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A CLASSIFICATION OF THE SUBTERRANEAN ENVIRONMENT AND CAVE FAUNA

KLASIFIKACIJA PODZEMELJSKEGA ŽIVLJENSKEGA OKOLJA IN JAMSKE FAVNE

SLAVKO POLAK [1]

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Slavko Polak: Klasifikacija podzemeljskega življenskega okolja in jamske favne

Veliko je bilo poskusov klasifikacije in sistemizacije jamskega okolja ter jamskih živali. Klima v podzemeljskem okolju je specifična na kar so jamske živali tudi podobno prilagojene. Danes je najbolj sprejeta delitev podzemeljskega okolja na akvatično in terestrično. Obe se dalje delita na različne tipe. Najpogostejša delitev jamskih živali je na lažne jamske prebivalce, ki so v jamah le občasni obiskovalci ter na prave jamske živali. Slednje delimo na troglobionte, troglofile in trogloksene.

Ključne besede: speleobiologija, podzemeljsko okolje, prilagoditve, jamske živali, klasifikacija.

Abstract UDC 591.542

Slavko Polak: A classification of the subterranean environment and cave fauna

There have been many attempts to classify and systemize cave environment and cave animals. The climate is specific to the subterranean environment and the cave animals are adapted to it in a similar way. The most accepted division of the underground environment is now into aquatic and terrestrial. Both of these are further divided into different types. The most used classification of underground animals is into false cave-dwellers, which are occasional visitors to the caves, and on the true cave-dwellers. The latter we usualy divide into: troglobiontes, troglophiles and trogloxenes.

Key words: speleobiology, subterranean environment, adaptations, cave animals, classification.

[1] Notranjski muzej, Ljubljanska 10, SI - 6230 POSTOJNA, SLOVENIJA

INTRODUCTION

The first more or less objective statement about the occurrence of cave animal came from Janez Vajkard Valvazor, who commented on the existence of a sort of dragon inhabiting subterranean lakes near Ljubljana in Slovenia. In 1768, Joseph Nicolaus Laurenti formally described the animal under name *Proteus anguinus* and noted, that the animal has nothing to do with dragons, and that it is indeed an amphibian.

Discovery of thes first cave vertebrate, which is the largest cave animal in Europe, was followed by the discovery of the first cave insect, *Leptodirus hochenwarti* - a bizarre beetle, blind and unpigmented, by Luka Čeč in the Postojna cave during one of his explorations. During the nineteenth century numerous other discoveries were made in Slovenian caves, the Balkan Peninsula, the Pyrenees and also in North America. Outside these main regions, some new discoveries were recorded from Japan, New Zealand and Mexico. However, in the last fifteen years, there has been an extraordinary increase in information about cave faunas in the tropics and in non-limestone subterranean habitats (Belles 1992).

The subterranean environment is not simpler than any surface environment. It is composed of a mosaic of microhabitats, each one with its own peculiarities. Moreover, subterranean environment isolation is relative. What is generally called "cave" is just a small part of the whole subterranean environment, and it is connected to the surface through fissures, cracks, microfissures, galleries, shafts, etc.

The subterranean environment being directly related to the exterior as we have seen, by means of fissures, cervices and ducts, so it is under direct influence of the regional microclimate. There are a few principles with govern the meteorology of caverns. These are low and constant temperature, permanent darkness and high humidity.

The only stable factor in this environment is the total darkness and, therefore, the absence of a photo period, a determining factor for adaptation of animals to this habitat. The only primary production comes from autotroph organisms such as Tiobacteria and Ferrobacteria, that live in clay. The main part of the food comes from the surface. Another part comes from the subterranean environment itself, from excrements of transient or permanent fauna. The animals that die in these places are also the part of the food resources.

The responses given by the subterranean animals are very different, although the environmental conditions are uniform in each specific habitat. A certain trend of features can be found, like depigmentation, loss of eyes, metabolic economy, increase in tactile sensitiveness, predominance of K strategy and others (Camacho et all. 1992).

SUBTERRANEAN ENVIRONMENT

Man has always attempted to "organise" the objects which surround him in the world, including the fauna. Racovitza (considered the Father of Biospeleology) was the first to make a coherent classification of the subterranean environment and of cave animals. He was the first to realise the true extension of its environment. He defined 6 divisions of the subterranean environment:

- **The caves** (accessible to humans), the only environment which had previously been considered.
- **The fissures and cracks** (not accessible to humans)
- **The interstitial spaces** such as sands and gravel, where the water saturates the soil and fills only the capillary interstices separating the soil fragments.
- **Hypogeus environment**. Mentions the existence of animals which live in the soil, both in the humus and in the clay, and which present the same characters as cave species and which seem to live in the soil and the caves indiscriminantly.
- **Microcaverns**, refers to the dark cavities built or excavated in soil and wood by animals (insects, reptiles, birds and mammals) and which some others animals choose as normal habitat.
- **Artificial caves**, includes all the cavities, mine galleries, catacombs, tombs, tunnels, etc., created by man.

Since this early classification many authors tried others, eliminating, adding or redefining some terms. An accepted division of underground environment is into aquatic and terrestrial subterranean environment (Camacho 1992).

The **terrestrial subterranean environment** is formed by caves, with all their habitats and microhabitats and underground superficial spaces (Fig. 1). The invertebrates (no terrestrial vertebrates are found in the caves, with the exception of bats, some birds and small rodents) which are found inside the cavities can move freely not only in caves accessible to man, and therefore where they can be directly observed, but also in the microcaverns burrows, holes etc. made by animals, under stones and adjacent microspaces and crevices, (not accessible to man). Subterranean fauna can also be found On the artificial tunnels and mines. In deposits of bat guano, the guanobionts form communities which are not real cave animals. They are the same species that can be found in the guano in other epigean environments. Superficial underground compartment was discovered by Juberthie et all. (1994) when they were looking for the frontier between the subterranean and ground fauna in a noncalcareus area. It is formed of cracks and fissures in rock in collapsed slopes. The species of this environment are connected with deep fissures and its fauna can be studied in artificial tunnels and caves.

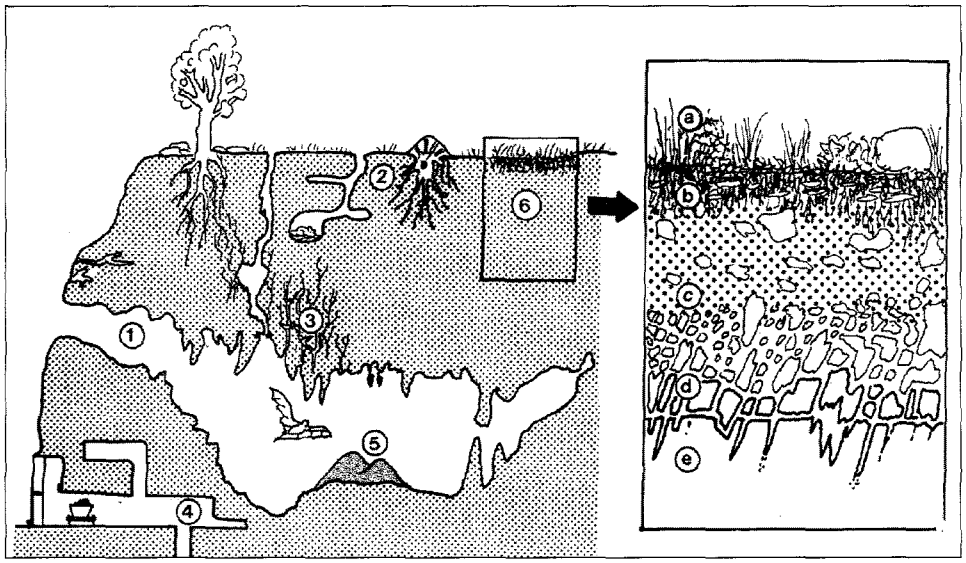

Fig. 1: The terrestrial subterranean environment. 1- caves (accessible to man), 2- microcaverns, 3- microspaces and crevices, 4- artificial tunnels, mines, 5- guano, 6- superficial underground compartment (a-moss, b- humus, c- soil, d- superficial underground compartment, e- deep underground compartment, rock with cracks)

Sl. 1: Terestrično podzemeljsko okolje. 1- jame (človeku dostopne), 2- rovi malih živali, 3- razpoke, 4- umetni tuneli, rudniki, 5- gvano, 6- površinski podzemeljski kompartment (a- mah, b- humus, c- prst, d- površinski podzemeljkski kompartment, e- globok podzemeljski kompartment, razpoke v matični kamnini)

The **subterranean aquatic environment** is initially more diversified than the terrestrial one. It is sometimes difficult to delimit the terrestrial and aquatic environment, since in environments saturated with humidity typically aquatic species can be seen mowing along subterranean biotopes.

Biologists, following the recommendations of Rough, should distinguish two fundamental types recognised by hydrogeologists (Camacho 1992).

Areas on permeable - karstic terrain is divided into an upper zone with capillary waters and lower zone subdivided into a part containing permanent waters and an part flooded only in high waters (Fig 2.). The springs of rivers also have specific aquatic fauna. The Interstitial environment was discovered by microscopic analysis of water of wells in order to check their suctability for drinking. All the studies show the great faunal richness of these environment also in the non-karstic areas.

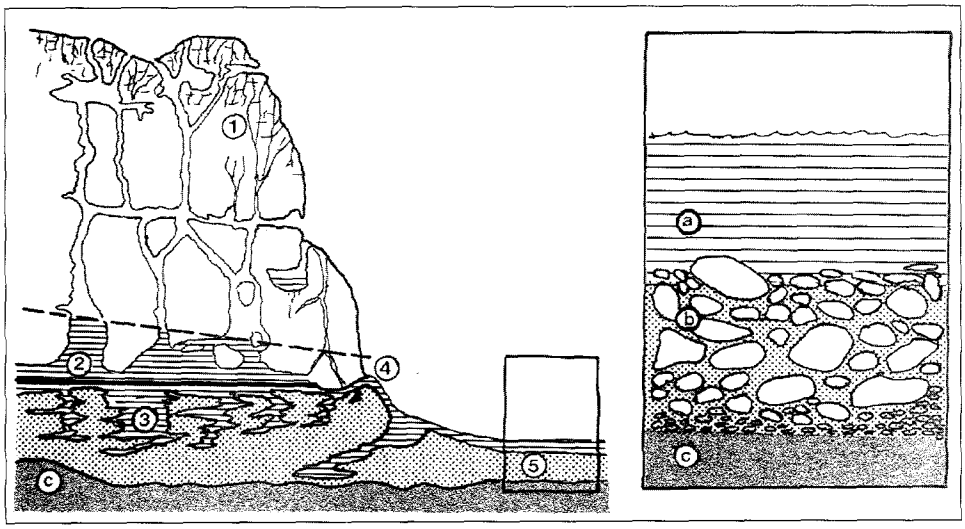

Fig. 2: The subterranean aquatic environment. 1- upper zone with capillary waters, 2- amphibian zone, 3- permanent flooded zone, 4- springs, 5- Interstitial environment (a- stream, b- Interstitial environment, c- impermeable rock)

Sl. 2: Vodno podzemeljsko okolje. 1- zgornja cona z kapilarnimi vodami, 2- občasno poplavljana cona, 3- stalno poplavljena cona, 4- izviri, 5- intersticielno okolje (a-vodni tok, b- intesticielno okolje, c- nepropustna kamnina)

CAVE FAUNA

Since subterranean animals werefirst discovered there has been an attempt to classify not only the environments, but also the fauna which inhabit them. Multiple criteria have been used such as topographical, ecological, etological, etc., some with more success than others.

It is very difficult to list animals as cave species with certainty. For many of reputed cave taxae their presence in surface habitats (particularly in soil) is very likely although not yet proved. The most used classification of subterranean animals (considered by Schiner 1854, Racovitza 1904, and Leruth 1939, after Camacho 1992), is based on etological classification, although it is really more ecological. There are proposed two large groups.

1. **False cave-dwellers:** Their presence in caves is not due to the search for determined meteorological conditions but they are occasional visitors. They are those who live by exploiting others in two different forms: in a direct form, the parasites; and in an indirect way, the guanobionts.

2. **The true cave-dwellers:** They were oldest colonists, who sought out he subterranean environment for its meteorological conditions (especially for its abundant humidity in the case of terrestrial species).
   It includes:
- **Troglobiontes:** only found in the caves and which are relicts totally pecialised to this lifestyle, They do not have near relatives among the pigean fauna, or else they belong to a group whose representatives are confined to the caves or where the related epigean forms are extinct or exist only in very distant regions.
- **Troglophiles**, which live in caves for meteorological reasons but can be found outside too, always in very humid environments (moss, dead leaves, humus, etc.). For some species the epigeic and hipogeic ecophasis is considered. Troglophiles can breed in the caves.
- **Trogloxenes,** which voluntarily penetrate into the underground environment for its trophism and attracted by the humidity They are incapable of breeding in this environment, do not present special adaptive features and live mainly at the cave entrances.

In Slovene caves we can find troglobiont representatives of diverse animal groups such as gastropods, worms, crustaceans, arachnids, myriapods and insects, especially beetles. Great number of troglophile (Fig. 4) and trogloxene animal species are also occur in caves.

Even some species of vertebrates, like fishes, birds, rodents, carnivores and bats occasionally penetrate caves, crevices and shafts, but they are, with the exception of *Proteus anguinus* (Fig. 3) not adapted to a troglobiotic lifestyle.

Taxonomical and faunial studies will continue to be presented in biospeleological literature. The character of relict species of many troglobites gives to them an exceptional value as paleogeographical indicators, and this will be revitalised, especially now when it seems that it is time to revive systematic and biodiversity studies. Cave animals, some of them at the extreme of K-strategies, can serve as suitable models to test theories on physiological ecology.

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KLASIFIKACIJA PODZEMELJSKEGA ŽIVLJENSKEGA OKOLJA IN JAMSKIH ŽIVALI

Povzetek

Odkritju človeške ribice Proteus anguinus, največje med evropskimi jamskimi živalimi, so v devetnajstem stoletju sledila odkritja in opisi številnih novih jamskih nevretenčarskih taksonov. Večina teh so endemiti, kar pomeni, da so zelo lokalno razširjeni.

Podzemeljsko okolje je z zunanjim povezano prek špranj in razpok ter tako pod neposrednim vplivom regionalne mikroklime. Nekaj glavnih parametrov karakterizira klimo v jamah. To so nizka in stalna temperatura, popolna tema, velika vlažnost in običajno pomanjkanje hranljivih snovi oziroma plena. Prilagoditve jamskih živali na te pogoje so razmeroma različne navzlic dokaj homogenim življenskim pogojem podzemeljskega okolja. Med pogostejšimi prilagoditvami so odsotnost pigmenta, izguba vida oziroma oči, racionalnost metabolizma, povečana taktilna čutnost in prevladovanje K razmnoževalne strategije.

Jamske živali je pogosto težko z gotovostjo opredeliti za prave jamske. Za številne prepoznane jamske vrste se predpostavlja da žive tudi v površinskih habitatih.

Najbolj je sprejeta delitev jamskega življenskega okolja na akvatično in terestrično jamsko okolje. Vsaka od teh ima številne različne tipe. Najpogosteje uporabljana delitev jamskih živali je na lažne jamske živali, ki so v jamah le občasni gosti ter prave jamske živali. Zadnjo skupino običajno delimo dalje na troglobionte, ki so popolnoma prilagojeni na življenje v podzemlju ter troglofile, ki se zatekajo v jame iz meteoroloških zahtev in v podzemeljskem okolju obligatno prežive del življenja. Tretja skupina so troglokseni, ki zahajajo v jame zaradi prehranjevalnih zahtev vendar se tu niso sposobne razmnoževati.

Med temi skupinami najdemo v Sloveniji številne predstavnike polžev, rakov, pajkovcev, stonog in žuželk, med katerimi prevladujejo hrošči ter drugi.

Celo nekateri vretenčarji kot ribe, ptice, glodalci in zveri se občasno zatekajo v jame in podzemlje, vendar z izjemo človeške ribice niso prilagojeni na podzemeljski način življenja.

Fig. 3: Proteus anguinus LAURENTI, 1768 the biggest and the best known European troglobiontic animal (Photo S. Polak).

Sl. 3: Človeška ribica Proteus anguinus LAURENTI, 1768 je največja in najbolj poznana europska troglobiontska žival (Foto S. Polak).

Fig. 4: Cave cricket Troglophilus cavicola KOLLAR, 1833 is a common troglophile cave-dweller (Photo S. Polak).

Sl. 4: Jamska kobilica Troglophilus cavicola KOLLAR, 1833 je pogosta troglofilen obiskovalec jam (Foto S. Polak).