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TITLE PAGE

Diet at Late Chalcolithic Çamlıbel Tarlası, North-Central Anatolia: an isotopic perspective

Authors: Catriona Pickard[1], Ulf-Dietrich Schoop[1], Alan Dalton[1], Kerry L Sayle[2], Ian Channell[1], Kevin Calvey[1], Jayne-Leigh Thomas[3], László Bartosiewicz[1] and Clive Bonsall[1].

[1]-School of History, Classics and Archaeology, University of Edinburgh, Edinburgh, EH8 9AG, UK.

[2]-Scottish Universities Environmental Research Centre, Scottish Enterprise Technology Park, Rankine Avenue, East Kilbride, G75 0QF, UK.

[3]-NAGPRA, Indiana University, Bloomington, Indiana, 47405-7000, USA.

Corresponding Author - Catriona Pickard. Email: Catriona.Pickard@ed.ac.uk

Abstract

Carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotope analysis of bone collagen from 57 human and 137 faunal samples was conducted with the aim of reconstructing human diet at the Late Chalcolithic (mid-4th millennium BC) site of Çamlıbel Tarlası, north-central Anatolia. The analyses indicate that the diet of the inhabitants of Çamlıbel Tarlası was based largely on C_3 resources. Comparison of human and faunal δ^{15}N values suggest that animal proteins were likely to be of secondary importance to diet, with cultigens such as wheat and barley and potentially pulses taking the role of dietary staples. Age-related variation in stable isotope signals was identified.

Keywords: Anatolia, stable isotopes, δ^{13}C, δ^{15}N, Chalcolithic, diet.

Highlights:

- Diet at Chalcolithic Çamlıbel Tarlası, north-central Anatolia, was constructed from human and animal C and N stable isotope data
- Human δ^{13}C and δ^{15}N values point to a predominantly C_3 terrestrial diet drawn principally from plant foods
- Age-related differences in C and N isotope values were identified
- Inter-individual variation in C and N isotope values may reflect dietary differences

Diet at Late Chalcolithic Çamlıbel Tarlası, North Central Anatolia: an isotopic perspective

1. Introduction

Chalcolithic settlements and societies on the Anatolian Plateau have received relatively little attention in comparison to earlier Neolithic and later Bronze Age sites and consequently the economy and society of prehistoric communities in this region are poorly understood (e.g. Parzinger, 1993; Steadman, 1995; Özdoğan, 1996; Düring, 2008; Schoop, 2011a). Çamlıbel Tarlası (ÇBT) is one of only a small number of prehistoric sites to have been excavated in north-central Anatolia (Schoop et al., 2009; Schoop, 2010, 2011b). Stable carbon and nitrogen isotope analysis of human and associated animal remains from Çamlıbel Tarlası was conducted in order to reconstruct dietary intake of the small rural farming community and to assess the relative importance of plant *vs* animal foods in diet.

2. Çamlıbel Tarlası – Archaeological Background

Over three seasons (from 2007 to 2009) Çamlıbel Tarlası was excavated under the direction of one of the authors (U-DS) with the express aim of expanding knowledge of prehistoric settlement, chronology and economy in north-central Anatolia. Çamlıbel Tarlası was a small, short-lived settlement located on a small plateau (*c.* 1040 m asl) in a narrow valley, approximately 3 km from the main Budaközü Plain, in the Turkish province of Çorum (see Figure 1; Schoop, 2010, 2011b, 2015). The main activities attested at the site are agriculture and extractive metallurgy. Palynological evidence indicates that the wider region was forested (Dörfler et al., 2000; Marsh, 2010). Surrounding plateaus would have been ideally suited to small-scale agriculture (cultivation and livestock husbandry). An outcrop of copper ore is located ~2 km to the east of the site (Marsh, 2010).

Figure 1. Map of Anatolia indicating the location of Çamlıbel Tarlası.

Seven phases of activity have been identified at Çamlıbel Tarlası (Table 1) and these have been dated to the Late Chalcolithic (Table 2). The earliest phase of activity (ÇBT I) is represented by numerous bowl furnaces, possible copper smelting installations cut into the ground surface and insulated with layers of potsherds, stones and clay. Following this initial phase of activity, there were three construction phases (ÇBT II, ÇBT III and ÇBT IV) interspersed with three non-architectural phases (phases of ephemeral use – FPEU, SPEU and TPEU) during which Çamlıbel Tarlası saw human activity probably on a seasonal basis. The whole sequence dates between 3650 and 3375 cal BC (Table 2).

Phase	Characteristic Features
TPEU	Fragmentary burials in plough zone
ÇBT IV	Habitations, large courtyard with evidence of slag processing, slag, crucibles
SPEU	Second phase of ephemeral use: seasonal presence, bowl furnaces, ore
ÇBT III	Large, free-standing buildings, crucibles, copper slag
FPEU	First phase of ephemeral use: seasonal presence, bowl furnaces, ore
ÇBT II	Dense architecture, room clusters, bowl furnaces, copper ore, many infant graves
ÇBT I	No habitation structures, water course, seasonal use?, bowl furnaces, copper ore
Virgin Soil / Bedrock	

Table 1. Phases of activity at Çamlıbel Tarlası

Lab. No	Botanical ID	Context	ÇBT Phase	^{14}C (BP)	cal BC age range (2Ã)
OZK 882	*Lolium* seed	floor	ÇBT IV	4735±40	3640-3375
OZK 883	Cereal grain	floor	ÇBT IV	4790±30	3610-3515
OZK 886	Cereal grain	floor	ÇBT II	4725±35	3635-3525
OZK 887	Cereal grain	floor	ÇBT II	4780±30	3640-3535

Table 2. Çamlıbel Tarlası radiocarbon determinations. Data from Schoop et al. (2009). The calibrated age ranges are quoted with endpoints rounded outwards to 5 years, following Mook (1986). The ranges have been calculated using the maximum intercept method (Stuiver and Reimer 1986), the IntCal13 calibration curve (Reimer et al. 2013) and the computer program OxCal v4.2.3 (Bronk Ramsey 2009).

3. Çamlıbel Tarlası – Human Remains

A large number of child burials were discovered within the settlement, either underneath the house floors or externally, in immediate juxtaposition to the house walls. Intramural burial appears to have been reserved for children; the few adults from Çamlıbel Tarlası appear to have been buried during the episodes without permanent settlement at the site. Nineteen individuals were excavated from 17 jar burials and primary inhumations at Çamlıbel Tarlası (Thomas, 2011; Irvine et al., 2014). Two distinct burial practices were observed at Çamlıbel Tarlası: although both children and adults were inhumed in a contracted, ‘hocker’, position with the head pointing to the south and facing towards the east, most of the very young children were interred in large pottery vessels (see Table 3; Schoop et al., 2009; 2011b). In addition to these identifiable graves, more human bones were recovered as isolated finds. All of these 68 instances were individual bones or small assemblages of bones in secondary contexts. These finds suggest that burial at the site continued during the non-residential episodes which generated comparatively little in the way of archaeological deposits. Such graves were exposed to disturbance during the construction activities of the following habitation phase. Despite their relocation, all of these bones are well-preserved and do not appear to have been subject to deposition conditions much different to those of the undisturbed graves.

Grave	GUSI	Context ID	Type	Age (Sex)	Phase
G 1	3106	204-1103	Jar Burial	9–15 mo	ÇBT II
G 2*	-	327-921	Jar Burial	0–3 mo	ÇBT II
G 3	3138	80-1086	Hocker	2–4 y	pre-ÇBT III
G 4	1579	406-3224	Hocker	8–10 y	ÇBT III
G 5	2282	464-4072	Hocker	6–8 y	unclear, probably pre-ÇBT IV
G 6	3240	649-4295	Jar Burial	18–24 mo	pre-ÇBT IV
G 7	3099	817-4779	Jar Burial	3–5 y	ÇBT III
G 8	2281	851-5543	Hocker	20–30 y (F)	probably TPEU
G 9	3101	859-5529	Hocker? (disturbed)	18–24 mo	ÇBT II
G 10	3141	923-5423	Jar Burial	foetus	ÇBT III
G 11	2278	970-6074	Hocker	7–9 y	ÇBT II
G 12	2279	884-5879	Hocker	30–40 y (M)	ÇBT I
G 13	2336	950-6118	Hocker	6–8 y	ÇBT II
G 14	3100	971-6144	Hocker	4–5 y	ÇBT II
G 15	3239	978-6140	Jar Burial	foetus–3 mo	ÇBT II
G 16	3142	894-5878	Jar Burial	15–18 mo	ÇBT II
G 17	2337	1010-5876	Hocker	12–15 mo	ÇBT II

Table 3. Contextual information of Çamlıbel Tarlası burials sampled for carbon and nitrogen isotope measurements. * - indicates insufficient collagen was recovered from the specimen for mass spectrometric analysis.

The human remains recovered from Çamlıbel Tarlası were recorded and age and sex determined according to the osteological standards set out in Van Beek (1983), Buikstra and Ubelaker (1994) and Bass (1995). Sex could be attributed in only three cases (Thomas, 2011).

Dental pathologies that may relate to diet were identified in ten individuals: signs of dental wear, which ranged from slight to extreme, were apparent in six children, two individuals >12 years and two adults (Irvine et al., 2014). Moderate to severe attrition was noted in four children aged between approximately 4 and 10 years. Patterns of dental wear and cupping at Çamlıbel Tarlası are consistent with a diet high in processed grains (Irvine et al., 2014). One child, aged 2–3 years, and another aged 4–5 years, have enamel hypoplasia (Irvine et al., 2014), which may be an indicator of physiological stress (Goodman et al., 1980).

4. Subsistence Indicators at Çamlibel Tarlasi

Traditionally, the diets of past populations have been reconstructed at the population level from the remains of plants and animals, as well as subsistence-related artefacts and features, recovered from archaeological sites.

The faunal assemblage from Çamlıbel Tarlası is dominated by the remains of domesticates: primarily cattle (*Bos taurus*) and pig (*Sus scrofa*) with the remains of caprines also common (Figure 2, see also Bartosiewicz and Gillis, 2011, table 10). Wild animal species constitute a tiny proportion of the assemblage (0.9% by NISP and 0.8% by weight) and may not have been taken for meat (Bartosiewicz and Gillis, 2011). The species representation at Çamlıbel Tarlası suggested that there had been "a heavy reliance on animal keeping at the settlement" (2011: 77) and a "dominance of beef in the meat diet" (Bartosiewicz and Gillis, 2011: 78). Secondary produce may have been exploited; cattle may have been used for traction and sheep may have been kept primarily for wool, while pigs would have been kept for meat (Bartosiewicz and Gillis, 2011).

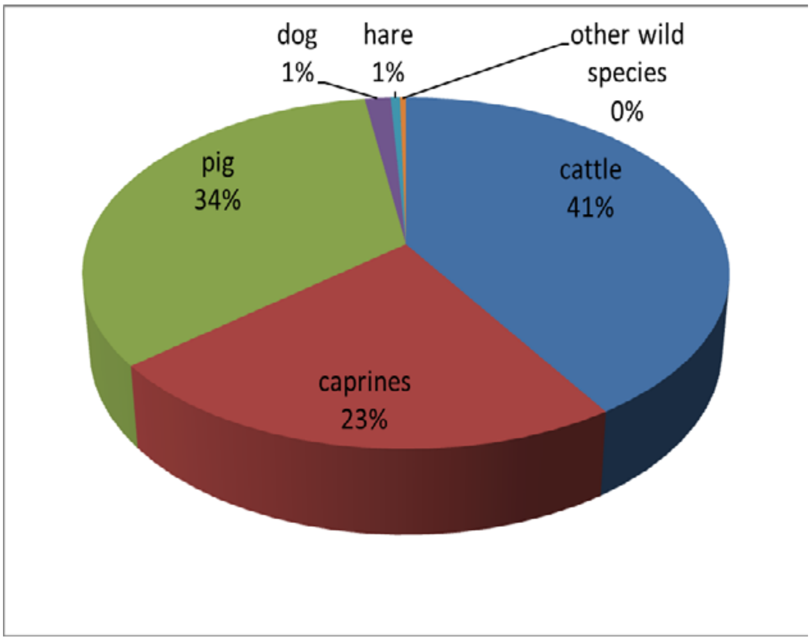

Figure 2. Animal taxa representation at Çamlıbel Tarlası by NISP (Total NISP = 2752).

Among the plant remains identified at Çamlıbel Tarlası, six crops are described as ‘reasonably abundant’: einkorn (*Triticum monococcum*), emmer (*T. dicoccum*) and ‘new type’ wheat, barley (*Hordeum vulgare*), lentil (*Lens culinaris*) and bitter vetch (*Vicia ervilia*) (Papadopoulou and Bogaard, 2012). Also recovered were small quantities of chickpea (*Cicer arietinum*), grass pea (*Lathyrus sativus/cicera*), Spanish vetchling (*L. ochrus*), and flax (*Linum* sp.), grasses (*Lolium* sp. and *Phalaris* sp.) with free-threshing wheat (*T. aestivum/durum*) tentatively identified (Papadopoulou and Bogaard, 2012). All of the plants identified to species/genus level have a C_3 photosynthetic pathway. A possible grain store, comprised of four chambers with stone foundations was identified at ÇBT I (Schoop, 2010). A few similar elevated storage features were identified in later settlement phases, while storage pits appear largely absent from Çamlıbel Tarlası. The importance of plant foods is underscored by finds of flint blades with ‘sickle gloss’ (Mili•, 2014).

Numerous finds of fragments of pottery churns point to the importance of dairy produce at the site. This is further supported by the identification of animal fats, in one case likely milk fat or a derivative, on two churn fragments analysed by gas chromatography from nearby, probably contemporaneous Yarıkkaya (Sauter et al., 2003, figs 1–3).

The initial impression gained from the analysis of animal and plant remains was that the inhabitants of Çamlıbel Tarlası subsisted largely on the meat of cattle and pig, dairy produce, and on wheat and barley. Stable carbon and nitrogen analysis of humans and associated faunal remains allows us to test this hypothesis and assess whether there are individual differences in dietary intake.

5. Stable Isotope Analysis and Dietary Reconstruction

Carbon (´^{13}C) and nitrogen (´^{15}N) stable isotope ratios in bone collagen have been demonstrated to be reliable indicators of dietary protein intake at the level of the individual (e.g. Chisholm et al., 1983; Schoeninger, 2010). ^{12}C/^{13}C isotopes are incorporated into plant tissues during photosynthesis. Carbon isotope ratios (´^{13}C) vary between plants depending on the mechanism used to fix atmospheric carbon. Most plants fix carbon through one of two routes, either the C_3 or C_4 photosynthetic pathway. C_3 plants comprise of cereals such as wheat and barley, and most fruits and vegetables, while C_4 plants include some tropical grasses, and cereals such as millet, sorghum, and maize. C_3 plants generally have ´^{13}C values significantly more depleted in ^{13}C than C_4 plants: modern C_3 plants have average ´^{13}C values of c. -26.5‰, while those of C_4 plants average c. -12.5‰ (Smith and Epstein 1971; Tieszen 1991). This variation in plant ´^{13}C is passed on through the food chain to the tissues of animal and human consumers. Fractionation (^{13}C-enrichment) occurs between plants and herbivores and again between herbivores and their human consumers. This results in a human-diet ´^{13}C offset of c. +5‰. Humans eating C_3 plants or C_3 plant consumers will have ´^{13}C values in the range -22‰ to -18‰, while those consuming predominantly C_4 plants or C_4 plant consumers will have ´^{13}C values in the range -11‰ to -7‰ (Tykot 2004). The ´^{13}C value of human bone collagen can therefore be used to determine the relative importance of C_3 *vs* C_4 plants and their consumers to diet (Vogel and van der Merwe, 1977; Tykot 2006).

^{14}N/^{15}N isotopes may be incorporated into plants from soils and can also be drawn from atmospheric N_2. Nitrogen isotope ratios (´^{15}N) exhibit a 'trophic level' effect, becoming more enriched in ^{15}N or 'heavier' with each step in the food chain. Enrichment of c. 3–5‰ between predator and prey has been observed in archaeological specimens (Bocherens and Drucker, 2003) although analyses of modern human tissue samples suggest that the diet to bone collagen enrichment may be greater than this, in the order of 6‰ (O'Connell et al., 2012).

Within a single biome plants have lower ´^{15}N values than herbivores, which in turn have lower values than carnivores (Katzenberg, 2000). ´^{15}N values can therefore indicate the relative contribution of plant *vs* animal proteins to diet and may also indicate the type of animal protein in diet, i.e. herbivore, omnivore, carnivore (DeNiro and Epstein, 1981).

´^{13}C and ´^{15}N values can also be used to explore the consumption of terrestrial *vs* aquatic foods. Freshwater resources have similar ´^{13}C values to terrestrial foods; however, ´^{13}C values vary between terrestrial/freshwater and marine foodwebs owing to differences in environmental carbon sources, with marine resources normally being relatively enriched in ^{13}C. Generally, high trophic level aquatic resources also have enriched ´^{15}N values, as aquatic foodwebs tend to be more complex, comprising more trophic levels, and may also be enriched through bacterial activity (Chisholm et al., 1982; Schoeninger and DeNiro, 1984; Schoeninger, 2010).

Thus co-analysis of ´^{13}C and ´^{15}N of humans and associated faunal remains can distinguish between diets based on terrestrial C$_3$ and C$_4$ plant foodwebs, freshwater and marine resources, and may also identify the trophic level of the consumer (Tykot, 2004).

5.1 Materials and Methods

Diet at Çamlıbel Tarlası was reconstructed from the ´^{13}C and ´^{15}N measurements of samples of human bone collagen and a comparative assemblage of faunal remains.

All of the formal/primary burials were sampled for ´^{13}C and ´^{15}N analysis (see Tables 3 and 4 for the contextual and demographic information of the human remains; 17 of 19 individuals had well preserved bone collagen). The other human remains (i.e. the secondary deposits), were selectively sampled to minimise the chance of sampling the same individual more than once. At most, only one element was sampled from each secondary deposit. Samples were further selected or discarded based on the age, sex and skeletal elements represented in the overall assemblage (i.e. where recovered skeletal elements likely belonged to an individual already sampled they were omitted from the analysis). Stratigraphic evidence was also taken into consideration when sub-sampling the secondary deposits of human remains. With the exception of three samples, discussed below, it is likely that the samples selected from the secondary deposits are from different individuals. A total of 58 human specimens were sampled.

Specimens of both domestic (dog, pig, goat/sheep and cattle) and wild game animals (wild sheep, deer and brown hare) from Çamlıbel Tarlası were selected to provide an indication of local foodweb isotope values for the interpretation of human diet. The animal bone samples were mostly taken from well-defined contexts, preferably from internal or external floors and the deposits covering these features. Visibly weathered or burnt specimens were rejected for analysis. Generally speaking, the taphonomic context of the animal bone sample is similar to that of the isolated human bones. A total of 182 animal specimens were sampled – Table 5.

Phase	**Sample (GUsi)**	**Skeletal element**	**Context**	**Age/Sex**	**´ ^{13}C**	**´ ^{15}N**	**C/N**	**%N**	**%C**
ÇBT I	2279	long bone	Grave 12	30-40 y (M)	-19.1	8.5	3.2	13.7	37.7
	2904	cranium	secondary	juvenile	-19.4	7.8	3.2	13.8	37.9
	2914	cranium	secondary	infant	-19.4	10.5	3.2	15.6	42.6
	2915	humerus	secondary	juvenile	-19.1	8.5	3.2	15.1	41.2
	2918	tibia	secondary	1 y	-17.8	12.2	3.2	14.6	40.0
	2920	long bone	secondary	adult	-18.9	8.9	3.2	11.0	29.9
	3087	rib	secondary	juvenile	-19.8	7.0	3.5	4.1	12.2
	3104	cranium	secondary	juvenile	-19.2	7.7	3.3	12.5	35.5
ÇBT I/II	3010	scapula	secondary	juvenile	-18.9	7.0	3.2	14.4	39.7
ÇBT I/III	3007	fibula	secondary	adult	-19.0	8.5	3.2	15.3	42.1
ÇBT II	2278	femur	Grave 11	7-9 y	-19.2	8.0	3.2	14.9	41.1
	2336	rib	Grave 13	6-8 y	-19.0	6.6	3.2	12.7	35.1
	2337	fibula	Grave 17	12-15 mo	-19.0	7.8	3.2	13.7	37.5
	2902	cranium	secondary	adult	-18.8	8.9	3.2	15.1	41.3
	2911	rib	secondary	6-8 y?	-18.9	7.0	3.2	14.0	38.4
	2921	femur	secondary	juvenile	-19.1	7.8	3.2	15.0	40.7
	2922	calcaneus	secondary	adult	-18.7	9.4	3.2	13.3	36.5
	2925	scapula	secondary	adult	-18.9	8.1	3.2	14.2	38.4
	3009	scapula	secondary	adult	-18.8	6.9	3.2	11.6	32.0
	3100	rib	Grave 14	4-5 y	-19.0	7.6	3.3	14.2	39.5
	3101	rib	Grave 9	18-24 mo	-18.3	11.0	3.2	11.0	30.5
	3106	rib	Grave 1	9-15 mo	-17.9	12.0	3.3	11.4	32.0
	3142	rib	Grave 16	15-18 mo	-18.1	11.7	3.2	14.4	40.0
	3239	rib	Grave 15	foetus-3 mo	-18.5	8.8	3.2	12.3	34.4
ÇBT II/III	2910	tibia	secondary	adult	-19.1	7.9	3.2	15.1	41.3
	3102	cranium	secondary	adult	-19.0	9.3	3.3	9.7	27.3

pre-ÇBT III	3138	rib	Grave 3	2-4 y	-18.8	9.6	3.2	8.9	24.6
ÇBT III	1579	rib	Grave 4	8-10 y	-18.8	7.3	3.3	12.5	34.9
	2905	femur	secondary	adult	-19.0	7.4	3.2	9.6	26.6
	2908	rib	secondary	adult	-18.9	8.7	3.2	13.6	37.3
	2909	rib	secondary	adult	-18.9	9.2	3.2	13.5	36.9
	2913	long bone	secondary	adult	-18.8	8.1	3.2	14.5	39.6
	2916	cranium	secondary	adult	-18.9	8.7	3.2	14.9	41.1
	2917	femur	secondary	adult	-19.1	7.4	3.2	11.2	31.1
	2919	metacarpal	secondary	juvenile	-19.1	8.1	3.1	12.1	32.3
	2923	cranium	secondary	adult	-18.9	8.4	3.2	12.7	34.6
	2924	cranium	secondary	juvenile	-19.2	8.4	3.2	11.1	30.6
	3005	humerus	secondary	adult	-18.9	8.4	3.2	14.6	40.4
	3006	cranium	secondary	juvenile	-19.0	8.4	3.2	15.0	41.6
	3008	ulna	secondary	juvenile	-19.3	8.0	3.2	10.8	30.2
	3011	cranium	secondary	adult	-18.9	8.7	3.2	12.8	35.1
	3012	tibia	secondary	adult?	-19.0	7.9	3.2	12.8	35.2
	3013	vertebra	secondary	adult	-18.9	9.7	3.3	13.2	36.9
	3014	clavicle	secondary	juvenile	-18.5	7.3	3.2	12.1	33.5
	3099	rib	Grave 7	3-5 y	-19.1	8.6	3.2	12.8	35.6
	3141	tibia	Grave 10	foetus	-18.4	8.9	3.3	23.3	8.2
ÇBT III/IV	2912	cranium	secondary	adult	-19.3	7.8	3.3	12.7	35.4
	2907	rib	secondary	juvenile	-18.5	8.7	3.2	12.8	35.2
	2280	femur*	secondary	adult	-19.1	7.5	3.2	13.1	36.2
	3105	cranium*	secondary	adult	-19.4	10.0	3.2	13.7	38.2
	3103	humerus	secondary	perinate	-18.9	10.9	3.4	9.1	26.4
Pre-ÇBT IV	3240	longbone	Grave 6	18-24 mo	-18.0	11.1	3.2	13.1	36.3
Probably pre-ÇBT IV	2282	long bone	Grave 5	6-8 y	-19.1	7.4	3.2	12.3	33.5
ÇBT IV	2903	metacarpal	secondary	juvenile	-19.0	7.6	3.2	14.3	39.2
	2906	cranium	secondary	?	-19.0	8.4	3.2	14.5	39.6
TPEU	2277	femur	disturbed grave in plough zone	21+ y	-18.6	7.7	3.2	14.5	39.9
Probably TPEU	2281	femur	Grave 8	20-30 y (F)	-19.3	7.3	3.4	5.7	16.5

Table 4. Contextual information and age and sex determination of Çamlıbel Tarlası humans measured for carbon and nitrogen isotope composition. * - indicates bones with cut marks.

Sample ID (GUsi)	Species	Phase	´ ^{13}C	´ ^{15}N	C/N	%N	%C
2202	Cattle (*Bos*)	ÇBT III	-19.4	5.9	3.1	13.8	37.1
2205	Cattle (*Bos*)	FPEU	-19.6	6.0	3.2	14.6	39.9
2207	Cattle (*Bos*)	ÇBT III	-19.4	8.0	3.2	13.3	35.9
2270	Cattle (*Bos*)	ÇBT III	-18.1	6.2	3.2	13.6	37.7
2271	Cattle (*Bos*)	ÇBT IV	-18.9	7.7	3.2	14.8	40.7
2272	Cattle (*Bos*)	ÇBT III	-17.6	9.8	3.2	14.2	39.1
2273	Cattle (*Bos*)	ÇBT IV	-19.0	8.1	3.2	14.3	39.8
2274	Cattle (*Bos*)	ÇBT II	-19.4	9.7	3.2	13.3	36.7
2275	Cattle (*Bos*)	ÇBT I	-16.8	7.0	3.2	12.1	33.6
2276	Cattle (*Bos*)	ÇBT I	-18.3	6.1	3.2	13.7	37.5
2326	Cattle (*Bos*)	ÇBT II	-19.4	6.7	3.2	13.3	36.9
2327	Cattle (*Bos*)	ÇBT I	-18.2	6.8	3.3	15.6	43.9
2328	Cattle (*Bos*)	ÇBT III	-20.1	7.0	3.2	13.6	37.4
2329	Cattle (*Bos*)	ÇBT I	-19.9	6.1	3.2	15.8	43.9
2330	Cattle (*Bos*)	ÇBT II	-19.5	8.6	3.3	14.1	39.5
2331	Cattle (*Bos*)	ÇBT I	-18.7	6.5	3.3	15.6	43.4
2332	Cattle (*Bos*)	ÇBT I	-18.3	6.7	3.3	15.4	43.4
2333	Cattle (*Bos*)	ÇBT IV	-18.8	6.3	3.2	12.4	34.1
2334	Cattle (*Bos*)	ÇBT II	-17.4	8.9	3.3	14.9	41.6
2335	Cattle (*Bos*)	ÇBT IV	-18.2	9.1	3.2	14.7	40.8
3096	Cattle (*Bos*)	SPEU	-19.6	6.4	3.3	11.4	31.8
3114	Cattle (*Bos*)	FPEU	-18.5	5.5	3.2	11.3	31.4
3115	Cattle (*Bos*)	ÇBT I	-17.0	7.5	3.2	11.8	32.6
3116	Cattle (*Bos*)	ÇBT IV	-17.5	7.4	3.3	10.7	30.1
3117	Cattle (*Bos*)	ÇBT III/IV	-20.1	7.4	3.3	13.0	36.7
3118	Cattle (*Bos*)	ÇBT III	-17.6	7.4	3.2	14.2	39.4
3119	Cattle (*Bos*)	ÇBT I	-17.6	6.5	3.3	13.8	38.9
3120	Cattle (*Bos*)	ÇBT II	-19.7	7.3	3.3	13.7	38.6
3135	Cattle (*Bos*)	ÇBT I	-18.8	6.8	3.3	12.7	36.3
3136	Cattle (*Bos*)	ÇBT III	-19.3	6.2	3.3	13.1	37.0
3137	Cattle (*Bos*)	ÇBT III	-18.4	6.5	3.3	10.3	29.2
3143	Cattle (*Bos*)	ÇBT I	-18.2	6.9	3.2	13.6	37.5
3144	Cattle (*Bos*)	ÇBT IV	-18.3	6.3	3.2	12.4	34.3
3145	Cattle (*Bos*)	SPEU	-19.2	7.5	3.2	14.3	39.7
3147	Cattle (*Bos*)	FPEU	-17.7	6.8	3.2	12.3	34.2
3149	Cattle (*Bos*)	SPEU	-18.1	8.2	3.3	10.6	29.8
3154	Cattle (*Bos*)	SPEU	-19.2	5.9	3.2	13.1	36.2
3155	Cattle (*Bos*)	SPEU	-19.5	6.0	3.3	11.6	32.4
3156	Cattle (*Bos*)	FPEU	-19.8	7.1	3.2	11.7	32.4
3157	Cattle (*Bos*)	ÇBT I	-20.0	6.1	3.2	12.4	34.3
2325	Caprine	ÇBT III	-19.2	6.5	3.2	14.8	41.3
3017	Caprine	ÇBT IV	-18.6	7.9	3.2	12.7	35.2
3022	Caprine	ÇBT I	-19.6	7.3	3.3	14.5	40.3
3023	Caprine	ÇBT II	-19.4	6.6	3.3	12.4	34.6
3092	Caprine	ÇBT III	-19.5	7.2	3.2	13.2	36.7

3254	Caprine	ÇBT I	-19.4	6.1	3.2	13.2	36.8
3255	Caprine	ÇBT II	-19.9	5.5	3.3	5.0	14.2
3256	Caprine	ÇBT I	-19.3	6.1	3.2	13.2	36.4
3257	Caprine	ÇBT II/III	-19.4	7.2	3.2	13.1	36.2
3258	Caprine	ÇBT III/IV	-19.6	7.2	3.3	7.2	24.1
3259	Caprine	ÇBT III	-18.8	6.2	3.2	14.3	39.6
3090	Goat (*Capra hircus*)	SPEU	-20.2	4.9	3.3	15.3	43.1
3161	Goat (*Capra hircus*)	ÇBT IV	-18.0	6.0	3.2	13.4	37.2
3164	Goat (*Capra hircus*)	ÇBT III	-19.3	5.1	3.2	10.6	29.1
3168	Goat (*Capra hircus*)	SPEU	-19.6	6.5	3.2	8.9	24.8
2204	Sheep (*Ovis aries*)	ÇBT I	-18.8	5.7	3.2	12.0	32.5
2268	Sheep (*Ovis aries*)	ÇBT III	-19.4	7.8	3.3	13.7	38.2
3018	Sheep (*Ovis aries*)	ÇBT IV	-19.7	5.4	3.3	12.1	34.0
3019	Sheep (*Ovis aries*)	ÇBT I	-19.0	6.2	3.3	15.5	43.4
3020	Sheep (*Ovis aries*)	FPEU	-19.2	7.1	3.2	13.9	38.4
3021	Sheep (*Ovis aries*)	ÇBT III	-19.6	6.4	3.3	7.6	21.8
3024	Sheep (*Ovis aries*)	ÇBT I	-18.1	6.7	3.2	13.7	38.0
3025	Sheep (*Ovis aries*)	ÇBT III	-19.2	7.0	3.3	13.5	37.6
3026	Sheep (*Ovis aries*)	ÇBT I	-19.0	6.1	3.2	14.7	40.6
3027	Sheep (*Ovis aries*)	ÇBT II	-19.3	6.1	3.2	13.4	36.9
3089	Sheep (*Ovis aries*)	ÇBT III	-19.2	6.4	3.2	15.6	43.2
3091	Sheep (*Ovis aries*)	SPEU	-18.7	6.6	3.3	11.0	30.7
3093	Sheep (*Ovis aries*)	ÇBT III	-19.6	7.1	3.2	14.6	40.4
3094	Sheep (*Ovis aries*)	ÇBT IV	-19.0	6.2	3.2	13.1	36.3
3095	Sheep (*Ovis aries*)	ÇBT IV	-19.1	6.0	3.2	13.6	37.7
3097	Sheep (*Ovis aries*)	SPEU	-20.2	5.6	3.2	14.6	40.6
3098	Sheep (*Ovis aries*)	FPEU	-19.3	6.5	3.3	7.7	21.9
3158	Sheep (*Ovis aries*)	ÇBT II	-19.5	5.9	3.3	13.9	38.8
3163	Sheep (*Ovis aries*)	FPEU	-18.2	5.9	3.2	13.5	36.9
3250	Sheep (*Ovis aries*)	ÇBT I	-18.8	7.1	3.3	14.6	40.9

3252	Sheep (*Ovis aries*)	ÇBT III	-19.3	6.5	3.2	14.2	39.6
3251	Sheep (*Ovis aries*)	ÇBT II	-18.5	5.7	3.2	13.0	35.8
3253	Sheep (*Ovis aries*)	FPEU	-19.6	6.0	3.2	13.9	38.5
3140	Wild sheep (*Ovis*)	ÇBT II	-18.7	6.3	3.3	9.1	25.6
2203	Pig (*Sus*)*	ÇBT III	-19.0	7.3	3.2	13.1	35.8
2651	Pig (*Sus*)*	SPEU	-20.1	5.5	3.2	9.8	27.4
2652	Pig (*Sus*)*	ÇBT III	-19.5	7.1	3.2	13.7	37.8
2653	Pig (*Sus*)*	ÇBT I	-19.9	5.6	3.4	4.5	12.9
2655	Pig (*Sus*)*	ÇBT II	-18.7	4.7	3.3	8.5	24.0
2657	Pig (*Sus*)*	ÇBT II	-19.2	7.3	3.2	11.8	32.9
2658	Pig (*Sus*)*	ÇBT IV	-18.9	5.9	3.3	10.2	29.0
2659	Pig (*Sus*)*	ÇBT II	-19.4	6.6	3.3	9.7	27.1
2661	Pig (*Sus*)*	FPEU	-19.8	8.0	3.2	9.7	26.9
2662	Pig (*Sus*)*	ÇBT IV	-19.8	6.7	3.3	10.9	30.9
2663	Pig (*Sus*)*	ÇBT III	-20.2	5.7	3.4	7.3	21.2
2664	Pig (*Sus*)*	SPEU	-20.0	6.5	3.3	8.9	25.3
2666	Pig (*Sus*)*	ÇBT IV	-18.7	6.0	3.3	8.7	24.8
2667	Pig (*Sus*)*	ÇBT II	-19.4	6.4	3.3	12.6	35.5
2668	Pig (*Sus*)*	FPEU	-19.7	7.6	3.5	4.0	12.0
2669	Pig (*Sus*)*	ÇBT IV	-20.3	6.7	3.3	10.4	29.2
2926	Pig (*Sus*)	ÇBT I	-19.1	6.0	3.2	13.2	36.2
2927	Pig (*Sus*)	ÇBT IV	-19.6	7.2	3.2	15.4	42.1
2928	Pig (*Sus*)	ÇBT I	-19.4	6.3	3.2	13.5	37.1
3015	Pig (*Sus*)	ÇBT I	-19.0	6.7	3.2	14.1	39.1
3016	Pig (*Sus*)	SPEU	-19.4	7.1	3.2	13.4	37.1
3088	Pig (*Sus*)	ÇBT IV	-19.5	6.9	3.2	9.4	26.1
3122	Pig (*Sus*)	ÇBT I	-19.6	6.6	3.3	9.0	25.3
3123	Pig (*Sus*)	ÇBT III	-19.4	6.9	3.3	9.6	27.4
3124	Pig (*Sus*)	ÇBT III	-19.3	7.0	3.3	9.8	27.5
3125	Pig (*Sus*)	ÇBT III	-20.3	6.7	3.3	13.5	38.0
3126	Pig (*Sus*)	ÇBT II	-19.8	6.2	3.3	9.6	27.0
3127	Pig (*Sus*)	ÇBT I	-19.6	7.7	3.2	12.9	35.6
3128	Pig (*Sus*)	ÇBT III	-19.5	7.6	3.3	14.0	39.2
3129	Pig (*Sus*)	ÇBT II	-19.4	6.5	3.2	12.1	33.7
3130	Pig (*Sus*)	SPEU	-19.0	8.2	3.3	12.4	34.7
3131	Pig (*Sus*)	ÇBT I	-19.3	6.1	3.3	9.8	27.4
3132	Pig (*Sus*)	FPEU	-19.0	6.8	3.3	12.5	35.2
3133	Pig (*Sus*)	ÇBT III	-19.2	7.8	3.4	5.6	16.4
3134	Pig (*Sus*)	ÇBT II	-19.3	7.0	3.2	11.6	32.2
3139	Pig (*Sus*)	ÇBT III	-20.3	6.4	3.3	10.5	29.6
3148	Pig (*Sus*)	SPEU	-19.1	7.3	3.2	8.7	24.3
3150	Pig (*Sus*)	ÇBT III	-19.0	6.0	3.2	11.8	32.8
3151	Pig (*Sus*)	ÇBT III	-19.0	6.6	3.2	12.6	35.1
3152	Pig (*Sus*)	ÇBT III	-19.0	7.1	3.2	13.0	36.1
3153	Pig (*Sus*)	ÇBT I	-19.5	6.0	3.2	13.4	36.9
3159	Pig (*Sus*)	FPEU	-18.3	5.4	3.2	8.8	24.4

3160	Pig (*Sus*)	FPEU	-19.5	7.6	3.2	12.0	32.8
3162	Pig (*Sus*)	ÇBT III	-19.3	6.6	3.2	12.6	35.0
3165	Pig (*Sus*)	ÇBT III	-19.0	7.3	3.3	10.0	28.0
3166	Pig (*Sus*)	ÇBT I	-18.6	6.0	3.2	18.3	50.7
3167	Pig (*Sus*)	ÇBT I	-18.8	6.4	3.2	13.0	35.9
3242	Pig (*Sus*)	ÇBT II	-19.2	6.7	3.2	13.5	37.4
3243	Pig (*Sus*)	ÇBT II/III	-19.4	7.3	3.3	13.8	38.6
3245	Pig (*Sus*)	FPEU	-19.1	7.8	3.2	11.3	31.1
3249	Pig (*Sus*)	ÇBT III	-19.4	7.1	3.2	10.0	27.8
3246	Pig (*Sus*)	ÇBT II	-19.9	6.6	3.3	13.2	36.8
3247	Pig (*Sus*)	ÇBT III	-19.9	7.0	3.2	12.0	33.3
3248	Pig (*Sus*)	FPEU	-19.4	6.0	3.3	12.3	34.5
2206	Dog (*Canis familiaris*)	ÇBT I	-19.4	6.2	3.1	12.6	34.0
3109	Dog (*Canis familiaris*)	ÇBT III	-19.0	7.7	3.2	12.7	35.1
3110	Dog (*Canis familiaris*)	ÇBT I	-18.9	8.3	3.2	12.4	34.2
3111	Dog (*Canis familiaris*)	ÇBT I	-19.3	6.1	3.3	11.0	30.9
3112	Dog (*Canis familiaris*)	ÇBT II	-18.9	6.9	3.2	13.5	37.4
3113	Dog (*Canis familiaris*)	FPEU	-18.6	9.8	3.3	11.3	32.2
3121	Dog (*Canis familiaris*)	ÇBT II	-18.9	7.2	3.2	10.9	30.4
3146	Dog (*Canis familiaris*)	ÇBT III	-19.4	6.5	3.3	8.3	23.3
3107	Hare (*Lepus* sp.)	ÇBT III/IV	-20.3	5.1	3.4	7.0	20.6
3108	Hare (*Lepus* sp.)	ÇBT II/FPEU	-21.6	2.5	3.3	10.9	30.6
3260	Deer (Cervidae)	SPEU	-20.1	5.1	3.2	10.6	29.6
3261	Deer (Cervidae)	FPEU	-19.5	6.7	3.3	4.6	13.0

Table 5. Stable isotope data and collagen preservation indicators of Çamlıbel Tarlası animal remains.*- indicates previously published in Vaughan et al. (2013).

5.2 Method

A ~1 g sample of human bone was taken from the cortical bone of each individual. Collagen was extracted from the sample 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, ultra-sonication in milli-Q™ purified water (carbon content <3 ppb), demineralization in 1N HCl at 4°C for a minimum of 24 hours, and gelatinization in 0.03N HCl at 80°C for ~16 hours; the resulting solution was centrifuged and the supernatant lyophilized. Samples with good collagen yields, i.e.

those with %wt yield of >1.00% (van Klinken, 1999; Brock et al., 2010), were measured for ´^{13}C and ´^{15}N at the SUERC radiocarbon facility East Kilbride, UK, using a Thermo Scientific Delta V Advantage continuous-flow isotope ratio mass spectrometer (CF-IRMS) coupled via a Thermo Scientific ConfloIV to a Costech ECS 4010 elemental analyzer (EA) fitted with a pneumatic auto sampler. In-house gelatine standards, which are calibrated to the International Atomic Energy Agency (IAEA) reference materials USGS40 (L-glutamic acid, ´^{13}CV-PDB = -26.39‰), USGS41 (L-glutamic acid, ´^{13}C$_{V\text{-}PDB}$ = +37.63‰), IAEA-CH-6 (sucrose, ´^{13}C$_{V\text{-}PDB}$ = -10.45‰), USGS25 (ammonium sulphate, ´^{15}N$_{AIR}$ = -30.41‰), IAEA-N-1 (ammonium sulphate, ´^{15}N$_{AIR}$ = +0.43‰) and IAEA-N-2 (ammonium sulphate, ´^{15}N$_{AIR}$ = +20.41‰), are run in duplicate for every ten unknown samples. Results are corrected for linearity and instrumental drift, and are reported as per mil (‰) relative to the internationally accepted standards V-PDB and AIR, with 1Ã precisions of ± 0.20 and ± 0.30 for ´^{13}C and ´^{15}N, respectively.

Collagen integrity was assessed according to the following criteria: (i) C:N ratio in the range 2.9 to 3.6 (DeNiro, 1985); and (ii) minimum %C e 13% and %N e 5% (Ambrose, 1990).

From a total of 58 human specimens sampled 57 produced well-preserved collagen that fulfilled the criteria listed above, while animal bones appeared to have less well preserved collagen with 137 of a total of 182 specimens sampled meeting the requisite criteria. These data are presented in Tables 4 and 5. Sample GUsi-2911 may have been associated with Grave 13 (GUsi-2336), sample GUsi-2920 with Grave 12 (GUsi-2279) while samples GUsi-3087 and GUsi-3104 may derive from the same disturbed burial, therefore only one set of values from each of these pairs of specimens have been included from the statistical analyses and interpretation presented below.

6. Results and Discussion

Average human ´^{13}C and ´^{15}N for the sampled population at Çamlıbel Tarlası are -18.9±0.4‰ and 8.5±1.3‰ respectively. Individual variation in both ´^{13}C values (with a range from -19.8‰ to -17.8‰) and ´^{15}N values (with a range of 6.6‰ to 12.2‰) are evident (Fig. 3).

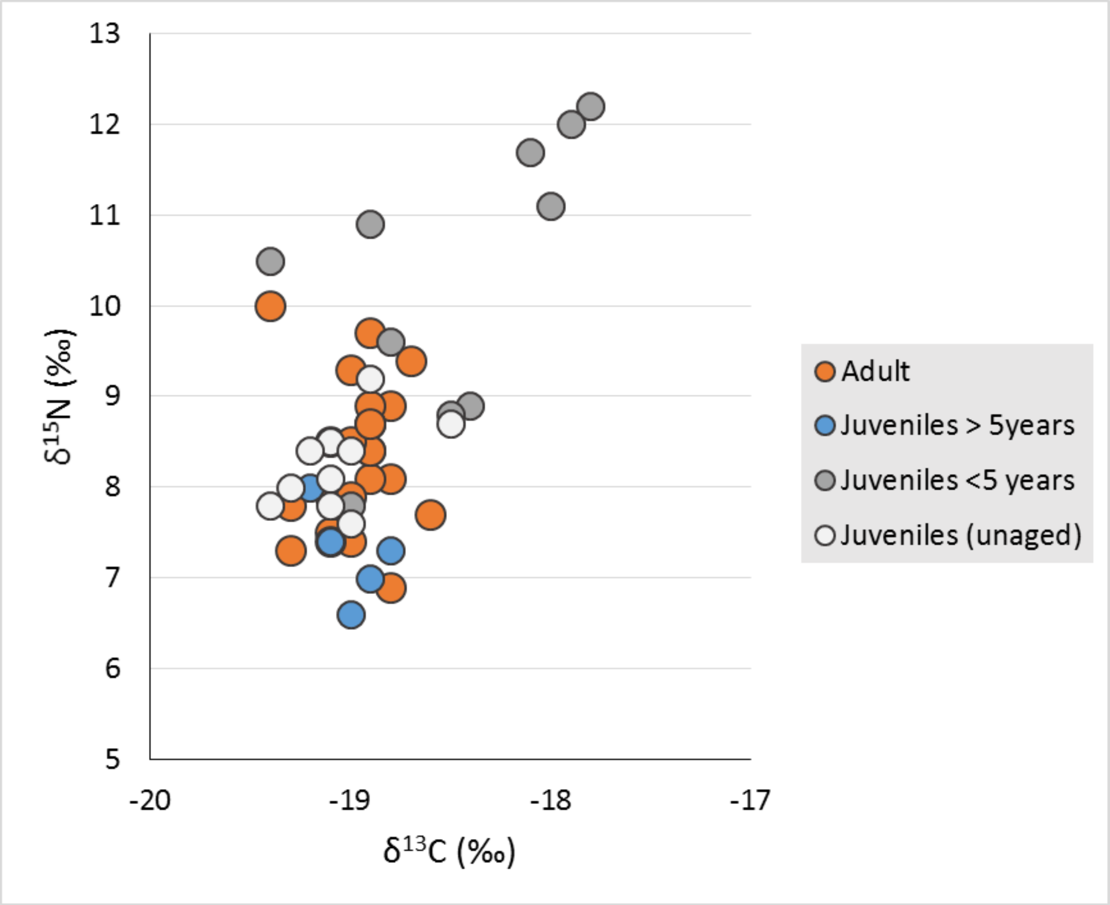

Figure 3. Scatterplot of the Çamlıbel Tarlası human δ^{13}C vs δ^{15}N values by age category.

6.1 Adult Isotope Values

Average adult δ^{13}C=-19.0±0.2‰ and δ^{15}N=8.3±0.8‰ (n=23) values are consistent with diets based principally on C_3 resources (e.g. Tykot 2004). The range of adult δ^{13}C values *may* indicate that diet included a small proportion of C_4 resources, either directly through the consumption of C_4 cereals, although none were evident at Çamlıbel Tarlası, or indirectly through the consumption of meat or other products of animals that had fed on C_4 grasses. The range of cattle δ^{13}C values, from -20.1‰ up to -17.0‰ suggests the availability of C_4 plants. While C_3 vegetation was dominant in Turkey throughout the Holocene (Rao et al., 2012), C_4 plants were present and have been recovered from Anatolian prehistoric sites and in some cases were evidently consumed by livestock (e.g. Richards et al., 2003; Cappers 2008). However, the consumption of C_4 resources is suggested tentatively as non-dietary factors, such as nutritional stress or physiology may affect isotope values (Fuller et al. 2005; Olsen et al. 2014).

Fuller et al. (2012) utilized a δ^{13}C threshold of -19.0‰ to determine C_4 input to human diet at Roman-Early Byzantine Düzen Tepe/Sagalassos in southwestern Turkey. Using the Fuller et al. (2012) value to assess C_4 intake by humans at Çamlıbel Tarlası indicates that adult diet included a small component of C_4 resources. Using a simple linear mixing model, with dietary endpoints of -19.0‰ = 100% C_3 resources and -7.0‰ = 100% C_4 resources, the highest δ^{13}C value of the Çamlıbel Tarlası adults corresponds to a 10.0-11.7% contribution of C_4 resources to human diet (allowing for δ^{13}C measurement error).

Comparison of human δ^{15}N values with those of associated faunal remains may indicate the proportion of animal *vs* plant foods in diet (Fig. 4). Average domesticate herbivore (i.e. cattle, goat and domestic sheep) δ^{15}N at Çamlıbel Tarlası is 6.7±0.9‰, while average adult human δ^{15}N is 8.3±0.8‰, i.e. there is a 1.6‰ difference in average values. These values suggest that plant foods were an important dietary staple. The range of adult δ^{15}N values (from 6.9‰ to 10.0‰) implies variation in individual intake of animal and plant proteins. Individuals with relatively low δ^{15}N values likely consumed a greater proportion of plant foods. However, uncertainty in δ^{15}N human-diet offset (e.g. Bocherens and Drucker 2003; Hedges and Reynard 2007; O’Connell et al. 2012), makes detailing the relative proportions of the different C_3 resources in diet non-trivial.

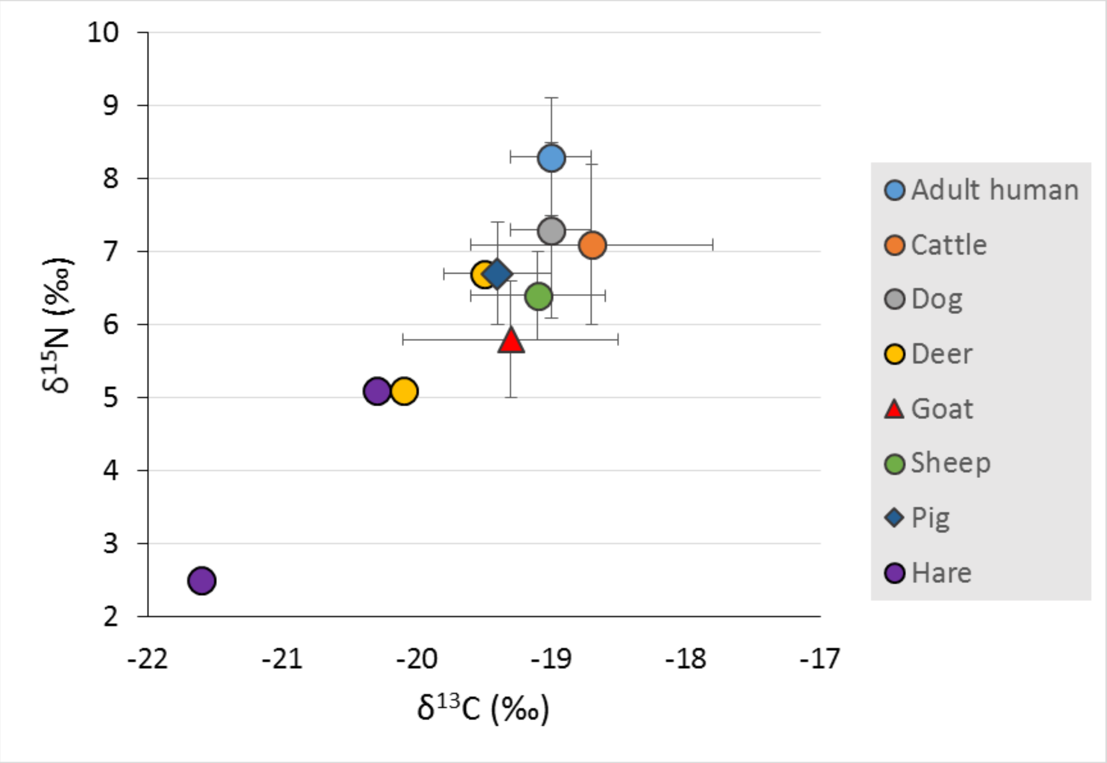

Figure 4. Scatterplot of adult human and animal remains average δ^{13}C vs δ^{15}N values with standard deviations presented as error bars. Deer and hare δ^{13}C vs δ^{15}N values are presented as individual values rather than an average with standard deviation owing to the small sample size, n=2.

Diet at Çamlıbel Tarlası has been modelled using FRUITS (Fernandes et al., 2014) to provide an indication of the proportions of cereal, pulse and animal proteins in diet with different δ^{15}N human-diet offset values (Table 6). The average nitrogen isotope values of modern and prehistoric cereals and pulses were used in the FRUITS model. Legumes can fix atmospheric N_2, and generally have δ^{15}N values of c. 0‰ (Szpak et al., 2014). Bogaard et al. (2015) presented lentil δ^{15}N values from Neolithic sites in central and southeast Europe that have an average value of 1.8‰. Average δ^{15}N values of cereals at Neolithic sites in southeast Europe were 4.6‰ (Bogaard et al., 2015). δ^{15}N values of flesh are reported to range from being comparable to bone values to being ^{15}N-enriched by +2‰ (Medaglia et al. 1990; Schulting 1998). The two extremes in offset values (i.e. 3‰ and 6‰) have very different implications for average human diet. The former suggests an important role for plants in diet, while the latter implies a dominant role.

δ^{15}N human-diet offset value (ppm)	Pulse δ^{15}N value	Cereal δ^{15}N value	Animal δ^{15}N value	Animal protein (%)	Cereal protein (%)	Pulse protein (%)
3	0.0	4.6	6.7	56	34	11
3	1.8	4.6	6.7	52	33	15
3	0.0	4.6	8.7	39	42	19
3	1.8	4.6	8.7	33	42	25
4	0.0	4.6	6.7	33	46	21
4	1.8	4.6	6.7	26	44	30
4	0.0	4.6	8.7	25	46	29
4	1.8	4.6	8.7	18	45	37
5	0.0	4.6	6.7	25	36	39
5	1.8	4.6	6.7	16	27	57
5	0.0	4.6	8.7	19	36	45
5	1.8	4.6	8.7	11	27	61
6	0.0	4.6	6.7	17	25	58
6	1.8	4.6	6.7	6	10	84
6	0.0	4.6	8.7	13	25	62
6	1.8	4.6	8.7	4	10	86

Table 6. Modelled values of dietary protein intake of the Çamlıbel Tarlası population using Food Reconstruction Using Isotopic Transferred Signals (FRUITS) version 1.0 (Fernandes et al., 2014). No priors were assumed.

The average of the nitrogen stable isotope data suggests that cattle protein was likely not a major component of human diet. Average δ^{15}N of adult humans is 8.3±0.8‰, while that of cattle is 7.1±1.1‰. In comparison caprines and pigs exhibit slightly lower δ^{15}N values (average $\delta^{15}N_{caprine}$= 6.4±0.7‰ and $\delta^{15}N_{pig}$ = 6.7±0.7‰). This situation is mirrored in the Early Chalcolithic contexts at Aktopraklık, which is situated in the Marmara region of northwestern Anatolia. Stable isotope values also indicated that animal, and again specifically cattle meat and dairy products, were likely a minor component of diet (Lillie et al., 2012; Budd et al., 2013).

Although it is possible that cattle were kept predominantly for traction at Çamlıbel Tarlası other lines of archaeological evidence, such as the abundance of churns, and the dominance of cattle remains in the faunal assemblage seem to imply the importance of meat and/or dairy products to the economy of the site’s inhabitants. This apparent contradiction between the zooarchaeological evidence and the stable isotope data may be the result of dietary factors, such as (although not limited to):

(i) Preferential consumption of processed milk products with reduced or little protein content (e.g. butter/ghee and cream/cream cheeses).

(ii) Consumption of a large proportion of legumes. The ´^{15}N values of legumes are generally depleted relative to other plants (DeNiro and Epstein, 1981). The inclusion of ´^{15}N-depleted pulses such as bitter vetch and lentil, attested at ÇBT and other prehistoric Anatolian sites, in human diet could potentially mask the total contribution of protein from animals consuming non-leguminous plants and grasses.

It is also possible that some of the remains of potential foodstuffs identified at the site were not consumed, in whole or in part, by those individuals normally resident at Çamlıbel Tarlası (cf. Arbuckle 2012).

It is often assumed that domestic dogs would have been fed on household waste, and therefore would have had similar diets to humans (e.g. Clutton-Brock and Noe Nygaard, 1990; Rick et al., 2011). At Çamlıbel Tarlası dogs (n=8) have average ´^{13}C = -19.0±0.3‰ and ´^{15}N = 7.3±1.2‰; these values are statistically indistinguishable from the human ´^{13}C and ´^{15}N values (Mann Whitney U-test, two tailed, $p>0.05$). Thus, the dogs may have been fed on household waste. However, given the range of ´^{13}C and ´^{15}N values evident in the wild species sampled it is equally possible that the diets of dogs was supplemented by hunting locally available prey.

6.2 Juvenile Isotope Values

The average diet of all the juvenile specimens sampled is similar to that of the adults at Çamlıbel Tarlası (average ´^{13}C=-18.8±0.50 and ´^{15}N=8.8±1.6‰, n=30) and reflects mainly C_3 dietary intake (see Fig. 3). No statistically significant difference between all children and all adult average ´^{13}C and ´^{15}N values is evident (for both variables, two-tailed Mann Whitney U test, $p>0.05$).

At Çamlıbel Tarlası the average infant/young child ´^{13}C is -18.2±0.3‰ and ´^{15}N is 11.1±0.80 (n=10). A wide spread of ´^{13}C and ´^{15}N values is evident with ´^{13}C ranging from -17.8‰ to -19.40 and ´^{15}N from 7.6‰ to 12.2‰.

Carbon and, in particular, nitrogen stable isotope values of infants and children have been used as an indicator of prehistoric weaning practices. Exclusively breastfed infants are effectively feeding at one trophic level above their mother and are anticipated to exhibit a c. 2-30   increase in ´ ^{15}N value and up to a c. 1‰ increase in ´ ^{13}C value (Fuller et al., 2006). Comparison of neonate and infant ´ ^{15}N values with the female average has been used to quantify weaning age in prehistoric populations (e.g. Herring et al., 1998; Richards et al., 2003; Pearson et al., 2010; Budd et al., 2013).

Two infants from Çamlıbel Tarlası aged c. 12 months (i.e. GUsi-2918 and GUsi-3106), two children c. 18-24 months (GUsi-3101 and GUsi-3240) and a further child aged c. 2-4 years of age (GUsi-3138) exhibit relatively high ´ ^{15}N values in comparison to the adult average value. While it is tempting to attribute these values to a nursing trophic level effect, there is only one individual securely identified as female at the site and this individual may not be representative of the population average value. Additionally, non-dietary mechanisms may cause ^{15}N enrichment in neonates and infants. *In utero* physiological stresses, such as maternal protein insufficiency, as well as post-birth nutritional stress, growth and illness can influence ´ ^{15}N values (Hatch, 2012; Beaumont et al., 2015).

The isotope values of children aged e 6 years at Çamlıbel Tarlası are ´ ^{13}C = -19.0±0.10   and ´ ^{15}N = 7.2±0.5‰ (n=5): the average ´ ^{15}N is slightly lower than the adult value (8.3±0.8‰); the difference is statistically significant (Mann Whitney U-test, two tailed, $p<0.01$) – see Fig. 5. This trend has been observed among many prehistoric Holocene populations and is more pronounced in agricultural than hunter-gatherer groups (Tsutaya and Yoneda, 2013). Tsutaya and Yoneda (2013) have linked this to the use of lower trophic level resources such as cereals as weaning foods in agricultural societies, which is supported by ethnographic evidence (e.g. Sellen and Smay, 2001). However, the slight reduction in ´ ^{15}N values may be an artefact of increased protein requirements during periods of growth, which result in less protein excretion and hence less fractionation of ^{15}N/^{14}N between diet and consumer (Fuller et al. 2005; Waters-Rist and Katzenberg, 2010).

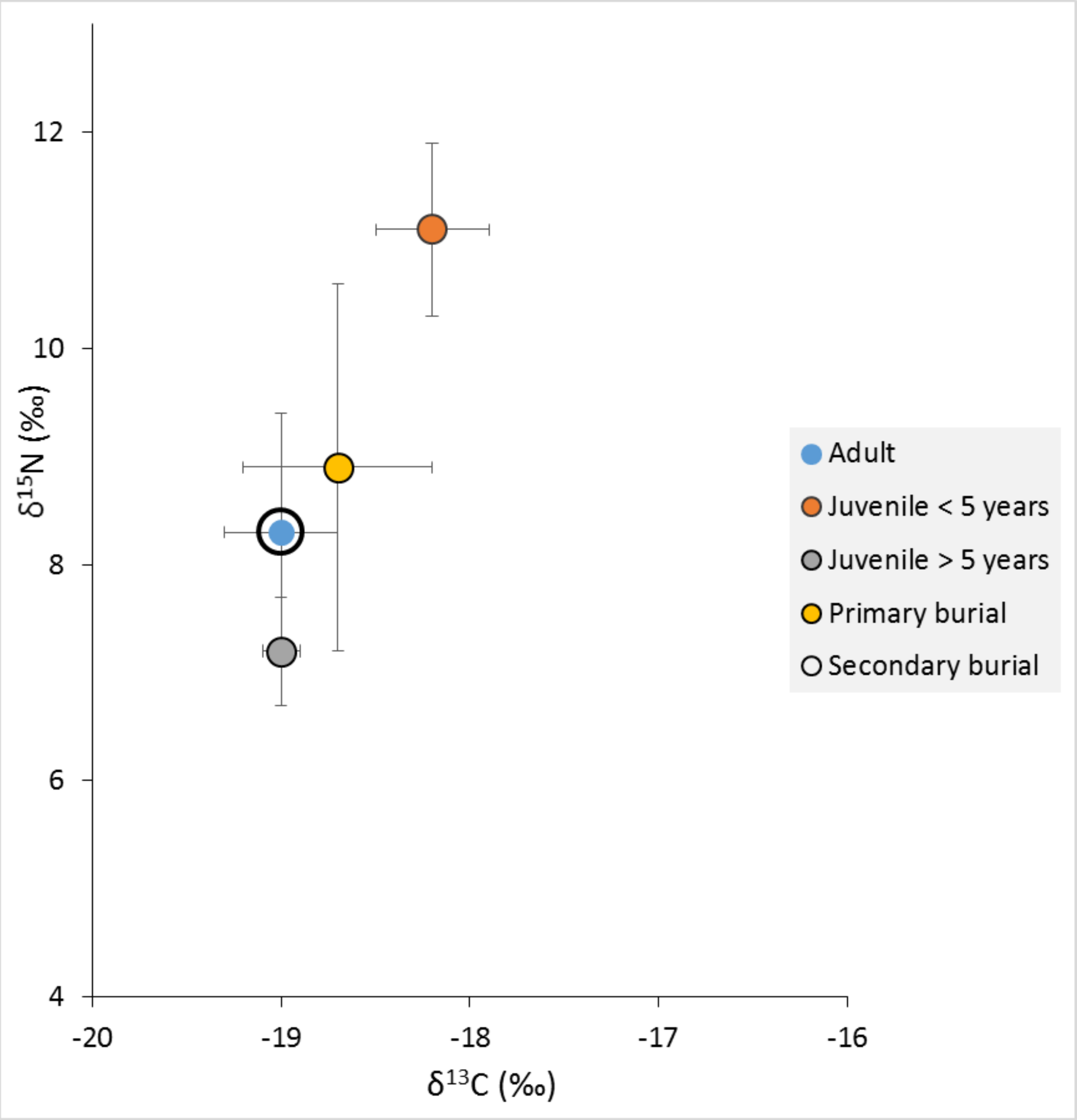

Figure 5. Scatterplot of average ´ ^{13}C and ´ ^{15}N values of Çamlıbel Tarlası human samples by age and by burial type with standard deviation indicated by error bars. Note: the average values of the adults and the secondary burials are the same, however the standard deviations are different (´ ^{13}C = -19.0±0.2‰, ´ ^{15}N = 8.3±0.8‰ and ´ ^{13}C = -19.0±0.3‰, ´ ^{15}N = 8.3±1.1‰ respectively).

7. Conclusions

Stable carbon and nitrogen isotope analyses of humans and associated animal remains from Çamlıbel Tarlası have provided the first indication of individual dietary intake in Late Chalcolithic north-central Anatolia. The data indicate that adult diet was based on C_3 resources. Comparison of adult human and herbivore nitrogen isotope values suggests that plant foods, presumably the crop species identified at the site, were important sources of dietary protein. Variation in adult $\delta^{15}N$ values indicates that animal protein was likely consumed in varying proportions with some individuals subsisting largely on plant foods. Relatively lower average $\delta^{15}N$ in older children may indicate reduced access to meat and other animal proteins during and possibly after weaning. However, the total contribution of animal protein to diet may be somewhat masked by the inclusion of ^{15}N depleted pulses in diet.

One of the major research questions of the Çamlıbel Tarlası project has been to investigate the specific human adaptations to a mountainous environment with dense vegetation cover in antiquity. While evidence for extensive pig-keeping and an emphasis on milking and milk products seem to point to the significance of domestic livestock, the present study suggests the less important role of animal protein in the local diet. Thus, the results of this present research demonstrate that the economic situation must have been more complex than our initial, relatively straight-forward assumptions. More research is needed to find a satisfactory explanation for these seemingly conflicting results.

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