GEOLOGIJA. 2008. Vol. 50. No. 4(64). P. 290–298
DOI: 10.2478/v10056-008-0054-x

Holocene malacofauna in calcareous deposits of Dūkšta site near Maišiagala in Lithuania

Aleksander Sanko,

Algirdas Gaigalas,

Eugenija Rudnickaitė,

Monika Melešytė

Sanko A., Gaigalas A., Rudnickaitė E., Melešytė M. Holocene malacofauna in calcareous deposits of Dūkšta site near Maišiagala in Lithuania. *Geologija*. Vilnius. 2008. Vol. 50. No. 4(64). P. 290–298. ISSN 1392-110X

The paper contains results of new investigations in Lithuania of the first occurrences of terrestrial molluscs in calcareous tufa (travertine), carbonate content and radiocarbon dating. Terrestrial fossil molluscs (35 taxa) prevail in the mollusc fauna, while freshwater species are much more rare (6 taxa). The Dūkšta terrestrial mollusc fauna embraces a complex of thermophiles including such forest species as *Acicula polita* (Hartmann), *Acanthinula aculeata* (Müller), *Aegopinella* cf. *pura* (Alder), *Bulgaria cana* (Held) and *Discus* cf. *rotundatus* (Müller), as well as mainly South European *Carychium tridentatum* (Risso) and mainly West European *Vertigo moulinsiana* (Dupuy). The radiocarbon age of the sediments was found to correspond to the end of the Atlantic climatic period and the beginning of the Subboreal.

Key words: malacofauna, calcareous deposits, radiocarbon age, Holocene, Lithuania

Received 17 March 2008, accepted 15 September 2008

Aleksander Sanko. Department of Physical Geography, Belarus State Pedagogical University, Sovetskaya str. 18, 220030 Minsk, Belarus. E-mail: sankoaf@tut.by; **Algirdas Gaigalas, Eugenija Rudnickaitė, Monika Melešytė.** Department of Geology and Mineralogy, Vilnius University, M. K. Čiurlionio 21/27, LT-03101 Vilnius, Lithuania. E-mail: Algirdas.Gaigalas@gf.vu.lt; Eugenija.Rudnickaite@gf.vu.lt

INTRODUCTION

The Dūkšta occurrence of buried malacofauna as one of the first occurrences of fossil terrestrial molluscs in Lithuania has been found and explored in Central Lithuania near Maišiagala in the outskirts of Bradeliškės village (Fig. 1). This place is related to occurrence of calcareous spring tufa (travertine) exposed on a slope of the right bank of the Dūkšta rivulet valley. The site of the calcareous tufa deposit surface lies 6–7 m above the river water boundary and borders on a 8–10-m high river terrace, its base being formed by yellowish-brown till loam (Fig. 2). The terrace setup shows a trail of calcareous tufa with rare mollusc shells most likely formed due to slope processes.

DESCRIPTION OF THE SECTION AND CALCAREOUS DEPOSITS

The Dūkšta calcareous spring tufa in the main deposits is represented by grainy, lumpy and farinaceous texture with inclusions, in some layers, of organic matter, sometimes wood and mollusc shells. The thickness of calcareous tufa exceeds 3.5 m. It occurs above the sand-gravel/till deposits and is covered only by recent soil.

Mollusc shells are concentrated in grainy and lumpy calcareous tufa enriched with organics. Farinaceous tufa contains few or no shells.

Description of section. From top to bottom lie the following strata:

0.00–0.30 m – recent soil, podsol;

0.30–0.76 m – sand, fine-grained, silty, dark grey, quartz dominates, feldspars rare, calcareous, total carbonate content 33.54–38.46%;

0.76–1.00 m – calcareous tufa in silt and clay fractions, dark grey, total carbonate content 90.54–90.73%, tufa samples No. 4 for carbon isotopes;

1.00–1.31 m – calcareous loam, silty, with different content of carbonates (68.00–91.30%), dark grey;

1.31–2.00 m – calcareous tufa in sand and silt fractions (travertine), bright yellowish grey, carbonate content 88.70–99.93%, tufa samples No. 3 for carbon isotopes;

2.00–2.21 m – peat, brown, with wood remains, total carbonate content 58.27–88.70%, wood samples No. 3 for radiocarbon;

2.21–2.45 m – calcareous tufa in sand and silt fractions (travertine), bright grey, total carbonate content 62.76–70.63%;

2.45–2.90 m – peaty soil, dark, with wood remains, interlayers of sand and silt in the lower part, total carbonate content 13.21–58.08%, wood sample No. 1 for radiocarbon;

2.90–3.11 m – calcareous tufa in sand and silt fractions (travertine), dark brown, ferruginised, total carbonate content 69.32–80.56–99.49%, tufa samples No. 2 for carbon isotopes;

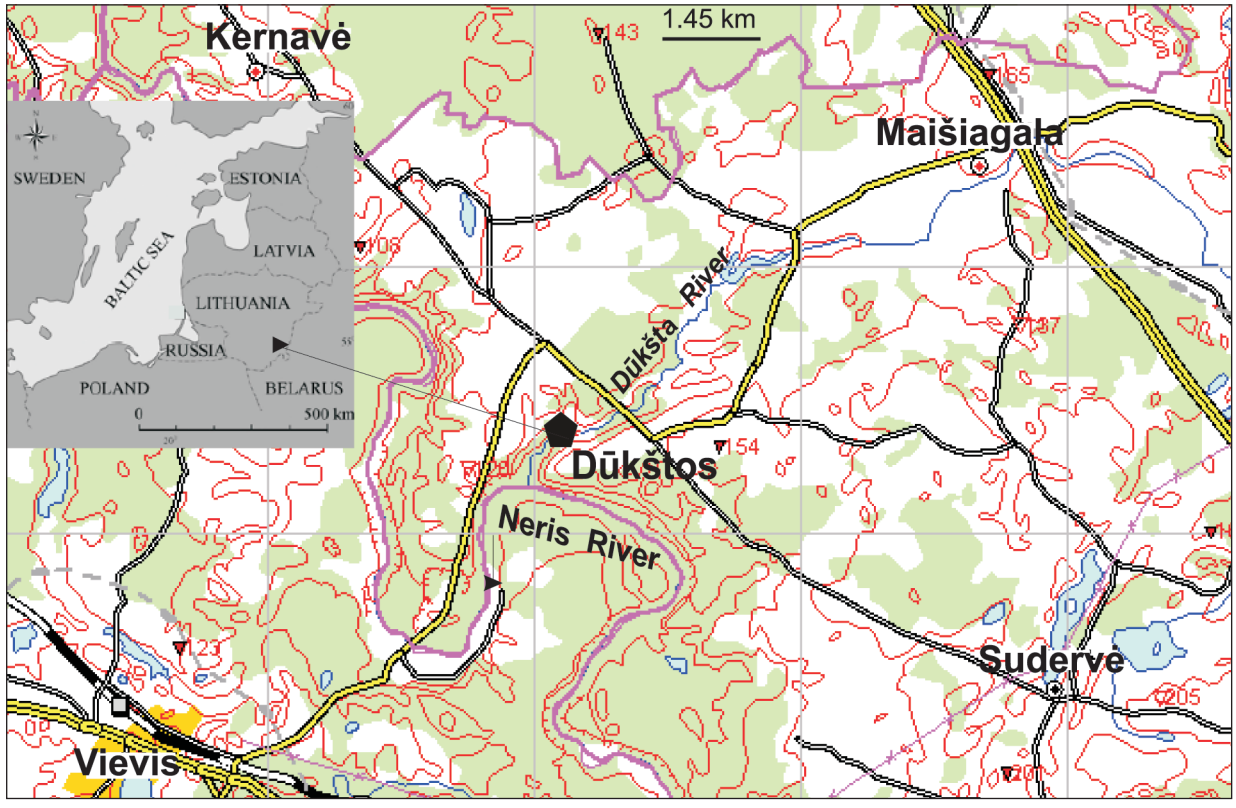

Fig. 1. Location of the Dūkšta section
1 pav. Dūkštos pjūvio padėtis

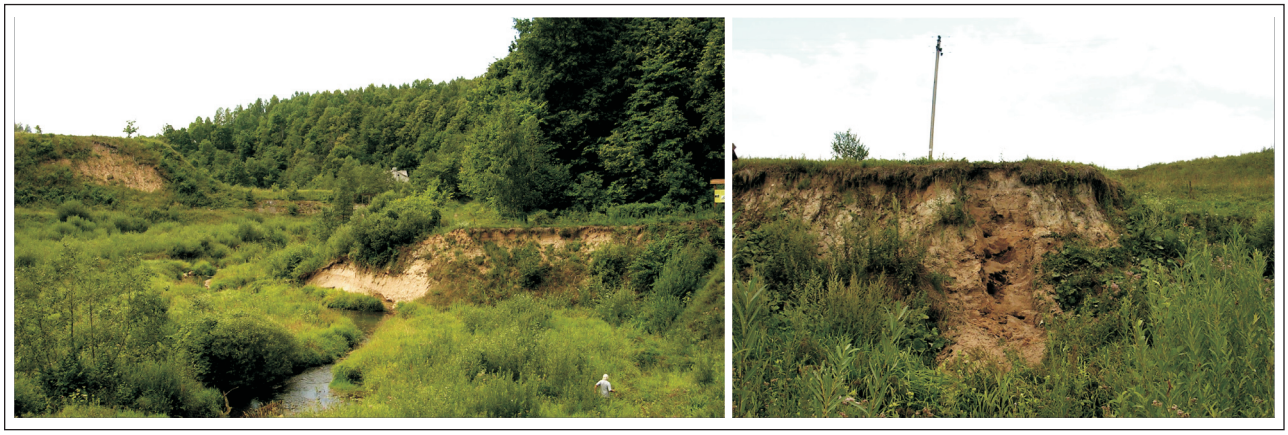

Fig. 2. The Dūkšta River valley (on the left side) and an exposure of calcareous tufa with mollusc fauna in the slope of a plane 8–10 m above water level in the Dūkšta River (on the right side)
2 pav. Vaizdas į Dūkštos upės slėnį (kairėje pusėje) ir karbonatinio tufo su moliuskais atodanga Dūkštos upės slėnio aikštelės, pakylančios 8–10 m virš vandens lygio, šlaite (dešinėje pusėje)

3.11–3.29 m – sand, peaty, dark brown, ferruginised, laminated, with organogenic and wood remains, wood samples No. 1 and No. 4 for radiocarbon;

3.29–3.54 m – travertine, total carbonate content 99.57%, travertine samples No. 1 for carbon isotopes;

3.54–3.74 m – sand, brown yellowish, fine-grained, total carbonate content 28.95–31.20%;

3.74–3.90 m – travertine, hard, breaks into pieces, total carbonate content 98.73%;

3.90–4.22 m – sand, coarse-grained, with gravel, pebbles and boulders, total carbonate content 20.14%;

4.22 m and deeper – till, brown, boulder loam, calcareous.

Calcareous deposits. In addition to other methods, carbonate analysis was used as well. The content of carbonates in the sediments was studied for the reconstruction of palaeosedimentary environments. The Dūkšta outcrop sediments were investigated in 34 samples by the method of Scherbina (Щербина, 1958)

improved by us (Rudnickaitė, 1980). Not only calcite, but also dolomite could be determined by this method. Total carbonate content determined by this method is usually higher than that determined by other techniques such as those of Kozlovskij or titration, etc. The carbonate content of tufa sediments was determined for a bulk sample. The calcimeter was used to determine CO_2 volume in the cross-section of the Dūkšta outcrop. It enabled us not only to obtain data on calcite, but also on dolomite content in the sediments. It allows also to determine other carbonate minerals, if they are present in significant amounts. It is known that the released CO_2 volume after 30 seconds of reacting with 5 ml of 5% cold HCl with powdered sediment or rocks indicates calcite. Later, the released volume of CO_2 plus the volume released after heating to 40 °C for 3 minutes indicates dolomite content. By the volume of CO_2 related to calcite and dolomite, we calculated the percentage of the mentioned minerals. The percentage of Ca and Mg oxides could be recalculated if needed.

Samples for carbonate analysis were taken from separate lithological beds. For the description of the cross-section of the outcrop in the field, the sampling interval was 5–10 cm. 50 g of the sample was taken for analysis. Samples were powdered, and 0.2 g was weighed for carbonate analysis. Prior to carbonate analysis, 2 or 3 samples of pure calcite (0.2 g) were analysed. The same procedure was repeated after each five samples. These measurements were used to calculate the calibration coefficient (k) which is temperature- and atmospheric pressure-dependent:

$k = 44/x$, where x is the pure calcite CO_2 value.

The carbonate analysis data of the Dūkšta outcrop are presented in Table 1 and Fig. 3.

A distinctive feature is that the dolomite percentage is lower than that of calcite in all the cross-section (Fig. 3 and Table 1).

When applying carbonate content data, it is important to consider the overall regime and the sedimentary environment. Carbonate content may be to some extent elevated by the allochthonous detrital part of sediments. The interpretation of carbonate content data should be integrative. Otherwise it could be misleading.

The vertical variation of carbonates reflects sedimentary environments and the past climate. The mentioned data enable to reveal the general features of the sedimentation conditions. Three layers of peat and peaty soil with wood remains were distinguished in the study section: the upper 2.00–2.21 m, middle 2.45–2.90 m and lower 3.30–3.54 m deep. The predominance of natural factors in sedimentation processes were manifested in the mean values of $CaCO_3$ and $CaMg(CO_3)_2$: in the upper layer 58.27–88.70%, the middle layer 13.21–56.0% and in the lower layer of peaty sediments 28.10–31.20%. Carbonate compounds can be either of allochthonous or autochthonous origin. The proportion of carbonate matter derived from these sources is a function of groundwater characteristics in relation to organic productivity. Carbonaceous sediments (calcareous tufa and travertine) are accumulated by groundwater and mineralized by mollusk shells. The values for carbonaceous matter in tufa sediments and travertine are higher than in the layers of peaty sediments and vary from 62.76% to 99.85%. Peaty sediments of the three layers reflect the time intervals of the drying of climate. The groundwater levels were low. The increasing humidity and a rize of groundwater level were favourable for calcareous sediments (tufa and travertine layers) in the study area.

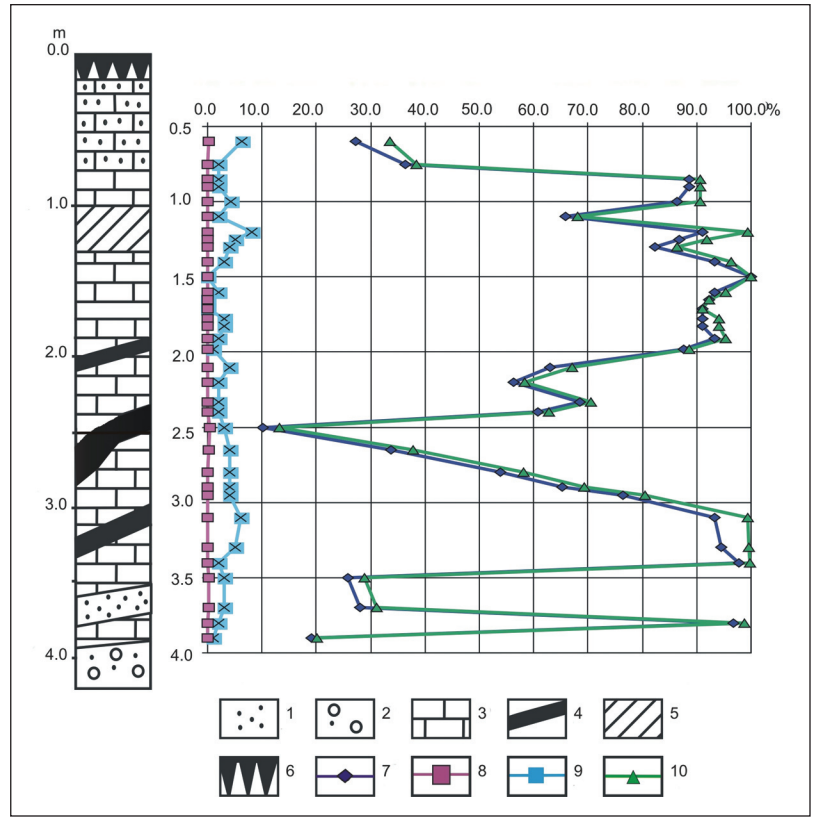

Fig. 3. Carbonate content in sediments the Dūkšta section.
1 – sand, *2* – sand with gravel and boulders, *3* – calcareous tufa (travertine), *4* – interlayers of humic organics with wood remnants, *5* – calcareous loam and sandy loam, *6* – recent soil, *7* – $CaCO_3$ (calcite), *8* – sampling points, *9* – $CaMg(CO_3)_2$ (dolomite), *10* – total carbonate content

3 pav. Dūkštos pjūvio nuosėdų karbonatingumas.
1 – smėlis, *2* – smėlis su žvirgždu ir rieduliais, *3* – karbonatinis tufas (travertinas), *4* – humusingos organikos tarpsluoksniai su medienos liekanomis, *5* – karbonatingas priesmėlis ir priemolis, *6* – dabartinis dirvožemis, *7* – $CaCO_3$ (kalcitas), *8* – pavyzdžių paėmimo vietos, *9* – $CaMg(CO_3)_2$ (dolomitas), *10* – bendras karbonatingumas

Table 1. **Carbonate content of sediments in the Dūkšta outcrop, %**
1 lentelė. **Tyrinėtos Dūkštos atodangos nuogulų karbonatingumas (%)**

Sample No.	Depth, cm	Calcite	Dolomite	Total amount	dol:calc
1	0.60	27.28	6.26	33.54	0.23
2	0.75	36.37	2.08	38.45	0.06
3	0.85	88.65	2.08	90.73	0.02
4	0.90	88.65	2.08	90.73	0.02
5	1.00	86.37	4.17	90.54	0.05
6	1.10	65.92	2.08	68.00	0.03
7	1.20	91.14	8.16	99.30	0.09
8	1.25	86.69	5.11	91.80	0.06
9	1.30	82.25	4.08	86.33	0.05
10	1.40	93.36	3.06	96.42	0.03
11	1.50	99.93	0.00	99.93	0.00
12	1.60	93.37	2.04	95.41	0.02
13	1.65	92.25	0.00	92.25	0.00
14	1.71	91.14	0.00	91.14	0.00
15	1.78	91.04	3.10	94.14	0.03
16	1.83	91.04	3.10	94.14	0.03
17	1.91	93.29	2.06	95.35	0.02
18	1.98	87.67	1.03	88.70	0.01
19	2.10	62.94	4.13	67.07	0.07
20	2.20	56.20	2.07	58.27	0.04
21	2.33	68.56	2.07	70.63	0.03
22	2.40	60.69	2.07	62.76	0.03
23	2.50	10.11	3.10	13.21	0.30
24	2.65	33.72	4.13	37.85	0.12
25	2.80	53.95	4.13	58.08	0.07
26	2.90	65.20	4.12	69.32	0.06
27	2.95	76.43	4.13	80.56	0.05
28	3.10	93.29	6.20	99.49	0.06
29	3.30	94.41	5.16	99.57	0.05
30	3.40	97.78	2.07	99.85	0.02
31	3.50	25.85	3.10	28.95	0.12
32	3.70	28.10	3.10	31.20	0.11
33	3.80	96.66	2.07	98.73	0.02
34	3.90	19.11	1.03	20.14	0.050

For radiocarbon dating and stable isotopic analysis of calcareous sediments, four samples of carbonates were collected. The results of radiocarbon dating are presented in Table 2. According to the radiocarbon dating, sedimentation of calcareous tufa (travertine) in the Dūkšta site lasted more than 3000 years. The calibrated age ranges from 2250 to 6470 BC. The sedimentation rate of all deposits in the Dūkšta section was about 0.9 mm / year.

Interpretation of the analytical data obtained with the stable isotope ^{13}C helps to solve the problem of formation temperature, environmental conditions and the genesis of calcareous sediments in the Dūkšta section. The obtained $\delta^{13}C$ are nearly indentical to the four samples of calcareous tufa (Table 2). The identity of $\delta^{13}C$ content in all sections of calcareous tufa indicates the stability of spring water temperature during tufa sedimentation. Carbon (^{13}C) stable isotope shows the cool groundwater conditions during the sedimentation of calcareous sediments from an underground spring in the study area.

MOLLUSC FAUNA

The taxonomic composition of fossil molluscs detected in the Dūkšta calcareous sediments is presented in Table 3. Terrestrial fossil molluscs (35 taxa) prevail, while fresh-water species are significantly more rare (6 taxa).

From the ecological viewpoint, the terrestrial fauna consists of forest species (11 taxa), open areas species (3 taxa) and mesophiles typical of changing living conditions (21 taxa). Except the mesophiles, the two other ecological groups indicate that forests prevailed in the area and covered 78.6%. The forest species detected most often were *Perforatella bidentata* (Gmelin) and *Acicula polita* (Hartmann). The East European species *Perforatella bidentata* (Gmelin) prefers wet alder thickets. The Central European species *Acicula polita* (Hartmann) now occupies moderately wet deciduous forests. There were also broad-leaved species indicated by presence of inhabitants of mainly broad-leaved forests, such as *Acanthinula aculeata* (Müller), *Aegopinella* cf. *pura* (Alder), *Discus* cf. *rotundatus* (Müller).

The most widely spread species of open biotopes is *Vallonia costata* (Müller) inhabiting mainly meadows with low grass or rarely sand dunes, light forests or bog edges. Its constant codweller *V. pulchella* (Müller) is significantly lower in number.

Table 2. **Results of radiocarbon dating of calcareous sediments from the Dūkšta section (results by N. D. Mikhailov, 2008)**
2 lentelė. **Dūkštos pjūvio karbonatinių nuogulų radiokarboninės datos**

No.	Sample No and depth (m)	Sample material	Laboratory number	^{14}C age (yr BP)	$\delta^{13}C$, % PDB	Calibrated age range(s) BC or AD	
						1δ (68.3 %)	2δ (95.4%)
1	No. 1 3.5	Calcareous tufa	IGSB-1366	7450 ± 100	–9.3	6420–6230 BC	6470–6080 BC
2	No. 2 3.0	Calcareous tufa	IGSB-1367	7440 ± 90	–10.0	6410–6230 BC	6460– 6090 BC
3	No. 3 1.35	Calcareous tufa	IGSB-1368	6660 ± 185	–10.0	5650–5510 BC	5720–5470 BC
4	No. 4 0.8	Calcareous tufa	IGSB-1369	3990 ± 70	–10.1	2620–2430 BC 2420–2400 BC 2380–2340 BC	2900–2800 BC 2750–2250 BC

Table 3. **Fauna of mollusc calcareous tufa in the Dūkšta section, 2006**

3 lentelė. **Moliuskų fauna (vnt.) iš Dūkštos atodangos karbonatinių tufų (2006)**

Taxon	Samples									
	1	2	3	4	5	6	7	8	9	10
Acicula polita (Hartmann)	2	92		183	182	9	4		17	1
Acanthinula aculeata (Müller)				6	10	1			1	
Discus ruderatus (Férussac)		12	2	45	55	7	1			
Aegopinella cf. *pura* (Alder)						3				
Clausilia cruciata (Studer)		2							1	
Clausiliidae gen.	1	40		10	9	7				2
Bulgaria cana (Held)					1		1	17	25	
Discus cf. *rotundatus* (Müller)				3					1	
Vitrea crystallina (Müller)						3		11	46	6
Bradybaena fruticum (Müller)		2		5	5		1		1	
Perforatella bidentata (Gmelin)	1	139	4	150	242	71	80	30	53	7
Pupilla muscorum (Linnaeus)			2						2	15
Vallonia costata (Müller)	4	97	27	680	737	18		10	97	52
Vallonia pulchella (Müller)		11	1	40	45	2	1	13	40	33
Cochlicopa lubrica (Müller)		5	10	10	23	1	2	17	10	6
Vertigo alpestris Alder				1	1				2	1
Punctum pygmaeum (Draparnaud)		1	14	10	21	1			8	
Nesovitrea hammonis (Strom)	2	22	8	200	130	1		80	10	
Limacidae gen.		5	2	20	24	4	2	2	5	1
Euconulus fulvus (Müller)			6	6	11			4	13	
Trichia hispida (Linnaeus)										2
Carychium tridentatum (Risso)		19	4	53	85	3	4	10	30	1
Columella edentula (Draparmaud)			1	4				5	2	
Vertigo angustior (Jeffreus)	3	63	39	575	691	10			19	2
Vertigo substriata (Jeffreus)		1	21	33	22	1	1	7	5	1
Succinea oblonga (Draparnaud)										12
Nesovitrea petronella (L. Pfeiffer)		4	2	10	24		2			
Carychium minimum Müller	1	160	69	700	831	15	10	137	202	1
Cochlicopa nitens (Gallenstein)				1	1					
Vertigo antivertigo (Draparnaud)									4	
Vertigo moulinsiana (Dupuy)										3
Succinea putris (Linnaeus)		7	6	7	8	3	5	15	48	19
Succinea elegans (Risso)				1				1	15	
Zonitoides nitidus (Müller)	3	1	4	21	61	2	7	21	10	
Monachoides rubiginosa (Schmidt)								3		
Valvata cristata Müller					1					
Valvata pulchella (Studer)		1								
Lymnaea truncatula (Müller)	1	3	14	90	58	13	45	72	79	9
Lymnaea stagnalis (Linnaeus)										2
Pisidium casertanum (Poli)		12		300	132	4	21		20	
Pisidium personatum Malm		4		50	38		30	1	13	
Total	18	703	236	3214	3448	179	217	456	779	176

Among mesophiles, the conditions were most favourable for *Carychium minimum* Müller and *Vertigo angustior* (Jeffreus). *Carychium minimum* Müller prefers low, moist and wet sites at the margins of bogging lakes. *Vertigo angustior* (Jeffreus) now occupies wet meadows in moss and grass, as well as lake shores. Shells of this species occur most often in Boreal deposits. The Dūkšta terrestrial mollusc fauna embraces a complex of thermophiles including such forest species as *Acicula polita* (Hartmann), *Acanthinula aculeata* (Müller), *Aegopinella* cf. *pura* (Alder), *Bulgaria cana* (Held) and *Discus* cf. *rotundatus* (Müller), as well as mainly South-European *Carychium tridentatum* (Risso) and mainly West-European *Vertigo moulinsiana* (Dupuy) (Fig. 4). Let us focus on the last species, *V. moulinsiana* (Dupuy), belonging to a group of thermophilic relicts. Its position within the ecological groups in the Netherlands is as follows: forest molluscs make up 28.6%, open biotope species 0, mesophiles 7.1%, and hydrophiles 50% (Meijer, 1985). This species prefers certain climatic conditions:

high air moisture, annual precipitation at least 600 mm, the mean annual temperature of 10 °C; the mean July temperature of 15 °C, and the mean January temperature above – 5 °C; the recent spreading of the species takes place mainly south of the 17 °C isoline (Johansen, 1904). The species withstands temperatures within the range of –10 to +30 °C (Butot, Neuteboom, 1958). These data indicate more favourable climatic conditions than those in the Vilnius area now.

The distribution of mollusc shells in the profile is in a malacological diagram (Fig. 5) showing how deposits were accumulating in six local malacological zones. The start of deposit formation coincides with a high representation of the Central Europian forest mollusc *Acicula polita* (Hartmann) (zone A. p.). The homonymous local zone reflects optimal climatic conditions which most likely should be attributed to the climatic optimum in the Holocene, i. e. its Atlantic period.

The next local zone is characterised by the following mesophilic species: *Carychium minimum* Müller, *Carychium tridentatum* (Risso), *Vertigo angustior* (Jeffreus) (zone C. t. + C. m.). An open bogged landscape started to prevail at that time in the vicinity of the profile with numerous *Vallonia costata* (Müller) specimens. However, soon forests occupied the area around the source. Wet alder thickets became more abundant, providing conditions favourable for the species *Perforatella bidentata* (Gmelin) under the canopy (zone P. b.). Later, the progressing humidity disturbed the functioning of the source, expressed in the replacement of calcareous tufa with humic sandy loam and loam, as well as in formation of a small lake in which the role of water molluscs, especially *Lymnaea truncatula* (Müller) (zone L. t.), increased. This typical amphibiotic species inhabits shallow overgrowing lakes, bogs and pools with a silty or clayey bottom. Soon the source regenerated, and mesophilic and hydrophilic fauna with prevailing *Carychium minimum* Müller, *Nesovitrea hammonis* (Ström) and *Cochlicopa lubrica* (Müller) populated its environs (zone C. m. + N. h.). At the final stage of the sources in the Dūkšta valley, the role of open landscape species, such as *Vallonia costata* (Müller) and *V. pulchella* (Müller), increased (zone V. c.). This seems to be related to forest felling by man. The disappearance of forests in the vicinity of the profile disturbed the hydrological regime in the underground and stopped the activity of sources and the formation of recent soil. The malacocenosis taken from the recent soil indicates that even more open landscape species played the leading role in the malacological spectrum, showing that the deforestation was increasing.

The distribution of the ecological groups of molluscs is illustrated on bi-component diagram (Fig. 6). The optimal environment for mollusc fauna occurred during the sedimentation of the lowermost part of the section (depth interval 2.5 to 3.5 m) where most specimens of molluscs (N_S) and the highest carbonate material content were established.

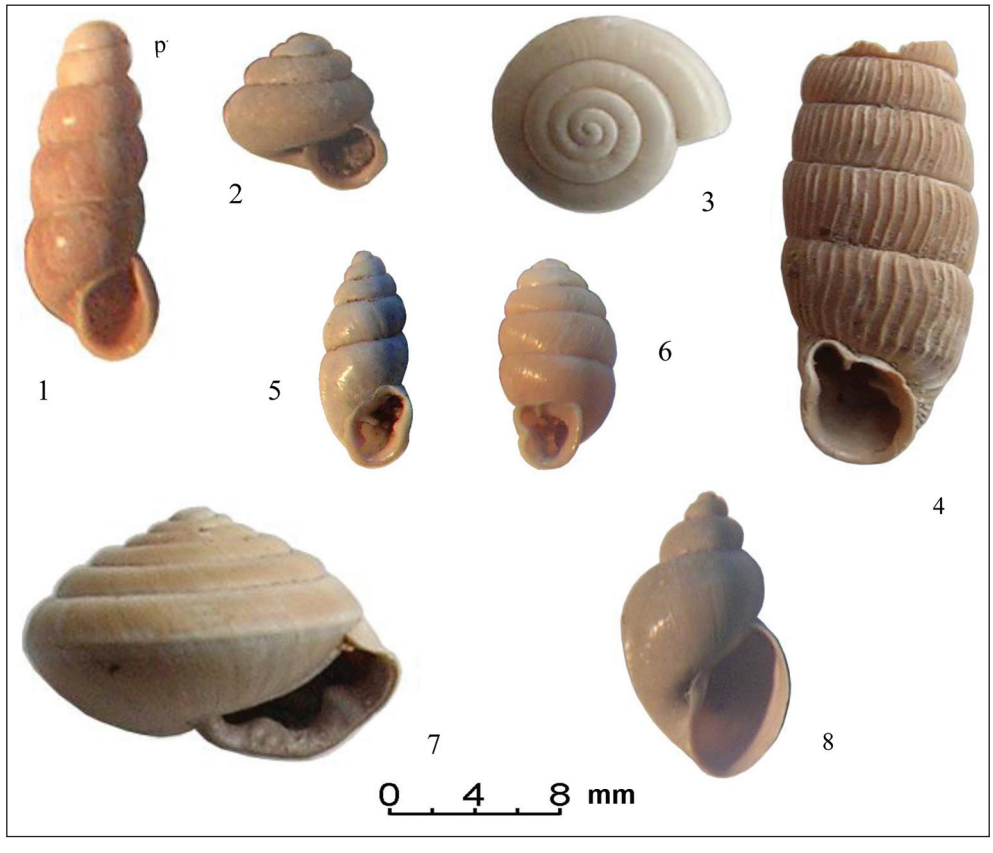

Fig. 4. Shells of the characteristic molluscs from the Dūkšta section deposits:
1 – Acicula polita (Hartmann), *2 – Acanthinula aculeata* (Müller), *3 – Vitrea crystallina* (Müller), *4 – Bulgaria cana* (Held), *5 – Perforatella bidentata* (Gmelin), *8 – Lymnaea truncatula* (Müller)
4 pav. Dūkštos pjūvio nuogulose surastų būdingiausių moliuskų kriauklės:
1 – Acicula polita (Hartmann), *2 – Acanthinula aculeata* (Müller), *3 – Vitrea crystallina* (Müller), *4 – Bulgaria cana* (Held), *5 – Perforatella bidentata* (Gmelin), *8 – Lymnaea truncatula* (Müller)

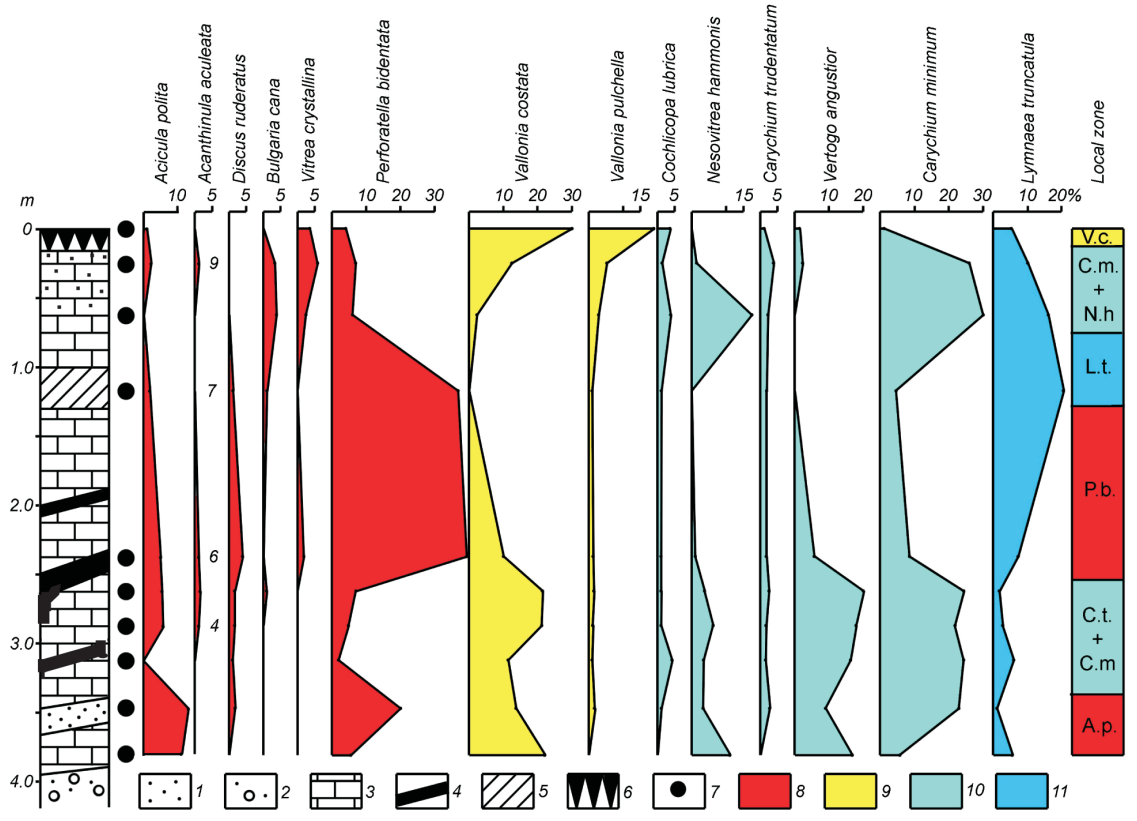

Fig. 5. Malacological diagram of calcareous deposits in the Dūkšta section.
1 – sand, *2* – sand with gravel and pebble, *3* – calcareous tufa (travertine), *4* – interlayers of humic organics with wood remains, *5* – calcareous loam and sandy loam with carbonates, *6* – recent soil, *7* – sampling points, *8* – forest molluscs, *9* – molluscs of open areas, *10* – mesophilic molluscs, *11* – freshwater molluscs

5 pav. Dūkštos pjūvio nuogulų malakofaunos diagrama.
1 – smėlis, *2* – smėlis su žvirgždu ir rieduliais, *3* – karbonatinis tufas (travertinas), *4* – humusingos organikos tarpsluoksniai su medienos liekanomis, *5* – karbonatingas priesmėlis ir priemolis, *6* – dabartinis dirvožemis, *7* – pavyzdžių paėmimo vietos, *8* – miško moliuskai, *9* – atvirų plotų moliuskai, *10* – mezofilai, *11* – gėlavandeniai moliuskai

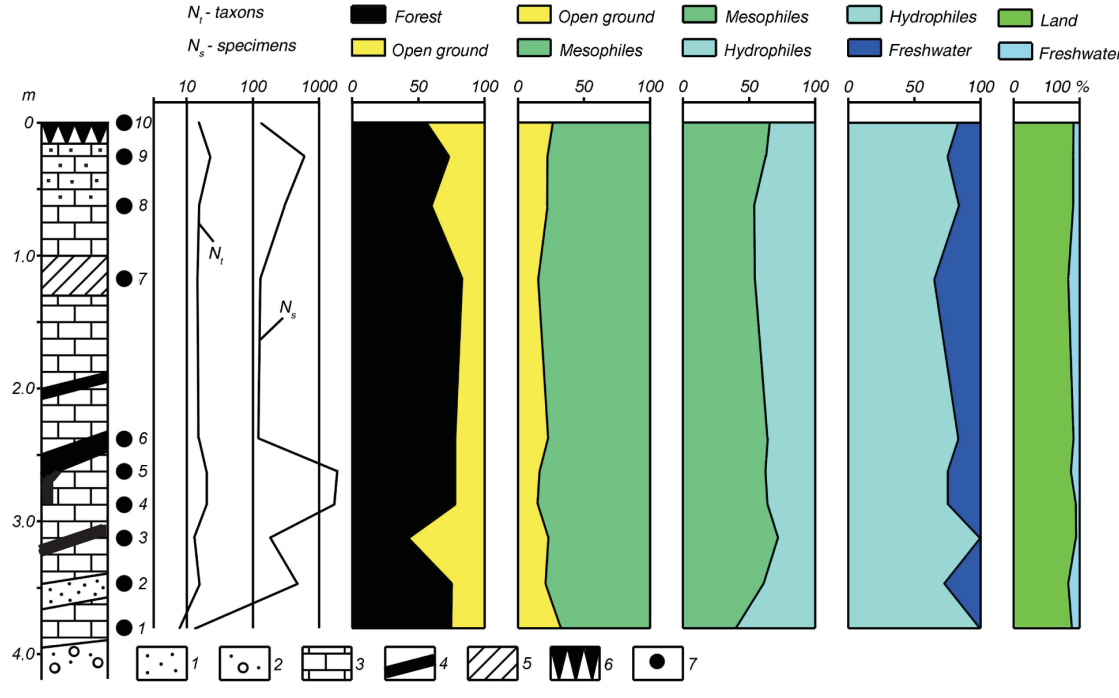

Fig. 6. Bicomponent malacological diagram of calcareous deposits in the Dūkšta section. For explanation, see Fig. 5
6 pav. Dūkštos pjūvio karbonatinių nuogulų dvikomponentė malakologinė diagrama. Paaiškinimus žr. 5 pav.

Table 4. **Radiocarbon dates of wood samples from the Dūkšta section (results by N. D. Mikhailov, 2008)**
4 lentelė. **Dūkštos pjūvio medžio mėginių radiokarboninės datos**

No.	Sample No. and depth (m)	Material	Laboratory number	^{14}C age (yr BP)	$\delta^{13}C$	Calibrated age range BC or AD	
						1δ (68.3 %)	2δ (95.4%)
1	No. 3 2.16	Wood	IGSB-1355	4210 ± 100	–25.5	2910–2830 BC 2820–2630 BC	3100–2450 BC
2	No. 2 2.84	Wood	IGSB-1360	4390 ± 115	–25.1	3330–3210 BC 3180–3160 BC 3120–2900 BC	3400–2650 BC
3	No. 1 3.20	Wood	IGSB-1354	4820 ± 110	–25.8	3710–3500 BC 3430–3380 BC	3950–3350 BC
4	No. 4 3.20	Wood	IGSB-1359	5280 ± 120	–24.4	4250–3970 BC	4350–3800 BC

The ratio of the forest and non-forest (open-area) mollusc species indicates a forested surrounding which exceeded 50% of the area and in some cases reached 80%. The dominance of non-forest species in the upper part of the section is related to the increasing human impact, mainly to deforestation. Some climate humidity increment was observed in sandy loam and loamy clay in the depth interval of 1.0 to 1.3 m (sample 7) where more hydrophilic than freshwater mollusc species were found.

RADIOCARBON DATING

For radiocarbon dating of calcareous sediments, four samples of wood remnants buried in different levels of the study section were taken (Table 4): 3.29–3.11 m (lower), 2.90–2.45 m (middle) and 2.21–2.00 m (upper). The dating (Table 4) was carried out in 2008 at the Radiocarbon Laboratory of the Belarus National Academy of Sciences, Head Dr. Nikolay Mikhailov.

Wood remains from the three levels in calcareous tufa showed radiocarbon dates from 5280 ± 120 to 4210 ± 100 BP. The calibrated dates of the samples cover the time period from 4350 to 2450 BC. This means that the calcareous tufa was formed during a short period. The sedimentation rate of calcareous deposits was about 1.5–2 mm / year. During the Atlantic period, thermophilic oak-tree forests were growing here. Analogous dates of buried oak trunks were obtained for the Valakupiai section in Vilnius vicinities about 50 km east from the Dūkšta section (Gaigalas et al., 2007).

The obtained $\delta^{13}C$ data for wood samples (Table 4) are nearly identical to all the four. The identity of 13C results indicates the stability of air temperature and warm climatic conditions.

Dry phases indicated by wood remmants in peat interlayers of calcareous tufa were dated to 5280 ± 120 – 4820 ± 100, 4390 ± 115 and 4210 ± 100 BP and reflected tree falls at that time. The calcareous tufa (Table 2) showed older dates (Table 4). A transformation of some portion of the enclosing rock carbonate material (dead radiocarbon) into a dissolved state of underground water caused a shift of the carbon isotopic composition relative to that determined in the calcareous material deposited from spring water. Thus, the spring calcareous sediments show an older age than wood remants in peat interlayers of the Dūkšta section.

CONCLUSIONS

The Dūkšta occurrence of fossil malacofauna is the first site of terrestrial molluscs in Lithuania. A trail of calcareous tufa with mollusc shells was formed due to slope processes during the Atlantic climatic optimum of the Holocene and later. Terrestrial fossil molluscs (35 taxa) prevail, freshwater species are rare (6 taxa). Terrestrial fauna had a complex of thermophilic forest species, such as *Acicula polita* (Hartman), *Acanthinula aculeata* (Müller), *Aegopinella* cf. *pura* (Alder), *Bulgaria cana* (Held) and *Discus* cf. *rotundatus* (Müller) as well as the South-European *Carychium tridentatum* (Risso) and the West-European *Vertigo moulinsiana* (Dupuy). From the ecological viewpoint, this malacofauna consists of forest species (11 taxa), open areas species (3 taxa) and mesophiles (21 taxa).

For wood remains from three levels in calcareous tufa, radiocarbon dates range from 5280 ± 120 to 4210 ± 100 BP. The calibrated dates of the samples cover the time period from 4350 to 2450 BC.

ACKNOWLEDGMENT

The study was supported by the Lithuanian State Science and Studies Foundation, grant No. T-37/08.

References

1. Butot L. J. M., Neuteboom W. H. 1958. Over *Vertigo moulinsiana* (*Dupuy*) en haar voorkomen in Nederland. *Baseria*. ***22***(*2–3*). 52–63.
2. Gaigalas A., Sanko A., Pazdur A., Pawlyta J., Michczyński A., Budėnaitė S. 2007. Buried oaks and malacofauna of Holocene oxbow lake sediments in the Valakupiai section, Lithuania. *Geologija*. ***58***. 34–48.
3. Johansen A. C. 1904. Om den fossile kvartaere molluskfauna i Danmark og dens relationer til forandringer i klimaet. *Land- og ferskvandsmolluskfaunaen*. ***I–IV***. København. 1–136.
4. Meijer T. 1985. The pre-Weichselian non-marine molluscan fauna from Maastricht–Belvédére (Southern Limburg, The Netherlands). *Mededelingen Rijks Geologische Dients*. ***39***(*1*). 75–103.

5. Kabailienė M., Vaikutienė G., Damušytė A., Rudnickaitė E. 2007. The Stratigraphy and palaeoenvironment of the Northern Part of Curonian Spit based on New Pollen. Diatom. Molluscs and carbonate analysis data. *The Quaternary of Western Lithuania: from the Pleistocene Glaciations to the Evolution of the Baltic Sea. Proceedings. The INQUA Peribaltic Group Field Symposium, May 27 – June 02, 2007, Plateliai, Lithuania*. Vilnius. 28–29.
6. Rudnickaite E. 2007. Reconstruction of palaeogeography of Pleistocene interglacials according carbonates content. *XVII INQUA Congress The Tropics: Heat Engine of the Quaternary, July 27 – August 03, 2007, Cairns, Australia. Abstracts / Quaternary International*. ***167–168***. 356.
7. Рудницкайте Э. Л. 1980. Методика определения карбонатов в разновозрастных моренах плейстоцена. *Полевые и лабораторные методы исследования ледниковых отложений. Тезисы докладов межведомственного совещания.* РИСО АН ЭССР. Таллин. 121.
8. Рудницкайте Э. Л. 1984. Палеогеографические условия осадконакопления межледниковых отложений в разрезе Жидини по содержанию карбонатов. *Палеогеография и стратиграфия четвертичного периода Прибалтики и сопредельных районов.* Вильнюс. 203–206.
9. Рудницкайте Э. Л. 1986. Особенности седиментации карбонатов на протяжении межледниковий плейстоцена (по материалам Литвы). *История древних озер. Тезисы докладов на VII симпозиуме по истории озер: история озер в дочетвертичное время, в голоцене и формирование полезных ископаемых в озерах. Ленинград, ноябрь 1986.* Ленинград: ГО СССР. 106–108.
10. Щербина В. Н. 1958. О методике массового определения карбонатности осадочных пород. *Труды института геол. наук АН БССР.* ***Вып. 1.*** Минск. 131–144.

Aleksander Sanko, Algirdas Gaigalas, Eugenija Rudnickaitė, Monika Melešytė

KARBONATINGŲ NUOGULŲ IŠ DŪKŠTOS APYLINKIŲ NETOLI MAIŠIAGALOS (LIETUVA) HOLOCENO MALAKOFAUNA

S a n t r a u k a

Šioje apylinkėje pirmą kartą Lietuvoje surastos ir ištyrinėtos sausumoje gyvenusių holoceno moliuskų liekanos. Moliuskų geldelės ir kriauklės surinktos iš karbonatinių tufų, kurių sudėtyje vyrauja kalcitas. Karbonatų (kalcito ir dolomito) kiekis dažnai yra didesnis nei 90%, o kai kada viršija 99%. Faunos amžius – holoceno Atlančio klimato optimumas iki šių laikų – patvirtintas radiokarboniniu datavimu. Malakofaunos ekologinė analizė leidžia mums tvirtinti, kad aplinkiniai plotai buvo apaugę tankiu mišku, taip pat padeda įvertinti temperatūrinį režimą, klimato drėgnumą ir žmogaus ūkinės veiklos įtaką.

Karbonatiniai tufai klostėsi veikiant šlaitų procesams. Sausumos malakofaunos kompleksą sudaro miško rūšys (11 taksonų), atvirų plotų (3 taksonai) ir mezofilai (21 taksonas). Faunos komplekse surastos termofilinės miško rūšys (*Acicula polita, Acanthinula aculeata* (Müller) *Aegopinella* cf. *pura* (Alder), *Bulgaria cana* (Held) ir *Discus* cf. *rotundatus* (Müller), taip pat pasitaikė Pietų Europos (*Carychium tridentatum*) (Risso)) ir Vakarų Europos rūšių (*Vertigo moulinsiana*) (Dupuy)).

Medienos likučių karbonatiniuose tufuose iš trijų vertikalių lygių radiokarboninės datos pasiskirsčiusios nuo 5280 ± 120 iki 4210 ± 100 BP. Kalibruotos mėginių datos rodo buvus 4350–2450 kalendorinių metų prieš Kristaus gimimą.

Александер Санько, Альгирдас Гайгалас, Евгения Рудницкайте, Моника Мелешите

МАЛАКОФАУНА ГОЛОЦЕНОВЫХ ИЗВЕСТКОВЫХ ОТЛОЖЕНИЙ ИЗ ОКРЕСТНОСТЕЙ ДУКШТЫ ВБЛИЗИ МАЙШЯГАЛЫ (ЛИТВА)

Р е з ю м е

В Центральной Литве обнаружена и исследована наземная фауна моллюсков. Раковины моллюсков в Дукштос встречены в известковых туфах, в составе которых резко преобладает кальцит. Содержание карбонатов (кальцит + доломит) в туфах часто составляет более 90%, достигая в некоторых пробах более 99%. Возраст фауны: конец атлантического оптимума голоцена – современность, что подтверждено радиоуглеродным датированием. Экологический анализ фауны позволяет говорить о довольно сильной залесенности окружающей территории, температурном режиме, влажности климата, а также о влиянии хозяйственной деятельности человека.

Карбонатные туфы отложились под действием склоновых процессов. Комплекс наземной малакофауны составляли лесные виды (11 таксонов), открытых пространств (3 таксона) и мезофилы (21 таксон). В комплексе фауны обнаружены термофиловые лесные виды (*Acicula polita* (Hartman), *Acanthinula aculeata* (Müller), *Aegopinella* cf. *pura* (Alder), *Bulgaria cana* (Held) и *Discus* cf. *rotundatus* (Müller)), а также найдены Южно-Европейский (*Carychium tridentatum* (Risso)) и Западно-Европейский (*Vertigo moulinsiana* (Dupuy)) виды.

Карбонатные туфы Дукштос накопились на склоне в результате деятельности родниковых вод. Для древесных остатков из трех уровней разреза карбонатовых туфов получены радиоуглеродные даты распределились в интервале 5280 ± 120 – 4210 ± 100 BP. Подсчитанный калибровочный календарный возраст соответствует 4350–2450 лет BC.