

*Preliminary Data of the Shell Morphometry of Populations of *Zebrina detrita* (Mollusca: Gastropoda: Pulmonata) from Bulgaria*

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Abstract. Six populations of *Zebrina detrita* Müller, 1774 (Mollusca: Gastropoda: Pulmonata) occurring in different habitats, regions and altitude were studied by shell morphology. The width and height of the shell and its aperture were measured, and also the last whorl height. Their proportions were calculated. Some differences in the shell size were registered in populations situated at different altitude.

Keywords: terrestrial, gastropod, shell size, shell morphology, *Zebrina detrita*, Bulgaria.

Introduction

The data of the shell size variations of the European terrestrial snails is relatively scarce. Few studies on the subject are done by WELTER-SCHULTES (2000, 2001), HAUSDORF (2003), NEKOLA *et al.* (2013), GIOKAS *et al.* (2014). Currently, there are no studies concerning the shell size of *Zebrina detrita* Müller, 1774 and its variations at different habitats and altitudes but many forms and subspecies were described (WELTER-SCHULTES, 2012). For example in Bulgaria, *Z. d. inflata* is known to be a high-mountain subspecies, typical for alpine areas of Pirin (mainly below Vihren peak) and Alibotush Mts. (DEDOV, 2008).

The aim of the current short communication is to present preliminary information on the variation of the shell characteristics in populations at different habitats and regions in various altitudes in Bulgaria.

Material and Methods

We measured a total of 168 empty shells of *Zebrina detrita*, collected from six localities in south Bulgaria between 2000 and 2013:

- Locality №1 - Upper Thracian Lowland, 100-150 m a.s.l., grasslands near an agricultural area at the village of Podslon, 36 shells;
- Locality №2 - Upper Thracian Lowland, 100-150 m a.s.l., grasslands near an agricultural area at the east part of Stara Zagora City, 15 shells;
- Locality №3 - Sarnena Sredna Gora Mts., 200-300 m a.s.l., grass and bush area east of Starozagorski Mineralni bani Resort, 43 shells;
- Locality №4 - Stara Planina Mts., 1441 m a.s.l., Hadzhi Dimitar Peak, 14 shells;
- Locality №5 - Sarnena Sredna Gora Mts., 240 m a.s.l., north of Stara Zagora City, bush terrains, 29 shells;
- Locality №6 - Sarnena Sredna Gora Mts., 240 m a.s.l., north of Stara Zagora

City, moderately wet bush area with *Clematis* sp., 31 shells;

The following main shell morphometric parameters (DAMJANOV & LIKHAREV, 1975) were measured, using caliper (with 0.1 mm accuracy): H – shell height, D – shell width, AH – aperture height, AW – aperture width, LH – body whorl height, as well as the following indices: D/H, AH/H, AH/AW, LH/H.

The results were statistically processed using descriptive statistics – mean, minimum value, maximum value, standard deviation, standard error and variation (FOWLER *et al.*, 1998).

For the statistical processing of the data we used the software package “PAST v.3.06” (HAMMER *et al.*, 2001). Also cluster analysis was performed to evaluate the similarity in the means of the conchiometric parameters between the studies populations, with group average link and Bray-Curtis index, calculated with the computer software “BioDiversityPro” (MCALEECE *et al.*, 1997).

Results and Discussion

The data about the measured conchiometric parameters of the studied populations of *Zebrina detrita* is given in Table 1.

The values of the height of the shell of the studied populations are within the limits of variation for the species, as referred to by WELTER-SCHULTES (2012), who reports shell height of this species of 12-30 mm and width of 8-12 mm.

The smallest shell height (H) have the individuals from the population at Hadzhi Dimitar Peak (Population №4). The average height is 18.4 mm (min-max: 16.8-20.0 mm). The studied populations from the Upper Thracian Valley have generally shorter shells (average 23 mm, min-max: 18.7-27.1 mm), than those in the adjacent slopes of the Sarnena Sredna Gora Mts. (on average 24-25 mm, min- max: 20.7-28.7 mm), but higher than those of specimens from the ridge of Stara Planina Mts.

We recorded differences in the values of the height of the shell in populations located

in one geographical area, but in different habitats. In the Upper Thracian Valley, the individuals from the population at Podslon Village, near arable land (Population №1) have slightly higher shells (10.3 mm) than the ones in the vicinity of Stara Zagora City, near the irrigation canal in herbaceous and shrub vegetation (Population №2) – 9.7 mm (Table 1).

At Sarnena Sredna Gora Mts., the individuals from the two populations inhabiting open grassland with shrubs have on average higher shells (approx. 25 mm) than the population located in damp and shady habitat with shrubs (mean of approx. 24 mm).

From altitude point of view, the shortest shells are from the individuals from the highest, studied population Hadzhi Dimitar Peak (Population №4), located at 1441 m a.s.l. The studied populations from the Upper Thracian Valley (100-150 m a.s.l.) have shells with medium height and the highest shells, which we recorded were at the populations on the slopes of Sarnena Stedna Gora Mts. – 200-300 m a.s.l. (Table 1).

The values of the width of the shell (D) of the studied populations are also within the limits of variation for the species, as referred to by WELTER-SCHULTES (2012), except for the recorded minimum values from Population №4 at Hadzhi Dimitar Peak (7.7 mm).

The smallest width of the shell are again among the population at Hadzhi Dimitar peak (average 8.4 mm, min-max: 7.7-8.9 mm). The studied populations from the Upper Thracian Valley have generally narrower shells (average 10 mm, min-max: 9.0-11.2 mm), than those in the adjacent slopes of Sarnena Sredna Gora Mts. (average 11 mm, min-max: 10.0-12.3 mm), but wider than those of the specimens from the ridge of Stara Planina Mts. The shells of the individuals from the population at Podslon Village (Population №1) are slightly wider than the shells of the individuals around Stara Zagora City – Population №2 (Table 1).

Lowest height (AH) and width (AW) of the aperture (opening of the shell) have the shells from the population at Hadzhi Dimitar Peak. The proportions of the

various parts of the shell are species specific for many types of gastropods and these results are expected. The average value of the height of the opening of the shell in this population is 8.1 mm (min-max: 7.5-8.8 mm) and width of 6.0 mm (min-max: 5.3-6.6 mm).

The body whorl height (LH) again was recorded at the population at Stara Planina Mts. (average 12.4 mm, min-max: 11.7-13.7 mm). The highest value was registered at Sarnena Stedna Gora Mts. populations in forest habitat and in the Upper Thracian Valley, with slightly lower values of about 1-2 mm.

In our opinion the conditions in some habitats and altitudes are unfavorable for this species, which leads to the small sizes of their shells. However, the proportions between the measured parts of the shell have strong overlapping values and have no relation to the habitat, the altitude or the geographical area. These ratios are probably species-specific, and although portions of the shell are different, their proportions are maintained.

The conducted cluster analysis shows that all six populations of *Zebrina detrita* are very similar based on their morphology (Fig. 1). The population from Hadzhi Dimitar Peak (Population №4) is most distinguishable among all in separate cluster at about 85% similarity. From the rest of the population two cluster are formed at about 95% similarity. They are grouped on geographic and altitude principle. The first cluster is formed by population №1 and №2 (96% similarity) from the surrounding of Stara Zagora City, located at similar altitude. The second cluster contains populations № 3, 5 and 6 (97% similarity), all from Sarnena Sredna Gora Mts., also located at similar altitudes. This confirms our conclusion that the registered differences in the measured conchiometric parameters and ratios is due to the habitat and altitude.

Overall, the dimensions of the conchiometric parameters vary more than the proportions between them. This indicates that although the size of the shell of each species varies to some extent, the

ratios between the different parts remains steady and that's why each species has a species-specific exterior (appearance). From all conchometric parameters the most variable is the height of the shell reaching index of variation of about 3.1 units in Sarnena Sredna Gora (Population №6). And the least variable height remains in the population at Hadzhi Dimitar Peak - about 0.9 units. The second most variable parameter is the height of the last turn (0.4 to 1.05 units). All other conchiometric parameters vary less and none exceed 0.5 units. The variation of the proportion of the shell is generally with index with values of about zero, but most varying is the ratio between the height and width of the aperture.

Conclusions

In habitats, geographic regions and altitude, considered unfavorable for the species, the shells usually have smaller size. The smallest shells in this study were recorded at Hadzhi Dimitar Peak in Stara Planina Mts., which minimal values of shell width exceeds the known values for the species. Although the conchiometric parameters vary from population to population, their ratios maintain relatively unchanged and that's why they can be considered species-specific.

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Table 1. Descriptive statistics of the conchiometric parameters of the shell of *Zebrina detrita* in the studied populations.

Population №	H	D	AH	AW	LH	D/H	AH/H	AH/AW	LH/H
Mean									
1	23,131	10,319	10,144	7,731	15,244	0,447	0,439	1,313	0,660
2	22,615	9,738	9,743	7,282	14,755	0,432	0,431	1,339	0,653
3	25,303	11,206	11,094	8,454	16,505	0,443	0,439	1,313	0,653
4	18,364	8,357	8,100	5,957	12,436	0,455	0,441	1,362	0,677
5	23,707	11,052	11,198	8,424	16,321	0,467	0,473	1,330	0,689
6	25,210	11,058	11,097	8,129	16,697	0,440	0,441	1,366	0,663
Minimum values									
1	21,000	9,600	8,800	7,000	13,600	0,410	0,400	1,170	0,620
2	18,710	9,010	8,770	6,220	12,850	0,403	0,405	1,278	0,614
3	22,290	9,950	9,680	7,350	14,590	0,418	0,410	1,161	0,621
4	16,800	7,700	7,500	5,300	11,700	0,430	0,421	1,206	0,634
5	20,700	10,000	10,000	7,400	14,600	0,431	0,443	1,178	0,639
6	21,500	10,000	9,000	7,000	14,600	0,348	0,383	1,235	0,564
Maximum values									
1	27,100	11,200	11,100	8,500	16,700	0,470	0,480	1,470	0,690
2	24,740	10,420	10,800	7,900	16,200	0,503	0,469	1,415	0,687
3	25,310	10,900	11,460	8,230	16,440	0,431	0,453	1,392	0,650
4	20,000	8,900	8,800	6,600	13,700	0,478	0,478	1,473	0,699
5	26,000	12,300	12,400	9,300	18,200	0,507	0,505	1,438	0,735
6	28,700	12,000	12,500	9,000	18,400	0,512	0,488	1,528	0,707
Standard Deviation									
1	1,205	0,403	0,531	0,339	0,699	0,018	0,017	0,059	0,017
2	1,521	0,436	0,603	0,493	1,017	0,025	0,019	0,046	0,025
3	1,472	0,522	0,658	0,450	0,874	0,015	0,017	0,053	0,020
4	0,930	0,396	0,376	0,341	0,636	0,015	0,015	0,066	0,021
5	1,397	0,656	0,679	0,447	0,908	0,019	0,016	0,064	0,019
6	1,760	0,604	0,857	0,544	0,942	0,030	0,025	0,071	0,027
Standard Error									
1	0,201	0,067	0,089	0,056	0,117	0,003	0,003	0,010	0,003
2	0,393	0,112	0,156	0,127	0,263	0,006	0,005	0,012	0,006
3	0,224	0,080	0,100	0,069	0,133	0,002	0,003	0,008	0,003
4	0,248	0,106	0,101	0,091	0,170	0,004	0,004	0,018	0,006
5	0,259	0,122	0,126	0,083	0,169	0,004	0,003	0,012	0,004
6	0,316	0,109	0,154	0,098	0,169	0,005	0,004	0,013	0,005
Variance									
1	1,4490	0,1671	0,2778	0,1129	0,4911	0,0003	0,0003	0,0035	0,0003
2	2,3215	0,1863	0,3691	0,2443	1,0525	0,0006	0,0003	0,0021	0,0006
3	2,1692	0,2734	0,4361	0,2057	0,7478	0,0002	0,0003	0,0028	0,0003
4	0,8640	0,1565	0,1415	0,1165	0,4040	0,0002	0,0002	0,0043	0,0004
5	1,9507	0,4304	0,4654	0,1998	0,8246	0,0004	0,0002	0,0041	0,0004
6	3,0976	0,3652	0,7343	0,2961	0,8870	0,0009	0,0006	0,0050	0,0007

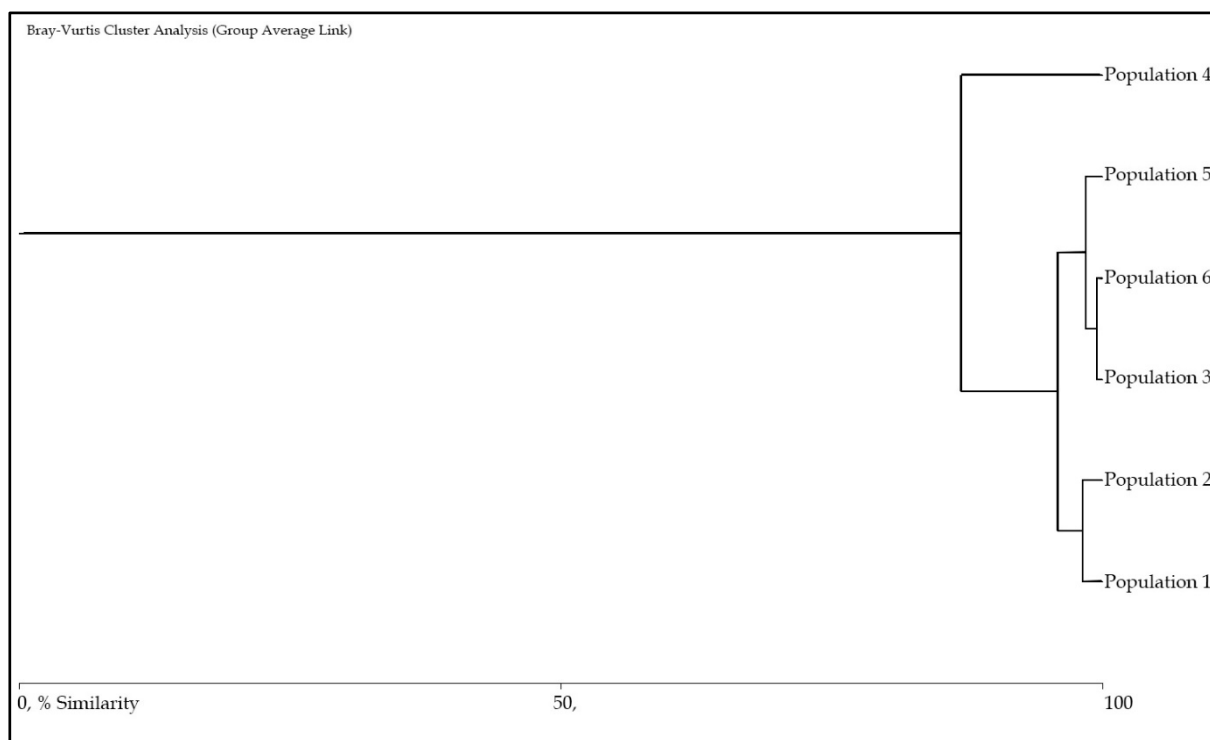


Fig. 1. Cluster analysis of the means of all measured conchiometric parameters and ratios of the six studied populations (Bray-Curtis index, group average link).

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