

NOTES ON INVERTEBRATES PREYED BY SHREWS  
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## ABSTRACT

*Until recently in Slovenia, the presence of invertebrates in the shrew diet had not been investigated. Here we present a list of invertebrates and other ingested items in five shrew species: Sorex alpinus, S. araneus, S. minutus, Crocidura suaveolens and Neomys fodiens in Slovenia. These shrews fed mostly on arthropods and earthworms. Among the arthropods, Araneae, Opiliones, Lithobiomorpha and Insecta were found. Oniscoidea and Diplopoda, generally abundant in the shrews' habitats, were not found. Among the identified species, Amaurobius ferox, Mitopus morio, Aptinus bombardarda and Apterygida media were the most common prey.*

**Key words:** shrew prey, Soricidae, Arthropoda, SloveniaNOTE SU INVERTEBRATI PREDATI DA TOPORAGNI  
(MAMMALIA: INSECTIVORA: SORICIDAE) IN SLOVENIA

## SINTESI

*Solo recentemente è stata indagata la presenza di invertebrati nella dieta del toporagno in Slovenia. Gli autori presentano l'elenco degli invertebrati e di altri oggetti ingeriti da cinque specie di toporagno: Sorex alpinus, S. araneus, S. minutus, Crocidura suaveolens e Neomys fodiens in Slovenia. Questi toporagni si nutrono per lo più di artropodi e lombrichi. Tra gli artropodi sono stati trovati rappresentanti di ragni (Araneae), opilioni (Opiliones), centopiedi (Lithobiomorpha) e insetti (Insecta). Non sono state rinvenute invece specie di oniscidi (Oniscoidea) e diplopodi (Diplopoda), generalmente abbondanti negli habitat dei toporagni. Tra le specie identificate le prede più comuni sono: Amaurobius ferox, Mitopus morio, Aptinus bombardarda e Apterygida media.*

**Parole chiave:** prede di toporagni, Soricidae, Arthropoda, Slovenia

## INTRODUCTION

Shrews (Soricidae) are small insectivorous mammals that occupy relatively small territories, are active many times a day throughout the year and are opportunistic feeders (Churchfield, 1994; Churchfield & Rychlik, 2006). They prey mostly on invertebrates, like arthropods, lumbricids, slugs and others. So far, their prey has rarely been determined on the species level (Denneman, 1990; Mitov, 1995; Novak *et al.*, 2006; Klenovšek *et al.*, 2013), as studies on the shrew diet have focused mostly on the quantity of the prey consumed. Such papers usually list families and higher taxa, along with the prey body length classes (e.g., Churchfield, 1994; Churchfield & Rychlik, 2006) or volume (Whitaker & Ruckdeschel, 2006), which are indicative of the prey body mass or its energy value to the predator. Besides consuming them, shrews cause injuries to living invertebrates, like the litter-dwelling opilionid *Trogulus nepaeformis*, where the legs of up to one-third of individuals in some populations have been damaged (Novak *et al.*, 2006). Such knowledge highlights the complexity of the impact of shrews on the syntopic invertebrates. Although shrews are opportunistic feeders, they are known to avoid Diplopoda (e.g., Churchfield & Rychlik, 2006), which are abundant in most habitats, and shrews presumably do not eat invertebrates living above the ground (Churchfield, 2002). Thus, they are not expected to eat all invertebrates within a territory, and in this way exert an unequal impact on the invertebrate population.

The aim of this paper is to present a list of invertebrate prey species and other consumed material based on food remnants found in the stomachs of five shrew species in Slovenia (*Sorex alpinus*, *S. araneus*, *S. minutus*, *Crocidura suaveolens* and *Neomys fodiens*). Selected photographs of recognized prey and other ingested items – such as those provided for neuropterans (Devetak & Duelli, 2007) – are included as indispensable for the recognition and determination of prey species. We also discuss the role of some invertebrate species as the shrews' prey and the role of shrews as natural predators of some invertebrates in Slovenia.

## MATERIAL AND METHODS

In total, the stomach contents of 204 shrews belonging to five species were considered: 124 specimens of *Sorex araneus* Linnaeus, 1758, 60 specimens of *S. minutus* Linnaeus, 1766, 18 specimens of *S. alpinus* Schinz, 1837, one specimen of *Crocidura suaveolens* (Pallas, 1811) and one specimen of *Neomys fodiens* (Pennant, 1771). Most of the stomachs accrued from investigations on Mt. Snežnik and Mts. Peca, Smrekovec and Olševa (in the following: the Koroška Mts.), in which small mammals and invertebrates were systematically sampled (Trilar, 1991; Kos *et al.*, 2000; Drovenik, 2001; Janžekovič & Čas, 2001). Nearly all of these stomachs were used for a trophic niches comparison of the three syntopic *Sorex* species in a montane habitat (Klenovšek *et al.*, 2013). The rest of the shrews were from other localities (Tab. 1).

The stomachs were dissected, and their contents transposed into 70% ethanol and inspected for major food remnants. Afterwards, the contents were heated in 10% NaOH at 80 °C for 4 hrs (Sommer & Sommer, 1997) to dissolve soft tissues. Undissolved remnants, like chitinous, cellulose and other similar particles, were examined under a Nikon Eclipse E800 compound microscope with a mounted digital Net camera DN100, and processed with Eclipse Net software. The photographed prey remains were identified by comparison to invertebrate specimens collected at the same time and in the same locality as the shrews. Most frequently small fragments of antennae, legs, elytrae, heads, chelicerae etc. were found, which enabled unambiguous comparison and determination.

## RESULTS

In 204 stomachs of five shrew species, a total of 180 animal prey items from 21 taxa were identified. In addition, we found soil and wood particles, rootlets and animal prey remnants, which could not be identified. The list of food items found is presented in Table 2, and selected

**Tab. 1: Locality, altitude, collection date, shrew species and the number of specimens investigated.**

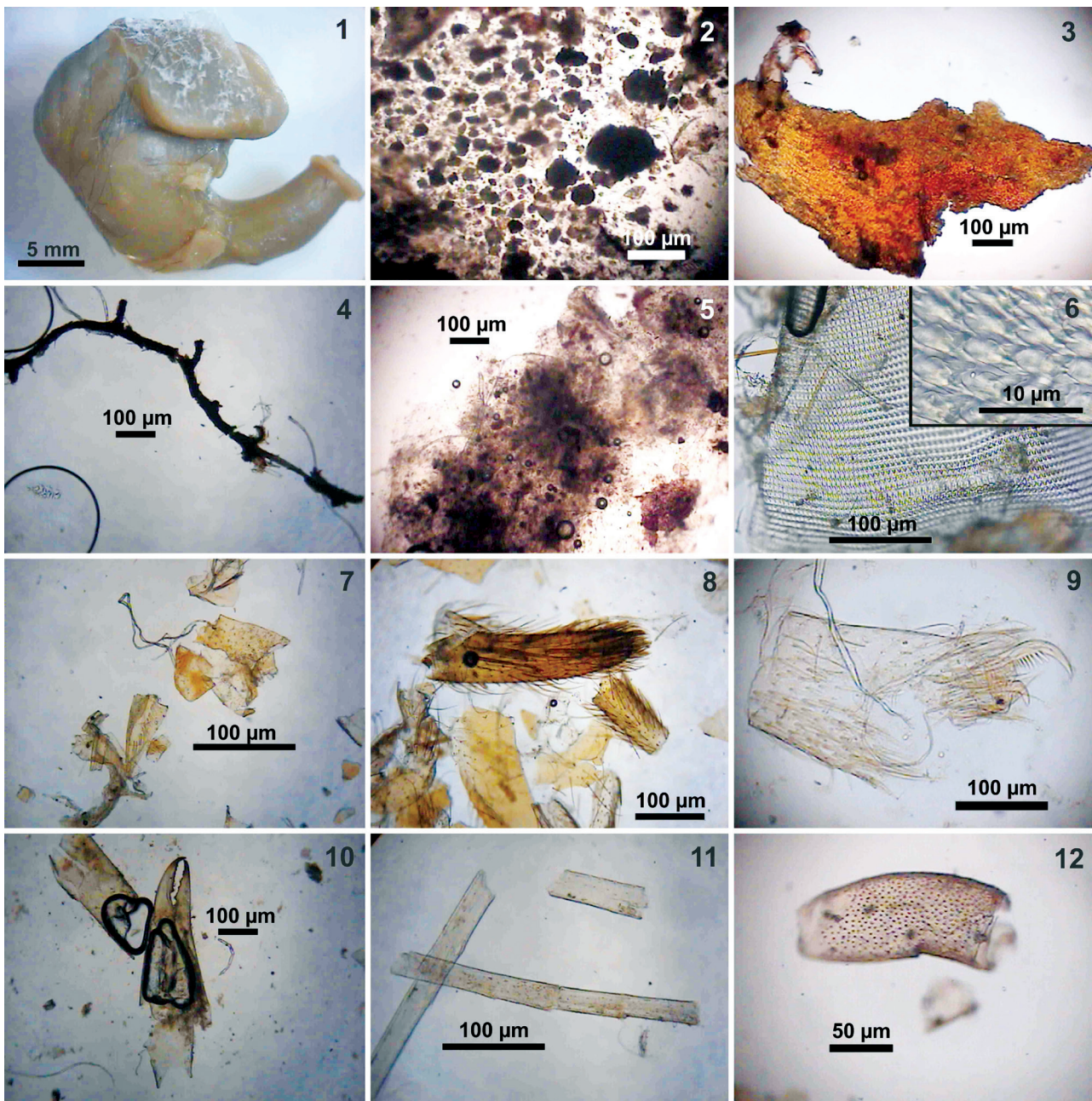
**Tab. 1: Lokaliteta, nadmorska višina, datum ulova, vrsta in število pregledanih osebkov**

Locality, altitude	Date	Shrew species	No of individuals
Mt. Snežnik, 1150–1350 m	1988–1990	<i>Sorex araneus</i>	65
		<i>S. alpinus</i>	1
Mts. Peca, Smrekovec and Olševa, 1030–1500 m	May/October 1999–2000	<i>S. araneus</i>	59
		<i>S. minutus</i>	58
		<i>S. alpinus</i>	14
Idrija, 520 m	13. 7. 2001	<i>S. alpinus</i>	3
Postojna, 530 m	13. 7. 2001	<i>S. minutus</i>	2
Dragonja, 60 m	13. 7. 2001	<i>Crocidura suaveolens</i>	1
Slovenj Gradec, 430 m	23. 6. 2000	<i>Neomys fodiens</i>	1

Tab. 2: List of invertebrates and plant material found in the stomachs of five shrew species.

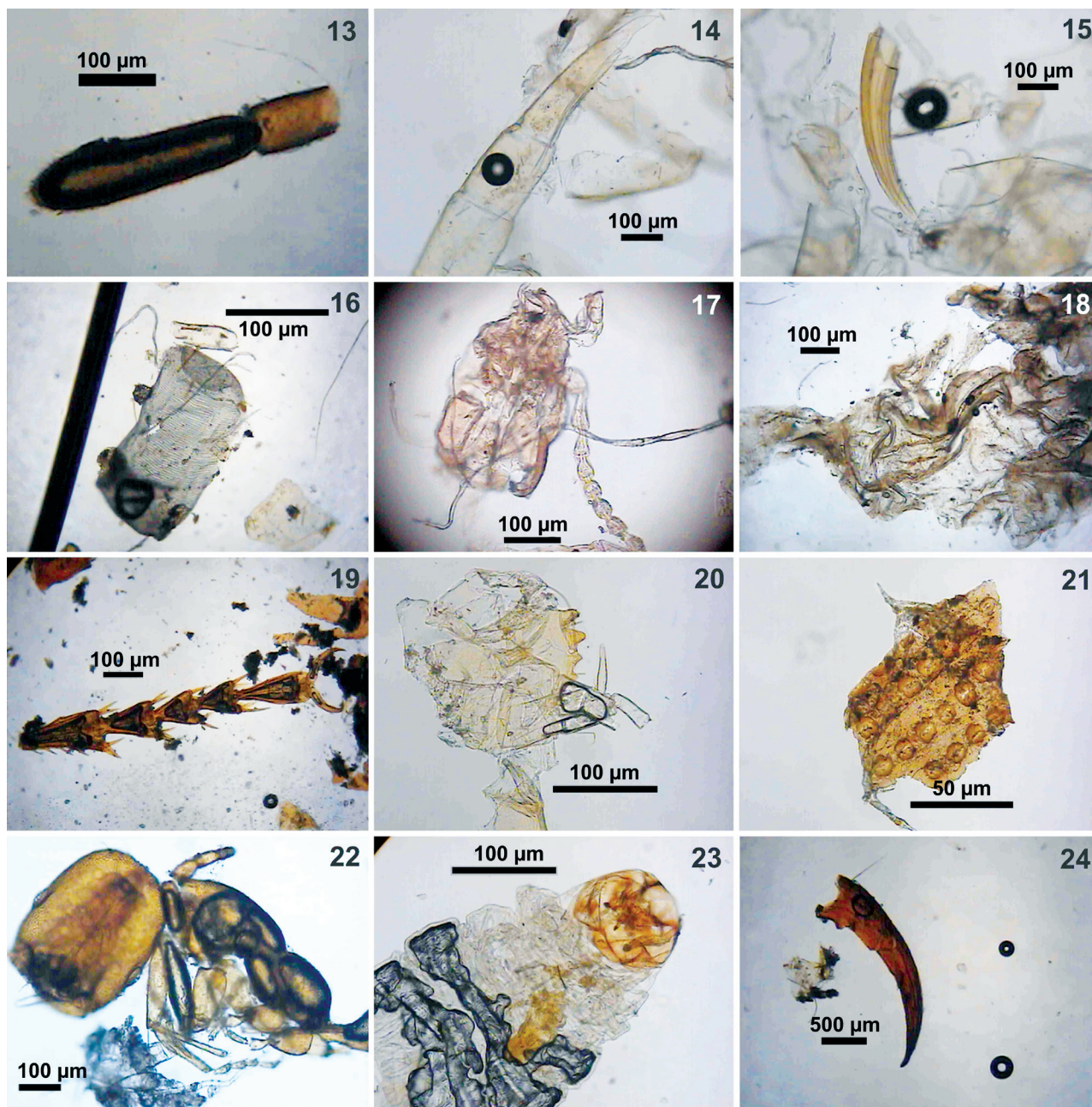
Tab. 2: Seznam nevretenčarjev in rastlinskega materiala, najdenega v želodcih petih vrst rovk

Food items			<i>Sorex araneus</i> (n=124)	<i>S. minutus</i> (n=60)	<i>S. alpinus</i> (n=18)	<i>Crocidura suaveolens</i> (n=1)	<i>Neomys fodiens</i> (n=1)
Wood particles			+		+		
Rootlets			+				
Prey							
Higher taxon	Family	Species					
Gastropoda indet. (slugs)			+				
Lumbricidae indet.			+	+	+		
Araneae indet.			+	+	+		+
	Amaurobiidae						
		<i>Amaurobius ferox</i> (Walckenaer 1830)	+	+	+		
Opiliones							
	Phalangiiidae						
		<i>Lacinius ephippiatus</i> (C. L. Koch 1835)	+				
		<i>Opilio dinaricus</i> Šilhavý 1938				+	
		<i>Rilena triangularis</i> (Herbst 1799)		+			
		<i>Mitopus morio</i> (Fabricius 1799)	+	+	+		
	Trogulidae						
		<i>Trogulus nepaeformis</i> (Scopoli 1763)	+				
Lithobiomorpha indet.			+		+		
Insecta indet.			+	+			
Dermaptera							
	Forficulidae	<i>Apterygida media</i> (Hagenbach 1822)	+	+	+		
Coleoptera indet.			+	+	+		
	Carabidae		+				
		<i>Aptinus (Aptinus) bombardata</i> (Illiger 1800)	+	+	+		
		<i>Carabus (Megadontus) violaceus</i> Linnaeus 1758	+				
		<i>Nebria dahlii</i> (Duftschmid 1812)	+				
	Staphylinidae	<i>Philonthus</i> sp.	+				
	Curculionidae	<i>Tropiphorus elevatus</i> (Herbst 1795)	+				
	Pselaphidae			+			
Hymenoptera							
	Myrmicidae		+				
Diptera							
	Cecidomyiidae	<i>Mikiola fagi</i> (Hartig 1839)	+				



**PLATE I: Shrew stomach and selected remnants of food items. Fig. 1: stomach of *Sorex araneus*; Fig. 2: soil particles; Fig. 3: wood particle; Fig. 4: rootlet; Fig. 5: earthworm residuals; Fig. 6: slug radula; Fig. 7: arthropod chitinous remains; Fig. 8: spider remains; Fig. 9: *Amaurobius ferox* tarsus; Fig. 10: *Rilaena trinagularis* chelicerae; Fig. 11: *Lacinius ephippiatus* legs; Fig. 12: *Mitopus morio* pedipalpal patella.**

**TABLA I: Želodec rovke in izbrani preostanki hrane. Sl. 1: želodec vrste *Sorex araneus*; Sl. 2: delci prsti; Sl. 3: delci lesa; Sl. 4: koreninica; Sl. 5: ostanki deževnika; Sl. 6: strgača polža; Sl. 7: hitinski ostanki členonožca; Sl. 8: ostanki pajka; Sl. 9: tarsus vrste *Amaurobius ferox*; Sl. 10: helicera vrste *Rilaena trinagularis*; Sl. 11: noge vrste *Lacinius ephippiatus*; Sl. 12: patela pedipalpa vrste *Mitopus morio***



**PLATE II:** Selected remnants of food items. Fig. 13: *Troglus nepaeformis* 2nd leg tarsus; Fig. 14: leg of lithobiomorphous; Fig. 15: lithobiomorphous maxillipede; Fig. 16: insect trachea; Fig. 17: *Aptinus bombardia* head; Fig. 18: *Carabus violaceus* proventricule chitinous inner covering; Fig. 19: *Nebria dahli* tarsus; Fig. 20: *Tropiphorus elevatus* maxilla; Fig. 21: *T. elevatus* fore-wing; Fig. 22: Myrmicid ant; Fig. 23: *Michiola fagi* larva; Fig. 24: *Apterygida media* cercus.

**TABLA II:** Izbrani preostanki hrane. Sl. 13: vrsta *Troglus nepaeformis* – tarsus druge noge; Sl. 14: noga strige; Sl. 15: maksiliped strige; Sl. 16: traheja žuželke; Sl. 17: glava vrste *Aptinus bombardia*; Sl. 18: hitinska notranja plast proventrikla vrste *Carabus violaceus*; Sl. 19: tarsus vrste *Nebria dahli*; Sl. 20: maksila vrste *Tropiphorus elevatus*; Sl. 21: prednje krilo vrste *T. elevatus*; Sl. 22: mirmicidna mravlja; Sl. 23: larva vrste *Michiola fagi*; Sl. 24: cercus vrste *Apterygida media*

photos of ingested items in Plates I and II. The majority of the preyed animals belonged to arthropods, and among the others we recognized slug and earthworm remnants. The most frequent determinable taxa were Insecta, Araneae, Lumbricidae and Opiliones, while Oniscoidea and Diplopoda were not found. Among the insects, Coleoptera were the most frequent prey.

### DISCUSSION

Shrews are opportunistic feeders that forage on various soil-, litter-, and water-dwelling invertebrates and small vertebrates (Churchfield & Rychlik, 2006; Churchfield, 2008). The shrews studied in our investigation fed mostly on earthworms, spiders, harvestmen and insects. Some prey remnants were determined to the species level, a process which was time consuming, but it did yield evidence of the impact of shrew predation on particular invertebrate species. Species-level determination is also indispensable in detailed comparative analysis of the shrew diet niches (Klenovšek *et al.*, 2013).

Earthworms are usually a common shrew prey (Churchfield & Rychlik, 2006). In our study they were found in all three *Sorex* species and were probably frequently eaten because of their large size, slow movement and abundance. Oniscoidea were reported in other *Sorex* species (Churchfield, 2002), but absent in our shrews.

Another frequent prey were spiders, from which only *Amaurobius ferox* was identified to the species level. This relatively large and, in woodlands widespread, ground-dwelling spider was obviously a profitable prey.

Mitov (1995) reported on five slow moving, hygrophilous opilionid species found in 33 shrew stomachs on Vitosha Mountain, Bulgaria. Novak *et al.* (2006) reported of leg damages in the opilionid *Trogulus nepaeformis* caused by shrews. In contrast to these reports, we found relatively rapidly moving species as prey, which search for daily refuge under stones, wood, bark, and similar microhabitats on the ground. Moreover, preying on the fast moving opilionid *Opilio dinaricus*, which mostly lives in the understory, demonstrates that shrews may also influence above-ground species.

Among the Myriapoda, only Lithobiomorpha were found. Diplopoda have been reported as being avoided by shrews (Grainger & Fairley, 1978; Klenovšek *et al.*, 2013), probably on account of their scent gland exudates. Such glands are also characteristic of harvestmen, but the chemical composition of their defence compounds (e.g., Raspotnig *et al.*, 2010) is obviously not as unpleasant to shrews as in Diplopoda. Beetles from the Carabidae family also produce defensive secretions, and some have been reported to be avoided by shrews (Bonaccini *et al.*, 2011). Surprisingly, *Aptinus bombardae*, which produces chemical repellents and popping sounds, was commonly preyed by the *Sorex* species.

Shrews prefer more profitable prey, but abundance may influence the predation of smaller prey. They probably become habituated to its availability. This could be the case when *S. araneus* was found to be feeding extensively on relatively small *Mikiola fagi* larvae on Mt. Snežnik in 1989 when *M. fagi* appeared in abundance (Trilar, 1991). In this way, shrews importantly regulated the population of *M. fagi*.

Since invertebrates in shrews' diet have seldom been identified on the species level, we believe that such studies can valuably contribute to the understanding of the shrew's impact on particular invertebrate species.

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## ZAPISKI O NEVRETEŃARJIH KOT PLENU ROVK (MAMMALIA: INSECTIVORA: SORICIDAE) V SLOVENIJI

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### POVZETEK

Rovke (*Soricidae*) so majhni žužkojedi sesalci, ki se prehranjujejo predvsem s členonožci, z deževniki, s polži in z drugimi nevretenčarji. V študijah o prehrani rovk avtorji običajno navajajo plen, določen do nivoja družin ali višjih taksonov, medtem ko je plen redko določen do vrste. V prispevku predstavljamo seznam uplenjenih vrst in druge želodčne vsebine pri petih vrstah rovk: *Sorex alpinus*, *S. araneus*, *S. minutus*, *Crocidura suaveolens* in *Neomys fodiens* v Sloveniji. Pregledali smo vsebino želodcev 204 rovk. S primerjavo ostankov zaužitega plena z zbirko nevretenčarjev, ulovljenih skupaj z rovkami, smo prepoznali 180 osebkov plena iz 21 taksonov. Preostanke plena in drugo vsebino želodcev smo fotografirali. Rovke so jedle predvsem členonožce in deževnike. Od členonožcev so bili najpogostejši plen pajki, suhe južine, strige in žuželke ter med slednjimi hrošči. Od prepoznanih vrst so bile najpogostejše *Amaurobius ferox*, *Mitopus morio*, *Aptinus bombardarum* in *Apterygida media*. Kočičev in dvojnog, sicer pogostih v habitatih rovk, nismo našli. Rovke običajno plenijo endogejične in epigejične nevretenčarje, zato je najdba suhe južine *Opilio dinaricus*, ki živi pretežno v podrastu, nakazala, da lahko rovke vplivajo na širši razpon nevretenčarjev, kot običajno pričakujemo. Rovke se navadno hranijo z večjim plenom, a če so manjši nevretenčarji, kakršne so ličinke *Mikiola fagi*, pogosti, iščejo in jedo tudi tak plen. Raziskave prehrane rovk z identifikacijo plena do vrste lahko pomembno prispevajo k poznavanju vpliva rovk na posamezne vrste nevretenčarjev.

**Ključne besede:** plen rovk, *Soricidae*, Arthropoda, Slovenija

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