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WHY AND HOW TO TAKE CARE OF SUBTERRANEAN AQUATIC MICROCRUSTACEANS?

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ABSTRACT

Subterranean habitats harbour a diversified fauna of microcrustaceans like copepods, ostracods, synconids. There are scientific, moral and practical (economic) arguments to protect groundwater organisms and to prevent the deterioration of their environment. Many subterranean crustaceans are the product of unusual long evolutionary histories, an important aspect of their scientific interest. Microcrustaceans, e.g. the copepods, have also practical value, when used as ecological sentinels. Moral arguments to protect such organisms and their environment should be integrated within the general principles of human ethics. Hotspot areas for stygobitic Crustacea should be viewed as “natural museums” with cultural value that merits to be protected. The example of the “Austrian National Park Danube Wetlands” is presented.

KEYWORDS: AQUATIC MICROCRUSTACEANS, ENVIRONMENTAL PROTECTION, SUBTERRANEAN HABITATS.

1. INTRODUCTION

The groundwater domain has an enormous extension below the soil-surface. Note that 30% of the total earth’s freshwater reserves are located in the subsurface, either in large spaces of consolidated rocks like in karstic areas or in porous voids of non-consolidated sediments. The biological exploration of this “subterranean ocean” existing below our feet was intensified during last years. Gilbert and Culver (2004) point out that about 7,700 aquatic stygobitic species were known by year 2000 worldwide and their number increases steadily with new exploration of various geographic areas. In Europe, Australia, South America, Asia, the recent European Community project PASCALIS (cf. this volume) documents well this positive trend.

We know now that microcrustaceans (animals with body length in the range of millimetres size) exist in a wide variety of aquatic subterranean habitats. In Europe more than two third of the exclusively dwelling subterranean crustaceans (cf. Bartschauer 1986) belong to groups with miniaturised body shape, like the Syncarida Bathyneola, (fig. 1), the Copepoda and Ostracoda.

Skeat (1999) compared the species richness of hypogean crustacean fauna of Europe with the oligopan one. He noted for instance that from a total of 254 species of Harpacticoida and 145 species of Cyclopoida mentioned in the Illies’ (1976) compendium “Limnofauna Europea” 75% of the former group and 60% of the latter in Europe, Australia, South America, Asia. The recent European Community project PASCALIS (cf. this volume) documents well this positive trend.

We know now that microcrustaceans (animals with body length in the range of millimetres size) one were stygobitites. There are other microcrustacean groups like Bathyneolaecidae and Thermothiramidae which are represented practically only by subterranean species. The importance of these minute crustaceans is not only scientific (they offer us new insight into the
diversity of life within one of the major segments of the earth crust) but also have cultural and in a lesser extent practical (economic) value.

With the increasingly high anthropogenic stress exerted on subterranean aquatic systems, like the over-extraction of water for human needs, chronic pollution, e.g. with various chemicals of both petrolious and karstic aquifers it becomes more and more common to see the local disappearance of subterranean dwelling animals and their specific habitats. This situation offers arguments for the necessity to view the environmental protection of subterranean organisms as a human ethical problem. In the following, we will offer examples for the why and how to take care of the subterranean life especially those of microcrustaceans, a group of animals that we observed intensively during many years. We will use not only already known arguments (cf. Snel 1999, Elliott 2004) but also our own experiences derived from groundwater ecology projects in Austria.

2. WHY TO TAKE CARE OF SUBTERRANEAN FAUNA?

2.1 Cultural (scientific) motivation

We use the term Culture in the everyday communication without difficulty. However when we intend to use it precisely, in our case related to scientific topics and/or the scientific endeavour, we discover that it has different meanings. D’Andrade (1994) mentions the following possible definitions: (1) accumulation and transmission of knowledge, (2) production of conceptual structures which help humans to understand the reality of the world they inhabit, (3) the extension of social institutions and human actions, an important factor for the acquisition and preservation of knowledge.

Subterranean microecosystems are replete with rare or unique stygobitic microcrustaceans. When the Copepods for instance one distinguishes nine orders with about 200 families and several thousands of species. The caddisfly Gyalophora Hyas has only one family erected for a unique genus Gyalophora Rousch & Leschach-Mouton1. This latter contains only two stygobitic species. Gyalophora Rousch & Leschach-Mouton and G. monachus Mosebyler & Rousch localised in restricted karstic areas in Europe and for which we know very little about their ecology and their phylogenetical affinities (Rousch and Kolesy 2003). In Austria a small stygobite Austrocypris antonius Karwein was described from a unique specimen caught in a well at Vienna (Karwein 1964). Its morphology was so strange that it was difficult to find the taxonomic position within the order. Only 30 years later Pospisil and Staab (1991) could solve the problem of this unique stygobitic crustacean using additional groundwater specimens. The genus Austrocypris Swansen contains marine Leptoceridae extracted species known from the Upper Cretaceous (about 90 My years) to the Recent. In all cases specialists never could observe living specimens, only valves were recorded (Namkajko et al. 2004). The unique species for which the limits were described is M. merenski Namkajko et al. stygobiotic recently discovered in an anchialine cave in the Indian Ocean on the Christmas Island (Namkajko et al. 2004).

Within the EC project PASCALIS a new stygobitic genus and species were discovered which has closely affinities with a Tertiary extracted group from China (Z. Giao, J.P. Colin, M. Anther, D.L. Danielopol et P. Manneville, in prep.). This new stygobitic species found in southern France can be considered a "living fossil". Such examples represent an important progress in our knowledge on the subterranean organismic diversity. It produces intellectual stimulation when thinking about the origin and the evolution of the lineages to which these species belong. It produces also for the scientists who study them a pleasant feeling, a kind of excitement once we better understand or even to reconstitute a tiny aspect of the earth’s history. Therefore, caves or even porous aquifers containing a high number of rare species are considered a kind of "natural museums" for which a wide spectrum of people display interest and admiration (Danielopol 1996). 

2.2 Practical (economic) aspects

Groundwater dwelling microcrustaceans especially copepods can be used as environmental descriptors. They are sometimes called “sentinels” because they offer information about the status of groundwater ecosystems. (Dole-Clavier et al. 1993). When successful this approach can offer an economic advantage to the environmental monitoring programmes. Rousch pioneered this approach using the haplacystid fauna of the Bagel karstic system in southern France. Using the taxonomic diversity of haplacystids he could document the origin and the dynamics of the water within the flooded karst, with the possibility to differentiate between this water coming from the main drains and those of lateral reserves (Rousch 1986). This approach was successfully used in other projects too (Gilbert 1993).

The presence of epigean microcrustaceans especially of cyclopoids in the dose groundwater karstic systems are in many cases related to rapid infiltration of water loaded with organic matter, hence the use of these crustaceans as ecological indicators (cf. Meier 2003).

Microcrustaceans can be used also for toxicity monitoring. Novakowski and Bloeserwink (1993) experimented with the haplacystid...
P. Meschler (2000) showed that the sensitivity of stygobitic microcrustaceans species were higher than those of epigean related species when tested for the survival in high concentrations of Kollam Chr.ckie.

3. Ethic and aesthetic values

P. Meschler and Daniilopol (1980) using the philosophical views of W. Schroeder consider that animals in their natural environment have to be protected following the rules we apply to humans. Respectively, we should not accept the systematic elimination of subterranean organisms that since immemorial generations live in equilibrium with their environment. Additionally, if we consider that he/she is an educated person who is able to value potential life on earth it is important to answer a question advanced by N. Gupta (2001) in “Human well-being and the natural environment” can we live comfortably with the idea of the exhaustion of natural resources?

Groundwater and the organisms which inhabit it extend since many centuries on the human mind a strong fascination combining feelings of pleasure with fear ones. One should remember how Antoine de Saint-Exupery (1939) characterized the subterranean water: “the world’s greatest treasure, and also the most delicate, so pure, deep within the earth...”.

During our long-year research in the Danube well ward Lobau, at Vienna, we were fascinated by the beauty of crustaceans when observing them in their natural environment with video microscopy techniques. It stimulated one of us (P.P.) to recreate the mysterious atmosphere of their life-habits within tiny porous space with virtual computer techniques (Fig. 2). The example below is an expression of this kind of aesthesis.

3.1 The danger of local extinction for valuable stygobitic species

There are a multitude of reasons which could eliminate various stygobitic species which closely fitted to the more or less stable environment of groundwater aquifers. Organic pollution along the rivers eliminate many hyporheic assemblages, including stygobitic microcrustaceans. Daniilopol (1980) showed such an effect at Vienna below a sewage outlet, where stygobitic ostracods were present only with the rest of their carapaces. Chronic chemical pollution of rivers achieve the same effect (Daniilopol et al., 2003). Local extinction of stygobitic fauna in some cases become a real tragedy because of impossibility to recover or compensate for their disappearance. This is the case of the minute isopod Microcerberus pleci Chappuis and Delamare Deboutteville (Fig. 3) known only from a unique site, a sandy-gravel bank in the cave Votu Cristului (Pestera lui Zechi) near Cluj, in Romania (cf. 2111986).

The interest of this species is related to the fact that the Microcerberidea represents an isoped group of marina origin spread around the Mediterranean as well as in tropical and subtropical areas worldwide (Hobbs 2000). Microcerberus pleci is a freshwater caramelicous species found only in Transylvania far away from the typical biogeographic distribution that we know nowadays. It is apparently a relic of a Tertiary warm fauna. During many years this species could always be collected in its unique terrestrial habitat from the Votu Cristului cave (Fig. 3).

During the last 10-15 years the cave became a tourist attraction and the sandy-gravel bank was completely deteriorated by the passage of visitors. Repeated investigations of this site showed the disappearance of this unique endemic species (S. Iopan, pers. comm. to D.L.D.) As the stygobitic fauna in Romania is very poor, respectively there are few species of

Figure 2: Virtual electronic image of life in a groundwater porous habitat (Artistic representation realised by P. Meschler)
Isopoda, mainly Asellitidae. The loss of the unique Microcerberidea representative known in Romania has a special significance. It is equivalent to the loss of a highly precious object of art in a museum.

3.2 Environmental protection strategies

One of the first measures we have to do is to proceed to map the submarine biodiversity at various spatial scales. Efforts for the development of effective algorithms are proposed in Culver et al. (2001). This was one of the aims of the EC project PASCALIS. Juberthie (2005) reviewed protection strategies for the caves and their environment, mainly the European Community legislation. Generally it is recommended to avoid pollution of groundwater by keeping clean the surrounding environment. Further it is advisable to concentrate the protection effort on sites with a special interest, e.g., those displaying a high species richness of stygobites. Culver and Sket (2000) provided a rule of thumb for such a measure, respectively they defined hotspot sites those areas like cave systems which have at least 20 stygobitic species. Worldwide only 25 karstic systems and two sites in porous aquifers can be termed as hotspot areas (cf. Culver and Sket 2000, Danielopol and Pospisil 2001). One of these sites is the Lobau wetland at Vienna, in the National Park. Its interest for the protection of groundwater fauna is briefly reviewed below.

3.3 The “National Park Danube Wetlands”, a natural reserve for groundwater fauna.

An area of about 9,300 ha of wetlands were declared national park in Lower Austria at the end of 1996. The park is located east of Vienna, down to the border with Slovakia, within the Danube flood plain, hence also the name "Danube Flood Plain National Park" (cf. Danielopol and Pospisil 2001, 2002). It protects one of the largest natural floodplain areas in Central Europe and has a wide variety of terrestrial and aquatic habitats which support a high number of species both plants and animals. The Lobau is a restricted wetland area within the national park and was already declared during the 70's as an UNESCO biosphere reserve. Long-term investigations of the groundwater fauna within an area of about 6.8 Km² in the Lobau allowed to discover 36 stygobitic species, from which 20+ are represented by microcrustaceans, viz. Copioidea and Ostracoda (Danielopol and Pospisil 2001). There are endemic species known only from this area like the ostracod Micrastacoda sparsith Rogulj & Danielopol, others which are very rare but occur also in other parts of the park and/or occasionally also in Lower Austria like Asellitidae or Pseudosquilla-Kieler, Acanthocylops pusillius Pospisil, Diacyclops fex Pospisil and Stock (Fig.4). Finally, there are stygobitic microcrustaceans which even if they have a wider geographical distribution in Europe they occur also in low numbers in completely isolated places. Such a case are those of the cyclopoid Grasteniella uniseta Grasse (Fig.4) and of the ostracod Cryptocentrona kieseri Kieser (Namitko et al. 2008). The comparative study of individuals of this latter species from France, Germany, Austria and Romania showed that the local populations found within the National Park belong to a new subspecies (Namitko et al. 2009). Especially interesting are the species of cyclopoids which differ not only through their morphology (Fig.4) but also through their ecological and microgeographical circumstances (Pospisil and Danielopol 2000).

Because many habitats where earlier we could sample cyclopoids and other groundwater microcrustaceans disappeared or became altered by various types of pollution, this is the case especially along large rivers and their floodplains like the Danube and/or the Rhine rivers, the possibility to keep protected rare or unique groundwater microcrustaceans in a national park is of extreme importance. It offers the chance to the future generation of groundwater specialists to continue studies on the ecology of these poorly known species.

Presenting the data to lay-people who visit the
4. NEEDS FOR MORE INFORMATION AND EDUCATION

For the sustainability of groundwater resources including the groundwater fauna, like the microcrustaceans and their habitats, one needs more education and information. We have to make understandable to a wide spectrum of humans the ecological research we are carrying on the groundwater environment and the interest for groundwater organisms. The publication of the first textbook on groundwater ecology edited by Gilbert et al. (1994) is in retrospect appreciated as a success if one considers that during its ten year existence more than 1,500 copies were distributed all over the world. A similar success seems to enjoy the first textbook on groundwater ecology written for German-speaking readers by Gröbner and Möstlachar (2003). Within one year more than 500 copies of this book were distributed. We need to intensify other forms of communication too. For instance one of us (PP) produced for lay-people an interactive play distributed on CD-ROM and on which one finds the multiple aspects existing in the underground of the city of Vienna from the life in groundwater to historical relics and the artistic production related to these aspects (Possill 2003). Several encyclopaedic books deal with topics related to caves and their environment. Such compendia have a high educational impact if well produced. The most recent one edited by Culver and White (2004) represents a superb achievement of this goal.

There are more and more educational programmes organised by various institutions especially within university departments dealing with groundwater ecology and the management and/or protection of groundwater resources. As an example one should mention an advanced study course on groundwater ecology organised by the Institute of Limnology at the Austrian Academy of Sciences, within the framework of the European Commission’s Environment and Climate Research Programme (Gröbler et al. 2001). Additionally, we have to become also activists for the protection of the groundwater environment making clear to politicians and/or decision makers the necessity to integrate within their policies also ecological views related to groundwater ecosystems (Danielepfel et al. 2003, 2005).

Finally, as environmentalists it appeared us that our duty is a long-term to contribute to a switch in the human perception for groundwater toward more hydrophilically, toward better protection not only of the subsurface water reserves but also of these invaluable small organisms.

CONCLUSION

Paraphrasing ideas expressed by the Austrian historian of art E.H. Gombrich (cf. "Klein and Idols", 1979) we will close this essay with the following statements:

1. The knowledge of the subterranean diversity of microcrustaceans yields pleasure and enrichment.

2. What makes subsurface systems so attractive is the awareness that there are things which are not only simply rare but unique.

3. We have faith in the power of a new creative generation of groundwater ecologists which espoused cultural values and will successful invest time and energy for taking care of the groundwater fauna and their environment.
As ecologists we have to communicate also the idea of the development of extended hydrologicality for groundwater sustainability. This should encompass the broad spectrum of ecological problems, from which we selected here a tiny fraction, those of the groundwater organisms.

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