

# CONTRIBUTIONS TO SPELEOBIOLOGY APPEARING IN ACTA CARSOLOGICA

## SPELEOBIOLOŠKI PRISPEVKI V ACTA CARSOLOGICA

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### Abstract

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**Tanja Pipan & David C. Culver: Contributions to Speleobiology Appearing in Acta Carsologica**

Although primarily known as a journal of karst geosciences and hydrology, *Acta Carsologica* has played a vital role in the development of speleobiology. A total of 65 biological papers on speleobiology were published in the journal from 1955 to 2014. Many of the papers, especially in the early years of the journal, added to the knowledge base of species distribution and description, but important conceptual and synthetic papers have also appeared. Two special issues were devoted to interdisciplinary topics with a major biological component-time in karst, and carbon and boundaries in karst.

**Key words:** biospeleology, cave biology, Egon Pretner, speleobiology.

### Izvleček

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**Tanja Pipan & David C. Culver: Speleobiološki prispevki v Acta Carsologica**

Čeprav je *Acta Carsologica* v prvi vrsti zbornik s področja kraške geoznanosti in hidrologije, ima ključno vlogo tudi pri razvoju speleobiologije. V obdobju od 1955 do 2014 je bilo v zborniku skupno objavljenih 65 prispevkov s področja (speleo) biologije. Številni prispevki, zlasti v prvih letih zbornika, so temeljili na opisu novih vrst in njihovi razširjenosti, objavljeni pa so bili tudi pomembni konceptualni in analitični prispevki. Dve posebni izdaji sta bili posvečeni meddisciplinarnim vsebinam z osrednjo biološko komponento – čas v krasu ter ogljik in meje v krasu.

**Ključne besede:** biospeleologija, jamska biologija, Egon Pretner, speleobiologija.

## INTRODUCTION

There are many processes and features either unique to, or especially pronounced in caves and karst. On the biological side, these features include the presence of the eyeless, depigmented denizens of subterranean habitats and the presence of carbon-limited ecosystems without any photosynthetic production of organic molecules (Culver & Pipan 2009). The evolutionary loss of characters, especially eyes and pigment, of subterranean organisms, is interesting in its own right but also informative to the larger disciplines of ecology and evolutionary biology.

Speleobiologists have long faced the dilemma of either publishing in specialized karst journals such as *Acta Carsologica*, or publishing in more broadly oriented scientific journals, such as *Evolution*. For many years, this choice was made easy because of the refusal of mainstream journals to publish karst studies. That time has passed, and speleobiologists do face a choice. In this contribution, we argue that journals like *Acta Carsologica* continue to be of fundamental importance in the growth and development of the field of speleobiology.

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*Acta Carsologica* plays two vital roles in karst science disciplines in general and speleobiology in particular. The first is that of a dependable outlet for karst research and especially for description and summaries of information on taxonomy, biogeography, and basic biology of subterranean species. Obvious examples include species lists, species descriptions, and species distributions, studies that form the necessary basis for more synthetic and speculative studies. The second is that it is a dependable outlet for those studies that build the disciplinary principles of speleobiology itself, and even the broader disciplines, such as biogeography. Examples include the restriction of dispersal due to geological barriers. There is nothing especially unique about this duality of the specific and the general. Most subdisciplines of biology and geology have specialized journals. What is unique about *Acta Carsologica* is that it has served this role, not only in the disciplines of karst geology and hy-

drology, its core disciplines, but in speleobiology as well. According to its mission statement,

*Acta Carsologica* publishes original research papers and reviews, letters, essays and reports covering topics related to specific of karst areas. These comprise, but are not limited to karst geology, hydrology and geomorphology, speleology, hydrogeology, biospeleology and history of karst science.

We discuss below the role the journal has played in the development of the disciplines of biospeleology, with its emphasis on the broader discipline of speleology and speleobiology, with its emphasis on the broader discipline of biology. In its earlier years, *Acta Carsologica* emphasized the Classical Karst, the area in SW Slovenia between Ljubljana and Trieste (Gabrovšek & Ravbar 2015), but there is scarcely any biological phenomenon occurring in caves that does not occur in the Classical Karst.

## A BRIEF HISTORY OF SUBTERRANEAN BIOLOGY

Barr (1966), writing about the history of subterranean biology in the United States identifies a time when most papers published in subterranean biology in the U.S. were taxonomic or distributional. This period was earlier in the U.S. than in Europe, and ended in 1955, according to Barr. In fact, taxonomic description and faunal distribution remains to this day the most common topic in subterranean biology. For example, the majority of papers in *Subterranean Biology*, the journal of the International Society of Subterranean Biology, are taxonomic.

Many of the trends in the study of subterranean biology are represented by papers published in *Acta Carsologica*. Ever since its beginning in 1955, important publications in subterranean biology have appeared (Tab. 1), including a series of taxonomic and distribution papers by the famed Slovenian biologist Egon Pretner. A total of 70 papers on speleobiology have appeared between 1955 and 2015 (Appendix 1). A number of biological papers on surface biota of karst (e.g., turloughs and disappearing [intermittent] lakes) have also appeared in *Acta Carsologica*, but will not be considered further. Speleobiological papers published in *Acta Carsologica* from 1955 to 1974 are mostly taxonomic and distributional. Pretner alone published nine papers on the distribution and taxonomy of cave beetles. In addition to the taxonomic and distributional studies, there were papers published, beginning in the mid-1970's, that were more synthetic and process oriented. Of special note are the papers published by Hadži, Briegleb, Schatz, and Istenič on the

physiology of that most iconic of cave animals, *Proteus anguinus*. Jovan Hadži, a prominent Slovenian biologist and speleobiologist, was the founding editor of the journal (Gabrovšek & Ravbar 2015). The paper by Briegleb and Schatz (1974) is especially noteworthy both because it puts forward the idea that caves are an extreme environment, but also that *Proteus* can be a model organism for the study of some aspects of animal physiology.

Between 1975 and 1994, little biological research was published in *Acta Carsologica*, although this period was one of intense research activity in speleobiology. There were several notable papers that did appear in *Acta Carsologica* during this period—notably continuing studies by Tone Novak on the microdistribution and ecology of terrestrial cave animals (Novak *et al.* 1980) and by Boris Bulog on the biology of *Proteus anguinus* (Bulog 1994). The reasons for this hiatus in biological publications in *Acta Carsologica* are complex but include the internationalization of studies in cave biology resulting in a larger number of outlets available for publication.

By the mid-1990's there was a burst of publications that continues to the present (Tab. 1).

In contrast to the earlier period of biological publications, the range of topics published after 1994 in *Acta Carsologica* is broad. Besides papers on the basic biology, ecology, and physiology of cave animals, topics that appear in the earlier period as well, there are new areas of research represented:

Tab. 1: Classification of articles on speleobiology in *Acta Carsologica* according to topic. A complete list of papers is given in Appendix 1.

Category	1955–1964	1965–1974	1975–1984	1985–1994	1995–2004	2005–2014	TOTAL
Taxonomy, species distributions	8	4	1		2	4	20
Basic biology, ecology, physiology	1	5	1	1	1	4	13
Conservation					1	1	2
Evolutionary ecology					4	2	6
Microbiology					2	3	5
Biogeography & Evolution					1	7	8
Ecosystems						7	7
Syntheses & reviews		1			2	2	4
Total	9	10	2	1	13	30	65

- Evolutionary ecology
- Microbiology
- Biogeography and evolution
- Ecosystems
- Conservation
- Syntheses and reviews

Especially noteworthy and influential in speleobiology have been the publications from two special symposia, organized in conjunction with the Karst Waters Institute (USA). Both symposia were broadly interdisciplinary and drew scientists from a number of countries. The first of these was a 2007 symposium on “time in karst.” Participants addressed the problem of how long both physical and biological processes in karst take, a topic of interest not only to evolutionary ecologists but to geologists and physical geographers as well. Seven biological papers were published in this special issue, and most of them directly addressed the difficult question of how long species, including Mexican and Brazilian cavefish (Porter *et al.* 2007; Trajano 2007), arthropods in the Dinaric karst (Trontelj *et al.* 2007), and planthoppers in Hawaiian and Australian lava tubes (Wessel *et al.* 2007) have been isolated in caves. Not surprisingly, estimates of time of isolation vary from group to groups, but with some clustering of estimates at around one to five million years ago. This set of papers was the first to bring together results for widely different groups of subterranean animals, but also in the dominance of DNA sequence data in the analysis. Interestingly, many physical processes in karst seemed to have a similar time frame of one to ten million years (Sasowsky 2007).

The second interdisciplinary symposium was held in 2013 on the topic of “carbon and boundaries in karst”, the origin, dynamics and fate of organic and inorganic carbon in caves and karst basins, a topic central to karst ecosystem studies. The topic is at the boundary of the biological and geoscience disciplines, and this is reflected in the published papers. Four of the 16 papers were primarily biological, but all had biological relevance. Caves are likely carbon-limited rather than nutrient limited

and the importance of different carbon pathways (e.g., epikarst), was the focus of two of these papers (Hutchins *et al.* 2013; Simon 2013). Novak *et al.* (2013) pointed out a little studied pathway (carbon from non-specialized terrestrial invertebrates) may be important, and Pipan and Culver (2013) demonstrated that bursts of organic carbon were likely important in shallow subterranean habitats.

Largely neglected until the last two decades, the importance of microbes in carbon processing and even in geochemical processes has begun to be recognized. Papers on microbiology in *Acta Carsologica* have provided an important basis of understanding the ubiquity of microbes in the karst environment, and the high taxonomic and metabolic diversity of forms (e.g., Mulec *et al.* 2012; Hillebrand-Voiculescu *et al.* 2014).

The growing importance of conservation is also reflected in the pages of *Acta Carsologica*. Most biological and many geological papers for that matter stress the importance of protection of fragile karst resources, and some are focused on the topic, especially that of Simões *et al.* (2014) on the cave fauna of the state of Minas Gerais, Brazil. Other conservation-oriented papers, but not on biological conservation, have appeared in *Acta Carsologica* (e.g., Restificar *et al.* 2006).

Finally, papers on biogeography and evolution have been a continuing theme in *Acta Carsologica*, beginning with Pretner’s studies of distribution of beetles from 1955 on (see Pretner 1974; Pipan 1997 for reviews). More synthetic approaches appear in papers by Moldovan and Rajka (2007) on the relationship between old historical biogeographic studies and contemporary phylogeographic studies based on DNA sequences and the possible connection between range size and phylogenetic age (Culver & Pipan 2007).

## THE HUMAN FACTOR

Science is not just driven by ideas; dedicated people are necessary as well. Four biologists have held positions at the Karst Research Institute, the home of *Acta Carsologica*—Egon Pretner, Tone Novak, Janez Mulec, and Tanja Pipan. Their presence in an institute dominated by geoscientists and geographers, has demonstrated the institute's continuing support for broad-scale interdisciplinary research. They have served and continue to serve as exemplars to their institute colleagues that there is more to karst science than geoscience.

Egon Pretner was the sole author of nine papers in *Acta Carsologica*. As Pipan (1997) pointed out, Pretner, more than anyone else, was responsible for the extensive collections of cave fauna throughout former Yugoslavia (more than 1400 caves), especially Slovenia (649 caves). One measure of his importance is that more than 25 spe-

cies have been named in his honor, and most of these species were ones he collected.

Tone Novak continued the tradition of careful and extensive collections of cave animals, and pioneered ecological studies of the terrestrial cave fauna (e.g., Novak 2005). Janez Mulec has been at the forefront of a new generation of microbiologists who investigate the distribution and metabolic roles of microbes, using both traditional culture techniques as well as molecular genetic approaches (e.g., Mulec *et al.* 2012). Tanja Pipan has extensively studied epikarst, and has shown its importance in subterranean biodiversity and as a source of organic carbon for caves (e.g., Pipan & Culver 2013). Both Mulec and Pipan have participated in numerous interdisciplinary studies centered at the institute (e.g., the study of Pivka Lakes, in volume 34, no. 3 of *Acta Carsologica*).

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## APPENDIX 1

YEAR	VOLUME	AUTHOR	TITLE
1955	1	Pretner E.	Genera <i>Oryotus</i> , <i>Pretneria</i> , <i>Astagobius</i> and <i>Leptodirus</i> (Coleoptera)
1959	2	Pretner E.	Contribution to the knowledge of genus <i>Aphaenopsis</i> J. Müller (Coleoptera, Trechinae)
1959	2	Strasser K.	<i>Verhoeffodesmus</i> n. g. <i>fragilipes</i> n. sp., a cave diplopoda from Istria
1959	2	Grom S.	Contribution to the knowledge of flora from Škocjanske jame
1959	2	Pretner E.	Genus <i>Ceuthmonocharis</i> Jeannel (Coleoptera, Catopidae)
1963	3	Pretner E.	Biological findings in Skakavac
1963	3	Pretner E.	Biological investigations in Serbia
1963	3	Briegleb W., Schatz A.	Eco-habitat of human fish ( <i>Proteus anguinus</i> Laur. 1768)
1963	3	Grom S.	Contribution to the knowledge of Bryophyta from Slovenian costal region
1966	4	Strasser K.	Diplopoda from Slovenia
1966	4	Pretner E.	Habitats of cave beetle <i>Spelaodromus pluto</i> Reitter 1881
1970	5	Us Pëtr A.	Contribution to the knowledge of cave Orthoptera from Yugoslavia (Orthoptera, Tettigoniodea)
1970	5	Pretner E.	<i>Leptodirus hohenwarti velebiticus</i> ssp. n. and <i>Astagobius hadzii</i> sp. n. from Velebit, <i>Astagobius angustatus deelemani</i> ssp. n. and <i>Astagobius angustatus driolii</i> ssp. n. from Lika (Coleoptera)
1970	5	Pretner E.	Remarks to the catalogue of Laneyrie's new classification of subfamily Bathysciinae (Coleoptera) and explanation to the catalogue of subfamily Bathysciinae
1974	6	Hadži J.	Human fish is neotenic or is not an amphibious
1974	6	Bole J.	Subterranean snails and zoogeographic conditions in Slovenian costal region
1974	6	Briegleb W., Schatz A.	Extreme cave biotop as a source of information for general physiology in the case of human fish ( <i>Proteus anguinus</i> Laur.)
1974	6	Istenič L., Sojar A.	Oxygen consumption of <i>Proteus anguinus</i>



YEAR	VOLUME	AUTHOR	TITLE
1974	6	Pretner E.	Historical review of researches of Coleoptera in Slovenian caves
1974	6	Drovenik B.	One year monitoring of cave beetles in two caves in Dobrovlje
1978	8	Us Pëtr A.	Second contribution to the knowledge of cave Orthoptera from Yugoslavia (Orthoptera, Tettigoniodea)
1980	9	Novak T., Kuštor V., Kranjc A., Sivec N.	Contribution to the knowledge of the across-passage distribution of fauna (in big passages)
1994	23	Bulog B.	Two decades of functional-morphological studies of <i>Proteus anguinus</i> (Amphibia, Caudata)
1996	25	Bulog B.	Analyses of some microelements in the tissues of <i>Proteus anguinus</i> (Amphibia, Caudata) and its habitat
1997	26/1	Brancelj A.	Fauna in selected karst springs from the Trnovsko-Banjška Planota
1997	26/2	Barabás E.	Emile G. Racovitza and his important role in speleobiology
1997	26/3	Pipan T.	A historical significance of Egon Pretner for biology
1997	26/4	Polak S.	A classification of the subterranean environment and cave fauna
2001	30/2	Pipan T., Brancelj A.	Ratio of copepods (Crustacea: Copepoda) in fauna of percolation water in six karst caves in Slovenia
2002	31/1	Culver D.C., Sket B.	Biological monitoring in caves
2002	31/2	Mulec J., Zalar P., Zupan Hajna N., Rupnik M.	Screening for culturable microorganisms from cave environments (Slovenia)
2004	33/1	Price L.	An introduction to some cave fauna of Malaysia and Thailand
2004	33/1	Gerič B., Pipan T., Mulec J.	Diversity of culturable bacteria and meiofauna in the epikarst of Škocjanske jame caves (Slovenia)
2004	33/2	Pipan T.	Ecological and microgeographical study of an epikarstic fauna in West Virginia (USA)
2004	33/2	Novak T., Sambol J., Janžekovič F.	Faunal dynamics in the Železna jama cave
2005	34/1	Novak T.	Terrestrial fauna from cavities in northern and central Slovenia, and a review of systematically ecologically investigated cavities
2005	34/3	Pipan T.	Fauna of the Pivka intermittent lakes
2007	36/1	Latella L., Sauro U.	Aspects of the evolution of an important geo-ecosystem in the Lessinian Mountain (Venetian Prealps, Italy)
2007	36/1	Moldovan O.T., Rajka G.	Historical biogeography of subterranean beetles – "Plato's cave" or scientific evidence?
2007	36/1	Culver D.C., Pipan T.	What does the distribution of stygobiotic Copepoda (Crustacea) tell us about their age?
2007	36/1	Porter M.L., Dittmar K., Pérez-Losada M.	How long does evolution of the troglomorphic form take? Estimating divergence times in <i>Astyanax mexicanus</i>
2007	36/1	Trontelj P., Gorički Š., Polak S., Verovnik R., Zakšek V., Sket B.	Age estimates for some subterranean taxa and lineages in the Dinaric karst.
2007	36/1	Trajano E.	The challenge of estimating the age of subterranean lineages: examples from Brazil
2007	36/1	Wessel A., Erbe P., Hoch H.	Pattern and process: Evolution of troglomorphy in the cave-planthoppers of Australia and Hawai'i – Preliminary observations (Insecta: Hemiptera: Fulgoromorpha: Cixiidae)
2007	36/2	Lewis J.J., Reid J.W.	Patterns and processes of groundwater invasion by copepods in the Interior plateaus of the United States
2007	36/3	Moldovan O.T., Pipan T., Iepure S., Mihevc A., Mulec J.	Biodiversity and ecology of fauna in percolating water in selected Slovenian and Romanian caves
2008	37/1	Pipan T., Navodnik V., Janžekovič F., Novak T.	Studies of the fauna of percolation water of Huda luknja, a cave in isolated karst in northeast Slovenia
2008	37/1	Mulec J.	Microorganisms in hypogean: examples from Slovenian karst caves

YEAR	VOLUME	AUTHOR	TITLE
2010	39/3	Culver D.C., Pipan T.	Climate, abiotic factors, and the evolution of subterranean life
2010	39/3	Mulec J., Kubešová S.	Diversity of bryophytes in show caves in Slovenia and relation to light intensities
2011	40/3	Papi F., Pipan T.	Ecological studies of an epikarts community in Snežna jama na planini Arto – an ice cave in north central Slovenia
2012	41/1	Silva M.S., de Oliveira Bernardi L.F., Martins R.P., Ferreira R.L.	Transport and consumption of organic detritus in a neotropical limestone cave
2012	41/2-3	Mulec J., Krištůfek V., Chroňáková A.	Monitoring of microbial indicator groups in caves through the use of RIDA®COUNT kits
2012	41/2-3	Pipan T., Fišer C., Novak T., Culver D.C.	Fifty years of the hypotelminorheic: What have we learned?
2013	42/2-3	Novak T., Janžekovič F., Lipovšek S.	Contribution of non-troglobiotic terrestrial invertebrates to carbon input in hypogean habitats
2013	42/2-3	Pipan T., Culver D.C.	Organic carbon in shallow subterranean habitats
2013	42/2-3	Hutchins B.T., Schwartz B.F., Engel A.S.	Environmental controls on organic matter production and transport across surface-subsurface and geochemical boundaries in the Edwards Aquifer, Texas, USA
2013	42/2-3	Simon K.S.	Organic matter flux in the epikarts of the Dorvan karst, France
2013	42/2-3	Herman J.S., Hounshell A.G., Franklin R.B., Mills A.L.	Biological control on acid generation at the conduit-bedrock boundary in submerged caves: quantification through geochemical modeling
2013	42/2-3	Schwartz B.F., Schwinning S., Gerrard B., Kukowski K.R., Stinson C.L., Dammeyer H.C.	Using hydrogeochemical and ecohydrologic responses to understand epikarst process in semi-arid systems, Edwards plateau, Texas, USA
2014	43/1	Al-Farraj A., Slabe T., Knez M., Gabrovšek F., Mulec J., Petrič M., Hajna Zupan N.	Karst in Ras Al-Khaimah, northern United Arab Emirates
2014	43/1	Castello M.	Species diversity of bryophytes and ferns of lampenflora in Grotta Gigante (NE Italy)
2014	43/1	Weigand A.M.	Next stop: underground. Variable degrees and variety of reasons for cave penetration in terrestrial gastropods
2014	43/1	Simões M.H., Souza-Silva M., Ferreira R.L.	Cave invertebrates in northwestern Minas Gerais State, Brazil: endemism, threats and conservation priorities
2014	43/1	Liu W., Brancelj A.	Hydrochemical response of cave drip water to snowmelt study from Velika Pasica Cave, Central Slovenia
2014	43/2-3	Hillebrand-Voiculescu A., Iltus C., Ardelean I., Pascu D., Persoiu A., Rusu A., Brad T., Popa E., Onac B.P., Purcarea C.	Searching for cold-adapted microorganisms in the underground glacier of Scarisoara Ice Cave, Romania
2014	43/2-3	Novak T., Csuzdi C., Janžekovič F., Pipan T., Devetak D., Lipovšek S.	Survival of the epigeal <i>Dendrodrilus rubidus tenuis</i> (Oligochaeta: Lumbricidae) in a subterranean environment
2015	44/1	Matavelli R., Campos A.M., Feio R.N., Ferreira R.L.	Occurrence of anurans in Brazilian caves
2015	44/2	Opalički Slabe M.	Patterns in invertebrate drift from an Alpine karst aquifer over a one year period
2015	44/3	Culver D.C., Pipan T.	Shifting paradigms of the evolution of cave life