AN ECOLOGICAL AND BIOGEOGRAPHICAL OVERVIEW OF THE TERRESTRIAL AND AQUATIC SUBTERRANEAN ENVIRONMENTS FROM ROMANIA

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Abstract. This article represents a synthesis of the results of biogeographical and ecological researches made so far on the terrestrial and aquatic subterranean environments in Romania, in the context of the present development of biospeology in the world.

Résumé. Ce travail est un aperçu sur les résultats des recherches écologiques et biogéographiques entreprises jusqu’à ce jour sur les milieux souterrains terrestres et aquatiques de la Roumanie, présenté dans le contexte du développement actuel de la biospéologie mondiale.

Keywords: biospeological division of Romania, terrestrial and aquatic organisms, classification and characters of subterranean environments, ecological categories, adaptations at subterranean life, subterranean ecosystems.

1. A short history

Negrea (1997, 1998 and 1999) divided the history of the biological knowledge to the subterranean environment to the Earth into three periods. The first is the previously period of E.G. Racovitza (from the beginning to 1907 – when appeared the paper “Essai sur le problèmes biospéologiques” where the great Romanian researcher put the scientific bases to the biospeology). The second is the E.G. Racovitza period (1907 – 1947) – in which the development of the new biological discipline was coordinated on the world by the founder himself. The third is the period after E.G. Racovitza (modern or actual: 1947 to present), in these period the biospeology known a special development in France (from The Moulis Subterranean Laboratory) and in Romania (from the Speological Institute “E. G. Racovitza”).

We will speak only about the main biospeological events connected with Romania – in rest to see the mentioned papers.

1.1. Previously period of E. G. Racovitza

In Europa, the first biospeological event registered was happened to 20 000 years ago. It’s about a bison bone fragment that was discovered in the Grotte Trois Frères (France) on witch was engraved by a prehistoric artist, with a silex, the first cavernicolous insect. He figured so exactly that it could be determinate to be from the genus Troglophilus (Orthoptera).

From the Romanian space, the first writing mention from the cavernicolous fauna is pseudoscientific. It’s about the book named “de Draconum Carpathicorum cavernis” (1672) in wich was point out the caves from Carpathian Mountains with “dragon bones” – in real bones from Ursus spelaeus. The first scientific information we owe to Austrian and Hungarian zoologists and it’s about troglobitic Bathysciinae Coleoptera from the Transilvania and Banat caves. Thus, Miller and Hampe described, in 1856, the first species from Apuseni Mountains (Drimeotus kovacsi to
Peștera* Igrita and Pholeon angusticolle from Peștera Zmeilor to Onceasa). Also Frivaldski described, in 1880 and 1884, the first species from Banat (Sophrochaeta insignis from Peștera Mare de la Șoroniște and S. reitteri from Peștera de la Bobot). At the end of XIX-th century was discovered and described Araneae species (Nesticus biroi Kulczynski, 1895 from Peștera Igrita) and Diplopoda (Trichopolydesmus eremitis Verhoeff, 1898 from the Peștera Hoților to Bâile Herculane).

1.2. The E. G. Racovitza period

The beginning of XX-th century coincided with the appearance the papers of zoologist Armand Viré: "La faune souterraine de France" (1900) and "La Biospéologie" (1904). In the last paper, beginning with the term "spelologie" (gr. spelen = cave) created by E. Rivièr and adopted by E. A. Martel in 1884, Viré formed the word "biospéologie" for the science who studied the being that populated the subterranean environments. But, E. G. Racovitza beginning with the term "spéologie" (gr. speos = grave, cave) created by L. de Nussac in 1892, proposed the word "biospéologie" because is more euphonic. Today, the form that was proposed by E. G. Racovitza is the most used by Romanian and French biospeologists and correspond better with the actual containing of the notion (the underground domain contain the artificial and natural cavities) and is shorter.

The fate did in 1904, when Viré published the synthesis upper part mentioned, E. G. Racovitza discovered at 15 July in a lake with fresh water in Cueva del Drach from Mallorca Islands (Baleare), an eyeless isopod, became famous, Typhlocirolana moraguesi. The little beings from the subterranean environment attracted the attention to the Antarctica explorer to the importance of the hypogean relics in the decipher of the evolution mechanisms. The unexpected discover determined E. G. Racovitza to abandon his biooceanographical researches and dedicated himself, body and soul, to cave exploring and studying the data existed at that time from the subterranean world. Only in three years, the Romanian Racovitza achieved that nobody did before him, including the French Viré: to explore many caves and, especially, to put in order the many data published until then. The result of his work was materialized in that famous “Essai sur les problèmes biospéologiques”, published in 15 Mai 1907 in Paris. In that paper E. G. Racovitza put the bases of a new biological science, defined, exactly like Viré, “the science of the life forms of the subterranean environments”. These essay, where Racovitza analyzed all knowledge - enough disconnected and contradicted - about cavernicolous fauna and presented a great plan to research was named by Gr. Antipa in 1927 “the birth certificate” of biospeology, by R. Jeannel in 1948 “the fundamental status” of a new subject, by A. Vandel in 1964 “the famous manifest of E. G. Racovitza” and C. Motaș in 1969 “the angle stone of biospeology”. Thus, by his substantial memorial elaborated at 39 years old, he remained in the science history as the biospeology founder.

Knowing that to the development of a new biological discipline wasn’t sufficient to established principles and methods, but realised also expeditions, collections and publications, E. G. Racovitza founded in 1907, at The Arago Laboratory to Banyuls-sur-Mer, an international enterprise named “Biospeologica”. He coordinated, having R. Jeannel like assistant, the activity a many collaborators from all over the world and the resulted papers was published in the international renown periodical “Archives de Zoologie expérimentale et générale” that was

* Peștera = Cave.
founded by Henri de Lacaze-Duthiers on Paris and that was grouped on two series. In “Biospeologica” appeared, in the period 1907 – 1962, 81 numbers, and in the “Enumération des grottes visitées”, in the period 1907 – 1948, 8 tomes containing the description of 1,129 caves, the last edited by H. Coiffait in 1958. It is obvious that E. G. Racovitza, R. Jeanne1 and P. A. Chappuis are the authors that published in “Biospeologica” their bulky studies about Isopoda, Coleoptera and Copepoda.

In 1920, came back in Romania, E. G. Racovitza founded the first institute of speology in the world at the University of Cluj and bring with him the big collections and the redaction of “Biospeologica”. In this way he transformed the capital of Transilvania in a world center of subterranean fauna research. Like director on life at the new Institute, beginning with 1926 and to 1939, Racovitza edited 9 tomes named “Lucrăriile Institutului de Speologie din Cluj”. But the most important realizations from the Racovitza period are linked also by “Biospeologica”. It is sufficient to remember the exploration of over 800 caves from Europe and North Africa when was collected over 20,000 samples. On these base was published 41 memories in “Biospeologica”. If we report only to Romania, in the 1921 – 1931 period was explored over 150 caves from Apuseni Mountains and approximately 100 from Meridionals Carpathian.

The underground aquatic fauna was investigated especially by P. A. Chappuis who explored, accompanying by Valer Puşcariu, especially caves from Romania and Yugoslavia. His name is linked to one method of collecting hyporheical fauna known today like “Karaman – Chappuis method”. Accomplished also by Radu Codreanu, he used successfully this method in the Romanian mountains water case. Later, this method was used by C. Motas and his assistants to collect Hidracarina.

Of course, the subterranean fauna and flora researches wasn’t limited at E. G. Racovitza and his school. In the same period of time, many systematic zoologists studied and published collected materials, especially from Transilvania caves. Between them, we mention Mihok, Knirsch and Bokor for Coleoptera, Chyzer and Kulczynski for Araneae, Daday and Verhoeff for Miriapoda, Thalhamer for Diptera and Mehely for Chiroptera. A special mention to C. N. Ionescu, Paul Bujor student at Iaşi, who was the first that investigated the subterranean fauna from outside Carpathian area (Oltenia and Dobrogea). He started his studies in 1910 under direction of E. G. Racovitza by letters and he published his results in our country (and not in “Biospeologica”) in 1912 – 1925 period. His important paper named “Biospeologia Carpaţilor Meridionali” (“The Biospeology of the Meridionals Carpathian”) appeared in 1914.

The second period of biospeoley history, which we linked from the name of the new biological discipline founder, was finish at his death, in 1947. It is true that P. A. Chappuis ensured the direction of the Cluj Institute two years after E. G. Racovitza, but only for ordinary problems. In the socio-political conditions from that time, the Institute was threatening with the disappearance of it. The return
in France of “Biospeologica” under R. Jeannel and P. A. Chappuis direction and the founded of Subterranean Laboratory to Moulis under A. Vandel direction, foreboded a new period in the development of biospeology in the world.

1.3. Present period of biospeology

After E. G. Racovitza death, the Cluj Institute of Speology restricted his activity only of the study of Ghețarul de la Scărișoara Cave. A team leaded by two disciples of the master did this study, Mihai Șerban and Dan Coman. Concomitantly, another team made by Valer Pușcaru (an old collaborator of E. G. Racovitza), Margareta Dumitrescu, Jana Tanasachi and Traian Orghidan – all from the Biology Faculty of Bucharest University – started the bats and guano deposit study from the Romanian caves.

After nine years of E. G. Racovitza death, Traian Orghidan and Margareta Dumitrescu succeeded to obtain the authorities accord to reorganize the Institute of Speology, with the center in Bucharest and one branch in Cluj, and determined the professor C. Motaș, hardly set free after seven years of political detention, to accept the director job. In this way, at 1 June 1956, began for Romanian biospeology a new development period, when was completed many of E. G. Racovitza dreams. In concordance with his thing, started the extensive study of subterranean fauna (of the biodiversity like we say today). It was continued the intensive study (of the populations and communities) and was started the experimental study (postembriological development, ethology and ecophysiology etc.).

In short time after the reorganization of Speological Institute, the teams of biospeologists started to explore extensive the subterranean terrestrial and aquatic environments from all over the karstic regions of the country and the specialists in different groups of animals to published the results in the Institute revue. Later, they started to study also abroad, doing the expeditions. Between these we will remember only the expeditions that had the results published together in the Speological Institute revue or in special tomes edited by Romanian Academy. We took about Bulgaria (L. Botoșăneanu - leader, V. Decu and T. Rusu, 1963); about the two great expeditions in Cuba – for four month each one, with results published in 4 tomes (L. Botoșăneanu – leader, V. Decou, St. Negrea and Gh. Racovită in 1969 and T. Orghidan – leader, L. Botoșăneanu, D. Coman, V. Decu and St. Negrea in 1973); about Mallorca (T. Orghidan - leader, Margareta Dumitrescu, Maria Georgescu and I. Tabacaru in 1971); about Venezuela (T. Orghidan – leader and V. Decu in 1982); about Israel (St. Negrea – leader, I. Căpușe, V. Decu and Alexandrina Negrea in 1990).

The “Banat” teams (with the nucleus made by L. Botoșăneanu, Alexandrina Negrea and St. Negrea) and “Oltenia” (with the nucleus made by V. Decu and Anca Decu-Burghelie) did the intensive study of subterranean fauna. These teams published papers about subterranean terrestrial and aquatic communities (see the bibliography). For Apuseni Mountains it must be marked the ecological study of Bathysciinae Coleoptera populations (Gh. Racovită, 1980). In three caves was done long studies by teams: of Ghețarul de la Scărișoara, Peștera lui Adam from Bâile Herculane (a cave with tropical type, with warm air purse and a big guano deposit; Peștera de la Movile (Mangalia), with primarily production base on autochtoine chemosynthesis, with thermophilic and tyophilic species. Different subterranean environments was described and defined or studied for the first time in Romania. We took about the hyporheic, phreatic, lithoclastic, hygroteric and superficial subterranean compartment (MSS) (see the bibliography). Another referential published studies had subject the cave climate (Gh. Racovită), delimitation of
Romanian biospeological provinces and zones on the base of troglobitic species and paleobiogeographic barriers (V. Decu and Şt. Negrea), water chisme (C. Marin), preservation and protection of subterranean terrestrial and aquatic environments and setting up the reserves (L. Botoşaneanu, Alexandrina Negrea and Şt. Negrea, V. Sencu, Gh. Racoviţă, V. Decu and others V. Decu and Gh. Racoviţă published in 1994 the chapter “Roumanie” in the tome serie “Encyclopaedia Biospeologica” that appear in France.

For the experimental study were done some underground invertebrate’s nursery in Peştera Cloşani (1961) with a view to follow in their natural habitat, the postembryonar development and their comportment. Because the scientific and auxiliary personal is missing at the Cloşani Speological Station, the nurseries was continued at the Speological Institute in Bucharest, in laboratory conditions (I. Tabacaru, V. Decu and others).

In present (2000 year), the biospeology collective from the Institute of Speology “Emile Racoviţa” has in project two main monographs: one about the subterranean system from “Peştera de la Movile (Mangalia)” and other about “Romanian subterranean fauna”.

2. Karstic regions of Romania

As a result of the geologic evolution, on the actual territory of Romania, situated between the 44° and 48° parallels on Nordic latitude, it was created a relief where the carbonated rocks occupy a very small area, 4,400 km² (1.4%). The explanation is the fact that in the plain and tableland areas the Pliocene camouflages the karstic formations and Quaternary deposits. (M. Bleahu and T. Rusu, 1965).

The main karstic regions are (in size order): The Meridionals Carpathians (aprox. 1,600 km²), The Apuseni Mountains (over 1,000 km²), Dobrogea (under 1,000 km²) and Orientals Carpathians (cca. 780 km²). To this must be added the small areas in the Moldavia and Transilvania tablelands (Fig. 1).

After Decou and Negrea (1969) and Decu and Racoviţă (1994), the karstifiable rocks where are developed exo- and endokarstic formations are varied. It’s about metamorphic limestones and dolomites, Triassic limestones and dolomites, Jurassic-Cretaceous and Neozoic limestones, salt and gypsum. Many of Romanian caves are diged in Jurassic limestones (Dogger and Malm) and Cretaceous (especially Neocomian) and very little in salt and gypsum. Horizontally prevail the Jurassic limestones (the most of it in Meridionals Carpathian – 1,227 km²), followed by crystalline Paleozoic limestones and dolomites (797 km²) and Triassic (779 km²) and Neozoic limestones – especially in Dobrogea (673 km²). Except the fact that are prevalents, the most of it are the biggest and most karstifiable Jurassic and Cretaceous limestones deposits. Vertically, the limestones are on a medium altitude, most of it between 500 and 1,000 m (47%) and little of it under 500 m (27%) or over 1,000 m (26%).

In the case of karstic cavities, the most of it are diged under 1,000 m – very little of it are over this altitude, the most of it from Apuseni Mountains. After Goran (1982), between 7,000 cavities inventoried until 1981 in Romania, 70% are under 50 m development. In present, when the number of inventoried caves almost double (cca 12,500 in 2000), the rapport modified itself to the small caves (under 50 m) and the smallest caves (under 10 m). In the case of the caves density, Goran (1989) consider the follow values: 1.52 caves/km² for Romania; 2.32 for Apuseni Mountains (maximum at 4.85 in Bihor Mountains); 1.92 for Meridionals Carpathian
Mountains; 1.22 for Orientals Carpathian Mountains; 0.09 for Dobrogea. This hierarchy of the cave density to every karstic region corresponds with these of the underground network density. These are the values of Goran (1989): 260.6 m/km² for Apuseni Mountains; 155.8 for Meridionals Carpathian Mountains; 76.1 for Orientals Carpathian Mountains and 5.9 for Dobrogea.

The authors of exo- and endokarstic formations from the areas of greatest karstic regions in Romania are the surface waters that dig at the exterior and so much in the interior of the limestones massifs, where the water infiltrate itself to swallow and rock fissures. Even in the case of thermomineral waters to the fault longitudinal zone of Cerna, also the surface water (meteoric, from Cerna and from tributaries) is the water that infiltrate itself to 1,000 – 2,000 m deep, heat itself to 190 °C, and after that it claim up to surface where break out in springs.

The subterranean waters are a reserve to 8.3 milliards m³/year, to this 5.1 are in phreatic environment and 3.2 in the deep waters. There distribution on the Romanian territory is unequal and that because the geologically structure, litology and climatic factors. Approximate 80% to the “fresh waters” are stocked in Pliocene and Quaternary plain and plateau deposits.

3. Evolutionary stages in karst formation

After Bleahu and Rusu (1964, 1965), in the geologically evolution of Romanian territory existed three karstification periods: superior Triassic, inferior Cretaceous and superior Cretaceous – Neozoic. The first and the second “are fossil karsts, with the erosion relief sealed like transgresive and residual materials”. The
last period started in superior Cretaceous, in the same time with the Carpathian uplift caused by subhercinic tectonic movements. It continued in Neozoic, exactly in Eocene, when was modeled the superior penplain; because the limestone was still covered, isn’t resulted an important karstic relief.

In Miocene produced the middle platform modelation because the savic movements. But, this time the limestone being development by erosion, the surface karstification was important. The epigean waters, gravitational drained through limestone fissures to the base level (in this case to the Miocene sea that surrounded the Carpathian chain already raised in block), given birth to the first caves formed in phreatic system.

In superior Pliocene, exactly in Villafranchian, had place the finished of orogenese process of the Carpathian Mountains like the following of wallachian movements. In the same time with the rising of “karstoplain”, the caves anterior formed started to be drain by the underground rivers, developed, continuously, in vadose system. At once with the deepened of hidrografical underground network, the local levels had go down, establishing the caves formed in phreatic system to pass to a vadose system. If these are the facts, why didn’t found yet the deposits oldest than middle Pliocene? After the mentioned authors, the explanation is in fact that these caves recently get out under the hydrostatic level. In Pleistocen period – they show – “the periglacial climate modified the karst Tertiary morphology, especially by a strong frost shattering and by a carstification stoping because the pergelisol”. The limestone areas weren’t touched by the Carpathian glaciation. In the present temperate conditions, followed the covering and solidification of limestone areas, in terms of altitude”.

So, results that in Romanian territory exist a transition type karst established by Cvijic, and is speak about “the causses type, and, pro parte, Jurassic type”, in it evolution was close linked by the rising stages of Carpathian Mountains.

4. Anthropic-impact and the protection of subterranean environment

The activity of men more and more diversified had and has an impact more important, with negative effects, on exo- and endokarstic formations, on the subterranean waters (especially on the phreatic waters) and on the fragile troglobitic and stygobitic fauna. Between these activities we mention the most important:

- The area karst denudation through space out the trees or through deforesting and other vegetal formations are destroyed.
- The limestone exploitation or other karstifiable rocks through the opening of the quarries that destroyed exokarstic formations and render ugly the landscape (like was the quarries from Domogled and Bula – Vânturarîa Massif).
- The natural subterranean gaps modification by broadening the opening and galleries (like was the case of the entrance of Matei Ghica Gallery to Peștera Cloșani).
- The distraing and appropriation of speleothem or of the archeological or paleontological pieces (like in the case of calcite monocrystals from Peștera Tecrii on the Streiului Valley; in the case of ornament aragonite from Peștera Fagului that was sold at the Beiuș fair; in the case of 400 foot traces let by Homo neanderthalensis 26,000 years ago in calcite crust through a cave to Pădurea Craiului Massive; in the case of candle-stalactite “forest” to Peștera Topolnița from Mehedinți Mountains or to Peștera Munticelu from Bicazului Gorges; in the case of prehistoric cemetery from 4,000 years ago, that although protected by a suup in an Apuseni Mountains Cave, that was destroyed by a adventure divers team; in the case
of translucid calcite bludgeon full of helictites named “Buzduganul” and with the transparent hangings named “Fanionul” from Peștera Pojarul Poliței; in the case of “Vâlul Miresei” to Peștera Muierilor (for more details to see Lascu, 1996).

- The deversation on the epigean and hypogeal karst waters of any kind of the industrial residues doing in this way the water broken by humans, animals or different economical activities. This measure must be establish especially in the case of city that use the cave water (like Aleșd city that use the water from Peștera Alișteu, Târgu-Jiu city use the water from Peștera Izverna, Târgoviște city use the water from Peștera Râiei, Zârnița city that use the water from Piatra Craiului fisures, Constanța that use the water from Caragea – Derem springs). Also it must protect not only the caves but also the hydrological alimentation areas, keep it from deversations, that can pollute the karst water that came out like karstic springs (izbucuri) with the best quality still water (like is the “Îzvorul Minunilor” from Stâna de Vale, “Îzvorul Domogled” from Băile Herculane or “Perla Mehedinților” from Peștera Izverna).

- The modification of hydrological network from karstic region through deviating of epigean and hypogeal water courses to different industrial installations; total assuming of little epigean courses to the city of works water alimentation; building of some small dam lakes called “haituri” for the transport of wood (like existed in Cerna Valley up of Băile Herculane in the 60-th); building of total caption systems of karstic springs; deviation of some water courses for passing in some lacks accumulation to another hydrografical basins (like it is the Cerna – Motru system); building the dams with accumulation lacks on limestone rocks that reduce the downstream debit lacking of poise the subterranean karstic hydrosystem.

- The introduction of terrestrial or aquatic allochtonous species on the epigean karstic ecosystems that could modified the autochtonous trophical cycles, reducing in this way the effective or disaparition of some rare elements.

- The terrestrial or aquatic invertebrate collecting through subterranean environments for another proposes that research. The biggest importance of the biospeological treasure obvious results through the following data: through the 450 species (250 terrestrial and 200 aquatic) more then 350 are endemisms. Despite this fact in Romania is exclusively protected on the biospeological base only the Peștera de la Movile (Mangalia) – that is already known in the world with over 30 new species described from here and through his trophical cycles started with chemoautothrophically bacteria from sulfurous mesothermal waters.

- The Chiroptera (of any species and any zone of Romanian territory) collecting or colony disturbing.

Through these data results the necessity of protection of some caves for their natural treasures, for their beautiful speleothems and some mineralogical rarities, for archeological and paleontological pieces, and not in the last way, for the troglobitic and stygobitic fauna. In this way it’s a necessity to start urgently the study of caves and some other subterranean environments that contain these scientific treasures, and in the same time to put the accent on the inventory of troglobitic and stygobitic species threaten with disaparition. These species must to be included on the “Red List” with animal species that must be protected in Romania and in the Council of Europe. In the same time it must be intensify the ecological education of people in all ways and complete the present with law of protecting speological patrimony, including the biospeological patrimony.
5. Biospeological division of Romania

The idea of a biospeological division of one country had Jeanne who, in 1926, divided France in six regions. More latter Espagnol (1961) did the same thing for Barcelona province and also Strinati (1966) for Switzerland.

To as, the firsts who attempt a some division was Danclu and Tabacaru (1964). They divided the karst from Meridionals Carpathian Mountains (West to Olt) and from Banat Mountains in 8 regions, based on the characteristic troglobitic fauna (especially on Diplopoda, Chilopoda, Isopoda and Coleoptera). The same authors motivated the importance of Timiș-Cerna Couloir like paleobiogeographical barrier. Two years latter, Botoșianeau (1966) divided the Carpathian Mountains (including the Apuseni Mountains) in 8 karstic regions on the base of the six subtroglophilic species of Trichoptera known from the Romanian caves. In 1967, Decu limited five biospeological provinces on the base of troglobitic Coleoptera. The merit of realization of the first biospeological division of all the Romanian karst on the base of all troglobitic endemic species come back to Decu and Negrea (1969). They motivate the division of the country in 5 biospeological provinces by Miocene paleogeographical couloirs and by endemic troglobitic species that are characteristic of these provinces. In the interior of each one provinces they delimitated many other zones, on the base of endemic troglobitic species that are characteristic of these areas, too (Fig. 2). The paleogeographical couloirs that separate the biospeological provinces formed it started with the superior Miocene. We talk about the Danube Couloir that transversally cut the Occidentals Carpathians and about The Timiș – Cerna, Mureș and Olt Couloirs that played the role of zoogeographically and climatically barriers. And about the provinces characteristic elements, these are especially Coleoptera, Diplopoda, Isopoda, Araneae and Pseudoscorpiones.

First province - The Occidental and Meridional Carpathians to Olt - contain small troglobitic elements (exactly neotroglobitic). From this point of view, Decu and Negrea (1969) appealed also to edaphobic elements. In present are known 7 species of Trechinae Coleoptera (Duvalius group of procerus, Duvaliotes), Diplopoda (Romanosoma), Araneae (Nesticus, Leptyphantes), and Pseudoscorpiones (Neobisium).

The second province - The Meridional Carpathians from Olt to Timiș – Cerna Couloir - contain the most diversificate cavernicolous fauna, having many endemic troglobitic species: Coleoptera – Trechinae (Duvalius the group of budai), Bathysciinae (Closania, Sophrochaeta, Tismanella); Diplopoda (Trachysphaera, Polydesmus, Trichopolydesmus, Napocodesmus, Lamellotyphlus, Tiphloiulus, Dacosoma, Anthroleucosoma), Isopoda (Haploptalmus, Trichoniscus), Chilopoda (Harpolithobius, Lithobius), Araneae (Centromerus, Nesticus, Troglohyphantes), Pseudoscorpiones (Neobisium), and Collembola (Onychiurus).

The third province - The Occidental Carpathians, at West to Timiș – Cerna Couloir (Banat Mountains) - contain relatively a few endemic troglobitic species. Also contain all the caves from the great band of Jurassic-Cretaceous limestone Reșița – Moldova Nouă. We speak about Coleoptera (Duvalius milleri, Banatiola vandelii), Diplopoda (Bulgarosoma, Banatodesmus, Banatoiulus and Tiphloiulus), Chilopoda (Thracothebionibus), Isopoda (Banatonicus) and Pseudoscorpiones (Chthonius). Through the edaphobic species important is Euaesthetotyphlus almajensis from Coleoptera.
Fig. 2. – The biospeological provinces established by V. Decu and Şt. Negrea (1969): I – Orientals and Meridionals Carpathians to Olt; II – Meridionals Carpathians between Olt and Timiş – Cerna Culoir; III – Occidentals Carpathians to West of Timiş – Cerna Culoir (Banat Mountains); IV – Occidentals Carpathians at North of Mureş Culoir (Apuseni Mountains); V – Dobrogea. The bolded points represent the cave distribution with endemically troglobites in the I – V provinces (after V. Decu and Gh. Racoviţă, 1994).

The fourth province – The Occidental Carpathians, at North of Mureş Culoir (Apuseni Mountains) – it is relatively reach in endemic troglobitic species, especially Coleoptera (Duvalius redtenbacheri, Drimeotus, Pholeuon, Protopholeuon). Also, are characteristic Diplopoda species (Trachysphaera, Typhloiulus), Isopoda species (Biharonicus, Haplophthalmus), Chilopoda species (Monotarsobius) and Pseudoscorpiones species (Neobisium).

The fifth province – Dobrogea – has a very reach fauna with many endemic troglobitic species, with some characteristics because of speciation in geographical isolation conditions. Before the discovery of Peştera de la Movile next to Mangalia, characteristic was the Coleoptera species (Trechus), Diplopoda species (Trachysphaera, Apfelbeckiella), Isopoda species (Caucasonethes), Araneae species (Caviphantes) and also Pseudoscorpiones species (Acanthocreagris). After the discovery of Peştera de la Movile (1986), the cavernicoulos fauna reached with new species from Coleoptera – Staphilinidae (Medon), Pselaphidae (Decoumarestus) and Scaritidae (Clivina), Isopoda species (Trachelipus), Araneae (Agraecina, Marianana, Lepthyphantes), Pseudoscorpiones (Chthonius) and Collembola species (Onychiurus, Oncopodura). We have to mention that also the stygobitic fauna reached itself with new species from Gastropoda (Heleobia), Hirudineae (Haemopis), Heteroptera (Nepa) etc.
6. Origins and evolution of subterranean fauna

The terrestrial cavernicolous fauna has rapport more complexe with different subterranean environments, comparatively with aquatic subterranean fauna. Although it live in the limits of the same life medium, the two category are different between them by their origin, by their colonization way of the subterranean domain, by the causes that established their penetration and their maintaining in the underground environments and also through the factors that govern their existence in underground (Racovită, 1980).

At the beginning of Paleocene, existed one Mediterranean continent, Mesogeida, which draw itself through the Thyrenian zone, over the Aegean zone to Caucaz. The transgression from the middle Æocene (Lutetian) fragmented the great continent into an occidental part, Thyrrnida, and an oriental part, Aegeida. At it turn, Aegeida stayed fragmented in two parts because the Transgeean ditches to the superior Miocene (Tortonian). Because these case, the two Aegeida faunas, the meridionale and septentrionale parts, evolved separately: poor in the first part and very reach in the second. The cavernicolous fauna to the Romanian Carpathians, especially the Apuseni and the Meridionals Carpathians, became in the most part of it to the septentrionale Aegeida. That explains the diversity and the wealth of it (Jeannel, 1931, Dancău and Tabacaru, 1964, 1969, Decou and Negrea, 1969).

The ancestor’s troglobitic migrations from the septentrionale Aegeida to North and their spreading in our mountains had place with the beginning of the Oligocene’s end and to the superior Miocene. This migration produced itself probably successive, by three main ways. The first way and also the most important tied the North of Aegeida to the West of Meridionals Carpathians, mountains that the Miocene Sea transformed itself into a great archipelago, favored in this way the spreading areas fragmentation and the diversification of the primitive ancestors. The second way of Aegean fauna migration was probably the traversation of Tisia Massive, of Triassic age, the avoiding of Banat Mountains and the colonization of Apuseni Mountains – wich, also is the North-spreading limit of these Tertiary fauna. The third way tied the Bohemian Massive to the Orientals and Meridionals Carpathians to the Olt. On this route could came especially the present edaphic fauna ancestors from the Romanian Carpathians.

The fifth biospeological province, Dobrogea, contains especially a refugial fauna of pontic (Black Sea) and east-Mediterranean origin. The actual species that populate the subterranean environments are probably of Pliocene age, but mostly Pleistocene (Decu and Racoviță, 1994).

In the fauna ancestors spreading that migrated to Romanian Carpathians, a special role, like barrier, played the couloirs formed by Danube, Timiș – Cerna, Mureș and Olt. These four couloirs isolated, some of it beginning with Eocene, another of it started with Miocene, the I – IV biospeological provinces, each one contained northern paleogeic (paleobalkanic) fauna elements. Decou and Negrea (1969) consider that Jiu Valley had, also, a barrier role, because it was heirress of an old sea channel.

The fourth main paleogeographical barriers delimited, in the superior Miocene, the fourth provinces with trogloboitic and edaphobitic fauna ancestors presented in the previously chapter. Inside each province, the Miocene Sea barrier-valleys, less extended, separated some zones: these are 25 biospeological zones separated by Decou and Negrea (1969) on the base of subterranean fauna spreading.
The ancestors of troglobitic and edaphobitic species in the Romania territory arise from the lines of gondwanian and angarian fauna established in Paleocene in septentriionale Aegeida, more precisely, in dinarique region and in Bohemian Massif – the both important spreading center. From these centers, in different periods, these ancestors migrated in our country territory (Decou and Negrea, 1969). Here is, tersely, how was produced these migrations in every five biospeological provinces, showed in the previous chapter.

**First province.** Less in the case of endemic edaphobitic Coleoptera species of *Duvalius* and *Duvaliopsis*, at the outset are the lines that started in Bohemian Massif, who in Paleocene migrated in all Carpathian Mountains, from North to South, until the Olt. Exception is *Duvalius delamarei* who exceed a little the Olt.

**The second province.** All troglobitic fauna have an Aegeidean, Dinaric or East-balkanic origin. Only *Duvalius* from merkli group arrived in Meridionals Carpathian, to the end of Oligocene, through the Tisia Massive. In the Mediterranean ancestor’s migration period, the Romanian territory had a subtropical-tropical climate and the fauna could spread itself unhampered. In present, the most of troglobitic species are billeted between Cerna and Jiu and only some of it between Jiu and Olt. The causes must not looked only in the postglacial climate, in the reduced degree of karstification through East or in the rarety of limestone nucleus between Jiu and Olt, but also in the paleogeographical factor, in glacial climate and in the low degree of expansion of different immigrates lines that early billeted here (Decou and Negrea, 1969).

**The third province.** All the species from Banat Mountains had Aegeidean origin. These ancestors came here in the Miocene; few forward that the great Tortonian transgression. It seams that all these migrations produced themselves independent that there from the Second province. Otherwise it can’t be explain, for example, the total absence from Almâj Massive, that is in the neighborhood (for details to see Decou and Negrea, 1969).

**The fourth province.** The troglobitic fauna from Apuseni Mountains has, also, a Meridional origin. At least the Coleoptera spreading can’t be done through Banat (avoid probably because geological causes) and West Meridionals Carpathian. The ancestors migration was done by the limestone Triassic Tisia Massive (Tisicia, Tisa) with his area between Dinaric Alps, Alps and Occidentals Carpathian – massive that by crashing give birth to the Pannonical Depression.

**The fifth province.** In Dobrogea, the troglobitic ancestor faunas came, also through South. From superior Eocene to superior Miocene, the Aegeidean fauna lines did migrations through Northeast to Crimea and Caucaz, over Dobrogea. Far away in Sarmatian, the South of Dobrogea being under waters, the oldest fauna disappeared or migrated to North. The migrations from South was resume in the Pliocene (Pontian and Dacian) through the ancestors with endogeous and cavernicolous representative, through the Diplopoda (*Trachysphaera, Apfelbeckiella*), Coleoptera (*Trechus*), Araneae (*Lessertiella*) and Pseudoscorpiones (*Microcreagris*).

The origin and evolution of stygobitic fauna from Romania doesn’t have a data synthesis before present, like troglobitic fauna. Otherwise, a same synthesis couldn’t be possible, because little aquatic subterranean environments from Romania was studied intensively, followed the fauna origin elucidation that live there. In this way, studying the springs and phreatical waters through Romanian Plain, Motaș, Botoșaneanu and Negrea (1962) arrived to the conclusion that it can
speak about springs and community relicts, about true “oasis” that represents the last refuges of some fresh water fauna on the disparition way, fauna that prosper here before deforestation. Between these oases with crenobic and phreatobic relict fauna, the most important is Corbii Ciungi (Dâmbovița country), that was declared Natural Reserve.

The problem of underground aquatic refugial environments concern always the Romanian biospeologists but are more things to studied and resolve. In this way, if it is known, until 1957, the Archaeannelida Troglochaetus beranecki is the only one relict of Tertiary seas, refuge in the interstitial of some underground and epigean rivers from Carpathians. Otherwise, the problem of presence and origin of a blind and unpigmentate Hirudinea to Haemopis genus discovered relatively recent in the Peștera de la Movile (Mangalia), still wait to be elucidate.

Because the inferior Danube basin, where exist also the Romanian territory, was the principal glacial refuge of the Tertiary fresh water fauna of central Europe, a team from the Institute of Speology “Emile Racovitza”, with Eugen Nitzu like leader, started the study of the structural and functional peculiarity the unique chemoautotrophically based ecosystem cave from Môvile karst, with a special view of the preservation of some relict species and of the assumption of a glacial endemic subrefuge.

7. Terrestrial and aquatic subterranean organisms

We shortly present the terrestrial and aquatic groups in accordance with their importance to subterranean domain.

7.1. Subterranean flora

The subterranean flora is less diversifi ed that subterranean fauna, especially because the lightness.

Prokaryota (Bacteria) Although have an important role in trophical cycles of some caves, exist also little papers about it. Between them we mention the microbiological study from Peștera Topolnița (Hodorogea, 1972), the study about nitriphicant bacteria from Peqtera Ghetarul de la Scririșoara (Pop, 1949) and the study about chemosynthesis bacteria from Peștera de la Movile (Sârbu and Popa, 1992).


Autotrophical Protista (Algae). Gruia (1973) did a list with 50 cavemicolous alga species, especially from Banat. After him, Geitleria calcarea Fried. an Cyanopichea species is the only one troglobitic alga species known from Romanian caves. Șerbănescu and Decu (1962) published about cavemicolous alga from Oltenia.

Bryophyta Metaphyta (Mosses). This flora group stayed in Ștefureac attention (1970) that studied the mosses from many caves entrance.

Palinology. We must remark the Pop and Ciobanu paper (1950) about the Peştera Ghetarul de la Scărișoara pollen analyze. This analyze established the glacier deposit age to about 3,000 years ago.

7.2. Terrestrial subterranean fauna

In Romania are known about 250 troglobitic species, the most of it endemic, known from 1 – 3 caves. From paleoclimatical reasons, the troglobitic fauna from
Meridionals Carpathians and Banat Mountains is billeted in caves to 300 – 750 m altitudes. These fauna is more billeted to the subterranean environment that the Apuseni Mountains fauna situated between 300–1,300 m altitude and where are predominant the troglophilic species (Decou and Negrea, 1969; Decu and Racoviță, 1994). We will speak only about the groups with troglobitic, troglophilic and subtroglophilic representatives.

**Oligochaeta.** In Romania exist only troglobitic species. From these the most frequent in Romanian caves, especially in Banat and Oltenia, are *Fridericia striata, Enchytraeus buchholzi, Allobophora rosea, Dentrobaena rubida, Eisenia spelaea, Eiseniella tetraedra* and *Octolasium lacteum*. Botea published about them (1970, 1973 etc.).

**Gastropoda.** Are known six endemic species, probably troglobitic species. Five from them are from the *Agardiella* (Orculidae) genus, and *Daudebardia cavernicola ponorica* (Daudebardidae) was described from a Banat cave. The troglobitic species are many more, but most frequently in caves are: *Laciniaria plicata* and *Cochlodina laminata* (Clausiliidae); *Troglovitrea argintarui, Enobisium* (Zonitidae); *Spelaeodiscus triaria* (Spelaeodiscidae), an endemic species to Banat and West Meridionals Carpathians; *Daudebardia spelaea* (Daudebardidae) an endemic species to Oltenia. From them published: Negrea (1974, 1979, 1994 etc.), Grossu and Negrea (1968), Loosjes and Negrea (1968), Negrea and Riedel (1968).

**Isopoda.** Are known 10 troglobitic endemic species from Trichoniscidae, Trachelipidae and Armadillidae (*Haplophthalmus* species in Apuseni Mountains and Oltenia; *Bihariscus* in Apuseni Mountains; *Banatoniscus* in Banat; *Trichoniscus* in Cerna Valley and Oltenia, also in MSS; *Caucasonethes, Trachelipus* and *Armadillidium* in Dobrogea). These are blind (except some species to *Trichoniscus and Armadillidium*) and unpigmentate species. Through troglobitic species, *Mesoniscus graniger* is blind and depigmentate and is frequent in the Apuseni Mountains and Banat karstic zones, also in MSS. Another troglobitic species is *Trachelipus trilobatus* who is a thermophilic species and live in Pesteiera lui Adam from Bâile Herculane. About them published: Radu et al. (1955), Graner and Tabacaru (1963), Tabacaru (1963, 1970, 1973, 1991, 1994, etc.).

**Pseudoscorpiones.** In Romanian caves are known 8 predators and troglobitic species, blind and depigmentate species (*Neobisium* species in Apuseni and Meridionale Carpathian Mountains; *Chthonius* in Banat and Dobrogea; *Acanthocrea gravis* in Dobrogea). From the troglobitic endemic species, *Neobisium blothroides* is frequent in Apuseni Mountains, and *Roncus ciobanmos* and *R.dragobete* in Pesteiera de la Movile and in the environs soil. Two new species from *Chthonius* genus (*C. decou* and *C. scythicus*) was recently discovered from Mangalia soil. About them published: Dumitrescu and Orghidan (1970 etc.), Boghean (1989), C. Curcic and others (1993), Georgescu and Căpușe (1994).

**Opiliones.** Three predators and troglobitic species are most frequently in caves and wet mountains forests: *Holosciotonemon granulatus* (with reduced eyes and a unpigmentate species from Carpathians, especially from the Meridionale Carpathians); *Paranemastoma silli* (especially in the Banat, Oltenia and Apuseni Mountains); *Ischyropsalis dacica* (especially from the Apuseni Mountains, but also in the Banat and Orientals Carpathians). Published: Avram (1972 etc.), Avram and Dumitrescu (1969).

**Chilopoda.** 3 species from Lithobiomorpha order are troglobitic and endemic species: *Harpolithobius oltenicus* (blind, Meridionale Carpathians), *Lithobius decapolitus* (Meridionale Carpathians from Olt to Cerna), and *Thracolithobius dacicus* (blind, Anina Mountains). Another 2 species are probably troglobitic species: *Harpolithobius dentatus* (Southeast Banat, Bulgaria, Serbia) and *Monotarsobius spelaeus* (Apuseni Mountains). The Scolopendromorpha order have 2 endogenous species *Cryptops*, in 2 worm caves: *C. hortensis* in Peștera lui Adam from Bâile Herculane and *C. anomalans* in the Peștera de la Movile, where exist a great permanently troglobitic population. From the troglophilic and subtroglophilic Lithobiomorpha species, most frequently in caves are *Lithobius forficatus* (Meridionale Carpathians and Banat Mountains), *L. agilis pannonicus* (idem), *Monotarsobius burzenlandicus burzenlandicus* (The Carpathians, including the Apuseni Mountains) and *M. pustulatus* (idem). The species from the Geophilomorpha order avoid the caves, except the *Strigamia* species that are more frequently and that have a phyletic anophtalmy. The Scutigeromorpha order is present only in the caves from Southeast Banat and from Dobrogea (*Scutigera coleoptrata*). Published in this way: Negrea (1962, 1964, 1965, 1966, 1969, in print, etc.), Matic (1966, 1968, 1972, etc.), Matic, Negrea and Prunescu (1962), Negrea and Minelli (1994).

**Collembola.** 10 species, 7 from them are endemic, troglobitic species. These belong to *Onychiurus* (Meridionale Carpathians, Banat, Apuseni), *Paronychurus* (Oriental and Meridionale Carpathians, Apuseni Mountains), *Tomocerus* (Oriental Carpathians and Apuseni Mountains), *Pseudosinella* (Hunedoara). These species have or not eyes and are or not depigmentates. 2 species from *Onocopodura*, blind and depigmentate, are from Peștera de la Movile, also found in the surround soil. Another 2 species are guanoptic species (*Acherontides spelaea* and *Mesogastrura ajcoviensis*) and are common in the caves with guano from Banat and Oltenia. Published about them: Ionescu (1912, 1914), Graia (1967, 1969, 1971, 1989, etc.).

**Diplura.** This is a less studied group and has blind and unpigmentate species, most of it from soil. Were described 2 species of *Plusiocampa* from Hunedoara caves and 1 species of *Paurocampa* from Peștera Hoților from Bâile Herculane, founded later in soil, too. Published: Ionescu (1955).

**Thysanura.** 3 subtroglophilic hibernating species are most frequently, through November to March, attract by the most highly temperature from entrance area from the Banat and Oltenia caves *Trigonophthalmus banaticus*, *T. alternatus* and *Machilis annulicornis*. Published: Hollinger (1978, etc.).

**Hymenoptera.** 2 subtroglophilic hibernating species are representative in many country caves: *Amblyteles quadrifurcatorius* and *Exalonyx longicornis*. Another 2 species from *Conomorium* and *Telenomus* genus are probably hibernating forms in Oltenia caves. Published: Bokor (1922), Collart (1941), Decou and Decou (1961 a).

**Trichoptera.** In Romania are some aestivanting subtroglophilic species from *Stenophylax* genus. From these the most frequently are: *S. permistus* and *S. nycterobia* (especially in the Meridionale Carpathians and Banat) and *S. testacea* (in the Apuseni Mountains). In Dobrogea caves they doesn’t exist because the arid climate. Published: Botoșăneanu (1966).
**Palpigradi.** These group have in Romania only 5 species from *Eukoenenia* genus: *E. margaretae and E. condei*, described from West Jiu Valley caves; *E. cf. austriaca*, a troglobilic species mentioned from Peștera cu Lăpt de la Runcu; *E. subangusta* and *E. mirabilis* obtained from washed soil from dolins that surround the great doline Obanu Mare at North from Mangalia. Published: Condé (1954), Orghidan et al. (1982), Georgescu and Decou (1994).

**Araneae.** By the great number of troglobitic species, the spiders are on the second place after Coleoptera. Are known in Romania 29 species of troglobitic spiders. Between them 23 are in Carpathians and 6 in Dobrogea – 5 from them are known from Peștera de la Movile (Mangalia). The troglobitic endemic species are depigmentate and blind or with small eyes. They are from the following genus: *Nesticus* (1 species – Peștera de la Movile); *Centromerus* (2 species – Oltenia and Apuseni Mountains); *Leptophyantes* (2 species – the Orientals Carpathians and Peștera de la Movile); *Troglophyphantes* (3 species – the Meridionale Carpathians and the Apuseni Mountains); *Caviphantes* (1 species – Central Dobrogea); *Agraezina* (syn. *Lascona* – 1 species from Peștera de la Movile); *Iberina* (1 species – Peștera de la Movile) and *Marianana* (1 species – Peștera de la Movile). Also troglobitic species is *Trogloneta granulum*, depigmentate with eyes, known from many European caves, including from the Meridionale Carpathians and the Apuseni Mountains. From the troglobitic species, most frequently in our caves are species: *Nesticus celulanus* (The Carpathian without Apuseni Mountains), *Troglophyphantes herculanus* (the Meridionale Carpathians and the Apuseni Mountains), *Porrhomma convexum* (The Carpathians – especially the Banat and the Apuseni Mountains), *Meta menardi* (the principal compound of the parietal biocoenosis – the Carpathians without the Apuseni Mountains). Published on this theme: Ionescu (1915), Dumitrescu (1979, 1980), Dumitrescu and Georgescu (1970, 1980, 1981), Georgescu (1989, 1994, etc.).

**Acari terrestria.** 4 troglobitic species, blind and unpigmentate hold our attention. The endemic uropodid *Chiropturopoda cavernicola* (described from Peștera lui Adam from Bâile Herculane – true termophilic relict), the nicoletiellid *Labidostomma motasi* (described from Peștera de la Movile) and 2 Rhagidiidae: *Traegaardhia dalmatina* and *Poecilophisis spelaea* (the both commons in the European caves). From the troglobilic guanophagous most frequent are *Trichouropoda orbicularis* (Peștera lui Adam), *Parasitus niveus*, *Euriparasitus emarginatus* and *Hypoaspis miles*. Through the ectoparasite species we mention *Ixodes vespertilionis* and 3 species of *Spinturnix*, frequently on bats in Banat, Oltenia and Dobrogea. Published: Juvara (1967, 1977), Georgescu (1968), Hutzu (1997), Iavorschi (1992), Negrea and Negrea (1971).

**Diplopoda.** By the great number of troglobitic species, this group is on the third place, after Coleoptera and Araneae. All troglobitic species are endemically, blind and unpigmentate and are from the following genus: *Trachysphaera* (Meridionale Carpathians, Apuseni Mountains, Dobrogea), *Polydesmus* (Oltenia), *Trichopolydesmus* (Oltenia and Banat), *Banatodesmus* (Banat), *Napocadesmus* (Oltenia), *Anthroleucosoma* (Banat, including Cerna Valley), *Dacosoma* (Meridionale Carpathians), *Bulgarosoma* (idem), *Lamelotyphlus* (idem), *Typhloiulus* (Apuseni Mountains), *Apfelbeckiella* (Dobrogea) and *Banatoiulus* (Banat). Through the troglobilic species, the most frequent in caves are *Trachysphaera costata* (in all the Carpathian Mountains), *Brachydesmus troglobius* (Banat), *Orobainosoma hungaricum orientale* (Banat and Oltenia). Published:
Lepidoptera. Some hibernating or aestivating subtroglophilic species shelter in the Carpathian caves. Most frequently are *Scoliopteryx libatrix*, a noctuine with deep hibernating sleep through the winter and 2 species from *Triphosa*: *T. sabaudiata* and *T. dubitata*. Published: Căpușe and Georgescu (1963, etc.).

Diptera. It is the most representative group in the parietal biocoenosis. Some species of *Speolepta*, *Corynoptera* and *Neosciara* are troglobitic species with a large area in the European caves. The subtroglophilic aestivating species are from *Tarnania, Limonia* and *Eccoptomera*; the subtroglophilic hibernating species are from *Exechiopsis*, *Culex*, *Theobaldia* and *Helomyza*. Exist also a Mycetophilidae species with both generations: aestivating and hibernating (*Tarnania fenestralis*). In a Romanian cave with guano is always present the guano fly (*Heteromyza atricornis*), and bats are frequently parasites with Nycteribiidae species – each species has his specific parasite. To retain that in Dobrogea the Diptera fauna is tight diversified. Exist only *Tarnania fenestralis*, *T. dziedzickii* and *Culex pipiens*. Published: Decu and Decu (1961), Decu–Burghiele (1963), Burghiele-Bălăcescu (1965, 1966).

Coleoptera. This group contain a great number of troglobitic species and because that is situated on first place. Were inventoried 149 paleo- and neotroglobitic endemic species and subspecies that represented 60% from all subterranean terrestrial taxons. From these 86 are blind and unpigmentate Bathysciinae and 59 Trechinae, some of them with eyes traces (Decu and Racoviță, 1994). The Coleoptera species populate caves from all over the biospeological provinces, sometimes MSS (that is still less studied in Romania). The Orientale Carpathians has only the *Duvalius* species. Trechinae populates the Meridionale Carpathians from *Duvalius* genus and by Bathysciinae from *Sophrochaeta*, *Tismanella* and *Closania* genus. The Banat Mountains have only one species from Trechinae (*Duvalius milleri*) and one from Bathysciinae (*Banatiola vandeli*). The Apuseni Mountains contained the greatest number of troglobitic species: 32 from Trechinae (all from *Duvalius* genus) and 55 from Bathysciinae (*Drimeotus, Pholeuon* and *Protopheleuon*). Dobrogea has 1 troglobitic and with eyes species from Trechinae (*Trechus dumitrescui*), 2 species from Staphylinidae (Medon), 1 from Pselaphidae (*Decoumarellus*) and one from Carabidae (*Clivina*). Also exist guanophilic troglophilic predator species from the genus *Quedius*, *Atheta*, *Aleochara*, *Choleva*, *Catops* and *Nargus*. Published: Ionescu (1912, 1914), Jeannel (1923, 1928, 1930, 1931, etc), Mallasz (1928), Decu (1962, 1964, 1967, 1980, etc), Racoviță (1971, 1973, 1980, 1985 etc), Moldovan (1989), Ienițtea (1955), Nitzu (1997, 1998, etc), Rusdea (1989), Decu and Nitzu (in print).

Siphonaptera. 5 flea species from Ischnopsyllidae family are parasite exclusively on cave bats, without exist some preference to some bat species (like in the Nycteribiidae case). We speak about one *Nycteridopsylla* species, three *Ischnopsyllus* species and one *Rhinolophopsilla*. Published: Prunescu (1959, 1962) and Suciu (1967, 1968).

Chiroptera. Seven bats species can be considerate troglophilic species. Some of them are present in all the biospeological provinces, having in caves hibernating, birth and permanents colonies (*Rhinolophus ferrum-equinum, Miniopterus schreibersi*) or only hibernating and birth colonies (*Myotis myotis*) or generally they didn’t do colonies (*Rhinolophus hipposideros*). Another species is known only from some biospeological provinces. *Pipistrellus pipistrellus* was identifying in some caves in the Apuseni Mountains and in Peștera Șura Mare (Hunedoara) where form an enorm
colony. *Rhinolophus euryale* has a very big summer colony in Peștera lui Adam from Băile Herculane. *Rhinolophus mehelyi* was found only in Dobrogea. Published: Dumitrescu, Tanasachi and Orghidan (1955, 1963, etc), Dumitrescu and Orghidan (1963), Valenciuc (1964, 1969, etc), that signed also the monography “Chiroptera” in the tome series “Fauna României” (“Romanian Fauna”, in print).

7.3. **Aquatic subterranean fauna**

In Romania are known about 200 stygobitic species. We will speak only about the groups that have representative stygobitic and stygophilic species.

**Tricladida.** In groundwaterers where identified 20 stygobitic species from *Atrioplanaria* (Planaridaceae) and *Dendrocoelum* (Dendrocoelidae). *A. racovitzai* is unpigmentate, has little eyes and live in caves, phreatic and springs in Europe (to Romania from Spain). All *Dendrocoelum* species are unpigmentate, blind and endemically and populate the three environments previously mentioned. Published: Codreanu and Bălcescu (1967, 1968, 1970 etc), Gourbault (1971), Motaș, Botoșăneanu and Negrea (1962), Botoșăneanu (1971, etc.).

**Oligochaeta.** 3 stygobitic species from different subterranean environments and they are from *Haplotaxis* (caves from the Aninei Mountains), *Lamprodrilus* (springs) and *Fridericia* (hyporheic). Published: Botea (1968, 1973 etc), Botea and Botoșăneanu (1966), Motaș, Botoșăneanu and Negrea (1962).

**Archiannelida.** One Tertiary stygobitic relict, *Troglochaetus beranecki*, was identified in epigean and cave hyporheic from the Orientale, Meridionale Carpathian and Apuseni Mountains. Published: Pleșa (1957, 1977).

**Hirudinea.** One species, *Haemopis caeca*, probably troglobitic and endemically was recently described from Peștera de la Movile. It is blind and has the tegument unpigmentate. Published: Manoleli, Klemm and Sărboiu (1998).

**Nematoda.** Are known 2 stygobitic species from *Mylonchulus* (in caves and phreatic, from Romania, Yugoslavia, Hungary and Italy) and 1 stygobitic and endemic species from *Anatonchus* (in hyporheic from underground and from surface watercourses in the Apuseni Mountains). One hyporheophilic species from *Mermithidae* (*Discomermis motasi*) was described from Cerna Valley at Băile Herculane. Published: Coman (1961, 1969 etc), Motaș, Botoșăneanu and Negrea (1962).

**Gastropoda.** Are known 4 stygobitic and endemic species: 3 from *Paladilhia* (waters from the Apuseni Mountains caves and springs) and 1 species from *Heleobia* (Peștera de la Movile from Dobrogea). Published: Boettger (1940), Soos (1940), Negrea (1994), Grossu and Negrea (1984, 1989), Bernasconi (1991, 1997), Motaș, Botoșăneanu and Negrea (1962), Negrea and Grossu (2001).

**Ostracoda.** Are described 9 stygobitic and endemic species, without eyes and transparent shell. These species are from *Mixtacandona* (wells, hyporheic and springs from Banat and Dobrogea), *Pseudocandona* (wells from South country), *Phreatocandona* (wells from Oltului Valley), *Kovalevskiiella* (hyporheic and phreatic from many stations) and *Darwinula* (hyporheic in Banat Mountains). Published: Danielopol (1965, 1978 and 1982), Danielopol and Cvetkov (1979), Motaș, Botoșăneanu and Negrea (1962).

**Cladocera.** 8 stygophilic or probably stygophilic species from *Ceriodaphnia, Macrotrich, Chydrorus, Leydigia* and especially *Alona*, populate different subterranean environments (waters from caves and hyporheic, wells, sand filters and water pipes, springs). It is a problem if *Macrotrich bialatus*, described from Bogata brook hyporheic (Perșani Mountains), is stygophilic or stygobitic endemic species;
the key will be possible when the species will be refound and solid redescribed. Published: Negrea (1983, 1994, in print), Dumont and Negrea (1996), Negrea, Botnariuc and Dumont (1999), Motuș, Botoșăneanu and Negrea (1962).

**Copepoda.** Are known 35 stygobitic species. From these 19 are endemic that populate the water caves, hyporheic, phreatic and springs from Romania. The 25 Harpacticoida species are from the genus Elaphoidella, Parastenocaris, Chappuisius, Ceuthonectes, Nitocrella, Spelaeocamptus and Bryocamptus, and the 10 Cyclopoida species are from the genus Megacyclops, Specycyclops and Graeteriella. Published: Chappuis (1924, 1928), Șerban et al. (1976, 1978, etc), Plesa (1969, etc), Damian-Georgescu (1963, 1970), Zincenco (1971), Motuș, Botoșăneanu and Negrea (1962).

**Bathinellacea.** 6 stygobitic species, unpigmentate and blind, from Bathynellidae and Parabathynellidae families populate the hyporheic and waters from Romanian caves. Bathynella genus is representative by 3 stygobitic endemic species in the Apuseni Mountains and 1 species in Peștera Cloșani. Antrobathynella genus has 1 species very spread in Europe and Parabathynella by 2 species (1 endemically in Peștera de la Tismana and the other species is an European species). Published: Botoșăneanu (1959), Botoșăneanu and Damian (1956), Șerban (1966, 1971, 1972 and 1975), Dancău and Șerban (1963).

**Isopoda.** 9 stygobitic species from Asellidae, Microparasellidae and Microcerberidae families populate the hyporheic and phreatic of underground and surface waters. These are from Microcharon (5 species), Proasellus (3 species) and Stygasellus (1 species). We have to mention the presence of a stygobitic population from Asellus aquaticus with blind and unpigmentate individuals in the groundwaters from Mangalia karstic zone, as is also exist in other Europe parts. Published: Motuș, Botoșăneanu and Negrea (1962), Șerban (1964), Negoescu (1989).

**Amphipoda.** From 37 species described from phreatic, hyporheic and cave waters, 26 are endemically. Most of these (31 species) are from Niphargus genus, and the rest of these are from Niphargopsis (1 species in phreatic and hyporheic from Olt and Cerna Valley), Karamaniella (1 species in Banat wells), Bogidiella (1 species in hyporheic from Cerna Valley), Pontoniphargus (1 endemic species in Mangalia aquifer), Symurella (2 species in the North of Orientale Carpathians and the Cluj region). Published: Cărăuşu, Dobreanu and Manolache (1955), Dancău (1964, 1970, 1971, 1972, etc).

**Acaria aquatic.** From almost 100 species that populate the groundwaters, 64 species are stygobitic species. From these 63 are hyporheobic species (characteristic to hyporheic environment) and only 1 phreaticobtic species (Phreatohydracarus mosticus, characteristic to phreatic environments). The most of species are from the Hydrachnellae group that has many families and numerous genus. We mention the following genus Kawamu-racarus, Wandesia, Konsbergia, Atractides, Chappuisides and Bogatia that contain endemically species to the Apuseni Mountains, Meridionals and Orientale Carpathians. All stygobitic species are more or less unpigmentate and have eyes, exception are 2 species (Phreatohydracarus mosticus and Mideopsis fonticola) that are blind, unpigmentate and very flattened. Published: Motuș (1959), Motuș and Șoarec (1939), Motuș and Tanasachi (1946, 1962 etc), Motuș, Tanasachi and Orghidan (1947, 1958, etc), Motuș, Botoșăneanu and Negrea (1962), Orghidan and Gruia (1982).
8. Ecology of the main subterranean environments

8.1. Classification of Romanian subterranean environments

The subterranean or hypogeous (gr. hypogeion = subterranean) domain is very extended. The terrestrial subterranean environments aren’t limited to the caves created by waters in limestone, granite, basalt, salt, gypsum, volcanic tuff, laterit, gristone or in conglomerates. Here enter also the fissure networks inaccessible for humans, the artificial cavities and subterranean superficial compartment (MSS). The soil and his direct annexes, so spreaded on the continents surface – being the biosphere main substrate – after the recently classifications doesn’t be a part of terrestrial subterranean environments, but close by them because some common characteristics. Also, the aquatic subterranean environments are very extended. They have, mainly, the karst water (caves and other cavities kind), interstitial natural environments (phreatic water accessible by wells and drillings, hyporheic, interstitial from lacks and seas), hyporheic environments, artificial environments, artificial environments (water pipes, sand or gravel filter, tanks or other reservoir kind, etc), water emergences (springs) from subterranean to light (karstic springs or all type unkarstic springs).

All these environments (Fig. 3 and 4) are in closely interdependence between them and with the epigeous domains, too. For example, one cave, even Peștera de la Movile (Fig. 5), that in some paleoclimatical conditions favorised the 34 new taxons speciation, is bound by outside by limestone pores and fissures. The presence of the other taxons from Peștera de la Movile, to 48 that were inventoried by now, proves, after us that in nature doesn’t exist closed systems. The most caves are bound by outside mainly by their opening – one or more. They are ventilated and traversed by infiltrate waters, temporary or permanently river, with organically suspensions. The bats feed theirself outside the caves, but they come and loose their dejection (guano) in caves. All these alochthone organically materials are added to the autochthon materials, and constitute the food for troglophilic and troglobitic cavernicolous invertebrate.

8.1.1. Hypogean terrestrial environments

The environments of profound and superficial terrestrial hypogean made the object of the terrestrial subterranean Biology that include the Biospeology (Biospeleology) (sensu stricto) – discipline that studied only the speleic environment. In the succinct presentation of Romanian terrestrial hypogean environments we used mainly the data from the paper of Negrea (1980) bring to today and the nomenclature proposed by Decu, Racoviță and Vaczy (1991), verified and completed with “Dicționarul etimologic de termeni științifici” (“The etymological dictionary with scientific terms”) by Nicolae Andrei (Ed. Științifică și Enciclopedică, 1987). For the history of these environments to see Negrea (1980), Dancău, Negrea (1989) and Camacho (1992).

8.1.1.1. Profound terrestrial hypogean environments

- Speleic environment (gr. spelaion = cave). The cave is only an enclaves of the subterranean domain through the human can take contact directly, but limitatly, with subterranean world. Approximately 90% to Romanian caves are digger in limestone rocks of Mesozoic age, most of these at the end of Tertiary so, geologically speak, on recent data. The most reach in fauna are caves developed on horizontally, little descendent, with subterranean, situated in the depth of limestone
Fig. 3 – The schematically representation of some terrestrial and aquatic subterranean environments, including soil and its annexes (after St. Negrea, 1980).
Fig. 4 – The schematically representation of the limits and space relationships between different terrestrial hypogeous and edaphic environments, including the terminology (after C. Juberthie and V. Decu, 1994).

Fig. 5 – Peștera de la Movile (Mangalia) in vertically profile (after C. Juberthie and V. Decu, 1994).
massifs covered by forests with falling leaves mainly with beech. The complex study of the speleic ecosystems made the object of Biospeology (sensu stricto). The totality of the organisms who populate the speleic environment are named speleon, and every inhabitant of it is an speleicolous (cavernicolous).

- **Cleithric environment** (gr. kleithria = fissure). The fissures network from limestone massifs created by erosion and internal corrosion totaled more vast spaces than realized by caves. In this way the network exist even in unlimestone massifs. By his profound fissuration, inaccessible for human, the water infiltrated itself more deep in the interior of massifs. The greatest constancy of speleoclimatical factors (especially the humidity) and the absence of ventilation made this environment the ideal biotop for troglobites. But, this domain, couled by R. Jeannel "the terrestrial phreatic", remained little known and the specialists opinions are diveded. After some authors, it is populated especially by an eutroglobitic fauna (Racovitza, 1907, Jeannel, 1926, Coiffait, 1956, Negrea, 1980). After others, it is populated only at the first centimeters depth in the interior of wall caves (Vandel, 1964). Using the method of marking and recapture, Delay (1975, 1978) and Racovitii (1978, 1980) proved the presence of troglobitic species in the fissures and tried even the estimation of all effective through a massive (commentary in Negrea, 1980). The cleithric environment is populated by cleithron, compound by cleithricolous organisms.

- **Fodinc environment** (lat. fodina = mine). All artificial cavities digged in rocks or sediments (mine galleries and quarries – especially the abandoned -, the catacombs, the cellars etc) offer to organisms conditions like in speleic environments, also has the construction wood and alimentary rests introduced by human. In France were made studies on mine galleries (Husson, 1936) and quarries (Balazuc, 1954). Among other things, is ascertained that the fauna diversity from mine exploitation gallery digs in limestone is rare that in salt works or copper gallery. In Romania the recherches were occasionally. Thus, in a mine gallery from Poiana Ruscă Mountains, we collected the endemic and troglobitic Coleoptera Duvalius coiffati, known only from a cave to these mountains. In fodinic environments live different trogophilic species from Oligochaeta, Pseudoscorpiones, Araneae, Diplopoda, Chilopoda, Isopoda, Collembola, Coleoptera, and also troglobitic and stygobitic species from Araneae, Coleoptera, Amphipoda etc. The interest of artificial cavities study consist to the possibility to dating more precisely the beginning of species subterranean adventure and in fact if they put the same adapting and evolution problems like in naturals cavities. Fodinic environment is populated by fodinon, and made by fodinicolous organisms.

### 8.1.1.2. Superficial terrestrial hypogeic environment

The superficial subterranean compartment (MSS) was discovered and published by Juberthie, Delay and Bouillon (1980) in France. It is large spread in orogenetic regions from temperate zones and well represented in Europe. First data for Romania was published by Juberthie, Delay, Decu and Racovită (1981), and the data about fauna dynamics by Racovită and Șerban (1982) and Racovită (1984).

The MSS is the subterranean environment compartment that has directly contact with inferior soil horizon and can have many meters in depth (Fig. 4). If the soil is in thin layer, we can touch the MSS digs only few centimeters. After Juberthie and Decu (1994), MSS is presented with two aspects: like intercommunicated microspaces in valley versant scree or like fissures in superficial zone of mother-rock. The classic MSS has his origins in mechanic erosion phenomena: to frost
shattering bound to altitude; to natural or anthropical disaparition of protective soil, to Quaternary glaciating periods. It is connected with profound subterranean environments, including with caves, by depth fissures of mother-rock. It is obvious differ from endogous environment from above (respectively from soil B-horizon), by texture, more great porosity and by its fauna that contain troglobitic species from Coleoptera, Miriapoda etc. These facts must carry on to the revise the term. For this moment, this environment, very stretched in Temperate Zone, is still very little know and it still waits its researchers. In 1983, Decu and Racovită proposed the replacement of MSS term with colluvic term (lat. colluvium = detritus matter accumulation on versant base), but it seems that this wasn’t accepted (including derived terms colluvion and colluvicolous).

Note. In the case of uncovered rocks, like are green schists from Dobrogea and from other country zone, the day fissures network constituted the lithoclasic environments (gr. lithos = stone and kasis = cracks – defined by Orghidan and Dumitrescu (1964) – the derived terms being lithoclasion and lithoclasicolous. After Negrea (1980) it speak about an ecotone, to a transition environment situated in epizonal sector of fissured massifs, and its fauna is in a directly dynamic network with neighboring environments (speleic, edaphic, trees’ bark, MSS), but without being from one of it. This environment represent a preferential habitat from many arthropods that has here populations with biggest densities.

8.1.2. Edaphic environments

These environments are richest in fauna if they belong to beech and oak trees forests situated on clay-limestone rocks or on dolomites. Although, different cavernicolous species, edaphic fauna present analogous characters from cave fauna: it is frequently unpigmentate, with reduced or without eyes, with body elongated, the insect wings are reduced, etc.

- Euedaphic environment (gr. eu = good, edaphos = land, earth). The synonyms terms: endogeic environment (gr. endon – inside and ge = earth), proposed by Pruvot (cf. Racovitza, 1907). This environment is made by mineral soil that is, as a rule, under humus layer. The soil microspaces are populated by edaphon, made by eudaphicole organisms. The soil biocoenosis are the study object for Edaphobiology or Pedology (gr. pedon = soil, land).

- Pholeic environment (gr. pholeos = cavern, cavities). This term is synonym with microcaverns environment created by Falcoz (1914) for the lairs, the nests and galleries builded by the soil animals; also him created the term pholeophilic to appoint the fauna who live in this environment. We speak about the lairs of some mammal’s digged on soil; about anthills; about wasp and other Hymenoptera nests; about mole, moll cricket and some insect’s larva galleries; about birds nets build in banks or rock cracks etc. The microcaves biocoenosis made from parasite or commensal Insecta, Arachnida, Crustacea and Miriapoda that live frequently with birds and mammals. The density and abundance of pholeophilic fauna depend especially from the food offered by the respectively biotops. The species specifically to the pholeic environments present adaptations through the subterranean life (for example: the mole and molecricket have the anterior legs transformed in shovels). The most pholeophilic species became from the epigean light-running fauna. Some of them are common to the microcaverns and the guano from caves where they arrived for the food looking (for ex. Atheta and Quedius through the Coleoptera) – in
another words they are in the same time pholeophile and guanophile. The pholeic environment is populated by pholeon made by the pholeophile organisms.

- **Hemiedaphic environment** (gr. hemi = on a half and edaphos = land, earth). Gisin (1943) created the term for the soil humus horizon situated between mineral soil and forest litter. This environment has the most diversificated and most reach fauna from all edaphic environments. After Grassé (1974) “the forest moss and humus constituted, for insects, the caves anteroom”, underlined in this way the hemiedaphic environment importance like species reservoir for population of subterranean environments, also the humus role like premier environment in that was prepared physiologic ancestors that migrated by network fissures contributed to the forming of cavernicolous fauna. The permanently exchanges between species from edaphic and subterranean environments explained the common fauna of these, and the particularities of each environments explained the characteristic fauna (Negrea, 1980). The hemiedaphic environment is populated by hemiedaphon with hemiedaphicolous organisms.

8.1.3. **The directly annexes of the soil**

- **Lapidic environment** (lat. lapis – idis = stone, marble). The more or less plugged in soil stones maintain the humidity from that profit the edaphic organisms, especially. Derived terms: lapidon for biocoenosis and lapidicolous for organisms that compound it. This environment doesn’t be mix up with epigeic environments from nude rocks, named petric (gr. petra = stone, rock) or lithic (gr. lithos = stone). From these are the derived terms petron or lithon, and petricolous or lithicolous.

- **Tanathostromic environment** (gr. tanathos = death, stroma = cover, carpet). The forest litter is made by death leafs layer, branches and other vegetal rests being in different decomposition phases. It is a favourable environment for a lot of organisms who are looking for shelter from sun and food. Derived terms: tanathostromon for biocoenosis and tanathostromicolous for the organisms that compound it.

- **Saproxylic environment** (gr. sapros = rotten, xylon = wood, forest). Branches and all kind of rotten woods made an ideal biotop for saprophagic species and the predator’s species that hunting it. The saproxycolous organisms made the saproxylon.

- **Muscicol environment** (lat. muscus = moss). The mosses represent a biotop populated by muscicolous species that made the muscion.

8.1.4. **Hypogean aquatic environments (stygal sensu lato)**

The aquatic permeable hypogean environments in great and in little are the object of Subterranean Aquatic Biology or Stygobiology. In a short presentation of existing subterranean environments in Romania we used especially the data from the papers of Negrea (1980) actualized and the classification proposed by Botosaneanu (1986) in “Stygofauna mundi”. The names were verified with the speiological and phreatobiological terms dictionary by Motaş (1976) and with the etymological dictionary with scientific terms by Nicolae Andrei (1987). The stygobitic term was introduced by Thienemann (1925) to defined the aquatic organisms specifically to subterranean environments – to these the following derived terms stygal, stygobiology etc. (gr. Stygios or Styx, lat. Stygius or Styx-ygis -one of the five rivers from Hell). For the history of aquatic subterranean environment studying to see Negrea (1980), Botoşaneanu (1986), Dancău, Negrea (1989) and Camacho (1992).
8.1.4.1. Permeable environments “in big” (karstostygal)

- Cave waters. It can be differentiate 3 zones:
  1. Percolation zone (the vadose zone). In this zone the water accumulate itself in “gours” (rimstone dam), stalamite heads, stalmitic dam lacks, in different depth on floor with or without guano etc, the trickeling walls on it have a hygropetric fauna (Orghidan, Dumitrescu and Georgescu – 1962).
  2. Circulation zone (epiphreatic or amphibian zone). This zone represent the permanently or temporarily subterranean watercourses, resting water in dry temporarily valley etc.
  3. Drowned zone (phreatic or saturated zone) that is accessible or not by sump lacks or by drillings. In some cases the water can be mesothermal (for example the Peștera de la Movile: 21°C).
- Waters from artificial karstic cavities. Are the waters that bring together in mine excavations, salt mines etc.
- Waters from inaccessible natural karstic cavities are the waters bring to light by artificial processes like: galleries died in rock, artesian fountains obtained by drillings etc.
- Another types from karst waters exist only in tropical zone (“cenotes”, “casimbas”, “grietas” etc.).

8.1.4.2. Permeable environments “in little” (interstitial)

In this category are grouped the groundwaters that imbue porous habitats.
- Artesian or not groundwaters imbued porous rocks from very big deep. These are, for example, the water from Romanian Plain (Motaș, Botoșanescu, Negrea, 1962).
- Phreatic waters s.str. (gr. phrear – phreatos = well, spring, fountain). Daubrée created this term (1877). Synonym term: eustygal (eu = good). Here enter the alluvial unartesian waters that form the “nappes-phreatiques” from little and medium deep, accessible by wells dig to some distance from watercourses – never in major riverbed (the flood plain) and also never in the minor riverbed (the riverbed through flow permanent or temporary the water). The phreatic water imbues the porous sediments above the impermeable layer.
- Interstitial waters from mobile sediments. In this category are included all types of interstitial waters. These are:
  - Hyporheic waters s. str. (gr. hypo = under, rheo-ein = to flow). Orghidan (1955, 1959) described this environment under the name “hyporheic biotope”. Synonym terms: hyporheal (gr. idem) created by Schwoerbel (1961), rhithrostygal (gr. rhithron = that flows), polamostygal (gr. potamos = river). These are the interstitial waters that accompany the flowing waters from minor and major riverbed (Fig. 6). These are supplied by the epigeic water, to a part, and by phreatic water that is in permanently or temporary contact with it and in concordance with level oscillations of “nappes phreatiques” (water table), on another part. In the case of Melanie from these two water types we will have an epigeic and subterranean fauna melange. From this motive Danielopol (1982) consider the hyporheic an ecotone.
  - Hyporheic waters from caves. Are the interstitial waters that accompany the subterranean courses, named troglorhithrostygal (gr. trogle = cave, rhithrosty gal = see above).
  - Interstitial waters from sediments on the bank stagnant fresh waters. These environments are known under different names: limnostygal (gr. limne = lake, pool),
Fig. 6 – The hyporheic environment of one water course and the its supplying by the superficial water in amount by a gravel bank (1), by the phreatic waters (2) and by the karst waters (3) (after C. Juberthie and V. Decu, 1994).

**hygropsammon** (gr. hygros = wet, psammos = sand); **eupsammon** (gr. eu = good, psammos = sand); **limnopsammal** (gr. limne = lake, pool, psammos = sand) etc.  
- **Interstitial waters from sand and gravel artificial filters** for the obtaining of drinking water.
- **Sea beaches interstitial waters**, for all sediments, if they are not washed by waves contained also the subterranean organisms. They are known like **thalassopsammal** (gr. thalassa = sea, psamon = sand), term created by Remane (1951) to the sea sand between epipsammal (through the surface) and endopsammal (through profound).

- **Interstitial waters from sea sublittoral** that are all the time under water contain organisms that have adaptations to this life.
- **Interstitial waters through sediments from bank salty and brackish lakes**. These still wait their researchers.

- **Waters from trickling colluvial and eluvial “nappes”** including epikarstic “nappes”. Synonym terms: **pedostygal** (gr. pedon = soil), **hypothelminorheic biotope** (gr. hypo = under, thelminos = mud, rheo = to flow), described by Mestrov (1962) like wet, mud and clayey zone, covered by leaves, humus and grasses and irrigated by little line waters.

- **Groundwaters from anthropic installations**. Here are drinking waters from pipes tanks and other reservoirs, came principally from phreatic.

- **Groundwaters came to light by springs**. In this category are all kind of springs: limnocrene, rheocrene and helocrene supplied by water table karstic springs, thermomineral springs etc. Because we speak about ecotone environments, the spring contain a melange of epigean and subterranean fauna.

8.2. **Subterranean environments characters**

8.2.1. **Subterranean terrestrial domain**

The subterranean climatologically researches demonstrated that the subterranean environments (especially the speleic environment) have a relatively stability. The caves are in an energetic circuit that due it some characters. The most
important physically characters are: obscurity, temperature, relatively humidity, ventilation and air composition – each of it having a role of limiting factor for the cavernicolous fauna. Except these factors, is another one that is the most important through the fauna: the trophic factor (the food). In its absence life doesn’t exist. All these factors are shortly presented in the follow paragraphs.

- **Obscurity.** By rapport with the entrance size and shape, the light penetrates more or less in the cave depth. In this case we have 3 zones: the photic zone (directly lighted), disphotic zone (with semi-darkness) and aphotic zone (with total obscurity). The ecological consequences are important: the absence of plants with photosynthesis (including the trophic cycles based on it) and the absence of circadian rhythm (the day-night alternance). In the light absence, the strictly cavernicolous animals are depigmentated (the tegument pigments became useless), light-runings (with thin tegument, without pigment protection, being vulnerable to UV) and anoptalmic (with reduced eyes to complete disparition). In darkness, the vertebrate hypophisis it’s not stimulated no more, these have repercussions to reproduction.

- **Temperature.** The medium temperature to the profound zone of caves with one entrance in Romania is 7–12°C, so very approached to the year medium temperature from outside (in the same zone). This value correspond to the temperature optimum of troglobites, that are not strictly stenotermic: the lethale limit is under −5°C, and the upper temperature sometimes is over +20°C. If in the cave profound zone of this type is a relative constancy (in Peștera Cloșani, for example, the year amplitude is about 3°C), in little caves, permanently ventilated, the amplitude is over 15°C. Generally, the year temperature variations from profound meroclimatic zones has an amplitude about tenth degrees order, and to microclimatic level about hundredth degrees order. With all these, the variations are sufficient to influence the physiological processes of troglobitic species and determined the biological rhythm modifications. Exist in Romania two caves from another type. One is the Peștera lui Adam from Bâile Herculane that has a gallery traversed by an air current about 40°C with vapors that generated a warm air purse about 29°C into a neighbor hall, with big guano deposit. This cave represents a tropical subterranean oasis in a temperate zone, populated by a biocoenosis with Acari and Chilopoda thermophilic species with meridionale origin. Another particular cave is Peștera de la Movile (Mangalia) feeding with mezothermale water (about 21°C) with H₂S. To opus pole it must be mentioned the Peștera Gețarul de la Scărișoara, with a very big denivelation (about -105 m), that contain a cold air purse generated by a big perennial ice deposit (about 70,000m³).

- **Relative humidity.** Generally, the air humidity from Romanian caves is about 95 – 100%, and the troglobitic species are stenhygrobitic adapted to this atmosphere approached to saturation. Having the tegument thin and without a waterproof layer to do not lost water from organism, they can’t leave from speleic environment. Instead, by the same reason, some stygobitic species, for example Niphargus sp., can resist in the cave atmosphere when water dry or when they go on land to search another water. The maximum relative humidity values are in summer and the minimum values in winter. The cave atmosphere is so wet when is less ventilated.

- **Ventilation** represent an unfavorable factor through troglobitic species even through some troglophilic species by the air drying action and to the mechanic action received by the sensitive hears, well developed to some species. As a result,
in galleries with air currents we don’t find troglobites, and in the presence of some currents even thin (by centimeters on seconds) in the “contact cover” can be determine the absence of troglobitic species.

The thermocirculation peculiarities that characterized a cave are determined especially by its topography, and in a special way, by the number entrance size and their space position. Based on these criteria, Racoviță (1975) distinguished many cave types (Fig. 7). Caves with one-directional ventilation (at least two entrance situated in different points and cotes, having a unique current between them that determine the absence of troglobitic species). Caves with bi-directional ventilation (with one entrance to that level formed two convection currents: one superior imergent and another lower current emergent, with influence to a limited area). Caves with intermittent bi-directional ventilation that can be ascendant caves (so named “warm caves”) or descendent caves (so named “cold caves”). These base functional models know in real so many another topoclimatically cave types. Because these Racoviță (1975) considered necessary to define two climatological levels of inferior rank: the meroclimate and the microclimate. The meroclimate has some characteristic phenomena only to some zone of the cave. Thus a “perturbation meroclimatic” from the vestibular zone liable to the meteorological factors through the exterior and a “stability meroclimate” in the profound zone. The microclimate include the mass and energetic changes localized to the “cover contact” layer, that is the air layer at the most 5 mm thickness (Juberthie, 1969) who is in direct contact

Fig. 7 – The cave classification after the ventilation way: A – cave with one-directional ventilation; B – cave with permanent bi-directional ventilation; C – cave with intermittent bi-directional ventilation (in the upward cave case); D – idem (the downward cave case) (after Gh. Racoviță, 1978, modified by Şt. Negrea, 1980).
with the substrate (rock, concretions, filling deposits) and where the true life environment of terrestrial cavernicolous.

Air composition. On the Earth exist caves with oxygen poor atmosphere; in that conditions can live only a few species, all troglobitic species, capable to adapt their metabolism to the hypoxy conditions. Also exist caves with CO₂ concentrations equal or upper to the exterior; nevertheless, they have a rich troglobitic fauna.

In Romania exist a cave unique in world, Peștera de la Movile, with the atmosphere and water rich in H₂S and poor in oxygen. For all that, in these extreme life conditions live tenth terrestrial and aquatic subterranean species, most of them with permanently populations.

Trophic factor. The alimentary resources are responsible in a large measure with the repartition and abundance of the cavernicolous fauna. In the photosynthesis plants absence (the primary producers), the organic matter from the trophic cycles base through the caves has an allochtonic origins. The autochtone Bacteria that are developing, principally, in the decalcification clay generating by chemosynthesys only some aminoacids and vitamins necessary the growing and the developing of troglobitic species. Exception of it is the Peștera de la Movile where the tyobacteria (sulphurous Bacteria) are at the base of an autochtonous chemosyntetically production, starting with H₂S from the mesothermal water that alimentated the cave. The allochtonous organic matter overtake in caves through many ways:

- by percolation (the most important way): the meteoric waters crossing the leaves, humus and soil deposited on limestones are load it with free aminic acids, free glucides, dissolved in suspension organic matter, animal or vegetal detritus etc. after that they infiltrate these in the fissures network;
- by the watercourses that enter through the insurgences, loaded with mud and organic rests (leaves, branches, logs, small and big animals, death or alive, etc.);
- by air currents that carry pollen, fungal spores and microorganisms of any kind (airplankton);
- by gravitation: vegetal and animal rests fall down from the slopes and accumulated them on the cave entrances or on the pothole bases;
- by the active penetrating: invertebrates that accidentally enter (trogloxenes) and dead inside; mammals that dig their gallery in caves; bats that alimentate outside and produces the guano deposit, pline with organisms (Bacteria, Actinomycetes, Fungi, etc.); visitors that let alimentary offals of any kind.

The only one kind of autochtonous organic matter is the matter became through cavernicolous animals discomposing death in the zone cave where exist reductors. In the primary producers absence (the photosynthesizing plants) and least in the presence of insignificant bacteria (exception Peștera de la Movile), the cave trophical cycles are simplified (short), formed by primary consumers (detritivorous) and secondary consumers (I and II level consumers).

8.2.2. Subterranean aquatic domains

The most important physic characteristics of the aquatic subterranean environments are: obscurity, temperature, debit, speed and water level, the oxygen content and the organically matter, trophical resources, granulometry (in the interstitial environments case) and salinity (in the salt waters case). We will refer, shortly, to the first four factors.
Obscurity and temperature are the common factors of the terrestrial subterranean environments. It can be added the fact that the groundwater has, generally, a lower temperature that the environing atmosphere (to 1 degree) because the evaporating and growing to depth. Thus, the thermic optimum of Niphargus species is between 8–14°C, and the lethal limits are between -0.5 and +24.5°C.

Debit, current and water level are tree different elements of hydrological regime. In the big permeable terrain (karstostygal), the meteoric water is absorbed immediately through fissures, crosses the percolation zones through the oblique flowing level. If the alimentation volume cross over the flowing capacity, the drawned level zone grow flooded partially or totality the cave galleries. As a result, it produces a mixture of the aquatic fauna from different biotopes, and the terrestrial fauna surprised and is drown. Result that the debit variations make, the extend of the aquatic domain to be very variable in space and time, the suddenly growth of water level in the abundant raining time (named in Romanian language “viituri”), especially, action like a very limiting important factor.

Karstic water chemistry is very important by the point of hydrological and mineralogical view. It is responsible of the cave digging (by corrosion) and of their clogging (through concretioning). The waters from limestone massifs have more calcium and because of it are incrusted. The dissolved salt mass varied with the water pH rapport that generally is neuter or poor alkaline. Between the calcium contain, alkalinity and pH exist closed relations. It is possible to be a bound between seasonal variations to these factors and the dynamic of aquatic fauna. The oxygen contain has values comparable at least to these to the epigeic water – in the case of underground torrents touched saturation. Exist also waters with a lower contain in oxygen populated by stygobitic species adapted to hypoxya (Juberthie and Decu, 1994). Because the green plants are absent through the cave in the aphotic zone, the oxygen presence is explained by a passive dissolving on water and air contact surface and by the lower stygobitic biological activity (the utilization of dissolved oxygen for the fermentation or respiration is very small). The organically materials dissolved in water, although in lower quantity, doesn’t mess from the underground waters (1 mg O₂/l like 2-4 mg O₂/l in epigean waters). They came especially from the dejections and from the death animal discomposing. In the summer time the quantity grows by the washing of soils through the exterior by the meteoric water.

Trophic resources are very diversificated, essentially or exclusively allochthonic. The percolation and flowing waters introduce in underground aquatic environments all kind of organically matter of vegetal nature, including epigean invertebrates (insect larvae, crustaceans, gasteropods, etc.). A part from bat guano deposits hand in, also, on the bottom of the stagnant or flowing cave waters, and the silt (limon) from these waters is consummated by different underground bionts, being very nourishing. It contain different organically matter, bacteria (10 – 250 millions on 1 gram of dried silt), microscopic fungi, protozoa’s, oligochaets, nematods, aminoacids, even vitamins from B group. The Ginet experiences (1955) demonstrated that Niphargus can survive and developed eating clayey silt. The silt consumers are also different copepods and isopods (Fig. 8).
Fig. 8 – The main trophical relationships in an aquatic speleic system. The continues arrow shows the decomposition, the interrupted arrow shows the utilisation (after Ţ. Negrea, 1980).
8.3. Ecological categories and the adaptation of subterranean life

8.3.1. Subterranean terrestrial fauna

The cavernicolous fauna represents an heterogeneous group. By the adaptation degree to this environment, the biospeologists created the ecological categories and classifications. By all this, the classification proposed by Schiner (1854), assumed by Racoviță (1907), and completed and modified by Jeannel (1926), Ruffo (1957), Motas (1962, 1976) and others became now classically. After this classification can be distinguished troglobitic, troglophilic, subtroglophilic (or regulate trogloxenic sensu R. Jeannel), trogloxenic, parasitic, guanobitic and guanophilic animals. These categories are in first place coenotically units, the differentiation based on ecologically criteria and in the second place on the morphologically, physiological and historical criteria.

- **Troglobites** (gr. *trogle* = cave, cavern, *byon, bionton* = live organism) live and reproduce themselves only in the cave profound zone (exceptionally, in similar conditions, also at the entrance zone or MSS) where they form populations, regularly small. The live in closed relations with the physique factor particularity of the underground environment. Liable to a long evolution, the troglobitic species present morphological and eco-physiological adaptive characters, extremes sometimes, that can’t allowed it to survived outside.

A. Morphological adaptations confer to troglobites a peculiar aspect that can be meet to all groups of animals with representatives in the hypogean environment, but also in soil. Generally, it speaks about morphological characters of regressive evolution, as following.

**Habitus.** The body form is going to total or partial narrow, simultaneous with the slender appendages (legs, antennas). Thus, the Coleoptera species have a slender head and thoraces, but the abdomen is spherical because the elitra are swell to keep under them a wet air reserve necessary to the tegumentary respiration. This phenomenon is named “the false physogastry”. The size is, generally, biggest to the epigean species in the same groups.

**Depigmentation.** The melanin pigments from tegument are absent partially or totally, because the body became white and sometimes translucid. Exist also species without pigment that if they are draw out they will be colored easily. That proves that they have still the ability to make pigments.

**Anophthalmy.** In the absence of light, the troglobites don’t have functional eyes. The lost of sight is caused by a long and historical process. The proof is that exist species with eyes more or less reduced (microphthalmic species) and species without eyes (anophthalmic species), the regression can affect or not the optic nervous centers. Instead, the species that don’t have eyes have tactile organs hypertrophiate.

**Apterism.** In the case of cavernicolous insects, the wings may be reduced to disappearance the capacity of fly (micropterous forms) or totally reduce (apterous forms).

B. Ecophysiological adaptations are attached by the way of life, by the place that the animals have in subterranean trophic cycles. We will present briefly.

**The absence of circadian cycle.** The absence of day and night alternance caused by the permanent obscurity and by the relative steadfastness of the temperature and another physical factors, make the activity of troglobites do not has any periodicity (the activity periods alternate with the rest periods).
Ecological stenothermy. Generally, the troglobites supports large limits of temperature so they are not strictly stenothermous how is well known. For all that, it can speak by an ecological stenothermy in the way that in thermic heterogeneity conditions where they live, the animals are going to be placed more closely to their preferred temperature, that are in reduced limits (optimum thermic). Because that it result seasoning migrations made to different environments of the karstic massive, from the profound levels to MSS (Racovită, 1980, 1996).

Stenohygrobiosis is bound by the relative humidity of the caves. The reducing of regulation capacity of the water losts from the body obliged the troglobites to live only in caves or in very wet zone of the cave. From this result that all are stenohygrobites.

Metabolism reducing. The experiences demonstrated that the respiration intensify (the oxygen consume) of troglobites is inferior by compression with the relative species from outside. So result that a reduced metabolism caused a motrique activity more slowed (also the predators’ species from the trophic cycles, like Araneae and Chilopoda species are moving more slowed than their relatives from the forest litter).

Reproductive cycle contracting. This contraction was distinguished to the first time by Deleurance-Claçon (1950) in the Subterranean Laboratory from Moulis (France). The females from troglobitic species Speonomus (Coleoptera, Bathysciinae) don’t deposit tenth eggs like the outside species, but only one, very voluminous and rich in vitelus. The larva, instead feed and moult itself, to some hours after hatching closed itself in a box made by itself from clay where stay months. After one year it transform in pupa, then in an adult capable to live 4–5 years. So result that the reproductive cycle phases are also compressed, the period is 5 to 10 time longer than the epigean species. To Aphaenops species (Trechinae) the enorme eggs are deposit one by one to 20–30 days interval, without seasoning cycle. A Spelaeoglomeris species (Diplopoda) deposit also one egg only, closed in an ootheca made by wood rests, from that after 4–5 months get out a larva with 6 pair of legs, stage that is absent to the Glomeris species developing from outside. And the examples can be more, from all it can result the contraction of reproductive cycle.

Are two kind of troglobites: paleotroglobites that don’t have any relative to outside, so veritable live fossils, and neotroglobites, recent forms, that have this kind of relatives. Also between edaphobites exist animal groups without closed relatives in the epigean fauna. Like that are leptotiphlites Coleoptera that, by the paleotroglobites analogy, can be named paleoedaphobites, true live fossils in soil (details in Negrea, 1980).

- **Troglophiles** (gr. 
  trogle = cave, cavern, philos = loving, amateur, friend) live and reproduce themselfs likewise in cave and outside. They have populations in underground, sometimes important, depend not only to the speleic environment but also with the food that they have to their disposition. They don’t have morphological characters of regressive evolution. The troglophiles are not light-lovers and hygrophilic species, with big populations in the edaphic environment and his annexes. They don’t have diapause, can be met in the profound cave zone, but prefer the vestibular zone.

- **Subtroglophiles** (lat. sub = under, 
  troglo = cave, philos = loving) live in cave but don’t reproduce them that only outside. The term was introduced by Pavan (1944) for the animals that, with all their preference for the cavernicolous
environment never reproduce theirself there. In strict sense, the subtrogliphiles are insects' species (Diptera, Lepidoptera, and Trichoptera) that have their diapause of their biologic cycle in the winter (hibernating species) but also in the summer (aestivating species). This species made the parietal biocoenosis (association) base (details in Negrea, 1980).

- **Trogloxenes** (gr. *troglo* = cave, cavern, *xenos* = stranger, guest) are animals from the epigean environments that occasionally enter in the vestibular caves zone, where they survived a time period and can reproduce them, but without made population here. The term was created by Racovitza (1907) with this sense. After Negrea (1980) the trogloxenic species are also animals that arrived in caves unwittingly, for example, rallied by the percolation waters or brought in the suddenly growth period of the water levels because the abundant rains in the spring by the epigean rivers that enter in caves by opening and swallet. Thus, we observed in the ceiling of Peștera Comamic, above the Pluto's siphon, from the subfossil gallery, to hundredth meters profounding, many Odonata adults, still alive, here hatched by the larva rallied by the Ponicova brook. We found also a small trout and crawfishes captive in the water eyes rests after the withdrawal of the growingth waters of the Comamic brook in the Peștera Exploratorii '85 etc.

- **Guanobites** (span. *guano* = bats and birds excrements, *bios* = life) make a special group of cavernicolous species that have their life exclusively in the cave guano, where they feed them and where they reproduce them, without present adaptive characters to the underground life. For these guanophagous, the trophic factor is the only a limiting factor. Jeannel (1942) distinguished also the guanophilic species that prefer or look for guano, without exclusively depend to this food resource and that can be found also outside the caves, on other trophic substratum.

- **Parasites** are the species directly bounded by their hosts, ecologically and biologically speaking (food, environment factors). They present regressive evolution characters not bounded by the speleic environment but by their parasitic way of life (depigmentation, anophthalmy, and wings reducing).

### 8.3.2. Subterranean aquatic fauna

Like the terrestrial subterranean fauna, the aquatic fauna represents a heterogenous group. For the adaptation degree differentiation to the subterranean aquatic environments, Thienemann (1925) proposed the replacement of the root *troglo* (gr. *troglo* = cave) with *styg* (from the gr. *Stygllos* and lat. *Stygius* = Hall river). As a result, today are used the stygobitic, stygophilic and stigoxenic terms. If we speak only about the phreatic fauna (s. str.) we use the terms created by Motaș (1962, 1963, 1976): phreatobitic, phreatophilic, phreatoxenic (gr. *phrear* – *phrestos* = well, fountain, spring). If we refer as to the interstitial sand fauna we use the psammobitic, psammophilic and psammoxenic terms (gr. *psammos* = sand). About another terms to see Motaș (1962, 1976) and Botosaneanu (1986). In the last decades of the XX-th century, especially under the scientific authority of Botosaneanu (Amsterdam) was created the international periodical "Stygology" and appeared the monograph "Stygofauna mundi" (1986) outlined in this way a new biological science the Stygobiology that occupied itselfs with the underground aquatic environments and their fauna.

- **The stygobitic species** leave and reproduce them only in the groundwaters. The morphological adaptations (the body form, unpigmentation, anophthalmy) and the eco-physiological adaptations (the circadian rhythm absence, the ecological stenothermy, the metabolism reducing, the reproductive cycle contracting) meet to
troglobitic species are found also to the stygobites. They were studied especially to the Subterranean Laboratory to Moulis on tricladids, copepods, amphipods, isopods and Proteus. They proved that tricladids have a lower reproduction speed, that Speocyclops can’t make an oviger bag like his relatives from outside, but deposit the eggs one by one, that the Proteus anguinus, the only stygobitic vertebrate from Europe, with serpentiform body, the reduces eyes hides under the skin, unpigmentated (but it was born pigmentate) and with lower movements, deposit a single egg mass with tenth eggs from that will hatch the larvae, but only in the natural environments. Many things from this place to see Negrea: “Prin pejterile lumii” (“Through the world caves”), Ed. Sport – Turism, București (1979). And the examples can continue.

- **The stygophilic species** leave and reproduces also in the underground and epigean waters. They haven’t adaptations to the subterranean environments.
- **The stygoxenic species** are occasionally or accidentally guests to the subterranean environments.

### 8.4. Subterranean ecosystems

The ecosystems of the subterranean domain are so varied and make a big biosphere macroecosystem that, despite the world efforts, are far away to be known to the level of outside ecosystems. Between the mezoecosystems, better studied are the temperate and tropical caves from the North hemisphere with their terrestrial (parietal, filling deposits, profound zone floor and guano) and aquatic ecosystems human accessible (the temporary percolation zone and amphibian zone).

#### 8.4.1. Terrestrial speleic ecosystems

Holding account only the meroclimatic factors we can distinguish in a cave three zones with variable dimensions: a vestibular zone (entrance zone), directly or diffuse lighting, sometimes with shadow plants and hygrophilic plants on the floor filling, with turned green walls by algas and mosses and with the big abiotic factor amplitude values, but under the exterior values; an intermediary zone (the buffer zone) where the vestibular meroclimatic effect is annihilated step by step, so this is an ecotone in which the animal species number is generally maxim; a profound zone, complete obscure, without green plants, with a lower abiotic factors amplitude values and with reduced trophic substrate: this is the troglobitic species zone (Negrea, 1980).

This zonation can’t be applied to all caves. The reality is more complex. Thus, Negrea and Negrea (1977), holding account by the topographically, topoclimatically and trophic substratum criteria, distinguish the following cave types:

- horizontally and subhorizontally cave by C type (“complete”) having all three zones;
- horizontally caves by P type (having only the “profound” zone), with total obscurity because the smallest entrance;
- horizontally caves by V type (having only “vestibular” zone), with total lighting by the big entrance;
- vertically and subvertically caves by C type (“complete”): these are closed pothole in “bag bottom”, with small platforms and filling in their basis, lighting diffuse or not through the bottom;
- vertically caves by F type (having only the “final” zone: are “a pic” pothole, without platforms;
caves by $F+P$ type: are pothole – caves, where the access pothole $(F)$ is continued with obscure horizontally or subhorizontally galleries $(P)$.

Between these base types the authors distinguished also, in the horizontally caves, the intermediary types $Pv$ and $Vp$, after the profound zone $(P)$ or vestibular zone $(V)$ domination.

After us, these tree meroclimatic zones (vestibular, intermediary and profound) aren’t occupied biotopes some of them by a single biocoenosis, so that can’t be considered ecosystems. Thus, the walls and ceiling to the vestibular zone are the parietal biocoenosis biotope. In this time the floor is the biotope to the filing deposits biocoenosis from this zone. The intermediary zone, being an ecotone, hasn’t a self-biocoenosis, with characteristic species, but only with a mixture fauna.

About the profound zone, the floor is occupied by the biocoenosis with the same name, and the walls and ceiling are from the parietal biocoenosis species that can arrived through here, including the bats colonies. Result that the space occupied by a cavernicolous biocoenosis can be the same with the space of meroclimatic zone, but this space can be smaller or bigger than it can. It formed itself in the cave space that carry out three conditions: offer to his species the necessarily microclimate and substratum, and in the first place offer the trophically resources (food).

In a cave, after our opinion, can be delimitated four biocoenosis types with more or less complex structure: the parietal; the filing deposits from the vestibular zones and pothole basis zone; the profound zone floor; the bat guano. Each of it are defined by characteristic species (that are constant), that are a few species that life only in a single biocoenosis, always present, frequently in some caves and often dominants, that, with preferent species (accessory), common to many biocoenosis, and with strangers species (accidentally or occasionally) populate the corresponding biotopes. For the moment, the interrelations between species and between biocoenosis are less known.

Following, we will present the Romanian cave biocoenosis (associations, communities), illustrate with the Negrea and Negrea data (1968, 1971, 1972, 1977) obtained after quantitative and qualitative researches for many years over 150 Banat Mountains caves – the only one zone from Romania that benefited to the systematically researches to the biocoenotic level. But we have to mention the Oltenia caves and theirs parietal fauna that were studied qualitative by Motas, Decu and Burghele (1967), and the guano fauna studied preliminary by Decou and Decou (1964). The Apusen Mountains benefited only to a study of the population level made by Racovită (1978, 1980).

**Parietal biocoenosis.** The walls and ceilings horizontally cave biocoenosis defined by Jeannel (1926) “parietal association” is one of the most rich and varied cavernicolous coenosis. It occupies the vestibulary and intermediary zones characterized by a transition meroclimate between the epigean and hypogean domains. Through the profound zone walls we can met only some troglobiphilic elements close by the rare troglobites that can appertained in fact to the floors biocoenosis through this zone.

In the parietal biocoenosis structure from the vestibular zone are species from all ecological categories, including some troglobites (to see Negrea, 1980), but characteristic for this are the subtroglobiphilic species, that are present in their diapause phase. From this reason, even sometimes are few species, the individual numbers can be impressionant. Being totally inactive, they are fall prey easily to the
carnivorous species from their trophic cycle. Thus, Negrea and Negrea (1972) show that from 43 characteristic and preferent species identified in the Banat caves represented 32.5% from parietal biocoenosis, 29 species are subtroglophiles (17 to Diptera, 5 Lepidoptera, 5 Trichoptera, 2 Hymenoptera), 14 species are troglophiles (4 Gastropoda, 8 Araneae, 2 Opilionida) and none troglobites (in that time Troglohyphantes herculanus was considered a recent troglobite). The rest of 89 species (67.5%), the most of them trogloxenes, are occasionally or accidentally guests, strangers from the parietal biocoenosis. Like frequency, on the first place are subtroglophilic species, too, headed by Diptera (Limonia nubeculosa – 49%, Culex pipiens – 45%, Helomyza captiosa – 24%, Tarnaria fenestralis – 22%), after these are Lepidoptera (Scoliopteryx libatrix – 24%, Tripoda dubitata – 33%, T. sabaudista – 21%) and Trichoptera (Stenophylax permistus – 24%, S. nycterobia 21%). Between troglophilic species, frequently are Araneae, the Diptera and Lepidoptera consumers – the main carnivorous species from parietal trophic cycle (Meta menardi – 64%, M. merianae – 22%).

The subtroglophilic insects presence in parietal biocoenosis isn’t occasionally. They look here the subterranean environment ambiance in one of their biologically cycle phases (Ginet and Decou, 1977). This ambiance and some values of meroclimatic factors are necessary to them in the diapause time. That means that the aestivating species (Trichoptera, for example) will be present and abundant in the summer and the hibernating species (Culicidae) in the winter and that with the aestivating and hibernating generations (some of Diptera and Microlepidoptera species) even in the summer and winter. Not even the biotope place that occupies each species isn’t fortuitous. Each species has his preferred niche in concordance with his ecological and biological needs. Generally, the subtroglophilic species avoid the quiet and calm zones, preferring the intermediate meroclimate between the interior and exterior, so the vestibular zones. Result that the main limiting factor in the subtroglophilic cave spreading is the relative constancy of physically factors in the profound zone.

The saprophagous and carnivorous (Opilionida, Araneae, Pseudoscorpiones) troglophilic species presence into the parietal biocoenosis is linked more from trophic factor, here they found more food resources and a convenient meroclimate. Beside the macroscopic species, in the parietal biocoenosis compound are also microscopically organisms. A rich microflora and microfauna, made by organisms that are from the percolation water or water inrush rallied populate the wet walls and ceilings (Bacteria, Fungi, Alga, Protozoa, Rotatoria, Tartigrada, Nematoda, Oligochaeta, Oribatida, etc.).

From the studies made by now result that the parietal fauna isn’t a simple crowd of species but a main biocoenosis of subtroglophilic species. Their make-up occupied preferred ecologically niches on the walls and ceilings from the zone where is a perturbation meroclimate and they are bound between them by relations more or less complex, especially food relations. Result, also, that the structure of this biocoenosis is conditioned by the abiotic factors (the varied topography of the entrances, walls and ceilings, the permanent ventilation, the circadian rhythm of the direct or diffuse light, the main temperature and humidity variations), but also the trophic factors (with the observation that the subtroglophilic insects participate passive in the trophic network chains); that the seasonal dynamic is in closed relation with the biological rhythms of the subtroglophilic species that came in cave for aestivating or hibernating; that the interest for this biocoenosis came to the active
participation to the underground world economy being one of the organically energy vectors in the epigean ecosystems to the hypogean ecosystems (Negrea, 1980).

- **Filling deposits biocoenosis** through the vestibular zone to the horizontally caves and to the pothole base. The filling, made by soil, animal and vegetal rests bring here by the waters etc is more dense in wet caves and potholes protected by forests, especially beech forests (in Romania approximatively 80% from the karstic cavities are situated between 250 and 1,000 m altitude, so in the wood-clad zone). This biotope has a diversified biocoenosis, compound from characteristic, preferent and accidentally species.

In the filling from vestibular floors case, a mixture of troglophilic and trogloxenic species makes the biocoenosis, including species that outside live in soil, humus, moss or litter, but inside live in the profound zone. If exist also shadow plants and hygrophilic plants in the vegetation period are add epigean species. The poor fauna is in the vestibular dry zones, with the floor made by nude or stalagmitated rock situated in the unforesting zones. Thus, in the Banat Mountains caves, Negrea and Negrea (1977) identified 135 species, between them 24 are characteristic and preferent species through this biocoenosis. These species appertained to the troglophilic and subtroglophilic species from endemic Miriapoda, troglophilic species from Gastropoda, Araneae, Isopoda and Collembola. Are attracted, also, Oligochaeta, Opiliones, Diptera, Thysanura and Coleoptera species that live outside in death leaves, humus and moss. The mentioned authors observed the effective fluctuations owing to the exterior through interior migrations and to profound filling because the variation amplitude values of the climatic factors that here are biggest that in the profound zone.

In the big deposits case from the base pothole, the biocoenosis can contained also the troglobitic species, if the pothole base communicate with a horizontally galleries and fissures network and if the variation amplitude of the physically factors is reduced. Thus, in the Banat pothole studied by Negrea and Negrea (1977) were identified 42 species. From these 8 are characteristic species, 11 preferent and 23 accidentally. In the first two category it remarks some troglobitic, troglophilic and subtroglophilic endemic species (*Troglohyphantes herculanus*, *Chthonius* sp., *Brachydesmus troglobius*, *Monotarsobius pustulatus*, *Duvalius coiffaiti*). Beside of these live species from Oligochaeta, Gastropoda, Acari, Isopoda, Collembola etc. Some potholes have on the access pothole trajectory rock platforms with filling deposits from where the mentioned authors identified troglophilic species from Araneae and Diplopoda, and from the access pothole walls (that are covered by a thin and discontinued layer of wet soil with mosses and ferns) many Collembola, Isopoda, Arachnida and Diptera adults and larva species. Only the pothole entrances with nude walls from the unforested zones are azoic. So, result that the access pothole zone with or without platforms and that are in the direct influencing of the exterior climate represents an ecotone.

The permanent presence of the characteristic and preferent species shows that the filling deposit biocoenosis is a reality. In the same time, the simultaneous presence of troglobitic and edaphobitic species proves that the vestibular cave zone and the pothole base represent an ecotone between the speleic and endogeous environments.

- **Profound zone floor biocoenosis**. In the temperate clime conditions this biocoenosis occupies the stalagmitic, clayey, sany or the naked floors, having different organically rests ununiformed distributed. Also this biocoenosis occupies
the fissures and niches through the walls from the profound horizontally cave zone where is a stability meroclimate. We speak about the “rock – clay – concretions” complex about Vandel (1964) was convinced that make an unitary ensemble that make “the troglobitic characteristic biotope”. Negrea (1980) think that Vandel has right, but one correction: the troglobitic biotope limits in fissures isn’t to first centimeters in the depth cave walls, but, according to Racovită (1978), must be extended to hole fissures network from the karstic massifs, where the physically factors are also the most constant and the organically detritus is found in so much quantities that in caves. The fissures network existence like live environment was confirmed by the researches results as regards the seasoning fluctuations of the cave animals number in terms of the climatically variations (Juberthie, 1969, Cabidoche, 1969, Racovită, 1971 – 1978, Delay, 1978, etc.). The climatically factors with a role in the cavernicolous population dynamic were grouped by Racovită (1973) in regular factors, resulted through a cyclic evolution of the topoclimate and irregular factors, occasionally factors (for example the suddenly level waters growing) that, if it has a seasoning character can perturbs the regular factors.

The emigration and immigration successions to and from the speleic space is, after Racovită (1978), the most important mechanism from it are realized the effective fluctuations of the cavernicolous populations from the floor bioecososis through the cave profound zone (Fig. 9). The effective autoadjust correspond to a dynamic equilibrium state between cave and fissures network, balance that tend to assure in the two territory stationary dimensions and in the same time an optima dimension for his

Fig. 9 – The month numbering variation of the Drimeotus kovacsi viehmanni population in Peștera cu Apă din Valea Leșului: A – A' long period tendency (after Gh. Racovită, 1978).
population. The intervention of each climatic factor can perturb the equilibrium determine the organism concentrations in the network or in cave. If the seasoning microclimatic variations are too small to unleash the number fluctuations it can be manifesting a reproductive periodicity (details in Racovită, 1978).

The trophically substrate through the profound zone is variety to a cave to another, quantitatively and qualitatively. These are life organically matter (clay, montmilch with synthesized substances by the microorganisms), death organically matter by vegetal nature (rotten wood, leaves and detritus) bring in from outside by the percolation waters and by the underground watercourses, or allochtone and autochtone animal nature (excrements and bodies with mould). In some caves are also the anthropic organically matter (food rests, diverse materials introduced by human).

The troglobitic fauna, relatively poor in individuals and less diversificated is attracted by the organically matter accumulations deposited at random on the naked rock, covered partially by a stalagmitic crust or by clay, concentrated itself in the wet places that offer the preferred microclimate. In this substrate mosaic populated by the cavernicolous species can’t be delimit the biotopes and biocoenosis because don’t exist characteristic species to each substrate, but only to the whole profound zone (Negrea, 1980). Are exceptions the important bat guano accumulations, where are developed a fauna with characteristic and preferent species, a whole biocoenosis specialized with a structure more simplified, more peculiar through the cavernicolous coenosis. The fauna that populated the profound zone isn’t compound only (or most only) from troglobitic species how it is still affirmed in some papers. Thus, in the 118 caves from Banat studied for their floor biocoenosis by Negrea and Negrea (1977) live 186 species. Through these 43 are characteristic species (23%), 29 are preferent species (16%) and 114 are stranger species (61%). If the troglobitic species doesn’t dominated by their number of species and individuals, but they make the characteristic element of the biocoenosis by their frequency and constancy. Is true that from the 43 characteristic species, 33 are troglobites (30 endemically species). Through them exist also species (or subspecies) from Gastropoda (Daudebardia cavicola ponorica), Pseudoscorpiones (Neobisium brevipes, N. minutum), Araneae (Nesticus cernensis), Isopoda (Trichoniscus inferus), Diplopoda (Trachysphaera orghidani, Bulgarosoma ocellatum, Anthroleucusoma banaticum, Trichopolydesmus eremitis, Typhloiulus mehedintzensis), Chilopoda (Lithobius decapolitus, Thracholithobius daciicus), Collombola (Onychiurus closanicus), and Coleoptera (Banatiola vandeli, Sophrochaeta racovitzai, Duvalius milleri, D. herculis). The rest of cavernicolous, species are troglophilic; through them are the Oligochaeta species Dendrobaena rubida rubida, the Opiliones species Paranemastoma sili, the Isopoda species Androniscus roseus roseus and the Diplopoda species Trachysphaera costata. The preferend species are from the same groups, the most of them are troglobilic, some of them endemically species. About the accidentally species, they came from the troglophilic, subtroglophilic and guanophilic species through the neighboring biocoenosis. Result that although the profound zone doesn’t belong in exclusively to the troglobites, almost they formed the characteristic element of this biocoenosis (Negrea, 1980).

Negrea (1980) enunciated the main particularities of the floor biocoenosis to the profound zone to the Romanian caves and generally from the North Temperate Zone. We will present it in a short variant.
1. The profound zone and his characteristic biocoenosis are characterized by an ecological diversity relatively big from an extreme environment and by a small effective, frame it to limit in the first biocoenotic principle of Thienemann.

2. The abiotic factors that action to the profound zone are less numbering that the epigean ecosystems. Varied between smallest limits, they action especially like selection factors, making a barrier in the species penetration way in the cave depth. If this limiting factors, with a selective character, determine the biocoenosis structure, the relative factor values constancy of these factors for a long period it award stability that loud the unfolding the permanent activity.

3. The ununiform repartition of the biocoenosis populations and their dynamic aren't the result of meroclimatic factors (that are relatively constancy), but the result of food factor and to the different behaviour of the species from the biocoenosis make-up. In his structure are many detritivorous species, to a big philetic diversity, that found in this extreme environment preferential condition. The profound zone and his biocoenosis form an incomplete ecosystem, having trophically chains much simplified, short and depend in a big measure by the ecosystem activities through the outside that it supply the organically matter for the saprophagous and coprophagous organisms. The trophic cycle realizes by autotrophic or heterotrophic organisms (limivorous, microphagous, detritivos, coprophagous, and carnivorous). Some trophical chains started by vegetal and death animal matter, consumed by detritivorous, and other chains by microflore chemosynthetising consumed by microphagous organisms. Totally exist three main trophical levels: of the producers (autotrophic microorganisms); of the primary consumers (microphagous species, detritivorous, coprophagous) and the secondary consumers chains (zoophagous species = carnivorous = predators) of I degrees and rarely of II degrees (Fig. 10).

4. The terrestrial speleic ecosystems are in permanent matter and energy exchange from outside, to that is tributaries. These are, in this way, opened ecosystems, in dynamic equilibrum. The organically matter and fauna exchange are more evident in the karstic fissured and forested massifs with a big layer of humus and soil, and the entrance of the caves are opened to North. Contrary, the exchange is very reduced in the opened caves in the deforested slope: their fauna is poor, without troglobitic species destroyed by the waters inrush.

5. The terrestrial speleic ecosystems even the most stabilized, have a small degree of resistance to the perturbing action of some extern factors. Because this fragility must impose the subterranean fauna protection through the uncontrolled anthropic actions. The abusive collecting of the cavernicolous fauna and the intense tourists exploitation lead to the disappearance of this fauna. Like this disappeared the Coleoptera species Pholeeon proserpinae glaciale from the Biserica Room from Ghețarul de la Scârșoaara, that, because the intensification of the tourists circulation wasn't found after 1963. The touristic arrangement and the visitors circulations can modified the ventilation regime and produce changes in the species biologic cycles. The introducing of some species can produce an interspecific competition, unfavorable to troglobites. The deforesting of the karstic massifs can determine the soil drying and degradation, the diminution of edaphic fauna and food resources in caves. Result the necessity of setting up the biospeological reserves closed to tourists. This can include not only the cave but also the whole massif where it is.

6. The terrestrial cave biocoenosis tends to climax phase, like any biocoenosis. The pioneer organisms, which aren’t in permanent associations, start
Fig. 10 – The food resources and trophically chains from the terrestrial environments from Peștera Topolnița. Continue lines frames shows an autochthonic origins, frames from interrupted lines shows an allochtonic origins (after P. Hodorogea, 1976, modified by St. Negrea, 1980).

by populating the deposit fillings from the active caves, immediately those are formed. Subsequent, in parallel with the cave evolution (that pass through the fossil and subfossil phases), constituted more outline cavernicolous biocoenosis, characterized, in the climax phases, by stable populations that harmonious developed in a relatively constant meroclimate. How the step by step cave clogging process with concretions, clay and guano can’t be stopped, after the climax phase follow a biocoenosis succession until the filling deposits cancel the vital space and
the cave disappeared with the final biocoenosis. The perturbing factors can influence slow or brutally stopped partially or totally the evolution in any phases.

- **Guano biocoenosis.** In many Romanian caves exist a big quantities of bat guano. Through these, Peștera lui Adam from Bâile Herculane, Peștera Mare de la Merești, Peștera Lilieclilor de la Bistrița and Peștera de la Gura Dobrogei are the most known. The guano deposits made a very specialized biotope, well delimited in the cave space, offered life conditions most peculiar to the biocoenosis that it occupy. This biocoenosis is a *synusie*, a simple coenosis, poor in species but very rich in individuals, include it in the second biocoenotic principle of Thienemann.

The guano quantities varied after if the cave has smallest or biggest bat colonies or only isolated bats. The guano is a heterogene biotope in it structure, nature and age to the surface and also in the depth of deposits from the same cave. The thin uncontinuous guano layers or thick layer to some meters, also the pile unfailing under the colonies, have braked up or subsided guano, wet or dried came by the insectivorous bats (from the caves through the North temperate zone), frugivorous, nectarivorous, pollenivorous and piscivorous (in the intertropicale caves), old and covered by mould or fresher where the colonies are in activity, mixed or not with clay and soil. The deposits situated in the perturbation meroclimate zone supports big humidity, temperature and pH variations.

The guano is a trophic substrate very nourishing from guanophagous animals. In 1 gram of dry guano of superficial horizon to one pile from Peștera Topolnița were numbered 1,556 millions bacteria, 19 millions Actinomycetes and 8,000 microscopic fungus. In the horizon from 10 to 20 cm were numbered 10 millions, 20 millions and respectively 826,000 (Hodorogea, 1976).

The guano biocoenosis has on his basis the guanophagous species; most of it derived from the coprophagous species that frequent the microcaverns (N. Leleup, 1956). They don’t look for the speleic environment, but the food that exist here. Historically speaking they have nothing with caves, so they can’t be considered troglobitic species, although some of it lives for all theirs live in this environment. “Introduced into a big mass of food matter, the guanobite ignore biologically that is in a cave”, write Jeannel (1926).

In the biocoenosis structure enter in the first place Acari (various species, generally dominant species), than Collembola (Hypogastruridae, Onychiuridae, Entomobriidae) and Diptera (especially guano fly, *Heteromyza atricornis*). In a small proportion enter saprophagous Coleoptera, Microlepidoptera (Thineidae), Oligochaeta (Lumbricidae, Enchytreae), Isopoda (Porcellionidae, Clistiscidae, Trichoniscidae), Diplopoda, Gastropoda (*Oxychilus* species), also some carnivorous species from Araneae, Chilopoda and Coleoptera (Staphilinidae, Hysteridae, Carabidae) etc. The number of guanobitic species (that have whole biologic cycle in guano) is relatively small. Except the numerous Acari species, we can remember *Mesachorutes ofovienis* (from Collembola), *Heteromyza atricornis* (from Diptera) or *Atheta subcavicola* (from Coleoptera). More species from this biocoenosis are guanophilic species; their number is so numbered that the cave entrance is bigger and the ventilation is better. The troglobites avoid the guano accumulated under colonies. But, on the old and wet small deposits of guano can be met Diplopoda, Isopoda and Coleoptera Bathyscinidae species that look for food.

The study made by Negrea and Negrea (1971) in the cave with guano from the Banat Mountains showed that the maximum density, indifferently the dominant
species and the guano characteristics, realized in the first 3–5 cm from the surface. After that is a suddenly diminution of the number; the Collembola and Coleoptera species get stock in substrate until to 20 cm and the Acari species until 30 cm. On horizontally, the repartition is also ununiformed because the heterogeneity of guano. The authors mentioned could frequently easy delimit spaces occupied preferential by some dominant species.

But not only in space (on vertically and horizontally), but also in time the guano, and at once with it, the biocoenosis support important modifications. As soon as the bat colony leave the cave for a period or if they enter in hibernation, the guano loose from the ammoniac quantity became alkaline, get mouldy on the surface and begin the aging and subsiding process. As a result, the simple trophic chains are more simplified, the species density of species lovers of guano fresh diminish rapidly and some species disappeared. On exchange appear another species from Acari, Collembola, Diptera (larva) and Coleoptera that love the old guano (Negrea and Negrea, 1971). Result so that in function by the presence or absence of bats colonies, the guano biocoenosis support radically transformations, a true succession of biocoenosis. In the same time with the colony reappearance (respectively with the hibernation exit) the ecological cycle take place again.

We can’t end without remember that in Romania exist a guano biocoenosis totally peculiar, almost unique in the world (Strinati described in 1953, a biocoenosis similarly from Spain). We speak about Peștera lui Adam from Bâile Herculane that under thermal waters influence became a true tropically oasis (the temperature is about 28 – 29°C all the time, relative humidity 98 – 100%, an immense colony of Rhinolophus euriale and a deposit guano over 3 m depth) populated by an extreme biocoenosis (Decou, Negrea and Negrea, 1974; Decu and Tufescu, 1976). This biocoenosis represent a limit case to the second biocoenotic principle of Thienemann, because a single Acari species, Chiropturopoda cavernicola, a thermopile relict, realized in the guano room 97% from the whole biocoenosis effective made by 12 Acari, Collembola, Diptera and Coleoptera species (to the deposit periphery to the access pothole base leave also 18 species). In a same less diversificate ecosystem, the information quantity is reduced (the Shanon function show a diversity by 0.443 bytes) and the organization is quit simple (2 trophic levels, a principal level of guanophagous saprophytes and another secondary of the carnivorous and only 7 species with an importance in the food chains). Because the big values of temperature and humidity (the main limitants factors), the simplified structure and organization of guano biocoenosis, Peștera lui Adam reproduce the more important features of the climatic and biologic type from a tropical cave with a warm air purse.

8.4.2. Aquatic subterranean ecosystems in karst

Considering the groundwaters from a karst, Cvijic (1918) differ 3 main levels (zones):

- **superior or temporary percolation zone**, in which the meteoric waters are infiltrated by the fissure network and appear in caves like drops and parietal trickling with organically substances and small fauna, to gathers in the alveolus’s from the stalagmite heats and in the stagnant water basins (especially in “gours” or rimstone dam and stalagmitic barrage lacks with various forms and volumes, with the walls and floors by calcite with deposit from clay silt);

- **medium or amphibian zone**, the trickling zone, in that the water circulates permanently or temporarily, like brooks of rivers to the cave emergence. They can
deposit on the cave floor, after the flood water or in the drought periods, different areas with stagnant water (different accumulations on clay and on the stalagmitic floor, giant's kettles with silt deposit on the bottom) and can be accompany by alluvia ("beaches" with sand or gravel) imbued with water;

- **inferior zones or the drowned karst zone**, in which the water is practically stagnant in the fissure network and in the submerse galleries, inaccessible to the man.

Delay (1978) differ a *dynamic volume*, in the movement through the "emergence" (the underground water exit to light) and a *profound volume* that participle to the "emergence" alimentations only in the measure that has place a water exchange with the dynamic volume, so indirectly. So, result that filtrate the drowned galleries water (accessible only rarely, in some points to the medium level) and the emergence waters, the fauna that love the calm and profound waters can't be captured, so known. Generally, the aquatic underground biocoenosis remain less known that the terrestrial biocoenosis.

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**Fig. 11** – The two main types of trophic cycles through the Romanian caves. A, the allothrophic cycle (without autochthonic producers, based on the allochthonic production – the ordinary case). B, the autotrophic cycle (with autochthonic producers, based on chemosynthesis – the unique case from Peștera de la Movile close by Mangalia) (orig. Șt. Negrea).
The aquatic biocoenosis from the temporary percolation zone. To the cave level, this zone correspond to the fossil galleries and rooms that are in different stages of clogging with concretions, clay and guano, in which percolation water gather it in all nature and form excavations that exist in walls and floor (Fig. 3). This biotopes fauna is made by Protozoa, Tricladida, Copepoda, Amphipoda and rarely by Isopoda and Bathynellacea. Make ingenious experiences Rouch (1968), Delay (1978) and others French biospeologists demonstrated that the aquatic invertebrate populations from the superior zone occupies the cave biotopes, but also the fissures network where are perennial water reserves. The cave populations represent in this way a part from the whole effective of respective populations. They can be isolated or in close relations with fissures fauna, even can be disappeared if the food aport stop and the food resources finish. The population size varied to some tenth individuals to some thousand individuals, sometimes with the young stage domination, another times with the adult domination. The population from the inaccessible network (Copepoda, Isopoda, Bathynellacea, Oligochaeta, etc.) can be studied by percolation water filtrating from the stalagmite level that supply the "gours" (rimstone dam), from the stalagmite heads or to the parietal seeping water. The development stages presence in these samples takes to the conclusion that the reproducing rhythms are a reality in this live environment.

Botoșăneanu (1971) came to the similar conclusions for the Banat Mountains cave (better studied to the populational and biocoenotic level from Romania) and mention the characteristic species to the temporarily percolation zone. Through them we mention Pristina menoni (Oligochaeta), Specyclops lindbergi and ParetHenocaris banaticus (Copepoda) and Pseudocandona sp. (Ostracoda) identified only in the specimens collected from this zone. About the “gours” fauna, Pleșa and Racoviță (1973) came to the conclusion that, in the drought period, when the water from this “gours” drain, the fauna resist a more period of time in the lower interstices, where the humidity persist and the air is very wet.

Aquatic biocoenosis from the amphibian zone. To the cave level, the amphibian zone corresponds to the subfossil and active galleries with temporarily or permanent waters courses, including also the all kind of water accumulations that accompany them and also the water that imbue the alluvia (Fig. 3). The fauna that populate this biotopes is often very rich, compound by a subterranean form mixture (stygobitic and stygophilic species) and epigean species. The researches made by Rouch (1968), Lescher-Moutoué and Gourbault (1970), Barr and Kuehne (1971), Delay (1978) and others due interesting results. Now it is know that the aquatic species of small size form populations, sometimes important, in the alluvia of underground waters (especially copepods, more rich in individuals), the big size forms from the underground rivers (decapods and stygobitic fishes – like Amblyopsis species from Mammoth Cave). The running or stagnant waters to the Pyrenees have populations made by a few individuals, frequently unstable; the small size species (especially crustacean species), because can be easily rallied, appear to the emergences (spring) level, but the big size species, that are present in galleries, never appears to light by emergences (for example Haplotaxis leruthi that can get stuck it in substratum).

From the Banat caves, Botoșăneanu (1971) made some indications for some characteristic species from the amphibian zone, found exclusively in the watercourses or in the water accumulations remained after the rivers draining (Dendrocoelum botosaneanui, Haplotaxis bureschi, Megacyclops viridis,
Niphargus puteanus, N. timavi, N. kochianus and Synurella ambulans coecca) and only one characteristic for the water that imbue the alluvia interstices (Bathynella species).

**Aquatic biocoenosis from the drowned karst zone.** The drowned karst zone (Fig. 3) is the most difficult to approach because practically is inaccessible to a direct study. The more important contribution to the knowledge of drowned karst populations from the North Temperate Zone was bringing by Rouch and his collaborators (1968 – 1976). Shortly, here are the conclusions for the Baget (the Pyrenees) karstic system study. The drowned zone populations occupied the water masses, mostly calms, situated under the emergences level, favorable to some swimming species. Is possible that to this level to exist sediments in witch the fauna can shelter itself. These populations are diversificated and have a big individuals density only in the tropical karst regions where the abundance on disposable organically matter, particularly guano, allowed the maintaining of stygobitic decapods and fishes populations. In the temperate karstic regions (respectively in the Pyrenees) the water filtrating method from the karstic emergences gave good results only in the microscopic species case, passive rallied (in the time of the suddenly of the level waters growthing cases was registrated true “hemorrhages”, between 450 and 600 thousand Harpacticoida captured on a single emergence!). The big size species and these that can be attached or stocked on the bottom don’t appear to day light. Because that, even some populations are important and stabile, it can be determinate exactly their size, density and space repartition.

To Rouch and Bonnet (1978) owed the knowledge about the ”Harpacticoida community” to the Baget karstic system. To the each emergence level studied by them, the Harpacticoida population proved a big stability quantitatively and qualitatively, that presumed a similar stability and a real regulation power to the whole drowned zone biocoenosis level. To this study resulted also that the biocoenosis organisation depend to the environment structure for the 8 stygobitic species identified and to the topographical conditions for the 13 species of epigean origins. In conclusion, the karstic system must be considered like a functional unity, like an ecosystem to an upper level.

The drowned zone biocoenosis from our country karst wasn’t studied yet, but it must be. The prove is that the water filtrating to the emergence Gaura Fetei of Svinita in Danube defile gave 15 individuals of Parabathynella stygia (Botoşăneanu, 1971).

At the ending of this chapter we must underlining the fact that the Romanian underground ecosystems include the peculiar live environments populated by specialized characteristic species, unable to live outside the ecosystems. The troglobites and stygobites don’t represent another thing that the adaptations result to the integration of some subterranean populations. They have a reduced metabolism, a slowed reproducing, so means a small vital capacity that it match to the live conditions from the hypogean ecosystems to our country characterized by uniformity and relative constancy. This is, by the way, the main feature that confer to the underground domain the characteristic of refugial environment where it could survived to our days the troglobites and stygobites, true live fossils (Negrea, 1980).
PRIVIRE GENERALĂ ECOLOGICĂ ȘI BIOGEOGRAFICĂ ASUPRA MEDIILOR SUBTERANE TERESTRE ȘI ACVATICE DIN ROMÂNIA

REZUMAT
Lucrarea este o sinteză a rezultatelor cercetărilor ecologice și biogeografice întreprinse până astăzi asupra mediilor subterane terestre și acvatice din România, prezentate în contextul dezvoltării actuale a biospeologiei pe plan mondial. După un scurt istoric, urmează capitolele: regionarea carstică a României; etapele evolutive în formarea carstului; impactul antropic și protecția mediilor subterane; divizarea biospeologică a României; originea și evoluția faunei subterane; prezentarea succintă a organismelor subterane terestre și acvatice din România; ecologia principalilor medii subterane din țara noastră. Ultimul capitol – cel mai cuprinzător – conține următoarele subcapitole: clasificarea mediilor subterane din România; caracteristicile mediilor subterane; categoriile ecologice și adaptările la viața subterană; ecosistemele subterane terestre și acvatice.

Ca prezentă în zonele temperate, mediile subterane din România sunt populate de specii caractéristice, specializate, incapabile de a trăi la suprafață. Troglobiontele și stigobiontele nu reprezintă altceva decât rezultatul adaptării, al integrării unor populații în biocenozele subterane. Ele au un metabolism redus, o reproducere încetinită, adică o capacitate vitală slabă care se potrivește condițiilor de viață din ecosistemele hipogeice din țara noastră, caracterizate printr-o uniformitate și constanță relativă. Aceasta este trăsătura fundamentală care conferă domeniului subteran caracteristica de mediu refugial în care au putut supraviețui până azi troglobiontele și stigobiontele, adevărate fosile vii.

Notă: Traducerea în engleză aparține celui de al doilea autor, cu excepția traducerii termenilor biologici și speologici care aparțin primului autor.

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