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SUBTERRANEAN FAUNA OF TWELVE ISTRIAN CAVES

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ABSTRACT

The subterranean fauna of twelve Istrian caves, six in Slovenia and six in Croatia, is presented in this paper. Caves in the carbonate region of White Istria (Čičarija) host the richest troglobiotic fauna in comparison to caves in the carbonate littoral region of Red Istria and the intermediate flysh region of Grey Istria. Caves in the contact zone of limestone and flysch situated in Grey Istria are inhabited by a surprisingly high number of troglobiotic taxa as well. Some subterranean taxa were found relatively far from their known distributional areas. In addition, several new taxa have been discovered for science. We briefly describe the general ecological conditions within the caves and estimate potential threats to their faunas. Istrian caves are inhabited by numerous endemic troglobiotic species, in this respect ranking this region close to the most diverse Dinaric region.

Key words: subterranean fauna, troglobionts, cave conservation, Istria

FAUNA SOTTERRANEA DI DODICI GROTTE ISTRIANE

SINTESI

L'articolo presenta la fauna sotterranea di dodici grotte istriane, sei delle quali presenti in Slovenia e sei in Croazia. Le grotte della regione carbonatica dell'Istria Bianca (Ciceria) ospitano la fauna di troglobi più ricca in confronto alle grotte della regione carbonatica costiera dell'Istria Rossa e della regione flyschoide intermedia dell'Istria Grigia. Peraltro, anche nelle grotte della zona di confine fra calcare e flysch, situate nell'Istria Grigia, è stato trovato un numero sorprendentemente alto di taxa di troglobi. Alcuni taxa sotterranei sono stati trovati relativamente lontano dalle loro aree di distribuzione conosciute. Nell'articolo vengono inoltre segnalati alcuni taxa nuovi per la scienza. Gli autori descrivono brevemente le condizioni ecologiche generali all'interno delle grotte, e valutano i fattori che potrebbero nuocere alla fauna locale. Le grotte istriane ospitano numerose specie endemiche di troglobi, al pari della ben diversa regione dinarica.

Parole chiave: fauna sotterranea, troglobi, tutela delle grotte, Istria

INTRODUCTION

The Istrian Peninsula consists of three main geomorphological units extending from (in order from northeast to southwest) the inner, partly mountainous limestone region known as White Istria; the external, low limestone plateau with typical red soils called *Red Istria*; and a hydrological barrier flysch zone in between known as Grey Istria (Krebs, 1907). Up to now, over 2000 caves have been registered in Istria, mostly in limestone. There are also caves which have developed in the contact area between flysch and limestone. The Istrian Karst is relatively well isolated from the main Dinaric Karst, and for this reason caves in Istria are very interesting for biological research. Although biospeleological exploration in Istria began early in the second half of the 19th century, the subterranean fauna of the area is not well known and has not been systematically explored and evaluated. Unfortunately, caves, springs and their fauna are under strong pressure from human activity (Sket, 1999; Culver & Pipan, 2009; Ozimec *et al.,* 2009; Polak & Pipan, 2011).

Geopolitically, the Istrian peninsula is divided among Croatia, Slovenia and Italy, a fact which necessitates international cooperation. Within the Karst Underground Protection project (KUP), biospeleological surveys, identification of potential threats to the subterranean environment and accompanying popularization activities have been carried out (Ozimec *et al.,* 2010, 2011). This project was financed by the OP IPA Slovenia - Croatia 2007–2013 program and led by the Istrian Region, with Natura Histrica as the Croatian partner and the Karst Research Institute ZRC SAZU from Postojna as the Slovenian partner. The aim of the speleobiological research within the framework of the KUP was to evaluate species richness and the ecological conditions of the subterranean habitats in Istria through a systematic survey of selected caves. In this paper we present an overview of the faunistic findings within twelve selected caves from Slovenian and Croatian Istria.

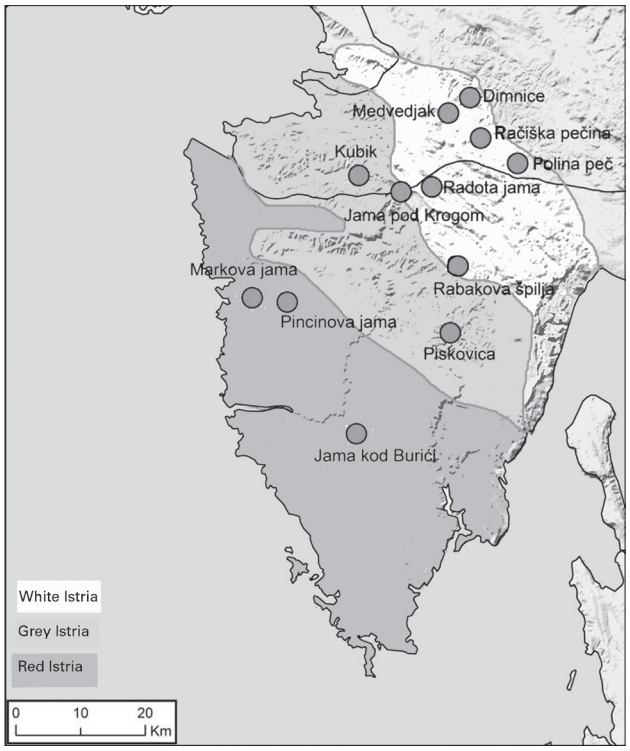

Fig. 1: Map of Istria showing locations of the12 caves investigated.
Sl. 1: Zemljevid Istre z lokacijami 12 raziskovanih jam.

Caves under study

In total, twelve caves were selected for investigation, six in Slovenia and six in Croatia (Fig. 1). Six of them were in Čičarija (White Istria), three in the contact zone of limestone and flysch (Grey Istria) and three caves were in the littoral region of Red Istria.

Some of the selected caves provide terrestrial and aquatic habitats (springs, subterranean rivers and lakes), whereas others feature only terrestrial habitats. The caves differ in terms of accessibility and use: some are accessed through an entrance shaft and are more difficult of access to people, while others are horizontal and regularly visited. Two of these caves have been used for tourism or by the military. In the following, we briefly present the caves being investigated. Cadastre Number (Cad. No.) refers to the corresponding Slovene cave cadastre. Number (Pećina br.) corresponds to the number of Istrian caves (Malez, 1960) and number No. VG (Grotte della Venezia Giulia) refers to the old Italian cave cadastre (Boegan, 1930).

1. Polina Peč (Cad. No. 938), Poljane, Obrov, Matarsko podolje, Čičarija, Slovenia

Synonymy: Caverna di Pogliane presso Castelnuovo, Polina pecina, No. 1105 VG (Müller, 1930).

With its entrance at the bottom of a small doline, this cave is easily accessible. It is 365 m long and 40 m deep, consisting of a large descending entrance hall, a narrow passage and a huge inner chamber. The temperature of the entrance hall is strongly influenced by cold air, especially in winter when ice is regularly deposited to the very bottom.

2. Račiška Pečina (Cad. No. 942), Račice, Starod, Matarsko podolje, Čičarija, Slovenia

Synonymy: Pečina pri Račicah, Grotta di Racizze, No. 613 VG, presso Castelnuovo (Müller, 1930).

The cave is horizontal and 304 m long by 29 m deep. Between World War I and II and until the 1980s, the cave was used as a fuel storage place for military purposes. For this reason, some parts of the cave have been devastated; the floor has been artificially levelled and the cave is partly polluted with oil. In the inner part,

bones and traces of a cave bear (*Ursus spelaeus*) have been discovered (Mihevc, 2003); due to these discoveries, the cave has been closed for conservation purposes since 2007.

3. Dimnice (Cad. No.735), Markovščina, Materija, Matarsko podolje, Čičarija, Slovenia

Synonymy: Grotte de Markovsina ou grotte d'Innice, Höhle bei Markovscina (Müller, 1905), Grotta Dimnice nei dintorni di Markovscina (Müller, 1906), Rauchgrotte bei Markovščina (Perko, 1909), Grotte Dimnice ou grotte qui fume, à Markovsina (Jeannel, 1911), Grotte di Marcossina detta Grotta del Fume, No. 626 VG, Grotta Dimnizze presso Slivje (Müller, 1928), Dimnica jama (Rauchgrotte) bei Slivia (Stammer, 1932).

The total length of the passages is 6020 m; the cave is 134 m deep. The Dimnice cave is the only tourist cave included in our study. Down the 39 m deep entrance pit, the cave extends into horizontal passages and chambers of impressive dimensions, some of them being 20 m wide and high. Relatively small water current flows through Dimnice.

4. Medvedjak (Cad. No. 881), Markovščina, Materija, Matarsko podolje, Čičarija, Slovenia

Synonymy: Medvedova jama, Grotta dell' Orso presso Markovsina (Perko, 1909), Medvedova jama bei Markovšina (Müller, 1913), Grotta dell'orso (medvedova jama) dist. Marcousina (Müller, 1928), Grotta ai piedi del Monte Medvediak, No. 70 VG, Grotta dell 'orso presso Marcossina, tra Cosinae Castelnuovo (Müller, 1930).

The total length of the cave is 1091 m with a depth of 129 m. The entrance section of the cave is a 45 m deep bell-shaped pit with a huge hall beneath. From this point, more or less horizontal galleries extend in different directions. In the upper parts there are many speleothemes, whereas the lower galleries are mostly muddy.

Jama Pod Krogom (Cad. No. 4524) – Špilja pod Krugom (Bedek *et al.,* 2006)., Mlini, Sočerga, Čičarija, Slovenia–Croatia

5. The Jama Pod Krogom spring cave is situated in the contact zone where the Paleocene limestone thrusts over the Eocene flysch. The cave is 570 m long and ascends for 25 m. The entrance opens on a vertical rock cliff, right on the Slovene - Croatian border. During rainy periods, the whole cave is flooded and water flows out at the entrance. During dry periods the water is caught in the cave lakes and siphons several meters above the level of the permanent spring in the village of Mlini (Habič *et al.,* 1982).

6. Kubik (Cad. No. 4524), Brezovica pri Gradinu, Koprska brda, Slovenia

Synonymy: Kobiak.

The Kubik cave is a 292 m long horizontal cave of small dimensions. The entrance opens into a small pit. In its farthest and lowest section where a small stream and water pools occur, the cave is 10 m below the surface. The cave lies in on the contact between flysch sandstones and nummulite, turbidite limestone originated by small stream erosion.

Rabakova Špilja, Roč, Ročko polje, White Istria, Croatia

Synonymy: Kerbauc pećina, Ročka Špilja, Grotta di Rabaco dei Bencici, No. 1193 VG, Pećina br. 4 (Malez, 1960).

7. Rabakova Špilja is 143 m long and 22 m deep (Malez, 1960). The cave was formed by the erosion of nummulite, turbidite limestones caused by periodic water flow. It is a complex cave system consisting of two morphologically different channels with periodic water flow in the lowest part.

8. Radota Jama, Radota brdo, Rakitovec, Brest, Buzet, White Istria, Croatia

Synonymy: Grotta di Garnchino (Radetik), No. 298 VG, Pećina br. 42 (Malez, 1960).

8. Radota Jama is located on the southwestern side of the Radota hill in Čičarija. It represents a simple cave system, 268 m long and 170 m deep (Malez, 1960). In the eastern part of the main cave chamber, a steep, partly vertical 150 m long channel starts, with an intermittent water pool on the bottom. The channel is completely covered with sinter.

9. Piskovica, Jaklići, Gologorica, Pazin, Grey Istria, Croatia

Piskovica is mostly a horizontal, 1036 m long passage, representing a simple, hydrologically active cave system. Two dozen meters before the end of the cave at its deepest point of 38 m, there are collapsed blocks with a water current flowing through. Piskovica cave was formed by water flow erosion of flysch sediments located between limestone layers. The cave has a unique and attractive morphology resembling a straight rectangular tunnel (Jekić & Zlokica, 1988).

Markova Jama, Štancija Špin, Tar, Poreč, Red Istria, Croatia

10. Markova Jama is a complex 291 m long and 82 m deep pit system with two entrances, one of them closed at the moment. The cave was discovered in 1975 (Legović, 1985). The deepest point at 82 m is 18 m below sea level; at this point a 3 m deep lake is located.

11. Jama Kod Burići, Kanfanar, Red Istria, Croatia

Jama Kod Burići is a complex, 100 m long and 127 m deep pit, with a narrow (0.5 x 0.7 m) entrance. A long inner chamber extends into several muddy pits. Jama Kod Buriči is hydrologically active during heavy rains (Legović, 1999).

12. Pincinova Jama, Tar, Poreč, Red Istria, Croatia.

The entrance of the cave Pincinova Jama is located at the bottom of a small doline in the vicinity of the village of Monfaber near Poreč. The cave is 100 m long, with the deepest point at 85 m (Legović, 1985). It is a simple pit with an underground water pool. The lake is, on average, 22 m deep. Since its discovery in 1976, many speleological research studies have been carried out within the cave.

MATERIALS AND METHODS

At the beginning of our research, published information on the caves with respect to their geomorphology, physical properties and faunas was compiled and studied. The speleological data, including the cave maps of Slovene caves were obtained from the Slovene Cave Cadastre (IZRK ZRC SAZU and the Slovene Caving Association). The maps and data for the Croatian caves were obtained from published reports (Malez, 1960; Legović, 1985, 1999; Jekić & Zlokolica, 1988). Older cave catalogues (Bertarelli & Boegan, 1926; Garibaldi, 1926; Boegan, 1930) were also studied. The published faunistic records were taken from the cave fauna catalogues (Hamann, 1896; Wolf, 19341938) and from numerous papers and revisions of particular animal taxa.

Field work in the selected caves was carried out during between two to four visits (at least two per cave) in different seasons. Measurements of environmental parameters are irrelevant for this study and are not presented here. The fauna was studied by systematic visual inspection of the cave floor, walls, ceiling and water micro-habitats. Sampling with baited pit-fall traps was not applied, except for one occasion in the Medvedjak cave to collect beetle specimens for photographic documentation and molecular studies. Most of the recorded species were photographed. Selected specimens were collected and preserved for further investigation. The biological samples from Slovenia are deposited in the Zoological Collection of the Department of Biology (Biotechnical Faculty, University of Ljubljana) and in the Notranjska Museum Postojna (Postojna). The material from Croatia is deposited in the Collection of the Croatian Biospeleological Society (HBSD). The collected fauna were mostly identified by the authors although some species were delivered to other experts.

We used classical classifications of subterranean environments and their associated fauna (*e.g.*, Schiner, 1854; Camacho, 1992; Sket, 2008; Culver & Pipan, 2009, Novak *et al.,* 2012). Troglobionts (stygobionts in the case of aquatic taxa) complete their life cycle in a completely dark, humid/water and thermally stable hypogean environment. Most of these clearly show troglomorphism. Troglophiles alternate between epigean and hypogean habitats or live permanently in subterranean habitats, and show some moderate adaptations to subterranean conditions, such a reduced eyes and adaptations to compensate for the lack of visual orientation. Some among these do not complete their life cycle underground, while others do. Trogloxenes are taxa which enter caves for shelter or feeding opportunities, but which exhibit no morphological adaptation to the hypogean environment and do not complete their life cycle there. Some edaphobionts living in soil are also common in the entrance sections of caves. Most of our field work focused on the troglobionts. Troglophiles and particularly trogloxenes were not sampled systematically. Small aquatic invertebrates (Turbellaria, Oligochaeta etc.), microscopic crustacean fauna (Copepoda), micro-organisms and fungi were not sampled and are not considered in this study. Owing to the lack of experts in some taxa and the absence of adult stages, some taxa have not been determined to the species level.

The lists of the subterranean faunas of the three regions - White, Grey and Red Istria - were tested for differences in the presence or absence of species using the Cochan Q test (Sokal & Rohlf, 1995), where 1 indicates the presence and 0 the absence of a species.

RESULTS

Our findings on the subterranean faunas, as well as the faunistic records from literature about these studied caves are summarised in Table 1.

1. Polina Peč

The fauna was investigated on 19.10.2010, 4.3.2011 and 22.6.2011. The cave is the type locality of the trechine beetle *Anophthalmus schmidti istriensis* (Müller, 1909) and the troglobiotic pselaphine beetle *Mahaerites novissimus* (Nonveiller & Pavićević, 2001). Apart from the original descriptions, the only published faunistic data from Polina Peč were reported by Polak (1997). During our investigations the presence of the trechine *Typhlotrechus bilimeki istrus* (Fig. 5) and the sphodrine *Laemostenus cavicola cavicola* were stated as common; however, surprisingly, no leptodirine *Leptodirus hochenwartii reticulatus* was found. Some forgotten pit-fall traps left by collectors were found. So far, 15 troglobionts have been recorded from this cave (Tabs. 1, 2). Among other invertebrates, our discovery of the cave centipede *Eupolybothrus obrovensis* is significant, since only a couple of Slovenian localities have so far been identified (Matic & Darabantu, 1968). In this cave the troglomorphic diplurian *Plusiocampa* cf. *nivea* (Fig. 7) is common. A small number of the woodlice *Titanethes dahli* and *Alpioniscus* cf. *strasseri* were also found.

2. Račiška Pečina

Before the military use of the cave, some biologists (J. Stussiner, J. Müller, K. Strasser) visited the cave and found the trechine beetle *Typhlotrechus bilimeki istrus* and the oniscoid *Mesoniscus graniger* (Verhoeff, 1933). The only published data on the fauna of Polina Peč were reported by Polak (1997). Our investigations on 20.10.2010 and 4.3.2011 resulted in a list of 16 troglobionts (Tabs. 1, 2). This cave is the second known locality for the leptodirine beetle *Prospelaeobates vrezeci* (Fig. 3), previously recorded only from the type locality: the Medvedjak cave. In total, five beetle species, three crustacean, two spider and four false scorpion species were found. We found the cave spider *Stalita taenaria* (Fig. 8) only in the deepest part of the cave with permanently dripping water.

Tab. 1: Checklist of the subterranean fauna of twelve caves in Istria. White Istria: 1 Polina Peč, 2 Račiška Pečina, 3 Dimnice, 4 Medvedjak, 5 Jama Pod Krogom, 7 Rabakova Špilja, 8 Radota Jama; Grey Istria: 6 Kubik, 9 Piskovica; Red Istria: 10 Markova Jama, 11 Jama Kod Burići, 12 Pincinova Jama. Legend: Tb - troglobiont, Tf - troglophile, Tx - trogloxene, Ed - edaphobiont, Par - parasite; * published data only.
Tab. 1: Seznam podzemeljske favne dvanajstih jam v Istri. Bela Istra: 1 Polina peč, 2 Račiška pečina, 3 Dimnice, 4 Medvedjak, 5 Jama pod Krogom, 7 Rabakova špilja, 8 Radota jama; Siva Istra: 6 Kubik, 9 Piskovica; Rdeča Istra: 10 Markova jama, 11 Jama kod Burići, 12 Pincinova jama. Legenda: Tb - troglobiont, Tf - troglofil, Tx - trogloksen, Ed - edafobiont, Par - parazit; * podatek samo iz literature.

Classis / Ordo	Familia (Subfamilia)	Genus, Species (Subspecies)	Status	White Istria	Grey Istria	Red Istria
Gastropoda / Pulmonata	Carychiidae	*Zospeum isselianum* Pollonera, 1887	Tb	1, 3, 6	6	
		Z. kusceri (A. J. Wagner, 1912)	Tb	2, 3*		
		Z. spelaeum schmidti (Frauenfeld, 1854)	Tb	4, 7, 8,	9	10
	Zonitidae	*Oxychilus* (*Oxychilus*) sp.	Tf		9	10, 11
Polychaeta / Canalipalpata	Serpulidae	*Marifugia cavatica* Absolon & Hrabe, 1930	Tb	5		
Clitellata / Haplotaxida	Haplotaxidae	*Haplotaxis* cf. *gordioides* (Hartmann, 1921)	Tf		9	
Clitellata / Hirudinea	Erpobdelidae	*Dina krasensis* Sket, 1968	Tf		9	
Arachnida / Araneae	Dysderidae	*Stalita taenaria* Schiödte, 1848	Tb	2, 3*, 4		
		Stalita sp.	Tb			10, 11
		Mesostalita nocturna (Roewer, 1931)	Tb	8		
	Nesticidae	*Nesticus* cf. *celullans* (Clerk, 1757)	Tf	1	9	
		N. eremita Simon, 1879	Tf	7	6, 9	10, 11, 12
		Nesticus sp.	Tf	5		
	Metidae	*Meta menardi* (Latreille, 1804)	Tf	1, 2		
		Metellina sp.	Tf	2		
	Agelenidae	*Tegenaria* sp.	Tf	2, 6	9	
	Linyphiidae	*Troglohyphantes excavatus* Fage, 1919	Tf	1		
		T. cf. *brignolii* Deeleman-Reinhold, 1978	Tf	2, 3*, 7		
		Troglohyphantes sp.	Tb	8		
		Walckenaeria mitrata (Menge, 1868)	Tx		9	
		Porrhomma cf. *microps* (Roewer, 1931)	Tf		9	
		Leptyphantes sp.	Tf			10, 11
		Diplocephalus cf. *crassiloba* (Simon, 1884)	Tx			10
Arachnida / Pseudoscorpiones	Chthoniidae	*Chthonius spelaeophilus histricus* Beier, 1931	Tb	1, 2, 7, 8		
		Chthonius sp.	Tb		9	11
		Troglochthonius doratodactylus Helversen, 1968	Tb	2, 8		11
	Neobisiidae	*Neobisium spelaeum istriacum* (Müller, 1931)	Tb	1, 2, 3, 4		
		N. reimoseri reimoseri (Beier, 1929)	Tb	2, 7, 8		
		N. reimoseri histricum Beier, 1939	Tb	3*		
		Neobisium sp.	Tb		9	

Classis / Ordo	**Familia (Subfamilia)**	**Genus, Species (Subspecies)**	**Status**	**White Istria**	**Grey Istria**	**Red Istria**
Arachnida / Opiliones	Phalangiidae	*Leiobunum rupestre* (Herbst, 1799)	Tf	1		
	Trogulidae	*Trogulus banaticus* Avram, 1971	Tf	5	6, 9	
Arachnida / Palpigradi	Eukoeneniidae	*Eukoenenia spelea* (Peyerimhoff, 1902)	Tb	4		
		Eukoenenia sp.		7, 8		
Arachnida / Ixodea	Ixodidae	*Eschatocephalus vespertilionis* (Koch, 1844)	Par	3, 7, 8	6	
Arachnida / Mesostigmata	Parasitidae	*Parastitus* sp.	Ed	8		
		Eugamasus cf. *inferus* Willmann, 1941	Ed	3		
	Rhagidiidae	*Rhagidia* sp.	Ed	3	9	
Arachnida / Oribatida	Galumnidae	*Liocarus* sp.	Ed	8		
		Galumna sp.	Ed	8		
	Belbidae	*Belba* sp.	Ed	7		
Arachnida / Prostigmata	Eupodidae	*Linopodes* sp.	Ed		9	
Malacostraca / Amphipoda	Niphargidae	*Hadzia fragilis* S. Karaman, 1932	Tb			12*
		Niphargus stygius (Schiödte, 1847)	Tb	2, 4		
		N. krameri (Schellenberg, 1935)	Tb	3*, 5, 7	6, 9	
		N. steueri steueri Schellenberg, 1935	Tb	5		12
		N. stochi G. Karaman, 1994	Tb	5		
		N. longicaudatus A. Costa, 1851	Tb		9	
		N. cf. *longicaudatus* A. Costa, 1851	Tb			10
		N. hebereri (Schellenberg, 1933)	Tb			12*
Malacostraca / Isopoda	Trichoniscidae (Trichoniscinae)	*Titanethes dahli* Verhoeff, 1926	Tb	1, 2, 3, 4, 5, 8		
		Alpioniscus strasseri (Verhoeff, 1927)	Tb		6, 9	10, 11, 12
		A. cf. *strasseri* (Verhoeff, 1927)	Tb	1, 2, 5, 7		
		Androniscus stygius (Nemec, 1897)	Tb	1, 4		
		A. roseus (C. Koch, 1838)	Tf		6, 9	
		Trichoniscus sp.	Tx		6	
		Hyloniscus sp.	Tx	3		
	Trichoniscidae (Haplophthalminae)	*Haplophthalmus* sp.	Tx		6	
	Trichoniscidae (Thaumatoniscellinae)	*Thaumatoniscellus speluncae* Karaman, Bedek & Horvatović, 2009	Tb	4		
	Mesoniscidae	*Mesoniscus graniger* (Frivaldsky, 1865)	Tf	2*		
	Ligiidae	*Ligidium* sp.	Tx	3		
	Trachelipodidae	*Trachelipus ratzeburgii* (Brandt, 1833)	Tx		9	
		Trachelipus sp.	Tx	7		12
	Agnaridae	*Protracheoniscus* sp.	Tx		6	
	Philosciidae	*Chaetophiloscia* sp.	Tx			12
	Sphaeromatidae	*Monolistra bericum hadzii* Sket, 1959	Tb	7	6	
		Monolistra sp. nov.	Tb		9	12
	Cirolanidae	*Sphaeromides virei virei* Brian, 1923	Tb	5		12

Classis / Ordo	**Familia (Subfamilia)**	**Genus, Species (Subspecies)**	**Status**	**White Istria**	**Grey Istria**	**Red Istria**
Malacostraca / Decapoda	Atyidae	*Troglocaris planinensis* Birštejn, 1948	Tb	5		12
		Troglocaris sp. nov.	Tb			12
Chilopoda / Lithobiomorpha	Lithobiidae	*Eupolybothrus obrovensis* (Verhoeff, 1930)	Tb	1, 3*, 4*, 8		
		Eupolybothrus sp.	Tx	7		
		Lithobius cf. *lapidicola* Meinert, 1872	Tf	7	9	
		L. cf. *erythrocephalus* C. L. Koch, 1847	Tx			12
		Lithobius sp. 1	Tb		9	
		Lithobius sp. 2	Tx	2		
		Lithobiidae indet.	Tx		6	
Chilopoda / Scolopendromorpha	Cryptopidae	*Cryptops* sp.	Ed	2*		12
	Scolopendridae	*Scolopendra cingulata* Latreille, 1789	Tx	7		
Chilopoda / Goephilomorpha	Linotaeniidae	*Strigamia* sp.	Ed		9	
Diplopoda / Glomerida	Trachysphaeridae	*Trachysphaera noduligera* (Verhoeff, 1906)	Tf	7		
		T. cf. *noduligera* (Verhoeff, 1906)	Tf	8		
	Glomeridellidae	*Typhloglomeris* cf. *fiumarana* Verhoeff, 1899	Tb		9	
	Macrosternodesmidae	*Verhoeffodesmus gracilipes* Strasser, 1959	Tb	7	9	
Diplopoda / Chordeumatida	Chordumatidae	*Melogena broelemanni* Verhoeff, 1897	Tx	7*		
	Chordeumatidae	Chordeumatidae indet.	Tx	1		
Diplopoda / Polydesmida	Polydesmidae	*Brachydesmus inferus concavus* Attems, 1898	Tb	3		
		B. subterraneus Heller, 1858	Tf	3, 7	9	12
		Brachydesmus sp.	Tf	4		
Diplopoda / Julida	Julidae	*Typhloiulus illyricus* Verhoeff, 1929	Tb	7	9	12
		Julus sp.	Tx	8	9	
		Julidae indet.	Tx		6	
Entognatha / Diplura	Japygidae	*Japyx* cf. *solifuga* Halliday, 1864	Ed			12
	Campodeidae	*Plusiocampa* cf. *nivea* (Joseph, 1882)	Tb	1, 2, 4, 8		11
Collembola / Entomobryomorpha	Tomoceridae	*Tritomurus scutellatus* Frauenfeld, 1854	Tb	1, 2, 4		
	Paronellidae	*Troglopedetes pallidus* Absolon, 1907	Tb	2, 4, 7, 8	6, 9	10, 11, 12
	Oncopoduridae	*Oncopodura* sp.	Tb	1, 3, 4, 7, 8	6	10, 11
	Entomobrydae	*Pseudosinella* sp.	Tb	3		
		Heteromurus nitidus (Templeton, 1835)	Tf	7, 8		10, 11, 12
	Isotomidae	*Folsomia* sp.	Tx		9	
	Cyphoderidae	*Cyphoderus* sp.	Tx			11
Collembola / Poduromorpha	Onychiuridae	*Onychiurus giganteus* (Absolon, 1901)	Tb	1, 3, 4, 8		
		Onychiurus sp.	Tb		9	
Collembola / Symphypleona	Sminthuridae	*Arrhopalites* sp.	Tx		9	

Classis / Ordo	**Familia (Subfamilia)**	**Genus, Species (Subspecies)**	**Status**	**White Istria**	**Grey Istria**	**Red Istria**
Collembola / Neelipleona	Neelidae	*Neelus* sp.	Tf	4, 8	9	
Insecta / Coleoptera	Carabidae (Trechinae)	*Typhlotrechus bilimeki istrus* (Müller, 1926)	Tb	1, 2, 3, 4, 7		
		Anophthalmus schmidti istriensis Müller, 1909	Tb	1*		
		A. spectabilis istrianus (Ganglbauer, 1913)	Tb	3		
	Carabidae (Sphodrinae)	*Laemostenus cavicola cavicola* Schaum, 1858	Tf	1, 2, 3, 4, 8		
		L. cavicola romualdi J. Müller, 1905	Tf			10, 11, 12
		L. elongatus (Dejean, 1828)	Tx	1*, 2*, 4*		
	Staphylinidae (Pselaphinae)	*Machaerites novissimus* Nonveiller & Pavićević, 2001	Tb	1		
		M. kastavensis Pavićević & Ozimec, 2009	Tb	7, 8		
		Machaerites sp. nov.	Tb		9	
		Pauperobythus globuliventris Nonveiller, Pavićević & Ozimec 2002	Tb			10
		Bryaxis sp.	Tx		9	
		Amaurops sp.	Ed	7		
	Staphylinidae (Staphylininae)	*Atheta spelaea* (Erichson, 1839)	Tf	8		10, 11
		Omalium validum Kraatz, 1857	Tx	1*		
		Staphylinidae indet.	Tx	5	6	
	Cholevidae (Leptodirinae)	*Oryotus schmidti subdentatus* Müller, 1904	Tb	3*		
		Prospelaeobates vrezeci Giachino & Etonti 1996	Tb	2, 4		
		Bathysciotes khevenhuelleri (Miller, 1852)	Tb	2, 7, 8	6, 9	
		Leptodirus hochenwartii reticulatus Müller, 1905	Tb	1*, 2, 3		
	Cholevidae (Cholevinae)	*Choleva* sp.	Tf	5	9	11
	Cholevidae (Platypsellinae)	*Leptinus testaceus* Müller, 1817	Tf	7		
	Curculionidae	*Otiorhynchus* (*Troglorhynchus*) cf. *anophthalmoides anophthalmoides* (Reitter, 1914)	Tf	4		
		Absoloniella sp. n.	Ed/ Tb?	7		
Insecta / Orthoptera	Rhaphidophoridae	*Troglophilus cavicola* (Kollar, 1833)	Tf	1, 2, 3, 4		
		T. neglectus Krauss,1879	Tf	1, 2, 3, 4, 5, 7, 8	6, 9	10, 11, 12*
Insecta / Trichoptera	Limnephilidae	*Micropterna sequax* McLachlan, 1875	Tf	3*		
		Stenophylax sp.	Tf	8		

Classis / Ordo	Familia (Subfamilia)	Genus, Species (Subspecies)	Status	White Istria	Grey Istria	Red Istria
Insecta / Lepidoptera	Tineidae	Tineidae indet.	Tx	8		
	Geometridae	*Triphosa dubitata* (Linnaeus, 1758)	Tf	1, 2, 3, 4, 7		
	Noctuidae	*Scoliopteryx libatrix* (Linnaeus, 1758)	Tf	7	6	
		Hypena obsitalis (Hübner, 1813)	Tf	5		
		Amphipyra effusa (Boisduval, 1828)	Tf	5		
Insecta / Diptera	Limoniidae	*Limonia nubeculosa* Meigen, 1804	Tf		6	
		Limonia sp.	Tf	1, 2, 3, 4, 5	9	10
	Culicidae	*Culex* sp.	Tx	7, 8	9	
	Tipulidae	Tipulidae indet.	Tx	8		
	Mycetophilidae	*Speolepta leptogaster* (Winnertz, 1863)	Tf	1		
Amphibia / Caudata	Proteidae	*Proteus* sp. nov.	Tb			12
Amphibia / Anura	Bufonidae	*Bufo bufo* (Linnaeus, 1758)	Tx			10
	Hylidae	*Hyla arborea* (Linnaeus, 1758)	Tx			10
	Ranidae	*Rana dalmatina* Fitzinger, 1838	Tx			10
Aves / Strigiformes	Strigidae	*Stryx aluco* Linnaeus, 1758	Tx	1*		
Mammalia / Chiroptera	Rhinolophidae	*Rhinolophus ferrumequinum* (Schreber, 1774)	Tf	1, 2, 3*, 4, 7, 8		10
		R. hipposideros (Bechstein, 1800)	Tf	1, 2, 3, 4, 7, 8	6	10
		R. euryale Blasius, 1853	Tf	7*		
	Vespertilionidae	*Barbastella barbastellus* (Schreber, 1774)	Tf	1*, 3*		
		Myotis myotis (Borkhausen, 1797)	Tf	8		10
		M. myotis / M. blythii	Tf	3*		
		M. blythii (Tomes, 1857)	Tf	3*		
		M. capaccinii (Bonaparte, 1837)	Tf	3*		
		M. daubentonii (Kuhl, 1817)	Tf	3		
Mammalia / Rodentia	Gliridae	*Glis glis* (Linnaeus, 1766)	Tx	2, 7		
Mammalia / Carnivora	Mustelidae	*Martes foina* Erxleben, 1777	Tx	1, 2*		

Our discovery of the pseudo-scorpion *Troglochthonius doratodactylus* (Fig. 9) was surprising, since there are no published records of this genus in Slovenia. In the cave, numerous troglophiles and trogloxenes can be found. In autumn (20.10.2010), 13 greater (*Rhinolophus ferrumequinum*) and 42 lesser horseshoe bats (*Rhinolophus hipposideros*) hibernated in the cave.

3. Dimnice

In the past, many naturalists and speleobiologists visited the cave and made a significant contribution to the knowledge about the Dimnice subterranean fauna. The cave is the type locality for *Neobisium spelaeum istriacum*, *Anophthalmus spectabilis istrianus* and *Oryotus schmidti subdentatus*. We visited Dimnice twice (20.10.2010 and 6.3.2011) and added to the list some further troglobionts, now amounting 17 taxa (Tabs. 1, 2). We found a large population of the leptodirine beetle *Leptoditus hochenwartii reticulatus* (Fig. 2). The bat fauna of Dimnice has been regularly monitored since 1991 (Presetnik *et al.,* 2009). During our study we spotted a colony of Daubenton's bats (*Myotis daubentonii*, Fig. 18) overwintering above the water current far from the tourist path. During our permanent temperature measurements we noticed significant temperature fluctuations. In winter the temperature

dropped below 0 °C, causing ice accumulation at the bottom of the entrance pits.

4. Medvedjak

Since its description in 1904, several early cavers and cave beetle collectors (*e.g.*, A. Perko, G. Ravasini, J. Müller) have reported on its beetle fauna. Bat observations have also been published (Presetnik *et al.,* 2009). A new leptodirine genus and species *Prospelaeobates vrezeci* (Giachino & Etonti, 1996) (Fig. 3) was described from this cave. During our investigation we recorded a rich subterranean fauna, counting 15 troglobionts (Tabs. 1, 2). Our finding of the tiny terrestrial isopod *Thaumatoniscellus speluncae* (Fig. 14) is the first record in Slovenia and the third known locality, previously recorded only on Mt. Učka in Istria (Croatia); its closest relatives live in Romania (Bedek *et al.,* 2006, 2011; Karaman *et al.,* 2009).

5. Jama Pod Krogom

We visited the cave twice, on 21.10.2010 and 9.9.2011. Since the cave is active and regularly flooded, the terrestrial subterranean fauna is scarce and consists mainly of troglophiles (Tab. 1). Our finding of the aestivating noctuid moths *Hypena obsitalis* and *Amphipyra effusa* in the entrance chamber is important, because the first one is rarely found in caves, and *Amphipyra* was recorded for the first time in caves, thus showing its sub-troglophilic habits in Slovenia. The cave is one of the most important habitats for the cave tubeworm *Marifugia cavatica* and the cave cirolanid *Sphaeromides virei* (Fig. 12) in south-western Slovenia. Additionally, two species of the amphipod genus *Niphargus*, the cave shrimp *Troglocaris planinensis* and two species of terrestrial isopods - seven troglobionts in total - were recorded in this cave (Tab. 2).

6. Kubik

There are no published data on this cave's fauna, even though it has been recently visited by biologists. We visited the cave on 21.10.2010 and 29.6.2011. The subterranean fauna found in the cave is listed in Table 1. Seven troblobiotic species have been recorded so far (Tab. 2). In the cave the leptodirine beetle *Bathysciotes khevenhuelleri*, the isopode *Alpioniscus strasseri*, two species of Collembola and the cave gastropod *Zospeum isselianum* have been recorded. Among the stygobionts, the amphipod *Niphargus krameri* and the isopod *Monolistra bericum hadzii* (Fig. 13), both endemic to Istria, live in the cave stream. A recent molecular study of *N. krameri* showed the existence of two distinct species in Istria (Fišer, 2011). Despite some old garbage in the cave, the subterranean stream seems not to have been seriously affected by pollution.

7. Rabakova Špilja

This cave is the type locality and up to now had been the only locality of the troglomorphic diplopod *Verhoeffodesmus gracilipes* (Strasser, 1959) (Fig. 11). The cave has also been visited by the Slovene biospeleologists J. Bole (Bole, 1974), F. Velkovrh, B. Sket and N. Mršić (Mršić, 1994) and by the Dutch arachnologist C.R. Deeleman–Reinhold in 1968 (Deeleman-Reinhold, 1978). During our research on 6.7.2010, 26.11.2010, 3.3.2011 and 26.6.2011 at least 13 troglobionts both terrestrial and aquatic, were recorded (Tabs. 1, 2). The small troglomorphic curculionid beetle of the genus *Absoloniella* was found in Croatia for the first time. The specimen

Tab. 2: Number of troglobiotic taxa found in the given Istrian caves. Prevailing habitat of the cave: a - aquatic, t - terrestrial.
Tab. 2: Število troglobiontov, ugotovljenih v raziskovanih istrskih jamah. Prevladujoč habitat jame: a - vodni, t - kopenski.

Region	Cave	Habitat	No. troglobionts
White Istria	Polina peč	t	15
	Račiška pečina	t	16
	Dimnice	a, t	17
	Medvedjak	t	15
	Rabakova špilja	t	13 (14)
	Radota jama	t	15
	Jama pod Krogom	a, t	7
Grey Istria	Piskovica	a, t	15
	Kubik	a, t	7
Red Istria	Markova jama	t	7
	Jama kod Burići	t	7
	Pincinova jama	a, t	11

from Rabakova Špilja is significantly smaller and different in shape, compared to the closely related *Absoloniella reitteri* (J. Müller, 1912) known from caves near Trieste. Since the cave lies in the middle of the village and is easily accessible, it is endangered by organic and inorganic pollution.

8. Radota Jama

Before our surveys on 27.11.2010 and 27.6.2011, the speleobiologists J. Bole and B. Drovenik investigated the cave in 1968 (Bole, 1974) and R. Ozimec in 2001(*unpubl.*). Fifteen troglobiotic taxa have been recorded so far (Tabs. 1, 2). The cave represents one of the few known localities of the cave centipede *Eupolybothrus obrovensis*, the palpigrade *Eukoenenia* sp. (*unpubl.*), the spider *Mesostalita nocturna*, the false scorpion *Troglochthonius doratodactylus* and the beetle *Machaerites kastavensis*. A large wintering colony of the greater mouse-eared bat (*Myotis myotis*) was found in the cave. Because of its remote location and difficulty of access, the cave has not been damaged or polluted.

9. Piskovica

Before our project surveys on 29.11.2010, 3.3.2011 and 27.6.2011, R. Ozimec provided the only intensive studies of the cave fauna in 1998 and 2001 (*unpubl.*). It turned out that both aquatic and terrestrial subterranean faunas are extremely rich and unique. Among the collected specimens, new taxa are in the process of description. Fifteen troglobionts have been found in Piskovica so far (Tabs. 1, 2). The cave is the second known locality of the millipede *Verhoeffodesmus gracilipes*. Additionally, the millipede *Typhloglomeris* cf. *fiumarana* (Fig. 10) recorded in the cave, and known to date only from the Liburnian Karst, represents a significant addition to the subterranean fauna of Istria.

The cave functions as a periodic sinkhole. Organic and inorganic debris are accumulated in the inner parts of the cave by intensive water flow during the rainy season. A serious threat to Piskovica cave is the intention of local inhabitants to exploit the cave for tourism.

10. Markova Jama

Speleobiologically, the cave was first explored in 1997 by members of the Croatian Biospeleological Society. The cave is known as an important site of a large summer maternity colony of the greater mouse-eared bat (*Myotis myotis*), with over 1000 individuals. In the cave, a new genus and species of the troglobiotic pselaphinae beetle *Pauperobythus globuliventris* (Fig. 4) have been found (Nonveiller *et al.,* 2002). Despite our careful research on 28.11.2010 and 29.6.2011 only seven troglobionts were recorded (Tabs. 1, 2). Markova Jama has been protected as a natural geomorphological monument since 1986. Nevertheless, the cave is endangered by organic waste disposal; sheep carcasses were found in the pit before and during our research. The cave fauna is vulnerable, especially the maternity colony of bats, which remains in the cave during spring and summer. For that reason, visits to the cave should be organized only during the period between October and March.

11. Jama Kod Burići

The first speleobiological survey was carried out by members of the Croatian Biospeleological Society in May 2001. On that occasion, the false scorpion *Troglochthonius doratodactylus* was recorded in Croatia for the first time (Ozimec, 2002). During our visits on 29.11.2010 and 28.06.2011, additional species were recorded (Tabs. 1, 2), but only seven among them were troglobionts. Sheep carcasses were found at the bottom of the pit. This put a stop to further exploration. In addition, the cave is critically endangered due to organic waste, especially dead goats and sheep. Besides, the cave fauna is potentially endangered by underground water pollution because of the industry nearby.

12. Pincinova Jama

Since its discovery in 1976, many speleological studies have been carried out in the cave. The endemic Istrian cave salamander *Proteus* sp. nov (Gorički & Trontelj, 2006) and other important stygobionts were found there (Rađa, 1980; Sket, 1994; Zakšek *et al.* 2009). In our visits on 28.6.2011 and 10.9.2011, eight stygobionts were recorded; besides the cave salamander, these were three amphipod species, two aquatic isopod species and two species of cave shrimp (Tab. 1). Since the dry part of the cave is short, only three terrestrial troglobionts were found. Since 1986, Pincinova Jama has received protection as a geomorphological monument. The cave is critically endangered by organic and inorganic pollution. Deposits of garbage are located less than 100 m in front of the cave entrance. At the same distance there is an old quarry, which is still periodically active. Recently the cave was closed off by gates, which are often breached by illegal visitors. A broken gate was also detected during our last visit.

The caves in the carbonate region of White Istria (Čičarija) hosted 44 troglobiotic species, *i.e.*, many more in comparison to the caves in the carbonate littoral region of Red Istria (19 troglobionts) and intermediate flysch Grey Istria (18 troglobionts). According to the Cochran test, the presence of species of subterranean fauna in White Istria differed significantly from both Grey Istria (Q test = 16.20, $p < 0.001$) and Red Istria (Q test = 14.69, $p < 0.001$), while there were no difference between Grey and Red Istria (Q test = 0.04; $p = 0.835$).

DISCUSSION AND CONCLUSIONS

Faunistic investigations of twelve caves in Istria allowed us to estimate and briefly evaluate the species

richness of the subterranean fauna in Istria and to provide some environmental and threat information for these caves. The most important finding was that the division of the Istrian peninsula into three main geomorphological units - the inland White, the Red littoral and the mainly noncarbonate intermediate region of Grey Istria - accurately reflects the distribution of subterranean species as well as species richness.

Caves located in the easternmost part of White Istria, in Matarsko Podolje and Čičarija, are biotically the most diverse. In each of these caves at least 15 troglobiotic taxa were found (Tab. 2). With respect to troglobiotic fauna, some of these caves (Polina Peč, Račiška Pečina, Dimnice, Medvedjak and Radota Jama) can be listed among the richest in the north-western Dinaric region. Given that the troglobiont lists are not complete, since the caves have not been investigated for microfauna and some taxa (*e.g.* copepods, Acarina), the number of troglobiotic species is undoubtedly greater. In contrast with Čičarija, the caves situated in the littoral region of Red Istria (Markova Jama and Jama Kod Burići) are inhabited by troglobiotic fauna only half as rich (Tab. 2). The profusion of troglobiotic fauna in White Istria reflects the close contact of White Istria with the rest of the Dinaric Karst, which is known to be the richest region in the world for subterranean fauna (Sket *et al.*, 2004; Culver *et al.*, 2006; Zagmajster *et al.*, 2008). Most of these troglobionts seem to be endemic to this area. Similar levels of troglobiont richness in the Red and Grey Istria regions and their composition similarity indicate that the flysch areas are also of considerable biospeleological importance. On the other hand, the noncarbonate belt of Grey Istria represents a physical barrier between the littoral Karst and the main Dinaric Karst, resulting in the endemic species and genera of the Red Istria region.

The similarities between the Grey and the Red Istrian subterranean faunas, on the one hand, and their divergence from those of White Istria, on the other, denote the very important role of Grey Istria in geological isolation and in preventing gene flow between the faunas. Other factors could influence differences in species richness among the regions. The Karst in Čičarija has been more fragmented on account of the orography (Otoničar, 2007) and is therefore more extensive in comparison to the more or less flat and unfractured littoral Karst of Red Istria. The climate of the mountainous White Istria region is more humid, providing many more Subsurface Subterranean Habitats (SSHs), like taluses and similar habitats with soil on the surface, in comparison with the more arid lowlands of Red Istria. Humidity in caves is essential for the existence of most terrestrial troglobionts, while, on the other hand, an arid climate is one of the main reasons forcing animals to seek refuge in the subterranean environment.

As result of our investigations, some subterranean taxa were discovered far from their known localities, indicating that their areas are considerably expanded. The new species (subspecies) discovered belong to the crustacean genera *Monolistra* and *Troglocaris* (the Istra phylogroup; Zakšek *et al.,* 2009), the false scorpion *Chthonius* and the *Machaerites, Absoloniella* and *Bathysciotes* beetles. Slovenian fauna has been enriched by the finding of the recently described oniscoid genus and species *Thaumatoniscellus speluncae* (Karaman *et al.*, 2009) in the Medvedjak cave, and the false scorpion genus *Troglochthonius doratodactylus* in the Račiška Pečina cave. In Slovenia, the latter species had previously been found by the Italian biospeleologist Fulvio Gasparo in Štefakova Pečina (No. 1142) near Materija and in Pečina Pod Medvejkom (No. 949) near Sežana (*unpubl.*, courtesy F. Gasparo). New localities have been found for some other troglobionts in Croatia, such as the millipedes *Verhoeffodesmus gracilipes* and *Typhloglomeris* cf. *fiumarana* that significantly extends their known distribution.

We evaluated the potential threats to these caves and their faunas. In large caves, such as the Dimnice cave, occasional visitors do not threaten the cave fauna. On the other hand, organized hikes into smaller caves, such as Polina Peč, Markova Jama and particularly Piskovica, can seriously disturb bat colonies and directly damage the subterranean habitat. The main threat to caves is the disposal of garbage and organic waste in caves. Caves near human settlements, such as Rabakova Špilja, Markova Jama and Jama Kod Burići, are especially threatened. Aquatic cave fauna is endangered by pollution of the underground water draining from the surface. So far, subterranean waters in Jama Pod Krogom, Kubik, Piskovica, Dimnice and Pincinova Jama remain sufficiently clean to host a rich stygobiotic fauna, including the endemic Istrian cave salamander in Pincinova Jama. This cave deserves special attention to avoid potential pollution from a quarry and rubbish dump in the near vicinity.

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PODZEMELJSKA FAVNA DVANAJSTIH JAM V ISTRI

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POVZETEK

V prispevku so zbrani literaturni podatki o podzemeljski favni dvanajstih jam v Istri in rezultati lastne natančne inventarizacije teh jam. Raziskava je bila opravljena v okviru projekta Karst Underground Protection v letih 2010 in 2011. Izbrane jame so v različnih predelih Istre in se razlikujejo med seboj po okoljskih dejavnikih, po tem, da je v njih le kopenska ali tudi vodna favna ter po različni stopnji ogroženosti jam in favne zaradi človeške dejavnosti. Za raziskavo smo izbrali naslednje jame v Sloveniji: Polina peč, Račiška pečina, Medvedjak, Dimnice, Jama pod Krogom in Kubik ter na Hrvaškem: Radota špilja, Rabakova jama, Markova jama, Jama kod Burići, Pincinova jama in Piskovica. Izkazalo se je, da so glede števila troglobiontov – vrst, specializiranih za življenje v podzemlju – jame na območju Čičarije (Bela Istra) več kot dvakrat bogatejše (44 vrst) od jam v Sivi Istri (18) in litoralnem območju Rdeče Istre (19). V posameznih jamah v Čičariji živi po 15 vrst troglobiontov ali več; te vrste so večinoma ozko sorodne s favno bližnjega severozahodno dinarskega območja. V dveh jamah Rdeče Istre je bilo najdenih po 7 troglobiontov. Jama pod Krogom in Pincinova jama sta pomembni zlasti kot habitat številnih vodnih troglobiontov – stigobiontov. Jame, nastale na kontaktu apnencev in fliša v nekraški Sivi Istri, so se izkazale za nepričakovano bogate s troglobionti. Nekatera odkritja so bila presenetljiva in predstavljajo pomemben prispevek k poznavanju razširjenosti nekaterih vrst in rodov podzemeljskih živali. V prispevku prvič objavljamo podatek o prisotnosti podzemeljskega paščipalca Troglochthonius doratodactylus v Sloveniji. Prav tako je bil podzemeljski enakonožni rak – mokrica Thaumatoniscellus speluncae – v Sloveniji najden prvič. Najdba podzemeljskih dvojnonog Vehoeffodesmus gracilipes in Typhloglomeris cf. fiumarana v jami Piskovica predstavljata znatno povečanje znanih območij njune razširjenosti. Majhen hrošč ril-

čkar iz rodu Absoloniella sp. je bil prvič najden na ozemlju Hrvaške. Med podzemeljskimi raki, pajkovci in hrošči je bilo nekaj taksonov že prepoznanih kot novih za znanost; njihovi znanstveni opisi so v pripravi. Za raziskane jame smo ovrednotili ekološke razmere ter ocenili sedanje in potencialne vire ogrožanja jam ter njihove favne. Ugotovili smo, da so nekatere jame organsko in anorgansko onesnažene zaradi nelegalnega odlaganja smeti in kadavrov domačih živali, potencialno pa tudi zaradi kamnolomov v bližini. Zaradi možnosti onesnaževanja podtalnih voda je še potencialno ogrožena vodna favna jam. Med potencialne grožnje favni štejemo tudi nenadzorovano nabiranje favne v jamah in v nekaterih primerih prepogost obisk jam.

Ključne besede: podzemeljsko živalstvo, troglobionti, varstvo jam, Istra

REFERENCES

Bedek, J., S. Gottstein Matočec, B. Jalžić, R. Ozimec & V. Štamol (2006): Katalog tipskih špiljskih lokaliteta faune Hrvatske (Catalogue of Cave Type Localities of Croatian Fauna). Nat. Croat., 15 (Suppl. 1), 11–54.

Bedek, J., S. Taiti & S. Gottstein (2011): Catalogue and atlas of cave-dwelling terrestrial isopods (Crustacea: Oniscidea) from Croatia. Nat. Croat., 20(2), 237–354.

Bertarelli, L. V. & E. Boegan (1926): Duemilla Grotte. TCI ed., Milano.

Boegan, E. (1930): Catastro delle Grote Italiane, Fasc. 1. Grotte della Venezia Giulia, Trieste.

Bole, J. (1974): Rod *Zospeum* Bourguignat 1856 (Gastropoda, Ellobiidae) v Jugoslaviji. Razprave SAZU, Cl. IV, 17(5), 249–291.

Camacho, A. I. (1992): A classification of the aquatic and terrestrial subterranean environment and their associated fauna. In: Camacho, A. I. (ed.): The natural history of biospeleology. Monografias, Museo nacional de ciencias naturales, Madrid, pp. 59–103.

Culver, D. C, L. Deharveng, A. Bedos, J. J. Lewis, M. Maden, J. R. Reddelli, B. Sket, P. Trontelj & D. White (2006): The mid-latitude biodiversity ridge in terrestrial cave fauna. Ecography, 29, 120–128.

Culver, D. C. & T. Pipan (2009): The biology of caves and other subterranean habitats. Oxford University Press, New York, 254 p.

Deeleman-Reinhold, C. L. (1978): Revision of the cave-dwelling and related spiders of the genus *Troglohyphantes* Joseph (Linyphiidae), with special reference to the Yugoslav species. Razprave SAZU, Cl. IV, 23(6), 1–221.

Fišer, Ž. (2011): Znotrajvrstna raznolikost istrske slepe postranice *Niphargus krameri*. Diplomsko delo. Biotehniška fakulteta, Ljubljana, 33 p.

Garibaldi, C. I. (1926): Catastro delle cavita naturali sotterranee della Venezia Giulia. L'Instituto Geografico Militare di Firenze, Firenze.

Giachino, P. M. & M. Etonti (1996): *Prospelaeobates* gen. nove due sp.n. di Leptodirinae delle Isole del Quarnero e dell'Istria (Coleoptera: Cholevidae). Acta Entomol. Slov., 4(2), 63–71.

Gorički, Š. & P. Trontelj (2006): Structure and evolution of the mitochondrial control region and flanking sequences in the European cave salamander *Proteus anguinus*. Gene, 378, 31–41.

Habič, P., R. Gospodarič, A. Mihevc & F. Šušteršič (1982): Movraška in Smokavska vala in Jama pod Krogom. Acta Carsologica, 11, 77–97.

Hamann, O. (1896): Europäische Höhlenfauna. Eine Darstellung der in den Höhlen Europas lebenden Tierwelt mit besonderer Berücksichtigung der Höhlenfauna Krains. Costenoble, Jena.

Jeannel, R. (1911): Biospeologica XIX. Rèvision des Bathysciinae (Coléoptères Silphides). Morphologie, distribution géographique, systématique. Arch. Zool. Expérimentale Gén., (5)7, 1–641.

Jekić, M. & M. Zlokolica (1988): Pećina Piskovica, Bilten SpeleoBih, 12, 69–78.

Karaman, I. M., J. Bedek & M. Horvatović (2009): *Thaumatoniscellus speluncae* n. sp. (Isopoda: Oniscidea: Trichoniscidae), a new troglobitic oniscid species from Croatia. Zootaxa, 2158, 57–64.

Krebs, N. (1907): Die Halbinsel Istrien Landeskundliche Studie, Geograph. Abhandl. hg. v. A. Penck IXj2, Leipzig.

Legović, S. (1985): Nova istraživanja Markove jame. Bilten SD Proteus, 4, 3–6.

Legović, S. (1999): Jama kod Burići, Kanfanar, Istra. Speleozin, 7(11), 12–17.

Malez, M. (1960): Pećine Ćićarije i Učke u Istri. Acta Geologica, 2, 164–260.

Matic, Z. & C. Darabantu (1968): Contributions à la connaissance des Chilopodes de Yougoslavie. Razprave SAZU, Cl. IV, 11, 201–227.

Mihevc, A. (2003): Sledovi jamskega medveda v Račiški pečini. Naše jame, 45, 48–55.

Mršić, N. (1994): The Diplopoda (Myriapoda) of Croatia (Dvojnonoge (Diplopoda: Myriapoda) Hrvatske). Razprave SAZU, Cl. IV, 35(12), 219–296.

Müller, J. [G.] (1905): Vier neue Höhlenkäfer aus dem österreichischen Litorale. Wien. Ent. Zeitg., 24, 32 p.

Müller, J. [G.] (1906): Nuovi coleoteri cavernicoli del Litorale. Il. Tourista, 11(1904), 12–15.

Müller, J. [G.] (1913): Beiträge zur Kenntnis der Höhlenfauna der Ostalpen und der Balkanhalbinsel, 2. Revision der blinden Trechus-Arten. Denkschr. Akad. Wiss. Wien, 90, 1124.

Müller, J. [G.] (1928): Il genere *Orotrechus* Mülle., Jeannel. Contributo ala conoscenza della fauna cavernicola friulana. Boll. Soc. Entomol. Ital., 60(6), 92–98.

Müller, J. [G.] (1930): I Coleoteri cavernicoli Italiani. Elenco geografico delle Grotte con indicazione delle specie e varietà dei Coleoteri cavernicoli finora trovati in Italia. Le Grotte d'Italia, 4, 65–85.

Nonveiller, G. & D. Pavićević (2001): Description d'une sous-espèce nouvelle et de six espèces nouvelles du genre *Machaerites* Miller, 1855 de Slovénie et de Croatie (Coleoptera, Pselaphinae, Bythinini). Nouv. Rev. d'Entomol., 18(4), 317–333.

Nonveiller, G., D. Pavićević & R. Ozimec (2002): Description d'un nouveau Pselaphidae cavernicole d'Istrie (Croatie): *Pauperobythus globuliventris* n. gen., n. sp. (Coleoptera, Pselaphinae, Bythinini). Bull Soc Entomol Fr., 107(1), 13–18.

Novak, T., M. Perc, S. Lipovšek & F. Janžekovič (2012): Duality of terrestrial subterranean fauna. Int. J. Speleol., 41(2), 181–188.

Otoničar, B. (2007): Upper cretaceous to paleogene forbulge unconformity associated with foreland and basin evolution (Kras, Matarsko podolje and Istria; SW Slovenia and NW Croatia). Acta Carsologica, 36(1), 101–120.

Ozimec, R. (2002): Review of genus *Troglochthonius* Beier, 1939 (Arachnida, Pseudoscorpiones, Chthoniidae), Abstracts of 16th International Symposium of Biospeleology. 815 September 2002, Verona, Italy, pp. 56–57.

Ozimec, R., J. Bedek, S. Gottstein, B. Jalžić, R. Slapnik, V. Štamol, H. Bilandžija, T. Dražina, E. Kletečki, A. Komerički, M. Lukć & M. Pavlek (2009): Crvena knjiga špiljske faune Hrvatske (Red book of Croatian cave dwelling fauna). Ministarstvo kulture & DZZP, Zagreb, pp. 1–371.

Ozimec, R., S. Polak, J. Bedek & V. Zakšek (2010): Biospeleological component of the project KUP (Karst Underground Protection) in Istra Peninsula. In: Moškrič, A. & P. Trontelj (eds.): Abstract book. 20th International Conference on Subterranean Biology. 29 Aug – 3 Sept 2010, Postojna, Slovenia, pp. 89–90.

Ozimec, R., S. Polak, J. Bedek & V. Zakšek (2011): Importance of biospeleological research for protection of cave fauna and their habitats – example based o the project Karst underground protection on the Istrian peninsula. In: Prelovšek, M. & N. Zupan Hajna (eds.): Pressures and Protection of the Underground Karst – Cases from Slovenia and Croatia (Pritiski in varovanje podzemnega krasa – Primeri iz Slovenije in Hrvaške; Pritisci i zaštita podzemnog krša – Primjeri iz Slovenije i Hrvatske). Karst Research Instutute, Postojna, pp. 160–168.

Perko, G. A. (1909): Speleologia. Grotta dell'Orso. Il Tourista, 12/13, 1905/06, 61–82.

Polak, S. & T. Pipan (2011): Subterranean habitats and fauna, their threats and conservation. In: Prelovšek, M. & N. Zupan Hajna (eds.): Pressures and Protection of the Underground Karst – Cases from Slovenia and Croatia (Pritiski in varovanje podzemnega krasa – Primeri iz Slovenije in Hrvaške; Pritisci i zaštita podzemnog krša – Primjeri iz Slovenije i Hrvatske). Karst Research Instutute, Postojna, pp. 23–32.

Polak, S. (1997): Prispevek k poznavanju podzemeljske favne nekaterih jamskih objektov Matarskega podolja, jugozahodna Slovenija. In: Bedjanič, M. (ur.): Raziskovalni tabor študentov biologije Podgrad '96. ZOTKS, Gibanje znanost mladini, pp. 45–54.

Presetnik, P., K. Koselj & M. Zagmajster (ur.) (2009): Atlas netopirjev (Chiroptera) Slovenije. Atlas faunae et florae Slovenia 2. Center za kartografijo favne in flore, Miklavž na Dravskem polju, 151 p.

Rađa, T. (1980): Čovječja ribica u Pincinovoj jami kod Poreča. Priroda, 48(7/8), 179–181.

Schiner, J. R. (1854): Fauna der Adelsberger-, Luegger-, and Magdalenen Grotte. In: Schmidt, A. (ed.): Die Grotten und Höhlen von Adelsberg, Lueg, Planina, und Laas. Braumüller, Vienna, Austria, pp. 231–272.

Sket, B. (1994): Distribution patterns of some subterranean Crustacea in the territory of the former Yugoslavia. Hydrobiologia, 287, 65–75.

Sket, B. (1999): The nature of biodiversity in hypogean waters and how it is endangered. Biodiversity Conserv., 8, 1319–1338.

Sket, B. (2008): Can we agree on an ecological classification of subterranean animals? J. Nat. Hist., 42(2122), 1549–1563.

Sket, B., K. Paragamian & P. Trontelj (2004): A census of the obligate subterranean fauna of the Balkan Peninsula. In: Griffiths, H. I., B. Kryštufek & J. M. Reed (eds.): Balkan Biodiversity: pattern and process in the European hotspot. Kluwer Academic Publisher, Dordrecht, pp. 309–322.

Sokal, R. R. & F. J. Rolph (1995): Biometry: The principles and practice of statistics in biological research. 3rd edition. W.H. Freeman, New York.

Stammer, H. J. (1932): Die Fauna des Timavo. Ein Beitrag zur Kenntnis der Höhlengewässer des Süß- und Brackwassers im Karst. Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere, 63, pp. 521–656.

Strasser, K. (1959): *Verhoeffodesmus* n. g., ein Höhlendiplopode aus Istrien (*Polydesmoidea*). Acta Carsologica, 2, 99–106.

Verhoeff, K. W. (1933): Arthropoden aus sudostalpinen Höhlen, gesammelt von Karl Strasser. Mitteilungen über Höhlen- und karstforschung, 4, 1–21.

Wolf, B. (1934-1938): *Animalium cavernarum catalogus*. Junk, s'Gravenhage.

Zagmajster, M., D. C. Culver & B. Sket (2008): Species richness patterns of obligate subterranean beetles in a global biodiversity hotspot-effect of scale and sampling intensity. Diversity Distrib., 14, 95–105.

Zakšek, V., S. Gottstein, D. Franjević, B. Sket & P. Trontelj (2009): The limits of cryptic diversity in groundwater: phylogeography of the cave shrimp *Troglocaris anophthalmus* (Crustacea: Decapoda: Atyidae). Mol. Ecol., 18, 931–946.

PLATE I: Some representatives of the Istrian subterranean fauna photographed during the study.
TABLA I: Nekateri predstavniki istrskega podzemeljskega živalstva, fotografirani med raziskavo
Photograph credits / Avtorji fotografij: RO – Roman Ozimec, SP – Slavko Polak, JB – Jana Bedek.
Fig. 2 / Sl. 2: *Leptodirus hochenwartii reticulatus* ***(SP)***
Fig. 3 / Sl. 3: *Prospelaeobates vrezeci* ***(SP)***
Fig. 4 / Sl. 4: *Pauperobythus globuliventris* ***(RO)***
Fig. 5 / Sl. 5: *Typhlotrechus bilimeki istrus* ***(SP)***
Fig. 6 / Sl. 6: *Onychiurus giganteus* ***(RO)***
Fig. 7 / Sl. 7: *Plusiocampa* ***cf.*** *nivea* ***(SP)***
Fig. 8 / Sl. 8: *Stalita taenaria* ***(RO)***
Fig. 9 / Sl. 9: *Troglochthonius doratodactylus* ***(SP)***

PLATE II: Some representatives of the Istrian subterranean fauna photographed during the study. Photographs credits as in Plate I.
TABLA II: Nekateri predstavniki istrskega podzemeljskega živalstva, fotografirani med raziskavo. Avtorji fotografij kot na Tabli I.
Fig. 10 / Sl. 10: *Typhloglomeris* ***cf.*** *fiumarana* ***(RO)***
Fig. 11 / Sl. 11: *Verhoeffodesmus gracilipes* ***(RO)***
Fig. 12 / Sl. 12: *Sphaeromides virei virei* ***(SP)***
Fig. 13 / Sl. 13: *Monolistra bericum hadzii* ***(JB)***
Fig. 14 / Sl. 14: *Thaumatoniscellus speluncae* ***(JB)***
Fig. 15 / Sl. 15: *Zospeum spelaeum schmidti* ***(SP)***
Fig. 16 / Sl. 16: *Triphosa dubitata* ***(SP)***
Fig. 17 / Sl. 17: *Myotis daubentonii* ***(SP)***

PLATE I/TABLA I

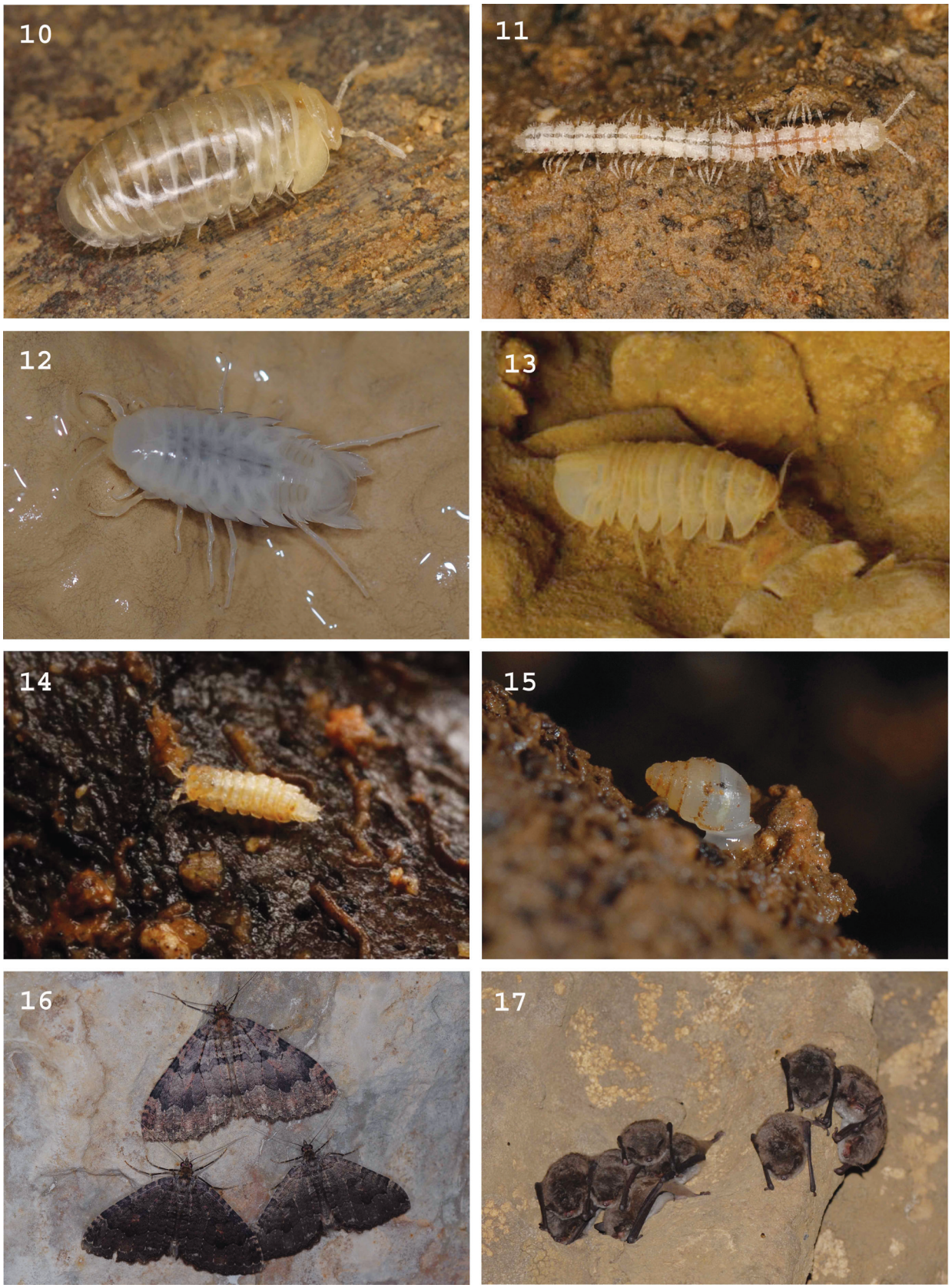

PLATE II/TABLA II