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ACTIVITY AND MOVEMENTS OF *ZOSPEUM ISSELIANUM* POLLONERA 1886 (GASTROPODA, PULMONATA, CARYCHIIDAE) IN A CAVE IN THE KAMNIŠKE-SAVINJSKE ALPS (SLOVENIA)

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Slapnik, R.: Activity and movements of *Zospeum isselianum* Pollonera 1886 (Gastropoda, Pulmonata, Carychiidae) in a cave in the Kamniške-Savinjske Alps (Slovenia). Nat. Croat., Vol. 10, No. 3, 153–162, 2001, Zagreb.

The objective of this work was to make periodic observations of hypogean *Zospeum isselianum* Pollonera 1886 snails on a sample rock surface in the Jama pod Mokrico cave in the Kamniške-Savinjske Alps and monitor the distance the snails moved over a given period of time. Between April 30 and August 1, 1997, the movement of the snails was recorded thirteen times. The air temperature in the cave was between 6.0 °C and 10.2 °C, and the relative humidity was between 97% and 100%. The snails moved over distances of from 1 to 15 cm per week. The average distance was 0.7 cm per day. The snails generally crept around the places they were initially found.

Key words: Gastropoda, *Zospeum*, activity, movements, cave, ecology

Slapnik, R.: Aktivnost i kretanje puževa vrste *Zospeum isselianum* Pollonera 1886 (Gastropoda, Pulmonata, Carychiidae) u špilji u Kamniško-Savinjskim Alpama (Slovenia). Nat. Croat., Vol. 10, No. 3, 153–162, 2001, Zagreb.

Cilj rada bio je obaviti periodička opažanja hipogejskih puževa *Zospeum isselianum* Pollonera 1886 na površini stijene u špilji Jama pod Mokrico u Kamniško-Savinjskim Alpama i monitoring udaljenosti koju su puževi prešli tijekom zadanog vremena. Između 30. travnja i 1. kolovoza 1997. pomicanja puževa bila su mjerena 13 puta. Temperatura zraka kretala se između 6.0 °C i 10.2 °C, a relativna vlaga između 97% i 100%. Puževi su se tjedno pomicali od 1 do 15 cm. Prosječna udaljenost bila je 0.7 cm dnevno. Puževi su uglavnom puzali oko mjesta na kojima su prvotno i pronađeni.

Ključne riječi: Gastropoda, *Zospeum*, aktivnost, kretanje, špilja, ekologija

INTRODUCTION

The movements of animals are often complex and responsive to subtle changes in environmental conditions, local features of the environment, or interactions with

food resources or other species. Movements may explain the patterns of distribution and abundance of a motile species and may therefore be studied to test specific hypotheses regarding the reasons behind their distribution. Recording undisturbed movements of animals in the field is necessary to determine natural patterns of movement. The distances moved, the mean direction moved, and the degree of randomness of movement of snails can be influenced by the size of the animals, the complexity of the topography, and the length of time the animals are left before their movements are monitored (UNDERWOOD & CHAPMAN, 1985; CHAPMAN & UNDERWOOD, 1992).

Troglobiotic snails of the genus *Zospeum* (Carychiidae, Archaeopulmonata) inhabit subterranean habitats of the central Pyrenees, the southern Alps, and the Dinaric karst from a few meters above sea level to an altitude of 2,000 meters (HAMANN, 1896; ZILCH & JAECKEL, 1962; BOLE, 1974; PEZZOLI, 1992; SLAPNIK, 1991). Knowledge on the ecology of *Zospeum* is very scarce. It is known that they live in caves and fissures and probably feed on the detritus found in loam and cave sediments (VELKOVRH, 1973). In caves, they occur on walls, on the floor beside puddles, or on organic matter (rotten wood).

The objective of the work was to make periodic observations of hypogean *Zospeum isselianum* Pollonera 1886 snails on a sample rock surface in the »alpine

Fig. 1. Shell of *Zospeum isselianum* from the Belojača cave at Makole, Slovenia (50 x)

karst« Jama pod Mokrico cave in the Kamniške-Savinjske Alps and monitor the distance the undisturbed snails moved over a given period of time. *Zospeum isselianum* (Fig. 1) occurs in northeastern Italy, southern Austria, Slovenia, and northwestern Croatia (BOLE, 1974; MAIER, 1975; MILDNER, 1976; SLAPNIK, 1991; 1994).

MATERIALS AND METHODS

The Jama pod Mokrico cave is situated at the altitude of 980 m on the southern slope of Mount Mokrica (UTM square VM63) in the Kamniške-Savinjske Alps in the central northern part of Slovenia (Fig. 2). The wall area in the cave where we

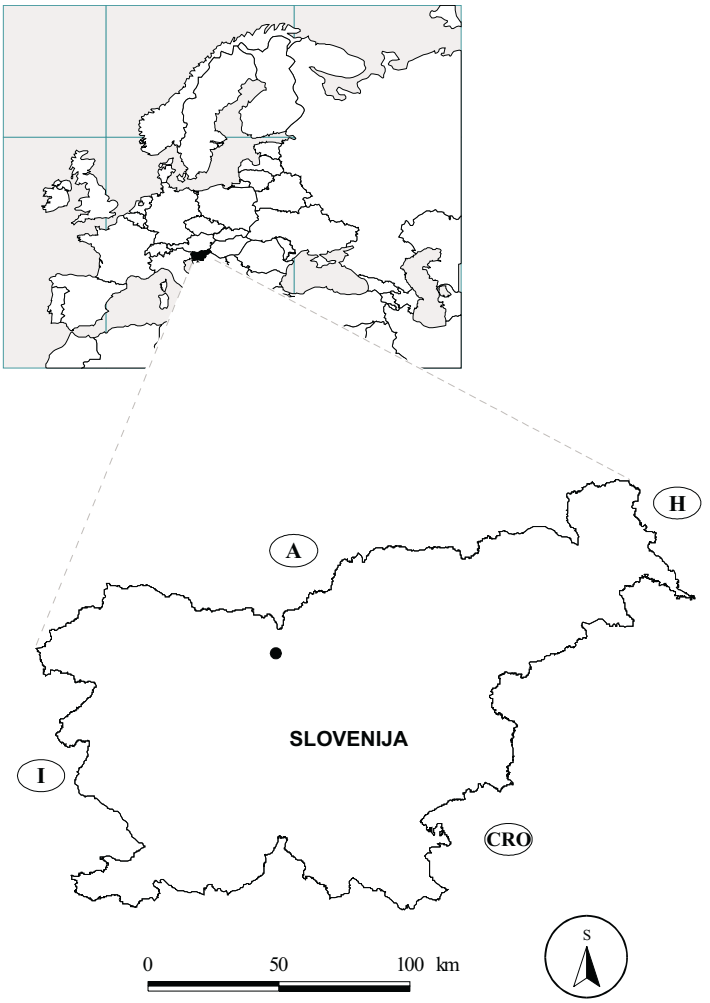

Fig. 2. The geographical location of the Jama pod Mokrico cave

monitored snail movements (Fig. 3) is slightly overhanging and smooth. Water slips over it in several places. Its highest point is about 2 meters, and its lowest about 40 cm above the ground. The area of the research wall surface amounts to about 2.5 m^2.

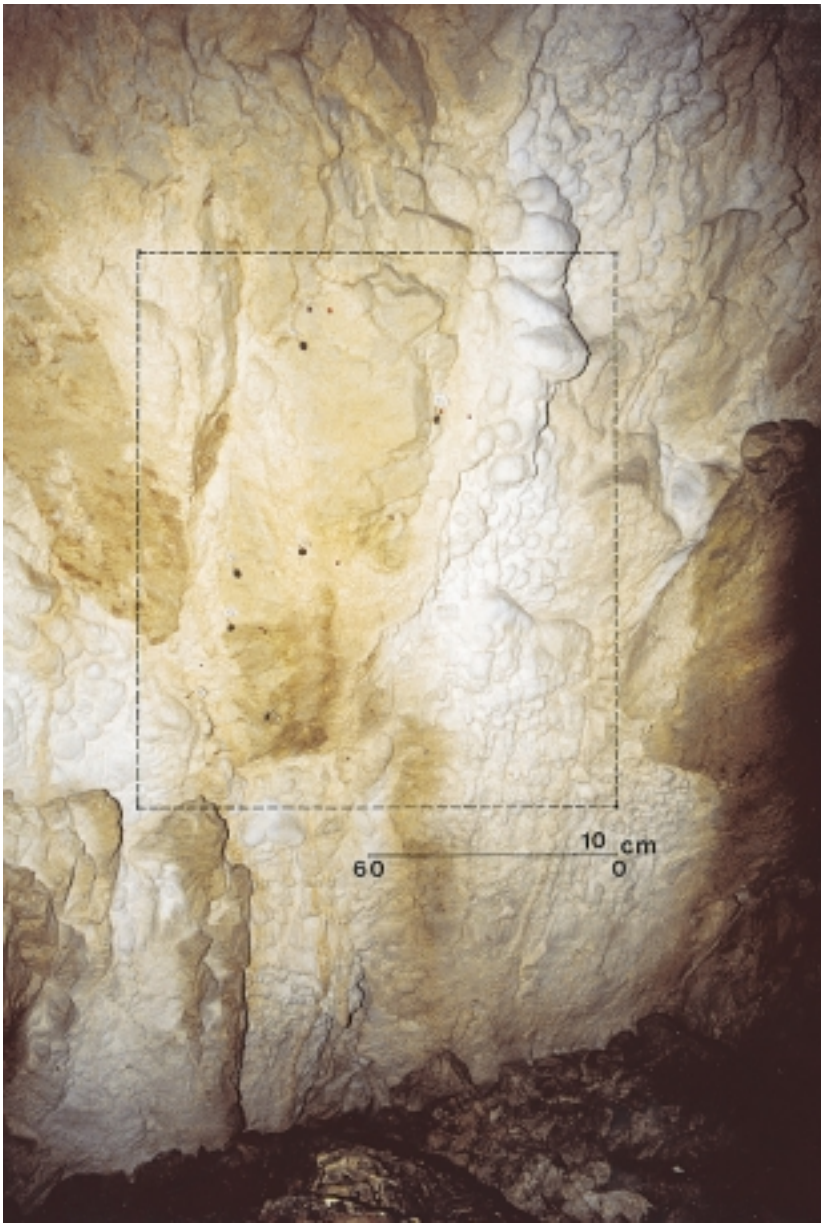

Fig. 3. Cave wall where snail movements were monitored

Between April 30th and August 1st, all movement of the snails always found on the research wall was recorded thirteen times without disturbing the snails. The period between individual observations was most frequently seven days. The distance from the previous position was recorded as the shortest distance between the two points regardless of surface corrugation or the creeping direction of individual snails. Their new positions were marked by plasticine of various colours. For identification, the snails were marked at various spots on their shells with various colours of permanent ink.

The air temperature and relative humidity inside the cave were measured in the middle of the chamber on a larger rock block 1.5 meters above the floor. The air temperature and relative humidity outside the cave was also measured at a point seven meters in front of the entrance. The air temperature and relative humidity inside and outside the cave were recorded on TH 02 Lamprecht thermohygrographs.

RESULTS AND DISCUSSION

1. Air temperature and relative humidity inside and outside the cave

The air temperature in the cave was between 6.0 °C and 10.2 °C (Fig. 4). From mid-April to mid-May in 1997 it remained constant and then increased; the highest temperature was recorded in mid-August. The temperature of the monitoring site in the cave closely followed the average temperature outside (Fig. 4). The temperatures are very similar to those recorded in the Potočka zijalka cave on Mount Olševa (also in the Kamniške-Savinjske Alps) at the altitude of 1,630 meters where

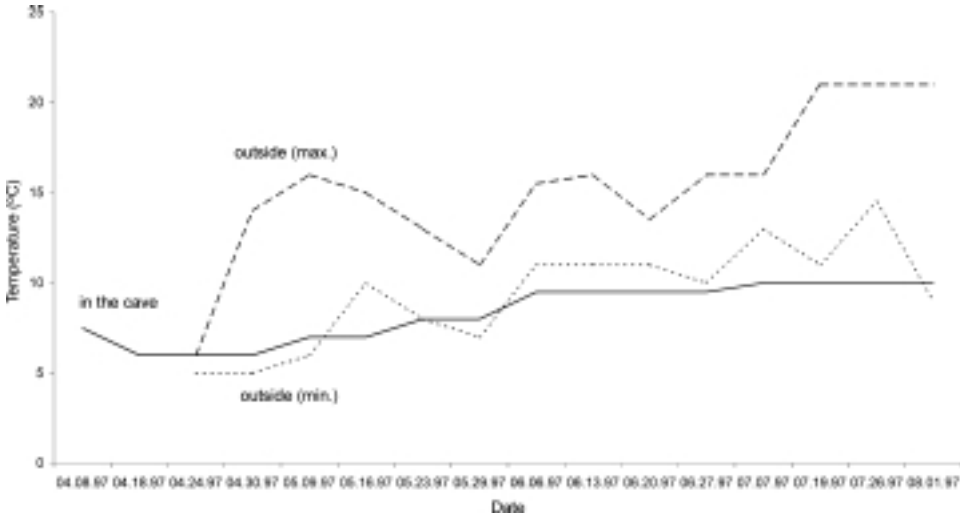

Fig. 4. Air temperatures in the monitoring chamber of the Jama pod Mokrico cave compared with temperatures recorded outside the cave

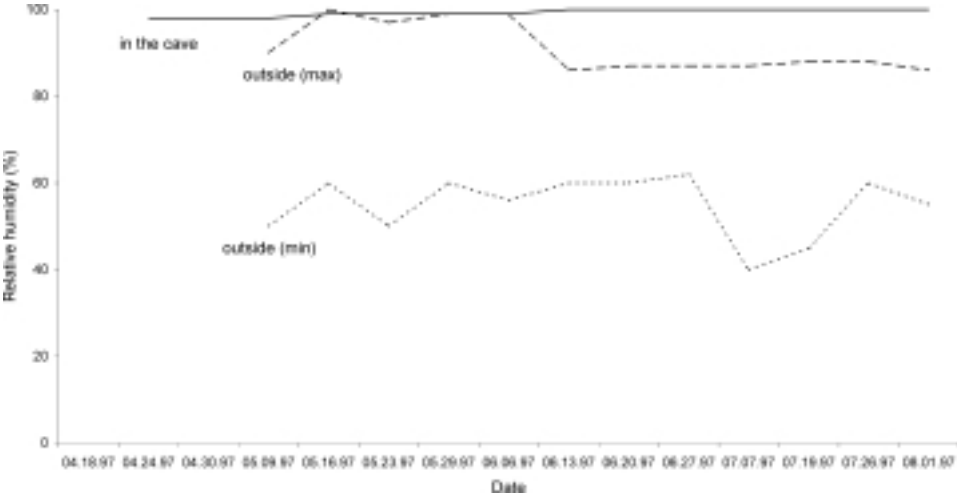

Fig. 5. Relative humidity in the monitoring chamber of the Jama pod Mokrico cave compared with relative humidity recorded outside the cave

cave temperatures begin to rise at the end of May, reach their peak in August, and then cool down again (BRODAR, 1931).

The relative humidity in the cave was between 97 and 100% (Fig. 5), lower in spring and constantly 100% in summer. External diurnal and seasonal fluctuations did not have an impact on relative humidity in the cave.

2. Activity of snails on the sampling surface

On first inspection of the sample surface on May 9th (Tab. 1 (A, B)), six snails were seen crawling along it. No major changes were discovered on the sample wall during the next two observations (May 16 and 23), and snails activity in May was still small. In the last week of May (May 29), six new snails appeared on the sample wall, and until June 20th, two or three new snails were found on each visit to the cave. Later, with the exception of the July 7th visit, no new snails were recorded on the sample wall. During the late spring period (May 16–20), only two snails left the sample wall (Tab. 1 (C)). In summer, the number leaving the sample wall increased considerably. The ratio between snails that were crawling during the observation period and those that were inactive only reflects their momentary state (Tab. 1 (D, E)). It does not show all the events on the sample wall between individual observations. The number of inactive snails increased appreciably toward the end of the observation period as the summer drought brought about reduced activity among the snails. In the middle of July, the number of snails that were crawling dropped even farther and approached very closely the number of snails that were inactive.

In some cases, marking the snail shells caused the snails to withdraw into their shells and to commence crawling again only after a long period.

Tab. 1. Snails dynamics on the sampling surface from May 9 to August 1, 1997 (**A** – number of snails on the sample wall, **B** – number of snails appearing for the first time, **C** – number of snails leaving the sample wall since the beginning of observation, **D** – number of creeping snails, **E** – number of inactive snails).

DATE	9.5.	16.5.	23.5.	29.5.	6.6.	13.6.	20.6.	27.6.	7.7.	19.7.	26.7.	1.8.
A	6	7	7	14	16	16	18	16	18	17	15	14
B		2	0	6	3	2	3	0	3	0	0	0
C		1	1	0	1	2	2	5	6	6	9	10
D		7	7	11	13	11	13	11	12	11	8	8
E		0	1	3	3	5	5	5	6	6	7	6

Tab. 2. *Zospeum isselianum*, Jama pod Mokrico cave. Distances moved (values of distances for particular snails in time intervals and calculated values of the entire distance in all days)

PERIOD	9.5.– 16.5. (cm)	16.5.– 23.5. (cm)	23.5.– 29.5. (cm)	29.5.– 6.6. (cm)	6.6.– 13.6. (cm)	13.6.– 20.6. (cm)	20.6.– 27.6. (cm)	27.6.– 7.7. (cm)	7.7.– 19.7. (cm)	19.7.– 26.7. (cm)	26.7.– 1.8. (cm)	Sum Length (cm)	Time (days)
SNAIL													
1	6	1	2,5	4	5	5						23,5	41
2	8	3	2	5,5	6,5	6	5,5	7,5	4			48	70
3	15	5,5	10,5	5	4	4	3	7	9,5	13	4,5	81	83
4	7	14	12,5	4,5								38	27
5		8	6									14	13
6		7	2	5,5			8,5	7	2,5			32,5	49
7						6	15	3	1			25	36
8				7,5	2,5	4,5	5	9				28,5	38
9					3	3	2,5	5,5	4	4,5		22,5	57
10				2,5	4,5	3	4	2,5				16,5	38
11							3,5	4	4	5,5		17	36
12							7	6	8	3,5		24,5	36
13							8,5			3,5		12	14
14										3		3	7
15									6	4		10	14

3. Movements of snails on the sample wall

The snails moved distances from 1 to 15 cm per week. The average minimum distance moved was 3 cm, and the average maximum distance was 8 cm. The average distance was 5.4 cm per week or 0.7 cm per day (Tab. 2, 3). The snails generally

Tab. 3. *Zospeum isselianum*, Jama pod Mokrico cave. Distances moved, statistics (values of minimum, maximum, and average distances and one-day distances for particular snails; calculated minimum and maximum averages; and standard deviation of minimum, maximum, and average values of these distances)

DISTANCE moved	min (cm)	max (cm)	average (cm)	Lenght/day (cm)
SNAIL				
1	1	6	3,9	0,6
2	2	8	5,3	0,7
3	3	15	7,3	1,0
4	4,5	14	9,5	1,4
5	6	8	7,0	1,1
6	2	8,5	5,4	0,7
7	1	15	6,3	0,7
8	2,5	9	5,7	0,8
9	2,5	4	3,8	0,4
10	2,5	4,5	3,3	0,4
11	3,5	5,5	4,3	0,5
12	3,5	8	6,1	0,7
13	3,5	8,5	6,0	0,9
14	3	3	3,0	0,4
15	4	6	5,0	0,5
min	1	3	3	0,4
max	6	15	10	1,4
average	3,0	8,2	5,5	0,8
stdev	1,3	3,9	1,7	0,3

crept around the places they were initially found or moved to the upper part of the sampling surface. The minimum and maximum values of the weekly distances are quite high. However, compared to the average weekly distances they vary considerably less. The differences in the movement are the consequence of changes on the sample wall. In the dry summer period, the sample wall was perceptibly drier, forcing the snails to move to wetter areas. This resulted in the relatively large number of snails that left the sample wall during the observation period.

CONCLUSIONS

Periodic monitoring of the number of snails on the sample wall and their movements in the period from May 9 to August 1, 1997, shows their activity in the given

period of time. Relative to movement, direction, and distance, there are no significant differences among the fifteen snails observed. The average distance a snail passes over in one day is presented statistically and roughly characterizes the mobility of the snails at the indicated place under defined conditions and over a certain time period. The results obtained form a good basis for further research.

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S A Ž E T A K

Aktivnost i kretanje puževa vrste *Zospeum isselianum* Pollonera 1886 (Gastropoda, Pulmonata, Carychiidae) u špilji u Kamniško-Savinjskim Alpama (Slovenia)

R. Slapnik

Cilj rada bio je opažanje kretanja hipogejskih puževa *Zospeum isselianum* (Carychiidae, Archaeopulmonata). Opažanja su vršena u špilji Jama pod Mokrico na visini od 980 m na južnim padinama planine Mokrica u Kamniško-Savinjskim Alpama. Zid u špilji koji smo promatrali je blago nagnut i gladak, a na nekoliko mjesta se preko njega cijedi voda. Nastojali smo ne uznemiravati puževe. Aktivnost puževa u svibnju je još bila mala. Tijekom zadnjeg tjedna u svibnju šest novih puževa se pojavilo na opažanoj stijeni, a do 20. lipnja svaki puta bi se pojavilo po još 2 ili 3 puža. Kasnije na stijeni više nisu zabilježeni novi puževi. Puževi su se pomicali po 1 cm do 15 cm tjedno. Prosječna udaljenost bila je 5.4 cm tjedno, odnosno 0.7 cm dnevno. Puževi su se uglavnom kretali oko mjesta na kojem su prvotno pronađeni ili su se pomicali na gornji dio plohe.