UNIVERZA V LJUBLJANI
BF Biotehniška fakulteta

NACIONALNI INŠTITUT ZA BIOLOGIJO
NATIONAL INSTITUTE OF BIOLOGY

NATURA SLOVENIAE

Revija za terensko biologijo • Journal of Field Biology

Letnik • Volume 26 Številka • Number 2

Ljubljana
2024

NATURA SLOVENIAE

Revija za terensko biologijo • Journal of Field Biology
Letnik/Volume 26 • Številka/Issue 2 • 2024

Založila • Published by
Založba Univerze v Ljubljani/University of Ljubljana Press
Za založbo/For the Publisher: Gregor Majdič, rektor Univerze v Ljubljani/the Rector of the University of Ljubljana

Izdajata • Issued jointly by
Biotehniška fakulteta, Univerza v Ljubljani
Jamnikarjeva 101, SI-1000 Ljubljana
Tel.: (0)1 320 30 00; Telefax: (0)1 256 57 82
https://www.bf.uni-lj.si
Za izdajatelja/For the Issuer: Marina Pintar, dekanja Biotehniške fakultete UL/the Dean of the Biotehnical Faculty UL

Nacionalni inštitut za biologijo
Večna pot 121, SI-1000 Ljubljana
Tel.: (0)59 232 700; Telefax: (0)1 2412 980
https://www.nib.si
Za izdajatelja/For the Issuer: Maja Ravnikar, direktorica/director

https://journals.uni-lj.si/NaturaSloveniae

Naslov uredništva • Address of the Editorial Office
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 **e-ISSN: 1854-3081** **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
2024

Naklada • Circulation
300 izvodov/copies

Tisk • Print
Cicero, Begunje, d.o.o.

Publikacija je brezplačna
The publication is free of charge

Sofinancira • Cofinanced by
Javna agencija za znanstvenoraziskovalno in inovacijsko dejavnost RS/Slovenian Research and Innovation Agency

Kazalo vsebine

NATURA SLOVENIAE 26(2): 5-20
ZNANSTVENI ČLANEK

Prejeto / Received: 25. 3. 2024
Sprejeto / Accepted: 6. 11. 2024

DOI: 10.14720/ns.26.2.5-20

Izbira habitata evropskega bobra *Castor fiber* (Rodentia: Castoridae) na Goričkem (severovzhodna Slovenija)

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Izvleček. Evropski bober je v Sloveniji in večjem delu Evrope v začetku 20. stoletja veljal za izumrlo vrsto. Ob koncu 20. stoletja se je po številnih reintrodukcijah in uveljavitvi ohranitvenih ukrepov ponovno razširil. V Sloveniji se je vnovič naselil leta 1998, na Goričkem leta 2016. V zimi 2021/22 smo na Goričkem popisali šest vodnih teles, na katerih je bilo med letoma 2016 in 2020 potrjeno pojavljanje te vrste. Namen popisa je bil ugotoviti značilnosti bobrovega habitata na Goričkem glede na ključne okoljske dejavnike, ki mu omogočajo preživetje. Zaradi zgodnje faze naselitve smo domnevali, da je bober za svoj teritorij izbral optimalne habitate. Na izbranih odsekih vodnih teles smo popisali 82 ploskev. Aktivnost bobra je bila potrjena na 71 % ploskev s stoječo in 26 % ploskev s tekočo vodo. Najpogostejši tip kopenskega habitata so bile njive. Gozd je pokrival le 18 % ploskev. Bober je bil najpogosteje zabeležen prav na ploskvah z gozdom (73 %). Brežine vodnih teles so bile v glavnem zelo strme (> 60°). Sledovi bobra so bili najpogosteje najdeni na brežinah z višino do vključno 1 m, naklonom 30°–60° in povprečno 500 m oddaljenostjo od naselij. Vodotoki, ki jih je na Goričkem naselil bober, so razmeroma ozki in plitki, a jih bober kljub temu naseljuje. Najpomembnejši okoljski dejavnik za bobre je razpoložljivost ustrezne lesne vegetacije, s katero se hrani predvsem jeseni in pozimi. Poznavanje značilnosti in izbire habitata je pomembno za varstveno upravljanje in monitoring bobra na Goričkem in v Sloveniji.

Ključne besede: *Castor fiber*, evropski bober, Goričko, habitat, ekološke spremenljivke

Abstract. Habitat selection of European beaver *Castor fiber* (Rodentia: Castoridae) in the Goričko region (Northeastern Slovenia) – The European beaver was considered an extinct species in Slovenia and much of Europe in the early 20th century. At the end of the 20th century, it expanded again following numerous reintroductions and the implementation of conservation measures. In Slovenia, it has been present again since 1998 and in Goričko since 2016. During the winter of 2021/22, we surveyed six water bodies in the Goričko region, where beaver presence was confirmed between 2016 and 2020. The purpose of the survey was to determine the characteristics of beaver habitat at Goričko based on key environmental factors that enable its survival. Due to the early stage of colonization, we assumed that beavers had chosen optimal habitats for their territory. We surveyed 82 plots in selected sections of the water bodies. Beaver activity was confirmed on 71% of plots with standing water and 26% of plots with flowing water. The commonest types of terrestrial habitats were fields, while forests were present on 18% of the plots. Beavers were most frequently found on plots with forested areas (73%). The banks of the water bodies were generally very steep (> 60°). Signs of beaver activity were most commonly found on banks with a height of up to 1 meter, a slope of 30°–60°, and an average distance of 500 metres from settlements. The watercourses inhabited by beavers at Goričko are relatively narrow and shallow, yet beavers can still be found there. The most important environmental factor for beavers is the availability of suitable woody vegetation, which they primarily feed on in the autumn and winter. Understanding habitat characteristics and selection is essential for conservation management and monitoring of beavers at Goričko and Slovenia.

Key words: *Castor fiber*, European beaver, Goričko, habitat, ecological variables

Uvod

Evropski bober (*Castor fiber* Linnaeus, 1758), največji evropski glodavec, ki je v preteklosti poseljeval celotno Evrazijo, od Sredozemskega morja na jugu do tundre na severu (Hartman 1996), je bil v 19. stoletju v večini dežel iztrebljen. Skupaj je ostalo okoli 1300 osebkov, od tega 700 v Evropi (Kryštufek et al. 2006). Po zaslugi ponovnih naselitev in varstvenih ukrepov se je bober po Evropi ponovno razširil in njegove populacije so stabilne ali se povečujejo (Batbold et al. 2021; Halley et al. 2021). V Sloveniji bober ponovno živi od leta 1998, ko je iz Hrvaške po reki Savi dosegel porečje Krke (Kryštufek et al. 2006). Iz Hrvaške je nato naselil še druge reke v vzhodni in severovzhodni Sloveniji. Bober je bil na Goričkem prvič zaznan šele leta 2016 na Hodoškem jezeru (Peček 2017). Od leta 2017 bobra najdemo še vsaj na Veliki Krki, Mali Krki s Križevskim jezerom, reki Ledavi in Ledavskem jezeru, Dolenskem potoku in Lukaj potoku (Malačič et al. 2018, 2020; BioPortal 2024).

Bober lahko živi v vseh tipih sladkih vod, v katerih je voda vse leto in je na voljo dovolj rastlinske hrane (Kryštufek et al. 2006). Večino časa preživi v vodi. Na kopnem se zadržuje predvsem v obvodnem pasu, večinoma do 20 m od vode. V tem pasu najdemo največ sledov njegovega gibanja (steze in stečine) in prehranjevanja (obglodano in podrto lesno vegetacijo). Spomladi in poleti se hrani večinoma z nelesno vegetacijo, jeseni in pozimi pa predvsem z lubjem grmovnih in drevesnih vrst (Macdonald 2001).

Je teritorialna žival, ki v začetni fazi poselitve novega območja izbira optimalne, z naraščanjem velikosti populacije pa tudi suboptimalne habitate (John et al. 2010; Zwolicki et al. 2018). Optimalni habitati so tisti s počasi tekočo ali stoječo vodo brez velikih nihanj gladine, globino 2–4 m, širino 10–100 m (če gre za reko), glineno ali ilovnato brežino z višino > 1 m in naklonom < 60°, gosto in visoko zeliščno ter mehkolesno vegetacijo, z majhnim vplivom človeka (Macdonald et al. 1995; Kryštufek et al. 2006). Bober lahko habitat tudi spremeni, da ga lažje izkorišča (Campbell-Palmer et al. 2016). Na vodah z nestalno gladino zgradi jezove, s čimer zviša gladino vode in upočasni vodni tok. Tako z ustvarjanjem in vzdrževanjem mokrišč zvišuje ekosistemsko in vrstno pestrost naseljenega območja (Kryštufek et al. 2006; Law et al. 2019). Zaradi prevelikih nihanj v nivoju vode, izčrpanja vegetacije ali prevelikih antropogenih motenj lahko območje tudi zapusti (Campbell-Palmer et al. 2016). V iskanju ugodnejših razmer se lahko seli tudi znotraj svojega teritorija (Fryxell 2001).

V skrajnem JV delu Prekmurja, kjer se je bober ponovno pojavil že leta 2003 (Kocjančič 2005), je bil v letih 2020–22 zabeležen že na večini vodotokov. Naselil je vse optimalne habitate, ki jih je bilo na raziskanem območju malo, in se v glavnem naselil na suboptimalnih habitatih, z izrazitim vplivom človeka v 20-metrskem obvodnem pasu (Vida 2022).

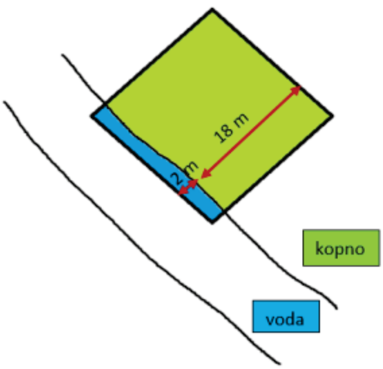
Na Goričkem je bil bober prvič ponovno zaznan leta 2016. V zimi 2021/22, kar je največ pet let po ponovni naselitvi, smo na Goričkem popisali šest vodnih teles, na katerih je bil bober potrjen med letoma 2016 in 2020. Namen popisa, ki ga predstavljamo v tem prispevku, je bil ugotoviti značilnosti izbranega habitata bobra na Goričkem. Popisali smo značilnosti habitata, ki veljajo kot ključne za bobrovo preživetje (Macdonald et al. 1995; Kryštufek et al. 2006). Na izbranih odsekih vodnih teles smo popisali tako dele s sledmi kot tiste brez sledov bobrove aktivnosti. Zaradi zgodnje faze naselitve smo domnevali, da je bober za svoj teritorij izbral optimalne habitate. Poznavanje značilnosti in izbire habitata je pomembno za varstveno upravljanje in monitoring bobra na Goričkem in v Sloveniji. Raziskava je bila del magistrskega dela Laure Kološa (2023) in v prispevku so predstavljeni izbrani rezultati njenega dela.

Materiali in methode

Raziskovalno območje je zajemalo izbrane odseke vodnih teles v Krajinskem parku Goričko v SV Sloveniji. Izbrali smo šest vodnih teles (Sl. 2; Tab. 2); od tega dve jezeri in štiri potoke. Vodna telesa so bila izbrana, ker je bilo na njih v obdobju 2016–2020 dokumentirano bobrovo pojavljanje (Gregorc & Zavratnik 2017; Peček 2017; Malačič et al. 2017, 2020). Bober je bil v letih 2017–2020 potrjen tudi na Ledavskem jezeru (Malačič et al. 2017, 2020). V raziskavo ga nismo vključili zaradi težke dostopnosti do območja s sledmi bobrove aktivnosti, ki so bile zabeležene v vrbovem sestoju severno od jezera. V dostopnem delu jezera v zimi 2021/22 sledov ni bilo.

Na vsakem od izbranih potokov smo popisali en odsek, razen na Mali Krki dva odseka. Izbrali smo odseke, za katere smo iz literature in predhodnih lastnih opažanj vedeli, da jih naseljuje bober. Ob Hodoškem jezeru smo v popis vključili celotno obrežje. V območjih, izbranih za vzorčenje, smo pregledali lesno vegetacijo. Iskali smo značilne znake bobrovega glodanja na drevesih in grmovnicah ter podrto lesno vegetacijo. Kot znak bobrove aktivnosti na območju smo upoštevali samo sveže sledi objedanja vegetacije.

Območje izbranih odsekov vodnih teles smo razdelili na popisne ploskve dolžine in širine 20×20 metrov. Ploskve smo orientirali pravokotno na vodno telo tako, da je posamezna ploskev obsegala 2 m širok pas vodnega in 18 m kopenskega habitata (Sl. 1). Med hojo vzdolž izbranega odseka potoka ali okrog jezera smo za popis naključno izbrali nekaj ploskev brez sledov in s sledmi bobrove aktivnosti (Sl. 2). Z večjim številom popisnih ploskev smo zajeli več spreminjajočih se parametrov vzdolž ali okoli vodnega telesa. Popisnim ploskvam smo na terenu določili geografske koordinate (Tab. S1). Skupaj smo popisali 82 ploskev, od tega 31 s sledmi bobrove aktivnosti (Tab. 2).



Slika 1. Skica popisne ploskve velikosti 20×20 metrov. Popisna ploskev kvadratne oblike z dvo-metrskim pasom v vodnem telesu in 18-metrskim pasom na kopnem.
Figure 1. Sketch of sample plot size 20×20 metres. The sample plot was square in shape with a two-metre strip in the waterbody and an 18-metre strip on land.

Slika 2. Satelitski posnetki odsekov vodnih teles, na katerih je potekalo vzorčenje, z vsemi potencialnimi popisnimi ploskvami (prazni kvadratki) in izbranimi ploskvami (polni kvadratki) s sledmi (rdeče barve) in brez sledov (bele barve) bobrove aktivnosti.
Figure 2. Satellite images of sections of water bodies where sampling was conducted, with all potential sample plots (empty squares) and selected plots (filled squares) with signs of beaver activity (red) and without signs (white).

Znotraj izbranih popisnih ploskev smo zbrali podatke o ključnih abiotskih in biotskih dejavnikih okolja, za katere domnevamo, da vplivajo na izbiro bobrovega habitata, ter se uporabljajo za oceno primernosti habitata za bobra (Macdonald et al. 1995; Kryštufek et al. 2016). Dejavniki okolja, ki so bili osnova za popis značilnosti habitata bobra, so našteti v Tab. 1.

Znotraj izbranih popisnih ploskev smo vodno telo kategorizirali kot tekočo, stoječo ali občasno vodo. Pripadajoči kopenski habitat smo opredelili kot enega od petih habitatov: antropogeni travnik, naravno zeliščno vegetacijo, gozd, ruderalno zeliščno združbo ali njivo. Če sta bila v okviru posamezne popisne ploskve dva ali več tipov kopenskih habitatov, smo zabeležili prevladujočega. Kopenskemu habitatu smo vizualno ocenili delež pokrovnosti z lesno vegetacijo in delež pokrovnosti z zeliščno vegetacijo. Brežino smo kategorizirali glede na nastanek kot naravno ali umetno in določili njeno strukturo (trden, sipek ali ilovnat material). Izmerili smo višino brežine na 10 cm natančno in naklon, ki ga brežina opiše, na 5^{o} natančno. Vodnemu telesu smo izmerili širino na pol metra natančno in globino vode na 1 cm natančno na razdalji 1,5 m od vodnega brega. Podatke o oddaljenosti popisne ploskve od infrastrukture (cesta, železnica) in njene oddaljenosti od najbližjega naselja smo pridobili s pomočjo Javnega pregledovalnika grafičnih podatkov (MKGP 2022). Vrednosti spremenljivk so za posamezne popisne ploskve navedene v prilogi (Tab. S1).

Podatke smo uredili in izračunali parametre opisne statistike za spremenljivke iz Tab. 1. Ploskve s sledmi in brez sledov bobrove dejavnosti smo obravnavali ločeno. Popisne ploskve smo nadalje ločili tudi glede na tip vodnega objekta, to je na tekoče in stoječe vode. Ploskev z občasno vodo ni bilo. Z opisno statistiko smo predstavili tudi značilnosti posameznih vodnih teles.

Tabela 1. Seznam dejavnikov okolja (spremenljivk; povzeto po Kryštufek et al. 2006), ugotovljenih na 82 popisnih ploskvah.
Table 1. List of abiotic and biotic environmental factors (variables; based on Kryštufek et al. 2006) recorded on 82 sample plots.

Spremenljivka	**Način vrednotenja**
Tip vodnega objekta	Tekoča voda – 1
	Stoječa voda – 2
	Občasna voda – 3
Kopenski habitat	Antropogeni travnik – 1
	Naravna zeliščna vegetacija – 2
	Gozd – 3
	Ruderalna zeliščna združba – 4
	Njiva – 5
Širina vodnega telesa	V metrih
Globina vodnega telesa	V centimetrih
Višina brežine	Plitvina (višina < 0,5 m) – 1
	Nizka brežina (višina 0,5–1 m) – 2
	Srednje visoka brežina (višina 1–2 m) – 3
	Visoka brežina (višina 2–4m) – 4
	Zelo visoka brežina (več kot 4m) – 5
Nastanek brežine	Protipoplavni nasip – 1
	Naravna brežina – 2
	Regulacija – 3
Struktura brežine	Trden material – 1
	Sipek material – 2
	Ilovnat material – 3
Naklon brežine	Ravnina (ni zaznati naklona) – 1
	Rahel naklon (kot med 1° in 15°) – 2
	Srednje velik naklon (kot med 15° in 30°) – 3
	Velik naklon (kot med 30° in 60°) – 4
	Navpična stena (kot med 60° in 90°) – 5
Pokrovnost z lesno vegetacijo	V deležu (%)
Pokrovnost z zeliščno vegetacijo	V deležu (%)
Bližina naselja	V metrih
Bližina infrastrukture	V metrih

Spremenljivke, podane v obliki kategorij (tip kopenskega habitata, višina brežine, nastanek brežine, struktura brežine, naklon brežine), smo opisali z deleži pogostosti pojavljanja posameznih kategorij. Spremenljivke, ki so bile ocenjene z deleži (%) (pokrovnost z vegetacijo), smo opisali s srednjo (mediana), minimalno in maksimalno vrednostjo. Spremenljivke, podane v merskih enotah (širina vode, globina vode, bližina naselja, bližina infrastrukture), so bile opisane z aritmetično sredino, standardnim odklonom, minimalno in maksimalno vrednostjo.

Za grafični prikaz frekvence ploskev brez sledov in s sledmi bobrove aktivnosti glede na širino in globino vodnih teles smo uporabili violinske diagrame, ločeno za tekoče in stoječe vode. Za prikaz frekvence ploskev brez sledov in s sledmi bobra glede na višino in naklon brežine vodnih teles smo uporabili stolpčne diagrame. Za urejanje in analize podatkov smo uporabili orodja programa Microsoft Excel (Microsoft Office, ver 2108).

Rezultati

Značilnosti habitata bobra

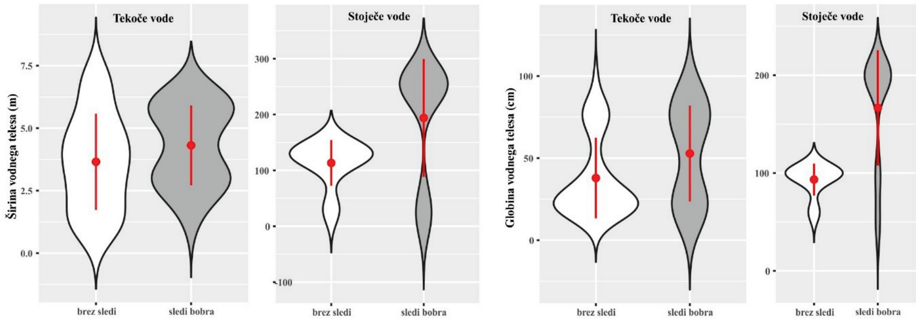
Popisali smo 82 ploskev (Tab. 2). Od tega jih je bilo 61 s tekočo in 21 s stoječo vodo. Sledi bobra so bile zabeležene na 16 ploskvah (26 %) s tekočo vodo in 15 ploskvah (71 %) s stoječo vodo (Tab. 4, 5).

Tabela 2. Seznam izbranih vodnih teles, na katerih je potekalo vzorčenje, s krajevnimi imeni, koordinatami (WGS84), številom popisnih ploskev (N) s sledmi in brez sledov bobrove aktivnosti ter datumom vzorčenja. Koordinate označujejo sredino vzorčenega odseka na vodnem telesu.
Table 2. List of selected water bodies where sampling was conducted, with place names, coordinates (WGS84), the number of sample plots (N) with and without signs of beaver activity, and the date of sampling. The coordinates indicate the centre of the sampled section on the water body.

Vodno telo	Vrsta vodnega telesa	Kraj vzorčenja	Koordinate središča vzorčenega odseka	Število popisnih ploskev; N (s sledmi + brez sledov)	Datum vzorčenja
Mala Krka (pri Domanjševcih)	potok	Domanjševci	46.781019, 16.285581	13 (3 + 10)	21.11.2021
Mala Krka (ob Križevskem jezeru)	potok	Križevci	46.791675, 16.248178	5 (0 + 5)	21.11.2021
Križevsko jezero	akumulacija na Mali Krki	Križevci	46.791067, 16.244732	5 (0 + 5)	21.11.2021
Hodoško jezero	akumulacija na Dolenskem potoku	Hodoš	46.837131, 16.308400	12 (12 + 0)	28.11.2021
Dolenski potok	potok	Hodoš, Dolenci	46.843107, 16.303642	14 (6 + 8)	28.11.2021
Velika Krka	potok	Krplivnik	46.818030, 16.317132	22 (5 + 17)	19.12.2021
Potok Lukaj	potok	Ropoča	46.762792, 16.047679	11 (5 + 6)	16.1.2022

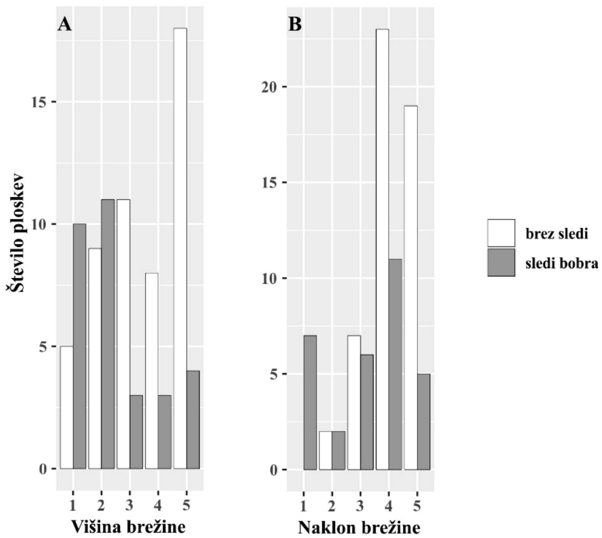
Širina vodnih teles s tekočo vodo je bila od 1 do 7 m, s stoječo pa od 4 do 255 m. Največja frekvenca ploskev s sledmi bobra je bila na lokacijah s širino vode 3–6 m na tekočih in 250 m na stoječih vodah (Sl. 3).

Globina vodnih teles s tekočo vodo je bila od 0,15 do 1 m, s stoječo pa od 0,4 do 2 m. Sledi bobra smo potrdili na ploskvah s celotnim razponom globin. Na tekočih vodah je bila frekvenca pojavljanja sledov bobra podobna za celoten gradient globin. Na stoječih vodah je bila največja frekvenca pojavljanja na lokacijah z 2 m globine. Na ploskvah brez bobrovih sledov je bila na tekočih vodah globina običajno nižja od 0,4 m.



Slika 3. Frekvenca ploskev brez sledov in s sledmi bobrove aktivnosti glede na širino in globino vodnih teles s tekočo ali stoječo vodo. Širina diagrama ponazarja gostoto podatkov, rdeče oznake povprečno vrednost in standardni odklon.
Figure 3. The frequency of plots with and without signs of beaver activity in relation to the width and depth of water bodies with flowing and standing waters. The width of the diagram represents data density, with red marks indicating the mean value and standard deviation.

Kopenski habitat je bila v največ primerih njiva (54 %), bobrovo pojavljanje pa smo največkrat potrdili v gozdu, kjer se je zadrževal v 73 % od skupaj 15 ploskev z gozdom. Na ploskvah z njivo (skupaj 44) je bil zabeležen v 23 %, na ploskvah z naravno zeliščno vegetacijo (skupaj 15) pa v 47 %.



Slika 4. Frekvenca ploskev brez sledov in s sledmi bobrove aktivnosti glede na višino (A) brežine (1 – < 0,5 m; 2 – 0,5–1 m; 3 – 1–2 m; 4 – 2–4 m; 5 – > 4 m) in naklon (B) brežine (1 – brez naklona; 2 – kot med 1° in 15°; 3 – kot med 15° in 30°; 4 – kot med 30° in 60°; 5 – kot med 60° in 90°).
Figure 4. The frequency of plots with and without signs of the beaver activity relative to the shore height (A) (1 – < 0,5 m; 2 – 0,5–1 m; 3 – 1–2 m; 4 – 2–4 m; 5 – > 4 m) and shore slope (B) (1 – no slope; 2 – slope angle between 1° and 15°; 3 – angle between 15° and 30°; 4 – angle between 30° and 60°; 5 – angle between 60° and 90°).

Višino brežine smo razdelili v pet kategorij višine od 0,5 m do višine nad 4 m. Sledi bobra smo našli na vseh višinah brežin, največkrat na območjih z višino brežine do vključno 1 m (Sl. 4A). Največja razlika med številom ploskev brez sledov in s sledmi bobra je bila na zelo visokih brežinah, kjer so bile sledi bobra samo na 18 % od 22 ploskev. Tudi naklone brežin smo razdelili v kategorije. Večina brežin je imela velik do navpičen naklon (Sl. 4B). Sledi bobra smo zabeležili na brežinah vseh naklonov, tudi najbolj strmih, a največkrat na brežinah z naklonom med 30° in 60°.

Ob vodnem telesu je bila največkrat zabeležena naravna brežina (95 % ploskev). Večina brežin (93 %) je bila iz ilovnatega materiala, ostale iz sipkega materiala. Bobrovi sledovi so bili v glavnem zabeleženi na brežinah iz ilovnatega materiala (94 %).

Delež pokrovnosti z lesno vegetacijo je bil nizek tako na ploskvah s sledovi kot na tistih brez sledov bobrove aktivnosti. Srednja vrednost je bila v obeh primerih 20 %.

Najmanjša oddaljenost ploskev s pojavljanjem bobra od naselja je bila 130 m, od infrastrukture pa 30 m. V povprečju so bile ploskve z bobrom od naselja oddaljene 505 m in brez bobra 334 m.

Posamezna vodna telesa

Značilnosti okoljskih spremenljivk na popisnih ploskvah s sledovi in brez sledov aktivnosti bobra so za posamezna vodna telesa ločeno za tekoče in stoječe vode opisane v Tab. 4 in Tab. 5.

Dolenski potok – Popisali smo 14 ploskev. Od tega so bili sledovi bobrove aktivnosti najdeni na 6 ploskvah. Prevladujoč kopenski habitat je bil njiva, tako na ploskvah brez kot na ploskvah s sledmi bobra. Na ploskvah s sledmi bobrove aktivnosti je bil potok širok povprečno 2,8 m in globok 0,7 m. Na teh mestih je bila brežina v glavnem nizka, a z velikim naklonom. Pokrovnost z lesno vegetacijo je bila 20 %. Vzorčena lokacija je bila od vseh najbolj oddaljena od naselij.

Potok Lukaj – Sledovi bobra so bili najdeni na 5 od 11 popisanih ploskev. Na popisanih ploskvah ni bilo njiv, ampak le zeliščna ali lesna vegetacija. Povprečna širina potoka na mestih s sledovi bobra je bila 4,5 m in globina 0,6 m. Brežina je bila ponekod sipka, sicer pa nizka do srednje visoka in s srednjim do velikim naklonom.

Velika Krka – Sledovi bobra so bili zabeleženi na 5 od 22 popisanih ploskev. Prevladujoč kopenski habitat je bil njiva. Pokrovnost z lesno vegetacijo je bila 20-odstotna. Na ploskvah z najdenimi sledovi bobra je bila reka široka povprečno 5,8 m in globoka 0,2 m. Brežina je bila v glavnem zelo visoka in z velikim do navpičnim naklonom. Na vzorčenem odseku je bila zabeležena naselju najbližja ploskev s sledovi bobra (oddaljena 130 metrov).

Mala Krka – Vzorčili smo odseke s tekočo in stoječo vodo. Sledovi bobrove aktivnosti so bili najdeni samo na stoječi vodi pri Domanjševcih s prevladujočim gozdnim in travniškim habitatom. Stoječa voda je bila širine pribl. 30 m in globine 0,8 m. Brežina je bila v glavnem visoka, s srednjim naklonom. V bližini (< 200 m) so bile ceste in naselje.

Hodoško jezero – Akumulacija na Dolenskem potoku. Popisali smo 12 ploskev s sledovi bobra. Povprečna širina jezera je bila 234 m in globina 1,9 m. Brežina je bila v glavnem ravna in zelo nizka ter poraščena z lesno in zeliščno vegetacijo. Podobno kot pri Dolenskem potoku so bila infrastruktura in naselja razmeroma oddaljena.

Križevsko jezero – Akumulacija na Mali Krki. Na nobeni od pregledanih ploskev nismo zaznali svežih sledov bobrove aktivnosti. Na popisanih ploskvah je prevladovala zeliščna vegetacija, ostalo je bil gozd. Povprečna širina jezera je bila 130 m in globina 1 m. Brežina je bila ponekod nizka, drugod visoka. Naklon brežine je bil velik do navpičen.

Tabela 4. Opisna statistika okoljskih spremenljivk za opis habitata bobra na vodnih telesih s tekočo vodo.
Table 4. Descriptive statistics of environmental variables for the description of beaver habitat on water bodies with flowing water.

	Dolenski potok		**Potok Lukaj**		**Velika Krka**		**Mala Krka**
	sledovi bobra N = 6	brez sledov N = 8	sledovi bobra N = 5	brez sledov N = 6	sledovi bobra N = 5	brez sledi N = 17	brez sledi N = 14
Kopenski habitat: Travnik - 1 Zeliščna vegetacija - 2 Gozd - 3 Ruderalna združba - 4 Njiva - 5	 1 – 14,3 % 2 - 0,0 % 3 – 0,0 % 4 – 0,0 % 5 – 87,5 %	 1 – 16,6 % 2 – 0,0 % 3 – 0,0 % 4 – 0,0 % 5 – 83,3 %	 1 – 20,0 % 2 – 40,0 % 3 – 40,0 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 16,7 % 3 – 50,0 % 4 – 33,3 % 5 – 0,0 %	 1 – 0,0 % 2 – 40,0 % 3 – 0,0 % 4 – 0,0 % 5 – 60,0 %	 1 – 0,0 % 2 – 11,8 % 3 – 0,0 % 4 – 0,0 % 5 – 88,2 %	 1 – 14,3 % 2 – 0,0 % 3 – 0,0 % 4 – 0,0 % 5 – 85,7 %
Širina vodnega telesa (m)	$\bar{x}$ = 2,8 StD = 0,8 Min = 1,5 Max = 4	$\bar{x}$ = 2,7 StD = 1,4 Min = 1 Max = 4	$\bar{x}$ = 4,6 StD = 1,5 Min = 3 Max = 6	$\bar{x}$ = 3,4 StD = 0,9 Min = 2,5 Max = 5	$\bar{x}$ = 5,8 StD = 0,4 Min = 5 Max = 6	$\bar{x}$ = 5,6 StD = 1,1 Min = 4 Max = 7	$\bar{x}$ = 2 StD = 1,0 Min = 1 Max = 4
Globina vode (cm)	$\bar{x}$ = 71,7 StD = 7,5 Min = 60 Max = 80	$\bar{x}$ = 67,5 StD = 14,9 Min = 40 Max = 80	$\bar{x}$ = 61,0 StD = 35,8 Min = 15 Max = 90	$\bar{x}$ = 30,8 StD = 24,6 Min = 15 Max = 80	$\bar{x}$ = 22,0 StD = 4,5 Min = 20 Max = 30	$\bar{x}$ = 29,4 StD = 19,2 Min = 20 Max = 100	$\bar{x}$ = 34,0 StD = 23,7 Min = 20 Max = 80
Višina brežine: Plitvina (< 0,5 m) - 1 Nizka (0,5–1 m) - 2 Srednja (1–2 m) - 3 Visoka (2–4m) - 4 Zelo visoka (> 4m) - 5	 1 – 0,0 % 2 – 76,9 % 3 – 23,1 % 4 – 0,0 % 5 – 0,0 %	 1 – 18,8 % 2 – 25,0 % 3 – 56,3 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 60,0 % 3 – 40,0 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 50,0 % 3 – 16,7 % 4 – 16,7 % 5 – 16,7 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 – 16,7 % 5 – 83,3 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 – 0,0 % 5 – 100 %	 1 – 7,1 % 2 – 7,1 % 3 – 50,0 % 4 – 35,7 % 5 – 0,0 %
Nastanek brežine: Nasip - 1 Naravna brežina - 2 Regulacija - 3	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2– 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %
Struktura brežine: Trden material - 1 Sipek material - 2 Ilovnat material - 3	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 30,8 % 3 – 69,2 %	 1 – 0,0 % 2 – 57,1 % 3 – 42,9 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %
Naklon brežine: Ravnina - 1 Rahel (1°–15°) - 2 Srednji (15°–30°) - 3 Velik (30°–60°) - 4 Navpičen (60°–90°) - 5	 1 – 0,0 % 2 – 0,0 % 3 – 16,7 % 4 – 66,7 % 5 – 16,7 %	 1 – 0,0 % 2 – 25,0 % 3 – 0,0 % 4 – 37,5 % 5 – 37,5 %	 1 – 0,0 % 2 – 0,0 % 3 – 20,0 % 4 – 80,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 0,0 % 3 – 16,7 % 4 – 66,7 % 5 – 16,7 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 – 40,0 % 5 – 60,0 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 – 41,2 % 5 – 58,8 %	 1 – 0,0 % 2 – 0,0 % 3 – 35,7 % 4 – 50,0 % 5 – 14,3 %
Pokrovnost z lesno vegetacijo (%)	Med = 20 Min = 5 Max = 20	Med = 12,5 Min = 0 Max = 30	Med = 30 Min = 10 Max = 70	Med = 60 Min = 5 Max = 100	Med = 20 Min = 10 Max = 30	Med = 20 Min = 5 Max = 50	Med = 20 Min = 0 Max = 20
Pokrovnost z zeliščno vegetacijo (%)	Med = 80 Min = 80 Max = 95	Med = 87,5 Min = 70 Max = 100	Med = 70 Min = 30 Max = 90	Med = 40 Min = 0 Max = 95	Med = 80 Min = 70 Max = 90	Med = 80 Min = 50 Max = 95	Med = 80 Min = 80 Max = 80
Bližina naselja (m)	$\bar{x}$ = 942 StD = 161,2 Min = 658 Max = 1150	$\bar{x}$ = 853 StD = 136,8 Min = 690 Max = 1150	$\bar{x}$ = 282 StD = 86,4 Min = 205 Max = 410	$\bar{x}$ = 290 StD = 111,0 Min = 190 Max = 1740	$\bar{x}$ = 373 StD = 217,8 Min = 130 Max = 590	$\bar{x}$ = 254 StD = 162,9 Min = 40 Max = 600	$\bar{x}$ = 184 StD = 45,1 Min = 110 Max = 280
Bližina infrastrukture (m)	$\bar{x}$ = 143 StD = 87,5 Min = 62 Max = 305	$\bar{x}$ = 180 StD = 100,3 Min = 60 Max = 310	$\bar{x}$ = 113 StD = 50,7 Min = 70 Max = 190	$\bar{x}$ = 218 StD = 78,9 Min = 120 Max = 330	$\bar{x}$ = 223 StD = 70,9 Min = 145 Max = 300	$\bar{x}$ = 216 StD = 85,2 Min = 90 Max = 350	$\bar{x}$ = 132 StD = 52,3 Min = 15 Max = 210

Tabela 5. Opisna statistika okoljskih spremenljivk za opis habitata bobra na vodnih telesih s stoječo vodo.
Table 5. Descriptive statistics of environmental variables for the description of beaver habitat on water bodies with standing water.

	Hodoško jezero	**Mala Krka**		**Križevsko jezero**
	sledovi bobra N = 12	sledovi bobra N = 3	brez sledov N = 1	brez sledov N = 5
Kopenski habitat: Travnik - 1 Zeliščna vegetacija - 2 Gozd - 3 Ruderalna združba - 4 Njiva - 5	 1 – 0,0 % 2 - 25,0 % 3 - 58,3 % 4 – 0,0 % 5 - 16,7 %	 1 – 33,3 % 2 - 0,0 % 3 – 66,7 % 4 - 0,0 % 5 - 0,0 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 – 0,0 % 5 - 100 %	 1 – 0,0 % 2 – 80,0 % 3 – 20,0 % 4 – 0,0 % 5 – 0,0 %
Širina vodnega telesa (m)	$\bar{x} = 234$ StD = 72,5 Min = 4 Max = 255	$\bar{x} = 33$ StD = 20,7 Min = 14 Max = 55	x = 30	$\bar{x} = 130$ StD = 0 Min = 130 Max = 130
Globina vode (cm)	$\bar{x} = 188$ StD = 15,2 Min = 40,4 Max = 200	$\bar{x} = 80$ StD = 34,6 Min = 40 Max = 100	x = 60	$\bar{x} = 100$ StD = 0 Min = 100 Max = 100
Višina brežine: Plitvina (< 0,5 m) - 1 Nizka (0,5-1 m) - 2 Srednja (1-2 m) - 3 Visoka (2-4m) - 4 Zelo visoka (> 4m) - 5	 1 – 75,0 % 2 – 25,0 % 3 – 0,0 % 4 – 0,0 % 5 – 0,0 %	 1 – 33,3 % 2 – 0,0 % 3 – 0,0 % 4 – 66,7 % 5 – 0,0 %	 1 – 100 % 2 – 0,0 % 3 – 0,0 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 60,0 % 3 – 0,0 % 4 – 40,0 % 5 – 0,0 %
Nastanek brežine: Nasip - 1 Naravna brežina - 2 Regulacija - 3	 1 – 0,0 % 2 – 91,7 % 3 – 8,3 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 0,0 % 2 – 100 % 3 – 0,0 %	 1 – 80,0 % 2 – 20,0 % 3 – 0,0 %
Struktura brežine: Trden material - 1 Sipek material - 2 Ilovnat material - 3	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 %
Naklon brežine: Ravnina - 1 Rahel (1° - 15°) - 2 Srednji (15° - 30°) - 3 Velik (30° - 60°) - 4 Navpičen (60° - 90°) - 5	 1 – 58,3 % 2 – 16,7 % 3 – 8,3 % 4 – 8,3 % 5 – 8,3 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 0,0 % 3 – 100 % 4 – 0,0 % 5 – 0,0 %	 1 – 0,0 % 2 – 0,0 % 3 – 0,0 % 4 - 40,0 % 5 – 60,0 %
Pokrovnost z lesno vegetacijo (%)	Med = 40 Min = 10 Max = 100	Med = 100 Min = 20 Max = 100	x = 20	Med = 60 Min = 40 Max = 100
Pokrovnost z zeliščno vegetacijo (%)	Med = 60 Min = 0 Max = 90	Med = 0 Min = 0 Max = 80	x = 80	Med = 40 Min = 0 Max = 60
Bližina naselja (m)	$\bar{x} = 531$ StD = 125,0 Min = 310 Max = 670	$\bar{x} = 192$ StD = 22,5 Min = 167 Max = 210	x = 150	$\bar{x} = 283$ StD = 40,2 Min = 240 Max = 340
Bližina infrastrukture (m)	$\bar{x} = 274$ StD = 172,6 Min = 30 Max = 640	$\bar{x} = 63$ StD = 13,7 Min = 48 Max = 75	x = 100	$\bar{x} = 223$ StD = 72,0 Min = 168 Max = 330

Diskusija

Bober je teritorialna žival, ki v začetni fazi poselitve novega območja izbira optimalne, z naraščanjem velikosti populacije pa tudi suboptimalne habitate (John et al. 2010; Zwolickiet al. 2018). V skrajnem JV delu Prekmurja je bil bober po desetih letih od ponovne naselitve v letu 2003 zabeležen že na večini vodotokov. Naselil je vse maloštevilne optimalne habitate, a se je v glavnem naselil na suboptimalnih habitatih (Vida 2022). Na Goričkem se je bober prvič ponovno pojavil leta 2016 na Hodoškem jezeru in se je že v letu 2017 naselil še vsaj na reki Ledavi, Ledavskem jezeru, Veliki Krki, Lukaj potoku, Mali Krki in Križevskem jezeru. V zimi 2021/22, kar je pet let po prvi naselitvi, smo popisali bobrov habitat na šestih vodnih telesih na Goričkem.

Bober ima raje stoječo kot tekočo vodo (Hartman 1996; Nowak 1999). Da bi upočasnil tok reke in obenem dvignil raven vodne gladine, gradi jezove. Hartman (1996) je v študiji pokazal negativno povezanost izbire bobrovega habitata s hitrostjo pretoka vode. Na Goričkem je bober ob vrnitvi takoj naselil Hodoško, Križevsko in Ledavsko jezero. V zimi 2021/22 svežih sledov bobra na Križevskem jezeru nismo našli, medtem ko so bile na Hodoškem jezeru sledovi na vseh popisnih ploskvah. Razen na obali Hodoškega jezera so bile sledovi tudi na odseku Dolenskega potoka, ki se izteka v jezero. Na Mali Krki so bili sledovi bobra najdeni samo na kratkem odseku s stoječo vodo. Več ploskev smo popisali na tekočih vodah, a delež bobrovih sledov na popisnih ploskvah je bil glede na tip vodnega telesa višji za stoječe vode. Na stoječih vodah s sledovi bobra je bila voda glede na druge lokacije najgloblja (več kot 0,4 m) in najširša (več kot 4 m). Brežina je bila v glavnem nizka in majhnega do srednjega naklona. Prevladujoč kopenski habitat ob vodnem telesu je bil gozd z vmesnimi sestoji naravne zeliščne vegetacije ali travnika, ki bobru vse leto zagotavljata vir hrane.

Na lokalitetah s tekočo vodo, na katerih smo našli sledove bobra, je bila širina vode večja od 1,5 m (v povprečju 4 m) in globlja od 15 cm (v povprečju 53 cm). V večini primerov so bile brežine nizke, a z velikimi nakloni. Zelo visoke brežine z navpičnimi nakloni so bile na Veliki Krki. Prevladujoč kopenski habitat je bil njiva, z izjemo Lukaj potoka z gozdom ali naravno zeliščno vegetacijo.

Optimalni habitati za bobra so tisti s počasi tekočo ali stoječo vodo, globino 2–4 m in širino 10–100 m (za reke) (Kryštufek et al. 2006). Voda z globino manj kot 1 m ali več kot 6 m se šteje kot neustrezna. Z vidika globine in širine vode torej obravnavane tekoče vode za bobra niso bile optimalne. Na nezasedenih ploskvah je bila globina navadno nižja od 0,4 m. Pri tem je treba poudariti, da je bila globina izmerjena na 1,5 m oddaljenosti od brega in ne na sredini vodotoka.

Bober je bil največkrat zabeležen v gozdu, kar se ujema z uvrstitvijo bobra med gozdne živali (Mitchell-Jones et al. 1999). Prevladujoči kopenski habitat na raziskanih odsekih vodnih teles so bile sicer njive, ki so lahko v določenem delu leta pomemben vir bobrove prehrane, vendar pa lahko pomanjkanje naravne zarasti, kot sta gozd in naravna zeliščna vegetacija, ključno vpliva na to, da se bober tam ne bo naselil (Zwolicki et al. 2018).

Pinto et al. (2009) so ugotovili, da bobri ne uporabljajo brežin z nakloni, večjimi od 36°. Dostop do kopnega je za bobra na brežinah z velikimi nakloni omejen. Podobno je pokazal Hartman (1996): izbira habitata je v negativni korelaciji z naklonom. Po Macdonald et al. (1995) ter Kryštufek et al. (2006) so za bobra optimalne brežine z naklonom manj kot 60° in višino več kot 1 m. Višina brežine je pomembna, ker v brežino bober izkoplje brlog. Visoke brežine za bobra niso ovira, saj so bila obglodana drevesa tudi v naši raziskavi najdena na brežinah, višjih kot 4 m. Večina brežin je imela velik do navpičen naklon, kar ni ugodno za bobrovo prehajanje iz vode in v njo. Bober je bil največkrat zabeležen ob vodnih telesih z naklonom brežine med 30° in 60°, na naklonih brežine več kot 60° pa ga v glavnem ni bilo.

Bober se je pojavljal v bližini tako asfaltiranih cest kot železnic, kar kaže na to, da ni občutljiv za prometni hrup. Pričakovali bi, da je bolj kot za vrsto infrastrukture občutljiv za njeno bližino, vendar se je izkazalo, da se je bober prehranjeval na brežini, ki je bila od infrastrukture oddaljena le 30 m. Najmanjša oddaljenost ploskev s pojavljanjem bobra od naselja je bila 130 m. Znano je, da bobra človekova navzočnost in njegove dejavnosti (npr. ribolov) posebej ne motijo (Halley & Rosell 2002; Vochl 2008; Juršič et al. 2017).

Vochl (2008) je ocenjevala habitat bobra v nižinskih poplavnih gozdovih Slovenije na odsekih reke Krke, Radulje in Drave. Habitat je ocenjevala v štirih kategorijah: voda, brežina, vegetacija in upravljanje, po metodi ocenjevanja primernosti habitata po Macdonald et al. (1995). Z vidika primernosti habitata je bila najslabše ocenjena naselbina na Radulji. Reka je bila z obeh strani obdana s kmetijskimi površinami, zato je bil vpliv človeka zelo velik (Vochl 2008). Kot optimalno območje je bilo ocenjeno območje Dravograjskega jezera. V odseku popisa je bila globina 1–2 m in širina reke 5–10 m. Brežine so bile ponekod navpične, drugod skoraj položne, visoke približno 1 m. V primerjavi z drugima dvema lokacijama, kjer je bil ob vodi le ozek pas dreves (do 2 m), je bil ob Dravi širši pas z lesno vegetacijo.

Tudi Vida (2022) je v raziskavi v skrajnem JV delu Prekmurja ocenjevala primernost habitatov za bobra (po Macdonald et al. 1995, 1997). Ugotovila je, da je 32 od 38 odsekov (84 %) popisanega obvodnega habitata zmerno primernih, 4 (11 %) dobro in 2 (5 %) slabo primernih za bobra. Primernost habitata za bobra se je v 14 letih v 20-metrskem pasu kopnega ob vodnih telesih zmanjšala zaradi spremenjene rabe zemljišč, to je zmanjšanja površine z lesno vegetacijo in povečanja kmetijskih in pozidanih zemljišč.

Juršič et al. (2017) so leta 2017 pregledali celoten tok reke Krke s pritoki in popisali 56 bobrišč. Ugotovili so, da sta bila ključna dejavnika bobrove razširjenosti obrežna vegetacija z velikimi drevesi majhnega premera in bogata zeliščna vegetacija. Bober je gradil tudi jezove in si tako omogočil preživetje tudi na manjših vodotokih. Večina bobrišč je bila bližje naseljem in njivam od optimalnih oddaljenosti.

Populacija bobra na Goričkem se še širi, zato bo bober v prihodnje naseljeval tudi manj ugodne habitate. Vodotoki na Goričkem so v primerjavi z vodotoki iz študij Vochl (2008), Juršič et al. (2017) in Vida (2022) ožji, plitvejši, a bober tam vseeno živi. Bobri so glede habitata prilagodljivi, saj preživijo in se razmnožujejo tudi v suboptimalnih habitatih, značilnosti habitata pa lahko z graditvijo jezov tudi izboljšajo. Bober lahko naseli tudi močno urbanizirana in kmetijska območja, a se tam dolgoročno ne ustali. Najpomembnejši dejavnik okolja je za bobra razpoložljivost ustreznih virov hrane (Hartman 1996; Zwolicki et al. 2018). To je še posebej pomembno v zgodnejših fazah vzpostavljanja teritorijev, saj mu omogoča preživetje in razmnoževanje (John et al. 2010). Družina bobrov (4–6 članov) za preživetje potrebuje približno 3 km vodnega toka s 6 m širokim pasom gozda (Kryštufek et al. 2006). V novem okolju je lahko začetna populacijska rast zelo hitra (20–34 % letno), nato začne upadati. Ob večanju populacijske gostote bobri vse bolj zasedajo obrobne habitate. Ključni dejavnik nosilne kapacitete okolja je lesna vegetacija, ki je na voljo pozimi. Pozimi bober večino aktivnega časa posveča iskanju hrane in prehranjevanju (Plut 2020). Razen ustreznih habitatov so za širjenje in stabilizacijo populacije pomembne tudi vodne migracijske poti brez večjih ovir (John et al. 2010).

Bober je na rdečem seznamu ogroženih živalskih vrst opredeljen kot prizadeta vrsta (Ur. l. RS 2002). Bober in njegovi habitati so zavarovani na več nivojih (Ur. l. EU 1992; Ur. l. RS 2004). Je tudi kvalifikacijska vrsta na izbranih območjih Nature 2000. Podatki o značilnostih bobrovega habitata na Goričkem so pomemben prispevek k razumevanju ekologije vrste, potenciala nadaljnjega širjenja populacije in k načrtovanju naravovarstvenih ukrepov za bobra na Goričkem.

Summary

The European beaver was considered extinct in Slovenia as well as in the majority of Europe in the early 20th century. After numerous reintroductions and the implementation of conservation measures, the beaver has recolonized Europe, and its populations are stable or increasing (Batbold et al. 2021; Halley et al. 2021). In Slovenia, the beaver has been present again since 1998, when it reached the Krka River basin from Croatia (Kryštufek et al. 2006). In the Goričko region (NE Slovenia), the beaver was first observed in 2016 at Lake Hodoš (Peček 2017). Since 2017, the beaver has also been present on the Velika Krka, Mala Krka, Lake Križevsko, Ledava River, Ledava Lake, Dolenski potok, and Lukaj potok (Malačič et al. 2018, 2020; BioPortal 2024). In the winter of 2021/22, five years after recolonization, we surveyed six water bodies (4 streams and 2 lakes) at Goričko, where beaver presence was confirmed between 2016 and 2020. The purpose of the survey was to determine the characteristics of selected beaver habitats at Goričko. We recorded habitat features considered key to beaver survival (Macdonald et al. 1995; Kryštufek et al. 2006) on 82 randomly selected sample plots. Descriptive statistics and frequency distributions were used for each variable separately for plots with and without signs of the beaver on standing and flowing waters. The beaver activity was confirmed on 31 plots. Beavers preferred standing water with higher water depth and width. Its presence was confirmed in 71% of plots sampled on the standing and 26% on flowing waters. Fields were the most common habitat type, while forest was found on 15 of 82 plots. Beaver was confirmed in 73% of the forest plots and 23% of the plots with fields. Shores with beaver signs were mostly 1 m high, or lower, and with a slope between 30° in 60°. Shores were in general very steep (> 60°). The nearest infrastructure was 30 m and human settlement 130 m away from the plots with beaver activity. Compared to similar studies in other parts of Slovenia (Kryštufek et al. 2006; Vochl 2008; Juršič et al. 2017; Vida 2022), the watercourses with beaver presence at Goričko are narrower and shallower, yet beavers are still present there. Beavers are adaptable in terms of habitat, as they survive and reproduce even in suboptimal habitats and can improve habitat characteristics by building dams. The most important environmental factor for beavers is the availability of suitable woody vegetation in winter (Hartman 1996; Zwolicki et al. 2018). In the initial phase of colonization, beavers select optimal habitats, but with the increasing population size they also settle in suboptimal habitats (John et al. 2010; Zwolicki et al. 2018; Vida 2022). Due to the early stage of recolonization at Goričko, we assume that beavers have chosen optimal habitats and will settle also in suboptimal habitats in the future. Knowledge of habitat characteristics and selection is important for conservation management and monitoring of the beaver at Goričko and Slovenia.

Zahvala

Zahvaljujemo se Tatjani Gregorc za ideje in nasvete pri načrtovanju terenskega dela ter recenzentoma za konstruktivne predloge za izboljšanje prispevka. Raziskava je bila pripravljena s podporo P1-0403 Računsko intenzivni kompleksni sistemi; financer: ARIS.

References

Batbold J, Batsaikhan N, Shar S, Hutterer R, Kryštufek B, Yigit N, Mitsainas G, Palomo L. 2021. *Castor fiber* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2021: e.T4007A197499749. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T4007A197499749.en

Bioportal 2024. Ujemite naravo! Bioportal, Center za kartografijo favne in flore. [dostop 8. 10. 2024]; http://www.bioportal.si/projekti_podatki.php

Campbell-Palmer R, Gow D, Campbell R, Dickinson H, Girling S, Gurnell J, Halley D, Jones S, Lisle S, Parker H et al. 2016. The Eurasian Beaver Handbook: Ecology and Management of *Castor fiber*. Exeter (UK): Pelagic Publishing.

Fryxell JM. 2001. Habitat suitability and source-sink dynamics of beavers. Journal of Animal Ecology. 70: 310-316. https://doi.org/10.1111/j.1365-2656.2001.00492.x

Gregorc T, Zavratnik S. 2017. Zimski monitoring (*Lutra lutra*) na Goričkem. Projekt: Raznoživost pod Vidrino streho na Goričkem. Zaključno poročilo. Ljubljana (SI): Lutra, Inštitut za ohranjanje naravne dediščine.

Halley DJ, Rosell F. 2002. The beaver's reconquest of Eurasia: status, population, development, and management of conservation success. Mammal Review. 32: 153-178.

Halley DJ, Saveljev AP, Rosell F. 2021. Population and Distribution of Beavers *Castor fiber* and *Castor canadensis* in Eurasia. Mammal Review. 51: 1-24. https://doi.org/10.1111/mam.12216

Hartman G. 1996. Habitat selection by European beaver (*Castor fiber*) colonizing a boreal landscape. Journal of Zoology. 240: 317-325. https://doi.org/10.1111/j.1469-7998.1996.tb05288.x

John F, Baker S, Kostkan V. 2010. Habitat selection of an expanding beaver (*Castor fiber*) population in central and upper Morava River basin. European Journal of Wildlife Research. 56: 663-671. https://doi.org/10.1007/s10344-009-0361-5

Juršič K, Zupančič K, Šet J, Mazinjanin K. 2017. Ocena številčnosti populacije evrazijskega bobra *Castor fiber* Linnaeus, 1758 na reki Krki in njenih pritokih v letu 2017. Natura Sloveniae. 19: 29-46. https://doi.org/10.14720/ns.19.2.29-46

Kocjančič J. 2005. Bobri so se vrnili v Prekmurje, v rokav reke Mure. Lovec. 88: 310-311.

Kološa L. 2023. Izbira habitata evropskega bobra, *Castor fiber* (Linnaeus, 1758) glede na abiotske in biotske dejavnike na Goričkem [magistrsko delo]. [Maribor]: Univerza v Mariboru.

Kryštufek B, Hudoklin A, Pavlin D. 2006. Bober *(Castor fiber*) v Sloveniji. Scopolia. 59: 1-41.

Law A, Levanoni O, Foster G, Ecke F, Willby NJ. 2019. Are beavers a solution to the freshwater biodiversity crisis? Diversity and Distributions. 25: 1763-1772. https://doi.org/10.1111/ddi.12978

Macdonald D. 2001. The New Encyclopedia of Mammals. Oxford (UK): University Press.

Macdonald DW, Tattersall FH, Brown ED, Balharry D. 1995. Reintroducing the European beaver to Britain: nostalgic meddling or restoring biodiversity? Mammal Review. 25: 161-200. https://doi.org/10.1111/j.1365-2907.1995.tb00443.x

Macdonald DW, Maitland P, Rao S, Rushton S, Strachan R, Tattersall F. 1997. Development of a protocol for identifying beaver release sites. Scottish Natural Heritage Research, Survey and Monitoring Report. No. 93.

Malačič K, Domanjko G, Podletnik M, Dešnik S. 2018. Priloga 1 k Letnemu poročilu o poslovanju 2017. Grad (SI): Javni zavod Krajinski park Goričko.

Malačič K, Domanjko G, Podletnik M, Dešnik S. 2020. Priloga 1 k Letnemu poročilu o poslovanju 2020. Grad (SI): Javni zavod Krajinski park Goričko.

[MKGP] Ministrstvo za kmetijstvo, gozdarstvo in prehrano. 2022. Javni pregledovalnik grafičnih podatkov MKGP. Ministrstvo za kmetijstvo, gozdarstvo in prehrano. [dostop 11. 7. 2022]; https://rkg.gov.si/GERK/WebViewer/

Mitchell-Jones AJ, Amori G, Bogdanowicz W, Krystufek B, Reijnders PJH, Spitzenberger F, Stubbe M, Thissen JBM, Vohralik V, Zima J. 1999. The atlas of European mammals. London (UK): T & AD Poyser.

Nowak RM. 1999. Walker's mammals of the World. Baltimore (USA): Johns Hopkins University Press.

Peček B. 2017. Dr. Marjana Hönigsfeld Adamič, varuhinja vider in bobrov. Bober se je vrnil domov, na Hodoš. Vestnik. 69: 15.

Pinto B, Santos MJ, Rosell F. 2009. Habitat selection of the Eurasian beaver (*Castor fiber*) near its carrying capacity: an example from Norway. Canadian Journal of Zoology. 87: 317-325. https://doi.org/10.1139/Z09-015

Plut P. 2020. Spremljanje vedenja evropskega bobra s pomočjo avtomatskih kamer [magistrsko delo]. [Ljubljana]: Univerza v Ljubljani.

Ur. l. EU. 1992. Direktiva Sveta 92/43/EGS z dne 21. maja 1992 o ohranjanju naravnih habitatov ter prostoživečih živalskih in rastlinskih vrst. UL L 206, 22.7.1992, p. 7-50 .

Ur. l. RS. 2002. Pravilnik o uvrstitvi ogroženih rastlinskih in živalskih vrst v rdeči seznam. Uradni list RS, 82/02, 42/10.

Ur. l. RS. 2004. Uredba o zavarovanih prosto živečih živalskih vrstah. Uradni list RS, 46/04, 109/04, 84/05, 115/07, 32/08 – odl. US, 96/08, 36/09, 102/11, 15/14, 64/16, 62/19.

Vida M. 2022. Razširjenost evropskega bobra (*Castor fiber*) v severovzhodni Sloveniji v povezavi z habitatnimi in antropogenimi dejavniki [magistrsko delo]. [Maribor]: Univerza v Mariboru.

Vochl S. 2008. Bober (*Castor fiber* L.) v nižinskih poplavnih gozdovih Slovenije [diplomsko delo]. [Ljubljana]: Univerza v Ljubljani.

Zwolicki A, Pudełko R, Moskal K, Świderska J, Saath S, Weydmann A. 2018. The importance of spatial scale in habitat selection by European beaver. Ecography. 42: 187-200. https://doi.org/10.1111/ecog.03621

Dodatek

Tabela S1. Seznam 82 popisnih ploskev z geografskimi koordinatami, imeni vodnih teles, imeni krajev, vrednostmi spremenljivk (iz Tab. 1) in klasifikacijo glede na prisotnost/odsotnost sledi bobra. Tabela je dostopna kot spletni suplement na naslovu https://doi.org/10.14720/ns.26.2.5-20.

Table S1. List of 82 sample plots with geographical coordinates, names of water bodies, place names, variable values (from Tab. 1), and classification based on presence/absence of signs of beaver activity. The table is available as an online supplement at https://doi.org/10.14720/ns.26.2.5-20.

NATURA SLOVENIAE 26(2): 21-33
SHORT COMMUNICATION

Prejeto / Received: 26. 11. 2024
Sprejeto / Accepted: 20. 12. 2024

DOI: 10.14720/ns.26.2.21-33

First records of two slug species, *Limax conemenosi* (O. Boettger, 1882) and *Limax dacampi* (Menegazzi, 1855) (Gastropoda: Limacidae) in Slovenia

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Abstract. In Slovenia, 27 species of slugs have been confirmed so far. Distributional data for two species from the genus *Limax* new for the country are presented herewith. *Limax conemenosi* was found for the first time in Slovenia at Nova Gora near Krško, whereas *Limax dacampi* was first recorded in the village of Osp and recently in the village of Abitanti. Species identities were assessed on the basis of external morphological features and diagnostic DNA sequences of cytochrome c oxidase subunit I. Subsequently, the new number of slug species confirmed in Slovenia is 29.

Key words: Gastropoda, slugs, *Limax*, DNA sequences, distribution, Slovenia

Izvleček. Prvi podatki o dveh vrstah golih polžev, pikastem slinarju *Limax conemenosi* (O. Boettger, 1882) in rdečem slinarju *Limax dacampi* (Menegazzi, 1855) (Gastropoda: Limacidae) v Sloveniji – Do zdaj je bilo v Sloveniji potrjenih 27 vrst golih polžev. V prispevku predstavljamo podatke o razširjenosti dveh vrst iz rodu *Limax*, novih za državo. Pikasti slinar *Limax conemenosi* je bil v Sloveniji prvič najden v Novi Gori v bližini Krškega, rdeči slinar *Limax dacampi* pa je bil prvič zabeležen v Ospu in nedavno v Abitantih. Vrsti smo potrdili na podlagi zunanjih morfoloških značilnosti in pridobljenih DNK-sekvenc podenote 1 citokrom C oksidaze. Tako je novo število potrjenih vrst golih polžev v Sloveniji zdaj 29.

Ključne besede: Gastropoda, goli polži, *Limax*, DNA-sekvence, razširjenost, Slovenija

Introduction

Slugs are an understudied group of molluscs in Slovenia, with the first comprehensive paper on slugs published in 2002 (Vaupotič & Velkovrh 2002). The authors published a revised list of species with maps of distributions, reporting on 27 slug species for Slovenia. They collected data from older publications and complemented them with additional species records with the study of approximately 600 samples of slugs from three collections, including six new species for Slovenia (Vaupotič & Velkovrh 2002). There are five different families of slugs in Slovenia – Milacidae, Limacidae, Boettgerilidae, Agriolimacidae and Arionidae (Vaupotič & Velkovrh 2002). The Limacidae family is represented by five species, two of them belonging to the genus *Limax*.

One of them is *Limax maximus* (Linnaeus, 1758), known for a distinct pattern of dark blots and dots on the upper side of the foot and mantle (Welter-Schultes 2012). The second one is *Limax cinereoniger* (Wolf, 1803), a species with highly variable dark colour patterns and a distinctive sole of the foot with two dark longitudinal bands on the sides (Welter-Schultes 2012) that make it easily recognizable. Both species have wide distribution in Slovenia (Vaupotič & Velkovrh 2002).

In this contribution, we report on new data for two species, *Limax conemenosi* (O. Boettger, 1882) and *Limax dacampi* (Menegazzi, 1885), new for Slovenia.

Materials and methods

Field work

Discoveries of both species are the result of accidental findings, with targeted field studies following the first discoveries.

At the site at Nova Gora near Krško (Figs. 1, 3) slugs were first found accidentally under a wooden board. We searched for the species again twice later on, during the day by flipping wooden material, and in the night when slugs are active (Salvador & Tomotani 2024) by slow inspection of the terrain. We collected the biggest individual for subsequent determination.

First discoveries of another species of slugs from the sites in southwestern Slovenia (Fig. 1) were also accidental. Slugs were found for the first time in the night time in 2011 at a site near Osp. Recently we found the species at another site in Abitanti (Figs. 1, 5) during our night fieldwork searching for amphibians. We observed slugs moving around in the grass and on the rock drywalls and collected one big individual for determination. Another search during the day by flipping rocks and wooden material wasn’t successful.

Morphological determinations

We determined both collected individuals still alive on the basis of the external morphological features described by Welter-Schultes (Welter-Schultes 2012). Both individuals were photographed and released in the places of their discovery.

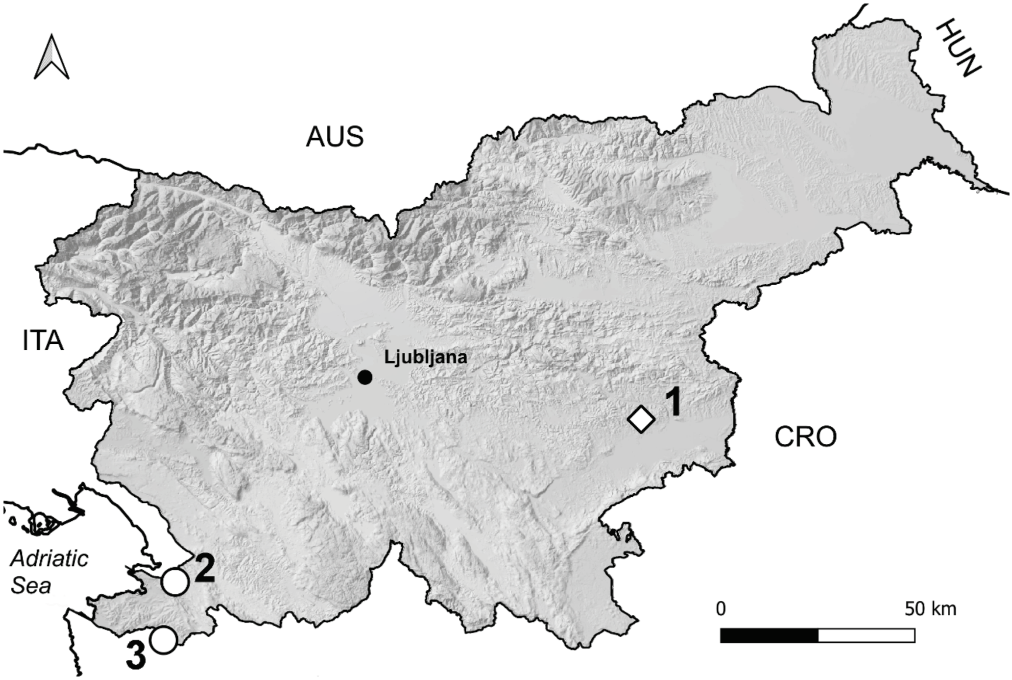

Figure 1. Distribution map of two newly discovered *Limax* species for Slovenia. Circles represent sites of discovery of *Limax dacampi* in southwestern Slovenia. Osp is marked with number 2 and Abitanti with number 3. Rhombus marked with number 1 represents site of discovery of *Limax conemenosi* in Nova Gora.

Slika 1. Zemljevid razširjenosti dveh novoodkritih vrst slinarjev (*Limax*) v Sloveniji. Kroga ponazarjata mesti najdb rdečega slinarja *Limax dacampi* v jugozahodni Sloveniji. Osp je označen s številko 2 in Abitanti s številko 3. Romb, označen s številko 1, ponazarja mesto najdbe pikastega slinarja *Limax conemenosi* v Novi Gori.

Molecular determinations

In order to confirm both morphological determinations, we sequenced and analysed DNA sequences of cytochrome c oxidase subunit I of collected individuals. We isolated DNA from a small piece of tissue from the tip of the tail, using MagMAX DNA Multi-sample Kit (Thermo Fisher Scientific Inc., United states), following the instructions of the producer. We amplified a 650 bp fragment of the mitochondrial cytochrome oxidase I (COI) gene using the KAPA2G Robust PCR Kit (Sigma-Aldrich, USA) and primers LCO1490 and HCO2198 (Folmer et al. 1994). The PCR products were purified with Exonuclease I and FastAP (Thermo Fisher Scientific, USA) and sequenced bidirectionally by Macrogen Europe (Amsterdam, Netherlands) using the same primers. Chromatograms were assembled and edited in Geneious Prime 2023.2.1. The sequences were aligned with sequences of the *Limax* species that are morphologically similar and hence mistakable for the species we found and are also available in Genbank. We constructed a maximum likelihood phylogenetic tree using IQ-TREE with default settings (Minh et al. 2020) to perform DNA barcoding and determining whether our samples match any of the available sequences.

Results and discussion

The data on two species of slugs, *Limax conemenosi* and *Limax dacampi*, indicate the first confirmation of their presence for Slovenia.

Comments on *Limax conemenosi* findings

Limax conemenosi is a cream or yellowish-coloured slug with numerous 1 mm big black dots equally distributed over the upper side of the mantle and the foot (Fig. 2). The sole is uniformly coloured (Welter-Schultes 2012). It lives in bush thickets and rocky open habitats, often as a synanthrope. It is less frequently found in forests (Wiktor 1996).

Figure 2. Conemenos' slug *Limax conemenosi* collected in Nova Gora on 6. 4. 2024. Photos are taken on one centimetre grid paper, showing external morphological features from different angles (photo: Maj Kastelic).
Slika 2. Pikasti slinar *Limax conemenosi*, ujet v Novi Gori 6. 4. 2024. Fotografiran je na papirju s centimetrsko mrežo iz različnih zornih kotov, ki prikazujejo njegove zunanje morfološke značilnosti (foto: Maj Kastelic).

Limax conemenosi probably originates from Greece, but is also found in Bulgaria, North Macedonia, Kosovo (Wiktor 1996), Albania (Dhora 2014) and Montenegro (Jovanović 1995). There are no official records from Bosnia and Herzegovina and Croatia (Wiktor 1996; Štamol 2010; Duda & Haring 2023), but photos of slugs on the citizen science platform iNaturalist that have external morphological features characteristic of *L. conemenosi* are from localities as far north as Croatian Istria (iNat 2024). In Serbia, there have been no official records of the species, even though the southernmost tip of the country is marked on the distribution map in the book European non-marine molluscs, a guide for species identification (Welter-Schultes 2012).

The slug *L. conemenosi* was first found accidentally under a wooden board in the village of Nova Gora near Krško (WGS84 lat./long.: 45.953872 °N, 15.399901 °E; alt. 415 m) (Fig. 3) on 30. 3. 2024. We found two individuals.

Figure 3. Habitat of *Limax conemenosi* in Nova Gora on 29. 9. 2024. All of the individuals were found in close proximity to the houses with several surrounding vineyards and extensive orchards (photo: Matej Kastelic).
Slika 3. Habitat pikastega slinarja *Limax conemenosi* v Novi Gori 29. 9. 2024. Vsi osebki so bili najdeni v bližini hiš. Ob hišah je veliko vinogradov in ekstenzivnih sadovnjakov (foto: Matej Kastelic).

The species was rediscovered on 6. 4. 2024 when six individuals were found during the day under wooden boards. The biggest one of them was collected for determination (Fig. 2). Three more individuals were observed on 7. 9. 2024 in the night time when they were active.

The species identity was confirmed using CO1 sequences. The Nova Gora slug sequence, deposited in GenBank under accession number PQ676333, shows 99.11% similarity to sequence MT293865.1, 99.07% to MT293864.1 and 98.48% to sequence MT975672.1 (Tab. S1, Supp. Mat.). All three reference sequences are deposited as *L. conemenosi*. The two most similar sequences (MT293865.1 and MT293864.1) were obtained from juvenile slugs near Lake Volvi (Dimzas et al. 2020). These identifications relied solely on external morphology, as reproductive system data was unavailable. At the time, no *L. conemenosi* sequences were officially designated (Dimzas et al. 2020). The third sequence (MT975672.1) comes from a slug collected on Corfu by R. Anderson in 2018 (Giusti et al. 2021).

The relationships between our sequence and the reference sequences are illustrated in the phylogenetic tree (Fig. 6).

Table 1. External morphological characteristics of the collected individual determined as *L. conemenosi* (»specimen«) and morphologically similar species living in Europe. Descriptions of characteristics are taken from Welter-Schultes (2012). Grey background with text in bold means that a certain characteristic of a species is the same as of the collected individual. White background with normal text signifies that a certain characteristic of a species differs from the characteristic of the collected individual. NA on white background means that a certain description is not available. Among the species in the table, which are all morphologically similar, only *L. maximus* was known to have occurred in Slovenia so far.

Tabela 1. Zunanje morfološke značilnosti preučevanega osebka določenega kot *L. conemenosi* (»specimen«) in morfološko podobnih vrst, ki živijo v Evropi. Opisi lastnosti so vzeti iz Welter-Schultes (2012). Sivo ozadje s poudarjenim besedilom pomeni, da je opisana lastnost enaka lastnosti preučevanega osebka. Belo ozadje z nepoudarjenim besedilom pomeni, da je opisna lastnost drugačna od lastnosti preučevanega osebka. NA na belem ozadju pomeni, da določen opis ni na voljo. Od vrst v tabeli, ki so si vse morfološko podobne, je bilo do sedaj v Sloveniji znano le pojavljanje vrste *L. maximus*.

Outer morphological characteristics	**»specimen«**	*Limax conemenosi*	*Limax millipunctatus*
mantle size	**relatively short (1/4 of body, 30 mm)**	**relatively short (1/4 of body, up to 22 mm)**	NA
mantle shape	**rounded at posterior end**	NA	mantle anteriorly rounded and pointed at posterior end, concentrically striated
keel	**very short and not prominent**	**very short (10 mm) and not prominent**	**short and not very prominent**
tubercules	**elongated**	NA	oval and not very prominent
dorsum of the foot	**rounded and little darker than sides**	**rounded and little darker than sides**	brown-reddish hue, coloured medial line in posterior section
sides of the foot	**a little lighter than dorsum**	**a little lighter than dorsum**	slightly less regular
sole of the foot	**sole light, like the background colour**	**sole light, like the background colour**	**evenly white**
dots	**numerous small black dots with sharp edges**	**numerous 1 mm large black dots with sharp edges**	**numerous black dots**
pattern of dots	**regularly spotted, many dots**	**regularly spotted**	**evenly distributed**
colour	**light creamish to pinkgray**	**dirty cream, yellowish or reddish grey**	**greyish or yellowish with brown-reddish hue**
size	**130 mm**	**up to 120 mm**	**115–120 mm**
pneumostome	**without distinct margin, slightly posterior of the centre of the mantle**	21–23 fine and flattened wrinkles between medial line of dorsum and pneumostome	**without distinct margin, slightly posterior of the centre of the mantle**
tentacles	**without dots, bases of tentacles not approaching each other**	NA	finely spotted, bases of tentacles not approaching each other
mucus	**colourless**	**colourless**	NA
known distribution	**Nova Gora near Krško**	originally probably Greece, at present also Bulgaria to Albania	Lombardia, N Apennines

(cont.)

Table 1. (cont.)
Tabela 1. (nad.)

Outer morphological characteristics	*Limax punctulatus*	*Limax canapicianus*	*Limax redii*	*Limax maximus*
mantle size	NA	NA	NA	30% of the body
mantle shape	NA	**rounded at posterior end**	NA	pointed at posterior end
keel	light and extending over 1/2 of the dorsum length	short and weakly lighter brown than dorsum	NA	clearly visible, 1/3 of body length
tubercules	**elongated and irregular**	NA	NA	NA
dorsum of the foot	**light greyish with yellowish hue**	**light brown**	**creamy or yellowish, sometimes with bluish hue**	**ash-grey-cream or brownish, variable**
sides of the foot	dots slightly less regular	**light brown**	**creamy or yellowish, sometimes with bluish hue**	**ash-grey-cream or brownish, variable**
sole of the foot	evenly white and subdivided in 3 equally wide longitudinal zones	**evenly white**	NA	**uniformly cream-coloured**
dots	**numerous black dots (0.5 mm big on mantle)**	**black, nearly rounded**	**small black**	most slugs with large blots and variable mantle spots
pattern of dots	evenly distributed (12–14 dots in 3 to 4 longitudinal rows)	NA	scattered black dots, less dotted on mantle	variable patterns of blots and dots
colour	**light greyish with yellowish hue (lighter than *L. millipunctatus*)**	**light brown**	**creamy or yellowish, sometimes with bluish hue**	**ash-grey-cream or brownish, variable**
size	**up to 130 mm**	**up to 140 mm**	**up to 150 (exceptionally 230 mm)**	**up to 200 cm**
pneumostome	darker margin, slightly posterior of the centre of the mantle	in the mid section of the mantle	NA	21–36 wrinkles between medial line of dorsum and pneumostome
tentacles	bases approaching each other	NA	grey	NA
mucus	NA	NA	NA	**colourless**
known distribution	N Italy, Bulgaria?	NW Italy (Alpi Graie)	N Italy (Como, Varese), S Switzerland (Ticino, W of Lago di Como)	Originally S and W Europe, perhaps also N Africa, today widespread in Europe, Caucasus and abroad

The specimen examined herewith best corresponds to description of *L. conemenosi* (Welter-Schultes 2012) (Tab. 1).

Comments on *Limax dacampi* findings

Limax dacampi is a red slug with dark colour bands at the sides or dark spots on the dorsum (Fig. 4). It grows up to 20 cm long and has a distinctive sole of the foot with two dark longitudinal bands on the sides as *L. cinereoniger* (Welter-Schultes 2012). It is known from different locations in Italy, where it was first described in 1885 at Lago di Garda by Menegazzi, even though new individuals were only rediscovered in type locality quite recently (in 2008) when mating was also documented (Falkner et al. 2008). It lives in different habitats, preferring forests and shrubs in lowlands (Welter-Schultes 2012). The species itself shows high morphological variability and is taxonomically problematic.

It is probably a complex of different species (Falkner et al. 2008). It is known from different localities in Italy (Falkner et al. 2008; Rowson et al. 2014) as well as Switzerland, Croatia and the UK (Rowson et al. 2014). In the UK, it is only found in one location in North-east Yorkshire and has almost certainly been introduced from central Italy (Rowson et al. 2014). There is no record of *L. dacampi* in Slovenia in older publications (Wiktor 1996; Vaupotič & Velkovrh 2002).

The species was first recorded in Slovenia on 11. 8. 2011, when Borut Kumar found *L. dacampi* in Osp. Identity of the slug was determined by Clemens M. Brandstetter (moderator of malacological part of forum Natura Mediteraneo, member of Die Gesellschaft zur Kartierung der Wirbellosen in Vorarlberg und Liechtenstein). The finding remained unpublished at the time.

We found *L. dacampi* for the first time on a forest road near the village of Abitanti (WGS84 lat./long.: 45.436781 °N, 13.822295 °E; alt. 396 m) (Fig. 5) on 11. 5. 2024 during the night when slugs were active. We found eleven individuals and took pictures of every individual. We collected one of them for identification (Fig. 4).

We revisited the site on 29. 8. 2024 in time of drought, but found no individuals.

The identity of the species was confirmed based on CO1 sequences. Sequence of the slug from Abitanti is deposited in GenBank under accession number PQ676334 and is 99.84% identical to the sequence JX435840.1, 99.68% to the sequence JX435860.1, 99.66% to the sequence JX435861.1, 97.71% to the sequence JX435862.1 and 96.61% to sequences KF894382.1 and KF894384.1. All six corresponding sequences are deposited in GenBank as *L. cf. dacampi*. Two most similar sequences (JX435840.1 and JX435860.1) come from slugs from Croatian Istria (Nitz 2013). Two least similar sequences come from slugs from north-east Yorkshire (Rowson et al. 2014). Slug with most similar sequence was found in 1991 at Motovun (Nitz 2013) just approximately 11 km from where we found *L. dacampi*, which could mean that *L. dacampi* was present in Slovenia for quite some time, before it was first found.

Figure 4. *Limax dacampi* collected at Abitanti on 11. 5. 2024. Photos are taken on one centimetre grid paper, showing external morphological features from different angles (photo: Maj Kastelic).
Slika 4. Rdeči slinar *Limax dacampi*, ujet v Abitantih 11. 5. 2024. Fotografiran je na papirju s centimetrsko mrežo iz različnih zornih kotov, ki prikazujejo zunanje morfološke značilnosti (foto: Maj Kastelic).

Figure 5. Habitat of *Limax dacampi* at Abitanti on 29. 8. 2024. Slugs were found on a forest road next to dry stonewalls (photo: Maj Kastelic).
Slika 5. Habitat rdečega slinarja *Limax dacampi* v Abitantih 29. 8. 2024. Gole polže smo našli na kolovozu ob suhozidih (foto: Maj Kastelic).

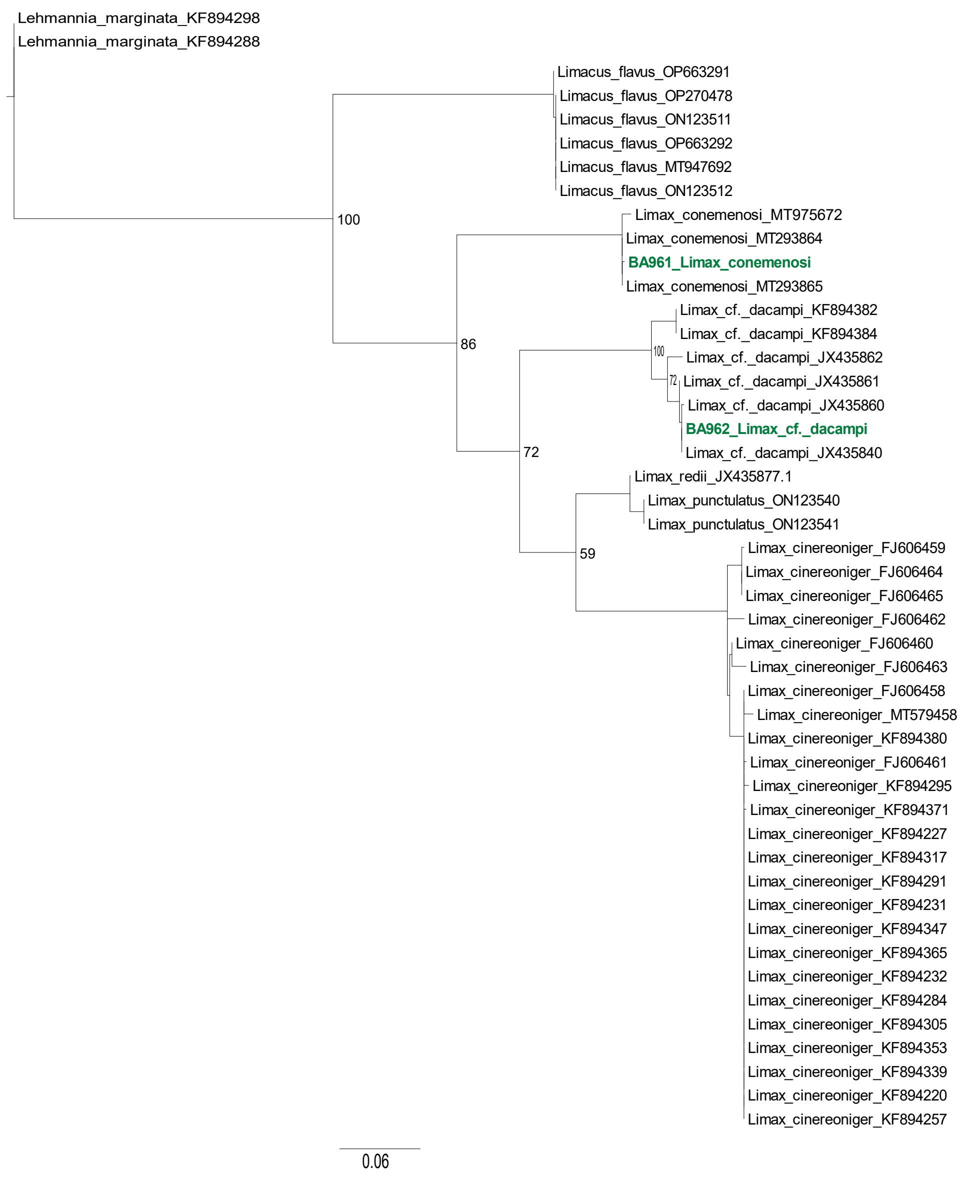

Figure 6. Phylogenetic tree including sequences of slugs examined herein (shown in green), morphologically similar species living in Europe and species from the Limacidae family living Slovenia. *Limax millipunctatus*, *Limax canapicianus* and *Malacolimax mrazeki* are not shown in the tree, since there are no available sequences. The numbers behind species name are accession numbers from GenBank. Numbers at nodes indicate bootstrap support. Sources of sequences are shown in Tab. S1 in Supplementary Material.

Slika 6. Filogenetsko drevo s sekvencama preučevanih golih polžev (napisani z zeleno barvo), morfološko podobnih vrst, živečih v Evropi, in vrst iz družine slinarjev Limacidae, ki živijo v Sloveniji. *Limax millipunctatus*, *Limax canapicianus* in *Malacolimax mrazeki* na drevesu niso prikazani, ker njihove sekvence niso na voljo. Števila za vrstnimi imeni so dostopne kode sekvenc, objavljenih na strani GenBank. Številke na razvejitvah prikazujejo vrednost samovzorčenja (bootstrap support). Viri sekvenc so prikazani v Tab. S1 v Dodatnem materialu.

By confirming the presence of both species in Slovenia, the number of *Limax* slug species in Slovenia has increased to four, and total number of known slug species to 29. The group remains severely understudied in Slovenia, and further research is needed to improve our knowledge. Additional studies are likely to uncover more previously unrecorded species for the country.

Povzetek

V kratki vesti so predstavljeni podatki o dveh prvih najdbah vrst iz rodu slinarjev *Limax*. Iz družine Limacidae je bilo do sedaj znanih pet vrst, od tega dve vrsti iz rodu *Limax* (Vaupotič & Velkovrh 2002). Rdečega slinarja *Limax dacampi*, ki izvira iz Italije (Rowson et al. 2014), je prvič našel Borut Kumar leta 2011 v Ospu, potrdil pa Clemens M. Brandstetter, vendar najdbe nista objavila. V Abitantih smo 28. 11. 2024 našli odrasle osebke vrste in enega izmed njih vzeli za determinacijo (Sl. 4). Pikastega slinarja *Limax conemenosi,* ki verjetno izvira iz Grčije (Welter-Schultes 2012), pa smo prvič odkrili 30. 3. 2024 v Novi Gori v bližini Krškega. Največjega izmed najdenih osebkov smo odvzeli za determinacijo (Sl. 2). Oba polža smo najprej določili na podlagi opisov zunanjih morfoloških znakov, opisanih v European non-marine molluscs, a guide for species identification (Welter-Schultes 2012), nato pa še na podlagi DNK-sekvenc podenote 1 citokrom C oksidaze. DNK smo uspešno izolirali iz vzorca tkiva iz konice repa in ga pomnožili z oligonukleotidnimi začetniki LCO1490 in HCO2198. Zaporedje so sekvencirali v Macrogen Europe (Amsterdam, Nizozemska) z uporabo istih začetnikov. Na podlagi dobljenih sekvenc in sekvenc morfološko podobnih vrst iz rodu slinarjev *Limax* in predstavnikov družine slinarjev Limacidae, ki živijo v Sloveniji, smo sestavili filogenetsko drevo (Sl. 6). Nekatere vrste v drevesu manjkajo, saj njihovih sekvenc v bazi GenBank ni. Novo število potrjenih vrst golih polžev v Sloveniji je tako 29.

Acknowledgements

We would like to thank Cene Fišer for helping us with slug determination and guiding us throughout the writing process, Rajko Slapnik for providing the information of the first find of *Limax dacampi* by Borut Kumar, and Borut Kumar for trusting us to publish his data. We also thank Marjan Vaupotič for his advice on studying slugs, Maja Zagmajster for providing the map of distribution, and the ARIS programme P1-0184 for funding this research. Special thanks go to everyone who helped with the fieldwork: to Romana Božič for helping search for *Limax conemenosi,* Blaž Pavlič, Lana Klemenčič, Nik Milek, Nik Šabeder and Val Milek with whom we searched for amphibians but discovered *Limax dacampi*, and to David Tomšič for his help during the second search for *Limax dacampi*.

References

Dhora D. 2014. Molluscs of Albania 2014: List of species and biogeographical data. Buletin Shkencor – Seria e shkencave të natyrës. 64: 149-181.

Dimzas D, Morelli S, Traversa D, Di Cesare A, Van Bourgonie YR, Breugelmans K, Backeljau T, di Regalbono AF, Diakou A. 2020. Intermediate gastropod host of major feline cardiopulmonary nematodes in an area of wildcat and domestic cat sympatry in Greece. Parasites & Vectors. 13: 345. https://doi.org/10.1186/s13071-020-04213-z

Duda M, Haring E. 2023. Molluscs (Gastropoda and Bivalvia) of the upper Neretva River. Natura Sloveniae 25: 15-17. https://doi.org/10.14720/ns.25.3.15-27

Falkner G, Brandstetter CM, Vogt DM, Niederhöfer H. 2008. Wiederentdeckung und Kopulationsbiologie von *Limax dacampi* Menegazzi 1855 am locus typicus (Gastropoda: Limacidae); [accessed 19. 9. 2024]. https://www.schnegel.at/download/pdf/limax_dacampi.pdf

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology. 3: 294-299.

Giusti F, Lesicki A, Benocci A, Pieńkowska J, Manganelli G. 2021. *Weltersia obscura*, a new slug from the island of Montecristo (Tuscan Archipelago, Italy): a hitherto undiscovered endemic or a recent alien? (Mollusca, Pulmonata, Limacidae). Systematics and Biodiversity. 19(3): 1-17. https://doi.org/10.1080/14772000.2021.1908442

[iNat] iNaturalist. *Limax conemenosi*; [accessed on 12. 9. 2024]. https://www.inaturalist.org/observations?subview=map&taxon_id=793336

Jovanović B. 1995. Diverzitet puževa (Gastropoda, Mollusca) Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović V, Vasić V, editors: Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Beograd: Biološki fakultet & Ecolibri. p. 291-293.

Minh B, Schmidt H A, Chernomor O, Schrempf D, Woodhams M D, von Haeseler A, Lanfear R. 2020. IQ-TREE 2: New Models and Efficient Methods for Phylogenetic Inference in the Genomic Era. Molecular Biology and Evolution. 37: 1530-1534. https://doi.org/10.1093/molbev/msaa015

Nitz B. 2013. Integrative systematic and biogeography of *Limax* (Gastropoda: Stylommatophora). [PhD thesis]. [München]: Ludwig-Maximilians-Universität München.

Rowson B, Anderson R, Turner JA, Symondson WOC. 2014. The slugs of Britain and Ireland: undetected and undescribed species increase a well-studied, economically important fauna by more than 20%. PLoS One. 9: 1-21. https://doi.org/10.1371/journal.pone.0091907

Salvador RB, Tomotani BM. 2024. Clocks at snail pace: biological rhythms in terrestrial gastropods. PeerJ. 12: e18318. http://doi.org/10.7717/peerj.18318

Štamol V. 2010. A list of the land snails (Mollusca: Gastropoda) of Croatia with recommendations for their Croatian names. Natura Croatica 19: 1-76.

Vaupotič M, Velkovrh F. 2002. Goli polži (Gastropoda: Pulmonata: Milacidae, Limacidae, Boettgerillidae, Agriolimacidae, Arionidae) Slovenije. Acta Biologica Slovenica. 45: 35-52. https://doi.org/10.14720/abs.45.2.16630

Welter-Schultes F. 2012. European non-marine molluscs, a guide for species identification. Göttingen: Planet poster editions.

Wiktor A. 1996. The slugs of the former Yugoslavia (Gastropoda terrestria nuda – Arionidae, Milacidae, Limacidae, Agriolimacidae). Annales Zoologici. 46: 1-100.

Supplementary material

Table S1. The list of GenBank (NCBI 2024) accession numbers with species determined and references, including new sequences reported here. The table is available as an online supplement at https://doi.org/10.14720/ns.26.2.21-33.

NATURA SLOVENIAE 26(2): 35-39
SHORT COMMUNICATION

Prejeto / Received: 5. 11. 2024
Sprejeto / Accepted: 18. 11. 2024

DOI: 10.14720/ns.26.2.35-39

Three new species of Niphargidae family added to the list of subterranean amphipods (Crustacea: Amphipoda) in Slovenia

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Abstract. Since the last comprehensive checklist of amphipods in 2021, three new species of subterranean amphipods have been confirmed for Slovenia: *Niphargus danielopoli*, *N. lurensis* and *N. julius*. Identification of all three species was based on molecular comparative analyses of the mitochondrial CO1 gene fragment, usually used in DNA barcoding identification. With these additions, we reached a total of 201 amphipod species confirmed for Slovenia, 60 of which are groundwater inhabitants, with 57 species belonging to the genus *Niphargus*.

Key words: groundwater, checklist, additional species, *Niphargus*, hotspot, barcoding, species richness

Izvleček. Tri nove vrste iz družine Niphargidae dodane na seznam podzemnih postranic (Crustacea: Amphipoda) Slovenije – Od zadnjega izčrpnega seznama postranic leta 2021 so bile za Slovenijo potrjene tri nove vrste podzemeljskih postranic: *Niphargus danielopoli*, *N. lurensis* in *N. julius*. Identifikacija treh vrst je temeljila na molekularnih primerjalnih analizah fragmenta mitohondrijskega gena CO1, ki se običajno uporablja pri identifikaciji s črtnim kodiranjem DNA. S temi dodatki je za Slovenijo potrjenih skupno 201 vrst postranic, od katerih je 60 podzemnih, s 57 vrstami iz rodu Niphargus.

Ključne besede: podzemne vode, seznam, dodatne vrste, *Niphargus*, vroča točka, barkodiranje, vrstno bogastvo

Introduction

In the recently published checklist of amphipods of Slovenia, 198 different species inhabiting marine, brackish, freshwater, and terrestrial habitats have been listed (Fišer et al. 2021). More than one-fourth (57 species) of them inhabit groundwater and can be treated as obligatory subterranean species. All but three belong to the family Niphargidae. The genus *Niphargus* is the most diverse genus of freshwater amphipods in the world and is distributed throughout the western Palearctic region (Borko et al. 2021). Due to its wide distributional range and high species richness, *Niphargus* is the focal group for various taxonomical, ecological, evolutionary and biodiversity studies (e.g. Stoch et al. 2020; Borko et al. 2021, 2022).

Subsequently, Borko et al. (2022) published a study with an extensive list of *Niphargus* species with corresponding CO1 barcoding sequences. Although some sequences could have been ascribed to morphologically described species, many of them present potential new species based on molecular differences. Further sequencing of the *Niphargus* CO1 marker in Ljubljana (SubBioLab, at Biotechnical Faculty, University of Ljubljana) and elsewhere allowed us to link the identity of two other MOTUs (molecular operational taxonomic units) in Borko et al. (2022) with valid species names. To keep the amphipod checklist for Slovenia updated, we report herewith on all three additional species for the country.

Material and methods

Information on the new species for Slovenia was registered in the SubBioDB database, a spatial relational database managed by SubBioLab. Info on the new species and MOTUs were extracted from Borko et al. (2022), where the sequences were originally used in the analyses of biodiversity patterns of subterranean amphipods in the Western Balkans.

DNA extraction from amphipods stored in the SubBioLab collection was based on a single appendage; hence the specimens remained in the collection for potential subsequent morphological identification. The protocol of DNA extraction and amplification of the Folmer's CO1 barcoding fragment (Folmer et al. 1994) for two species followed the one described in Borko et al. (2021), with post-sequencing species identification using the BLAST tool (Altschul et al. 1990). Species identification was made based on widely used 97% match (Ratnasingham & Hebert 2007) with the barcoding fragments of CO1 stored in GenBank.

All sequences were deposited in GenBank, with access numbers given in the Results section.

Results and discussion

Three new groundwater amphipod species were recorded at four different localities in Slovenia (Tab. 1). One of them, *N. danielopoli*, was identified to the species level by Borko et al. (2022), while the other two were referred to as different MOTUs (Tab. 1). A comparison of acquired sequences with those stored in GenBank or originating in neighbouring countries (Stoch et al. 2020) allowed us to unambiguously identify two additional *Niphargus* species.

Niphargus danielopoli Karaman G., 1994 was described from Austria. It is a small species that has been reported from several localities geographically scattered in central Europe and northern Italy (Karaman 1994), and confirmed in Northern Slovenia (Borko et al. 2022).

Niphargus lurensis Schellenberg, 1935 was first described as a form of *N. tatrensis* Wrześniowski, 1888. In their molecular study, Stoch et al. (2020) provided evidence that this form should be treated as a valid species distributed in Styrian karst in Austria. Based on the barcoding fragment published by Stoch et al. (2020), the identification of material from Northeastern Slovenia revealed that this species is also present at two sites in Slovenia (Tab. 1).

The third species, *N. julius* Stoch, 1997, has been reported from several caves and springs in the Nadiža/Natisone and neighbouring river valleys in northeastern Italy, close to the Slovenian border (Stoch 1997; Karaman 2020). Its presence in Slovenia was confirmed after comparing sequences of individuals collected in a cave close to Kobarid with sequences from Italy (Stoch et al. 2023; Tab.1).

Table 1. The list of new groundwater amphipod species confirmed as occurring in Slovenia, with reported details on findings (taken from the SubBioDB database). Coordinates (Lat: N latitude; Long: E longitude) are given in WGS84 decimal degrees. The Acc. No. refers to the sequence's GenBank access number and a code in brackets to the specimen's voucher number in the SubBioDB. The name, under which it was reported in Borko et al. (2022), is given in the last column.

Tabela 1. Seznam novih vrst podzemnih postranic, ki se potrjeno pojavljajo v Sloveniji, s podrobnejšimi podatki o najdbah (povzeto po podatkovni bazi SubBioDB). Koordinate (Lat: severna geografska širina; Long: vzhodna geografska dolžina) so podane v WGS84 decimalnih stopinjah. Okrajšava Acc. No. se označuje GenBank identifikacijsko številko, medtem ko se oznaka v oklepaju nanaša na številko osebka (voucher) v SubBioDB. V zadnjem stolpcu je navedeno ime, pod katerim je bila vrsta navedena v Borko et al. (2022).

Species	**Locality**	**Lat, Long**	**Date**	**Collectors**	**Acc. No. (voucher)**	**Name in Borko et al. (2022)**
Niphargus danielopoli G. Karaman, 1994	Izvir Veliki Javornik, Javorniški rovt, Jesenice (spring)	46.458228, 14.108519	27.5.2017	Simona Prevorčnik	OK156541 (NC216), OK157026 (ND518), OK157027 (ND519)	*N. danielopoli*
Niphargus lurensis Schellenberg, 1935	Vodnjak pri hiši Cven 1c (well)	46.551063, 16.208525	14.8.2011	Jasmina Kotnik	OK156762 (ND186)	*N.* spn ND186
	Vodnjak ob hiši Ribiška 24 in Veržej (well)	46.586558, 16.165139	9.6.2017	Maja Zagmajster, Simona Prevorčnik, Nataša Mori	OK157130 (ND642)	*N.* spn ND186
Niphargus julius Stoch, 1997	Turjeva jama (Slovene cave Registry No. 821), Kred, Kobarid (cave)	46.241212, 13.500463	15.1.2018	Teo Delić, Špela Borko, Klemen Koselj, Maja Zagmajster	OK157116 (ND624)	*N.* spn ND624

Even though Slovenia has already been recognised as a hotspot of groundwater amphipod diversity in the Western Balkans (Bregović et al. 2019), the ongoing analyses, run by the SubBioLab members, revealed new species for the country. The new observations reported herein increase the number of amphipod species for Slovenia to 201, with 60 of them from groundwater, and 57 belonging to the genus *Niphargus*.

Povzetek

V zadnjem objavljenem pregledu postranic Slovenije je bilo naštetih 198 vrst iz različnih habitatov, od teh 57 iz podzemnih voda (Fišer et al. 2021). Od slednjih vse razen treh vrst pripadajo družini Niphargidae. Rod *Niphargus* je vrstno najpestrejši rod postranic, ki je razširjen po območju cele zahodne Palearktike (Borko et al. 2021). V študiji Borko et al. (2022) je bil uporabljen in objavljen seznam številnih vrst rodu *Niphargus* s pripadajočimi CO1 sekvencami. V tem seznamu je navedena nova vrsta za Slovenijo, še dve pa sta bili v tej študiji navedeni kot molekulski operativni taksonomski enoti, ki sta potencialno svoji vrsti. Za identifikacijo smo uporabili postopek BLAST (Altschul et al. 1990) in na podlagi 97-% ujemanja s sekvencami na GenBanku potrdili identiteto teh osebkov.

Skupno so bile identificirane tri nove vrste postranic za Slovenijo, najdene na štirih različnih lokalitetah (Tab. 1). *Niphargus danielopoli* Karaman G., 1994 je bil znan iz srednje Evrope. *Niphargus lurensis* Schellenberg, 1935 je razširjen po Štajerskem delu Avstrije, potrjena je bila tudi v severovzhodni Sloveniji. Tretja vrsta, *N. julius* Stoch, 1997, je bila znana iz doline reke Nadiže/Nattisone v Italiji, zdaj smo jo potrdili tudi v jami blizu Kobarida.

Nova opažanja so povečala skupno število potrjenih postranic v Sloveniji na 201, od katerih jih 60 živi v podzemnih vodah.

Acknowledgements

We are grateful to the collectors of the material. The species identity of reference sequences from GenBank was confirmed by Dr. Fabio Stoch (Italy). The preparation of updates to the checklist has been encouraged by the need of NarcIS – Nature Conservation Information System (http://narcis.gov.si), established via the EU-funded project LIFE NarcIS (LIFE19 GIE/SI/000161). The research of Slovenian amphipod fauna was cofounded by the Slovenian Research Agency through core program P1-0184. The study was additionally funded by Biodiversa+, the European Biodiversity Partnership under the 2021-2022 BiodivProtect joint call for research proposals, co-funded by the European Commission (GA N°101052342), and with the funding organisations Ministry of Universities and Research (Italy), Agencia Estatal de Investigación – Fundación Biodiversidad (Spain), Fundo Regional para a Ciência e Tecnologia (Portugal), Suomen Akatemia – Ministry of the Environment (Finland), Belgian Science Policy Office (Belgium), Agence Nationale de la Recherche (France), Deutsche Forschungsgemeinschaft e.V. – BMBF-VDI/VDE INNOVATION + TECHNIK GMBH (Germany), Schweizerischer Nationalfonds zur Forderung der Wissenschaftlichen Forschung (Switzerland), Fonds zur Förderung der Wissenschaftlichen Forschung (Austria), Ministry of Higher Education, Science and Innovation (Slovenia), and the Executive Agency for Higher Education, Research, Development and Innovation Funding (Romania); and Biodiversa+, the European Biodiversity Partnership, in the context of the Sub-BioMon – Developing and testing approaches to monitor subterranean biodiversity in karst project under the 2022-2023 BiodivMon joint call. It was co-funded by the European Commission (GA N°101052342) and the following funding organisations: Ministry of Higher Education, Science and Innovation (Slovenia), The Belgian Science Policy (Belgium), Ministry of Universities and Research (Italy), National Research, Development and Innovation Office (Hungary), Executive Agency for Higher Education, Research, Development and Innovation Funding (Romania) and self-financing partner National Museum of Natural History Luxembourg (Luxembourg).

References

Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ. 1990. Basic local alignment search tool. Journal of Molecular Biology. 215: 403-410. https://doi.org/10.1016/S0022-2836(05)80360-2

Borko Š, Trontelj P, Seehausen O, Moškrič A, Fišer C. 2021. A subterranean adaptive radiation of amphipods in Europe. Nature Communications. 12: 3688. https://doi.org/10.1038/s41467-021-24023-w

Borko Š, Altermatt F, Zagmajster M, Fišer C. 2022. A hotspot of groundwater amphipod diversity on a crossroad of evolutionary radiations. Diversity and Distributions. 28(12): 2765-2777. https://doi.org/https://doi.org/10.1111/ddi.13500

Bregović P, Fišer C, Zagmajster M. 2019. Contribution of rare and common species to subterranean species richness patterns. Ecology and Evolution 9(20): 11606-11618. https://doi.org/10.1002/ece3.5604

Fišer C, Mavrič B, Govedič M, Pekolj A, Zagmajster M. 2021. Checklist of amphipod crustaceans (Crustacea: Amphipoda) in Slovenia. Natura Sloveniae. 23(2): 5-24. https://doi.org/10.14720/ns.23.2.5-24

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology. 3: 294-299.

Karaman GS. 1994. Contribution to the knowledge of the Amphipoda. Further studies on genus *Niphargus* Schioedte 1849 from Europe, *N. ivokaramani*, n. sp and *N. danielopoli*, n. sp. The Montenegrin Academy of Sciences and Arts: Glasnik of the Section of Natural Sciences. 10: 113-133.

Karaman GS. 2020. Biodiversity of subterranean waters: redescription of poorly known *Niphargus julius* Stoch, 1997 (Crustacea: Amphipoda: Niphargidae) from Italy (Contribution to the knowledge of the Amphipoda 314). Agriculture & Forestry. 66(4): 239-258. https://doi.org/10.17707/AgricultForest.66.4.19

Ratnasingham S, Hebert PDN. 2007. BOLD: The Barcode of Life Data System (www.barcodinglife.org). Molecular Ecology Notes. 7: 355-364. https://doi.org/10.1111/j.1471-8286.2006.01678.x

Stoch F. 1997. La fauna delle acque carsiche sotterranee delle Valli del Natisone. In: Il fenomeno carsico delle Valli del Natisone. Memorie dell'Istituto Italiano di Speleologia. s. II, vol. IX. p. 89-100.

Stoch F. Christian E, Flot JF. 2020. Molecular taxonomy, phylogeny and biogeography of the *Niphargus tatrensis* species complex (Amphipoda, Niphargidae) in Austria. Organisms Diversity & Evolution. 20: 701-722. https://doi.org/https://doi.org/10.1007/s13127-020-00462-z

Stoch F, Salussolia A, Flot JF. 2023. Polyphyly of the *Niphargus stygius* species group (Crustacea, Amphipoda, Niphargidae) in the Southern Limestone Alps. bioRxiv. https://www.biorxiv.org/content/10.1101/2022.04.28.489871v2.full

NATURA SLOVENIAE 26(2): 41-44
FIELD NOTE

Prejeto / Received: 29. 11. 2024
Sprejeto / Accepted: 19. 12. 2024

DOI: 10.14720/ns.26.2.41-44

First record of the pill bug *Armadillidium arcangelii* Strouhal, 1929 (Crustacea: Isopoda) in Slovenia

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Abstract. Numerous novel occurrences of *Armadillidium arcangelii*, a terrestrial isopod native to Italy, have been reported in recent years in synanthropic habitats across much of Europe. These records indicate that the species is rapidly spreading, likely via the transport of plants. On 21. 9. 2023, a male of this species was collected on turf near Seča on the Slovenian coast. This is the first record of *A. arcangelii* in Slovenia. The record is all the more relevant as *A. arcangelii* is a potential agricultural pest.

Izvleček. Prva najdba pasavčka vrste *Armadillidium arcangelii* Strouhal, 1929 (Crustacea: Isopoda) v Sloveniji – V zadnjih nekaj letih so v sinantropnih habitatih v različnih delih Evrope opazili kopenskega enakonožca, pasavčka vrste *Armadillidium arcangelii*, ki izvira iz Italije. To kaže na hitro širjenje te vrste, najverjetneje s transportom rastlin. Samca vrste *A. arcangelii* smo našli 21. 9. 2023 na trati ob morju blizu Seče. To je prvo opažanje vrste *A. arcangelii* v Sloveniji. Najdba je pomembna tudi, ker je bila vrsta prepoznana kot potencialen škodljivec na poljščinah.

Terrestrial isopod crustaceans (Oniscidea) are a substantial part of soil invertebrate fauna. Over the past decades, numerous species have been introduced to parts of the world where they had not been present previously (Sfenthourakis & Hornung 2018). In certain regions of North America, the terrestrial isopod fauna may consist almost entirely of introduced species, predominantly of European origin (Szlavecz et al. 2018).

Recently, an enigmatic *Armadillidum* species has been recorded from numerous locations in Europe and Britain, with most of these occurrences likely representing recent introductions. While some uncertainty remained regarding the identity of the species that is rapidly colonizing synanthropic habitats across Europe, its morphological features matched those of *Armadillidium arcangelii* Strouhal 1929 (Noël et al. 2022), a species native to Italy (Schmalfuss 2003). In the past decade, these pill bugs have been collected and examined in the United Kingdom (Gregory 2014; Hughes et al. 2024), Spain (Garcia & Cabanillas 2021), France, Greece, the Netherlands (Noël et al. 2022), and Belgium (De Smedt & Van Dijck 2023). Citizen science data on the iNaturalist platform (https://www.inaturalist.org/) suggest that it is likely present in several other European countries as well, including Austria, Croatia, Germany, Poland, and Portugal (Noël et al. 2022). Nevertheless, the identification of this species, now widespread in Europe, is provisional, as *A. arcangelii* is morphologically very similar to *Armadillidium apenninorum* and *Armadillidium marmoratum*, and some of these species names might be synonyms (Schmalfuss 2003; Noël et al. 2022; Hughes et al. 2024).

On 21. 9. 2023, a single adult male of a terrestrial isopod belonging to the genus *Armadillidium* was collected by the author of this field note on the Slovenian Adriatic coast (Fig. 1). The small, mottled pill bug was found under dead wood on a public turf along the shore near Seča (45.502944 N, 13.589944 E; 5 m a.s.l.). Further examination of the habitus and male characters revealed that the isopod matches the descriptions of *A. arcangelii*. The isopod and its dissected appendages are kept in the author’s collection at the Department of Biology, Biotechnical Faculty, University of Ljubljana.

Several features can be used to identify *A. arcangelii*. The species is relatively small, with females reaching 8–9 mm in length and males being smaller (Strouhal 1929; Noël et al. 2022). The colour, while variable, is usually mottled brown (Strouhal 1929; Noël et al. 2022; Fig. 1A). The antennal lobes are small, protruding, and rounded, and the dorsal margin of the frontal shield reaches slightly above the frontal edge of the cephalothorax (Fig. 1A, B). The proximal article of the flagellum of the second antenna is shorter than the distal article (Strouhal 1929; Fig. 1A). The lateral parts of the posterior margin of pereonite 1 are curved, not sharply bent (Fig. 1A). The pleotelson is triangular, with straight lateral edges and rounded tip (Strouhal 1929; De Smedt & Van Dijck 2023; Fig. 1C). Diagnostic characters include the shape of the uropods (Strouhal 1929) and male characters, specifically the male pereopod 7 and pleopod 1 (Garcia & Cabanillas 2021; Noël et al. 2022). The posterior edge of the uropod exopodite in both sexes is not rounded (Strouhal 1929; Fig. 1C). The exopodite of the male pleopod 1 ends in a triangular distal lobe and the posterior edge of the exopodite bends near the distal end of the perispiracular area (Garcia & Cabanillas 2021; Noël et al. 2022; Fig. 1D). The tip of the male pleopod 1 endopodite curves outwards (Noël et al. 2022; Fig. 1E). The ventral edge of the ischium on the male pereopod 7 is straight (Noël et al. 2022; Fig. 1F).

Figure 1. *Armadillidium arcangelii*, male, collected near Seča, Slovenia. A – habitus; B – cephalothorax; C – pleotelson with uropods; D – pleopod 1 exopodite with a bent posterior edge (arrowhead); E – pleopod 1 endopodite with the tip curving outward (arrowhead); F – straight ventral edge of ischium (arrowhead) on pereopod 7. Scale bars: 1 mm (A); 0.5 mm (B, C, F); 100 µm (D); 50 µm (E) (photo: M. Vittori).

Slika 1. *Armadillidium arcangelii*, samec, nabran blizu Seče v Sloveniji. A – habitus; B – glavoprsje; C – pleotelzon z uropodi; D – eksopodit pleopoda 1 s pregibom na posteriornem robu (puščica); E – endopodit pleopoda 1 s konico, upognjeno navzven (puščica); F – raven ventralni rob ischiuma (puščica) na pereopodu 7. Merilca: 1 mm (A); 0,5 mm (B, C, F); 100 µm (D); 50 µm (E) (foto: M. Vittori).

In Britain, initial reports came from greenhouses, but the species has since also been reported in garden centres (Hughes et al. 2024). In Spain, it was reported in habitats affected by human activities such as mining and industrial waste disposal near Madrid and Cádiz (Garcia & Cabanillas 2021; Garcia & Rojas 2021). In France, the species occurs in synanthropic habitats outdoors, mainly close to the coast (Noël et al. 2022). In Belgium, *A. arcangelii* was recorded on the green roofs of the University of Hasselt, where it was collected on several occasions over the span of 4 years (De Smedt & Van Dijck 2023).

The main route of the introduction of the species to several European locations was likely the transport of plants (Noël et al. 2022; De Smedt & Van Dijck 2023; Hughes et al. 2024). While terrestrial isopods generally do not cause agricultural damage, *A. arcangelii* was recently identified as a potential agricultural pest in Italy, as it may feed on young melon plants (Fusaro et al. 2024). The species had not been known to affect crops before.

As it had not been reported in Slovenia previously, despite extensive past research of the area (Potočnik 1984), and as it is known to have been introduced in other parts of Europe, *A. arcangelii* may have been introduced to Slovenia. Nevertheless, since Italian populations are relatively close, it is also possible that the species spread to Slovenia naturally, or that it was present in this area in the past, but never collected or recognized. Given its wide distribution and rapid spreading (Noël et al. 2022), the finding of *A. arcangelii* in Slovenia had been expected. Considering previous checklists of the terrestrial isopod fauna of Slovenia (Vittori et al. 2023), recent records (Jakob et al. 2024), and the record of *A. arcangelii* reported here, there are currently 76 recorded species of Oniscidea in the country.

Acknowledgments

This work was supported by the University Infrastructural Centre »Microscopy of Biological Samples« at the Biotechnical Faculty, University of Ljubljana.

References

De Smedt P, Van Dijck T. 2023. The first record of the terrestrial isopod *Armadillidium arcangelii* Strouhal, 1929 (Isopoda: Armadillidiidae) from Belgium, on an extensive green roof. Bulletin de la Société royale belge d'Entomologie / Bulletin van de Koninklijke Belgische Vereniging voor Entomologie. 159: 124-129.

Fusaro S, Taiti S, Dorigo L, Paoletti MG. 2024. A terrestrial isopod (*Armadillidium arcangelii* Strouhal, 1929) as a potential agricultural pest: a case study on melon crop (*Cucumis melo* L.) in Italy. Redia. 107: 31-37. https://doi.org/10.1926/REDIA-107.24.04

Garcia L, Cabanillas D. 2021. Los isópodos terrestres (Crustacea, Isopoda, Oniscidea) del entorno de las Lagunas de Ambroz: una zona urbana en proceso de renaturalización en el municipio de Madrid (España). Boletín de la Asociación española de Entomología. 45: 161-175.

Garcia L, Rojas D. 2021. Isópodos terrestres (Crustacea: Oniscidea) de Andalucía. Nuevas citas y especies interesantes. Revista de la Sociedad Gaditana de Historia Natural. 15: 47-52.

Gregory SJ. 2014. Woodlice (Isopoda: Oniscidea) from the Eden Project, Cornwall, with descriptions of new and poorly known British species. Bulletin of the British Myriapod and Isopod Group. 27: 3-26.

Hughes TD, Northfield A, Maguire W. 2024. The Conquest Continues: First Outdoor Records of *Armadillidium arcangelii* Strouhal, 1929 in the British Isles (Isopoda: Oniscidea: Armadilliididae). Bulletin of the British Myriapod and Isopod Group. 36: 14-19.

Jakob A, Kuhar U, Vittori M, Klenovšek T, Strgulc Krajšek S. 2024. Significant records of plants, algae, fungi, and animals in SE Europe and adjacent regions, 2. Acta Biologica Slovenica. 67: 58-63. https://doi.org/10.14720/abs.67.2.19618

Noël F, Gregory SJ, Agapakis G. 2022. *Armadillidium arcangelii* Strouhal, 1929 (Isopoda: Oniscidea): a step towards the conquest of Europe? Bulletin of the British Myriapod and Isopod Group. 32: 72-82.

Potočnik F. 1984. Mokrice (Isopoda terrestria) slovenske obale Jadrana. Biološki vestnik. 32: 77-86.

Schmalfuss H. 2003. World catalog of terrestrial isopods (Isopoda: Oniscidea). Stuttgarter Beiträge zur Naturkunde. Serie A, 654. Stuttgart: Staatliches Museum für Naturkunde.

Sfenthourakis S, Hornung E. 2018. Isopod distribution and climate change. ZooKeys. 801: 25-61. https://doi.org/10.3897/zookeys.801.23533

Szlavecz K, Vilisics F, Tóth Z, Hornung E. 2018. Terrestrial isopods in urban environments: an overview. ZooKeys. 801: 97-126. https://doi.org/10.3897/zookeys.801.29580

Strouhal H. 1929. Die Landisopoden des Balkans. 3. Beitrag: Südbalkan. Zeitschrift für wissenschaftliche Zoologie. 133: 57-120.

Vittori M, Mavrič B, Pekolj A, Govedič M, Zagmajster M. 2023. A checklist of isopods (Crustacea: Isopoda) in Slovenia. Natura Sloveniae. 25: 27-52. https://doi.org/10.14720/ns.25.2.27-52

NATURA SLOVENIAE 26(2): 45-47
FIELD NOTE

Prejeto / Received: 24. 8. 2024
Sprejeto / Accepted: 14. 11. 2024

DOI: 10.14720/ns.26.2.45-47

Tropidia scita (Harris, 1780) (Diptera: Syrphidae), a new hoverfly species for Slovenia

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Abstract. The hoverfly genus *Tropidia* Meigen, 1822, with the species *T. scita* (Harris, 1780), is recorded for the first time in the hoverfly fauna of Slovenia. This species was found at Draga ponds near Ig, Slovenia, on the 16th of June, 2024. With this new record, the number of hoverfly species in Slovenia has increased to 363.

Izvleček. ***Tropidia scita* (Harris, 1780) (Diptera: Syrphidae), nova vrsta muhe trepetavke za Slovenijo –** Rod *Tropidia* Meigen, 1822 z vrsto *T. scita* (Harris, 1780) je prvič zabeležen v favni muh trepetavk Slovenije. Ta vrsta je bila najdena 16. junija 2024 na ribnikih v Dragi pri Igu v Sloveniji. S tem novim zapisom se je število vrst muh trepetavk Slovenije povečalo na 363.

In Slovenia, there are 362 reported species of hoverflies (Diptera: Syrphidae) and many other species likely remain to be still found there (Kočić et al. 2023). Of these, the genus *Tropidia* Meigen, 1822 is completely lacking from the Slovenia fauna. Members of *Tropidia* are medium-sized (7–12 mm) flies that may resemble *Xylota* Meigen, 1822, and some species of *Myolepta* Newman, 1838, but are recognizable by their enlarged hind femur with a triangular lamina on the apical part, and a carinate face with a medial ridge (Reemer et al. 2009; Bot & van de Meutter 2023). Because of triangular lamina on the apical part of the hind femur, *Tropidia* may be confused with *Merodon* Meigen, 1803, but in *Merodon* vein M1 is recessive. The genus has two species in Europe, *Tropidia scita* (Harris, 1780) and *T. fasciata* Meigen, 1822. Shorter hairs on the body and gently curved vein R4+5 differentiate *Tropidia scita* from *T. fasciata* (Bot & van de Meutter 2023). Both species are likely to occur in Slovenia, based on records in surrounding countries and the presence of suitable habitats, but have not been previously reported. The known range of *T. scita* includes the entire Palearctic from western Europe to Japan (Reemer et al. 2009; Speight 2020) and includes the surrounding countries of Austria, Italy, and Hungary (Speight 2020; Reverté et al. 2023). In this article, we present the first record of *T. scita* in Slovenia.

The species occurs in humid and wet eutrophic habitats with open water, including marshy forests. Adults are found close to their reproduction sites, where they fly low through the vegetation or sit low at ground level on leaves or reed stems. Little is known regarding the larval stage, but it is assumed that it lives in decomposing plant material found in reed beds and other wetland areas (Reemer et al. 2009; Speight 2020). The published red list of hoverflies of Europe showed that this species has the status of »Least Concern« (Vujić et al. 2022). An assessment of the status in Slovenia is presently not possible due to data deficiency.

Material examined (Fig. 1): Slovenia, Draga pri Igu, along Srednji ribnik; one of a series of ponds along a small valley ~13 km south of Ljubljana (WGS84: 45.93649 N, 14.55108 E), 16.06.2024, 310 m a.s.l., 1♂, leg. B. Schwartz.

Figure 1. Male *Tropidia scita* found at the fish ponds at Draga pri Igu in June 2024 (photo: B. Schwartz).
Slika 1. Samec *Tropidia scita*, najden pri ribnikih v Dragi pri Igu junija 2024 (foto: B. Schwartz).

Habitats within 50 m of the observation site (Figs. 2-3) include open ponds with deep water, marshy pond edges and adjacent open marshes with abundant rushes, sedges, scouring rushes and other emergent vegetation, forested swamps, small forest seeps and springs, and dry adjacent forested hillslopes. The specimen was found perching on leaves of *Carex sp.* (Cyperaceae) in the morning sun at 09:00 hrs. It seemed to prefer perching on leaves that were partly sheltered by an open overhanging canopy of the same plant, and moved frequently, but spent most of its time perching rather than flying or hovering. It was quite wary and did not allow a close approach. A single photo of a male was taken from several meters away using a 100-400mm zoom lens with a 1.4× teleconverter (560mm equivalent) on a Sony a7Rv full-frame digital camera.

The location where the specimen was found is typical habitat for *T. scita*. In Slovenia, many similar places like fishing ponds occur throughout the central and eastern parts of the country and with a thorough survey many more locations with this species may be found.

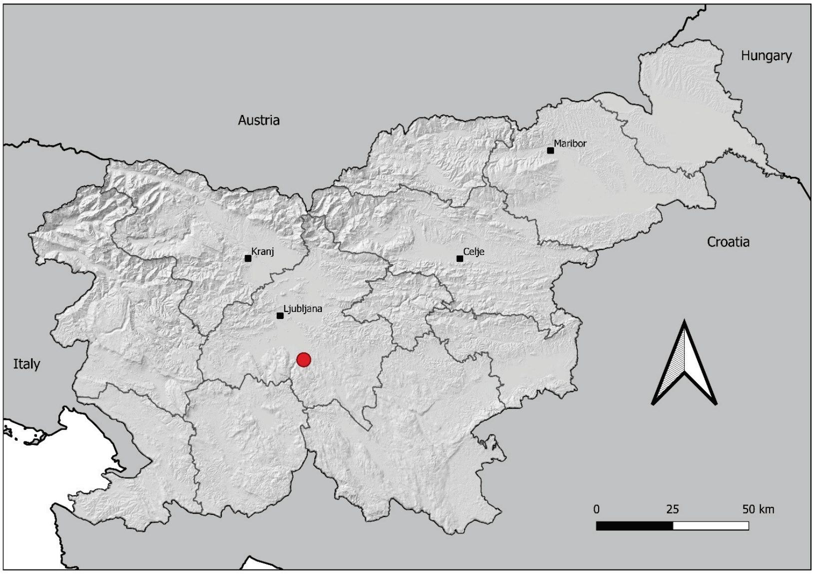

Figure 2. Map of Slovenia showing location of new record for *Tropidia scita* (red circle), major cities (black squares), and statistical regions.
Slika 2. Zemljevid Slovenije, ki prikazuje lokacije novo odkrite vrste *Tropidia scita* (rdeči krogec), večjih mest (črni kvadratki) in statističnih regij.

Figure 3. Satellite image of new record location (yellow circle) showing ponds, adjacent marshy forests, and hillslope forests. Source of image: Google Earth, 12 August 2024.
Slika 3. Satelitska slika lokacije novo odkrite vrste (rumeni krog) z ribniki, okoliškimi močvirnatimi gozdovi in gozdovi na pobočjih. Vir satelitske slike: Google Earth, 12. avgust 2024.

Acknowledgments

Benjamin Schwartz thanks members of the Subterranean Biology Lab, Department of Biology, Biotechnical Faculty, at University of Ljubljana for graciously hosting him during his visit to Slovenia. Maarten de Groot was supported by the research core program »Forest biology, ecology and technology« (P4-0107), financed by the Slovenian Research and Innovation Agency.

References

Bot S, van de Meutter F. 2023. Hoverflies of Britain and North-west Europe: A photographic guide. London (UK): Bloomsbury Wildlife.

Kočić A, Vujić A, Tot T, Milosavljević MJ, de Groot M. 2023. An updated checklist of the hoverflies (Diptera: Syrphidae) of Slovenia. Zootaxa. 5297: 189-227. https://doi.org/10.11646/zootaxa.5297.2.2

Reemer M, Renema W, van Steenis W, Zeegers T, Barendregt A, Smit JT, Van Veen MP, van Steenis J, van der Leij LJJM. 2009. De Nederlandse zweefvliegen (Diptera: Syrphidae). Nederlandse Fauna 8. Leiden: Natuurhistorisch Museum Naturalis, KNNV uitgeverij, European Invertebrate Survey - Nederland.

Reverté S, Miličić M, Ačanski J, Andrić A, Aracil A, Aubert M, Balzan MV, Bartomeus I, Bogusch P, Bosch J et al. 2023. National records of 3000 European bee and hoverfly species: A contribution to pollinator conservation. Insect Conservation and Diversity. 16(6): 758-775. https://doi.org/10.1111/icad.12680

Speight MCD. 2020. Species accounts of European Syrphidae, 2020. Syrph the Net, the database of European Syrphidae (Diptera), vol. 104. Dublin: Syrph the Net publications.

Vujić A, Gilbert F, Flinn G, Englefield E, Ferreira CC, Varga Z, Eggert F, Woolcock S, Böhm M, Mergy R et al. 2022. The European Red List of Hoverflies. Brussels: European Commission.

Popravki

Erratum: **» A contribution to the Slovenian spider fauna – V«**
Kuralt Ž., Pajek Arambašič N., Ferle M., Kostanjšek R., Natura Sloveniae 26(1), 2024, str. 29-42.

Str. 31–39: pravilne navedbe avtorstva v članku omenjenih vrst so:
Pages 31–39: correct author citations for species mentioned in the paper are as follows:

Larinioides patagiatus (Clerck, 1757) – Araneidae
Cyrtarachne ixoides (Simon, 1870) – Araneidae
Pritha nana (Simon, 1868) – Filistatidae
Marinarozelotes adriaticus (Caporiacco, 1951) – Gnaphosidae
Micaria micans (Blackwall, 1858) – Gnaphosidae
Scotophaeus blackwalli (Thorell, 1871) – Gnaphosidae
Zelotes similis (Kulczyński, 1887) – Gnaphosidae
Agyneta orites (Thorell, 1875) – Linyphiidae
Donacochara speciosa (Thorell, 1875) – Linyphiidae
Lasiargus hirsutus (Menge, 1869) – Linyphiidae
Trichoncus sordidus Simon, 1884 – Linyphiidae
Walckenaeria vigilax (Blackwall, 1853) – Linyphiidae
Alopecosa taeniata (C. L. Koch, 1835) – Lycosidae
Pardosa oreophila Simon, 1937 – Lycosidae
Pardosa paludicola (Clerck, 1757) – Lycosidae
Pardosa sordidata (Thorell, 1875) – Lycosidae
Pardosa sphagnicola (Dahl, 1908) – Lycosidae
Xerolycosa miniata (C. L. Koch, 1834) – Lycosidae
Mimetus laevigatus (Keyserling, 1863) – Mimetidae
Philodromus laricium Simon, 1875 – Philodromidae
Philodromus vagulus Simon, 1875 – Philodromidae
Attulus rupicola (C. L. Koch, 1837) – Salticidae
Marpissa radiata (Grube, 1859) – Salticidae
Micrommata ligurina (C. L. Koch, 1845) – Sparassidae
Euryopis quinqueguttata Thorell, 1875 – Theridiidae
Parasteatoda tabulata (Levi, 1980) – Theridiidae
Phoroncidia paradoxa (Lucas, 1846) – Theridiidae
Rhomphaea rostrata (Simon, 1873) – Theridiidae
Robertus mediterraneus Eskov, 1987 – Theridiidae

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Znanstveni članek je popoln opis izvirne raziskave, vključno z uvodnim pregledom ozadja in stanja poznavanja tematike. Struktura sledi principu »IMRAD« (uvod, material in metode, rezultati, razprava), sledijo sklepi (neobvezno), zahvala (neobvezno), literatura, povzetek, dodatno gradivo (neobvezno).
Kratka znanstvena vest je izvirno delo, ki poroča o manjšem naboru podatkov ter o delnih ali predhodnih rezultatih raziskav. Struktura sledi principu »IMRAD«, vendar je poenostavljena, na primer z enotnim razdelkom »rezultati in razprava«. Glavnemu besedilu sledijo zahvala (neobvezno), literatura, povzetek in dodatno gradivo (neobvezno).
Terenska notica je kratko poročilo o novih in zanimivih najdbah, ki izhajajo iz biološkega terenskega dela ali so z njim povezane. Vsebuje glavno besedilo, zahvalo (neobvezno) in literaturo.

Naslov prispevka mora biti informativen, jasen in jedrnat. Naslovu morajo slediti imena in priimki ter polna imena avtorjev s poštnimi in elektronskimi naslovi. Lahko so dodane številke ORCID.

Vsak prispevek mora vsebovati **izvleček**, ki vključuje zgoščeno predstavitev ciljev, uporabljenih metod, rezultatov in zaključkov. Izvleček naj ne bo daljši od 250 besed za znanstvene članke, 200 besed za kratke znanstvene vesti in 100 besed za terenske notice.

Avtorji naj vključijo **pet do največ deset ključnih besed**, zapisanih po abecednem vrstnem redu, ki morajo odražati področje raziskav in vsebino, zajeto v prispevku. Terenska notica ne vsebuje ključnih besed.

Znanstveni članki in kratke znanstvene vesti morajo vsebovati **povzetek**, ki sledi glavnemu besedilu rokopisa. Namen povzetka je zagotoviti izčrpne informacije za slovensko govoreče bralce, kadar je prispevek napisan v angleščini, ali neslovensko govoreče, kadar je prispevek v slovenščini. Povzetek naj ne bo le ponovitev izvlečka, ampak naj vsebuje več informacij o ciljih, metodah, rezultatih, razpravi in lahko vključuje navedbe literature ter sklice na slike in tabele. Priporočena dolžina povzetka je približno 500 besed za znanstvene članke in 300 besed za kratke znanstvene vesti. Pisci, ki ne govorijo slovensko, lahko pripravijo angleški izvleček, ključne besede in povzetek, te pa bo uredništvo prevedlo v slovenščino. Terenska notica nima povzetka.

Rokopisi morajo biti predloženi v enem od razširjenih formatov za urejanje besedila, kot sta Microsoft Word (docx, doc) ali tekstovni dokument ODF (odt), po možnosti s pisavo »Times New Roman« velikosti 12, levo poravnavo in 3 cm robovi na A4 straneh. Med vrsticami naj bo dvojni razmik, vrstice naj bodo oštevilčene neprekinjeno po celem rokopisu. Naslov prispevka ter naslovi poglavij in podpoglavij morajo biti napisani s krepko pisavo velikosti 14. Znanstvena imena vseh rodov in vrst morajo biti zapisana v ležečem tisku.

SLIKE IN TABELE
Prispevki lahko vsebujejo do deset slik in/ali tabel. Tabele in slike, vključno z legendami, je treba umestiti v rokopis na želeno mesto. Ločljivost slik v rokopisu je lahko nižja, da se zmanjša velikost oddane datoteke. Če je rokopis sprejet v objavo, je treba slike predložiti ločeno kot visokokakovostne vektorske ali rastrske grafike v formatih pdf, svg, jpg ali tiff. Slike morajo biti pripravljene brez elementov, kot so robovi in podnapisi; te lahko dodate v rokopis z uporabo urejevalnika besedil. Če potrebujete pomoč pri pripravi grafike ustrezne kakovosti, se obrnite na urednika.

Slike in tabele morajo biti oštevilčene zaporedno (Slika 1, Slika 2 ..., Tabela 1, Tabela 2 ...), v tekstu se je treba vsaj enkrat sklicevati na vsako sliko in tabelo v skrajšani obliki (Sl. 1 ali Sl. 1, 2; Tab. 1 ali Tab. 1, 2).

Tabele in slike morajo skupaj s naslovi/podnaslovi in legendami vključevati dovolj podrobnosti, da so razumljive same po sebi. Naslovi/podnaslovi naj bodo v obeh jezikih (angleščini in slovenščini), ne glede na glavni jezik besedila. Za neslovensko govoreče avtorje bo za slovenske prevode poskrbelo uredništvo.

Če so vključene fotografije, je treba v oklepaju navesti ime in priimek avtorja.

DRUGA NAVODILA ZA OBLIKOVANJE

Vsi datumi se pišejo s številkami, ne glede na jezik prispevka, gre za obliko: Dan.Mesec.Leto, na primer 23.5.2000, 16.6.2015.

Domačih imen ne pišemo z veliko začetnico, izjema je poimenovanje po osebi (npr. Savijev netopir).

Kadar se domače in znanstveno ime uporabljata skupaj, velja naslednje: znanstveno ime sledi domačemu brez oklepajev le v naslovu, v besedilu pa ga je treba navesti v oklepaju. Obe imeni skupaj naj se uporabljata le pri prvi omembi v besedilu prispevka, pozneje pa naj se dosledno uporablja le ena oblika. Vsako znanstveno ime naj bo vsaj enkrat zapisano v celoti, tj. vključno z avtorjem in letnico opisa.

Koordinate lokalitet naj bodo v WGS84 decimalnih stopinjah. Za Slovenijo so lahko tudi v veljavnem koordinatnem sistemu ETR89. Koordinatni sistem mora biti jasno označen.

LITERATURA
Navajanje literature in seznam literature naj bosta v skladu s slogom »Council of Science Editors« (CSE) (https://www.councilscienceeditors.org/scientific-style-and-format), z uporabo sistema »Name-Year«, z nekaterimi spremembami (navedenimi v nadaljevanju): https://www.mcgill.ca/library/files/library/cse-name-year-citation-style-guide.pdf

V besedilu:
V besedilu sta priimek avtorja in letnica objave navedena v oklepaju takoj za besedilom, na katerega se nanaša:

Večina samic odlaga jajca v prvi polovici junija (Fritz 2003) in...

Če ima vir dva avtorja, sta navedena oba priimka med katerima je znak "&" (to se razlikuje od navodil na zgornji povezavi!). Pri delih s tremi ali več avtorji se navede samo priimek prvega avtorja, ki mu sledi "et al.":

...označene želve z marginalnim vrezovanjem (Vamberger & Kos 2011)...
...živi v spodnjem toku reke Save na Hrvaškem (Šalamon et al. 2013)...

Če se navaja več virov hkrati, jih je treba navesti v kronološkem zaporedju in po abecednem redu, če so viri objavljeni v istem letu strani istega avtorja/-jev, med sabo pa jih ločiti s podpičjem. Dve ali več del, ki jih je napisal isti avtor v istem letu, je treba letnici dodati oznako (a, b, c ...). Enake oznake se navedejo v seznamu literature.

... (Müller 1921; Seifert 2007a, 2007b; Ionescu-Hirsch et al. 2009; Lapeva-Gjonova & Kiran 2012; Wiezik & Wieziková 2013).

Če je avtor reference organizacija, inštitucija, univerza itd., se v besedilu uporabi skrajšana oblika imena, tako da se ohrani prva črka besed v imenu ali priznana kratica:

... (ARSO 2022).

Seznam literature:
Seznam literature naj sledi spodnjim primerom, a za dodatne primere naj se sledi prej navedenim smernicam za citiranje:

[ARSO] Agencija Republike Slovenije za okolje. 2022. Podnebne značilnosti oktobra 2022. Ljubljana (SI): Agencija Republike Slovenije za okolje, Ministrstvo za okolje, podnebje in energijo. [accessed on 26.11.2022]; https://meteo.arso.gov.si/met/sl/climate/current/climate_month/

Balestrieri A, Remonti L, Prigioni C. 2015. Towards extinction and back: Decline and recovery of otter populations in Italy. In: Angelici FM, editor. Problematic Wildlife. Springer International. Switzerland. p. 91-105. https://doi.org/10.1007/978-3-319-22246-2_5

Gregorc T, Nekrep I. 2010. Poročilo skupine za vidro. In: Vinko D, editor. Raziskovalni tabor študentov biologije Most na Soči 2010. Ljubljana (SI): Društvo študentov biologije. p. 12-21.

Kruuk H, Conroy JWH, Glimmerveen U, Ouwerkerk EJ. 1986. The use of spraints to survey populations of otters (*Lutra lutra*). Biological Conservation. 35: 187-194. https://doi.org/10.1016/0006-3207(86)90050-9

Gorički Š, Stanković D, Snoj A, Kuntner M, Jeffery WR, Trontelj P, Pavic M, Grizelj Z, Năpăruș-Aljančič M, Aljančič G. 2017. Environmental DNA in subterranean biology: Range extension and taxonomic implications for *Proteus*. Scientific Reports. 7: 1-11. https://doi.org/10.1038/srep45054

Navajanje zakonodajnih dokumentov:
Slovenska zakonodaja:
Navajanje v besedilu: (Ur. l. RS 2002) ali (Ur. l. RS 2004a) ali (Ur. l. RS 2004b)
Seznam literature:
Ur. l. RS. 2002. Pravilnik o uvrstitvi ogroženih rastlinskih in živalskih vrst v rdeči seznam. Uradni list RS, št. 82/02, 42/10.
Ur. l. RS. 2004a. Uredba o zavarovanih prostoživečih živalskih vrstah. Uradni list RS, št. 46/04, 109/04, 84/05, 115/07, 32/08 – odl. US, 96/08, 36/09, 102/11, 15/14, 64/16, 62/19.

Zakonodaja EU, mednarodne konvencije:
Navajanje v besedilu: (UL ES 1992)
Seznam literature:
OJ EC. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities L 206, 22.7.1992. p. 7-50.

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The mission of **NATURA SLOVENIAE** is to foster the understanding of the natural history of Central and Southeastern Europe by publishing the results of field-biological research and data. Manuscripts reporting significant and new distributional records, species lists from all kingdoms as well as ecological, biogeographical, biodiversity and conservation studies are welcome. Papers are published in English or Slovenian language.

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Manuscripts should be submitted via the web portal of the University of Ljubljana Press:
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All manuscripts will be subject to peer review by at least one referee. Authors are invited to suggest the names and contacts of potential referees, although the editor reserves the right to select any other. Once reviewed by the referee(s), the manuscript should be revised by the author or authors themselves. The revised manuscript should be returned with marked changes (Track changes tool can be used) along with a clean version (no marked changes or comments) and a rebuttal letter explaining the changes made.

The submitted manuscript must not have been previously published in any form and must not be simultaneously submitted elsewhere (in other journals, bulletins or congress publications). By submitting a manuscript, the authors the authors grant the publisher right of first publication with the work simultaneously licensed under the Creative Commons Attribution 4.0 International License.

TYPES AND FORMAT OF CONTRIBUTIONS
Manuscripts may be submitted for consideration as Scientific Papers, Short Communications and Field Notes. Other formats of contributions are also welcome (review articles, comments, opinion papers), but should be discussed beforehand with the editor.

Scientific Paper is a complete description of original research including an introductory overview of the state-of-the-art. The structure is typically IMRAD (Introduction, Material and Methods, Results, Discussion), followed by Conclusions (optional), Acknowledgements (optional), References, Summary, Supplementary material (optional).
Short Communication is an original paper reporting on a smaller dataset as well as partial or preliminary research results. The structure follows the IMRAD logic but is simplified, for example by fusing the Results and Discussion sections. The main text is followed by Acknowledgements (optional), References, Summary, and Supplementary material (optional).
Field Note is a short report on new and interesting findings coming from or related to biological field work. It contains information in the main text, Acknowledgements (optional) and References.

The **title of the contribution** should be informative, clear and concise. The title should be followed by the **name(s) and full affiliations of the author(s)**, with postal and e-mail addresses. ORCID numbers are optional.

Each contribution should contain the **abstract** which includes concise information about the objectives, methods used, results and conclusions. The abstract should not exceed 250 words for Scientific Papers, 200 words for Short Communications and 100 words for Field Notes.

Authors should include **five to maximum ten keywords**, written in alphabetical order, which must accurately reflect the field of research and content covered in the paper. A Field Note does not contain key words.

Scientific Papers and Short Communications should include a **Summary** following the main text of the manuscript. The purpose of the Summary is to provide comprehensive information for Slovenian or non-Slovenian speaking readers when the contribution is written in English or Slovenian, respectively. The Summary should not be a repetition of the abstract but contain more information on objectives, methods, results, discussion, and may include citations from the reference list or mentions of figures and tables. The recommended length is about 500 words for Scientific Papers and 300 words for Short Communications. Non-Slovenian speaking writers can provide English Abstract, Keywords and Summary. These will be translated into Slovenian by the editorial team. A Field Note does not contain a Summary.

Manuscripts should be submitted in one of the major text editing formats such as Microsoft Word (docx, doc) and ODF text document (odt), preferably using »Times New Roman« size 12 font, align left and margins of 3 cm on A4 pages. Double spacing should be used between lines, which should be numbered continuously for the whole manuscript. The manuscript title and headings of chapters and subchapters should be written in bold font size 14. The scientific names of all genera and species must be written in italic.

ILLUSTRATIONS AND TABLES
Papers should contain up to ten figures and/or tables. Tables and figures, including legends, should be inserted in the manuscript at the desired position. The resolution of figures in the manuscript may be reduced to ensure a manageable file size. If the manuscript is accepted for publication, figures should be submitted separately as high-quality vector or raster graphics, in pdf, svg, jpg, or tiff formats. Figures should be prepared without graphical elements such as borders and captions; those can be added in the manuscript using the word processor instead. Please contact the editor if you need assistance with preparing graphics of sufficient quality.

Figures and tables should be numbered consecutively throughout the manuscript (Figure 1, Figure 2 …, Table 1, Table 2 …). Each Figure and Table should be referred to at least once in the main manuscript text, in abbreviated form (Fig. 1 or Figs. 1, 2; Tab. 1 or Tabs. 1, 2).

Tables and figures along with their titles and legends should contain enough details to be self-explanatory. Titles should be given in both languages (English and Slovenian), regardless of the language of the main text. For non-Slovenian speaking writers, Slovenian translations will be provided by the editorial team.

When photographs are included, the author's name and surname should be given in brackets.

OTHER FORMAT GUIDELINES
All dates are written with numbers, no matter the language of the contribution, it is the form: Day. Month. Year, for example 23. 5. 2000, 16. 6. 2015.

Vernacular names should not be capitalized, an exception being naming after a person (e.g. Savi's pipistrelle). When vernacular and scientific name are used together, the following applies: the scientific name follows the vernacular without brackets only in the title, while in the text it should be given in parentheses. Both names together should be used only at the first mention in the contribution text, while later only one form should be used consistently. Each scientific name should at least once be written in full, i.e. including taxonomic authority and year of description.

Coordinates of localities should be given in WGS84 decimal degrees format. For Slovenia, they can also be in the valid ETR89 coordinate system. The coordinate system must be clearly indicated.

REFERENCES
Citing of the references and the format of the reference list should follow the Council of Science Editors (CSE) style (https://www.councilscienceeditors.org/scientific-style-and-format), using Name-Year system, with some modifications (listed below): https://www.mcgill.ca/library/files/library/cse-name-year-citation-style-guide.pdf

In the text:
The author's surname and the year of publication are enclosed in parentheses immediately following the text to which it refers:

Most females lay eggs in the first half of June (Fritz 2003) and…

If a reference has two authors, both surnames are included separated by "&" (this is different to instructions in the link!). For works with three or more authors, only the first author's name is included, followed by et al.:

…marked turtles by marginal notching (Vamberger & Kos 2011)…
…does live downstream along the Sava River in Croatia (Šalamon et al. 2013)…

If several sources are cited at once, they should be listed in chronological order and alphabetically among references published in the same year, separated by a semicolon. Two or more works written by the same author in the same year should be marked by a designator (a, b, c…) to distinguish them. The same designators are used in the reference list.

… (Müller 1921; Seifert 2007a, 2007b; Ionescu-Hirsch et al. 2009; Lapeva-Gjonova & Kiran 2012; Wiezik & Wieziková 2013).

If the author of a reference is an organization, institution, university, etc., an abbreviated form of the name is used in the in-text citation, by retaining the first letter of each word in the name, or some other recognized abbreviation:

… (FAO 2007).

Reference list:
The reference list should follow the below examples, but see the above given citation guidelines:

[ARSO] Agencija Republike Slovenije za okolje. 2022. Podnebne značilnosti oktobra 2022. Ljubljana (SI): Agencija Republike Slovenije za okolje, Ministrstvo za okolje, podnebje in energijo. [accessed on 26.11.2022]; https://meteo.arso.gov.si/met/sl/climate/current/climate_month/
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Gregorc T, Nekrep I. 2010. Poročilo skupine za vidro. In: Vinko D, editor. Raziskovalni tabor študentov biologije Most na Soči 2010. Ljubljana (SI): Društvo študentov biologije. p. 12-21.
Kruuk H, Conroy JWH, Glimmerveen U, Ouwerkerk EJ. 1986. The use of spraints to survey populations of otters (*Lutra lutra*). Biological Conservation. 35: 187-194. https://doi.org/10.1016/0006-3207(86)90050-9

Citing legislation documents:
Slovenian legislation:
Citation in the text: (Ur. l. RS 2002) or (Ur. l. RS 2004).
Reference list:
Ur. l. RS. 2002. Pravilnik o uvrstitvi ogroženih rastlinskih in živalskih vrst v rdeči seznam. Uradni list RS, no. 82/02, 42/10.
Ur. l. RS. 2004. Uredba o zavarovanih prosto živečih živalskih vrstah. Uradni list RS, no. 46/04, 109/04, 84/05, 115/07, 32/08 – odl. US, 96/08, 36/09, 102/11, 15/14, 64/16, 62/19.

EU legislation, international conventions:
Citation in the text: (OJ EC 1992)
Reference list:
OJ EC. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities L 206, 22.7.1992. p. 7-50.