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Faunistic survey of terrestrial isopods (Isopoda: Oniscidea) in the Boč Massif area

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Abstract. In 2005, terrestrial isopods were sampled in the Boč Massif area, eastern Slovenia, and their fauna compared at five different sampling sites: forest on dolomite, forest on limestone, thermophilous forest, young stage forest and extensive meadow. Two sampling methods were used: hand collecting and quadrate soil sampling with a subsequent heat extraction of animals. The highest species diversity (8 species) was recorded in the forest on dolomite and in young stage forest. No isopod species were found in samples from the extensive meadow. In the entire study area we recorded 12 different terrestrial isopod species and caught 109 specimens in total. The research brought new data on the distribution of two quite poorly known species in Slovenia: the *Trachelipus razzauti* and *Haplophthalmus abbreviatus*.

Key words: species structure, terrestrial isopods, Boč Massif, Slovenia

Izvleček. Favnistični pregled mokric (Isopoda: Oniscidea) na območju Boškega masiva – Leta 2005 smo na območju Boškega masiva v vzhodni Sloveniji opravili vzorčenje favne mokric. V raziskavi smo primerjali favno mokric na petih različnih vzorčnih mestih: v gozdu na dolomitu, v gozdu na apnencu, termofilnem gozdu, mladem gozdu in na ekstenzivnem travniku. Vzorčili smo z dvema metodama, in sicer z metodo ročnega pobiranja ter z odvzemom talnih vzorcev po metodi kvadratov. Medtem ko smo v okviru raziskave ugotovili največjo vrstno pestrost mokric (8 vrst) v gozdu na dolomitu in mladem gozdu, na travniku nismo ulovili nobenega osebka. Na celotnem območju preučevanja smo ulovili 12 različnih vrst mokric in skupno 109 osebkov. Raziskava je prav tako prinesla tudi nove podatke o razširjenosti vrst *Trachelipus razzauti* in *Haplophthalmus abbreviatus*, katerih razširjenost je na območju Slovenije še dokaj slabo poznana.

Ključne besede: vrstna sestava, mokrice, Boški masiv, Slovenija

Introduction

Previous research (Potočnik 1978, 1980, 1993) has shown that the fauna of terrestrial isopods in Slovenia is very rich indeed. The reason for this high species biodiversity lies in the geographical position of the country, which is situated in the contact area of different biogeographical regions (Mršić 1997). Although the terrestrial isopod fauna in Slovenia is well known, the distribution of some species is still either not sufficiently known or these species are known only from their *locus typicus.* Furthermore, new species are still being discovered in the territory of Slovenia (e.g. Vilisics & Lapanje 2005). Any further faunistic research therefore contributes to a better knowledge of species distribution and brings data that is pertinent for the conservation status of isopod fauna. Especially welcome are the data from those areas of Slovenia, where systematic faunistic research has not been conducted. One of such areas is undoubtedly the eastern part of Slovenia, where different geographical and geological features combined with various types of land use intertwine. Within this area, the Boč Massif is especially interesting owing to its solitary limestone mountain at the edge of the Pannonian Plain, where the contact of three macro-regional units can be seen. This also has an influence on its climate and consequently on its flora and fauna. For these reasons, the Boč Massif was chosen as a sampling area of our terrestrial isopod fauna research.

Material and methods

Study area

The Boč Massif is situated in the northern part of the Voglajnsko-Soteljska region, which is part of eastern Slovenia (Fig. 1). The highest peak, Boč, rises to 979 m a.s.l. The Boč Massif lies in the contact area of three large European macro-regional geographic units: the Alpine, Pannonian and Dinaric. The massif consists of Paleozoic and Mesozoic rock: in the southern and eastern parts, mostly dark grey limestone, flint sandstone, conglomerate and clay slate can be found, while in the eastern part the dolomite is added (Gams 1984). On the limestone bedrock, varied karst features have developed (sinkholes, uvalas, swallow holes, caves).

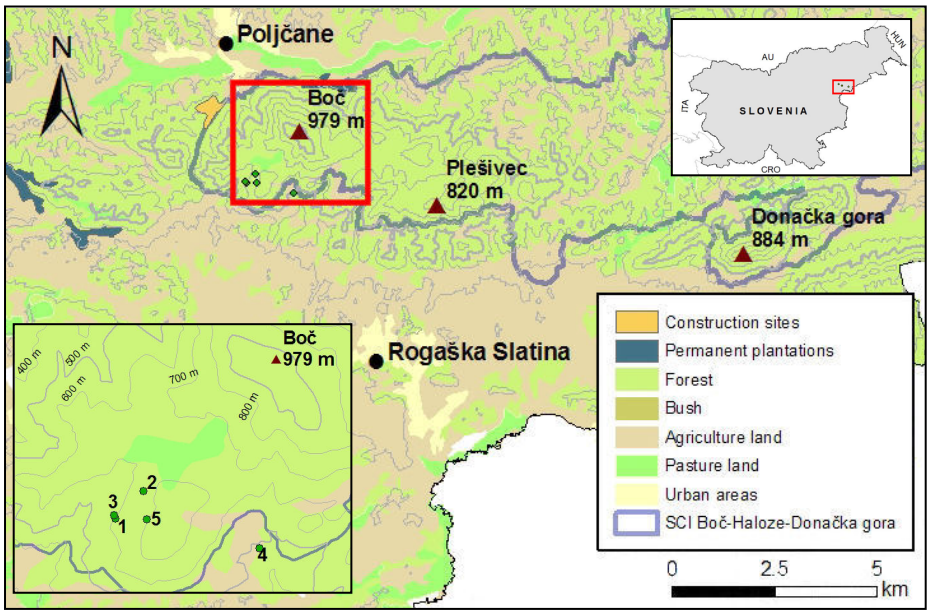

Figure 1. Map of Slovenia and a detailed map of Boč Regional Park, with the research area (Boč) and sampling sites marked (for detailed information on sampling sites see Table 1). Height distance between two isohypses is 100 m; the 500 m and 900 m isohypses are thickly marked.

Slika 1. Karta Slovenije s podrobnejšo karto Regionalnega parka Boč z območjem raziskovanja – Bočem in označenim vzorčnimi mesti (podrobnejše informacije o vzorčnih mestih so v tabeli 1). Razmiki med izohipsami na karti znašajo 100 m višine, debelejše sta označeni izohipsi za 500 m in 900 m.

The climate on the Boč Massif is continental-central-European, with a pronounced Mediterranean character on the sun-exposed slopes. Some characteristics of the steppe climate are also noticeable, such as hot, dry summers and winters with low temperatures. Owing to its climate, the Boč mountain chain belongs to the sub-Pannonian phytogeographical region with pronounced mountain characteristics (Wraber 1969). The limestone and dolomite of the Boč Massif are home to all four xerothermic continental forest communities: *Genisto-Pinetum*, *Querco-Ostryetum*, *Ostryo-Fagetum* and *Lathyro-Quercetum* (Cimperšek 2005). On sunward slopes, the thermophilic beech forest also proliferates.

The wider area of Boč with Donačka gora and Plešivec mountains is protected as a regional park (Boč Regional Park). The two mountains are also part of the limestone mountain chain, where Donačka gora is the southeastern remnant of the Karavanke Mountain Chain. Its northern slope is an old beech forest protected reserve. Five additional forest reserves are also located in the Boč mountain chain: Boč, Galke, Plešivec, Mala Kopa and Šodergraben. The forests in these reserves belong to a special category of forests, i.e. special purpose forests. For example, the slopes of Boč are home to the protected forests of Scotch pine (*Genisto januensis – Pinetum sylvestris*) and pubescent oak hornbeam (*Querco-Ostryetum carpinifoliae*), while Galke is known for its thermophilic forests with the *Carici albae – Fagetum* community. At Plešivec, on the other hand, old beech forest stands are present. Any management in these reserves is strictly prohibited (Cimperšek 2005). They are also part of the Boč – Haloze – Donačka gora (SI3000118) NATURA 2000 area (Ur. l. RS 2013).

Sampling sites

Terrestrial isopods were investigated at five sampling sites, which differ mostly in forest stand growing phase and plant community type. All sampling sites were chosen randomly. Among five sampling sites, four belong to the forest landscape and one to the grasslands. Two of them (1 and 2) are old beech forest stands, where sampling site 1 is located in a moist hollow and sampling site 2 on a sunward slope. Sampling site 3 is a mixed thermophilic forest stand in pole and timber phase. Sampling site 4 is a mixed young stage forest, while sampling site 5 is an extensively managed dry meadow (Tab 1). Sampling was performed in 2005, i.e. in spring (7.5., 9.5. and 14.5.), summer (21.6., 2.7.) and autumn (19.10., 22.10.), and was done on the same day at all sampling sites. At every sampling site, the coordinates, altitude, exposition and inclination were recorded. Inclination was divided into three categories: steep (angle between 40° and 60°), gently sloping (angle between 15° and 40°) and plane (angle between 0° and 15°).

Sampling methods

Two different sampling methods were used: hand-collecting and quadrate soil sampling. On every sampling site, specimens under stones and under dead wood plant material were picked five times for 20 min in a semicircular transect with the hand-collecting method. In case of the quadrate soil sampling method, six soil sample units were taken on each sampling site and then the animals extracted from the samples with Tullgren funnels (Kos 1988). The depth of the samples was 15 cm and they were taken with a sampling drill of 21 cm in diameter. Each extraction cycle lasted for 21 days. The collected and extracted animals were preserved in 70% ethanol. The animals were then determined using the identification keys in Mršič (1997), Schmalfuss & Lapanje (2006, unpublished) and Hopkin (1991). It was impossible to determine some female specimens to the species level, which is why we classified them into their higher taxonomic group. All of the collected material is deposited in the collection of soil animals at the Department of Biology of the Biotechnical Faculty, University of Ljubljana.

Table 1. List of sites where terrestrial isopods were sampled, and their descriptions. UTM – square (10×10 km) of Universal Transverse Mercator projection.
Tabela 1. Seznam vzorčnih mest vzorčenja mokric, z opisi. UTM – kvadrat (10×10) Univerzalne prečne Mercatorjeve projekcije.

SAMPLING SITE	**1**	**2**	**3**	**4**	**5**
Habitat	Beech forest	Beech forest	Thermophilic forest	Mixed forest	Dry meadow
Sampling date of hand-collecting method	7.5. 14.5. 2.7. 22.10.	7.5. 14.5. 2.7. 22.10.	7.5. 14.5. 2.7. 22.10.	7.5. 14.5. 2.7. 22.10.	7.5. 14.5. 2.7. 22.10.
Sampling date of quadrate method	9.5. 21.6. 19.10.	9.5. 21.6. 19.10.	9.5. 21.6. 19.10.	9.5. 21.6. 19.10.	9.5. 21.6. 19.10.
UTM	WM42	WM42	WM42	WM42	WM42
Coordinates	Lat: 46°16'58" Lon: 15°35'3"	Lat: 46°17'6" Lon: 15°35'13"	Lat: 46°16'60" Lon: 15°35'2"	Lat: 46°16'51" Lon: 15°35'57"	Lat: 46°16'59" Lon: 15°35'15"
Wider geographical classification	Boč, Rogaška Slatina Municipality	Boč, Rogaška Slatina Municipality	Boč, Rogaška Slatina Municipality	Boč, Rogaška Slatina Municipality	Boč, Rogaška Slatina Municipality
Altitude m a.s.l.	625	652	675	610	625
Inclination	steep	gently sloping	steep	gently sloping	plane
Exposition	S	SW	S	SE	flat
Bed rock	dolomite	Triassic limestone	dolomite	limestone	limestone
Soil type	rendzina, brown postcarbonate base	rendzina	rendzina, brown postcarbonate base	rendzina, brown postcarbonate base	brown postcarbonate base
Dominant plant community	white sedge and beech community (*Carici albae – Fagetum*)	white sedge and beech community (*Carici albae – Fagetum*)	manna ash and iron wood community *(Fraxino orni-Ostryetum carpinifoliae)*	iron wood and beech community *(Ostryo-Fagetum)*	furrowed fescue and meadow brome community (*Festuco-Brometalia*)

Results

At all sampling sites, a total of thirteen taxa of terrestrial isopods were recorded, 12 of which could have been determined to the species level. Whereas in a dry meadow not as single species was caught, we caught 8 species in forest on dolomite and in young forest, 6 species in forest on limestone, and 5 species in thermophilic forest. Some of them (9 species) were found only at one of the five sampling sites (Tab. 2). In total, 109 specimens of terrestrial isopods were caught, where 7 species were obtained only through hand-collecting and 5 species only through soil sampling (Tab. 2). The determined species belong to 6 different families. The species found at sampling sites in the Boč area are mostly distributed in southeastern and southern Europe. The same distribution is attributed to the species *Ligidium germanicum*, whereas *Mesoniscus graniger* is distributed from the Carpathians over the Dinaric region to the SE Alps. The *Porcellium fiumanum* can be found from the eastern Alps to the Kvarner region, and the same is known for the *T. illyricus*. The next three species, *Protracheoniscus politus, Trachelipus arcuatus* and *Trachelipus ratzeburgii*, are present in southern as well as central Europe. Other species, such as *Ligidium hypnorum* and *Platyarthrus hoffmannseggi*, are distributed all over Europe. Among all species, *Trachelipus ratzeburgii* and *P. fiumaranum* also have a wide range of ecological amplitude; the latter can even be found in coniferous forest stands (Potočnik 1993).

Discussion

The thirteen terrestrial isopod species found on the Boč Massif comprise 18% of all terrestrial isopod species known in Slovenia (Potočnik 1993). Some species (e.g. *P. politus, T. arcuatus, T. ratzeburgii, L. germanicum, Tachysoniscus austriacus* and *Trichoniscus illyricus*) are mostly known from southern Europe (Schmalfuss 2003) and were found all over Slovenia (Potočnik 1989, 1993). We caught two species that had been identified only in western Slovenia so far. The first one, *P. hoffmannseggii,* was mostly recorded in the Karst (one record is also known from Novo mesto (Vilisics & Lapanje 2005). The fact that it has been found during our research is possibly related to its general distribution across the whole of Europe. As this is a myrmecophilous species, it is closely connected to ant nests, so its presence in soil samples was most likely confirmed by coincidence (Potočnik 1993). The second species, *M. graniger,* has so far been known only from the Postojna area, which should be its western edge of distribution (Potočnik 1980). Our finding from the Boč Massif contributed to the knowledge about its distribution in Slovenia.

Table 2. The list of terrestrial isopod species with the number of specimens collected at five sampling sites, using two methods: hand-collecting method (hc.) and soil sampling method (ss.). Sampling sites are marked with numbers, with detailed descriptions in Tab. 1.
Tabela 2. Seznam vrst ter število osebkov posamezne vrste, ulovljenih na petih vzorčnih mestih z metodo pobiranja (hc.) in talnimi vzorci (ss.). Vzorčna mesta so označena s številkami, njihov podrobnejši opis je v Tab. 1.

SAMPLING SITE	**1**		**2**		**3**		**4**		**5**	
	hc.	ss.	hc.	ss.	hc.	ss.	hc.	ss.	hc.	ss.
f. Ligiidae										
Ligidium germanicum Verhoeff, 1901							1			
Ligidium hypnorum (Cuvier, 1792)			1							
f. Agnaridae										
Protracheoniscus politus (C. Koch, 1841)	10		7	4	7		4			
f. Philosciidae	1				1			1		
f. Platyarthridae										
Platyarthrus hoffmannseggii Brandt, 1833			3							
f. Trachelipodidae										
Porcellium fiumanum (Verhoeff, 1901)								6		
Trachelipus arcuatus (Budde-Lund, 1885)	8		1		1		3			
Trachelipus ratzeburgii (Brandt, 1833)	6				9		1			
Trachelipus razzauti (Arcangeli, 1913)	1									
f. Mesoniscidae										
Mesoniscus graniger (Frivaldsky, 1865)			1							
f. Trichoniscidae										
Haplophthalmus abbreviatus Verhoeff, 1928		1								
Hyloniscus sp.		1								
Tachysoniscus austriacus (Verhoeff, 1908)								2		
Trichoniscus illyricus Verhoeff, 1931		3		11		10		4		
Total specimens number	26	5	13	15	18	10	9	13	0	0
Total species number	**8**		**6**		**5**		**8**		**0**	

Although Potočnik, based on his research (1980, 1989, 1993), claimed that the fauna of terrestrial isopods in Slovenia is well known, our research showed that the actual distribution of some species in the country is still poorly known. From the faunistic point of view, the records of the species *T. razzauti* and *H. abbreviates* are especially important**.** Specifically, the known distribution of *H. abbreviatus* is only in central Italy and has also been found at one site in Croatia (Schmalfuss 2003). Until our research presented here with, only a single record of this species was made in Slovenia, i.e. in the Kočevje region (Potočnik 1993). Its ecological demands are not well known, but it should be a hydrophilic species (Potočnik 1993). On Boč it was found in soil of old beech forest stand. The sampling site was in a wet, shady hollow. The species *T. razzauti* is distributed from the Middle East, over the Balkans to northern Italy (Schmalfuss 2003). But Vilisics et al. (2012) found this species also in an urban habitat of

Lugano (Switzerland), which is also under the influence of Mediterranean climate. There are no sufficient data on its distribution in Slovenia and its ecological demands (Potočnik 1993). On Boč, this species was found at the same sampling site as *H. abbreviatus*.

The comparison between forest stands has shown that the highest number of species was found in the beech forest on dolomite and in young stage forest, while the lowest number was recorded in the thermophilic forest. No specimens of terrestrial isopods were found in the extensive meadow during the whole sampling period. We can conclude that the above-mentioned beech forest and young stage forest are the most suitable habitats for most terrestrial isopods species, especially for those that are distributed all over Slovenia. We also found the commonly distributed species in the thermophilic forest, which shows that these terrestrial isopod species are adapted to various living environments and therefore have a wide range of ecological amplitude. Concerning the species *L. germanicum, L. hypnorum, M. graniger, H. abbreviatus* and *Hyloniscus* sp., only one specimen per species was caught. A possible reason could be that all the above-mentioned species are hydrophilic (Spungis 2008) (also all species within the genus *Hyloniscus*) and prefer wet places, whereas all the sampling sites included in this study represent drier habitats. The species *L. germanicum* and *L. hypnorum* in particular are close related to wet habitats. In previous research, Farkas et al. (1999) established that the occurrence of the species *L. germanicum* mostly depended on habitat type. They were found in high numbers in an alder stand near a stream, and the number of specimens decreased as the distance from the water sources increased. A similar distribution is known for the species *L. hypnorum*. This species is mostly abundant in mixed wet forests, floodplain forests, fens and wet calcareous grasslands (Spungis 2008). The relationship with a specific type of environment is notable also in the beech forest on limestone. At that sampling site we found, specifically, the species *M. graniger* with a wider Balkan distribution. By its geographical definition, this sampling site actually belongs to the fluviokarst and is therefore suitable for species related to karst regions.

A probable reason for no species being found in the meadow is that this is a dry type of meadow void of wet shelters (dead wood, stones) where isopods could hide. With the use of pitfall traps and with a higher number of sample units taken, we could have probably caught isopods in the meadow as well. If used, the same method (pitfall traps) would have probably deliver some new data on other sampling sites as well. This is why a combination of different sampling methods was recommended by some authors (e.g. Paoletti & Hassall 1999, Giurginca & Ilie 2003) for a detailed examination and for studying the woodlice fauna in a certain area.

The presence of some isopod species at only one sampling site confirms the importance of heterogeneous environmental constitution for species diversity. Environmental heterogeneity on the Boč Massif is rather high, while our research included only a small part of the area. There are various plant communities and some xerothermic forest communities that are vegetation relicts of the past dry and cold preboreal and the warmer boreal periods (Cimperšek 2005). The comparison of the isopod fauna between various communities could also have brought some new interesting data. In any case, to get a better insight into the woodlice fauna, additional research in a broader area of the Boč Massif and in the region is needed.

Povzetek

Zaradi geografske lege Slovenije na stičišču treh biogeografskih regij je tudi vrstna pestrost mokric pri nas zelo bogata. Kljub sicer dokaj dobremu poznavanju favne mokric na območju Slovenije pa še vedno ostajajo nekateri deli, kjer je favna mokric slabše raziskana. Mednje vsekakor sodi tudi Boški masiv v Voglajnsko–Soteljski regiji (vzhodna Slovenija).

Boč leži na stičišču treh velikih evropskih makroregionalnih geografskih enot: alpske, panonske in dinarske. Zaradi geografske lege in klime smo tam pričakovali tudi pestro favno mokric. Na petih vzorčnih mestih, ki se med seboj razlikujejo predvsem po razvojni fazi sestoja, tipu rastlinske združbe in matični podlagi, smo v letu 2005 opravili vzorčenje mokric z dvema vzorčevalnima metodama. Pri vzorčenju smo uporabili metodo ročnega pobiranja živali pod kamenjem in odmrlimi rastlinskimi ostanki ter metodo kvadratov. Pri slednji smo odvzeli vzorce prsti in živali nato ekstrahirali na modificiranih Tullgrenovih lijakih.

Skupno smo na vseh petih vzorčnih mestih ulovili 12 vrst mokric. Medtem ko smo največje število vrst (8) ulovili v gozdu na dolomitu in mladem gozdu, nobene vrste nismo našli na ekstenzivnem travniku. Med ulovljenimi vrstami so prednjačile tiste, ki so razširjene predvsem v južni Evropi (e.g. *P. politus, T. arcuatus, T. ratzeburgii, L. germanica, T. austriacus* in *T. illyricus*) (Schmalfuss 2003) in so jih med dosedanjimi raziskavami našli tudi v različnih predelih Slovenije (Potočnik 1989, 1993). Našli smo tudi vrsti *P. hoffmannseggii*, ki je do sedaj poznana predvsem s Krasa, in vrsto *M. graniger*. Slednjo so našli (Potočnik 1980) v Postojni, kjer naj bi dosegala skrajni zahodni rob svojega areala. Podatki, ki smo jih pridobili v naši raziskavi, so tako prispevali k dodatnemu poznavanju distribucije omenjene vrste v Sloveniji. Nekatere izmed vrst smo zabeležili samo na enem izmed vzorčnih mest, kar je lahko posledica navezanosti le-teh na specifične okoljske dejavnike (npr. na večjo vlažnost). Prav tako vse vrste niso bile enako ulovljive z obema vzorčevalnima metodama. Razlog je v velikosti osebkov določene vrste in njihovem življenjskem okolju. Prav zaradi tega je za celostno vzorčenje favne mokric pomembna kombinacija različnih vzorčevalnih metod.

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