

Eco-climatic Conditions and Biodiversity of Orlovača Cave

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Abstract: Within specific ecological condition of Orlovača cave existed living world failing rich and large in number. They are adapted on absentia light as well as the other characteristic ecology parameter. On an occasion of researching and organizing Orlovača cave, several representative organisms were discovered. They have been convalescent at the Faculty of Biology in Belgrade. Climate parameters like air temperature and air humidity have been measured in some parts of the cave system which has provided a better understanding of microclimatic characteristics of the Orlovača cave as a habitat of troglobites as a specific cave fauna. In addition, Orlovača cave is a paleontological locality of the cave bear. In this research we created web oriented data base for presenting results and teaching students.

Key Words: Orlovača cave, software, data base, cave ecosystems, cave biodiversity, cave microclimate, troglobionts

1. Introduction

Orlovača cave (948 m) is located at 1056 m altitude in the western part of Romanija mountain in the basin Mokranjska Miljacka, respectively, in the valley of its right tributary Sinjava. The village where Orlovača cave is located is called Sumbulovac. Geographic coordinates of sites

Orlovača are: 43°51' north latitude and 18° 36' east longitude. Romanija region is located in the central western part of the acts of the Balkan peninsula and the eastern part of the Republic of Srpska and has a relatively peripheral position in relation to the most continental roads.

The most natural consequence of the properties Orlovača course of karst processes. In this

relatively small area is expressed most karst groundwater and surface relief and hydrological phenomena. Nearest urban centers are Sarajevo (15 km) and Pale (10 km).



Fig 1. Geographical position of the Orlovača cave

2. Microclimatic characteristic

Changing weather conditions in the dark systems such as caves is performed using the heat come into cave is due in four ways. These are: the heat transfer by the rocks above the cave system that received heat from the sun during the day, the rocks below the cave system, which transfers heat from the interior of the Earth, the air that enters the cave by cave openings and cracks, water in different ways due to the cave.

The most significant amount of heat is provided by transferring heat from inside the cave system and entrance surface air through the openings. The temperature increases with depth and thermal difference is represented by geothermal gradient. When the geothermal gradient is high, the cave temperature depends on the heat transfer from the interior of rocks and the air along the surface. When the geothermal gradient is low, cave temperature depends essentially on the surface air. Others contributing to the heat in the caves are weaker. Each cave is characterized by unique microclimatic characteristics that contribute to the development of wildlife in cave ecosystems. The troglobite community is adapted to the climate in which they have long developed and gained some features such

as relict and endemic. Spatial environment of the cave Orlovača has mountain climate characterized by relatively low temperature, transparency of air, strong winds, reduced amount of humidity, the greater amount of rainfall, but also reduced the presence of aerosols and microorganisms in the air. The cave is characterized by small amplitudes of climatic elements. Uniformity of climate elements is the result of the complex deep cave system where outside influence disappears.

During the speleological research in different parts of the cave temperature and relative humidity have been measured at 2 m height by digital device called Huger. The first measurements started on 15th August 2002 year at 3 pm. The outside temperature was 28.7 °C and the relative humidity was 37%.

The observations of temperature and relative humidity were carried out in the hall of Romania between 9 am and 6 pm every two hours during the period from 14th to 25th September 2002. Measurements were found that temperature and relative humidity in the deeper part of the cave are almost unchanged values. Temperature is 8.8 °C and relative humidity is 90%.

This can be seen on the line Figure 2 which initially shows temperature to decrease and relative humidity to increase. In the deeper parts of the cave, such as Thermopylae passage and hall Romania, values of these parameters showed very little variability. [1]

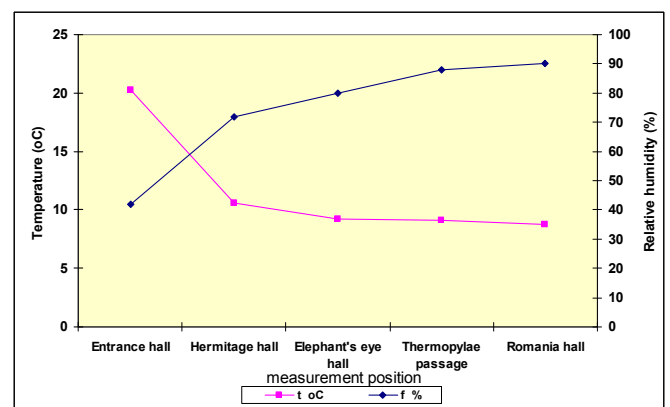


Figure 2 Measured air temperature and relative humidity in the different part of the Orlovača cave

External temperature changes over the same period ranged between 8 °C and 21°C and did not affect the temperature fluctuations in the depths of a cave

system. Differences in values of relative humidity in relation to the measure in august and september are result of rainfall that caused the increased circulation cave water.

3. Living world of the Orlovača cave

The underground karst forms of relief meets the specific fauna that is still largely unknown. Orlovača cave is a habitat of specific, rare and endemic representatives of the cave fauna of which is the common name troglobite fauna. Troglobite animals are primarily small and medium-sized body. They are characterized by specific morphology and color. Their most distinctive characteristic is eye and pigment absence, which is closely correlated with environmental conditions they live in.

In Orlovača cave occur all underground biotopes and appropriate communities of troglobites that are defined by Latinger and Tvrčković (1986): These are: half dark entrance due to the presence of light provides an opportunity for the formation of mural, hydrophilic phytocenosis dominated by algae and moss. Zoocenosis composition depends on the intensity of climate change inside the cave (Fig. 3),



Figure 3 Extremophiles in half dark parts of cave

clay sediments with autotrophic bacteria are an important food source for underground animals, specially insects while they are in the doll stage, cave interior corridors and cracks are covered by travertine crust and they are without light. They represent typical biotope inhabited by the land troglobites, guano (bat droppings accumulation) is nutrient substrate in cave cracks systems. On this substrate and accumulation of organic matter often grow fungus and molds, also space

between the limestone tube who are periodically under water called *Marifygia cavatica* and bottom waters inhabited by water troglobites, intercellular space between particles of sand and gravel caused by alluvial accumulation. Organisms that inhabit this biotope play an important role in karst water purification. The cave system Orlovača observed traces presence of organisms in all these biotopes mentioned above. [7]

4. Biodiversity of the Orlovača cave

The most numerous inhabitants of Orlovača cave are invertebrates (*Invertebrata*), phylum *Arthropoda*, classes *Insecta*. The numerous is a group of insects from the genus *Coleoptera* (Beetle), but the most common are representatives of family *Carabidae* and *Cholevidae*.

So far, the most important troglobite of the Orlovača cave is *Charonites orlovacensis* Reitter (*Bathysciinae*, *Cholevidae*, *Coleoptera*, *Insecta*, *Arthropoda*) (Figure 4).

This beetle was named after the locality where found. Description of this species dates back to the 1913th by Reitter. He found a significant taxonomical and morphological characteristic of kinship with the other species of the genus *Charonites Apfelbeck*. The founded individual Reitter has treated as subspecies *Charonites zoppai orlovacensis* (Jeannel, 1924). Čurčić et al. (2002.2003) was performed redescription of *Charonites orlovacensis* presenting new insights into the taxonomic and ecological characteristics of this species. All features of *Charonites orlovacensis* are detailed, updated and illustrated.

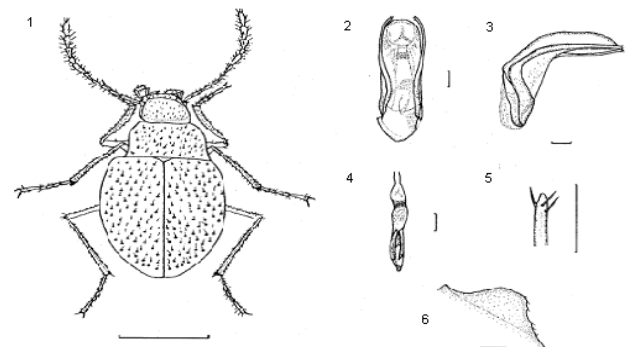


Figure 4. *Charonites orlovacensis* Reitter topotype 1-scale lane=1mm: 2-aedeagus (dorsal view); 3-aedeagus (lateral view); 4-inner sac (dorsal view); 5-left paramere (dorsal view); 6- mesosternal carina (lateral view), scale line= 0.10 mm

Charonites orlovacensis is known only from Orlovača cave and is its endemic species. Specimens were collected in the first third of the cave about 300 m from the entrance, but there is also in other parts of the cave, on the walls of the hall and on the surface of the cave ornaments. [8]

Charonites orlovacensis has some predatory characteristics because they are fed smaller insects such as representatives of the *Colembolla* order.

Genus *Charonites Apfelbeck* consists of five species and three subspecies, all from the caves located close to Sarajevo. All species are endemic to certain caves (Müller, 1912, Jeannel, 1924, Pretner, 1968).

Two very important families in the caves in Bosnia and Herzegovina are *Cholevidae* and *Carabidae*. The first group of specialists were found in Orlovača cave as family from *Trechini* group and *Duvalus (Duvaiotes) ssp. winneguthi winneguthi* (Apfelbeck, 1907), (third of, *Trechinae, Carabidae, Coleoptera, Insecta, Arthropoda*).

Another individual, very similar to the previous one, was found in this locality and belongs to a *Sphodrini* group. This is the *Laemostenus (Antisphodrus) cavicola ssp. modestus* (Schaum, 1858.), (*Sphodrini, Pterostichinae, Carabidae, Coleoptera, Insecta, Arthropoda*).

The representatives of the order *Diplura* are wingless insects without metamorphosis. These are small insects whose length does not exceed 1 cm mostly bright colors. They are extremely feature extensions on the abdominal segment. *Diplura* has three families and the family *Campodeidae* has one individual that was found in deeper part of the Orlovača cave. It belongs to the genus *Campodea sp.* (Westwood).

The representatives of the order *Colembolla* are also winless insects very numerous and widespread. They vary in shape and color, and length do not exceed 1 cm. There are three individuals found in Orlovača cave. Two of them belong to the family *Entomobryidae* and one belong to the family and *Sminthuridae*, gender *Sminthurus sp.* (Latreille).

Order *Diptera* (biplanes) is also found in the Orlovača cave approximately 200 adults and 20 larvae. This is a unique group of insects whose rear wings are underdeveloped and has no flight function. In addition to insects, spiders

(*Chelicerata*) are part of the cave fauna. There are two individuals were collected. Both of them belong to the order *Aranea*. They were determined to the genus level, *Troglohyphantes sp.* (*Linyphiidae, Aranea, Arachnida, Chelicerata, Arthropoda*).

In Orlovača cave is also found millipede (*Uniramia*) as a separate group of the *Arthropoda*. This group consists of two classes *Diploda* and *Chilopoda*. At the various places in the cave was found a very unusual centipede. It is thought that might be a completely new species, because it has so far determined only to the genus level *Brachydesmus sp.* (*Polydesmoidea, Chilognatha, Diploda, Umiramia*). It can be observed after 100 m from the entrance to the cave on the cave walls and ornaments.

The complete determination can not be done, because all the collected individuals are females and young, sexually indeterminate. Determination is possible only on males, because of the sexual organs anatomy which is characteristic of the species.

Orlovača cave is also palaeontological destination of the cave bear. This fossil species of bear is called *Ursus spelaeus*. The name is given in 1794. by Heinroth and Rosenmüller.

During the work on arranging walking paths through the cave, paleontological material was collected. Skeletal remains were found along the route paths, often on the surface or very shallow in clay. Dominant bones are ribs and limb bones (Figure 5).

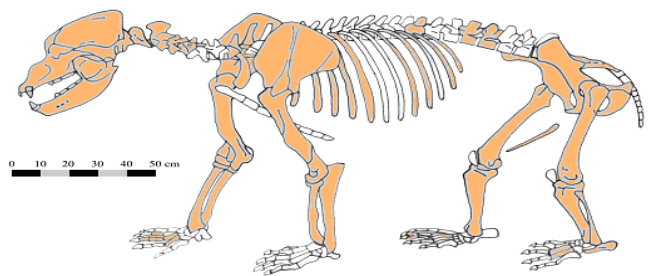


Figure 5. Reconstruction of cave bear skeleton (according to Rabeder, et al., 2000). Bones founded in Orlovača cave are shaded

Cave bear (*Ursus spelaeus*) is the evolutionary successor of the Deninger's bear (*Ursus deningeri*) that appeared on the Earth before 1,3 million years in the lower Pleistocene. This species was widespread and areal was included

area of the British Isles to eastern Asia. About 130 000 years ago, at the beginning of the last interglacial in Europe, Deninger's bear was succeeded cave bear (Rabeder et al., 2000).

These results are collected in a data base, and prepared in Power Pint presentations. Teachers can use presentations to show content using multimedia. Students intensively follow multimedia presentation, better remembered teaching facilities (especially those who tend to learn by listening and reading) and actively participate in the process of learning new content. Faster knowledge enables students to think, analyze and conclude, to devote more research to learning, discovery and problem solving, and thus give greater contribution to its development. It is particularly important to mention that modern computers can be used by students at home and thus acquire both of which are related to curriculum and beyond. [5]

In the last two years we created a Web portal for the planning, implementation and optimal organization of teaching and on-line permanent education.

Educational value of didactic media could be reduced to the conditional proven fact: didactic media allow faster and better realization of the objectives and tasks of education, they are an important prerequisite for modernization and acceleration methods and forms of teaching, an important factor for the alignment of teaching with life, theory with the practice and teaching content customization features, prior knowledge, needs and interests of young people and adults, their important functions in engaging multiple senses, encouraging and maintaining the attention of students, develop curiosity and desire for learning, for active participation in the educational process and its development.[3] Didactic media can actively involve students in the process of preparing, teaching and evaluation of realization. Didactic media allow individual work of students, transfer of knowledge and its application in the work and mastering the techniques of self-education; important presumption that equitable engagement of cognitive, emotional and conative power of personality in teaching and learning, they are important factor in directing student's activities insight stimulate learning, problem solving and creative activities. [4] In Figure 1 is shown WEB

portal which contains teaching resources for preparing and teaching.

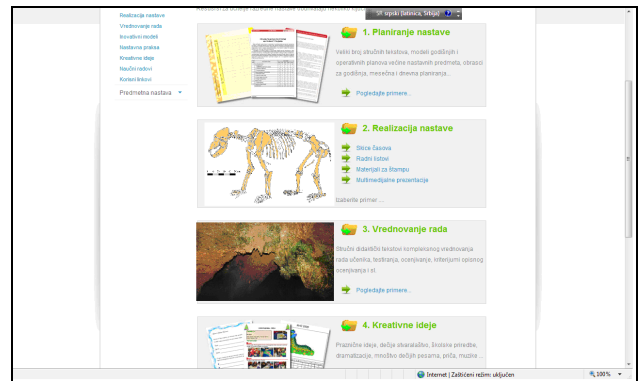


Figure 6 Teaching materials

Didactic media were created as a result of many years of studying the essence of their pedagogical and practical efficiency, and some of them have applied for years in our schools and have proved their undeniable value. This gives us the basis for the claim that it is professionally produced, diligently selected and skillfully applied, affect the teaching organizational, contents, methodology and results. [5]

5. Conclusion

After the formation of large masses of carbonate rocks in the Tertiary, and their faulting and karstification processes, caves have become habitat-specific species. Dinaric holokarst, with all phenomena, is one of the main features of the Balkan penninsula. At a global scale, Dinaric karst is a unique karst within the animal life that inhabits it.

Each cave is characterized by unique microclimatic characteristics that contribute the development of wildlife in the cave ecosystems. Appropriate troglobiont community is adapted to the microclimatic conditions in which they have long development and gained some features such as relict and endemic.

In this study, some species were collected from one or two cave ecological niches or microhabitats which gives relatively good insight into the fauna inhabited on the walls of the hall or cave ornaments. In several different locations air temperature (8.8 °C) and relative humidity (90%) were measured. The values show uniformity in the deeper part of the cave such as Romania and

Thermopiles hall passage. Even thus small inventory of species has demonstrated the uniqueness of the Orlovača cave locality. One endemic was determined called *Charonites orlovacensis Reitter*. Described millipede genus *Brachydesmus sp.* waits for final determination that could indicate entirely new species. The future research in the Orlovača cave will provide valuable presentation of the underworld which should find a place in biospeleology development in Balkan penninsula region. These results are collected in a data base, and prepared in Power Pint presentations. Teachers can use presentations to show content using multimedia. It increases the quality of teaching and learning and the students are included and more interested in this organization of classes.

References:

- [1] Pecelj, M., Markovic, S., Jovic, G., Pecelj, J., Pecelj, M.: Пећина Орловача-Монографија, Завод за уџбеника и наставна средства, Источно Сарајево, 2006, pp. 37-46 .
- [2] Ćurčić, S. B., Pecelj, J., Stojkoska, E.: *A Redescription of Charonites Orlovacensis Reitter with some Notes on its Systematic Position and Ecolog*, Arch. Biol.Sci., Belgrade, 2002, 54(3-4), 129-132.
- [3] Mandic, D.: **Knowledge Based Multimedia System for Teacher's Education**, in the book 9th WSEAS Intenational Conference. on ARTIFICIAL INTELLIGENCE, KNOWLEDGE ENGINEERING AND DATA BASES (AIKED '10), ISBN: 978-960-474-154-0, ISSN: 1790-5109, University of Kmbridge, Cambridge, United Kingdom, 2010, pp.221-226.
- [4] Mandic, D, Lalic, N., Bandjur, V.: **Managing Innovations in Education**, in the book 9th WSEAS Intenational Conference. on ARTIFICIAL INTELLIGENCE, KNOWLEDGE ENGINEERING AND DATA BASES (AIKED '10), ISBN: 978-960-474-154-0, ISSN: 1790-5109, University of Kmbridge, Cambridge, United Kingdom, 2010, pp.231-237
- [5] Mandic, D. : **Distance education in multimedia classrooms**, in the book: Education and new educational technologies, 4th. International scientific conference on educational technology, World scientific engineering academy and society, Corfu, Greece, 2008, pp. 147-153. (ISBN: 978-960-474-013-0)
- [6] Pecelj, M. R., Marković, S.B., Jovanović M. Pećina Orlovača, Filozofski fakultet Univerzitet u Srpskom Sarajevu, Pale, 2002, 1-66
- [7] Pecelj, M. M., Pecelj, J., Milanović, M.: *Digitalni prikaz pećine Orlovače*, Međunarodni naučni skup" Srbija i Republika Srpska u regionalnim i globalnim procesima", Trebinje, 2007, 671-680.
- [8] Jennel, R.: *Monographie des Bathysciinae. Biospéologica*. L. Arch. Zool. Exp. Gén. Paris, 1924, 63, 1-436