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High Resolution Stratigraphic Distribution of Coprolites within Eneolithic Middens, a Case Study: Hârsova-Tell (Constanta County, Southeast Romania)

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Abstract

Quantitative distribution of coprolites, fish bones and mammal bones recovered by wet screening from an Eneolithic midden at Hârsova-tell (southeast Romania) is surveyed within a high resolution stratigraphic framework. The coprolites, all containing bone fragments, are attributed to carnivores/omnivores: dog, pig, man. Highly significant correlation (Spearman's coefficient of rank correlation $r_s = 0.46$, $p < 0.0001$) between coprolite distribution and the seasonality-related fish bone distribution suggests that seasonality controls the stratigraphic distribution of coprolites recovered by wet screening within middens. Periods of high fish bone input into the midden, correlated with frequent coprolite occurrences, correspond to the warm season (late spring to early autumn). Assessment of potential factors controlling coprolite distribution within the midden suggests that sections of high coprolite concentration reflect preservation of faeces until embedding in sediments, and/or rapid embedding of faeces. Preservation of faeces is favored by dry periods, characteristic of the summer season in the highly continental climate of the region. Rain, freeze-thaw cycles or other wet season processes favor faeces disintegration. Our results suggest that the stratigraphic distribution of coprolites obtained by wet screening may represent an indicator of seasonality in middens. Additional studies are needed to better characterise this relationship and refine interpretations.

Keywords: Coprolites, Eneolithic, Fish bones, Midden, Romania, Seasonality

Introduction

Midden deposits are known in Romania from a few Eneolithic (Chalcolithic) and Bronze Age sites in the southeastern part of the country. Their number is increasing as they are identified as such at more archeological sites. One of the sites where middens are known and studied is Hârsova-tell (Constanta County, 44°41' N / 27°58' E), an important proto-urban, tell-type settlement on the right bank of the Danube (Fig. 1). The settlement comprises principally Neolithic (Boian culture, ca. 5350–4600 BC) and Eneolithic (Gumelnita culture, ca. 4600–4000 BC) layers, but also includes a thin Cernavoda I component (fourth millennium BC). Excavations undertaken at Hârsova in the last decade have provided the deepest insight into the life, economy and dynamics of the Gumelnita populations to date. Several middens have already been excavated in the Gumelnita layers at Hârsova. Shells and fish bones are present in large amounts in most of them, together with mammal bones, ash, charcoal, fragments of building material and a fair amount of coprolites. Following an idea of D. Popovici (National History Museum of Romania), one of these

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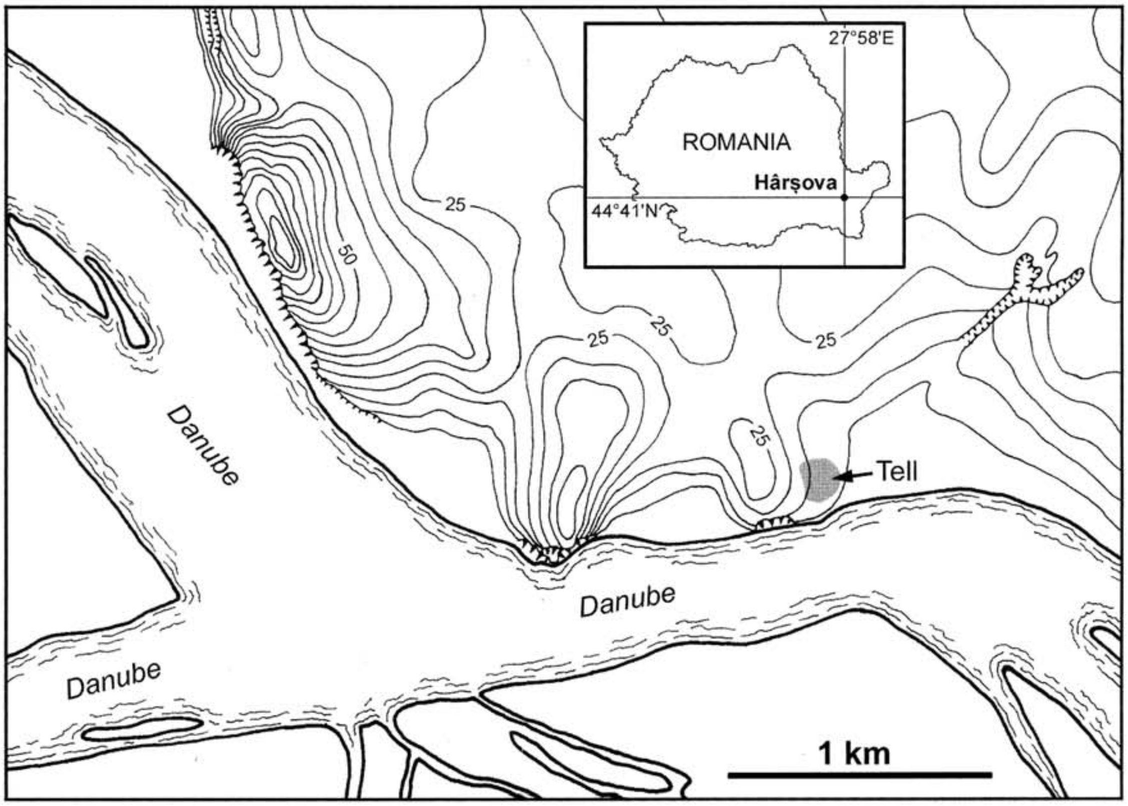

Figure 1. Location map of Hârsova-tell.

midden deposits, designated as complex C521, was excavated with the declared aim of looking for seasonality indices.

Assessing the seasonality of the layers that form middens is important for a better understanding of the economy and dynamics of prehistoric communities and settlements. Furthermore, as pointed out by Popovici *et al.* (2000), assessing seasonality in middens provides information about the cyclicity and temporal aspects of different human activities related to the accumulation of these deposits. This helps in assigning a temporal extent to midden complexes, which, in turn, provides a reference for assessing the temporal extent of other stratigraphically related structures and complexes. At the larger scale of the site, this leads to a better understanding of the dynamics of space utilisation within the prehistoric settlement and may be of great help in reconstructing the detailed chronology of the settlement.

Midden deposits often include indicators of seasonality. Most common among these are shells and fish vertebrae, both of which bear a seasonal signal due to their discrete growth in annual increments. The study of growth rings in common carp (*Cyprinus carpio carpio* L.) and zander (*Stizostedion lucioperca* (L.)) vertebrae from the midden complex C521 (Radu 2000) provides strong evidence for seasonality. This evidence is in good accord with the seasonality of fishing and fish-preparation activities as reflected by the stratigraphic distribution of fish bones within the complex. Based on this evidence and on the interpretation of archeological information from the midden layers it has been inferred (Radu 2000; Popovici *et al.* 2000) that the midden complex formed in a period of 12–18 months.

The stratigraphic distribution of coprolites within Eneolithic middens has not been addressed by any study to date. This paper analyses the stratigraphic distribution of coprolites within the midden complex C521 that has been excavated at Hârsova-tell. The goal of the study is to identify patterns in this distribution and potential relationships of these patterns with the distribution of other types of material within the midden. The stratigraphic distribution of coprolites is compared to that of fish and mammal bones. Also, the distribution of coprolites is correlated with the data on seasonality provided by the study of fish bones with the aim of obtaining a better understanding of the factors that control it.

Material and Methods

Coprolites

The coprolites present in the archeological layers at Hârsova-tell fall within two main categories. One of these includes cohesive coprolites almost always containing bones (mainly fish bones) fragmented to various degrees, included in a yellowish to brown matrix (Fig. 2). Although they are most usually fragmented, these coprolites sometimes preserve their original shape (Fig. 3). The recognition of fragments as coprolite fragments is based on the close similarity of their texture, color and content with those of complete coprolites. Based on the bone content, coprolites in this category are attributed to carnivores or omnivores.

The second category is comprised of low cohesion, yellowish to reddish-brown coprolites of sandy to dusty texture. These coprolites are found as thin patch-forming crusts that sometimes form groupings at certain places and stratigraphic levels of the site. Their shape, suggestive of a softer consistency at origin, and the absence of bone fragments suggest that they were produced principally by herbivores or omnivores.

The method used for recovering the materials of different types from the midden deposits (i.e. wet screening) eliminates the low cohesive coprolites of the second category, where present, and preserves only the cohesive ones, the coprolites containing bone fragments. Therefore, it should be emphasised that only these coprolites, attributed to the broad group of carnivores/omnivores, are taken into account by our analysis. Hence, a null value of the coprolite content does not necessarily imply absolute absence of the coprolites from a particular stratigraphic unit. Herbivore coprolites and even lower cohesive carnivore/omnivore coprolites, if present, were dispersed and washed away during wet screening, and thereby could not be taken into account.

Establishment of a sedimentary and stratigraphic framework

The establishment of a stratigraphic framework appropriate to the type of sedimentation characteristic of midden deposits, and which would provide high stratigraphic resolution was crucial for the subsequent processing and interpretation of the data. At Hârsova-tell, the midden deposits form lenses of varying size and thickness. They usually occupy hollow areas of the synchronic stratigraphic surfaces and are made of domestic refuse: ash and charcoal, building material (daub), potsherds, bones, shells and lithic fragments. The stratigraphy of the middens is constituted by numerous (up to several hundred) fine, generally lenticular, partially overlapping layers of anthropogenic origin. Each discrete layer represents one sedimentation event, that is, one load of domestic refuse disposed of at one point in time.

A thick, large-sized midden designated as complex 521 (C521) was excavated in the Eneolithic Gumelnita layers with the aim of looking for

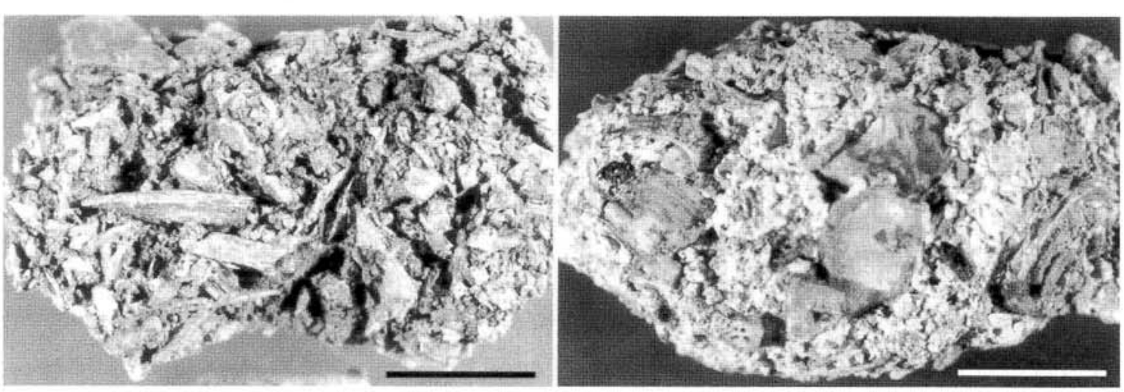

Figure 2. Coprolites showing bone content (midden complex C521, Hârsova-tell, southeast Romania); bars = 1 cm.

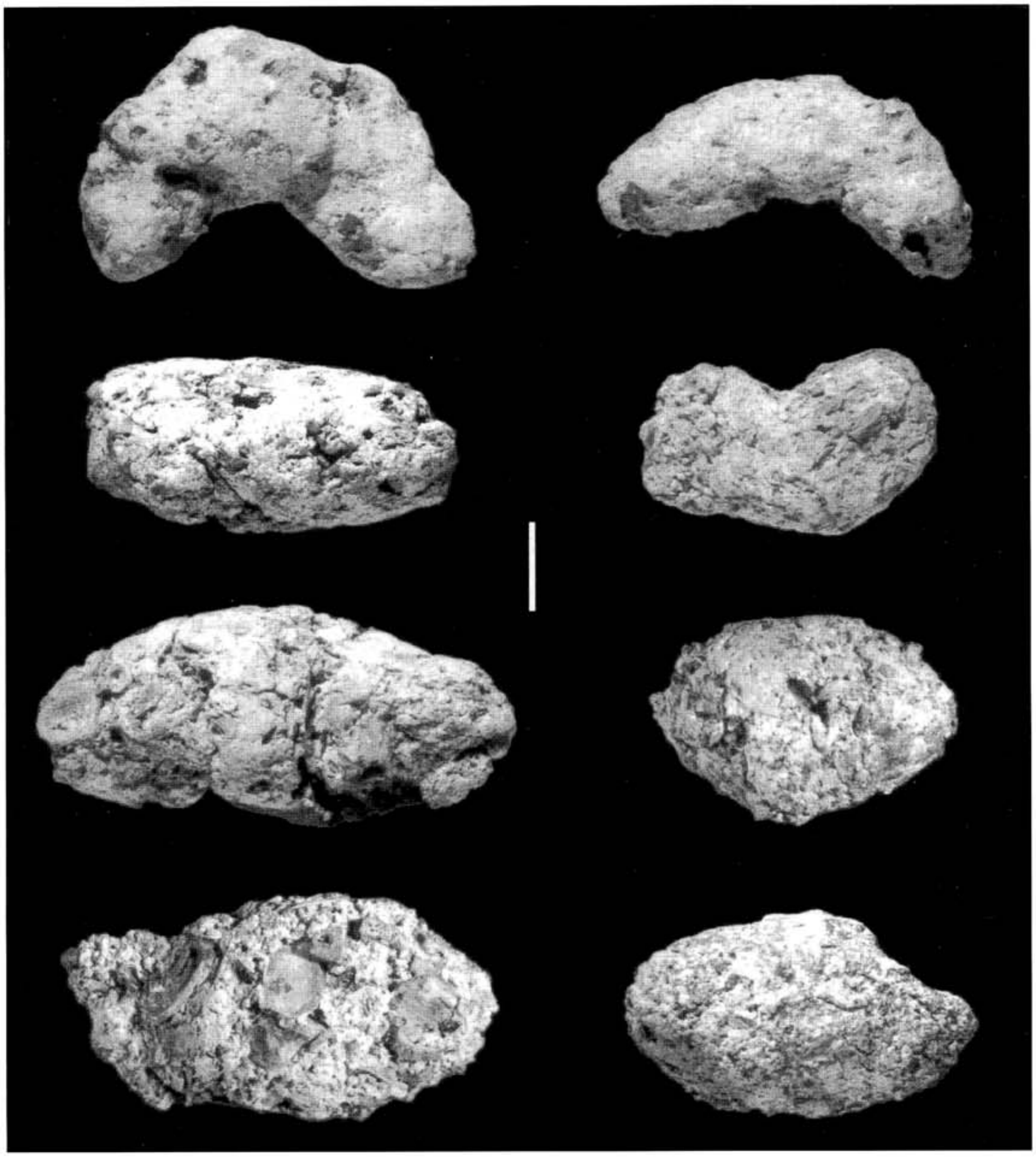

Figure 3. Coprolites recovered by wet screening from the midden complex C521 (Hârsova-tell, southeast Romania); bar = 1 cm.

seasonality indices. The midden was underlain directly by the remains of a large clay dwelling that had been abandoned by its inhabitants and left to crumble. Stratigraphic relationships between the different layers of the midden complex prove that crumbling of the dwelling and midden formation were synchronous, resulting in heaps of building material from the walls occasionally interspersed between midden layers. Midden complexes deposited in the crumbling remains of abandoned dwellings have been observed by the authors in several instances at Hârsova and in other archaeological excavations of the Neolithic and Eneolithic of southeast Romania. The practice of discarding domestic refuse within the ruins of abandoned dwellings is commonplace even today. Brochier

(1994) reports it from the modern village of Kovacevo in Bulgaria, and it also was observed in the modern town of Hârsova.

The midden complex C521 covered an estimated area of over 52 m^2 and its maximum thickness reached 0.6 m. An area encompassing almost half of the spatial extent of the midden (24.7 m^2) was subjected to a careful and detailed stratigraphic excavation (Fig. 4). The individual lenticular layers that made up the midden (Fig. 5), termed stratigraphic units (SU) and distinguished based on their particular structure, texture and content, were removed in inverse order of their deposition. Upon excavation, each SU received a number and its stratigraphic relationships with adjacent underlying and overlying stratigraphic units were recorded. This could not have been done if the stratigraphy of the settlement had not been preserved so well, down to the features of the finest stratigraphic unit. More than 650 SU were thus identified, excavated and recorded. Their individual volumes varied between less than 0.001 m^3 and more than 0.3 m^3, yielding a total excavated volume of about 6.7 m^3.

Over 500 of the stratigraphic units were grouped in larger units termed stratigraphic sequences (SS). The grouping was done based on both the stratigraphic relationships of the units and the type of material that dominated their content: ash, charcoal, daub, burnt daub and organic remains other than

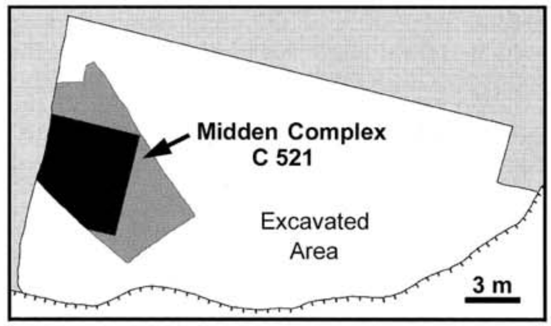

Figure 4. Location of the midden complex C 521 within the excavated surface; the black area represents the sector subjected to detailed stratigraphic excavation.

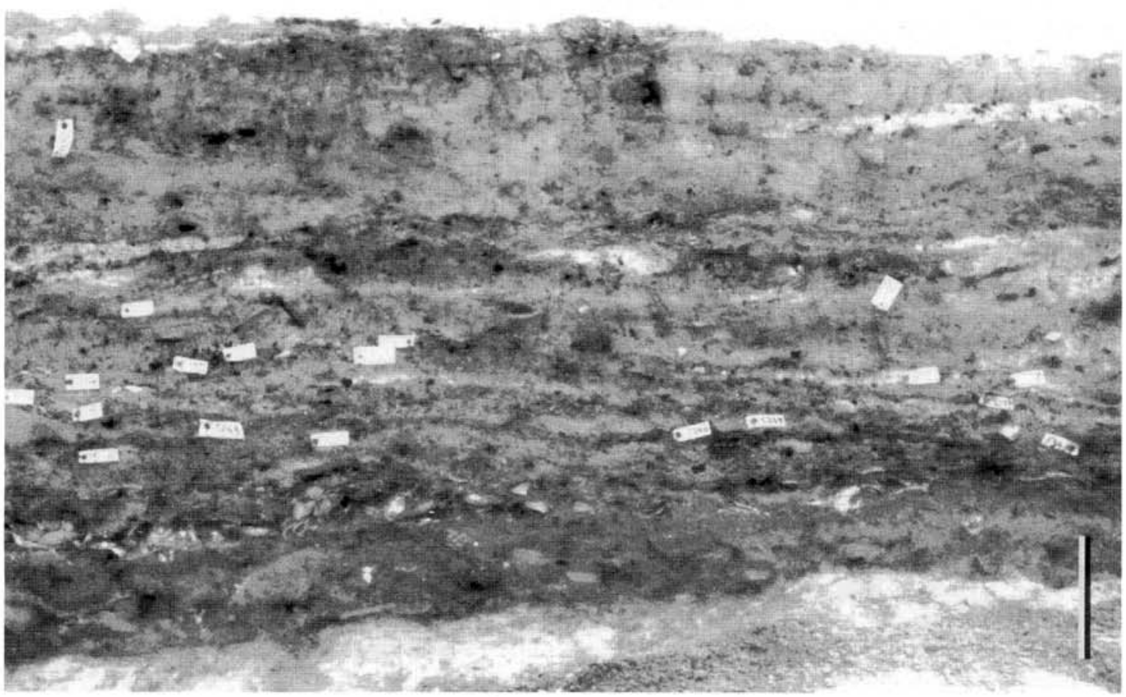

Figure 5. Vertical section through the stratigraphy of C 521 showing the succession of thin-lenticular, partially overlapping stratigraphic units; bar = 10 cm.

ash and charcoal (Popovici *et al.* 2000). Stratigraphic units excluded from the grouping were those at the periphery of the midden complex, where the thickness of the complex tapered to zero and the stratigraphic relationships were less certain. The grouping resulted in a stratigraphic succession of 118 SS. The main benefit of the grouping in stratigraphic sequences was to provide a unique and simple stratigraphic framework that insured high stratigraphic resolution, at the same time reflecting accurately the stratigraphic relationships within the complex. This framework allowed for a straightforward representation and correlation of the information concerning the stratigraphic distribution of the different types of material recovered from the midden C521.

Sampling and analysis

Upon excavation, the volume of disaggregated, loose sediment in each stratigraphic unit was measured using a graded container, following which the sediment of each SU underwent wet screening (4 mm mesh sieve). The material retained by the sieve was sorted by hand into several categories – charred remains, shells, fish bones, mammal bones, potsherds, lithic fragments and coprolites. The coprolites, fish bones and mammal bones in each SU were weighed and the weights were summed up by SS, to reflect the stratigraphic distribution of the three types of remains within the succession of stratigraphic sequences of the midden. For simplicity reasons, only those SS bearing at least one of the three types of remains dealt with in this study (coprolites, fish bones and mammal bones) are taken into account here. This results in a stratigraphic succession of 88 SS numbered according to their order of deposition (1 being the oldest and 88 the most recent). To normalise the data, the weight of each type of remains in a SS was divided by the volume of the SS. The resulting values represent the variation of the concentration of each of the three types of remains along the stratigraphy of the midden complex.

The relationships between the distributions of the three types of remains were characterised by calculation of correlation coefficients for each of the three possible pairs of remains: fish bones – coprolites, mammal bones – coprolites and fish bones – mammal bones. The non-parametric structure of the data for each type of remains imposed the use of Spearman's coefficient of rank correlation (r_s), a non-parametric correlation coefficient. This coefficient gives a measure of the correlation between the order of the ranks in the two variables after conversion of the continuous data to ranks for each of the variables. When several of the ranked data points are of equal value for one variable, the arithmetic mean of their ranks is calculated and assigned to all the equal valued points. Values of r_s and their corresponding p-values were calculated using NCSS© software.

Results

The stratigraphic sequences included in the study (4832.1 dm^3 of sediment) incorporate a total of 3.370 kg of coprolites, 21.542 kg of fish bones and 11.574 kg of mammal bones, distributed as shown in Table 1 and Figs. 6–8. Comprehensive faunal lists for fish and mammal species identified on bones recovered from the midden C521 are presented in Table 3.

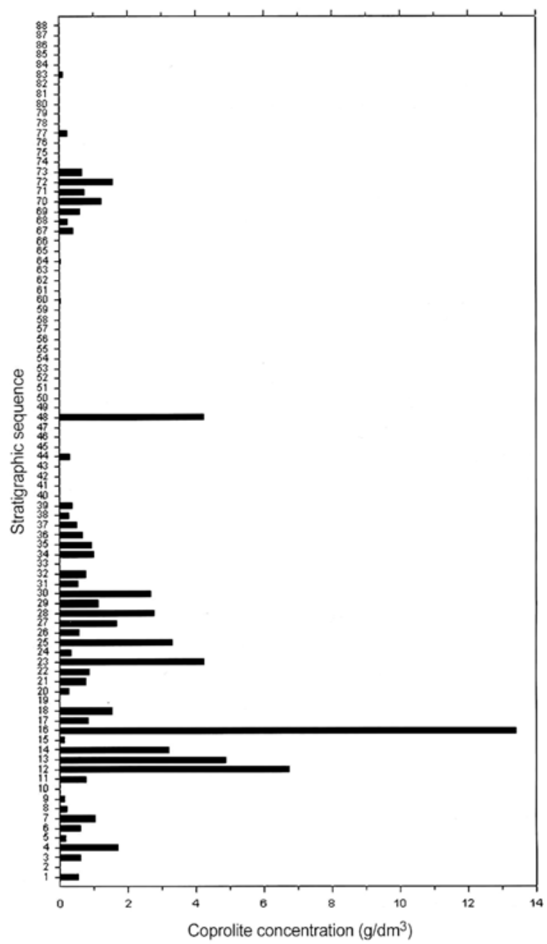

Figure 6. Quantitative stratigraphic distribution of coprolites within the midden complex C521 at Hârsova-tell (southeast Romania).

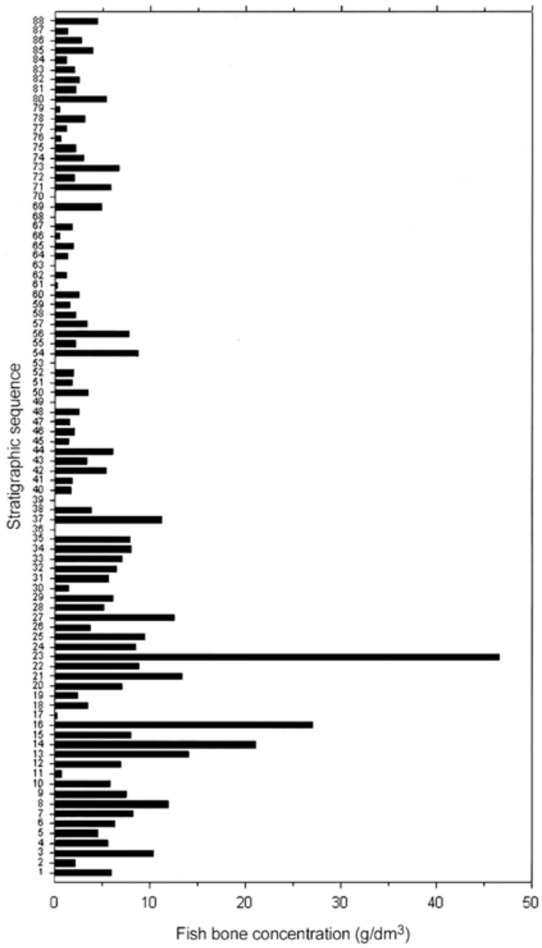

Figure 7. Quantitative stratigraphic distribution of fish bones within the midden complex C521 at Hârsova-tell (southeast Romania).

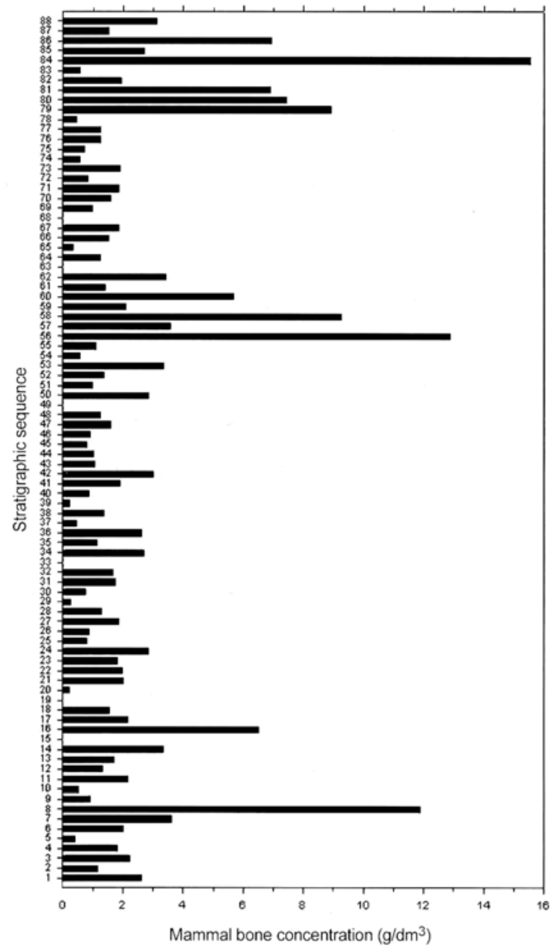

Figure 8. Quantitative stratigraphic distribution of mammal bones within the midden complex C521 at Hârsova-tell (southeast Romania).

The quantitative stratigraphic distribution of coprolites in the midden complex C521 (Table 1 and Fig. 6) comprises two main sections. The lower one (SS 1 to 39) is characterised by the presence of coprolites in all but four of the sequences. Except for SS 48, all of the sequences containing coprolites in excess of 2 g/dm^3 sediment are found in the lower section. The upper section (SS 40 to 88) includes the majority of stratigraphic sequences that lack coprolites. However, eleven of the sequences in the upper section contain coprolites (sometimes exceeding 1 and even 4 g coprolite/dm^3 sediment). Four of them seem randomly dispersed within this section, whereas the other seven form a consistent grouping (SS 67 to 73).

Fish bones occur in 81 of the 88 stratigraphic sequences. Their distribution (Table 1 and Fig. 7) shows a considerable amount of variation, characterised by rapid rises and falls in concentration. The only trend that stands out in this distribution is the apparent grouping of most of the fish bone-rich sequences in the lower section of the complex (SS 1 to 37).

The stratigraphic distribution of mammal bones (Table 1 and Fig. 8) also shows a lot of rapid variations. Only six stratigraphic sequences lack this type of remains. The distribution pattern of mammal bones seems to be more complex, with two peaks in the lower section of the complex and at least two others in the upper section. Concerning the mammal bones, it should be noted that the distribution of their concentrations within the

Stratigraphic sequence	Volume (dm3)	Coprolites (g/dm3)	Fish bones (g/dm3)	Mammal bones (g/dm3)	Stratigraphic sequence	Volume (dm3)	Coprolites (g/dm3)	Fish bones (g/dm3)	Mammal bones (g/dm3)
88	181.00	0.00	4.42	3.09	44	14.50	0.29	6.00	1.03
87	20.50	0.00	1.27	1.51	43	6.75	0.00	3.26	1.04
86	66.70	0.00	2.67	6.94	42	7.00	0.00	5.29	3.00
85	44.50	0.00	3.93	2.70	41	17.40	0.00	1.78	1.90
84	10.30	0.00	1.17	15.53	40	25.40	0.00	1.61	0.87
83	11.00	0.10	2.00	0.55	39	9.00	0.36	0.00	0.22
82	137.70	0.00	2.40	1.92	38	63.40	0.27	3.75	1.37
81	98.00	0.00	2.08	6.89	37	21.00	0.47	11.19	0.43
80	7.40	0.00	5.27	7.43	36	16.55	0.66	0.00	2.60
79	9.00	0.00	0.44	8.89	35	95.00	0.91	7.85	1.11
78	14.10	0.00	3.05	0.43	34	31.00	0.98	7.97	2.68
77	19.00	0.23	1.16	1.26	33	6.00	0.00	7.00	0.00
76	31.30	0.00	0.54	1.25	32	68.50	0.75	6.42	1.66
75	108.50	0.00	2.11	0.72	31	8.00	0.51	5.50	1.75
74	28.90	0.00	2.91	0.55	30	21.50	2.67	1.40	0.74
73	39.40	0.65	6.57	1.90	29	19.00	1.12	6.00	0.26
72	17.30	1.56	2.02	0.81	28	14.00	2.77	5.07	1.29
71	225.80	0.73	5.84	1.86	27	62.50	1.66	12.48	1.84
70	76.00	1.23	0.00	1.58	26	68.50	0.54	3.65	0.86
69	20.70	0.58	4.78	0.97	25	74.80	3.29	9.36	0.79
68	26.30	0.23	0.00	0.00	24	30.95	0.32	8.40	2.84
67	27.75	0.38	1.73	1.84	23	5.00	4.22	46.60	1.80
66	15.75	0.00	0.38	1.52	22	107.10	0.84	8.78	1.96
65	6.30	0.00	1.90	0.32	21	18.00	0.77	13.33	2.00
64	16.20	0.03	1.23	1.23	20	32.80	0.26	6.98	0.21
63	2.70	0.00	0.00	0.00	19	3.00	0.00	2.33	0.00
62	8.75	0.00	1.14	3.43	18	99.00	1.53	3.43	1.54
61	41.00	0.00	0.22	1.39	17	165.00	0.82	0.24	2.15
60	88.90	0.02	2.43	5.68	16	2.00	13.39	27.00	6.50
59	9.10	0.00	1.54	2.09	15	13.00	0.12	7.92	0.00
58	35.30	0.00	2.07	9.26	14	68.10	3.19	21.00	3.35
57	25.00	0.00	3.28	3.56	13	17.80	4.84	14.04	1.69
56	14.00	0.00	7.64	12.86	12	10.00	6.73	6.90	1.30
55	61.90	0.00	2.12	1.10	11	745.50	0.75	0.67	2.17
54	15.80	0.00	8.61	0.57	10	4.00	0.00	5.75	0.50
53	3.00	0.00	0.00	3.33	9	11.00	0.12	7.45	0.91
52	20.00	0.00	1.85	1.35	8	32.00	0.18	11.88	11.88
51	73.20	0.00	1.79	0.96	7	328.00	1.03	8.23	3.60
50	14.00	0.00	3.36	2.86	6	301.00	0.57	6.31	1.99
49	8.00	0.00	0.00	0.00	5	10.20	0.15	4.51	0.39
48	13.00	4.23	2.46	1.23	4	113.00	1.68	5.58	1.81
47	39.30	0.00	1.53	1.58	3	27.00	0.59	10.30	2.22
46	5.60	0.00	1.96	0.89	2	34.00	0.00	2.06	1.18
45	13.90	0.00	1.37	0.79	1	253.00	0.53	5.89	2.61

Table 1. Quantitative stratigraphic distribution of coprolites, fish bones and mammal bones within the midden complex C521 (Hârsova-tell, southeast Romania).

midden is somewhat prone to error because the size of some of these bones exceeded the thickness of the stratigraphic units of the midden. Every effort was made to overcome this stratigraphic problem by attributing the larger mammal bones to the uppermost SU that was in contact with them, without being interrupted by them. However, the effects of such processes as post-depositional compaction of the sediment or trampling of bones into soft layers, could not be accounted for totally.

The quantitative stratigraphic distribution of the three types of remains suggests the following relationships: similar variation patterns of coprolites and fish bones and inverse variation of these two with respect to the mammal bones. To test these hypotheses we used Spearman's coefficient of rank correlation (r_s). The analysis shows that there is a highly significant correlation between coprolite distribution and fish bone distribution within the midden complex (Table 2). On the other hand, there is no definite relationship between the mammal bone distribution and either coprolite or fish bone distribution.

Remains	r_s	p
Coprolites / Fish bones	0.46	< 0.0001
Mammal bones / Coprolites	0.03	0.79
Mammal bones / Fish bones	0.13	0.23

Table 2. Results of Spearman's coefficient of rank correlation analysis on the three types of remains from the midden complex C521 (Hârsova-tell, southeast Romania).

Fish species	Mammal species
Alosa pontica (Eichwald)	*Bos taurus* L.
Esox lucius L.	*Ovis aries* L.
Aspius aspius (L.)	*Capra hircus* L.
Abramis brama (L.)	*Sus domesticus* Erxl.
Alburnus alburnus (L.)	*Equus caballus* L.
Blicca bjoerkna (L.)	*Canis familiaris* L.
Cyprinus carpio carpio L.	*Bos primigenius* Boj.
Leuciscus idus (L.)	*Cervus elaphus* L.
Pelecus cultratus (L.)	*Capreolus capreolus* L.
Rutilus rutilus (L.)	*Sus scrofa* L.
Scardinius erythrophthalmus (L.)	*Felis silvestris* Schreb.
Tinca tinca (L.)	*Vulpes vulpes* L.
Silurus glanis L.	*Martes martes* L.
Gymnocephalus cernuus (L.)	*Castor fiber* L.
Perca fluviatilis L.	*Lepus europaeus* L.
Stizostedion lucioperca (L.)	*Lutra lutra* L.

Table 3. Comprehensive list of fish and mammal species identified on bones from the midden complex C521 (Hârsova-tell, southeast Romania).

Discussion

The quasi-ubiquity of fish bones of various size and species in the stratigraphy of the Gumelnita settlement at Hârsova-tell, as well as the numerous finds of fishing tools in the settlement, speak of the important role played by the Danube river in the economy of the settlement. Animal husbandry and hunting were nonetheless important components of the subsistence economy, a fact proved by the very large numbers of mammal bones excavated at the site. The importance of plant cultivation and gathering, for which evidence was also found at Hârsova-tell, is more difficult to assess presently.

The quantitative stratigraphic distribution of fish bones within the midden complex C521 has been demonstrated to be related to seasonality (Radu 2000; Popovici *et al.* 2000). The relative chronology and seasonal framework for that has been established based on seasonal growth rings of vertebrae coming from two fish species, the common carp (*Cyprinus carpio carpio* L.) and the zander (*Stizostedion lucioperca* (L.)). All of the vertebrae representing the two species in the midden C521 were studied and the seasonal signal borne by their growth rings was recorded. Plotted against the relative time scale provided by the stratigraphy of the midden, the individual data for each of the two species concurred suggesting that the section comprised of stratigraphic sequences 1 to 38, characterised by high inputs of fish bones, accumulated during the warm season including at least part of the summer and the warm beginning of autumn. In the subsistence economy of the Gumelnita settlement, this period of the year would have corresponded to intense activities of fishing and possibly processing of the fish surplus (e.g. smoking) to be kept as food reserve for the cold season. This intensity of fishing and fishing-related activities in the warm season would be related to favourable weather and the seasonality of fish reproductive cycles. According to the same data, sequences 39 to 71, characterised by low inputs of fish bones, accumulated during the cold season: autumn, winter and the beginning of spring. The upper section of the midden stratigraphy (sequences 72 to 88) accumulated in a second warm season that includes at least the warm end of spring and probably also the beginning of summer (Radu 2000).

Correlating the data from fish bones with archaeological evidence available from the midden for seasonality and small-scale relative chronology, such as the cyclicity of different aspects of the subsistence economy or that of the maintenance of the walls of clay dwellings and ovens, Popovici *et al.* (2000) concluded that the midden complex C521 accumulated in a period ranging between 12 and 18 months, that included one cold season and at least parts of the two adjacent warm seasons.

Our results show a highly significant correlation between the distribution of coprolites and that of fish bones in the midden. Based on this, the seasonal aspect inferred for the latter suggests that coprolite distribution within the midden complex might also bear a seasonal signal. In the following we will try to assess the factors that control coprolite distribution within the midden and their level of support for this hypothesis.

Coprolite distribution within the midden, as approached by this study, is controlled at several levels: production, preservation and recovery. Relative to coprolite production, the questions that arise are: by whom and where were the coprolites produced? The bone content of the coprolites proves their origin in carnivores or omnivores. This brings into discussion three species as potential sources for the coprolites: dog, pig and man. Dog and pig are important presences in the species list of both the settlement as a whole, and the midden complex C521 (Table 3). Also, the frequent occurrence in the midden of large bones of mammals and fish with gnaw marks (Fig. 9) speaks of the presence of dogs

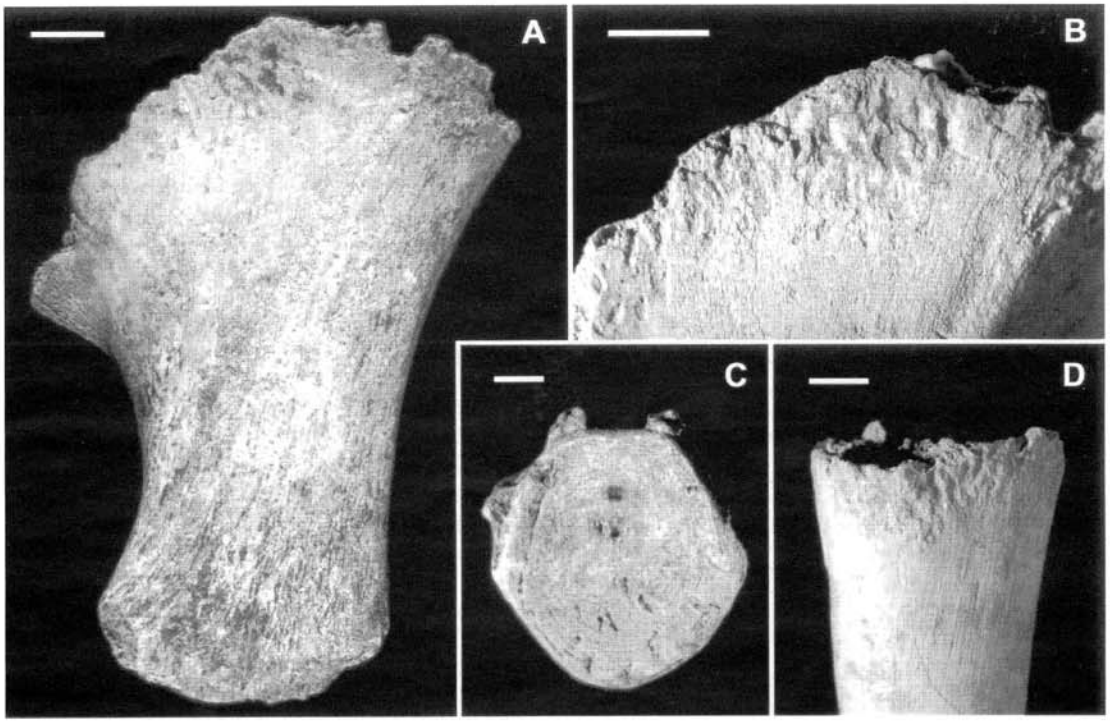

Figure 9. Bones with gnaw marks from the midden complex C521 (Hârsova-tell, southeast Romania). A. Right coxal (ilium), Sus scrofa L.; B. Detail of A; C. Vertebra, Silurus glanis L.; D. Right femur (proximal diaphysis), Bos taurus L.; bars = 1 cm.

during deposition of the complex. Although the shape and size of some of the coprolites that are preserved intact suggests their origin in dogs, this hypothesis needs further testing by chemical analyses that have proved useful in identifying the producers of fossil faeces, such as the multimolecular biomarker techniques (Bethell *et al.* 1994; Evershed and Bethell 1996; Evershed *et al.* 1997).

There are two possibilities as to where the faeces that generated the coprolites were produced. They were either produced on the spot and incorporated in the midden with subsequent accumulation of domestic waste, or were produced at some other place and reached the midden as a result of cleaning activities. The latter would imply very high hygiene standards for the Gumelnita population, a hypothesis that runs counter to observation of hygienic practices in some present-day rural communities. However, this hypothesis cannot be ruled out entirely as there is no indication that modern rural communities should set the standard for the Gumelnita population. If the coprolites had been deposited directly on to the midden, then they would appear at the base of each of the stratigraphic units. Unfortunately this level of stratigraphic detail is not available for the midden C521. In any instance, climatic factors affecting coprolite preservation would act either in the midden or in other areas of the site.

Coprolite preservation is controlled by climate and sedimentation rate within the midden complex. The intensity of the action of certain climate components on the original material of coprolites (faeces) prior to embedding strongly influences coprolite preservation. The main natural agent that disintegrates faeces is rain, or humidity from rain alternating with subsequent drying of the faeces. Therefore, faeces are more likely to be preserved and subsequently embedded during dry seasons than during wet seasons. The frequent autumn rains would disintegrate most faeces prior to their embedding, unless a new layer of domestic waste quickly covered them. The high humidity due to winter-end thaws, as well as high frequency of freeze-thaw cycles during this period of the year, also would lead to the disintegration of the poorly covered faeces produced during the winter season. Therefore, coprolites will be more frequent in the stratigraphic sequences deposited during the generally dry season (end of spring, summer, and beginning of autumn) and less frequent in SS deposited during rainy and humid seasons (autumn, winter, and beginning of spring). One line of thought would suggest that disintegration of bone-containing faeces during wet seasons results in higher amounts of bones modified by digestion. This type of data is not available presently for the midden C521. However, experimental studies undertaken by Butler and Schroeder (1998) clearly proved that many fish remains can pass through human and non-human digestive tracts and show no sign of digestion. Therefore even though the presence of bones modified by digestion provides evidence for the presence of faeces disintegrated prior to burial, there is no way to assess the quantity of faeces based on the percentage of modified bones.

The rate of sedimentation (and therefore of coprolite embedding) within the midden concurs with the climatic factor in controlling the preservation of coprolites. The faster the original material of a potential coprolite is covered with sediments, the greater its chances of being preserved as a coprolite. However, at present, we cannot characterise precisely the seasonal variability of sedimentation rates within an Eneolithic midden. Sedimentation here is anything but constant, and most likely of highly variable rate. This is apparent from the wide variability in the size and shape of the stratigraphic units that compose the complex. They vary from small lenses of domestic waste thrown here and there and resulting from daily activities, to important layers that sometimes exceed ten centimeters in thickness and cover almost all the surface of the midden zone. The latter units are usually the result of concerted activities in the community, such as the gathering and preparation of bivalves (generating important layers of *Unio* shells), or the preparation of large quantities of fish for food provisions (generating important accumulations of fish bones and scales). Normalisation of the data by transformation into concentrations of remains per volume of sediment should take care of the effects of variable sedimentation rate.

Coprolite recovery is influenced by the method used to retrieve them from the archeological sediments. As shown above, the method used for this study (wet screening) only allowed the recovery of the most cohesive coprolites. Hence, the reported coprolite distribution is that of cohesive coprolites. Several authors (Leroi-Gourhan 1966; Jones 1982; Sené 1992) have suggested that the bone content of some coprolites may play an important role in their cementation, permineralisation and preservation. The Ca and P content of the bones might represent a source for sindepositional and/or diagenetic permineralising agents. However, these hypotheses have not been tested, to our knowledge, by chemical analyses.

Assessment of the factors that control coprolite distribution within the midden sheds some light on the correlation between fish bone and coprolite distribution. As shown above, the periods of high input of fish bones into the midden are spring, summer and the beginning of autumn, whereas periods of lower such inputs are cold periods such as the end of autumn, winter and the beginning of spring. According to our discussion of the factors that control coprolite distribution within the midden, the constant presence of coprolites in the section SS 1 to SS 39 could be interpreted in terms of a dry period favourable to coprolite preservation. In this region of high climate continentality, the driest period of the year corresponds to the warm season (summer, beginning of autumn), also indicated by the distribution of fish bones. Conversely, the general absence of coprolites in the upper section of the midden stratigraphy could be interpreted as indicating wet seasons that are favorable to coprolite disintegration (corresponding generally to the cold period autumn, winter, beginning of spring), which is again in accord with the interpretations based on fish bone distribution. The group of stratigraphic units containing coprolites in the upper section of the midden (SS 67 to SS 73) corresponds to a slight increase in fish bone concentration thought to be due to the first important spring fishing that probably preceded the annual spring floods (Radu 2000). Under these circumstances, the coprolite occurrences in this stratigraphic position would be due rather to accidental preservation by rapid embedding of faeces during the wet period than to the onset of dry conditions at the beginning of another warm period. Still, we do not entirely exclude the other possibility, namely that of a short dry spell, favorable to coprolite preservation, during this predominantly wet season.

Conclusions

A note of caution is necessary here. When reading the following conclusions it should be borne in mind that they refer only to cohesive coprolites, the ones that withstood wet screening without being disaggregated.

This is the first study approaching the stratigraphic distribution of coprolites within an Eneolithic midden and the first attempt to relate this distribution to seasonality. Our results suggest that under specific conditions (e.g. coprolites obtained by wet screening) the stratigraphic distribution of coprolites may be used as indicator of seasonality in middens. Some points needing further clarification stem from the impossibility to identify with certitude the producers of the coprolites. As pointed out above (p. 8), in theory this could be done using multimolecular biomarker techniques. However, the high number of coprolites and the fragmented state of their majority, as well as the impossibility to extrapolate origin from one fragment to the other, render this approach unrealistic. Incongruent results obtained from experimental studies by Jones (1984; 1986) and by Butler and Schroeder (1998) suggest that the degree of digestion and/or destruction of fish bones passing the digestive tract of different mammal species is not a reliable indicator of the species that produced the coprolites. Digestion and destruction of fish bones varies for the same mammal species depending on a multitude of factors including the species and quantities of fish ingested, the frequency of meals, the types of food ingested along with the fish. Comparing fish remains modified by coyote and human digestive process, Butler and Schroeder (1998) also point out that distinguishing fish remains generated by the two species is not possible using proportions of destroyed bones or proportions of bones revealing different types of modification. Another direction where further investigation is needed concerns the position of coprolites within the stratigraphic units. The study of micromorphological thin sections could help to distinguish between coprolites located at the base of stratigraphic units, implying production on the spot, and coprolites found in the middle of the units, most likely incorporated in the waste disposed of and therefore resulting from cleaning activities.

Irrespective of these unresolved aspects that need to be approached by future studies, there remains the fact that patterns observed in the distribution of coprolites and fish bones are undoubtedly correlated. Our results demonstrate that high-resolution stratigraphic coprolite distribution bears a seasonal signal. There is a highly significant correlation (calculated using Spearman's coefficient of rank correlation – r_s) between coprolite distribution and fish bone distribution within the Eneolithic midden complex C521 at Hârsova-tell ($r_s = 0.46$, $p < 0.0001$). However, using the same correlation coefficient does not yield any definite relationship between the mammal bone distribution and either the coprolite or the fish bone distribution.

The significant correlation that exists between coprolite distribution and the seasonally-controlled distribution of fish bones suggests that seasonality exerts at least an indirect control on coprolite distribution. Seasonality determined based on fish bone distribution suggests that periods of high fish bone input into the midden and high coprolite concentrations correspond to the warm season, i.e. late spring to early autumn.

A direct seasonal influence may have been exerted on the coprolite distribution by seasonal variations in climate humidity. Wet, cold seasons (autumn through early spring) favour the disintegration of faeces. Frequent autumn rains, high humidity due to winter-end thaws, as well as high frequency of freeze-thaw cycles during this period of the year would disintegrate feces unless a new layer of domestic waste quickly covered them. Dry seasons (late spring through early autumn) favour preservation of faecal material and coprolite formation, provided that this material is rapidly embedded. However, it is difficult to assess the influence of the highly variable sedimentation rates on coprolite distribution within the midden. Sections of high coprolite concentrations in the stratigraphy of the midden deposits would therefore represent the result of (1) preservation of the faeces until embedding in sediments; this is favoured by dry periods, whereas rain, freeze-thaw cycles or other wet season processes favour faeces disintegration; (2) rapid embedding of faeces by covering with sediment.

Knowing more about the coprolites, who produced them, or what are the factors that influence their cohesion, would undoubtedly refine the interpretation of their stratigraphic distribution and add more support to our hypothesis. Additional high resolution studies approaching the stratigraphic distribution of coprolites in middens are also needed to better assess and characterise the seasonal aspects of this distribution. Until then, the distribution of coprolites should be used only in conjunction with other methods or to confirm results obtained by other methods.

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