

VARIATION IN THE CARBON AND NITROGEN ISOTOPIC SIGNATURES OF PIG REMAINS FROM PREHISTORIC SITES IN THE NEAR EAST AND CENTRAL EUROPE

AZ ŐSKORI HÁZISERTÉS KÖZEL-KELETI ÉS KÖZÉP-EURÓPAI MARADVÁNYAINAK SZÉN- ÉS NITROGÉNIZOTÓP ÖSSZETÉTELÉNEK VÁLTOZÉKONYSÁGA

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Abstract

The first results of carbon and nitrogen ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) stable isotope analyses of domestic pig (*Sus domesticus* Erxl., 1777) remains from three prehistoric sites are presented. Of these, comparison of the datasets from Tell Aqab in Syria and Çamlıbel Tarlası in Turkey suggests different dietary patterns, and possibly different pig husbandry practices, at these sites. The study highlights the need for supporting evidence from archaeobotanical and palaeoenvironmental investigations in the interpretation of stable isotope data.

Kivonat

A cikk régészeti házisertés (*Sus domesticus* Erxl., 1777) leleteken mért szén- és nitrogén izotóp ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) méréseinek első eredményeit ismerteti. A leletek három őskori lelőhelyről származnak. Ezek közül a szíriai Tell Aqab és a törökországi Çamlıbel Tarlası mintái szignifikánsan különböző takarmányozási módokra utalnak, amelyek a két település eltérő sertéstartási gyakorlatával függhetnek össze. A tanulmány rámutat az eredményeket megerősítő régészeti növénytani és környezetrégészeti kutatások fontosságára a stabilizotóp adatok értelmezésében.

KEYWORDS: CARBON, NITROGEN, ISOTOPES, PIGS, DIET

KULCSSZAVAK: SZÉN, NITROGÉN, IZOTÓP, SERTÉS, TÁPLÁLKOZÁS

Introduction

Carbon and nitrogen stable isotope values in bone collagen of domestic livestock have been used to infer animal husbandry and stock management strategies (e.g. Pearson et al. 2007; Atahan et al. 2011). Stable isotope analysis of domestic pig (*Sus domesticus* Erxl., 1777) remains was conducted to investigate prehistoric pig management/husbandry practices at three sites, Çamlıbel Tarlası in north-central Anatolia, Tell Aqab in northeast Syria and Kaposújlak-Várdomb in southwest Hungary (Fig. 1.).

Çamlıbel Tarlası (ÇBT) was a small-scale settlement occupied between c. 3590 and 3470 cal BC (i.e. Late Chalcolithic) by agro-metallurgists (Schoop et al. 2009; Schoop 2010, 2011). The site is located on a small plateau in a mountainous region that on palynological evidence was heavily forested until the Iron Age (Dörfler et al. 2000).



Fig. 1.: Map indicating the locations of sites discussed

1. ábra: A lelőhelyek földrajzi elhelyezkedése

Tell Aqab (TA) is situated in an area of fertile, alluvial soils within the Khabur River catchment, with sufficient rainfall for dry farming.

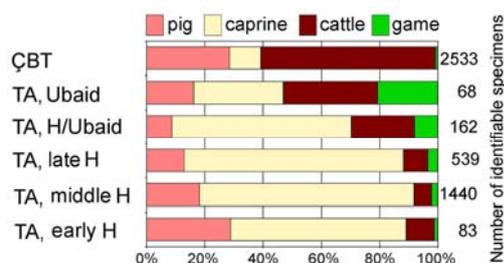


Fig. 2.: The contribution of pig to the numbers of identifiable bones at the two Near Eastern sites

2. ábra: A sertécsontok részesedése a két közelkeleti lelőhely meghatározható állatsont anyagából

The occupation of the tell settlement spanned the Halaf and Ubaid periods (i.e. Neolithic into the Chalcolithic) from c. 6000 to 4200 cal BC (Davidson & Watkins 1981). The natural vegetation of xeric Mediterranean forest-steppe (grassland interspersed with areas of mainly pine woodland or forest) reflects a climate with lower annual rainfall than north-central Anatolia.

Kaposújlak-Várdomb (KV) is a Late Neolithic and Bronze Age hillfort site situated in a formerly forested area along the Kapos River valley (Gál 2011). The samples analyzed come from Early Bronze Age Somogyvár-Vinkovci culture contexts (corresponding to c. 2500-2300 cal BC). Although only two samples from this site yielded sufficient quantities of collagen for analysis, they were included in the study for the sake of comparison.

The domestic status of the pigs discussed in this paper is based on the small size of their bones and the fact that hunting played a negligible role in meat provisioning at the studied sites. Even relatively high contributions by game to the smaller Halaf/Ubaid and Ubaid assemblages from TA consisted mostly of gazelle and equid bones; the proportion of pig remains varied between 10 and 30% – see Fig. 2. (Bartosiewicz & Gillis 2011; Bartosiewicz unpublished data).

Methods

A c. 1 g sample of bone was taken from each specimen. Collagen was extracted from the samples using a modified Longin (1971) method (Brown et al. 1988). Pre-treatment consisted of sample cleaning by removal of the outer 2 mm of the bone surface, demineralization in 1N HCl at 20°C for a minimum of 24 hours, and gelatinization in 0.03N HCl at 80°C for ~16 hours; the resulting solution was lyophilized. Mass spectrometric analysis was undertaken at the SUERC radiocarbon facility East Kilbride, UK, using a Costech ECS 4010 combustion elemental analyser coupled to a ThermoFisher Delta V Advantage gas source isotope ratio mass spectrometer. Mass spectrometric systematic errors are $\pm 0.2\%$.

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Collagen integrity was assessed according to three criteria:

- The percentage weight yield of collagen relative to original sample weight was determined. Only samples with a %wt yield of $>1.00\%$ (quoted for well-preserved bone, e.g. van Klinken [1999]; Brock et al. [2010]) were analyzed.
- Samples with a C:N ratio within the range 2.9–3.6, quoted for well-preserved collagen (DeNiro 1985), were included in the comparative analysis.
- Well-preserved human bone collagen has total %wtC $\geq 13\%$ and %wtN $\geq 4.8\%$, as described by Ambrose (1990); this criterion was met by the majority of the samples analyzed (see Table 1.). Four of the samples have %wtC values in the range 10.1% to 12.9% and five of the samples have %wtN in the range 3.5% to 4.5%. These samples were included in this analysis as they met the two criteria outlined above. Ambrose (1990) indicates that samples should be rejected as diagenetically altered at %wtN $< 0.5\%$ and %wtC $< 4.5\%$.

Results and discussion

A total of 41 pig bone specimens were sampled. However, only 26 of the samples (ÇBT, $n = 17$; TA, $n = 7$; KV, $n = 2$) fulfilled the ‘reliability’ criteria outlined above. The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope values of the pig bone samples from each of the sites are presented in Table 1., and are plotted in Figs. 3. and 4.

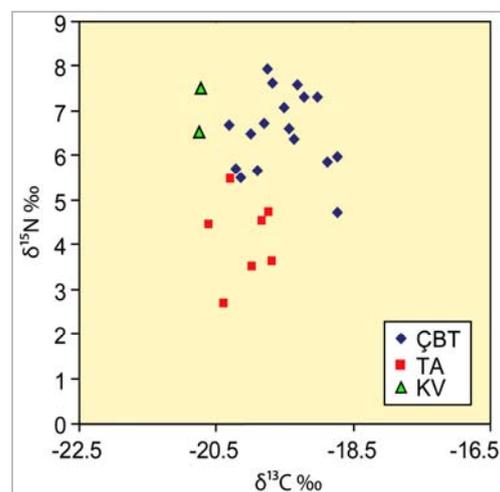


Fig. 3.: Scatterplot of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of *S. domesticus* remains from Çamlıbel Tarlası in Turkey, Tell Aqab in Syria and Kaposújlak-Várdomb in Hungary

3. ábra: A házisertés maradványok $\delta^{13}\text{C}$ és $\delta^{15}\text{N}$ értékei (Çamlıbel Tarlası, Törökország; Tell Aqab, Szíria; Kaposújlak-Várdomb, Magyarország)

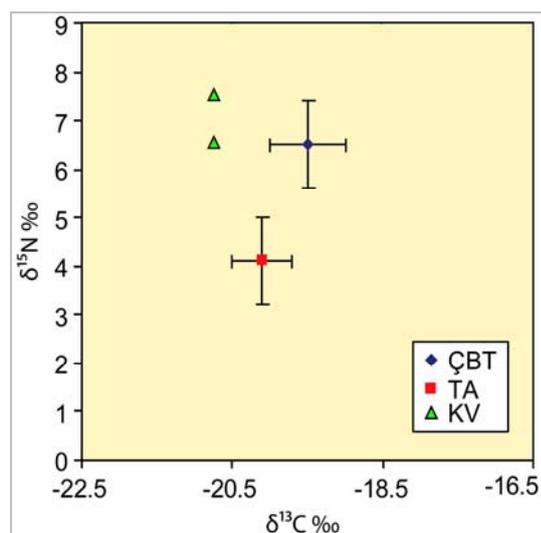


Fig. 4.: Scatterplot of mean with standard deviation $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of *S. domesticus* remains from Çamlıbel Tarlası in Turkey, Tell Aqab in Syria and Kaposújlak-Várdomb in Hungary

4. ábra: A házisertés maradványok $\delta^{13}\text{C}$ és $\delta^{15}\text{N}$ értékeinek átlagai és szórásai (Çamlıbel Tarlası, Törökország; Tell Aqab, Szíria; Kaposújlak-Várdomb, Magyarország)

Two of the specimens sampled (GuSi 2663 ÇBT and GuSi 2684 KV) were sub-adults. However, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of these specimens overlap those obtained for the adults. In other words, no suckling enrichment effect is evident in their isotope values and so they have been included in the analysis.

Conventionally $\delta^{13}\text{C}$ values in the range -21.5‰ to -20.0‰ are considered characteristic of diets based exclusively on C_3 terrestrial plant species (e.g. Chisholm et al. 1982; Richards et al. 2003), while $\delta^{13}\text{C} \geq -18.0\text{‰}$ is usually taken as indicative of the inclusion (directly or indirectly) of C_4 plants in the diet (Pearson et al. 2007). $\delta^{13}\text{C}$ values for the pigs from ÇBT, TA and KV range between -20.8‰ and -18.7‰ (Table 1) with average values at ÇBT of $\delta^{13}\text{C} = -19.5 \pm 0.5\text{‰}$ and at TA of $\delta^{13}\text{C} = -20.1 \pm 0.4\text{‰}$, which is consistent with diets derived principally from the C_3 plant foodweb. C_4 plants (mainly grasses) are likely to have been present in the local vegetation at ÇBT and TA especially, as indicated by the relatively heavy $\delta^{13}\text{C}$ values for some of the cattle and caprines from ÇBT (Pickard, unpublished data). However, pigs generally consume less grass than do cattle and caprines, and therefore will tend to ingest less C_4 plant material. Moreover, C_4 species tend to be less abundant in the shade of trees, a niche that would have been favoured by pigs.

A much larger range (from 2.7‰ to 8.0‰) is observed for the $\delta^{15}\text{N}$ values, and inter-site

comparison shows that the values for the ÇBT pigs ($6.5 \pm 0.9\text{‰}$) and KV pigs (7.5‰ and 6.5‰) are similar and markedly different from the TA population ($4.1 \pm 0.9\text{‰}$).

Several factors can lead to variations in the $\delta^{15}\text{N}$ profiles of livestock from different localities. For example, $\delta^{15}\text{N}$ enrichment has been observed in animals from arid/hot regions and is attributed to heat/water stress (e.g. Ambrose 1991). Elevated $\delta^{15}\text{N}$ values have also been observed in consumers of halophytic plants (Britton et al. 2008). However, neither of these enrichment mechanisms is consistent with the geographical locations and soil conditions of the sites sampled nor with the observed enrichment patterns, although the relationship between aridity, temperature and $\delta^{15}\text{N}$ enrichment is complex (cf. Fraser et al. 2011). Of the three sites under consideration, TA would have experienced the highest temperatures and lowest rainfall in summer, with obvious implications for levels of heat/water stress in livestock, yet the pig $\delta^{15}\text{N}$ values at TA are significantly lighter than at the other two sites (Mann-Whitney U test $n_{\text{ÇBT}}=17$, $n_{\text{TA}}=7$, $U=118.0$, $p < 0.01$ [$p = 1.16 \times 10^{-5}$] two-tailed test).

Another explanation for the relatively low pig $\delta^{15}\text{N}$ values at TA is that they reflect differences in the pig diet compared to ÇBT and KV, which in turn may be a function of the livestock management conditions.

Traditionally, three types of husbandry systems have been used by pig farmers:

- (i) allowing the pigs to roam and forage freely;
- (ii) keeping them in fields, sometimes with other livestock;
- (iii) confining them in pens or 'pig houses' (sties).

The diets of domestic pigs tend to vary according to the management strategy employed. Free-range pigs may have diets that differ significantly from those of animals kept in close confinement. Pigs will naturally forage over a large home range (Studnitz et al. 2007) and consume a wide variety of plant foods, as well as insects, worms, small mammals and even birds' eggs. Thus, like wild boar, free-range pigs are predominantly herbivorous, and their bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values tend to be close to those of strict herbivores such as deer, cattle and sheep.

In contrast, penned animals cannot forage for themselves and have to be fed. Their diets will comprise mainly plant fodder (e.g. grain, pulses, hay and straw) and/or domestic food waste. Where the domestic waste fed to pigs includes significant amounts of animal protein (from meat or milk), this can result in enrichment of bone collagen $\delta^{15}\text{N}$ values compared to free-foraging animals.

Table 1.: $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of *S. domesticus* specimens from Çamlıbel Tarlası in Turkey, Tell Aqab in Syria and Kaposújlak-Várdomb in Hungary**1. táblázat:** A házisertés maradványok $\delta^{13}\text{C}$ és $\delta^{15}\text{N}$ értékei. ÇBT=Çamlıbel Tarlası, Törökország; TA=Tell Aqab, Szíria; KV=Kaposújlak-Várdomb, Magyarország)

GUsi No.	Species	Site	Element	Age	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	C/N	%N	%C
2203*	<i>Sus</i>	ÇBT	Occipital	Adult	-19.0	7.3	3.2	13.1	35.8
2650	<i>Sus</i>	ÇBT	Mandible (L)	Adult	-19.3	7.6	3.3	11.8	33.0
2651	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-20.1	5.5	3.2	9.8	27.4
2652	<i>Sus</i>	ÇBT	Mandible (L)	Adult	-19.5	7.1	3.2	13.7	37.8
2653	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-19.9	5.6	3.4	4.5	12.9
2655	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-18.7	4.7	3.3	8.5	24.0
2657	<i>Sus</i>	ÇBT	Mandible (L)	Adult	-19.2	7.3	3.2	11.8	32.9
2658	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-18.9	5.9	3.3	10.2	29.0
2659	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-19.4	6.6	3.3	9.7	27.1
2661	<i>Sus</i>	ÇBT	Mandible	Adult	-19.8	8.0	3.2	9.7	26.9
2662	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-19.8	6.7	3.3	10.9	30.9
2663	<i>Sus</i>	ÇBT	Mandible (R)	Sub-adult	-20.2	5.7	3.4	7.3	21.2
2664	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-20.0	6.5	3.3	8.9	25.3
2666	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-18.7	6.0	3.3	8.7	24.8
2667	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-19.4	6.4	3.3	12.6	35.5
2668	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-19.7	7.6	3.5	4.0	12.0
2669	<i>Sus</i>	ÇBT	Mandible (R)	Adult	-20.3	6.7	3.3	10.4	29.2
2671	<i>Sus</i>	TA	Ulna (L)	Adult	-20.0	3.5	3.4	3.5	10.1
2672	<i>Sus</i>	TA	Humerus (L)	Adult	-20.6	4.4	3.4	6.5	18.8
2673	<i>Sus</i>	TA	Parietal (L)	Adult	-19.7	4.7	3.4	5.1	14.8
2674	<i>Sus</i>	TA	Scapula (L)	Adult	-20.3	5.5	3.6	4.5	13.9
2675	<i>Sus</i>	TA	Scapula (L)	Adult	-20.4	2.7	3.5	3.5	10.5
2676	<i>Sus</i>	TA	Temporal (L)	Adult	-19.7	3.6	3.3	8.8	25.0
2678	<i>Sus</i>	TA	Temporal (L)	Adult	-19.8	4.5	3.2	9.7	27.0
2680	<i>Sus</i>	KV	Scapula (R)	Adult	-20.7	7.5	3.2	11.3	31.2
2684	<i>Sus</i>	KV	Fibula (L)	Sub-adult	-20.8	6.5	3.3	8.0	22.8

* from Channell (2012)

Conversely, if pigs are fed large amounts of pulses as fodder or domestic waste, then (since pulses have lower $\delta^{15}\text{N}$ values than cereals and grasses) their bone collagen may show significantly lighter $\delta^{15}\text{N}$ values compared to free-range pigs and herbivores; in theory this effect could be masked by manuring using animal dung, which has been observed to elevate the $\delta^{15}\text{N}$ signatures of crop plants (Fraser et al. 2011), although it seems that

unusually intensive manuring is required to raise pulse $\delta^{15}\text{N}$ values significantly and there is little evidence that such intensive manuring was widely practised in prehistoric Europe or the Near East (cf. Bogaard et al. 2013).

In contrast to cattle and sheep (which are ruminants) a diet based on grass is not nutritionally sufficient for pigs, and even field-reared pigs would

need their diets to be supplemented by higher protein foods such as cereals, pulses and/or animal products.

It follows that any interpretation of bone collagen stable isotope data for pigs needs to take account of the types of plant food that were available to livestock, including the kinds of crops that were grown and potentially used as fodder. Archaeobotanical evidence from Tell Aqab indicates that cereals (barley and emmer) and a range of pulse crops (lentils, field peas and bitter vetch) were cultivated (McCorrison 1992). It is possible therefore that the lower average $\delta^{15}\text{N}$ value of the pigs from this site compared to ÇBT and KV reflects intensive foddering with pulses or the waste from crop processing. This could have been done as part of a close confinement or field-rearing system of pig husbandry.

For the moment, this should be regarded as a working hypothesis, which would be strengthened considerably if it could be shown that the remains of domestic cattle and caprines and wild herbivores from the site have more elevated $\delta^{15}\text{N}$ values than the pigs. Wild herbivores would have had little or no access to pulses, while the herding of caprines and cattle (vs pigs) arguably would have been less reliant on foddering in the forest-steppe environment of Tell Aqab.

Conclusions

In this paper $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ stable isotope domestic pig remains from the three prehistoric sites, Çamlıbel Tarlası, Tell Aqab and Kaposújlak-Várdomb, were compared. The bone collagen $\delta^{13}\text{C}$ values indicate that at each of the sites studied dietary protein was derived largely from C_3 resources. Inter-site variation in $\delta^{15}\text{N}$ values is suggestive of variation in dietary constituents, possibly reflecting differences in pig husbandry practices. These findings should be regarded as preliminary for several reasons. First, they are based on relatively small sample sizes. Second, for two of the sites there are as yet no comparative isotopic data for other livestock or wild herbivores/omnivores. Third, investigation of livestock management practices in prehistory should never rely exclusively on bone collagen stable isotope data. A more holistic approach is necessary – ideally, one that combines isotopic data with information on local climate, vegetation and soil conditions as well as the arable components of the farming system.

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