The Lower Danube mollusc assemblages: zooarchaeological and paleoenvironmental data from Eneolithic settlements Hârșova *tell*, Bordușani *Popină* and Taraschina (Romania, 5th millennium BC)[1]

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Abstract: *The molluscs can provide important evidences concerning the activities of prehistoric communities and useful data to reconstruct the pleoenvironment. The information related to ecological requirements of molluscs and their biologic specificities, as well as the zooarchaeological data, can provide details referring to the capture season, the frequency and the area of the harvesting or the diet of the prehistoric people. The study of the aquatic molluscs from the Eneolithic settlements (5th millennium BC) Hârșova* tell *and Bordușani* Popină *located in the Danube Valley or Taraschina in the Danube Delta contribute to the reconstruction of the fluvial-lacustrine component of the environment. During the occupation of the Hârșova and Bordușani tell settlements, the bivalve spectrum changes especially in terms of reducing the frequency of rheophylus water species. These results are correlated with significant changes occurring in the hydrological network and in its dynamics like for example transition from a network dominated by branches to a network dominated by lacks and ponds. The bivalve taxonomical spectrum from Taraschina is characteristic for a Danube active branch and a brackish lagoon which was a very different landscape from today. All these observations related to the environment are supported by additional data provided by all three settlements.*

Rezumat: *Moluștele pot oferi dovezi importante privind activitățile comunităților preistorice și date utile pentru reconstrucția plaeomediului. Informațiile referitoare la cerințele ecologice ale moluștelor și caracteristicile biologice al acestora, precum și datele arheozoologice, ne pot oferi detalii referitoare la sezonul, frecvența și locul de recoltare sau alimentația oamenilor preistorici. Studiul moluștelor acvatice din așezările eneolitice (mileniul V BC) Hârșova* tell *și Bordușani* Popină *situate în Valea Dunării sau Taraschina din Delta Dunării contribuie la reconstituirea componentei fluvio-lacustre a mediului. În timpul locuirii așezărilor de tip* tell *de la Hârșova și Bordușani, spectrul bivalvelor identificate se modifică mai ales în ceea ce privește reducerea frecvenței speciilor reofile. Aceste date au fost în corelație cu schimbările semnificative care au avut loc în rețeaua hidrologică și în dinamica râurilor, cum ar fi, de exemplu, trecerea de la o rețea dominată de brațe la o rețea dominată de lacuri și bălți. Spectrul taxonomic al bivalvelor de la Taraschina este caracteristic pentru un braț activ al Dunării dar și pentru o lagună salmastră, un peisaj foarte diferit de cel de astăzi. Toate aceste observații legate de mediu sunt susținute și de datele suplimentare furnizate de toate cele trei așezări.*

Keywords: *Eneolithic, Lower Danube, mollusks, zooarchaeology, paleoenvironment*

Cuvinte-cheie: *Eneolitic, Dunărea de Jos, moluște, arheozoologie, paleomediu*

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◈ 1. Introduction

Every animal has some specific ecological requirements which represent useful information that could help reconstruct the paleoenvironment. Generally, the molluscs are widely distributed in various environments. But each species lives especially in that places where these specific requirements are optimal. Moreover for most of them their degree of mobility is low. These are the reasons why in some circumstances they can be good environmental indicators. An important amount of the mollusc shells from the archaeological sites comes from the volunteer harvesting of the molluscs by man for food or for other purposes (ornaments, tools, construction materials etc.). Another component is involuntarily brought to the site or even lives on the areas inhabited by man. All these species, except the ones imported from long distances, are important sources on useful information for the reconstruction of the environment surrounding the settlements and its evolution over time.

In Romania, the only attempts to reconstruct the environment based on the data provided by the molluscs recorded in the archaeological levels were those of Grossu (1957; 1970; 1976) and recently those of Radu (Radu *et alii* 2016; Radu 2022). However in SE Europe the most complex studies regarding the role of the freshwater bivalves and other molluscs for the reconstruction of the paleoenvironment, the evolution of settlements in response to the changes in the environment, or the diet of prehistoric populations, were conducted in Neolithic and Eneolithic settlements (Starčevo-Criş and Tisza cultures) from the Hungarian Plain (Gulyás, Sümegi 2004; 2011a; 2011b; Gulyás *et alii* 2007; Sümegi 2007; Szilagyi *et alii* 2013).

The data provided by the mollusc remains, especially those of bivalves, can contribute to complex analyses, such:

- quantitative and qualitative comparisons between occupational levels;
- the characterization of potential harvesting areas (lakes, river or its tributary);
- the timing and seasonality of harvesting significant quantities of bivalves;
-the ratio between bivalve harvesting, fishing and other activities such as animal breeding or hunting in the prehistoric subsistence economy of this period;
- and regarding the environment, it can capture some major environmental changes that took place during successive occupations, and the relationships of humans communities with their environment in the context of the development of tell settlements.

In this paper we will analyse the assemblages of molluscs from three Eneolithic sites located along the Danube: Bordușani *Popină*, Hârșova *tell* and Taraschina that benefited in recent years of complex archaeological research supported by multidisciplinary analyses in order to reconstitute both the life of the Neolithic peoples and their interactions with the environment.

◈ 2. Archaeological context

The samples analysed in this paper were provided by the prehistoric settlements Hârșova *tell* and Bordușani *Popină* located on the banks of the Danube River and Taraschina located nowadays in the Danube Delta. They are pluristratified settlements formed by accumulation of remains of houses and household goods and domestic waste representing several levels of habitation (Chapman 2010).

Hârșova *tell* is located on a river terrace of the Danube (fig. 1). Boian and Gumelnița Eneolithic levels are preserved to a depth of about 12 m. The area of the tell site was about two hectares which was among the largest in the area of the Gumelnița

culture (Randoin *et alii* 2000; Popovici *et alii* 2000; 2014a). The Boian and Gumelnița levels date between *c.* 4700 and 4050 BC (Bréhard, Bălășescu 2012; Popovici *et alii* 2001). The areas excavated are approximately 400 m². Recently, a new surface was investigated (SCpP) where the Hamangia culture is present with very consistent remains (Popovici *et alii* 2016).

At present, Bordușani *Popină* is located in the floodplain area (Balta Ialomiței) adjacent to the Borcea arm of the Danube (about 1 km away) (fig. 1). Boian and Gumelnița Eneolithic levels are preserved to a depth of about 7 m at Bordușani *Popină* (Marinescu-Bîlcu *et alii* 1997; Popovici *et alii* 2003; 2014b). The Eneolithic level belonging to the Gumelnița culture (*c.* 4600-3800 BC), which is a part of the larger Kodjadermen-Gumelnița-Karanovo VI cultural complex of the Balkan area (Bailey 2000; Marinescu-Bîlcu 2001; Popovici 2010; Ştefan 2010) is the best represented and preserved. Radiocarbon dating has shown that the duration of the Gumelnița (phase A2) occupation of the tell stretches between *c.* 4500 and 4250 BC at Bordușani *Popină* (Gillis *et alii* 2013). The areas excavated are approximately 800 m².

Complex multidisciplinary studies were conducted in both settlements and all significant archaeological structures where carefully sampled. The analyses performed included sedimentology (Haită 1997; 2012), carpology (Monah 2000; Popovici *et alii* 2014a; 2014b), anthracology (Tomescu 2003), palynology (Tomescu 1997) and archaeozoology (Sárkány-Kiss, Boloş 1996a; 1996b; Kessler, Gál 1997; Venczel 1997; Moise 1997; 2000; Radu 1997; 2003; 2020; Bălăşescu *et alii* 2003; 2005; Gál, Kessler 2002; 2003; Bréhard, Bălăşescu 2012; Mărgărit, Popovici 2012; Gillis *et alii* 2013, Balasse *et alii* 2016; Radu *et alii* 2016), seasonality and its indicators (Bréhard *et alii* 2014; Haită, Radu 2003; Radu 2000; Tomescu *et alii* 2003) or anthropology (Bălteanu 1997; Vasile 2003).

For the present study we analysed the material sampled from the two sites belonging to Boian and Gumelnița cultures (4700-3900 BC).

Taraschina is a partially submerged site located in the middle of the Danube Delta (fig. 1), 4.5 km SE of Mila 23 town, on the banks of a small navigational channel built through the site and affecting a part of it. The research area of about 1 ha was explored using the whole set of methods provided by archaeology: geophysical prospections, coring, digging (two sections of about 180 m²), typological analysis and mobile technology (Carozza *et alii* 2011a; 2013). The main occupation identified in this site is the prehistoric one belonging to Boian and Gumelnița cultures developed between *c.* 4800-4300 BC (Carozza *et alii* 2011b). Other punctual subsequent settlements (Hellenistic, Roman and Medieval) were discovered (Micu *et alii* 2011).

The analysed material are sampled from the sections 1 and 2 of the levels classified as belonging to Gumelnița culture (4500-4300 BC).

◈ 3. Methods

The materials are sampled directly, or after a certain number of liters of sediments had been sieved first (see data in figures 3 and 6).

After sorting, the faunal materials were determined, and the *Unio* sp. bivalves were, also, measured. Their dimensions are needed both to approximate their nutritional value and to capture de differences between different samples generate by multiple sampling, overharvest etc.

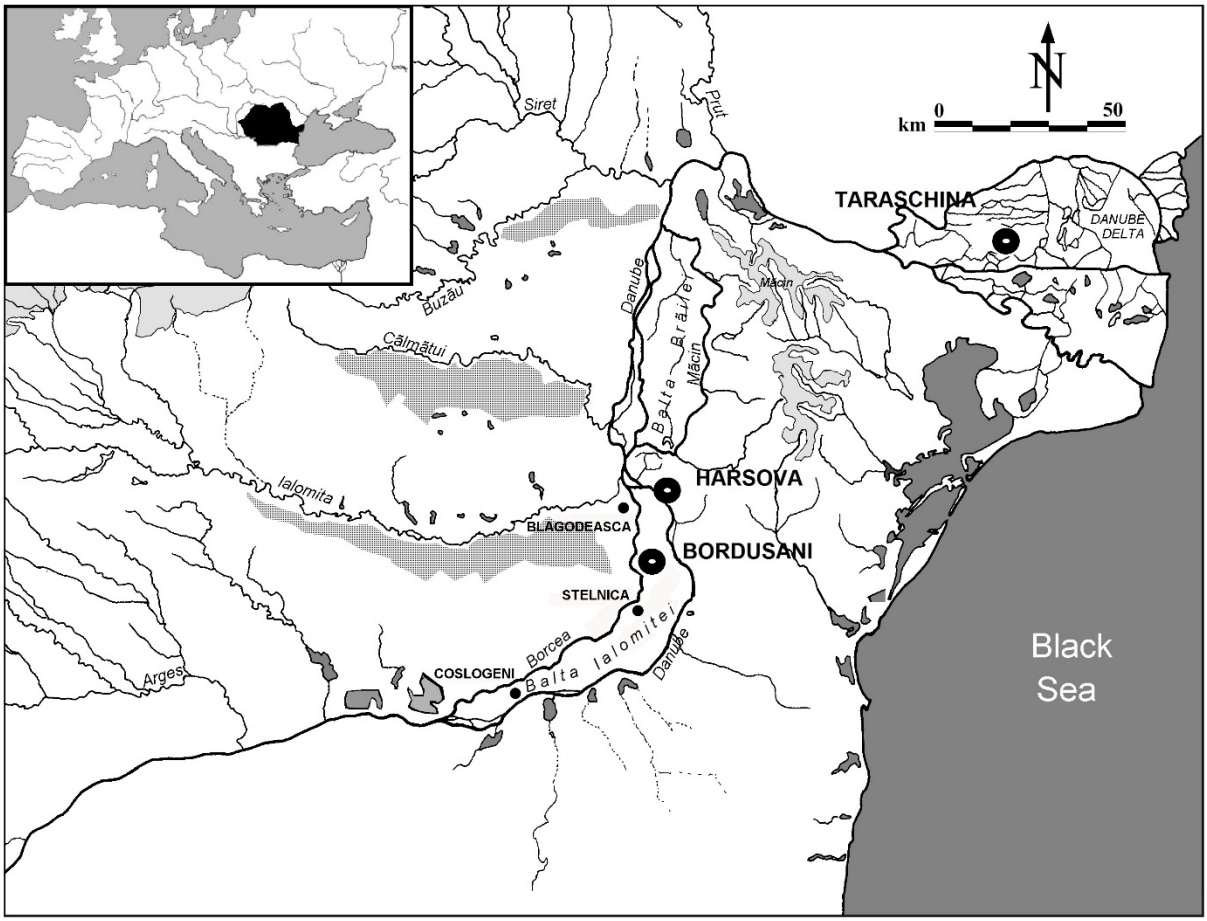

Fig. 1. The location of the sites Hârșova *tell*, Bordușani *Popină* and Taraschina.
Localizarea siturilor Hârșova *tell*, Bordușani *Popină* și Taraschina.

A taxonomic list was realized for each sample and the identified species were grouped according to their ecological requirements. Three large groups were formed (fig. 2): rheophilus water species that prefer moving water (rivers, streams), slow-moving waters species (ditches, lakes) and stagnant water species that prefer standing waters bodies (ponds, shallow waters). The species were assigned to one of three groups using the data provided by Grossu (1962; 1993). Some species were difficult to classify because they, accidentally, can be found in at least two groups. This is the case for *Viviparus* sp., a rheophilic species, which is also found in lakes permanently supplied by the river or for *Limnaea* sp., *Planorbis* sp. and *Planorbarius* sp. which are stagnant water species, but can also be found in tributary branches with low current.

We used useful data from present day bivalves individuals (*Unio* and *Anodonta* species) from samples harvested from different areas of the Danube's floodplains near Hârșova (Radu 2011). These database was necessary to establishing the characteristics of the harvest site. In our attempt to reconstruct the characteristics of the environment, we focus our attention only on the aquatic component of the ecosystems around the settlements, using all data provided by the aquatic molluscs. Three parameters were analysed for every site: the frequencies of mollusc species from various samples, the bivalve ratio *Unio*/*Anodonta* from the archaeological samples and the comparisons with the present day data to establishing the harvesting site and the evolution of their size.

	Taxa	Taraschina		Bordușani		Hârșova			
		Gumelnița		Gumelnița		Boian		Gumelnița	
		%min	%MAX	%min	%MAX	%min	%MAX	%min	%MAX
moving waters (rheophilous)	*Dreissena polymorpha*	0.33	0.35	1	13.72	3.66	5.66	2.3	13.27
	Unio crassus	0.02	0.1	0.06	6.63	6.92	7.67	0.68	3.35
	Theodoxus danubialis					0.87	2.52	0.54	2.3
	Theodoxus fluviatilis	0.02	0.09	0.1				0.95	
	Viviparus acerosus	9.57	12.51	1.44	10.46	0.35		5.59	19.71
	Viviparus contectus							0.18	
	Lithoglyphus naticoides			0.06	1.13	2.44		7.8	
slow-moving waters	*Unio tumidus*	7.33	10.26	7.98	26.97	11.15	14.47	7.35	28.89
	Unio pictorum	2.06	3.66	1.55	46.99	5.05	13.84	9.92	46.68
	Anodonta cygnaea	2.03	2.96	1.88	39.71	10.06	15.16	0.05	20.73
	Pseudanodonta complanata			0	0.14				
	Sphaerium solidum					0.35		0.06	0.09
	Valvata pulchella			0.34				0.81	
	Bithynia tentaculata							0.9	
	Bithynia leachi			0.41				0.36	
	Esperiana esperi			0.34		0.52	1.26	5.37	
	Esperiana acicularis			0.21	0.78			0.68	
stagnant waters	*Planorbis planorbis*	0.05	0.08	0.03				0.09	
	Planorbarius corneus	0.51	0.62					0.23	
	Limnaea stagnalis							0.09	

Fig. 2. The distribution of aquatic molluscs in ecological groups after the main ecological requirements. The values represent the minimum and maximum frequency of determined remains relative to the total analysed found in multiple samples.
Distribuția moluștelor acvatice pe grupe ecologice după principalele cerințe ecologice. Valorile reprezintă frecvența minimă și maximă a resturilor determinate în raport cu totalul analizat provenit din multiple probe.

◈ 4. Assemblages

4.1. Hârșova *tell* settlement

The most common shells among the bivalve and gastropods identified in different samples belong to the aquatic species (98%).

The freshwater bivalves, like *Unio* sp. and *Anodonta* sp. are the most common. The *Unio* species dominate the samples with 45-80% of all mollusc shells (fig. 3). The marine species like *Cardium* (*Cerastoderma*) sp. are also present but they are used for ornaments and are obtained from trade (Mărgărit, Popovici 2012).

The dominant gastropods species are the aquatic species like *Viviparus* sp., *Lithogliphus naticoides*, *Theodoxus* sp. and *Esperiana* sp. and they are present in almost all the samples. The rheophilus species like *Theodoxus* or *Lithoglyphus* are identified both in Boian and Gumelnița level.

In the case of the tell settlement from Hârșova it's clear that these molluscs were brought to the site by prehistoric people. Some of the molluscs were brought involuntary, but most of them were collected for consumption or other purposes (Pickard *et alii* 2017).

The aquatic mollusc species are dominated by rheophilus water taxa. The three *Unio* species (*U. tumidus*, *U. pictorum* and *U. crassus*) are dominant compared to *Anodonta* sp.

			Boian (4700-4500 BC)				Gumelnița (4600-3900 BC)					
			110 litres		221.5 litres		498 litres		3184 litres		3003 litres	
		Taxa	**NR**	**%NR**	**NR**	**%NR**	**NR**	**%NR**	**NR**	**%NR**	**NR**	**%NR**
Bivalvia	fresh- wather	*Unio* sp.	72	45.28	302	52.61			2953	25.37	311	18.26
		Unio tumidus	23	14.47	64	11.15	163	7.35	3363	28.89	230	13.51
		Unio pictorum	22	13.84	29	5.05	1035	46.68	3410	29.29	169	9.92
		Unio crassus	11	6.92	44	7.67	63	2.84	79	0.68	57	3.35
		Anodonta cygnaea	16	10.06	87	15.16	1	0.05	546	4.69	353	20.73
		Pseudanodonta complanata					x					
		Sphaerium solidum			2	0.35	2	0.09			1	0.06
		Dreissena polymorpha	9	5.66	21	3.66	51	2.30	547	4.70	226	13.27
	marine/ brackish	*Cardium edule*			1	0.17			17	0.15	11	0.65
Gasteropoda	aquatic	*Theodoxus danubialis*	4	2.52	5	0.87	51	2.30	63	0.54	18	1.06
		Theodoxus fluviatilis					21	0.95				
		Viviparus acerosus			2	0.35	437	19.71	651	5.59	327	19.20
		Viviparus contectus					4	0.18				
		Valvata piscinalis					20	0.90				
		Valvata pulchella					18	0.81				
		Lithoglyphus naticoides			14	2.44	173	7.80				
		Bithynia tentaculata					1	0.05				
		Bithynia leachi					8	0.36				
		Esperiana esperi	2	1.26	3	0.52	119	5.37				
		Esperiana acicularis					15	0.68				
		Planorbis planorbis					2	0.09				
		Planorbarius corneus					5	0.23				
		Limnaea stagnalis							10	0.09		
	terrestrial	*Condrula tridens*					2	0.09				
		Helicella obvia					19	0.86				
		Campilea faustina					3	0.14				
		Cepaea vindobonensis					4	0.18	3	0.03		
		Mollusca	**159**	**100**	**574**	**100**	**2217**	**100**	**11642**	**100**	**1703**	**100**

Fig. 3. Mollusc assemblages (Boian and Gumelnița levels) from Hârșova *tell* (after Sárkány-Kiss, Boloș 1996a, Radu 2011 and unpublished data).
Eșantioane de moluște (nivelurile Boian și Gumelnița) de la Hârșova *tell* (după Sárkány-Kiss, Boloș 1996a, Radu 2011 și date nepublicate).

The comparison between the *Unio* and *Anodonta* species, taxa with different ecological requirements allowed us to characterize the harvesting places frequently used by the prehistoric peoples. The ratio of the frequencies between these two taxa resulted for archaeological samples is similar to the ratio recorded nowadays for the river and its tributary (fig. 4).

At Hârșova we noticed smaller sizes for the Gumelnița level compared to the present day samples (fig. 5). Excluding ecological factors, these data may be the consequence of intensive harvesting. The repeated selection of large shells, no longer allowed the shell to grow to their maximum size.

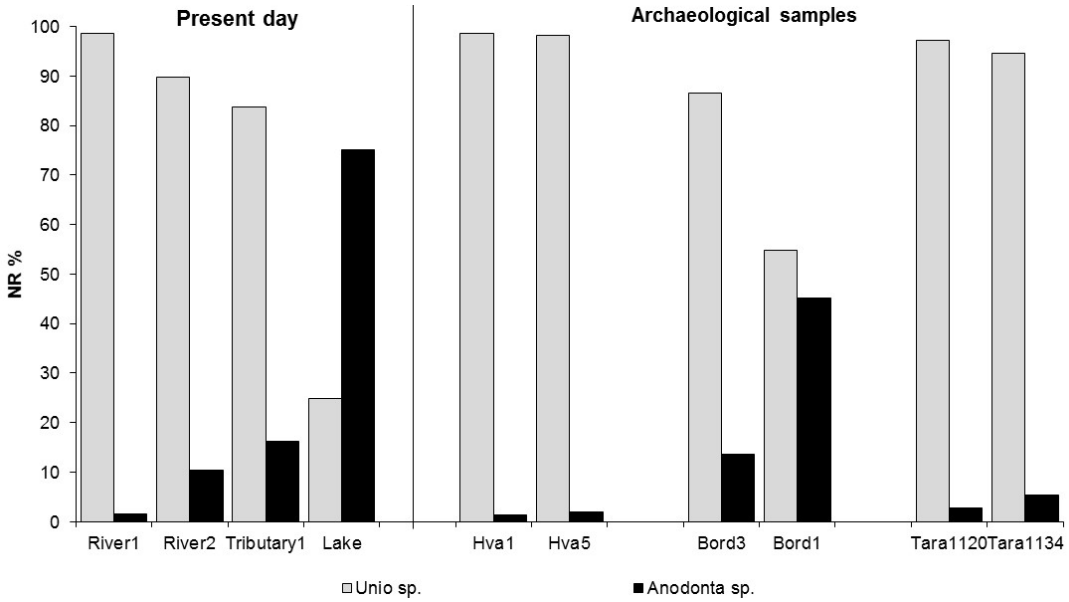

Fig. 4. The ratio of the Unio (*U. tumidus*, *U. pictorum* and *U. crassus*) and *Anodonta* shells valves (% of number of remains) between the present day samples from the Danube (River1, River2, Tributary1 and Lake) and the archaeological ones from Hârșova *tell* (Hva1 and Hva5), Bordușani *Popină* (Bord1 and Bord3) and Taraschina (Tara1120 and Tara1134).
Raportul dintre valvele de Unio (*U. tumidus*, *U. pictorum* și *U. crassus*) și *Anodonta* (% din numărul de resturi) comparativ între eșantioanele actuale din Dunăre (River1, River2, Tributary1 și Lake) și cele arheologice de la Hârșova *tell* (Hva1 și Hva5), Bordușani *Popină* (Bord1 și Bord3) și Taraschina (Tara1120 și Tara1134).

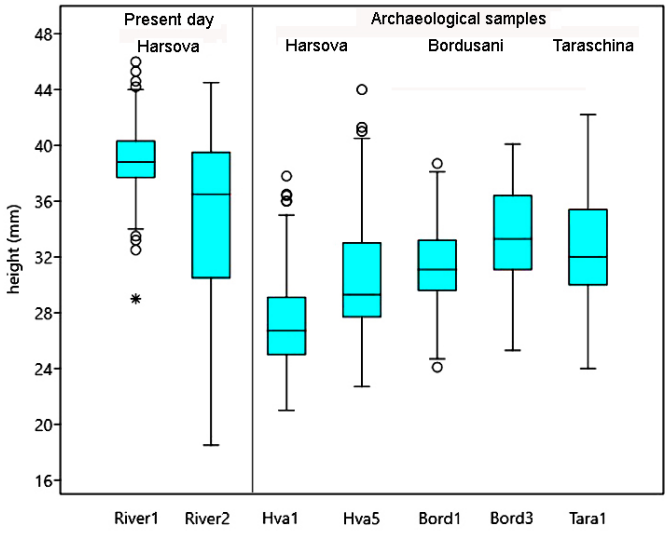

Fig. 5. Comparison between the height of the *Unio tumidus* valves from the present day samples (River1, N = 264 and River2, N = 152) and the archaeological samples from Hârșova *tell* (Hva1, N = 210 and Hva5, N = 219), Bordușani *Popină* (Bord1, N = 60 and Bord3, N = 84) and Taraschina (Tara1, N = 51).
Comparație între înălțimea valvelor de *Unio tumidus* din eșantioane actuale (River1, N = 264 și River2, N = 152) și cele arheologice de la Hârșova *tell* (Hva1, N = 210 și Hva5, N = 219), Bordușani *Popină* (Bord1, N = 60 și Bord3, N = 84) și Taraschina (Tara1, N = 51).

Regarding the *Unio crassus* bivalve we observe that in Boian level and in early Gumelnița level the frequencies of this mollusc reaches up to 7% of all the molluscs, while in Gumelnița the frequencies decrease towards 4% (fig. 3). This species prefers well-oxygenated rivers (Stoeckl, Geist 2016) and in its development cycle has a short-term larval stage (glochidium) that develops as an obligate parasite stage on specific fish (Douda *et alii* 2012; Taeubert *et alii* 2012a; 2012b; Schneider 2014).

4.2. Bordușani *Popină* tell settlement

As in the case of Hârșova, the taxonomic list (fig. 6) is dominated by the aquatic species (over 95%).

The most common are the *Unio* bivalves with 52-87% of all the mollusc shells remains, but here the first places are shared with *Anodonta* sp. whose frequencies are between 1-40%. The marine *Cardium* sp. shell is present here, too. And among the gastropods, excepting the *Viviparus* species which is present occasionally in water with low current, we found rheophilus water species like *Theodoxus* sp. and *Lithogliphus naticoides*.

The taxonomic spectrum from the Gumelnița level is similar to the one from Hârșova from the same cultural level. We found the same rheophilus water species like *Unio crassus*, *Lithoglyphus naticoides* or *Theodoxus* sp.

The ratio of the *Unio*/*Anodonta* frequencies is variable, the data from *Anodonta* species ranging between 1 and 40% (fig. 4). Probably, these fluctuations occur because of the alternation of the harvesting places and suggests that in proximity, besides this tributary, there were also areas with lakes/ponds permanently supplied by the Danube River (Radu *et alii* 2016). Depending on the level fluctuations of the river, the bivalves were harvest either from the tributary arm (mainly *Unio* sp.) or from the lakes (mainly *Anodonta* sp.). The size of the *Unio* sp. individuals vary depending on the place of harvest, but in general, these are also smaller than the present day individuals (fig. 5) which confirms that here also, like at Hârșova, there were multiple places of harvest positioned near the site and they were intensively exploited.

Concerning the shell remains obtained from the S1E section which is a representative sample for all the occupational levels, like in Hârșova, we notice that the *Unio crassus* species is more frequent in early cultural levels of the settlement than in the later ones at the end of Gumelnița occupation.

			Gumelnița (4600-4000 BC)								sondage SIE	
			652 litres				181.6 litres					
		Taxa	NR	%NR	NR	%NR	NR	%NR	NR	%NR	NR	%NR
Bivalvia	fresh-wather	*Unio* sp.	193	40.55	11	0.38	1187	38.40	233	33.57	168	31.52
		Unio tumidus	38	7.98	789	26.97	390	12.62	230	33.14	126	23.64
		Unio pictorum	24	5.04	1375	46.99	48	1.55	97	13.98	150	28.14
		Unio crassus	3	0.63	131	4.48	2	0.06	46	6.63	54	10.13
		Anodonta sp.	189	39.71	55	1.88	807	26.11	70	10.09	11	2.06
		Pseudanodonta sp.			1	0.03			1	0.14		
		Dreissena polymorpha	21	4.41	42	1.44	424	13.72	7	1.01		
	marine/ brackish	*Cardium edule*			1	0.03						
Gasteropoda	aquatic	*Viviparus acerosus*	8	1.68	306	10.46	204	6.60	10	1.44	18	3.38
		Viviparus contectus			1	0.03						
		Valvata piscinalis			10	0.34						
		Lithoglyphus naticoides			33	1.13	2	0.06				
		Bithynia leachi			12	0.41						
		Esperiana esperi			10	0.34	24	0.78				
		Esperiana acicularis			6	0.21						
		Radix peregra			10	0.34						
		Planorbarius corneus			1	0.03						
		Theodoxus fluviatiluis					3	0.10				
	terrestrial	*Oxychilus inopinatus*			1	0.03						
		Euomphalia strigella			10	0.34						
		Lindholmiola corcryensis			10	0.34						
		Campilea balcanica			4	0.14						
		Cepaea vindobonensis			63	2.15					4	0.75
		Helix pomatia			44	1.50					2	0.38
		Mollusca	**476**	**100**	**2926**	**100**	**3091**	**100**	**694**	**100**	**533**	**100**

Fig. 6. Mollusc assemblages from Bordușani *Popină*, Gumelnița level (after Sárkány-Kiss, Boloş 1996b, Radu 2011 and unpublished data) and from section S1E (all the occupational levels).
Eșantioane de moluște de la Bordușani *Popină*, nivelul Gumelnița (după Sárkány-Kiss, Boloș 1996b, Radu 2011 și date nepublicate) și din secțiunea S1E (toate nivelurile ocupaționale).

4.3. Taraschina settlement

Bivalve and gastropod shells were identified (fig. 7). The aquatic species are dominant, but there are also remains of individuals from terrestrial species (up to 13%).

Both freshwater species like *Unio* and *Anodonta* and marine/brackish species like *Cardium* or *Hypanis* are found among the bivalve.

The freshwater component of the bivalve is dominated by the *Unio* species (71-84%). These are accumulations resulted from the harvesting and the consumption of the bivalves by prehistoric people.

Among the marine species some bivalves are perforated and they were mainly used for making ornaments.

The aquatic and the terrestrial gastropods are dispersed in all levels, at all depths. Their shells are usually complete with minor injuries due to post-depositional interventions.

All *Unio* shells are found generally in the archaeological complexes. *Unio tumidus* and *U. pictorum*, as well as the *Anodonta* sp. *Dreisssena* sp. and *Viviparus* sp. species, prefer the tributaries arms and the lakes permanently connected and supplied by the Danube River. On the other hand, *Unio crassus* bivalve and the gastropod *Theodoxus* sp. can only be found on the tributary arms with high water flow and in the Danube River.

			Gumelnița (4500-4300 BC)			
			zone 1		**zone 2**	
		Taxa	**NR**	**% NR**	**NR**	**%NR**
Bivalvia	freshwater	*Unio* sp.	3468	71.39	3173	57.42
		Unio tumidus	356	7.33	567	10.26
		Unio pictorum	100	2.06	202	3.66
		Unio crassus	5	0.10	1	0.02
		Anodonta cygnaea	144	2.96	112	2.03
		Dreissena sp.	17	0.35	18	0.33
	marines/ brackish	*Cardium* sp. / *Hypanis* sp.	10	0.21	8	0.14
Gasteropoda	aquatic	*Viviparus* sp.	465	9.57	708	12.81
		Planorbarius sp.	30	0.62	28	0.51
		Planorbis sp.	4	0.08	3	0.05
		Theodoxus sp.	1	0.02	5	0.09
	terrestrials	*Cepaea* sp.	256	5.27	688	12.45
		Helix sp.	2	0.04	13	0.24
		Mollusca	**4858**	**100**	**5526**	**100**

Fig. 7. Mollusc assemblages (Gumelnița level) from Taraschina (Bălășescu, Radu 2011; 2022). Eșantioane de moluște (nivel Gumelnița) de la Taraschina (Bălășescu, Radu 2011; 2022).

Concerning the *Unio*/*Anodonta* ratio the frequencies of remains recorded in various archaeological complexes from Taraschina were compared with the present day data recorded at Hârșova from various characteristic areas of the Danube Valley (main river, tributary arm, lake) (fig. 4). We observe that, also, for this type of analysis, the resulted values are close to the ones recorded for the main tributary arm or the Danube.

The average shell height measured in our case for *Unio pictorum* and *Unio tumidus* individuals was smaller in Taraschina than the average shell height of the individuals from the present day sample from Hârșova which have not been subjected to stress due to repeated harvest (fig. 5).

The effects of an intensive harvesting could have been registered only on the samples collected from the immediate vicinity of the site where the access was easy and repeated.

All this data provided by the molluscs analysis place the Taraschina settlement on the banks of a main tributary branch of the Danube with a high water flow rate, and nearby some areas with lakes, situation which is completely different from the present day (in the middle of the Danube Delta and surrounded by ponds and lakes connected by channels).

◈ 5. Discussions

5.1. Voluntary, accidentally or intrusive?

Even if it is fragile, the shell of the molluscs is preserved in archaeological sediments (especially with basic and neutral pH values) for longer periods of time. During the diagenesis process (Schöll-Barna *et alii* 2012; Prendergast, Stevens 2013) the recrystallization of the shell takes place (alteration of aragonite to calcite) and the shell fossilize in time (Debruyne 2014). The shells from the Neolithic sites it's not that old so that we can differentiate them based on the state of fossilization (Barbin 2000). Sometimes, like in our study, it's difficult to make the difference between the archaeological and the intrusive shells (after the state of preservation). We propose further some characteristics that can be followed during this type of analysis.

The type of the site and its location. For the tell settlements, the accumulation of a few meters of anthropic sediments as a result of successive occupations reduces the accumulation of intrusive material from the overlying layers. At Hârșova, the tell settlement area was inhabited in the course of millennia until nowadays, and the post-depositional interventions are minimal (excepting the large-scale anthropogenic ones). Mainly we refer to the tree roots and the galleries dug by animals (rodents, badgers, foxes, etc.) that can mix the materials accumulated in various archaeological levels or can bring voluntarily (storage, prey) or involuntarily (flooding/clogging galleries) other materials from the environment (bioturbation). However, the short accumulation time of anthropogenic deposits (Haită, Radu 2003) as well as their thickness (0.5-1 m) reduced the intervention of burrowing animals and the contamination of archaeological layers, especially after the first 3 meters of deposits.

Furthermore, in Bordușani, due to its location in the floodplain, many animals found shelter digging galleries especially in the marginal area of the tell settlement. Here, the degree of the post-depositional processes is important and difficult to approximate. Only a careful and fine digging can distinguish these interventions and thus can exclude from the analysis the material that can contaminate the studied samples.

At Taraschina, the site being temporarily underwater, both the aquatic plants like reed with rhizome deeply rooted in the sediment and burrowing animals (rodents) modified profoundly the surface of the site (Carozza *et alii* 2011a), and the shells of the aquatic and terrestrial molluscs were integrated frequently in the archaeological levels. An analysis of mollusc shells considered intrusive shows a decrease in the frequency of these remains with depth (Bălășescu, Radu 2022, p. 347) In this case, except the species consumed frequently (bivalves) an analysis of mollusc remains sampled from the site area must be realized with precaution.

The ecology of the identified taxa is closely related to the location of the site especially for the prehistoric settlements.

The high frequencies of terrestrial species places the site in an area with few watercourses, while the high frequencies of freshwater species or marine species places the site in fluvial or littoral areas. In general the molluscs that can be imported trough trade or through access to ancient sedimentary deposits are poorly represented.

The preservation state of the materials. The inspection of the external surface of the archaeological materials, especially the Neolithic ones, show a different wear from the current ones, frequently the loss of the natural colours and sometimes even a fine carbonate crust or deposits agglutinated by various sediments.

Anthropic interventions. The macroscopic and microscopic inspection of the molluscs shell can reveal the existence of some interventions: traces of hitting/ scratches/ burns for the

meat consumption, traces of processing for the production of tools and beads, traces specific to the thanatocenosis assemblages etc.

The anthropogenic deposits that formed in Hârșova and Bordușani sites were not flooded and majority of the aquatic molluscs present here in large quantities were impossible to be accumulate naturally and therefore the studied material being representative for each of the analysed levels. However, in Taraschina, the quantitative analyses were oriented mainly towards the bivalves, the only ones that couldn't be accumulate naturally in great quantities in the various archaeological structures. The qualitative analyses were just a support in interpreting the data.

Once established the anthropogenic origin, the question about the voluntary or accidentally transportation of the molluscs to the site still remains. The dimensions of the shell can be an argument in this analysis if we take into considerations the nutritional value of the animal. The *Unio* and *Anodonta* large bivalves as well as the gastropods *Viviparus*, were collected principally for food purposes. But not always their shells are food waste. At Hârșova, the areas between houses were paved with *Viviparus* shells collected from thanatocoenosis, the existence of juvenile shells inside the adult shells confirming this (Radu 2011, p. 99). Instead, the small molluscs such as *Lithogliphus*, *Bithinia*, *Theodoxus* could have been collected for manufacturing beads (Mărgărit, Radu 2014; Mărgărit 2016). But most often their number is small due to the fact that they can be transported involuntarily with other materials like alluvial sediments (*Lithogliphus* sp.), rocks (*Theodoxus* sp.), aquatic vegetation (*Dreissena* sp.) and attached to larger shells (*Dreissena* sp.) or even from the fish that consumes molluscs (catfish, sturgeon and gobies) after evisceration.

5.2. Reconstruction of the environment

Malacological studies realized on the archaeological remains contribute together with other disciplines like the geology, sedimentology, palynology, carpology, anthracology and archaeozoology etc. to the reconstruction of the environment around the prehistoric settlements. Concerning this study our purpose was to reconstruct an image of the environment and its evolution around settlements from Hârșova, Bordușani and Taraschina using especially the data provided by the aquatic molluscs found in the archaeological layers. This is why many of these proposed scenarios are open to broad speculation until they are confirmed or not by the results of the future researches.

The mollusc assemblages from the three sites consist mainly of remains resulting from various human activities (food, construction, tools manufactory etc.). But, over time, contamination with terrestrial (*e.g.*, Bordușani and Taraschina) and aquatic shells (*e.g.*, Taraschina) is inevitable due to post-depositional factors. The faunal material from Hârșova (Gumelnița level) is the least affected to this process, and we consider that the data obtained from here representing a referential set for the study of molluscs.

The analysis of the three parameters considered by us as the most important ones to characterize the environment around the sites provided interesting observations.

Identified species and their frequencies represents a parameter that is affected by the volunteer harvesting, and dominated especially by the species destined for consumption (*Unio* and *Anodonta*). Other species found in the same environment as those for consumption were brought to the site involuntarily such us: the epilithes attached to stones (*Theodoxus*, *Dreissena*), from alluvial deposits (*Liyhogliphus*, *Bithynia*, *Esperiana*) or attached on various plants (reed, cattail, etc.) that live in the aquatic ecosystems (*Planorbis*, *Planorbarius*, *Lymnaea*). These species,

with a few variations, are found both in Hârșova and Borduşani, and some of them in Taraschina as well.

We would like to emphasize in all three sites the presence of the species that prefer well-oxygenated and high speed waters and hard substrate like the *Unio crassus* bivalves and *Theodoxus* and *Lithoglyphus* gastropods. They are together with species that prefer slow-moving waters and lakes permanently supplied (*Unio tumidus*, *Unio pictorum*, *Anodonta* sp., *Viviparus* sp. or *Dreissena* sp.) but can also be found on rivers when the ecological conditions are favourable. Stagnant water species or species that love the aquatic vegetation are also encountered in Hârșova and Bordușani which suggests that people have frequented particular areas like shallow water or ponds and involuntarily brought these species together with other materials.

The ratio between *Unio* and *Anodonta* provides us information about harvesting areas. The three species of *Unio* and the species of *Anodonta* have specific ecological requirements, such as the nature of the substrate or water turbidity and velocity, the oxygen concentration of the water etc. and they are encountered only in specific aquatic environments. Usually, in the *Unio* populations all three species can be found, the dominant species varying depending on the water basin (Grossu 1962, p. 151). The experimental studies conducted in area of the Hârșova site provided the necessary data to know the ratio between the different species of *Unio* and *Anodonta* encountered in the river, in the tributary arm or in the lakes permanently supplied by river (Radu 2011). Comparisons between archaeological and present-day datasets can indicate with some precision the places where the bivalves used for food are collected. The volunteer selection of a certain species based on qualitative or quantitative aspects can be an important factor that would change these values. According to Gulyas *et alii* (2007, p. 411), the harvesting place could have been specifically chosen at least from qualitative reason (*Unio crassus* tastier than *Unio pictorum*). For the three sites studied here it's difficult to highlight the effect of selection on a particular species. Small samples are difficult to identify *in situ* from an archaeological point of view (also it may contain shells harvested in different days), and the presence of large samples (Radu *et alii* 2016) make it difficult to capture the effects of selection (in case it existed). We assume that for the studied assemblages the comparison with the present day data largely reflects the ratio in which these species (*Unio* and *Anodonta*) were found in the harvesting places. The variety and the large number of the analysed samples and most importantly the constant results of the obtained data for each site can be strong arguments for the validation of the present day analyses regarding the frequencies of the *Unio* and *Anodonta* species or their dimensions even if this database (present day bivalves) needs to be supplemented with new sites on the Danube.

The only selection recorded was the one regarding the **dimensions of the *Unio* bivalve shells.** The quantitative preferences are revealed by the effect of overharvesting (size reduction) noticed in all three sites (fig. 5). This phenomenon wouldn't have been produced if certain factors would not emerge at the same time:

- the interest of the prehistoric people in *Unio* bivalve consumption;
- the presence of harvesting places near the sites;
- a low level of the river which determine the concentration of the bivalve individuals.

The ecological data of bivalves place the harvest activity throughout the entire summer season, but its intensity varies depending on the river level fluctuations, the accessibility to these resources or the overexploitation due to intense harvesting. Furthermore, at Hârșova and Bordușani the shell harvesting was integrated into an economic strategy developed for each season involving all animal food resources (Radu *et alii* 2016; Brehard *et alii* 2014;

Balasse *et alii* 2016), but probably also the vegetal ones like in Gumelnița tell settlement (García-Vázquez *et alii* 2023).

◈ 6. Conclusions

The data provided by the molluscs sampled from the three sites allow some particular observations regarding the environment.

At Hârșova, the environmental changes during this period are not significant if we consider the data provided by mollusc species. The only important observation is related to a decreased frequency of the *Unio crassus* bivalve, also observed at Bordușani, during the transition from Boian to Gumelnița culture about 4500 BC. Capturing these fluctuations in both sites confirms that maybe their nature might be rather ecological than anthropic (related to food preferences). Most probably this is a response to a constant change of the general hydrological regime parameters in the Danube floodplain, such as reduced water flow rate, decreasing areas with tributary arms and increasing areas with ponds and lakes like in the area surrounding the Eneolithic settlement Pietrele (Benecke *et alii* 2013), due to an increased sedimentation rate etc. Most probable these changes took place before this period (4500 BC) and continued gradually until today with different intensities. For *Unio crassus*, the changes affected not only the ecological parameters (the substrate, water velocity, the oxygenation degree of the water etc.) but also the scarcity or the disappearance of rheophilic water fish species from this area of the Danube which usually are the main hosts in the development cycle of the bivalve. The irreversible changes in the floodplain area (Balta Ialomiței) have led gradually to the decrease in the number of individuals. Today *Unio crassus* are rare in the lower Danube region and even absent in Danube Delta (Sárkány-Kiss 1996; Cioboiu 2006).

The information provided by molluscs from the Bordușani *Popină* indicate that the landscape around the site was different in prehistoric times. An important tributary arm but also areas with lakes permanently supplied must have been at short distance from tell settlement. The fluctuating values of the ratio of *Unio* and *Anodonta* species suggests this configuration during Gumelnița period. Over the millennia, the site would remain within the influence of a major tributary arm and will be periodically affected by floods during the times with high levels of water. The Eneolithic habitation was founded on a remnant loess deposit part of the Pleistocene loess platform (as well as the Taraschina site) eroded over time by the river and its tributaries (Haită 2012). According to sedimentological coring realized near Stelnica village (10 km downstream from Bordușani) the loess platform must have been most advanced into the floodplain in this area (Apostol 1974). A similar landscape to the one from the Eneolithic times where loess remnant persist can be found today towards north, at Popina Blagodeasca, also a site inhabited in the Neolithic period and located in the area where the Ialomița River flows in the Danube (Sîrbu, Corbu 2006; Corbu 2013).

Until the end of the Getic period all this data does not support important modifications. Therefore, we can conclude that no major changes of the environment that could have affected the human habitation in Bordușani *Popină* can occur by the end of the 1st century AD. However, several sites from the west and south of the Balta Ialomiței floodplain, some of them inhabited since the Neolithic period (5th millennium BC), cease to exist even during the Getic period. First, the southern settlements like Coslogeni *Măgura lui Negoiță* (5th-4th century BC), in the centre-west the site from Stelnica *Grădiștea Mare* (4th-3rd century BC) and the last in the north-west Bordușani *Popină* (1st century AD) (Sîrbu 1999; Conovici, Matei 1999; Trohani 2005; 2006). These events, with the exception of those of an anthropic nature (social, political etc.) evolve

temporally in the direction of the river flow and we believe that they are most likely correlated with the formation and evolution of a new Danube arm called *Borcea* today. This tributary arm becomes an important watercourse on the left side of the Danube Valley, establishing its trajectory towards the west most point of the Danube valley cutting this loess remnant and isolating the settlement, circumstances that led sooner or later to the disappearance of the habitation from Bordușani *Popină*. Although this evolution can be accepted for now only as hypothetical because new data is required to be correlate especially with the level fluctuations of the Black Sea and the evolution of the Danube Delta from the 7th century BC (Vespremeanu-Stroe *et alii* 2013; Bony *et alii* 2015), we believe that this data can be considered important benchmark in the formation and evolution of the *Borcea* arm for the area where the Bordușani *Popină* settlement is situated.

The data from molluscs obtained at Taraschina places this settlement near an important tributary arm of the Danube River and close to a lake or lagoon already mentioned by previous studies or ancient maps (Mihăilescu 1989; Filip, Giosan 2014; Carozza *et alii* 2012a). The dominance of the *Unio* species, but also the presence of the marine/brackish shells like *Cardium* and *Hypanis* suggests this location. The high percentage of fish, such as pikeperch which is very common in lagoon areas support also this affirmation (Bălășescu, Radu 2011). The dominance of ruminant mammals from Taraschina, animals that would have need forage all year, places the settlement near or connect to a higher terrain with surfaces for grazing. The sedimentology data conducted in the area confirm that the site is founded on a remnant loess deposit part of the larger plateau located to the north (Pardina lowland) (Carozza *et alii* 2012b; 2013).

All these environmental changes and evolutions are multiples cause such as geological, climate changes or the evolution of the Black Sea level (Panin 2004; Giosan *et alii* 2006; Lericolais *et alii* 2009; Carozza *et alii* 2011c; Weninger and Harper 2015) and the malacological analyses can provide also useful information to study and understanding them.

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