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SHEDDING LIGHT ON CRUSTACEAN SPECIES DIVERSITY IN THE ANCHIHALINE CAVES OF CROATIA

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In the framework of our research, this study was focused on crustaceans in the anchihaline caves along the Eastern Adriatic coast. From August 2002 to June 2006 we collected 99 samples in 39 anchihaline caves. A total of 33 crustacean taxa were identified. Affinities were found in the rare, endemic or ecologically restricted crustaceans recorded in fewer than 10 caves, belonging to copepods, isopods and amphipods. A high species richness was recorded in the Central Adriatic threshold and the South Adriatic Basin. Stratified caves rich in organic matter or even heavy metals had the highest species richness. The cave Medvjeđa špilja on Lošinj Island was detected as a hot spot with 12 recorded taxa.

Key words: Adriatic coast, Crustacea, anchihaline caves, hot spot, species richness

INTRODUCTION

Crustacea constitute a large, morphologically diverse and dominant aquatic taxon in the subterranean environment. One such environment is formed by anchihaline caves, complex subterranean habitats which are not isolated from surface ecosystems, but nevertheless constitute a highly integrated and distinct environment (HOBBS III, 2000; ILLIFE, 2000). Previous studies conducted on the obligate groundwater crustaceans in the anchihaline caves of the Eastern Adriatic coast have been focused on new species records, descriptions of new taxa, geographically limited reports of community structure as well as biogeographic and habitat notes (RIEDL, 1966; RIEDL & OZRETIĆ, 1969; RUFFO & KRAPP-SCHICKEL, 1969; RUFFO & VIGNA TAGLIANTI, 1968; SCHELLENBERG, 1933; SKET, 1977, 1986, 1996; SKET & KARAMAN, 1990). Detailed analysis of the crustacean community in comparison to abiotic factors in the anchihaline caves of the Kornati islands was conducted by GOTTSTEIN *et al.* (2007). In the last decade, 4 new species have been described from the anchihaline caves of Croatia (KRŠINIĆ 2005a, b; 2008, 2012).

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Tab. 1. The list of study sites with macro-geomorphological regions (M-G regions) according to BOGNAR (1999) with indicated number of taxa for each anchihaline cave

Study caves	Locality/ Island	M-G regions	Na taxa
Jama na Punta Korente (pit)	Rovinj	the North Adriatic shelf	8
Jama pod vodu pod Dragami (pit)	Krk		2
Vrtare male (pit)	Crikvenica		6
Medvjeđa špilja (cave)	Lošinj		12
Špilja na Punta Ert (cave)	Kraljevica		3
Urinjska špilja (cave)	Rijeka		6
Well-pit on the Bisaga island	Kornati, Bisaga	the Central Adriatic threshold	3
Well-pit on the Kameni Žakan island	Kornati, Kameni Žakan		2
Well-pit on the Skulj island	Kornati, Skulj		3
Well-pit Šipnate	Kornat		2
Buža Kukurina (pit)	Pag		1
Gradina (pit)	Žirje		2
Gravrnjača (pit)	Kornati, Kurba Vela		2
Jama ispod Vruljskog brda (pit)	Kornat		1
Jama iznad uvale Velika Ropotnica (pit)	Kornat		1
Jama iznad Vrulja (pit)	Kornat		3
Jama na Gajcu (pit)	Pag		1
Jama pod Orljakom (pit)	Šibenik		8
Jama u uvali Mag (pit)	Rab		1
Katina Buža (cave)	Pag		1
Mandalina špilja (cave)	Šibenik		5
Medova Buža (cave)	Rab		4
Nozdarica (pit)	Murter		5
Podvodnje (pit)	Žirje		3
U vode (pit)	Kornati, Smokvica		3
Vodena jama (pit)	Kornati, Gustac		5
Jama na Badiji (pit)	Badija (Korčula)	the South Adriatic Basin	2
Bijaka (pit)	Brač		6
Jama u šumi uvale Bjejajka (pit)	Mljet		4
Jama ispod Maranovica (pit)	Mljet		5
Jama kod Dubokog doca (pit)	Pelješac		2
Jama na rtu Lenga (pit)	Mljet		7
Podstražišce (pit)	Brač		3
Stračincica (pit)	Korčula		5
Supurina (pit)	Vis		10
Šipun (cave)	Cavtat		8
Zaglave (pit)	Korčula		3
Zaglavica (pit)	Mljet		8
Živa voda (cave)	Hvar		9

The aims of this research are: (a) to present total species richness of crustaceans in the anchihaline caves of Croatia; (b) to compare crustacean species richness between three macro-geomorphological regions of the Adriatic coast; (c) to shed some light on the hot spots along the Eastern Adriatic coast, and (d) to evaluate the early records of Crustacea in the light of new taxa.

STUDY SITES

The eastern coast of the Adriatic Sea is a part of the Adriatic and the Dinaric carbonate platform (HERAK, 1986) characterized by numerous caves and pits in the paralittoral region.

Research was conducted in 38 solutionally-developed limestone anchihaline caves on the Northwestern to the Southeastern Adriatic coast of Croatia in the three macro-geomorphological regions according to BOGNAR (1999): the North Adriatic shelf, the Central Adriatic threshold and the South Adriatic Basin (Tab. 1).

MATERIAL AND METHODS

Specimens from deep stratified caves were collected by plankton net with a mesh size of 80 mm. A hand net with a mesh size of 150 mm was used for collecting specimens from the limnic water layer.

All samples were preserved in the field with 4% buffered formalin for subsequent identification. Crustaceans were sorted and counted in the lab using a stereo microscope (Zeiss, Stemi 2000-C). Specimens were deposited at the Natural History Museum in Zagreb and at the Department of Zoology, University of Zagreb.

The crustaceans collected were identified to the lowest taxonomic level possible to determine the species richness of each cave.

RESULTS AND DISCUSSION

Diverse groundwater crustaceans were noted in all three macro-geomorphological regions of the Adriatic coast of Croatia according to BOGNAR (1999) (33 taxa), but the highest species richness was recorded in the Central and South Adriatic Basin (21 taxa) (Tab. 2, Fig. 1). The species richness of crustaceans inhabiting the anchihaline caves of the Eastern Adriatic coast is strongly dependent on the structure of the habitats, the functioning of the underlying ecosystems and energy input (GOTTSTEIN *et al.*, 2007; SKET, 1986). In this research we were recorded a hot spot

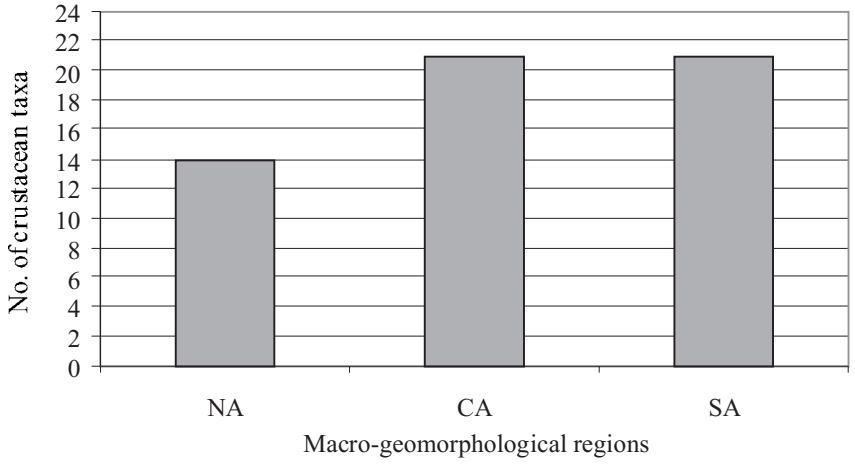

Fig. 1. The number of crustacean taxa in the anchihaline caves of the macro-geomorphological regions of the Adriatic coast according to BOGNAR (1999): NA – the North Adriatic shelf; CA – the Central Adriatic threshold, and SA -the South Adriatic Basin.

Tab. 2. The list of recorded taxa in the anchihaline caves of Croatia during the research from 2002 to 2006 with ecological notes: B – brackish water; FW – freshwater; M – marine water, together with data on endemicity, and the number of records (Nr).

	TAXA	ecology	Nr
Amphipoda	*Hadzia fragilis* S. Karaman, 1932**	BM	7
	Niphargus aquilex Schiodte, 1855	FW	1
	Niphargus hebereri Schellenberg, 1933**	B	18
	Niphargus hvarensis S. Karaman, 1952*	FW	1
	Niphargus pectencoronatae Sket & G. Karaman, 1990*	FW	1
COPEPODA			
Calanoida	*Badijella jalzici* Kršinić, 2005*	BM	7
	Calanipeda sp.	BM	1
	Exumella mediterranea Jaume & Boxshall, 1995	BM	1
	Heterocope sp.	BM	2
	Isisas sp.	BM	1
	Metacalanus sp.	BM	5
	Paramisophria mediterranea Jaume, Cartes & Boxshal, 2000	BM	6
	Speleohvarella gamulini Kršinić, 2005*	BM	12
	Stephos boettgerschnackae Kršinić, 2012*	BM	5
	Stephos sp.+	BM	2
	Stygocyclopia balearica Jaume &Boxshall, 1995	BM	16
	Troglodiaptomus sketi Petkovski, 1978**	FW	1
Cyclopoida	*Cyclopina* sp.	BM	5
	Cyclopinoides sp.	BM	1
	Diacyclops bicuspidatus (Claus, 1857)	B	1
	Diacyclops crassicaudis (Sars, 1863)	B	2
	Diacyclops languidoides (Lilljeborg, 1901)	B	2
	Halicyclops dalmatinus Petkovski, 1955	B	2
	Halicyclops sp.	BM	2
	Megacyclops viridis (Jurine, 1820)	B	1
	Metacyclops sp.	B	1
	Neocyclops sp.	BM	1
	Paracyclopina sp.	BM	1
Misophioida	*Speleophria mestrovi* Kršinić, 2008*	BM	7
	Speleophriopsis sp.	BM	1
Harpacticoida	*spp.*	BM	5
Isopoda	*Proasellus* sp.	FW	2
Thermosbaenacea	*Tethysbaena halophila* (S. L. Karaman, 1953)	FW/BM	14

* – species endemic to Croatia; ** – species endemic to Dinaric karst; + – new species

cave on Lošinj island (12 recorded taxa) rich in organic material. The most widespread species was *Niphargus hebereri* Schellenberg, 1933 with the highest number of records (18 anchihaline caves), found in previous research on the Kornati Islands too (GOTTSTEIN *et al.*, 2007).

Crustaceans of marine origin, e.g. calanoids, misophrioids, and thermosbaenaceans, were far more dominant than freshwater taxa at study sites with a stratified physico-chemical profile. The thermosbaenacean species *Tethysbaena halophila* (S.L. Karaman, 1953) is very euryoecious, inhabiting 14 caves with oligohaline to polyhaline water layer, and appearing with high population densities in the anoxic (or

suboxic) water layers in the anchihaline caves on the islands Korčula, Mljet and Vis as well as inside the pit Jama pod Orljakom in the estuary of the Krka River near Šibenik.

CONCLUSIONS

The results of the faunistic research indicate that biodiversity of crustaceans in the anchihaline caves of Croatia is very high on the local scale (the cave Medvjeđa špilja on Lošinj island with 12 crustacean taxa) as well as over a wider area (the Eastern Adriatic coast with more than 33 species).

Only an intensive, quantitative, and systematic sampling program will allow a correct evaluation of the crustacean diversity in the anchihaline caves of Croatia, and this is in progress.

The results of our study are a workable basis for future studies, and will lead to additional discoveries and to a full understanding of crustacean diversity and distribution patterns in the anchihaline caves of Croatia.

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