ABIOGENIC AND ORGANIC COMPONENTS OF MODERN TERRESTRIAL GASTROPODES OF AZERBAIJAN: STUDY OF MACRO-, MICRO- AND BIOELEMENTS

As a result of field campaign in the Greater Caucasus the big faunal material has been collected from the southern and northern slopes of these mountains. The material included shells of both living and dead terrestrial gastropods, found mainly on the territory of Guba district – an administrative region within Azerbaijan, located on the northern slope of the Greater Caucasus. The collected shells were then compared to gastropods found in the Shamakhi, Sheki and Gakh regions in the southern slope of the Greater Caucasus, and with shells from the Caspian Sea coast. In total, 70 samples of shells belonging to mollusk Helix lucorum L. have been analyzed.

The total organic matter (TOM) and several bioelements - organic carbon, protein nitrogen and phosphorus, have been determined in the shell material. Besides that macro- and microelement distribution in skeleton remains of the collected mollusks has been investigated. The results achieved allowed conclusion about the controling factors on the composition of calcium carbonate and the organic component of the shell material of studied gastropods.

Keywords: South-Eastern Caucasus, terrestrial gastropods, shells, organic matter, calcium carbonate, proteins, chemical elements

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Material and methodology

In order to ensure the study accuracy of the organic components and elemental composition of the terrestrial gastropod skeletons, the well-developed and undamaged shells were selected. The study was implemented on a vast area covering the northern part of the Azerbaijani segment of the Caspian coast and the southern and northern slopes of the Greater Caucasus mountain system (Figure 1). Different individual age representatives of the same species were selected to study ontogenetic factors affecting the accumulation of the organic matter. The samples were prepared following a single procedure: the soft tissue was separated and shells were washed for one hour under running water at 20–22ºC. The soft tissue attachment sites and foreign matters were carefully scraped. After that the gastropod skeletons were dryed in the dark room. In order to produce reliable analytical results the parallel analyses were performed.

Organic carbon was determined by the method of I.V.Tyurin (Standard method …., 2021). The method is based on the oxidation of an organic matter in shells with chromic acid until forming of carbon dioxide. Protein nitrogen analysis was performed according to the Bremner method (1965). Macro- and microelement contents were determined by the X-ray spectroscopy technique.

Discussion of results

Distribution of organic component in the shell material of terrestrial gastropods

Samples of this terrestrial mollusk species were collected in six areas of Azerbaijan located on the southern and northern slopes of the

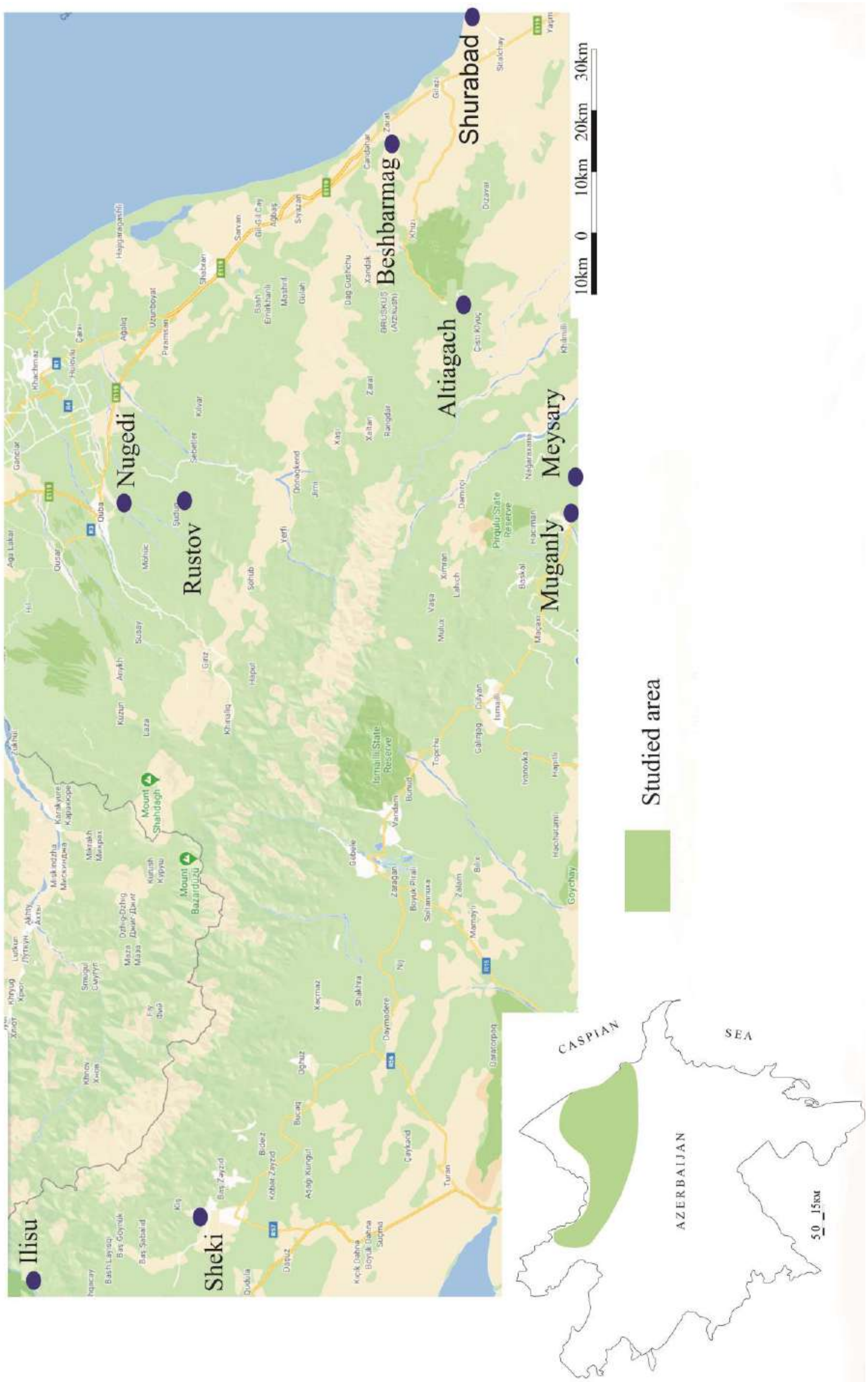

Figure 1. Location map of the collected shell samples of terrestrial gastropods within studied area

Greater Caucasus that not significantly differing by the environmental and geochemical characteristics. Samples found in the Guba area in the northern slope were compared with those ones collected from the Shamakhi, Sheki and Gakh regions in the southern slope. The shells found in four localities in the Guba and Shamakhi regions (Nugedi, Rustov, Meysary and Muganly) belonged to the adult gastropods, while the other sample sets collected in Sheki and Ilisu sites contain different-age individuals. In total, 26 samples with well formed and undamaged shells have been analyzed.

We have recorded that amount of bioelements in the studied skeletons is varying in a wide range – from 0.17% to 0.50% with an average value equaling to 0.25% in case of organic carbon (C_{org}), and from 0.37% to 0, 125% with an average value of 0.057% in case of $N_{protein}$ (Figure 2).

The highest organic carbon and protein nitrogen quantities were identified in the samples collected from Rustov and Nugedi localities (Guba region), and the smallest – in the shells found in Muganly and Meysary (Shamakhi region). Relatively high contents of the bioelements were determined in the samples collected from Ilisu locality (Gakh region) hypsometrically located 1300 m above sea level, and in shells from Sheki region.

We can report that these bioelement concentration differences are mainly due to ontogenetic control. It was recognized that organic carbon and protein nitrogen amounts are equal on average to 0.5% and 0.125% respectively in the young forms; 0.31% and 0.075% in the middle-aged samples, and 0.20% and 0.0049% in the adult shels (Figure 2). These data testify to gradual decrease of the bioelement quantities in the skeleton material of *Helix lucorum* L. mollusk with the age.

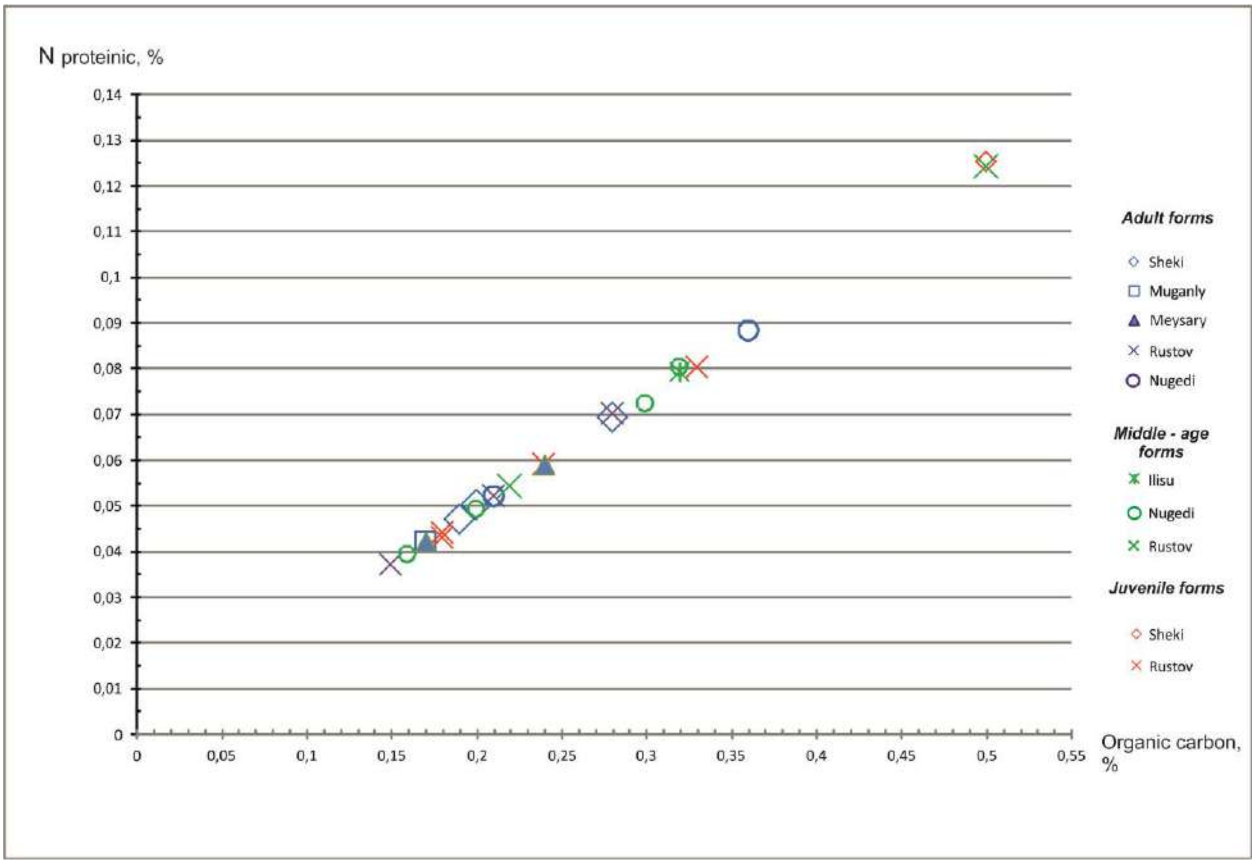

Figure 2. Plot of organic carbon and proteinic nitrogen content values in the different-age shells of *Helix lucorum* L.

Another reason for the wide variations of the bioelement amounts is the individual impact of the studied mollusks. In order to assess this effect on the in-shell concentrations of the organic carbon and protein nitrogen, four specimens of *Helix lucorum* L. of the equal age and size in each locality – Rustov and Nugedi, were analyzed. The age of the analyzed skeletons was determined to be equal to three years. The shells from the Rustov locality have the height of 35 mm, height of the last whorl – 25 mm, and diameter of the last whorl – 28 mm (Table 1). We should mention that these shells differed from each other by wall thickness and color.

According to the analysis results, light colored thick-walled shell contains 0.18% of the organic carbon and 0.043% of protein nitrogen. $C_{org.}$ / $N_{prot.}$ ratio is equaling to 4.18 (Figure 3, Table 1). The less light thick-walled shell demonstrates the organic carbon amount of 0.18%, the protein nitrogen – 0.044%, and the $C_{org.}$ / $N_{prot.}$ ratio of 4.09. The less thick-walled dark shell contains 0.24% of the organic carbon and 0.059% of the protein nitrogen, $C_{org.}$ / $N_{prot.}$ ratio of 4.06. Finally, the thin-walled dark shell is characterized by 0.33% of the organic carbon, 0.080% of the protein nitrogen, and $C_{org.}$ / $N_{prot.}$ ratio is equaling to 4.12.

Table 1

Composition of the organic component of the *Helix lucorum* L. gastropod shells

#	Location	Ontogenetic age / size	Note	C org. %	N prot. %	C org. / N prot.	Org. matter, %	Protein, %
1	2	3	4	5	6	7	8	9
1	Ilisu	Middle age	Did’t treated w/dist.w.	0,32	0,079	4,06	0,628	0, 475
2	-------	Adult	Treated w/dist. water	0,28	0,069	4,07	0,547	0,415
3	Sheki	Middle age	Light form	0,22	0,054	4,07	0,430	0,331
4	-------	Middle age	Dark form	0,16	0,040	4,00	0,313	0,240
5	Sheki	Adult		0,20	0,050	4,00	0,319	0,301
6	--------	Adult		0,19	0,047	4,04	0,372	0,283
7	-------	Middle age	3 specimens	0,30	0,075	4,00	0,587	0,452
8	-------	juvenile	5 speciments	0,50	0,125	4,00	0,978	0,753
9	Muganly	Adult	4 specimens	0,17	0,042	4,05	0,332	0,253
10	Meysary	Adult	3 speciments	0,17	0,042	4,05	0,332	0,853
11	Rustov	Adult	Thin-walled light form	0,28	0,070	4,00	0.547	0,421
12	Nugedi	Adult	Thin-walled light form	0,36	0,088	4,09	0,704	0,530
13	Rustov	43*30*45	Thin-walled dark form	0,21	0,052	4,03	0,410	0,313
14	------	-------	Thin-walled dark	0,15	0,037	4,08	0,283	0,231
15	Meysary	44*30*45	Thin-walled dark	0,24	0,059	4,06	0,469	0,355
16	Nugedi	44*28*43	Thick-walled light	0,21	0,052	4,03	0,410	0,313
17	Rustov	35*25*38	Thick-walled light	0,18	0,043	4,18	0,355	0,259
18	-	35*25*38	Thin-walled dark	0,18	0,044	4,09	0,355	0,265
19	-		Thin-walled	0,24	0,059	4,06	0,469	0,355
20	-		Thin-walled	0,33	0,080	4,12	0,645	0,482
21	Nugedi	38*27*42	Thin-walled	0,32	0,080	4,00	0,628	0,482
22	-		Thick-walled	0,30	0,072	4,03	0,587	0,434
23	-		Thick-walled	0,16	0,039	4,1	0,313	0,235
24	-		Thick-walled	0,20	0,049	4,08	0,391	0,295
25	*Rustov*	38*28*43	Thick-walled	0,22	0,054	4,08	0,430	0,325

1	2	3	4	5	6	7	8	9
26	-		Thick-walled dark	0,16	0,039	4,10	0,313	0,325
27	-			0,50	0,124	4,03	0,978	0,747

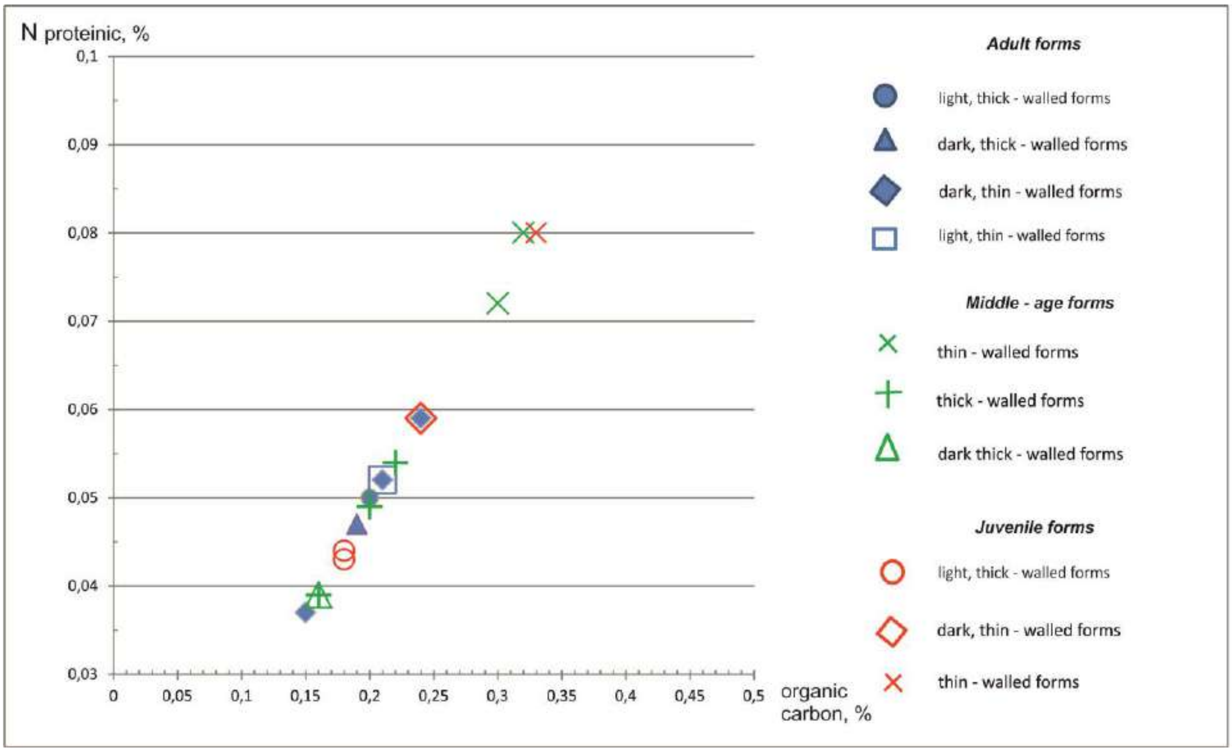

Figure 3. Plot of organic carbon and proteinic content values in the shells of *Helix lucorum* L. by the thickness and color of the shell walls

The Nugedi site shells have the following parameters: shell height – 38 mm, height of the last whorl – 27 mm, diameter of the last whorl – 42 mm. The shells are dark in color.

According to the analysis results, the first thin-walled shell demonstrates 0.32% of the organic carbon and 0.080% of the protein nitrogen in the organic matter composition. The shell has a $C_{org.}$ / $N_{prot.}$ ratio equaling to 4.00.

The second thin-walled shell has the carbon content of 0.30%, nitrogen content of 0.072%, and the $C_{org.}$ / $N_{prot.}$ ratio of 4.03. The third thin-wall shell contains 0.20% of the organic carbon and 0.049% of the protein nitrogen, with $C_{org.}$ / $N_{prot.}$ ratio equaling to 4.08. Finally, the fourth relatively thick-walled shell had 0.16% of the organic carbon, 0.039% of the protein nitrogen, and $C_{org.}$ / $N_{prot.}$ ratio of 4.1.

The data indicate the different bioelements concentrations identified in the shell material of *Helix lucorum* L. even collected from the same area and sometimes from the same plant. It is worth to mention that content levels of the organic carbon and protein nitrogen are higher in the specimens with thin-walled shells rather in thick-walled forms. As it was demonstrated by the investigations of skeletons collected from the Nugedi locality, those mollusks have the least calcified shells and higher organic carbon and protein nitrogen. Shells from Meysary and Muganly localities are well calcified with lower amount of the both bioelements.

These results allowing conclusion on significant individual controls on the quantity of bioelements in the *Helix lucorum* L. shells.

The interesting point in these investigations is the similar $C_{org.}$ / $N_{prot.}$ ratio values in the shells with very different bioelement quantity values.

Thus, this study demonstrated that the $C_{org.}$ / $N_{prot.}$ ratio in the shell material of the *Helix lu-*

corum L. is a typical species character that is not affected by environmental variations, geochemical factors and mollusk ontogeny. The calculations indicate the narrow range of the $C_{org.}$ / $N_{prot.}$ ratio variations in the *Helix lucorum* L. shell material – from 4.00 to 4.09 with average value equaling to 4.04. Vriously colored forms have the same ratio value. For example, $C_{org.}$ / N_{prot} ratio equals four in both light and dark colored shells collected in the southwestern outskirts of the Sheki city.

It is important to clarify whether this ratio can be considered as a typical chemical sign of the separate species of terrestrial gastropods.

Relatively low $C_{org.}$ / N_{prot} ratio in the shells of *Helix lucorum* L. is due to large protein matter in the organic component of their skeletons. In the adult forms of this mollusk selected in the Ilisu locality (the altitude is 1300 m), proteins make up about 76% of the entire organic phase, while the remaining 24% are non-protein matter. Protein and non-protein fractions relate to each other as 3 to 1. Similar relation between the proteins and the sum of non-protein compounds were identified in shells collected from the other localities. Such constancy of the protein to non-protein ratio is typical biochemical characteristic of the *Helix lucorum* L. mollusc, as it neither changes in ontogeny and nor depends on the environmental conditions and geochemical factors of the habitats.

Correlation analysis between the amounts of organic matter and proteins in the samples collected from the various places, didn’t demonstrate any geographical patterns in this parameter’s value (Figure 4).

The lowest ratio values speaking for the increased protein quantity in the organic component were determined in the shells from Sheki and Rustov. The highest values of 1.35 were detected in the shells from Rustov and Nugedi. Finally, majority of the samples collected from different places was characterized by the medium ratio values of 1.3–1.35.

We also tried to find other controls affecting this ratio such as wall thickness and color of the shells as well as individual age of the specimens. We have revealed thatthis parameter demonstrates the greater variations in the thick-walled shells (Figure 5). In such samples values of the ratio vary within the wide range of 0.95–1.37. However, in the thin-walled shells it appears to be more constant (1.23–1.34), which is hard to be explained by degree of calcification of the gastropod’s skeletons.

Speaking about values of the OM / N_{prot} ratio in different-color shells, it has to be noted that it is relatively higher in the light-colored shells due to slightly less amount of proteins comparing to dark-colored samples (Figure 6). The minimal value of this ratio equals to 1.05, the maximum one – to 1.37. In the dark shells, the values change between 0.95 and 1.33.

At this stage, it is quite difficult to find an explanation of this fact. Probably, the reason lies more in the ontogenetic control over the content of organic components rather in the morphological characteristics of the shells. The plot displaying OM / N_{prot} ratio depending on the individual age of the studied mollusks supports this idea (Figure 7).

It is clear from this plot that the discussed ratio is relatively lower and more variable in the mature forms and displays more or less constant values in the young specimens.

It allows coming to conclusion about relatively lower protein content in the juvenile forms of the terrestrial gastropods. Based on this result we tend to think that the lower protein content in the light-colored shells of the *Helix lucorum* L. is due to their young individual age.

Distribution of some macro and microelements in the shell carbonate of terrestrial gastropods

Along with organic components, the studies also covered distribution of some macro and microelements in a skeleton material of the analyzed gastropods.

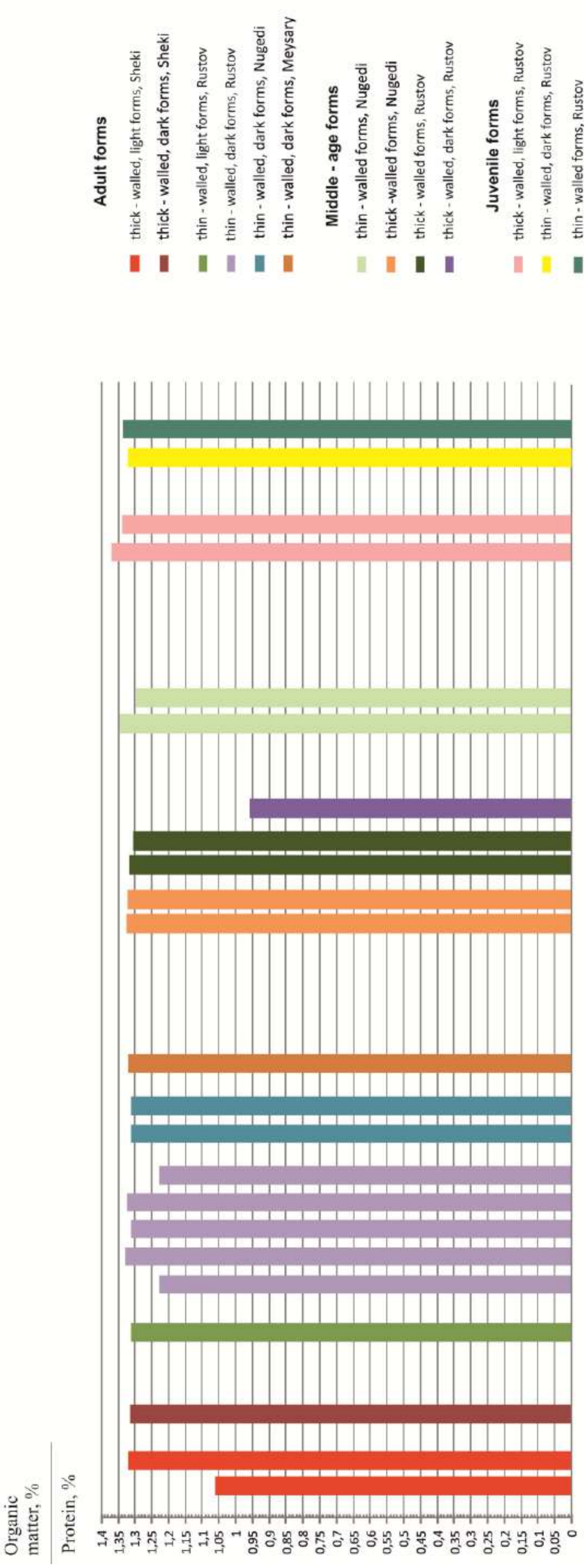

Figure 4. Organic matter to proteins ratio in the shells of *Helix lucorum* L. collected from various localities

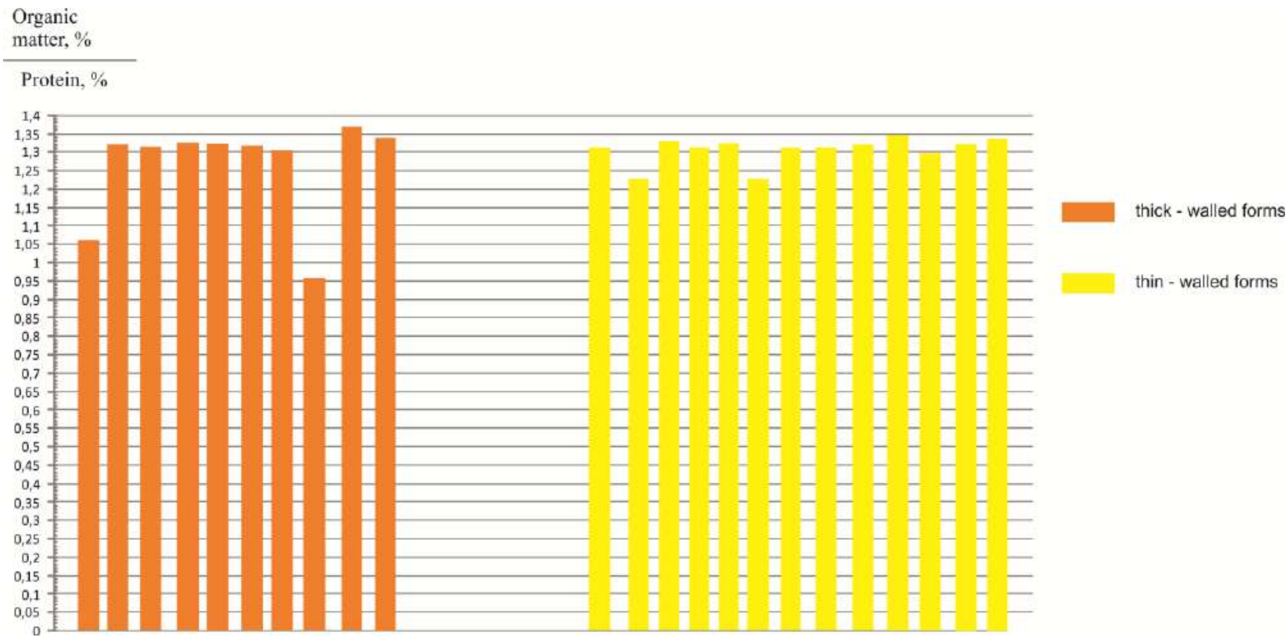

Figure 5. Organic matter to proteins ratio in the shells of *Helix lucorum* L. versus shell-wall thickness

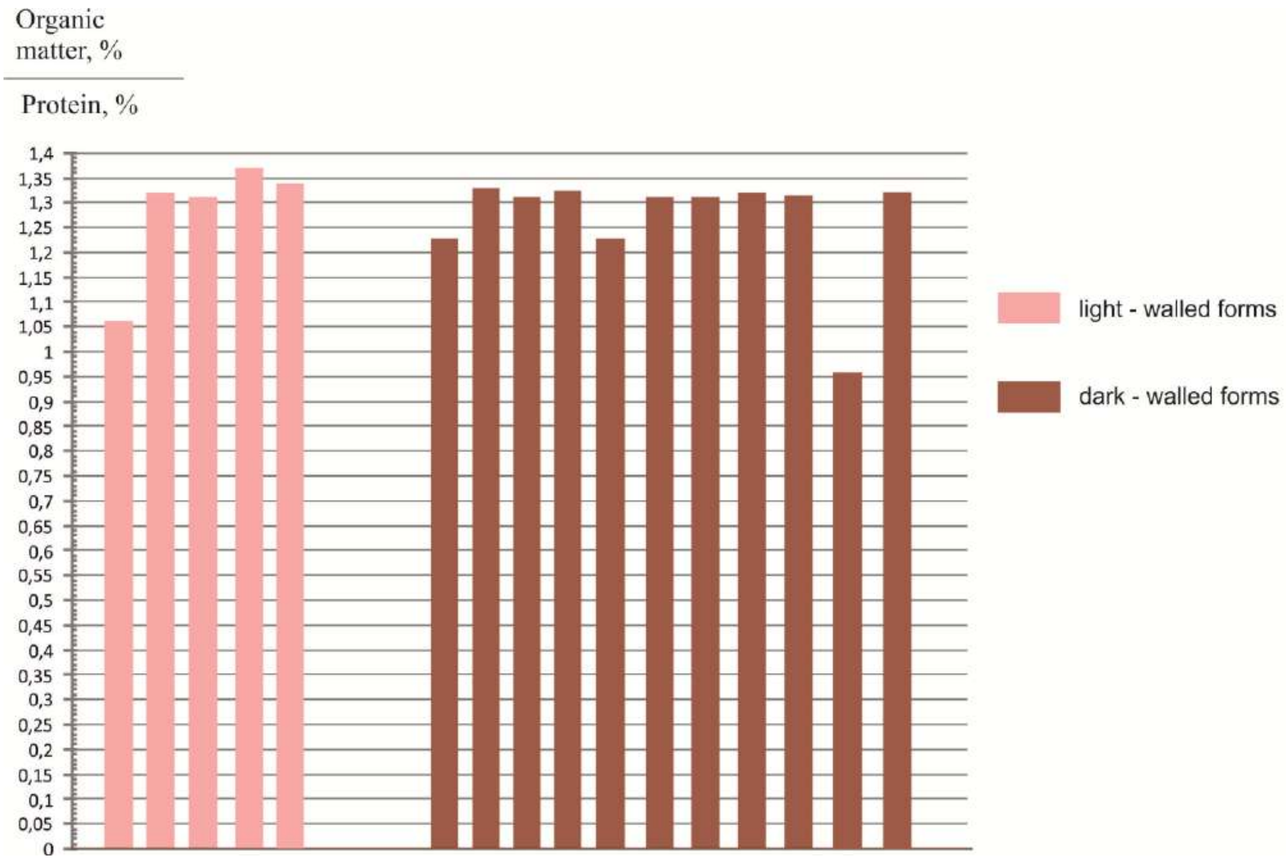

Figure 6. Organic matter to proteins ratio in the differently colored shells of *Helix lucorum* L.

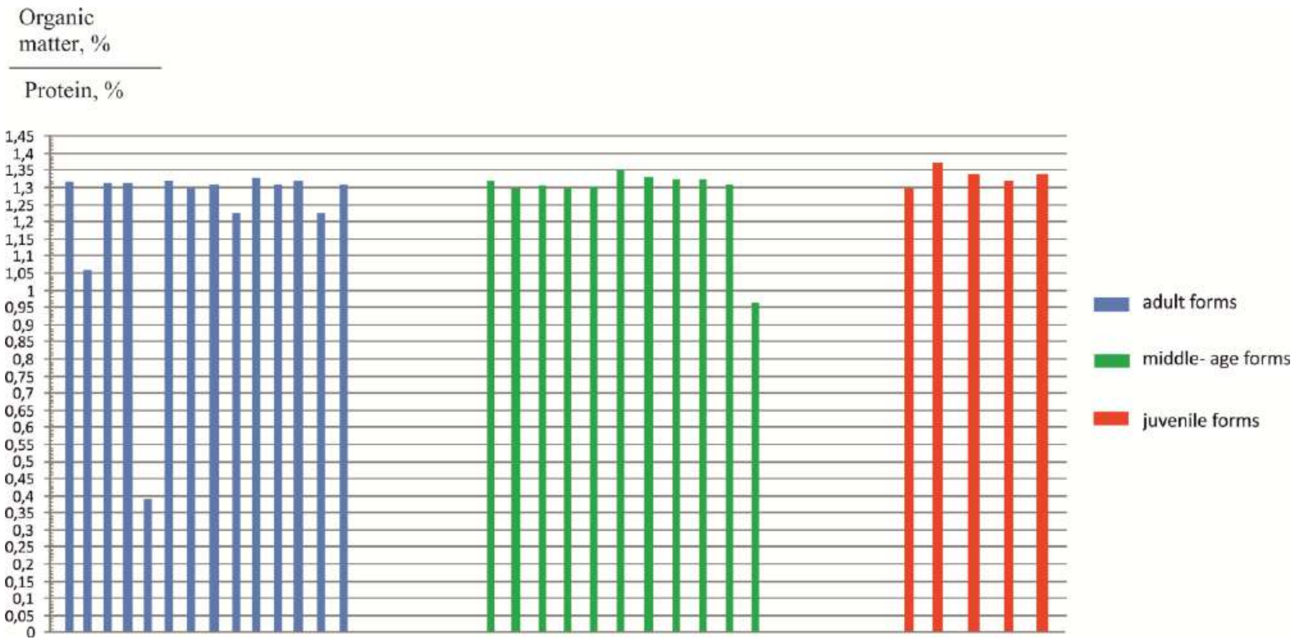

Figure 7. Organic matter to proteins ratio in the various individual age shells of *Helix lucorum* L.

It was identified by the studies that calcium content is slightly higher (nearly 1%) in more mature forms (Figure 8a). For example, *Ca* content of the samples collected in Altiaghach site (location in Figure 1) makes up 35.5% in the young and 36.5% in the middle-age specimens. In case of the samples collected in Shurabad, difference in *Ca* content between young and middle-age gastropods makes 0.65%. Although the calcium proportion in the adult forms is relatively reduced, it is still higher than in the young ones.

The highest calcium content was recorded in the shells collected in Shurabad (location in Figure 1). This phenomenon is observed in both young and middle-age individuals. Difference in the calcium content between Altiaghach and Shurabad samples reaches 2% in the both age groups.

The opposite tendency is observed in the silicon content. The highest concentrations were found in the specimens from Altiaghach locality, while the lowest amounts were registered in the samples collected in Shurabad site (Figure 8b). Difference in the amounts makes up 2–2.5 times in all age groups. Meanwhile, shells collected from Beshbarmag and Shurabad sites are characterized by similar silicon contents. The same regularity is observed in potassium and aluminum geographical distribution (Figure 8e, f).

In ontogeny silicon demonstrates rather inconsistent behavior. In the samples from Altiaghach silicon content in the young shells is by 1.5 times higher than in the adults. Difference in the silicon content between the young and middle age samples from Shurabad is just 0.07%, varying from 0.92% in the young to 0.85% in the middle age specimens. At the same time, content in the adults sharply increases and reaches 1.62%.

It is commonly known that phosphorus is a vital element involved in the structure of the bone tissue (up to 85%) and being a part of the organism's proteins. Some authors formerly argued that there is a difference in phosphorus content of the different-size shells, and the highest contents are usually registered in the big forms (Jurkiewicz-Karnkowska, 2002). The opposite tendency has been recorded in our samples. For example, phosphorus content in the middle age specimens from Altiaghach locality appeared to be 3.5 times lower than in young specimens (Figure 8c). In the samples collected from Shurabad locality, this difference is just 1.5 times.

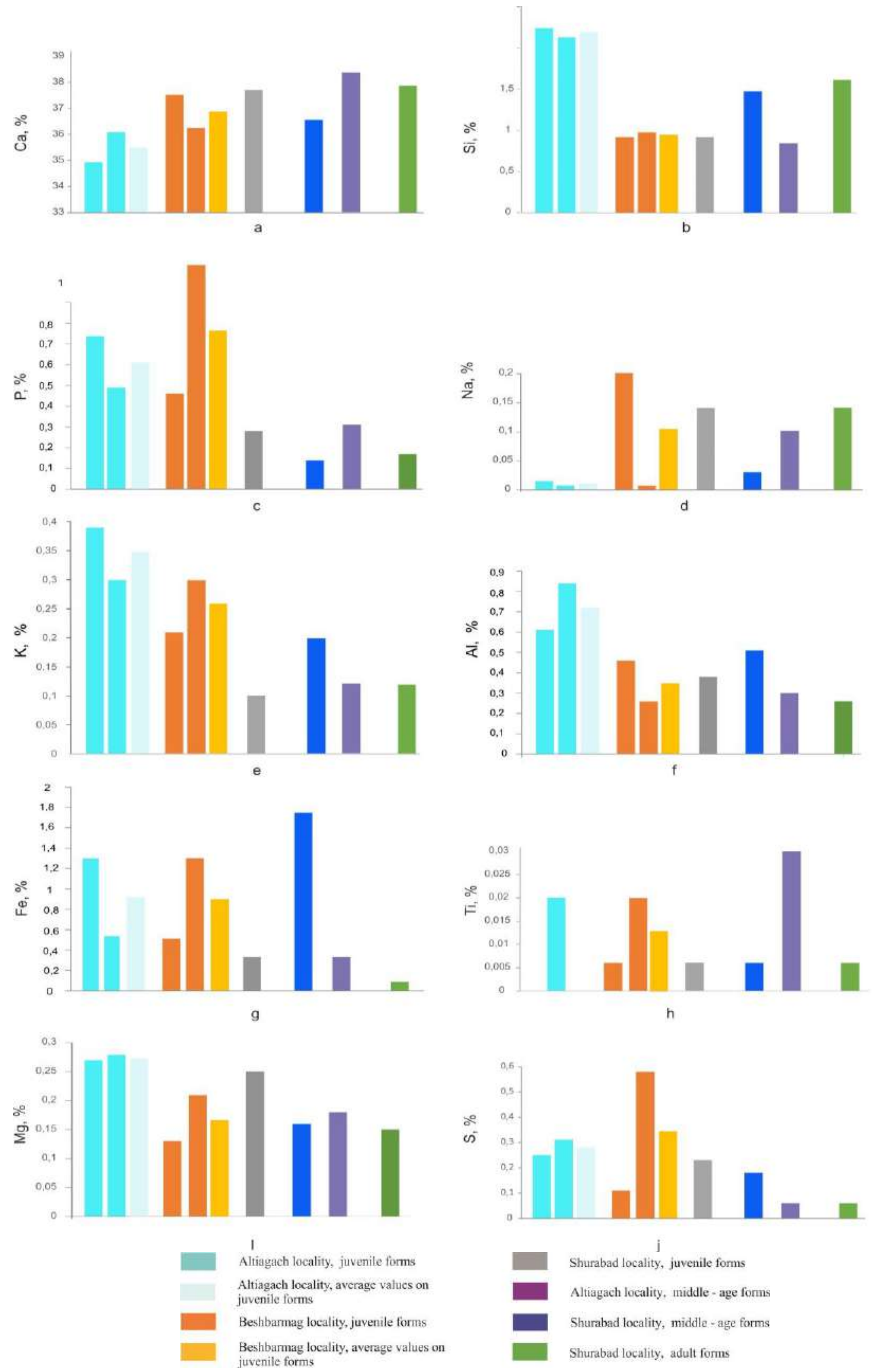

Figure 8. Content values of some macro- and microelements in the shells of different-age terrestrial gastropods found in Azerbaijan

There are no geographical regularities observed in the distribution of phosphorus content of the shells.

Sodium content of the shells doesn't demonstrate any distribution by the mollusk age. Thus, sodium amount in the young shells from Altiaghach site exceeds that of the middle age samples by 3 times (Figure 8d). This tendency is the opposite in the specimens found in Shurabad site. Here the difference in the sodium contents is not more than 1.5 times.

The highest sodium content was recorded in the same-age samples collected from Shurabad site, while the lowest values are reported in the Altiaghach forms. This difference is 14 times in the young forms, and 3.5 times in the middle age shells. Such geographical distribution of sodium is similar to that of calcium.

Potassium contents in the gastropod shell material do not also demonstrate any ontogenetic regularities (Figure 8e). However, geographical variations of this element are observed. Alike *Al*, potassium contents are the highest in Altiaghach and lowest in Shurabad forms. Difference makes up nearly 3.5–1.5 times. The wide range of the variations is observed in the young forms. Samples collected in Beshbarmag site occupy intermediate position.

Distribution of aluminum contents demonstrates both age and geographical variations (Figure 8e). Thus, amount of this element becomes 1.3–1.5 times lower with age of the specimens. On the other hand, aluminum content of the shells from Shurabad site is 1.8–1.6 lower than in the same-age skeletons from Altiaghach locality. Aluminum content in the shell material in Beshbarmag samples is similar to that in the Shurabad forms.

There are no ongenetic variations in the iron contents (Figure 8g). Meanwhile, there are strong geographical variations expressed in the 3 to 6-times higher *Fe* content in the samples from Altiaghach locality comparing to shells collected in the Shurabad site. Also, it should be mentioned that the variation range increases with age of the studied gastropods. Average *Fe* content in the young forms found in the Beshbarmagh site is close to that in the shells from Altiaghach locality.

The plotted data on macro-, microelemental composition of the shell material demonstrate that the titanium content doesn't reveal neither ontogenetic nor geographical regularities (Figure 8h). For this reason, it is difficult to speak about controls for this element concentrations in the shell carbonate.

Magnesium content in the shell carbonate doesn't express any geographical regularities (Figure 8i). Meanwhile, it changes in the different age groups, declining by 1.7–1.4 times in the older specimens.

Distribution of sulphur is subject to both ontogenetic and geographical control (Figure 8j).

Our investigations also covered the analysis of correlation between the various elements (Figure 9). It was recorded that *Mg* content displays the moderate negative correlation with the amount of *Ca* (Figure 9a). It is known that magnesium is able to replace calcium in the crystal lattice of calcium carbonate that conditioned the negative relationship between these two elements. Judging by the differences in *Mg* contents in the young and adult shells, we can assume that the amount of magnesium is controlled not only by post-life transformations in the mollusk's skeleton, but also by biogenic processes. In other words, replacement of calcium by magnesium in the shell calcium carbonate takes place already during mollusk's lifetime, and this process is weakining in the mollusk ontogenesis.

On the other hand, the moderate – strong negative correlation with calcium is also characteristic of a number of the other elements constituting the calcium carbonate of the gastropod shells. Such negative correlation is demonstrated by silicon, iron, titanium, aluminum, phosphorus and sulphur, and very strong negative correlation is recorded for potassium. The good positive correlation was reported only for sodium. Such negative relationship between some elements and the calcium in an abiogenic component of the shell material can be explained by silicification processes and replacement of calcite by silicon oxide containing some admixtures.

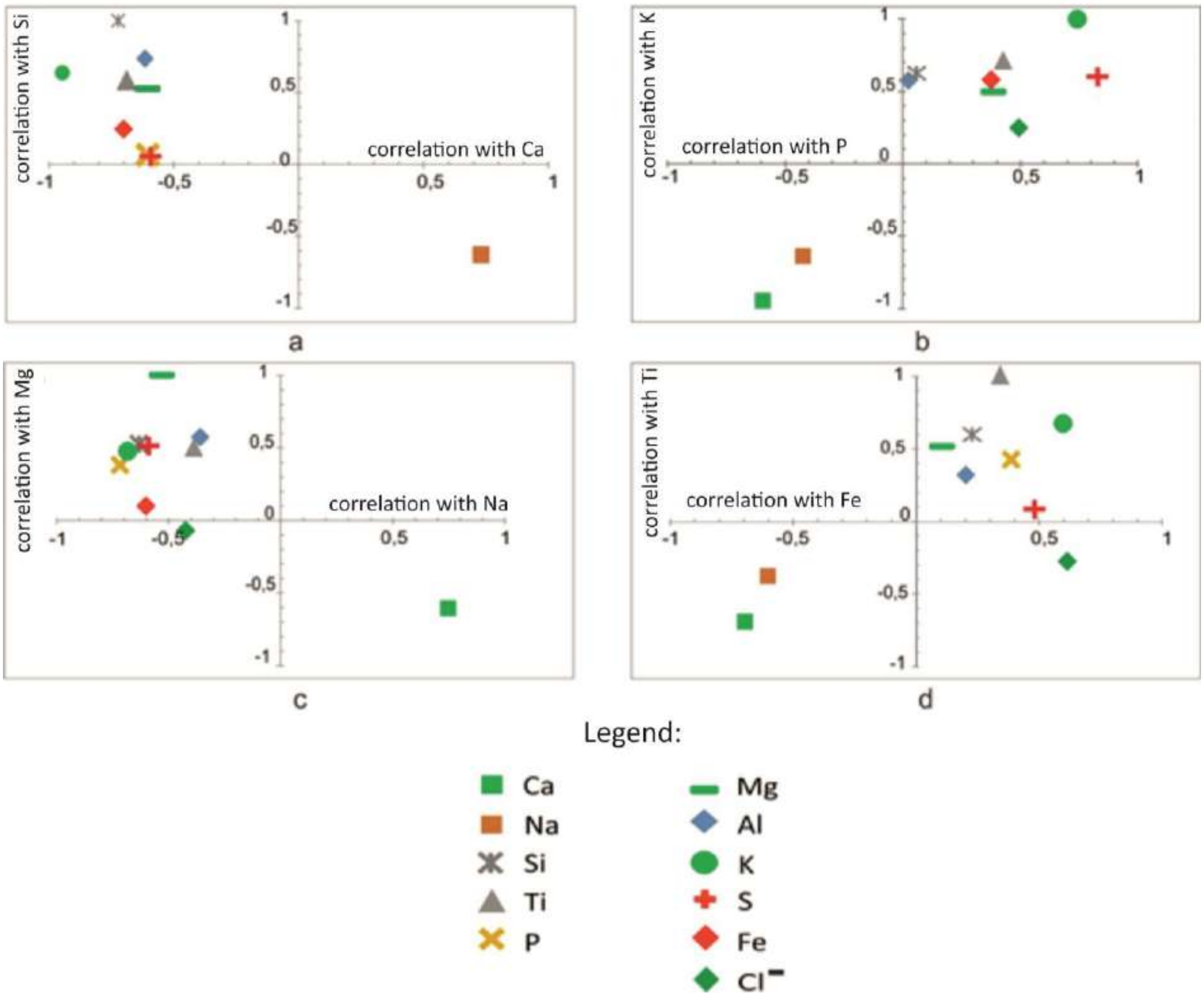

Figure 9. Correlations between macro- and microelements in the shell material of the terrestrial gastropods collected in Azerbaijan

Regarding to negative correlation between the phosphorus and calcium, we assume that this phenomenon is a result of binding capacity of phosphorus and decrease of free calcium content as the phosphorus amount is increasing in the organism.

As it was demonstrated above, both phosphorus and calcium show opposite behavior in ontogenesis. Reduction of phosphorus content in the older forms apparently causes growth of the calcium amount.

There is a significant positive correlation between many elements and silicon. Especially, the strong correlation is observed between silicon and aluminum contents that testifies to the presence of aluminum silicates in the studied shells, probably, in the contaminating terrigenous material. Besides main elements (aluminum and silicon), aluminum silicates may contain cations of potassium and magnesium as well. Revealed positive correlation between *Si*, *Al* and *K* contents in the calcium carbonate of gastropod shells confirms our conclusion about similarity of these elements' geographical distribution, to wit – the lowest amount in the shells collected in the Shurabad site and the highest – in the samples from the Altiaghach locality that is, probably, due to contamination of these shells with terrigenous particles. At the same time, magnesium and titanium displaying good positive correlation with the *Si* content do not demonstrate such geographical variations. Therefore, it gives us a ground to assume that positive correlation of these elements with silicon is a result of silicification rather than terrigenous contamination.

Weak positive correlation between silicon and sulphur, phosphorus observed against the background of negative moderate relationship of these elements with calcium, indicates the absence of significant changes of the above mentioned elments' amount due to silicification of the shell material and dominating biogenic controls that is proved by the positive significant correlation between sulphur and phosphorus (Figure 9b).

The significant positive correlation with phosphorus is also demonstrated by potassium (Figure 9b) that can be considered as an indication of the biogenic character of these elements and their participation in the metabolic processes of the mollusks. Sulphur, silicon, aluminum, magnesium, titanium and iron manifest considerable positive relation with potassium content in the studied shells. Meanwhile, absence of correlation between these elements (except for sulphur) and the phosphorus is apparently an evidence of their relation with abiogenic processes, such as silicification, contamination of mollusk skeletons with soil and rock particles as well as replacement of the atoms of calcium during post-life transformations in the crystal lattice of shells. The study results also suggest that potassium plays a dual role in the shell carbonate of the gastropods. The primary role is connected to biogenic component, while the secondary role is related with shell contamination.

Accumulation of sodium in the gastropod shells demonstrates no changes by age and clearly pronounced geographical variations. The latter is expressed in higher sodium content in the specimens collected in the Shurabad site. Similar tendency is observed for the calcium content that indicates the better preservation of Shurabad samples. Increased sodium content in these shells can be, probably, related to higher concentrations of this element in the soils and plants in this site. It should be mentioned that the sampling points are located close to the Caspian coast, and the background sodium content in this area is high due to salt precipitation from the seawater. Thus, in spite of completely different controlling factors for calcium and sodium accumulation in the shell material of studied gastropods, the similar geographical variations of the both elements within the research area brought to positive correlation between these two elements' content.

The other revealed elements in the shell matter of gastropods are characterized by negative, mainly moderate, correlation with sodium content (Figure 9). We think that this fact is additional evidence to that the sodium content in the studied shell substance is most likely not controlled by the post-life processes of skeleton silicification and contamination with terrigenous particles, but is rather determined by the other factors, which have already been discussed above. Observed inverse correlation between the quantities of sodium and *Si*, *Al*, *K* is apparently caused by the opposite character of their accumulation in shell material within the study area.

To explain the negative correlation between the sodium and phosphorus contents is more complicated. One of the possible explanations may lie in the Na^+ toxicity and depressing effect of sodium on the vital processes of organisms (this impact was discussed early based on the coastal plants' study results) (Du, Hesp, 2020) .

Another question is the reason standing behind the negative even weak correlation between the amounts of sodium and chlorine ion. Possibly, such phenomenon is connected to a selective ability of the gastropods to absorb certain elements from the ambient environment.

The role of magnesium in the shell matter and its' correlation with calcium content was discussed above. Correlation of magnesium with the other elements is weak, which is, probably, an indication of the absence of any dominating factor affecting its' accumulation (Figure 9c). The only exception is a moderate correlation with aluminum (the correlation ratio is 0.57).

Iron content in the shells demonstrates direct correlation with all elements, except for *Ca* and *Na*, with which the iron displays inverse moderate correlation (Figure 9d). The positive correlation of *Fe* with all elements is weak or negligible except for potassium and chlorine. The inverse correlation with calcium and absence of any correlation with silicon and aluminum indicates that iron is not binded to aluminum silicates in the shell matter. Accumulation of this element in the mollusk skeletons is, probably, a result of either oxidization and calcium replacement processes in the shell carbonate, or rich iron content in the soil substrate. At the same time, inverse correlation between the iron and sodium contents is, apparently, caused by the opposite character of their accumulation within the area under study.

The significant positive correlation between iron and potassium, chlorine we explain by an enrichment of the substrate and plants with all three elements. Similar explanation can be given to the behavior of titanium. A good direct correlation of this element with silicon tells about possible occurrence of titanium in the silicon compounds (Figure 9d).

Conclusions

1. The organic matter in the shell material of the terrestrial gastropods *Helix lucorum* L. displays an ontogenetic variations of its composition. Protein content in the young forms is relatively low as compared to the older speciemens. The juvenile shells are also characterized by higher organic carbon and protein nitrogen amount. Finally, calcified shells have reduced bioelements concentrations;

2. The impact of wall thickness and color of gastropod shells on the ratio of protein-nonprotein components in the organic matter is not registered. The geographical variations are not also recorded.

The ontogenetic development is a dominanting control on the organic matter formation and relationship of its components in the gastropod skeletons.

3. Studied macro- and microelements in the shell material can be grouped as follows:

a. biogenic elements directly contributing to a mollusk's life cycle – calcium, phosphorus, sulphur and magnesium. The accumulation of these elements is affected by the ontogenetic variations.

b. such elements as *K*, *Mg* and possibly *Ti* are accumulated in the shell material as a result of the post-life transformations due to either silicification of the calcium carbonate or its contamination with terrigenous components. Amounts of these elements demonstrate good positive correlation with silicon and aluminum.

c. elements accumulated through the replacement of calcium as a result of metabolic processes and post-life transformations. Such element is magnesium. It was recorded that replacement ability of calcium with magnesium in a shell's crystal lattice decreases with the age of the mollusk.

d. elements – *Na, Fe, Ti, K, Cl,* controlled by the habitat of the mollusk.

e. dual nature elements. Their concentration in the shell carbonate is affected by both biogenic and abiogenic factors, for instance, potassium in the shells. Being associated with physiological processes of an organism, this element contributes to organism development and demonstrates a well-pronounced ontogenetic variations. At the same time, potassium content is closely related to the shell's post-life transformation processes, including silicification and contamination with soil elements. Finally, the third factor influencing potassium amount in the shell material is its concentrations in the ambient environment.

REFERENCES

Bremer, J.M., 1965. In "Methods of Soil Analisis. 2. Chemical and Microbiological Properties". C.A. Black et al. (Eds.) Madison, Amer. Soc. Agron., Inc.

Jurkiewicz-Karnkowska, E., 2002. Differentiation of Phosphorus Concentration in Selected Mollusc Species from the Zegrzynski Reservoir (Central Poland): Implications for P accumulation in Mollusc Communities. Polish Journal of Environmental Studies, No. 11, pp. 355–359.

Standartnaya rabochaya metodika dlya *Organicheskiy uglerod pochv*. Spektrofotometricheskiy metod Tyurina, 2021. (Standard worked method for organic carbon in soils. Spectrophotometric method of Tyurin). The Food and Agriculture Organization of the United Nations. Rome. (in Russian)

Du, Jianhui, Hesp, Patrick A., 2020. Salt Spray Distribution and Its Impact on Vegetation Zonation on Coastal Dunes: a Review. Estuaries and Coasts, vol. 43, #8, pp. 3–25.

AZƏRBAYCANIN MÜASİR YERÜSTÜ QASTROPODLARININ ABİOGEN VƏ ÜZVİ TƏRKİBLİ QABIQLARININ ƏSAS, MİKRO VƏ BİOELEMENTLƏRİNİN ÖYRƏNİLMƏSİ

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Həyata keçirilmiş çöl tədqiqatları zamanı Böyük Qafqaz dağlarının cənub və şimal yamaclarından faunistik material yığılmışdır ki, həmin materiala əsasən Böyük Qafqazın şimal yamacının Azərbaycan sektorunda yerləşən Quba rayonunda yığılmış mövcud həm də nəsli kəsilmiş yerüstü qastropodların qabıqları daxildir. Qubada aşkar edilmiş qastropod nümunələri Böyük Qafqazın cənub yamacına cavab verən Şamaxı, Şəki və Qax rayonlarında, eləcə də Xəzər dənizinin sahilində tapılmış analoqları ilə müqayisə edilmişdir. Tədqiqatlar zamanı Helix lucorum L. cinsinə aid olan 70 qabıq nümunəsi xüsusi analizlərdən keçirilmişdir.

Aparılmış analizlər çərçivəsində mollyuskların skelet qalıqlarında üzvi maddələrin tərkibi həm ümumi olaraq, həm də üzvi karbon, zülali azot və fosfor kimi ayrı-ayrı bioelementlər səviyyəsində təhlil olunmuşdur. Tədqiqatlara həmçinin bəzi əsas və mikroelementlərin qabıq cismində paylanmasının təhlili daxil olmuşdur.

Həyata keçirilmiş araşdırmalar nəticəsində tədqiqatın predmetini təşkil edən qastropodların qabıq cismlərində kalsium karbonatın və üzvi maddələrin tərkibinə təsir göstərən amillər haqqında mülahizələr irəli sürülmüşdür.

АБИОГЕННАЯ И ОРГАНИЧЕСКАЯ СОСТАВЛЯЮЩИЕ РАКОВИН СОВРЕМЕННЫХ НАЗЕМНЫХ ГАСТРОПОД АЗЕРБАЙДЖАНА: ИЗУЧЕНИЕ ОСНОВНЫХ, МИКРО, И БИОЭЛЕМЕНТОВ

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В результате проведения полевых работ был собран фаунистический материал с южного и северного склонов Большого Кавказа, включающий в себя раковины, как живых, так и умерших наземных гастропод из, преимущественно, Губинского района, расположенного на северном склоне азербайджанской части Большого Кавказа. Для сравнения изучались гастроподы Шемахинского, Шекинского и Гахского районов, расположенных на южном склоне данной горной системы, а также раковины из прибрежной части Каспийского моря. Всего было проанализировано 70 образцов раковин, принадлежащих моллюску Helix lucorum L.

В скелетных остатках определялась как содержание органического вещества в целом, так и отдельных биоэлементов органического углерода, белкового азота, фосфора. Также изучалось распределение некоторых основных и микроэлементов в раковинном веществе этих моллюсков. Полученные результаты позволяют сделать выводы о факторах, контролирующих состав карбоната кальция и органической составляющей раковинного материала изученных гастропод.