SLOVENIAE 22(1): 35-38
FIELD NOTE

Prejeto / Received: 11. 3. 2020
Sprejeto / Accepted: 31. 7. 2020

First capture of the greater noctule bat *Nyctalus lasiopterus* (Schreber, 1780) individuals in Slovenia

Prvi ulov osebkov velikega mračnika *Nyctalus lasiopterus* (Schreber, 1780) v Sloveniji

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The greater noctule bat, *Nyctalus lasiopterus* (Schreber, 1780), is the largest bat species in Europe and one of the Europe's rarest and most enigmatic bats (Popa-Lisseanu et al. 2009, Dietz & Kiefer 2014). This tree-dwelling species is largely dependent on mature, preferably deciduous and mixed forests (Popa-Lisseanu et al. 2009, Alcaldé et al. 2016). Hunting grounds are usually in forests and in the vicinity of water (Estók 2011, Uhrin et al. 2016), where bats fly 10–20 m above the ground (Alcaldé et al. 2016). Its distribution range extends over central and southern Europe and reaches into the Mediterranean region – from the Iberian Peninsula to the Balkans (Ibáñez et al. 2004, Dietz & Kiefer 2014, Alcaldé et al. 2016). It is considered »vulnerable« in the IUCN Red List of Threatened Species (Alcaldé et al. 2016) and listed as »data deficient« in the Slovenian Red List of endangered species (Ur. l. RS 2002). Until recently, the only record of the species for Slovenia referred to historical data from Piran in the southwestern part of the country (Dal Piaz 1927). Due to the species presence in the neighbouring countries (Vergari et al. 1997, Tvrtković & Baltić 1996, Estók 2011) and its migratory behaviour, it was assumed that it at least occasionally occurs in the country (Petrinjak 2009). It was only recently that the species was confirmed at a few locations in southern Slovenia, by recording its echolocation calls (Presetnik & Knapič 2015, Presetnik 2017, Presetnik & Šalamun 2019). Here, we present the first record of captured individuals of this species in Slovenia.

During the fieldwork carried out by the bat research group within the framework of the »Biological Research Camp for High School Students 2017«, we used different methods to inventory bats in the region around Gračišče in SW Slovenia. On the evening of 27. 6. 2017, we set the mist nets around approximately 25 × 35 m large pond on the hilltop, 350 m east of the village Poletiči (lat. 45.4957 °N, long. 13.8679 °E; 340 m a.s.l.). The pond is situated at the eastern end of the forested Istria's hilly area, with sub-Mediterranean climate (Ogrin 1996). The pond's bank was not overgrown with any vegetation and water surface was mainly open. However, the dense mixed forest of planted *Pinus nigra* and of *Quercus pubescens*, *Ostrya carpinifolia* and *Fraxinus ornus* surrounded the pond approx. 10 m away on the NE and SE sides. We used four mist nets, three (two polyester 12 × 3 m and one nylon 15 m × 2.5 m) were erected right on the NE and E sides of the pond's banks, while one (polyester 12 × 3 m) was set approximately 10 m away from the E side of the pond, right along the forest edge. Mist nets were erected at sunset (20:57) and checked every few minutes until 1:00 a.m. next day. The captured bats were immediately taken from the nets and processed; we measured their weight (using Pesola 60 g scale, 0.5 g accuracy), forearm length (calliper, 0.1 mm accuracy) and determined their age, sex and reproductive status (Haarsma 2008, Dietz & Kiefer 2014). After determining the species, we released the individuals at the same site in the shortest time possible.

At 23:34, a distinctly large bat was caught in the centre of the 15 m mist-net at the eastern pond's bank at a height of approximately 1.5 m. The second individual was caught at the same point at 00:33. Both bats were flying from NE of the outer side of the pond (Fig. 1a). They were measured (Tab. 1) and identified as *Nyctalus lasiopterus* (Dietz & Kiefer 2014). In the hour between these two captures, another similar sized bat flew in the same net, but managed to escape before our arrival at the spot. Based on its size and strength, it could also have been *N. lasiopterus*. Both inspected individuals (Tab. 1) were adult sexually mature male greater noctules, with well-developed buccal glands (Fig. 1b) and enlarged testicles (Fig. 1c). At the back of one individual's head there was a small distinct white patch of fur (Fig. 1d), which could indicate an example of piebaldism – total local lack of fur pigment (Lucati & López-Baucells 2016). The overall observed bat assemblage was diverse with additional species: *Hypsugo savii*, *Pipistrellus kuhlii*, *Nyctalus leisleri, Myotis myotis/M. oxygnathus*, *M. mystacinus* and *Plecotus macrobullaris*.

Table 1. Measurements of the greater noctule bats (*Nyctalus lasiopterus*) caught in the mist nets at the pond near Poletiči in southwestern Slovenia at the night from 27. to 28. 6. 2017. Abbreviations: AB – forearm length, D3 – third finger length, D5 – fifth finger length, T – testicles, E – epididymis. Reproductive status is described with a four-level estimate of enlargement: »/« – not swollen, »+« – slightly swollen, »++« – intermediate, »+++« – very obviously and largely swollen.

Tabela 1. Meritve velikih mračnikov (*Nyctalus lasiopterus*), ujetih v mreže ob kalu pri Poletičih v jugozahodni Sloveniji v noči 27. / 28. 6. 2017. Okrajšave: AB – dolžina podlakti, D3 – dolžina tretjega prsta, D5 – dolžina četrtega prsta, T – moda, E – obmodki. Razmnoževalni status je opisan s štiristopenjsko lestvico povečanja: »/« – niso zatečeni, »+« – rahlo zatečeni, »++« – srednje zatečeni, »+++« – zelo očitno in močno otečeni.

Species	Sex	Age	AB [mm]	Weight [g]	D3 [mm]	D5 [mm]	Reproductive status	Time of capture
Nyctalus lasiopterus	male	adult	65.1	53.0	116.0	71.5	T: ++, E: +	23:34
Nyctalus lasiopterus	male	adult	66.0	54.0	/	/	T: ++, E: /	00:33

Figure 1. a) Greater noctule bat (*Nyctalus lasiopterus*) caught near Poletiči, SW Slovenia (photo: Simon Zidar). b) Enlarged buccal glands of the caught male (photo: Živa Bombek). c) Enlarged testicles (photo: Simon Zidar). d) White tuft of hair at the back of the bat's head indicates piebaldism (photo: Simon Zidar).

Slika 1. a) Veliki mračnik (*Nyctalus lasiopterus*), ujet pri Poletičih v JZ Sloveniji (foto: Simon Zidar). b) Povečane bukalne žleze ujetega samca (foto: Živa Bombek). c) Močno povečani testisi (foto: Simon Zidar). d) Svetel šop dlak na zatilju nakazuje piebaldizem (foto: Simon Zidar).

Our observation represents the first recent capture of individuals of *N. lasiopterus* in Slovenia. As the species normally flies high above treetops (Alcaldé et al. 2016), we assume that we interrupted the individuals during their drinking attempts. The records of the caught individuals of this species are rare also in the neighbouring Italy (Vernier & Vedovato 2011, Lapini et al. 2014) and Croatia (Kovač et al. 2011, Mazija et al. 2015), where only males had been reported. The nearest known large population of *N. lasiopterus* inhabits the northern part of Hungary, where it was observed in woodland sites associated with running or standing waters (Estók 2011, Uhrin et al. 2016). Recent observations of *N. lasiopterus* (Presetnik & Knapič 2015, Presetnik 2017, Presetnik & Šalamun 2019, this study) indicate that the species regularly occurs in Slovenia, at least in its Mediterranean part. However, it is unclear whether the observed bats constitute the resident population or are just vagrant animals detected during their migration. Additional research, especially at forested water sites, should reveal more records, and at the same time greatly contribute to a better understanding of the species' distribution and ecology in this part of Europe.

Acknowledgements

We would like to thank two anonymous reviewers for the valuable comments that strongly improved the manuscript. Additionally, we want to acknowledge Matija Mlakar Medved, Nejc Poljanec and Živa Bombek for their assistance in the field. Special thanks are due to Nino Kirbiš from the Slovenian Herpetological Society for the organization of the camp. The research work would not have been possible without the equipment borrowed from the Slovenian Association for Bat Research and Conservation and Monika Podgorelec.

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