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ECOLOGY, BIODIVERSITY AND VULNERABILITY OF ŠIPUN CAVE (CAVTAT, DUBROVNIK, CROATIA)

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Šipun is one of the first mentioned anchialine caves in the world, located in the region of Dubrovnik in Croatia. During more than 100 years of research, over 100 taxa were detected, 38 of them troglobitic, with 18 taxa described from the cave. Some anchialine ecological features were first described in this cave. During recent biospeleological research in the period of 2000–2012 by members of the Croatian Biospeleological Society, the first complete cave sketch was finished, and much ecological and taxonomical research were performed. The cave is endangered due to human activities, but also vulnerable due to the fragility of karst substrate. A management plan, it is suggested, is necessary for adequate cave administration and protection.

Key words: Dinaric Karst, Biospeleology, endemism, cave vulnerability, monitoring

INTRODUCTION

Šipun Cave is located on the northeast part of Rat peninsula in the town of Cavtat, near Dubrovnik city in the Konavle region in Croatia (Fig. 1). Šipun Cave is a simple cave; it consists of 120 m long passage, partially flooded with an anchialine lake. The entrance of the cave is 24 m above sea level. The main channel starts at –10 m in the NW direction and after 70 m ascends to the entrance level. The second, SE channel, descends to the anchialine lake at sea level. The lake is up to 8 m deep, depending on the tide, and the flooded channel is 45 m long with deepest point of the cave located up to –32 m under the cave entrance.

It is one of the longest-known caves in the world, mentioned in some ancient legends, such as the one of St. Hillary and the dragon Boaz first noted in the 4th century. According to some authors it is mentioned in the 1st century, by Pliny the Elder, but researched only at the end of 16th century by Dubrovnik scientists Jakov Sorkočević and Nikola Gučetić (DADIĆ, 1984; BOŽIĆ, 2006). The cave was used in the past for economic purposes (water supply, periodical residence, silk worm production) and for tourist purposes ever since the 19th century, fully equipped from 1978. Šipun awakens interest among biospeleologists around the world, because of its unique ecological and geomorphologic values, and also as an exceptional cultural and historical heritage site. The cave was researched during a long period by many European biospeleologists: H. Neumann, L. Weirather, G. Paganetti-Hummler, K. Absolon, A. Winkler, S. Karaman, F. Nikolić, E. Pretner, B. Sket, G. & A. Vigna, J. Kratochvil, J. Purkrabek, C. Deeleman, B. Hauser, P. Striniati, B. Jalžić and many others. The famous Karel Absolon researched the cave on at least 14 occasions and Boris Sket recorded some of the first data regarding anchialine ecology here (SKET, 1981). The cave's geomorphologic and biospeleological diversity has a great environ-

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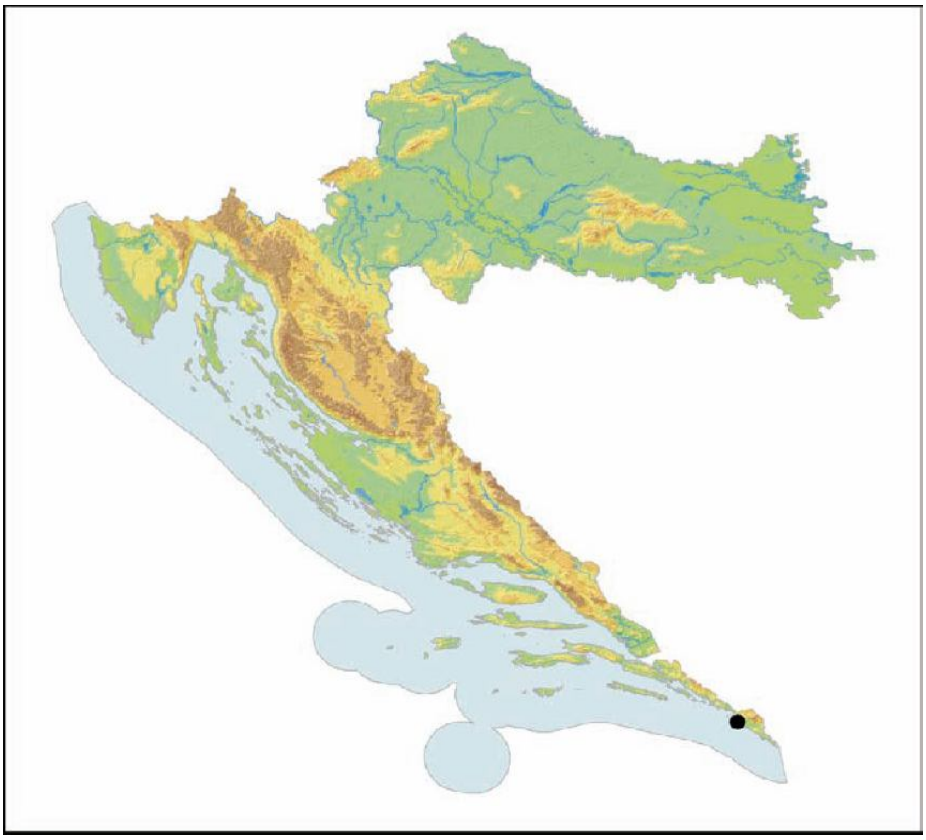

Fig. 1. Map of Croatia with location of Šipun Cave

mental value, because 18 taxa have been described from the cave (BEDEK *et al.*, 2006). Therefore Šipun is the richest cave type locality in Croatia, but even during recent research taxa new to science are still being discovered. In the period 2002–2012 biospeleological research was conducted by a team from the Croatian Biospeleology Society. Since 2011 monitoring of cave habitats and fauna have also started. During recent research, the first complete speleological map was made, including the flooded part (Fig. 2).

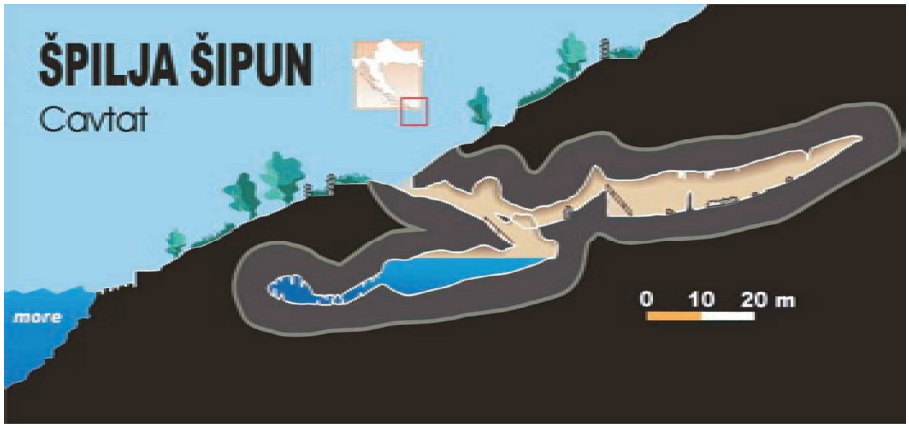

Fig. 2. Simplified speleological map of the Šipun cave (topography: H. Cvitanović, A. Kovačević, V. Jalžić; measurements P. Rade, A. Kovačević; survey: H. Cvitanović, A. Kovačević; computer design M. Lukić)

Tab. 1. List of described & endangered cave fauna from Šipun Cave (according to BEDEK *et al.*, 2006; OZIMEC *et al.*, 2009)

Classis	Ordo	Taxa	IUCN category
Gastropoda	Neotaenioglossa	*Saxurinator sketi* **(Bole, 1960)**	EN: B1ab(iii)+2ab(iii)
Crustacea	Cyclopoida	***Metacyclops trisetosus* Herbst, 1957**	
		***Thermocyclops dalmatica* Petkovski, 1956**	
	Isopoda	*Cyphoniscellus herzegowinensis* (Verhoeff, 1900)	VU: B1ab(iii)+2ab(iii)
		Typhlarmadillidium trebinjanum (Verhoeff, 1900)	EN B1ab(iii)+2ab(iii)
	Amphipoda	[***Salentinella gracillima balcanica* S. Karaman, 1953**]*	
Malacostraca	Thermosbaenacea	***Tethysbaena halophila* (S.L. Karaman, 1953)**	
Arachnida	Acari	***Belba gratiosa* Willmann, 1940**	
		***Nothrotrombidium bulbifera* (Willmann, 1940)**	CR: B1ab(iii)+2ab(iii)
		***Spelaeothrombium caecum* Willmann, 1940**	EN: B1ab(iii)+2ab(iii)
		[***Spelaeothrombium caecum grandis* Willmann, 1940**]*	
	Pseudoscorpiones	***Chthonius magnificus* Beier, 1939**	EN: B1ab(iii)+2ab(iii)
		***Neobisium lethaeum superbum* Beier, 1939**	CR: B1ab(iii)+2ab(iii)
	Aranea	***Palliduphantes brignolii* (Kratochvil, 1978)**	CR: B1ab(iii)+2ab(iii)
		[***Folkia purkrabeki* Kratochvil, 1970**]*	
		***Histopona dubia* (Absolon *et* Kratochvil, 1933)**	
Oligoentomata	Collembola	[***Pseudosinella heteromuroides* nom. nud. (Absolon, 1932)**]*	
Pterygota	Coleoptera	***Pholeuonella erberi epidaurica* Z. Karaman, 1953**	
Pterygota		***Speonesiotes narentinus latitarsis* (Apfelbeck, 1919)**	
Pterygota		***Tychobythinus neumanni* (J. Müller, 1909)**	

Remarks:
Taxa described from the Šipun cave are marked in bold
An asterisk indicates an invalid taxon described from Šipun Cave.

MATERIAL & METHODS

Speleological research, including cave diving techniques, as well as biospeleological and occasional microclimatic research were performed. Topographic methods were used for cave mapping, as well as photographing and filming methods for documentation. Air temperature and humidity were measured with a Mini Thermometer TESTO H1 and a Kestrel 3000, atmospheric CO_2 was measured by a Telaire 7001. Water temperature was measured by a TESTO H1 while temperature and other water parameters (salinity, dissolved oxygen concentrations, pH and redox) were determined *in situ* with a Hach Lange HQ40D Multimeter. Fauna and other biota were collected using water and terrestrial traps with attractants, samples for Berlese sieves, and also with nets and tweezers. All collected material is preserved

in 70% or 96% ethanol. Cave habitats and fauna have been photographed as part of the Šipun Cave Database, together with the complete cave biota checklist and bibliography.

RESULTS AND DISCUSSION

Šipun Cave can be classified as an anchialine cave (Pal. Class: 65.815; Natura 2000: 8330; NKS: H.1.4.) according to GOTTSTEIN, 2010, but includes other cave habitats: Karstic caves (Pal. Class: 65; Natura 2000: 8310; NKS: H.1.) with terrestrial karst cave habitats and sweet water karst cave habitats; Interstitial underground habitats (Pal. Class: 65.9, 65.A; NKS: H.3.) with interstitial terrestrial and water habitats and Anthropogenic underground habitats (NKS: H.4). In deeper parts of the cave where complete darkness and cave habitat dominate, air temperature varied between 13°C in winter periods of the year and 17.3°C during summer. Consequently, the temperature of the substrate varied between 13 to 16.4°C. Relative humidity (RH) is always around 100%. Atmospheric CO_2 concentration in Šipun Cave varied between 681–4990 ppm but in the summer in deeper parts of the cave it is frequently significantly high. Air flow in the cave has never been detected.

Cave water temperature on the surface layer of the anchialine lake varied between 14.4 and 16°C. Salinity values of the cave water confirmed intrusion of the sea water with salinity varying from 1.6 to 4%, while concentrations of dissolved oxygen varied from 3.35 mg/L to the 7.49 mg/L. The pH value varied from 7.19 to the 7.54 and redox potential from –34 mV to the –55 mV.

In the Šipun cave more than 100 taxa have been detected, with 38 of them troglobitic (troglobionts and stigobionts), with high number of endemic taxa, while some of the collected specimens are still in the procedure of identification. Šipun is the type locality for 18 taxa, 14 still valid. At least 6 taxa new to science were detected, but still have not been described. The recorded fauna is a mixture of troglobionts, troglophiles and trogloxenes, due to the relatively limited cave habitat, as well as to the strong influence of external habitats due to the cave's relatively thin ceiling. At the moment known troglobitic and stigobitic cave fauna is represented by 38 taxa belonging to: Nematoda (1), Gastropoda (1), Copepoda (3), Isopoda (3), Amphipoda (3), Thermosbaenacea (1), Aranea (4), Pseudoscorpiones (6), Acari (3), Palpigrada (1), Chilopoda (1), Diplopoda (1), Collembola (4), Diplura (1), Coleoptera (5).

The cave and its habitats are presently endangered due to: location of the cave in the urban zone, building works, penetration of plant roots due to the shallow upper stratum, illegal visits and renovation activities. Eight taxa were recognised as endangered: CR (3), EN (4) and VU (1) (OZIMEC *et al.*, 2009) (Tab. 1). In the future, threats will occur due to tourist industry activities and perhaps because of the inadequate management and the building of a local road. Due to pre-existing endangerment, the monitoring of Šipun Cave started in parallel activities related to tourist infrastructure construction.

CONCLUSIONS

More than 60 anchialine caves have been recorded along the Croatian eastern Adriatic coast, but Šipun is particularly famous due to its long known history and

research and the richness of its fauna. In the more than 100 years of biospeleological research, over 100 taxa have been detected with 38 true cave animals. From the cave, 18 taxa were described, and still taxa new to science are being detected. But the cave is endangered especially due to its position in the urban zone and to anthropogenic influences, as well as the thinness of the substrate. Due to plans to use the cave as a tourist attraction, a management plan is necessary for adequate administration of Šipun Cave.

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REFERENCES

BEDEK, J., GOTTSTEIN MATOČEC, S., JALŽIĆ, B., OZIMEC, R. & ŠTAMOL, V., 2006: Katalog tipskih špiljskih lokaliteta faune Hrvatske (Catalogue of Cave Type Localities of Croatian Fauna), Natura Croatica **15**, Suppl. 1, 1–154.

BOŽIĆ, V. 2006: Legende o špilji Šipun u Cavtatu, Subterranea Croatica **6**, 41–46.

DADIĆ, Ž., 1984: Osvrt Nikole Gučetića u 16. stoljeću na dvije spilje u okolici Dubrovnika. Zbor. pred. 9. jug. Spel. Kongr., 741–746, Zagreb.

GOTTSTEIN, S., 2010: Priručnik za određivanje podzemnih staništa u Hrvatskoj prema direktivi o staništima EU. Državni zavod za zaštitu prirode, 1-99, Zagreb. (In Croatian)

OZIMEC, R., KATUŠIĆ, L. (eds.), BEDEK, J., GOTTSTEIN, S., JALŽIĆ, B., SLAPNIK, R., ŠTAMOL, V., BILANDŽIJA, H., DRAŽINA, T., KLETEČKI, E., KOMERIČKI, A., LUKIĆ, M. & PAVLEK, M., 2009: Crvena knjiga špiljske faune Hrvatske (Red book of Croatian cave dwelling fauna), Ministarstvo kulture, Državni Zavod za zaštitu prirode, 1–371, Zagreb.

SKET, B., 1981: Fauna of anchialine (coastal) cave waters, its origin and importance. Proc. 8th Intern. Congr. Speleol. (Bowling Green), 645–647.