FOLIA MALACOLOGICA
Vol. 6: 7–13
ISSN 1506-7623
The Association of Polish Malacologists
& Faculty of Biology, Adam Mickiewicz University
Poznań 1998

MORPHOMETRIC COMPARISON OF *VESTIA ELATA* (ROSSMÄSSLER, 1836) (GASTROPODA: PULMONATA: CLAUSILIIDAE) FROM THE ŚWIĘTOKRZYSKIE MTS AND THE CARPATHIANS

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ABSTRACT: Biometrical analysis including six metric and one non-metric shell characters of *Vestia elata* (Rossm.) from the Świętokrzyskie Mts, Bieszczady Mts and S Carpathians revealed a clear separation of the isolated population from the Świętokrzyskie Mts. Snails of this population have smaller and stouter shells than those from the Carpathian populations. Values of most studied parameters increase southwards. The least variable character of a high heritability is the width of embryonic whorls.

KEY WORDS: snails, interpopulation variation, morphometry, Clausiliidae

INTRODUCTION

Vestia elata (Rossmässler, 1836), a member of the subfamily Baleinae, is a Carpathian species whose range comprises the Southern Carpathians, Transylvanian Upland, Eastern Carpathians and the eastern part of the Western Carpathians (Fig. 1). According to LIKHAREV (1962) the snail does not occur in the Ukrainian Carpathians. In Slovakia it reaches the eastern part of Nizke Tatry, Slovenske Rudohorie and Slovensky Kras (LOŽEK 1957, STWORZEWICZ 1973). In Poland it has been recorded from the Bieszczady Mts – the village of Dwernik (STWORZEWICZ 1973), Strzyżów in the Beskid Niski Mts (BĄKOWSKI & ŁOMNICKI 1892, STWORZEWICZ 1973) and from isolated sites in the Świętokrzyskie Mts: Łysa Góra, Łysica, Niwki Daleszyckie, Mt. Szczytniak in the chain Pasmo Jeleniowskie (PIECHOCKI 1981, 1982, URBAŃSKI 1937). The localities in the Świętokrzyskie Mts are remote from the main, Carpathian, part of the range and thus are of insular character. In the Carpathians *V. elata* lives in beech forests typical of the lower mountain zone. It stays under stones, logs, fallen leaves, bark and in screes. The species appeared in the Świętokrzyskie Mts probably during the Atlantic climatic optimum, when the beech-fir forests extended their range northward (PIECHOCKI 1981). An evidence for northward migration of an array of Carpathian snails is their occurrence in Holocene deposits of the Cracow-Częstochowa Upland (ALEXANDROWICZ 1983, ALEXANDROWICZ & STWORZEWICZ 1983, STWORZEWICZ 1973) and of the surroundings of the Świętokrzyskie Mts (PIECHOCKI 1977, 1981). Later cooling down and aridization of the climate resulted in a retreat of the beech forests to south-western refugia, and the same happened to many invertebrate species.

The isolated position of the localities of *V. elata* in the Świętokrzyskie Mts could result in differences between the local population and the Carpathian populations of the main range (geographical population; MAYR 1974). The objective of this study was to check if such differences actually occurred.

Fig. 1. Distribution range of *V. elata*

MATERIAL AND METHODS

A total of 190 shells from three distribution areas were analysed.

1. Świętokrzyskie Mts (range Pasmo Łysogórskie) – 86 specimens, A. Piechocki's collection. The materials were collected on Łysa Góra, in a forest which is a poor variant of Carpathian beech forest of lower altitudes. Besides the dominant fir (*Abies alba* Mill.) and beech (*Fagus silvatica* L.) there is sycamore (*Acer pseudoplatanus* L.), linden (*Tilia cordata* Mill.) and maple (*Acer platanoides* L.). *V. elata* was numerous on the southern slope of Łysa Góra in a humid patch of beech forest with a rich undergrowth of *Sambucus nigra* L., *S. racemosa* L., *Evonymus* sp., *Sorbus aucuparia* L. and *Rubus* sp. This is the richest

site of *V. elata* in the Świętokrzyskie Mts – the mean density was 412 individuals per 1 m^2 (PIECHOCKI 1982).

2. Bieszczady Mts – 45 specimens; Dwernik on the San River, own collection and the Museum and Institute of Zoology, PAS, Warsaw. The snails were collected on a steep slope next to the San River, in a beech forest with rich litter cover. The undergrowth comprised *Sambucus racemosa* L., the herb layer – *Urtica dioica* L. The sample from the Bieszczady Mts was pooled with a sample from the neighbouring Beskid Niski, collected in alder thickets in Surowica on the Wisłok River.
3. Southern Carpathians (Romania) – 59 specimens, collection of the Senckenberg Museum, Frankfurt a.M., and the Natural History Museum in London. Of many samples examined only those five were used whose labels made it possible to locate the site (Muntii Fagarasului and vicinity of Sibiu). The scanty information precluded description of habitats where the snails were collected.

The following characters were analysed (Fig. 2): 1. shell height, 2. shell width, 3. width of embryonic whorls, 4. aperture height, 5. aperture width, 6. lip thickness. The only analysed non-metric character (7) was the number of folds in the aperture. All the measurements were taken with 0.1 mm accuracy.

Analysis of discriminant function was used in order to find out which variables provide the best discrimination of the studied groups (DOMAŃSKI 1990, MISZTAL 1997). Since using variance analysis it was impossible to maintain the assumption of equality of variance in all the possible transformations, values of characters between samples from the three geographical areas were compared with non-parametric Kruskal-Wallis test (AFIFI & CLARK 1990, SOKAL & ROHLF 1981).

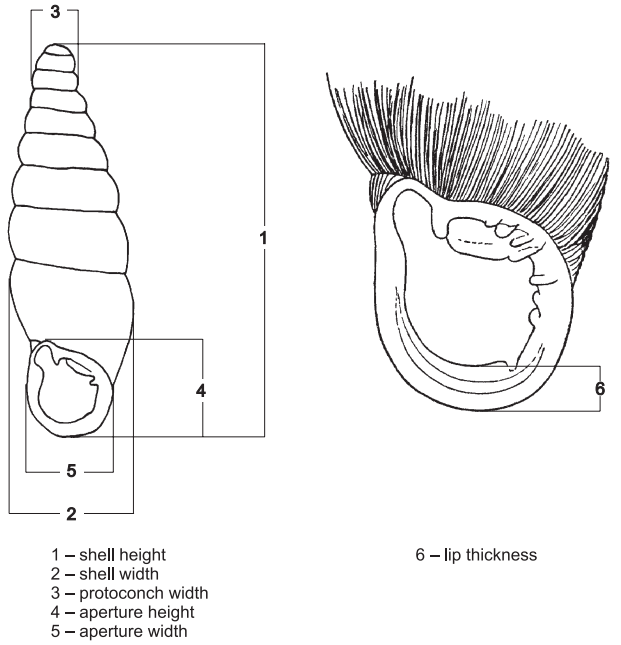

Fig. 2. Studied metric characters of *V. elata*

Statistical analysis was performed with Statistica, version PL 5.1. The significance level adopted was 0.05. Null hypothesis versus alternative hypothesis was subject to two-sided test.

RESULTS

Discriminant analysis has revealed that the strongest discriminant properties are displayed by: shell height (character 1), shell width (2), embryonic whorls width (3) and lip thickness (6) (Table 1). The remaining characters, not included in the table, are insignificant.

The graph of distribution of canonical values for discriminant functions of metric characters in *V. elata* shows differences between populations (Fig. 3). The population from the Świętokrzyskie Mts is clearly separated from the Bieszczady and S Carpathian populations, and at the same time the least variable. Both the Carpathian populations are clearly similar, and more variable; the studied characters have the widest variability ranges in the S Carpathian popula-

Table 1. Functions of discriminant analysis

character	Wilks	Partial	Rejection F(2.184)	Significance	Tolerance
1	0.370212	0.683700	42.56200	0.000000	0.484777
6	0.347903	0.727542	34.45321	0.000000	0.935928
2	0.281160	0.900249	10.19394	0.000063	0.474726
3	0.267173	0.947377	5.11028	0.006920	0.865576

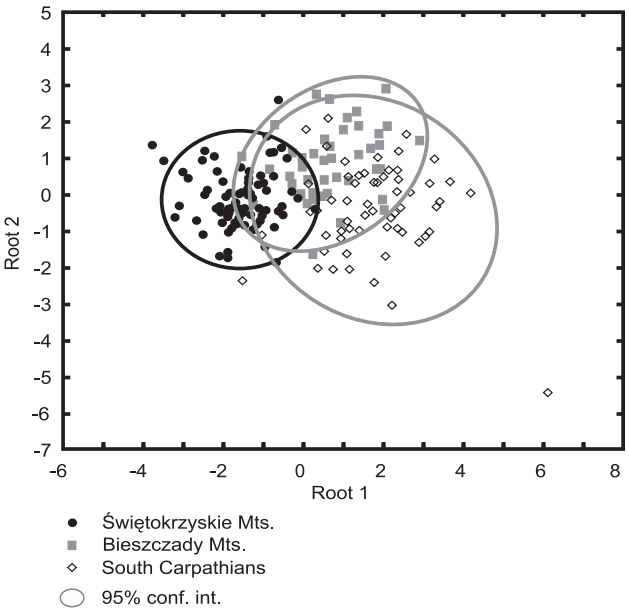

Fig. 3. Dependence of canonical values for discriminant functions

tion. This results probably from the fact that the individuals came from various sites and different habitats.

Based on Kruskall-Wallis test (Table 2) it can be said that the interpopulation variation of all the studied characters is statistically significant. This testifies to large differences in character values between the studied populations. Character 3, width of embryonic whorls, is the least varied between the three areas.

Table 3 presents mean values of the examined characters, with their standard deviations.

The values of characters 1, 2, 4, 5, 6, 7 increase from north to south; the Bieszczady population assumes intermediate values. For example the distribution of shell width is presented in Fig. 4. Character 1 (shell height) which also shows significant differences between the studied populations (Student t-test: t = 13.81, p = 0.1^{-7}) is the least variable between the Carpathian populations. A similar variation is shown by the height/width ratio (Table 4, Fig. 5). The width of embryonic whorls (3) has turned out to be the least variable character within the whole distribution range of *V. elata* (Fig. 6).

Table 2. Kruskall-Wallis test – comparison of characters between the three populations

	Świętokrzyskie Mts		Bieszczady		S Carpathians				
character	mean rank	number of measurements	mean rank	number of measurements	mean rank	number of measurements	D.F	significance	chi square*
1	48.37	86	127.95	44	138.40	59	2	0.0000	115.5995
2	63.54	86	103.93	45	135.65	59	2	0.0000	61.5581
3	106.13	86	82.53	45	89.89	59	2	0.0422	6.3315
4	51.33	86	115.03	44	143.72	59	2	0.0000	107.5181
5	56.74	86	114.00	45	137.89	59	2	0.0000	82.8758
6	51.91	86	103.68	44	150.68	58	2	0.0000	115.7551
7	79.66	86	94.09	43	116.42	59	2	0.0000	15.9736

* for = 0.05 test function chi square = 5.991

Table 3. Mean values of the examined characters [mm] and standard deviation (SD)

area:	Świętokrzyskie Mts		Bieszczady		S Carpathians	
number of specimens:	86		45		59	
shell characters:	mean	SD	mean	SD	mean	SD
1. shell height	12.58	0.62	14.43	1.22	14.84	0.90
2. shell width	3.75	0.14	3.88	0.27	4.06	0.15
3. width of embryonic whorls	1.42	0.67	1.39	0.13	1.39	0.09
4. aperture height	3.10	0.14	3.40	0.24	3.59	0.20
5. aperture width	2.63	0.12	2.82	0.20	2.94	0.14
6. lip thickness	0.57	0.08	0.69	0.13	0.84	0.09
7. number of folds	1.90	0.55	2.09	1.31	2.73	0.73

In the literature on the clausiliids, there is a large discrepancy in the measurements of *V. elata* (Table 5) which results probably from the absence of data on populations from the whole distribution area.

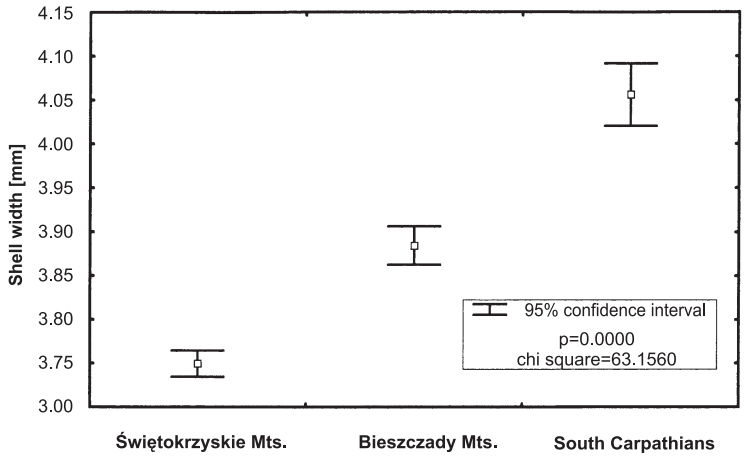

Fig. 4. Mean shell width in three populations of *V. elata*

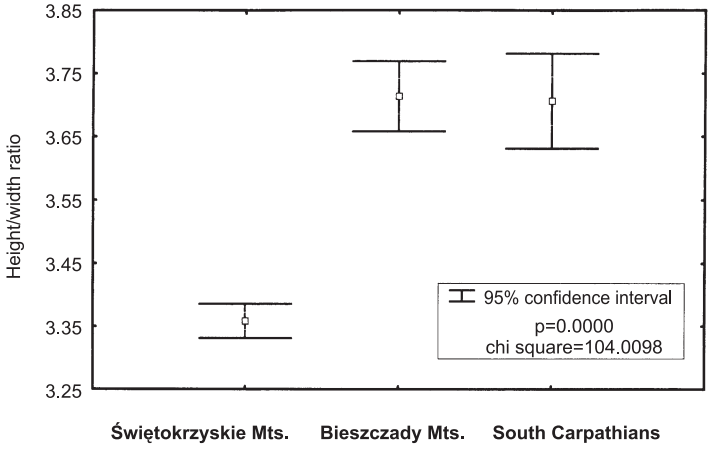

Fig. 5. Mean shell height/breadth ratio in three populations of *V. elata*

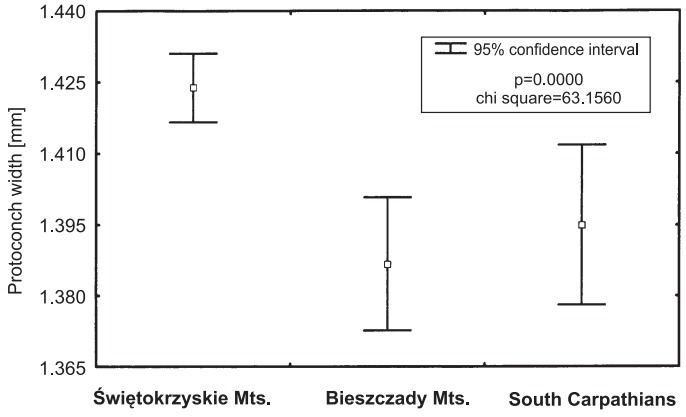

Fig. 6. Mean width of embryonic whorls in three populations of *V. elata*

Table 4. Height/breadth ratio, basic statistics

area	Świętokrzyskie Mts	Bieszczady	S Carpathians
mean	3.358	3.714	3.706
95% confidence limits	3.330–3.385	3.657–3.771	3.629–3.783
minimum value	3.050	3.32	3.08
maximum value	3.81	4.13	4.89
standard deviation	0.129	0.188	0.295

Table 5. Comparison of literature data and measurements of *Vestia elata* obtained in this study

no.	author	shell height [mm]	shell width [mm]	region
1	Urbański (1937)	12.0–14.0	3.5–4.0	Świętokrzyskie Mts
2	Piechocki (1982)	11.0–14.4	3.5–4.0	Świętokrzyskie Mts
3	own data	11.5–14.3	3.4–4.0	Świętokrzyskie Mts
4	Ložek (1956) Kerney (1983)	15.0–18.0 (14.0–20.0)	4.3–4.6	whole area
5	Likharev (1962)	12.0-15.0 (up to 20.0)	3.5–4.5	whole area
6	own data	13.0–16.1	3.7–4.1	Bieszczady
7	own data	11.7–18.3	3.5–4.7	S Carpathians

DISCUSSION

1. The analysis has revealed geographic variation of *V. elata*. Shells from the Świętokrzyskie Mts are smaller than within the main, Carpathian, distribution range which was pointed out already by URBAŃSKI (1937). The specimens from Łysa Góra are also stouter.
2. The shell parameters examined, except the width of embryonic whorls, display a wide intrapopulation variability, the Carpathian samples being more similar to each other, while the sample from the Świętokrzyskie Mts is remote from them. The values of shell height, shell width, aperture height, aperture width, lip thickness and number of folds increase from north (Świętokrzyskie Mts) to south (S Carpathians) with intermediate values in the Bieszczady Mts. Variability coefficients for two characters (shell height and height/breadth ratio) are significantly lower in the population from the Świętokrzyskie Mts (4.92 and 3.83, respectively) than in the Bieszczady (8.45 and 5.06) or S Carpathian (6.06 and 7.96) populations.
3. The narrow variation within the population from the Świętokrzyskie Mts may indicate a limited gene pool.
4. In contradistinction to the remaining characters, the width of embryonic whorls is little variable in all the examined populations. The character is determined by genes that are activated in the initial phase of development, and their action is only negligibly affected by habitat.
5. The conchological separateness of the population of *V. elata* from the Świętokrzyskie Mts may have three reasons: a) geographic isolation preventing gene flow between it and the Carpathian populations; b) unfavourable edaphic conditions; c) climatic differences between the studied areas. In the area called Okręg Łysogórski the main rocks are quarzites, greywacke, sandstones and schists, i.e. non-calcareous rocks, additionally easily radiating heat. Likewise, the soils of the area are poor in calcium and strongly acid (pH 3.5–4.5) (BARGA-WIĘCŁAWSKA 1996, WARĘSKI & ADAMOWICZ 1970).

ACKNOWLEDGEMENTS

We are grateful to Dr. Z. WOJCIECHOWSKI (University of Łódź) for his help with statistical analysis of the data.

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received: July 15th, 1998
accepted: September 18th, 1998