Historia naturalis bulgarica, 21: 257-266, 2015

Quantitative comparison of the complexes of terrestrial arthropods (Arthropoda) in two caves, located in different karst regions in Western Rhodopes mountains, Bulgaria

Stanimira Deleva[1], Dilian Georgiev[2],

Abstract: Comparative analysis of the microclimatic parameters, the seasonal dynamics and quantitative comparison of the complexes of terrestrial arthropods (Arthropoda) is done in two caves, located in different karst regions in Western Rhodope Mountains, Bulgaria (Yubileyna and Gargina Dupka caves). For this purpose the following parameters have been investigated: temperature and air humidity in both caves and the relation between them and the distribution of the terrestrial arthropods, thereof the quantitative comparison of the different taxonomic and ecological groups of animals in the two caves; seasonal dynamics of the groups of arthropods in the studied caves.

Key words: caves, pitfall traps, cave ecology, Arthropoda

Introduction:

The underground habitats are among the most common living conditions on the land and continental shelf of the Earth (Gibert & Deharveng, 2002). Taking into account the mainland, 97% of the unfrozen fresh water is under the land surface. The terrestrial underground habitats occupy the entire unsaturated with water zone, which is most evident in karst areas (caves, cracks, crevices etc.), representing nearly 4% of the rocks of the world. Karst is developed in sedimentary rocks which protect it from environmental changes. The underground ecosystems, in contrast to most surface ecosystems that are transient (rivers, forests, wetlands, etc.) can survive unchanged for millions of years (Gibert & Deharveng, 2002). Groundwater ecosystems have long been regarded as an extreme environment inhabited by very few, specialized species.

This statement has been revised, as many studies have shown that this environment provides shelter for various species, mainly invertebrates (Gibert & Deharveng, 2002). Difficult working conditions in an underground environment had made available to study only a small part of these habitats. These are the surface layers of soil and caves, "windows to the underworld". These interesting habitats, previously regarded as separate and isolated areas, now refer to a much broader environment in which they do not take the lead role (Giachino & Vailati, 2010). As a rule, caves and other underground shelters (rock crevices, soil, etc.), are divided into two separate categories (Culver & Ripan, 2009). This study is addressed only to caves as habitat.

Bulgaria is a country with a well-developed karst, which covers 22.7% of its territory (Popov, 1976). There are over 6000 caves and pits in the country. The total number is variable because new studies and expeditions are conducted and new caves are discovered every year (Main database of the caves in Bulgaria; source: http://hinko.org/). Despite numerous studies and biospeleological research, published over 582 scientific papers, the species composition of cave fauna cannot yet be considered fully investigated (Beron, 2005; http://nmnhs.com/biospeleology-research-centre-bg.html). Example for that is the cave "Gargina Dupka" which is considered to be well studied. Eighteen species of animals are reported to inhabit the cave, but recently new freshwater snail species is discovered,

stygobite, in the same cave (Gloer & Georgiev, 2009).

To increase our knowledge of the ecology of cave fauna, the present study investigates environmental parameters (temperature and humidity) within a calendar year, as well as species composition and abundance of the complex of terrestrial arthropods in two caves in the Western Rhodopes. Such study provides valuable information about the conditions in Bulgarian caves and their impact on the invertebrate cave fauna.

Material and methods:

The studies were carried out from 26.03.2010 to 19.03.2011 in the cave Yubileyna and from 10.04.2010 to 11.04.2011 in the cave Gargina Dupka.

The material for the study was collected by Pitfall traps method (Barber, 1931) – containers filled with ethylene glycol were placed in different substrates in the caves. The containers were buried in the substrate to the edge and covered with stones in order to prevent falling of larger animals (Petrov & Stoev, 2009).

In Yubileyna cave 5 pitfall traps were placed (Fig. 1.), situated in the following substrates:

Trap No. 1 – guano, Trap No. 2 – guano, Trap No. 3 – clay, Trap No. 4 – clay, Trap No. 5 – sand.

In Gargina Dupka cave 3 pitfall traps were placed (Fig. 2.), situated in the following substrates:

Trap No. 1 – clay, Trap No. 2 – clay, Trap No. 3 – guano.

The content of the pitfall traps was collected in average over a period of 2 months. At each visit temperature and humidity were measured, and location of each trap was used for point. The tool for measuring these indicators is an electronic thermometer/hygrometer (Conrad mark). The collected material was determined by taxonomic reference using a guide of Zoology of Invertebrates (Tomov, 1998) and stored in 70% ethanol. For the mathematical analysis of the data was used references (Lakin, 1990; Krebs, 1989), and software (BioDiversity Professional). The calculated values are indexes of similarity and diversity - index of correlation, index of Simpson, Sörensen index and cluster analysis is made (Bray-Curtis single linkage). The collected material was submitted for detailed identification and storage in the collections of the National Museum of Natural History (Bulgarian academy of Science). To determine the representatives of groups Acari, Diplura, Collembola, Coleoptera: Staphylinidae and Diptera: Nematocera we could not find specialists in Bulgaria, so shall refrain from giving scientific names.

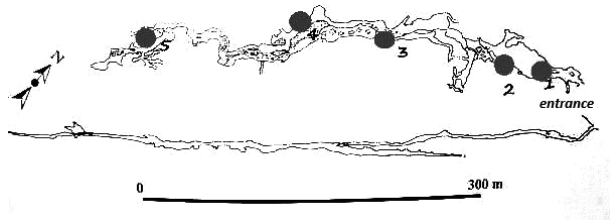

Fig. 1. Distribution of pitfall traps (points) in Yubileyna cave (right to left – № 1, 2, 3, 4, 5)

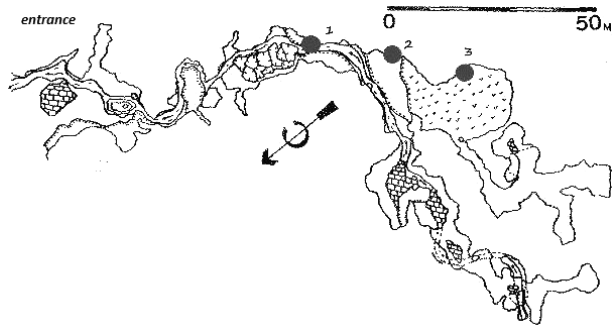

Fig. 2. Distribution of the pitfall traps (points) in Gargina dupka cave – left to right - № 1,2,3)

Two recorded Staphylinidae morphotypes are indicated in the text as Staphylinidae big spp. and Staphylinidae small spp.

Results and discussion:

1. Investigation on some parameters of the environment in the caves

Air temperature

Yubileyna cave

We found an average temperature (average of all points and seasons) of 12.7°C. The maximum of 13.2°C, we have measured on 19.03.2011 in point 3. The minimum recorded temperature was 11.3°C on 19.03.2011 from point 4.

We have recorded that the air temperature at a given point varies by less than 1°C between two visits (as average value). The average unit of variation is 0.1-0.7°C. In general the difference in the minimum and maximum average temperature between two visits is 0.9°C.

Gargina Dupka cave

We found an average temperature (average of all points and seasons) of 12.1°C. The minimum recorded temperature was on 10.04.2010 in point 2 of 11.1°C. The maximum was on 27.07.2010, in point 1-13.7°C.

The variation in each point and as average value is less than 1°C between 2 visits. Average variation –

0.1-0.5°C. The difference between the minimum and the maximum temperature average value between two visits is 0.8°C.

Comparison of the air temperature in the studied caves

It can be concluded that the two surveyed caves have relatively high and constant temperature of the air during the year, which in the various parts varies with less than 1°C. In the cave Yubileyna the average temperature is higher than that found in a cave Gargina Dupka (12.7°C and 12.1°C, respectively). Taken as the average of individual visits, temperature ranges more in cave Yubileyna (index of variation, Var. = 0.155), than in Gargina Dupka cave (index of variation, Var. = 0.083).

Dependence of the amount of multiple groups of terrestrial invertebrates from the air temperature, index of correlation

Yubileyna cave

Weekly positive correlation was established between the captured species of millipede (Myriapoda), and the temperature (correlation index = 0.094).

There was the same correlation found with the springtails (Collembola), (correlation index = 0.105), and with the ground beetle (*Laemostenus plasoni*) (correlation index = 0.254) and with true flies (Diptera) (correlation index = 0.218). There was negative correlation established only for rove beetles (Coleoptera – Staphylinidae) between the numbers in the traps and the air temperature (correlation index = - 0.670).

Gargina Dupka cave

Positive correlation was established with the springtails (Collembola), but twice higher than the values in Yubileyna cave (correlation index = 0.299), the true flies (Diptera) had also the same correlation but weaker (correlation index = 0.055).

For the rove beetles (Coleoptera – Staphylinidae) species there was a negative correlation between the numbers in the traps and the air temperature (correlation index = -0.456).

Table 1. Correlation index between the quantities of captures of multiple taxa of land invertebrates and air temperature in the caves researched

	Cave, correlation index	
Taxon	Gargina Dupka	Yubileina
Myriapoda	-	0.094
Collembola	0.299	0.105
Coleoptera, Carabidae	-	0.254
Coleoptera, Staphylinidae	-0.456	-0.670
Diptera	0.055	0.218

Established general tendencies of dependence between multiple group quantities of captured species of invertebrate and the temperature.

Positive correlation was established between the number of captured land invertebrates and air temperature in the following taxa: Myriapoda, Collembola, Carabidae - *Laemostenus plasoni* and negative correlation for Coleoptera – Staphylinidae (table 1).

This tendency is confirmed in the two caves for the taxa: Collembola, Coleoptera and Diptera.

Air humidity

Yubileyna cave

Average air humidity was established (average arithmetical value of all measurements and seasons) of 91.2% (table 4, fig. 3).

The minimal value of 85%, was measured on 01.08.2010 at point №5, and the maximum of 99% on 19.03.2011 at point № 1, 3, and 5.

Gargina Dupka cave

Average air humidity was established (average arithmetical value of all measurements and seasons) of 93.4%.

The minimal value of 86%, was measured on 10.04.2010 at point №2, and the maximum of 99% on 13.09.2010 and 03.10.2010 at all point.

Air humidity in the researched caves – summary

Average air humidity in Gargina Dupka cave is slightly higher (93.4%) than that of Yubileyna cave (91.2%).

The highest air humidity 99% was established in both caves in March (Yubileyna cave), and September and October (Gargina Dupka cave).

The lowest air humidity 85% was measured in Yubileyna cave in 01.08.2010 and point №5.

The following tendencies were established: lower air humidity in spring and summer and higher in autumn and winter.

Air humidity and temperature dependence in the researched caves

The index of negative correlation between air temperature and humidity is higher for Yubileyna cave (correlation index = - 0.722), than that of Gargina Dupka cave (correlation index = - 0.517).

Research on the taxonomic diversity and relative numbers of land Arthropods in caves

Yubileyna cave

Percent ratio between taxa

The insects are predominantly present as individuals captured in the traps (92.5% of all arthropods) with the springtails (Collembola) – 925 individuals, 58% of all captured. The rove beetles (Coleoptera – Staphylinidae) – 238, followed by *Laemostenus plasoni*

Table 2. Taxonomic diversity (minimal number of species) and number of individuals for the months when the traps were being checked in Yubileina cave

Date, number of species / Taxon	26.03.2010	06.05.2010	01.08.2010	05.09.2010	13.11.2010	18.12.2010	1.03.2010	Total
Myriapoda								
Schizopetalidae, *Balkanopetalum rhodopinum*	3	2	4	16	0	0	1	26
Lithobiidae, *Lithobius stygius*	1	4	4	0	0	1	2	12
Myriapoda	4	6	8	16	0	1	3	38
Arachnida								
Arachnida, Pseudoscorpiones spp.	0	1	0	0	0	0	0	1
Arachnida	0	1	0	0	0	0	0	1
Hexapoda								
Hexapoda, Collembola spp.	20	250	50	100	500	0	5	925
Hexapoda, Diplura spp.	1	4	0	0	0	0	0	5
Hexapoda, Inscecta, Coleoptera, *Laemostenus plasoni plasoni*	1	8	64	44	13	20	22	172
Hexapoda, Inscecta, Coleoptera, Staphylinidae (small spp.)	0	0	4	12	2	0	0	18
Hexapoda, Inscecta, Coleoptera, Staphylinidae (big sp.)	0	0	0	0	0	20	200	220
Hexapoda, Inscecta, Heteroptera, Pentatomidae spp. (larva)	0	1	0	0	0	0	0	1
Hexapoda, Inscecta, Diptera spp.	1	24	28	48	9	20	9	139
Hymenoptera spp.	0	1	0	0	0	0	0	1
Hexapoda	23	288	146	204	524	60	236	1481
Insecta, larva indet.	0	2	17	0	42	15	8	84
Total	27	297	171	220	566	76	247	1604

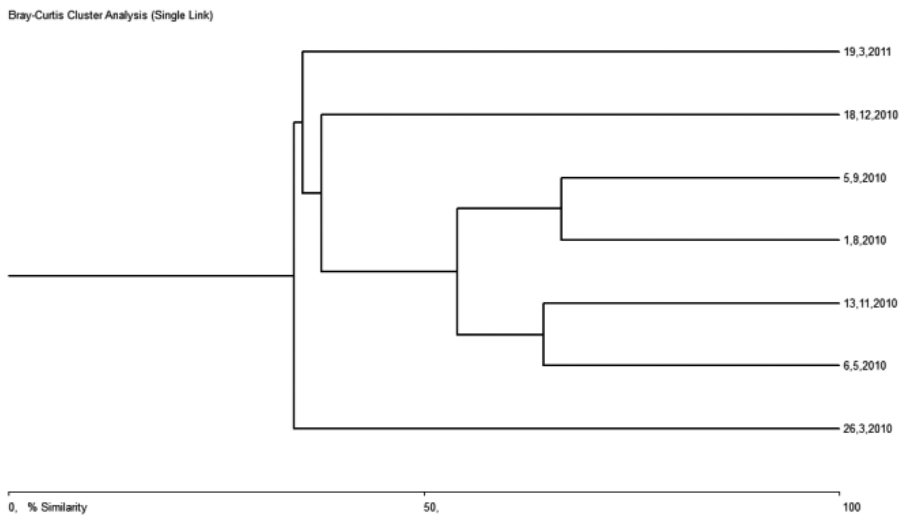

Fig. 3. Cluster analysis considering the minimal count of individuals of a specified taxonomy group during the months of exploration in Yubileina cave

– 172 (11%), and true flies (Diptera) – 139 (9%). The rest of the taxa are represented by a very low percentage. 36 individual multiplied (Myriapoda) have been captured, 26 (2%) of which are the endemic for the Rhodpoes *Balkanopetalum rhodopinum* specie. During the span of the research only one false scorpion (Arachnida, Pseudoscorpiones) has been captured, the only representative of the arachnids. The Heteroptera, Pentatomidae, and Hymenoptera, Vespidae taxa, also had only one representative.

Simpson's index of quantity diversity

Simpson's index of quantity diversity is at its highest in March and November (S=0.64 and 0.44 respectively) and is as the lowest during the rest of the period (March S=0.35, August S=0.21, September S=0.24 and December S=0.24) (Table 2).

Seasonal and monthly numeral dynamics in the established arthropod taxa data

The seasonal dynamics in the numbers of the established taxa shows a general peak tendency in the summer, but there are some differences in the different taxa.

The millipede (Myriapoda) had the greatest numbers in the summer and had the least numerical representation in the traps in other seasons.

The numbers of captured springtails (Collembola) had two peaks – a lesser one in the spring and approximately twice as large in the autumn. The numbers significantly decrease in the winter, and have average numbers in the summer.

The true flies (Diptera) have another peak in the numbers in the summer (September) and average numbers in the spring. Very low numbers in autumn and winter.

The same trend was established for the *Laemostenus plasoni*. The peak of the numbers was in summer and the lowest was in autumn and winter.

The peak of the rove beetles, (Coleoptera – Staphylinidae) was established in the winter, and considerably less in the summer.

Monthly Sörensen's index of quantitative similarity

The highest value of the similarity index (over 50%) was calculated between the land arthropods' communities in August and September (S=64.52), November and May (S=62.34) and September and May (S=53.38).

Between August and May, August and November, November and September, December and March 2011, and December, values between 25% and 50% were established.

Between March 2010 and May, August, September, November, December and March, but 2011, there was little similarity or value under 25%. There was also little similarity between March 2011 and May and November. The lowest value was established between November and March 2010 (S=0.70).

Monthly cluster community analysis

When cluster analyzing of quantitative data from the species caught in the traps in monthly relation (Fig.1), we have established a separation of March 2011 from all other months. They form a large cluster, which is separated with similarity under 50%.

Gargina Dupka cave

Taxon ratio in percent

As a rule the insects (Insecta) are dominant (93.8% of all arthropods) (Table 4).

The biggest number of individuals captured in the traps were the rove beetles (Coleoptera – Staphylinidae) – 1051 individuals, 66% of all. Second to them are true flies (Diptera) – 219 (14%), followed by springtails (Collembola) – 178 (11%).

The rest of the taxa were very poorly represented. The arachnids (Arachnida) 42 (3%) were caught.

Of the rove beetle taxon (*Laemostenus plasoni*) 34 individuals were caught (2%), and only one specimen of *Apterygota, a Diplura (0.07%). There was also one* Chilopoda – *Lithobius* sp.

Seasonal and monthly numeral dynamics in the established arthropod taxa data

The seasonal dynamics in the numbers of the established taxa shows a general peak tendency in the summer, but there are some differences in the different taxa.

The numbers of captured springtails (Collembola) had two peaks – bigger in the spring and lesser in the summer.

The true flies (Diptera) have another peak in the numbers in the summer and average numbers in the spring. Very low numbers in autumn and winter.

The same trend was established for the *Laemostenus plasoni*. The peak of the numbers was in summer and the lowest was in autumn and winter.

The peak of the rove beetles, (Coleoptera – Staphylinidae) was established in the winter, and considerably less in the summer.

Simpson's index of quantity diversity

The Simpson index is as its highest in January and May (S=0.65 and S=0.53 respectively) (Table 5).

Monthly Sörensen's index of quantitative similarity

The highest value of the similarity index (over 50%) was calculated between the land arthropods' communities in September and October (S=81.65), October and June (S=73.68), November and October (S=66.94), September and June (S=60.25), June and July (S=56.22), November and July (S=58.82), and November and September (S=58.50) (Fig.13).

Table 4. Taxonomic diversity and minimum specie number according to monthly visits for collecting results in Gargina Dupka cave

Date, number of species / Taxon	10.04.2010	17.05.2010	18.06.2010	27.07.2010	13.09.2010	03.10.2010	14.11.2010	29.01.2011	11.04.2011	Total
Myriapoda										
Lithobidae, Lithobius spp.	0	0	0	0	0	0	0	0	1	1
Myriapoda	0	0	0	0	0	0	0	0	1	1
Arachnida										
Arachnida, Araneae	2	4	1	0	1	0	2	7	3	20
Arachnida, Opilones	0	1	0	1	2	0	0	1	10	15
Arachnida, Acarina	0	1	0	3	0	0	3	0	0	7
Arachnida	2	6	1	4	3	0	5	8	13	42
Hexapoda										
Hexapoda, Collembola spp.	0	130	0	18	3	0	12	0	15	178
Hexapoda, Diplura spp.	0	0	0	1	0	0	0	0	0	1
Hexapoda, Inscecta, Coleoptera, Staphylinidae big spp.	2	27	20	19	23	19	15	82	77	284
Hexapoda, Inscecta, Coleoptera, Staphylinidae small spp.	2	6	36	24	103	72	52	445	27	767
Hexapoda, Inscecta, Coleoptera spp.	0	0	1	0	0	0	0	0	0	1
Hexapoda, Inscecta, Diptera spp.	3	6	14	56	25	17	14	20	64	219
Hexapoda	8	176	78	120	154	108	93	553	194	1484
Larva indet.	0	0	2	12	1	1	38	2	0	56
Total	10	182	81	136	158	109	136	563	207	1583

Between June and May, June and January, July and May, November and May, November and May, and January and October, values between 25% and 50% were established.

Little similarity or value under 25% was established in the other combination of months. The lowest value was established between January and April (S=3.49)

Monthly cluster community analysis

When cluster analyzing of quantitative data from the species caught in the traps in monthly relation (Fig.2), we have established a separation of May and April from all other months. They form a large cluster, which is separated with similarity under 50%.

Special distribution of complex land invertebrate Yubileyna cave

Specimen of Heteroptera – Pentatomidae and Hymenoptera – Vespidae trogloxenes were established only in position 3 (App. 3 fig. 14). The two species of Coleoptera – Staphylinidae are concentrated in the center of the cave (pos. 2 and 3), but one of them is only present in position 3 (Coleoptera

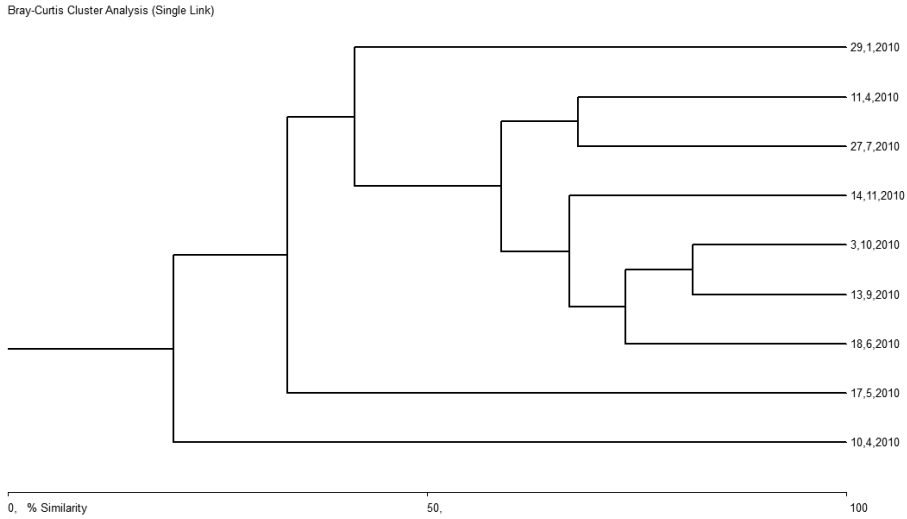

Fig.4. Cluster analysis considering the minimal count of individuals of a specified taxonomy group during the months of exploration in Gargina Dupka cave

Table 5. Simpson's index of quantity diversity value for specimens caught in traps during the months of research in Gargina Dupka Cave

Index	April	May	June	July	September	October	November	January	April
Simpsons Diversity (D)	0.133	0.534	0.288	0.241	0.468	0.486	0.25	0.647	0.256
Simpsons Diversity (1/D)	7.5	1.873	3.473	4.154	2.135	2.056	4	1.546	3.913

– Staphylinidae big specimens). The springtails (Collembola) are seen only in pos. 1 and 2 and are absent from the cave interior. The most of the numbers were in position 2. *Laemostenus plasoni* is not established near the entrance of the cave (position 1) – the highest numbers are in position 2 (72 specimen), in the other position there were almost the same number of specimen.

The number of true flies (Diptera) augments from the entrance to the interior of the cave, and the highest count of specimen (40) was determined in position 5. One false scorpion was found in position 2. The Dipluras are predominant in position 5 (sand substrate).

It was established that the Myriapodas are predominant in position 2, but are also present in position 1 and with lesser numbers in position 5 (confirmed for the two established species *B. rhodopinum* and *L. stygius*). There were no larvae at the entrance (pos. 1) and their number gradually increases as we proceed to the interior of the cave, the highest count was in position 5 – 46 specimen.

The highest count of captured invertebrate is established at position 2 (739 specimens), and the lowest at position 4 (86 specimens). At positions 1 and 3 similar numbers were discovered (331 and 300 specimens respectively). At position 5 the count of the determined invertebrates is 119.

The highest taxonomy diversity was established at position 2 (10 taxa), and the lowest at position 1 (3 taxa).

Gargina Dupka cave

The rove beetle (Coleoptera – Staphylinidae), as a whole, have high numbers in the cave, but their highest numbers are at the entrance of the cave (position 1 – 125 specimens). *Laemostenus plasoni* is evenly spread at the three positions. Collembola are most numerous at the entrance of the cave (position 1 – 104 specimens). Their number decrease at position 2, but increase at position 3 (57 specimens). Harvestmen (Opiliones) as a whole have low numbers in the cave (15 specimens). They have highest numbers at position 1 – 6 specimens. The true flies (Diptera) have highest number at position 1 (120 specimens), and their numbers progressively decreases, and at position 3 there were only 6 specimens.

The only representative of Diplura was established at position 1. The arachnids (Araneae) have the highest numbers at position 2 (8 specimens), and the same numbers at the other positions. The acari (Acarina) are established only at position 1.

The insect larvae have the highest numbers at position 2 (47 specimens), and have considerably less numbers at the other two positions. One specimens of Chilopoda – *Lithobius* sp. was established at position 2.

The highest number of captured land invertebrate is established at position 1 (751 specimens), and the lowest number is established at position 3 (124 specimens, fig. 18):

The highest taxonomic diversity is established at position 1 (10 specimens), and the lowest at position 3 (8 specimens).

Taxonomic part

Yubileyna cave

According to literature data (Beron, Petrov & Stoev, 2011) the following taxa are established in the cave:

Araneae: *Nesticus cellulanus*

Pseudoscorpiones: *Chthonius* sp., *Roncus* sp.

Diplopoda: *Balkanopetalum rhodopinum*

Chilopoda: *Lithobius lakatnicensis, Lithobius stygius*

Orthoptera: *Troglophilus serbicus*

Coleoptera, Carabidae: *Laemostenus plasoni*

Lepidoptera: *Scoliopteryx libatrix*

During this study the following species were confirmed:

Pseudoscorpiones: *Roncus* sp.

Diplopoda: *Balkanopetalum rhodopinum*

Chilopoda: *Lithobius stygius*

Coleoptera, Carabidae: *Laemostenus plasoni*

Other than the above mentioned taxa, via pitfall traps, the following groups were determined:

Collembola

Diplura

Coleoptera – Staphylinidae – 2 species

Diptera – minimum of 2 species

Hymenoptera - Vespidae

Heteroptera - Pentatomidae spp. (larva)

These taxa are mentioned for the first time in this study in Yubileyna cave fauna. More in-depth research is at hand for the gathered biological material. More detailed information will be obtained for the specie appurtenance.

Gargina Dupka cave

According to literature data (Beron et al., 2011) the following taxa are established in the cave:

Opiliones: *Paranemastoma radewi*, *P. aurigerum aurigerum*

Araneae: *Meta menardi*, *Porrhomma convexum*, *Diplocephalus foraminifer*, *Metellina merianae*

Acari: *Spinturnix dasycnemi*, *S. psi*

Collembola: *Tritomurus terrestralis*

Coleoptera, Carabidae: *Trechus austriacus*, *T. quadristriatus*, *Laemostenus plasoni*

Coleoptera, Staphylinidae: *Atheta macroptera*

Diptera: *Nycteribia pedicularia*, *Penicilidia conspicua*, *P. dufouri*, *Heteromyza atricornis*

Lepidoptera: *Scoliopteryx libatrix*

The following species of aquatic invertebrate:

Amphipoda: *Niphargus* sp.

Gastropoda, Hydrobiidae: *Bythinella markovi*

Copepoda: *Paracyclops fimbriatus*

During this study the following specie was confirmed:

Coleoptera, Carabidae - *Laemostenus plasoni*

The following taxa were established:

Arachnida

Araneae

Opiliones

Acarina

Hexapoda

Diplura spp.

Coleoptera – Staphylinidae spp. – 2 species

Diptera spp.

Conclusions:

Positive correlation was established between the number of captured land invertebrate and air temperature with the following taxa: Myriapoda, Collembola, Coleoptera:

Carabidae and Diptera and a negative for Coleoptera: Staphylinidae. This trend was confirmed for the two cases for specimens of Collembola, Coleoptera and Diptera.

The insects had the most numbers in both caves. As a whole predominant are the groups of Collembola, Coleoptera (Carabidae, Staphylinidae) and Diptera.

The seasonal dynamics of the numbers of the multinumber taxa shows a general trend of peaks in the summer and/or spring, and only the rove beetles have their peak in winter.

The number of captured specimens of all groups for both caves in at its highest in spring and autumn.

There was a trend established in spatial distribution of land arthropod complexes in both caves.

The data we have is showing that in both caves the Coleoptera – Carabidae and Diptera taxa inhabit the whole habitat area, but the springtails (Collembola) have the highest numbers in the space near the entrances of the caves.

Some of the species of land invertebrate, established here, are mentioned for the first time as fauna for this caves.

Acknowledgments: Slaveya Stoycheva and Ivan Prodanov, who took part in all field researches. We thank to Boyan Petrov for consulting us during the field research and writing this article.

Our thanks go to the National Natural Museum, which funded parts of this research and Dr. Borislav Georgiev, Professor Pavel Stoev and Nikolai Simov for the time and identification of the biological material. We thank also Hristo Harizanov – Hinko for giving us important scientific articles and materials.

We thank the people that took part in the field research and had significant contribution for the smooth workflow: Aleksandar Stoev – Speleological Club Puldin – Plovdiv, Lyubomir Kovatchev (Speleological Club Academic – Sofia), Nikolay Krastev (Climbing Club Blue Rocks – Sliven).

References

Barber H. 1931. Traps for cave-inhabiting insects. – Journal of Elisha Mitchell sciences society, **46** (3): 259-266.

Beron P. 2004. Biodiversity of cave fauna in Bulgaria. In: Petrova A. (ed.). Contemporary state of biodiversity in Bulgaria – problems and perspectives. Bulgarian bioplatform, Sofia, 397-420.

Beron P. 1994. Résultats des recherches biospéléologiques en Bulgarie de 1971 à 1994 et liste des animaux de cavernicoles bulgares. – Editions de la Fédération bulgare de Spéléologie, Série Tranteeva, Sofia, 137 p.

Biospeleological research center. National museum of natural history (Bulgarian academy of science). http://nmnhs.com/biospeleology-research-centre-bg.html

Beron P., Petrov B, Stoev P. 2011. Invertebrate cave fauna of the western rhodopes (Bulgaria and Greece). – In: Beron P. (ed.) Biodiversity of Bulgaria 4. Biodiversity of the Western Rhodopes (Bulgaria and Greece). Pensoft & NMNH Sofia, 583-661.

Culver D., Pipan C. T. 2009. The biology of caves and other subterranean habitats, Oxford University Press, Oxford, 254 p.

Giachino P., Vailati D. 2010. The subterranean environment. Hipogean life, concepts and collecting techniques. – WBA Handbooks, 3, Verona, 132 p.

Gibert J., Deharveng L. 2002. Subterranean ecosystems: a truncated functional biodiversity. – Bioscience, **52** (6): 437-481.

Glöer P., Georgiev D. 2009. New Rissooidea from Bulgaria (Gastropoda: Rissooidea). – Mollusca, **27** (2): 123-136.

Harizanov H. 2011. Caves in Bulgaria. Electronic data base. – Available at: http://hinko.org/ (last visited January 2013)

Lakin G.F. 1990. Biometrics. Vysshaya shkola, Moscow, 351 p. (In Russian).

Krebs C. 1989. Ecological methodology. Harper Collins Publ., New York, 654 p..

Petrov B., Stoev P. 2007. The underground world of the mountain Rhodopes. UNDP – GEF, Project "Rhodopes", 86 p. (in Bulgarian).

Petrov B., Stoev P. 2009. Methods for gathering and preserving cave animals – In: Zhalov A., Delchev P. (eds.), "80 years of organised speleology in Bulgaria". Symposium proceedings. Bulgarian Federation of Speleology, Sofia, 127-135 p. (In Bulgarian).

Popov V. 1976. Zoning of Caves in Bulgaria. – Problems of Geography, 2(2): 14-24. (In Bulgarian)

Tomov V. 1998. Manual of zoology of invertebrates. Plovdiv University Press "Paisii Hilendarski", 164 p. (In Bulgarian).

Received 16.12.2014

Authors' addresses:
Stanimira Deleva, Green Balkans NGO, Skopie 1 Str, 4000 Plovdiv, Bulgaria, email: stanimira.deleva@gmail.com
Dilian Georgiev, Department of ecology, University of Plovdiv "Paisii Hilendarski", 4000 Plovdiv, Bulgaria, email: diliangeorgiev@abv.bg

Количествена съпоставка на комплексите от сухоземни членестоноги (Arthropoda) в две пещери, разположени в различни карстови райони на Западни Родопи, България

Станимира Делева, Дилян Георгиев

(Резюме)

Извършен е сравнителен анализ на микроклиматичните показатели (температура и влажност), сезонната динамика и количествена съпоставка на комплексите от сухоземни членестоноги (Arthropoda) в две пещери, разположени в два различни карстови района на планина Западни Родопи в България (Юбилейна и Гаргина дупка). За целта са проучени температурата и влажността в двете пещери и зависимостта в разпространението на сухоземните членестоноги от тях. Проучено е количественото съотношение и сезонната динамика на отделните таксономични и екологични групи животни в двете пещери. Направени са изследвания на пространственото разположение на комплексите от сухоземни безгръбначни; видовия и възрастов състав на събраните сухоземни безгръбначни.