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Diet and Social Divisions in Protohistoric Greece: Integrating Analyses of stable Isotopes and Mortuary Practices

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Introduction

The Early Iron Age (EIA, 11th – 8th century BC) in Greece is the transitional period following the end of the Mycenaean civilisation. The first half of this period is the so-called Protogeometric period (11th – 10th century BC) during which the mainland communities had to recover from the collapse of the Mycenaean palatial system, a centralised economic system of a stratified society.[1] Social and economic structures were both severely damaged in the 12th century BC, resulting in various changes in technology, material culture and mortuary practices across the entire Aegean in the ensuing periods. These changes also affected the region of Thessaly, located at the northern margin of the Mycenaean world.[2]

Mortuary practices have been used as proxies for social reconstruction.[3] In this paper we focus on the Early Iron Age cemeteries, which are an excellent source of information. The study of funerary data from Protogeometric Thessaly has revealed a marked diversity in mortuary practices; traditional Mycenaean practices had either survived or been imitated while new practices had also been introduced.[4] There is significant variety in the types of graves, body treatment and grave goods.[5] Tholoi are present alongside simpler grave types such as pits and cists as well as tumuli.

1 Wright 2010
2 Papadimitriou 2008; Eder 2009; Feuer 2011
3 Mee and Cavanagh 1984; Voutsaki 1998
4 Dickinson 2006
5 Snodgrass 1964: 159–167; Snodgrass 1971: 140–197; Lemos 2002; Dickinson 2006; Georganas 2009; Lagia *et al.* 2010

Figure 1. Map of Thessaly and Greece. the blue area on the map of Greece indicates Thessaly, the red frame indicates the enlarged area, and the numbers 1) Athens, 2) Pharsala Site 1, 3) Pharsala Site 2, and 4) Chloe (created by Remco Bronkhorst)

Furthermore, inhumations and cremations co-existed, while various types of grave goods of clay, bronze and iron were included.

Here we need to stress that the Protogeometric *tholoi* retained the basic characteristics of a Mycenaean construction – dromos, entrance, tholos – but were much smaller in size and less wealthy than the Mycenaean ones. They were essentially subterranean vaulted stone-built tombs. Protogeometric tholoi cannot therefore be considered on their own as the embodiment of high social status like the Mycenaean tholoi. We can only regard them as composite constructions compared to simple pits and cists and need to examine for other aspects that also point to a higher social status.

The two cemeteries at Pharsala and Chloe (Figure 1) date to the Protogeometric period and are roughly contemporary. They both provide ideal case-studies in terms of location and diversity of the mortuary practices observed in them. Both sites are situated in the Thessalian plain but in different sub-regions. Their comparative analysis therefore provides the opportunity to explore differences and similarities between the sites focusing on variable interregional contacts and patterns of land exploitation. Furthermore, at Pharsala traditional mortuary customs exist alongside newly adopted practices and forms, while in Chloe the traditional mortuary forms are adhered to almost exclusively.

This paper investigates the relation between diet – reconstructed by means of stable carbon and nitrogen isotope analysis of skeletal remains – and the social structure of a community – reconstructed on the basis of a contextual analysis of mortuary practices integrated with the osteological analysis of human remains. In this volume, it has been demonstrated that the results of an osteological analysis should be enhanced by the mortuary data for a thorough understanding of the patterns underlying the mortuary behaviour.[6] Our first goal is to correlate social divisions along age, sex, and possibly status, with differences in diet. Indeed, a main tenet of our approach is that diet is dependent on access to and control over resources, and is therefore inextricably connected with social divisions. Our second goal is to emphasize the need for close contextual observations on the mortuary data and for osteological analysis of human remains prior to, and as a basis for sampling for isotope analyses. The contextual analysis forms the backbone of the analysis of both mortuary and dietary variability.

Materials and methods

Materials

The cemeteries of Pharsala

Rescue excavations carried out from 2004 to 2008 at the western end of the modern city of Pharsala uncovered two burial grounds, ascribed the names Site 1 and Site 2, dating to 1050 – 900 BC (Figures 1 and 2).[7] Site 1 was the expansion to the north of the earlier Late Bronze Age cemetery. It included 35 graves distributed in an open area (in the following referred to as 'Site 1-cemetery') and a *tumulus*, a mound of soil and stones covering burials, with eight graves (in the following referred to as 'Site 1-tumulus'). Site 2, constructed 6 km north-east of Site 1 along the ancient road leading to other important settlements of the period, such as Larisa, consisted of only two tombs.[8]

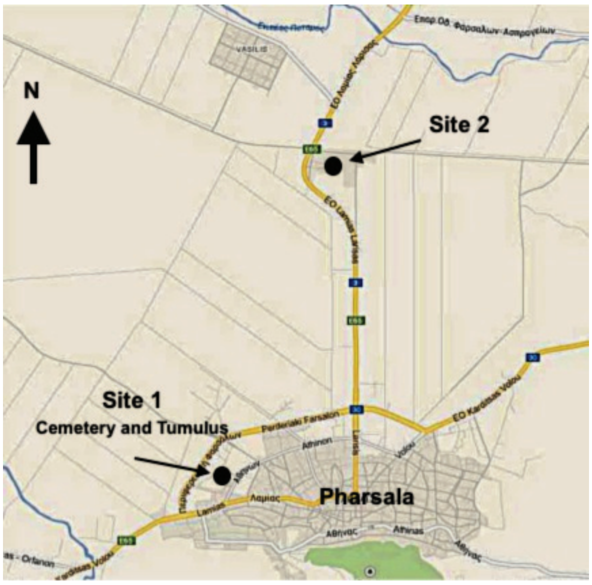

Figure 2. Excavation plan of the cemeteries of Pharsala (after Katakouta 2012)

The cemetery of Chloe

The cemetery of Chloe, dating to 1000 BC – 875 BC, is located in eastern Thessaly.[9] Eight *tholoi* were constructed on a plain near the modern village of Chloe (Figures 1 and 3).[10] This cemetery is one of the burial grounds of Pherai, a site occupied continuously from the Late Neolithic (4500–3200/3000 BC) to the Roman period (31 BC – 324 AD).[11] The present study includes the two best documented of the eight *tholoi*, EII and ZI.

[6] Jones, this volume.
[7] Katakouta 2012; Tziafalias and Batziou-Efstathiou 2010
[8] Katakouta 2012
[9] Doulgeri-Intzesiloglou 1996; Arachoviti 2000
[10] Doulgeri-Intzesiloglou 1996; Arachoviti 2000
[11] Doulgeri-Intzesiloglou 1994; Doulgeri-Intzesiloglou and Arachoviti 2006; Georganas 2008

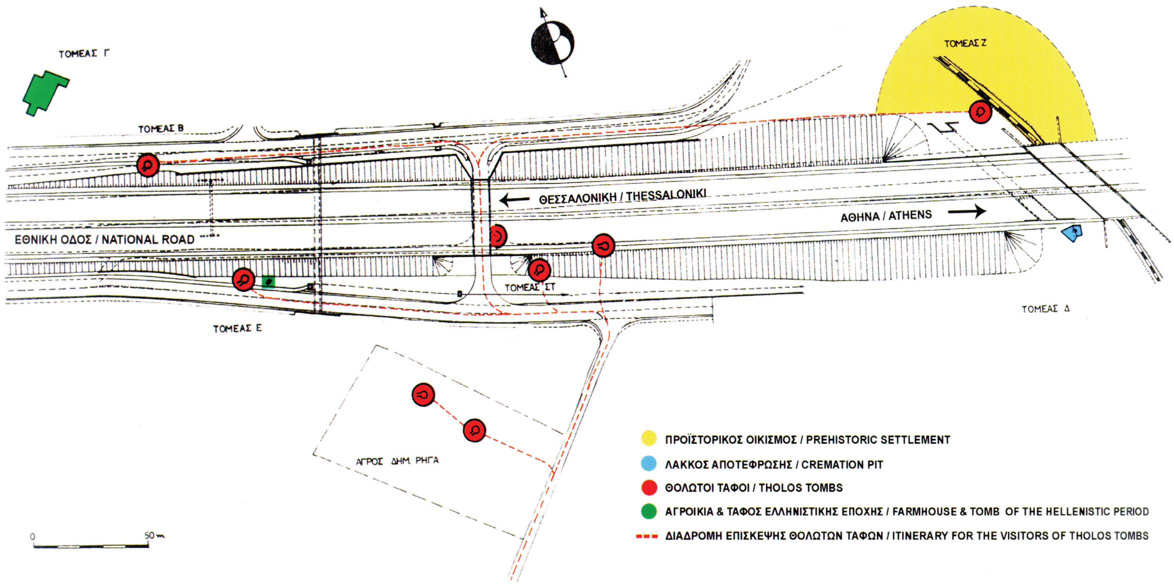

Figure 3. Excavation plans of the cemetery of Chloe (after Arachoviti 2000)

The human osteological assemblage

The preservation state of the human skeletal assemblage was good although sometimes the sex and age estimation of the individuals was difficult. These difficulties emerged from the partial fragmentation of the material and the commingled state of the multiple burials; one may encounter such difficulties when studying multiple burials and reused tombs. Nevertheless, in general terms, the material was in good condition and could be used for the purposes of this study.

Methods

Osteological analysis

The osteological assemblage was analysed in order to reconstruct the basic demographic parameters, i.e. to estimate age, sex and the Minimum Number of Individuals (MNI), as the basis for the contextual analysis. We followed the standard procedures for complete and commingled material discussed in Buikstra and Ubelaker.[12] The sex of the individuals was estimated only for adults with mature characteristics.

Contextual analysis

Contextual analysis is widely used in the study of mortuary practices in archaeology in order to establish normative practices but also to study variation and detect the underlying patterns.[13] The main aspects of the burial practices studied here are: a) the spatial organisation of the cemetery, b) the different grave types that have been used, c) the different modes of treatment of the body, and finally, d) the different grave goods that have been placed in a grave. According to the contextual method, all these different aspects are examined in terms of their statistical occurrence, but are

[12] Buikstra and Ubelaker 1994
[13] Hodder 1985; Voutsaki 1998; Parker Pearson 1999

also correlated with each other and with other aspects, primarily age, sex, and social status –as much as this can be reconstructed on the basis of tomb elaboration and grave goods.

Sampling design

A main principle of our research is that isotope analysis for dietary reconstruction has to be based on a careful sampling procedure, which takes into account a) the patterns and correlations detected by means of the contextual analysis described above, b) the research questions arising from our contextual observations, and c) the preservation and sample quality of the osteological material. Our study does not include cremations, as cremated bones do not contain collagen suitable for isotope analysis.

Isotope analysis

The stable isotope ratios of the skeletal material from Pharsala and Chloe were measured for the bone collagen fraction. The analysis was conducted at the Centre for Isotope Research of the University of Groningen. The collagen was extracted using an improved version of the methodology by Longin.[14] We took the following steps: a) samples were mechanically cleaned, cut to appropriate size and weight, b) samples were put in weak acid (1% HCl) for bone demineralisation, c) humic acids were washed away by alkalic solution (1% NaOH), and d) samples were put in slightly acidic demineralised water and in an oven (90^{o}C) so that the organic part, i.e. the collagen fraction of the bone, was solubilised. A pure collagen solution was collected after filtration (50μm). Finally, the solution was dried resulting in solid collagen.

The collagen was then combusted and purified into gas (CO_2 and N_2 for ^{13}C and ^{15}N analysis, respectively) using an Elemental Analyser (EA), coupled to an Isotope Ratio Mass Spectometer (IRMS). We used two instruments, a Carlo Erba/Optima and an Isocube/Isoprime EA/IRMS combination, providing the isotope ratios $^{13}R = {}^{13}C/{}^{12}C$ and $^{15}R = {}^{15}N/{}^{14}N$ as well as the C and N yields of the collagen. The isotope ratios are expressed in permil deviations from a reference material, reported as delta values: δ=[Rsample/Rreference]-1(x1000‰). The analytical precision is 0.1‰ and 0.2‰ for δ^{13}C and δ^{15}N, respectively. The reference materials are the internationally recommended compounds VPDB (belemnite carbonate) for δ^{13}C and ambient air for δ^{15}N.[15]

The bone collagen quality parameters are assessed using the carbon content (30–40%), nitrogen content (11–16%) and the atomic C/N ratio (2.9–3.6).[16] When the results are deviating from these numbers, the bone is considered (partially) degraded which may cause deviating isotope ratios and produce misleading conclusions on the diet of prehistoric populations.[17]

Results And Discussion

Demographic profile

The Minimum Number of Individuals in the cemeteries of Pharsala is estimated at 54 (MNI=54). Subadults are underrepresented (n=8) ranging from neonate (n=1) to 16 years old (n=1), while the 46 adults range from 20 to 50 years old. The adults include 11 males or probable males, 11 females or probable females, and a large number of indeterminate individuals (n=24).

In more detail, Site 1-cemetery included the majority of the population: six young subadults (0 – 10 years old) and 30 adults (20 – 50+ years old) – five males or probable males, seven females

[14] Longin 1971
[15] DeNiro 1987; Mook 2006
[16] DeNiro 1985; Ambrose 1990; van Klinken 1999
[17] Bocherens and Drucker 2007

or probable females and 18 indeterminate individuals. Site 1-tumulus included two adolescents (11 – 16+ years old) and 10 adults (20 – 45 years old) – three males or probable males, two females or probable females, and five individuals of indeterminate sex. At Site 2, the two *tholoi* contained only adults (n=6). *Tholos* 1 had one indeterminate individual and *tholos* 2 contained three males or probable males and two females or probable females.

The MNI in the two *tholoi* of Chloe was estimated at 25. The demographic profile of *tholos* EII is different from *tholos* ZI. *Tholos* EII includes only adults (n=10) but further estimation of the age was not possible with the exception of one individual of approximately 20 – 30 years old; four males or probable males, one probable female and five indeterminate individuals were found. *Tholos* ZI contains 15 individuals, including both adults and subadults. Nine subadults range from 5 to 16+ years old and six adults from 18 to 30+. The adults' group comprises two males or probable males, two females or probable females and two indeterminate individuals.

In summary, adults predominate in both cemeteries. The two sexes do not show significant differences but the large number of indeterminate individuals prevents us from reaching certain conclusions.

Contextual analysis of the mortuary data

The contextual analysis of the mortuary data is divided into two parts. In the first part, we analyse the mortuary data from the cemeteries of Pharsala and Chloe by site and then combine them with the data of the osteological analysis. In the second part, we compare the cemeteries of Pharsala with the cemetery of Chloe and reach conclusions on social structure and social divisions.

With regard to the analysis of wealth we based our analysis on the grave goods found in each grave.[18] However, we have followed a slightly different approach for each site for reasons explained below. In Pharsala, where a detailed list of the grave goods ascribed to each individual is available, but where no significant differences in the type and material of the objects can be noted, we divide the graves on the basis of differences in the number of grave goods. We have classified the graves in three categories: wealthy (three or more grave goods ascribed to each individual), poor (two or less grave goods ascribed to each individual), and empty (no grave goods were found in the grave with the individual). In Chloe, on the other hand, it is not possible to attribute grave goods to specific individuals because of the commingled state of the skeletal assemblage. Taking into account the number of grave goods, the quality and diversity of the objects and the value of the raw material of the objects found in the tholoi of Chloe, we consider the tombs wealthy – not the individuals buried in them. Therefore, we based our comparisons between the sites of Pharsala and Chloe on their overall wealth and the differences both in quality and quantity of the grave goods; the two *tholoi* of Chloe are considered wealthier than the graves of Pharsala because they included a greater number of grave goods as well as a greater range of materials.

The analysis of the site of Pharsala showed that the burial practices are significantly diverse. Site 1-cemetery showed most diversity in terms of tomb types and body treatment. The dominant grave type was the cist (n=29), a rectangular pit having the sides and top covered with limestone slabs; the type was used in Thessaly in the Mycenaean period, but became more common in the Protogeometric period.[19] However, one *tholos* and two burial enclosures (which are probably poor imitations of a *tholos* tomb) were also found, indicating that simpler and more complex, or traditional and new types were used alongside each other. While most graves contained inhumations, body treatment is also characterised by diversity as five vases with cremations were also found in a small area between the cist graves. Site 1-tumulus was less diverse: It covered a pit, five cists and two

[18] Voutsaki 1995
[19] Dickinson 2006

tholoi all containing inhumations only. Site 2 in Pharsala appears to be the most homogeneous as it consisted exclusively of two tholoi with inhumations.[20] Hence the main practice of body disposal was inhumation; cremation was present only in Site 1-cemetery.

Subadults in Pharsala were found only in Site 1; the youngest group (0 – 10 years old) was buried exclusively in cist graves. The two subadults in the *tumulus* were older (11 – 16+ years old) while in Site 2 no subadults were found. We can therefore suggest that age differentiation can be attested in the cemeteries of Pharsala as young subadults were excluded from certain burial forms. Considering the high infant mortality attested in pre-industrial societies (30–50%),[21] infants and babies are underrepresented in both cemeteries. In the Mycenaean period young subadults – especially the age group under 4 years – were receiving differential burial treatment; they were generally excluded from tholoi and other burial forms but occasionally they were included, especially in northern regions of the Mycenaean world – albeit still underrepresented.[22] The differential treatment of subadults in Protogeometric cemeteries could suggest a continuity of Mycenaean traditions into that period.

Differences based on sex are not attested neither between the burial grounds or between the different tomb types. There are almost equal numbers of males and females in Site 1 and Site 2 and in the tomb types. However, as explained earlier, some caution is necessary because of the high number of indeterminate individuals.

The grave goods in Pharsala covered a range of types and materials – pottery, iron and bronze ornaments, and iron tools and weapons.[23] Exceptional objects such as gold or imports were not found. The number of grave goods attested in each grave did not vary significantly between the different burial grounds nor did it correlate with specific tomb type. This implies that wealth divisions (which may be seen as an indication of social status) were neither marked nor rigid.

In Pharsala grave goods accompanying subadults were different from those found in adult burials. Subadults (neonates to 16+) were offered mostly bronze ornaments and/or pottery. Adults, on the other hand, were accompanied by a more varied and rich assemblage also including iron ornaments, tools and weapons. We therefore do observe age differentiation in grave goods.

The examination of grave goods against the sex of individuals did not show differences between males and females in the number of offerings. However, differences are observed when we examine the type and material of the objects. Females in single burials did not receive pottery, iron ornaments, tools or weapons, which are only found in male burials, but were offered only bronze ornaments. However, it is important to be very cautious when reaching conclusions on gender differentiation in Pharsala for three major reasons: a) there is a large number of indeterminate individuals, b) the secondary depositions found in complex tombs (*tholoi* and enclosures) were sometimes commingled, and c) in graves with double or multiple burials, the grave goods cannot always be attributed to specific individuals.

The cemetery of Chloe is different from the cemetery of Pharsala. It comprised mainly *tholos* tombs, similar to those of Pharsala, and they contained multiple inhumations. The grave goods included pottery, iron weapons and tools, gold and bronze ornaments, and beads of various materials such as gold, glass and faience.[24] The osteological analysis showed that one *tholos* (ZI) contained more subadults (5–18 years old, n=9) than adults (n=6) while in the other *tholos* (EII) only adults were

[20] Katakouta 2012
[21] Bocquet-Appel and Masset 1977; Masset 1973
[22] Lewartowski 2000; Papathanasiou *et al.* 2012
[23] Katakouta 2012
[24] Doulgeri-Intzesiloglou 1994; 1996; Arachoviti 2000; Adrimi-Sismani and Doulgeri-Intzesiloglou 2010

buried. This indicates that age differentiation occurred also in Chloe as subadults under the age of 5 years old were excluded; as mentioned earlier, this is a Mycenaean practice, although in the later periods of the Mycenaean period subadults were receiving extra-muros burial.[25] Sex differentiation, on the other hand cannot be studied, because of the number of the indeterminate individuals and the commingled nature of osteological material.

The comparison of the two sites based on the contextual analysis indicates that burial practices in Pharsala appear very diverse while the cemetery of Chloe appears relatively homogeneous showing only subtle differences. In Pharsala we see simple and complex tombs, inhumations and cremations, and new and traditional tomb types, while Chloe consisted mainly of 'traditional' *tholoi* with inhumations. The variation observed in spatial organisation and grave types might indicate emerging social differentiation. The separate burial location of Site 2 in Pharsala and the cemetery of Chloe, both exclusively with *tholoi*, but also the tomb types of tumulus, burial enclosure and *tholoi* could be associated with social divisions.

However, we can assign higher status and reach firm conclusions on social divisions only if we incorporate other aspects of burial practices, such as the wealth placed in the graves. Although the site of Pharsala appears more diverse than Chloe in terms of burial practices, the grave goods assemblage of Chloe is richer than that of Pharsala with higher quality and greater range of raw materials and greater diversity of types of objects.

The study of wealth in relation to tomb elaboration or burial location shows that there is a general correlation between these aspects. However, while there is some differentiation between the burial grounds, there is also considerable overlap between them - for instance, *tholoi* and comparable types of grave goods are found in all cemeteries, both sexes and most age groups are present (though in varying proportions), and the predominant treatment is inhumation. The mortuary record therefore shows subtle variation rather than rigid differentiation. While mortuary practices in the Mycenaean period present a much more stratified and hierarchical picture,[26] in the Protogeometric period, the mortuary record shows only a small degree of emerging differentiation along age and perhaps sex and status divisions.

The contextual analysis of the mortuary practices has offered us some insight into the social structure of the Pharsala and Chloe communities, but also to formulate new and informed questions arising from the patterns we identified. We want to complement the analysis of the archaeological data, and explore dietary differentiation between social groups based on sex and grave wealth. Therefore the questions we address here are:

1. Was there variation in diet between social groups?
2. Does dietary variation correlate with mortuary variation?

Sampling

The sampling strategy of the analysis has been designed on the basis of the patterns observed during the contextual analysis of the archaeological data. However, certain biases in the data should be noted again: a) the poor preservation of the osteological material has prevented us from sexing all individuals; as a result, the sex of 26 individuals from both sites could not be estimated; b) the commingled state of the multiple burials found in some of the tombs did not permit the attribution of grave goods to all individuals; c) the skeletal remains chosen for isotope analysis were mainly either rib or long bone fragment, but cranium samples were also collected in some

[25] Lewartowski 2000
[26] Wright 2008

cases from Chloe because, due to the commingled state, these skeletal materials could only be correlated to age and sex of the individuals.

Our first concern was to examine the cemeteries in order to select a sufficient number of samples from the different burial grounds, tomb types, modes of treatment, wealth classes, age groups and sex categories. Samples from different burial locations are represented by 27 samples from Site 1-cemetery, ten samples from Site 1-tumulus, six samples from Site 2 in Pharsala and 16 samples from Chloe. Furthermore, samples from different tomb types have been collected; samples from one pit (n=1), cists (n=25), burial enclosures (n=6), and *tholoi* (n=12) have been collected from Pharsala, the cist and *tholos* types being better represented than the other two types. More samples were collected from the *tholoi* of Chloe – seven samples from *tholos* EII and nine samples from *tholos* ZI. This sampling strategy allows us to make comparisons between the adults of Pharsala and Chloe, and between the adults of the same tomb type – the *tholos*.

At Pharsala the number of males (n=11) and females (n=10) sampled enables us to study sex differentiation. At Chloe comparisons between males (n=4) and females (n=3) can be made but the number of indeterminate individuals (n=6) is too large to allow credible conclusions (Figure 4). Samples from subadults have not been taken because the sample size was too small and no safe conclusions could be reached.

Finally, the different social groups from Pharsala based on the grave wealth are represented by a) ten samples of both sexes from empty graves, b) 13 samples from poor graves, and c) 17 samples from wealthy graves (Figure 5). All samples obtained from Chloe are considered wealthy.

Isotope analysis

Collagen extraction was conducted on 43 human and one animal bone samples from Pharsala. Based on the collagen quality criteria, 18 human out of 43 and one animal samples were accepted for the paleodietary study. Twenty samples yielded no collagen and five had C/N ratio, carbon content (%) and/or nitrogen content (%) or which falls outside the acceptable range (Figure 4). Only 45 % of the human skeletal assemblage is well preserved. Environmental conditions – water from the rivers flooding the graves and ploughing of the surface soils – may have contributed to the relatively poor preservation of the bone assemblage and resulted in the relatively small number of acceptable samples.

Fifteen human (13 adults / 2 adolescents) and two animal bone samples were analysed from Chloe. The application of quality criteria showed that a small number of samples (only five individuals) could be accepted for dietary reconstruction; approximately 33 % of the samples were well preserved; the rest yielded either no collagen or collagen with non-acceptable quality parameters (Figure 5).

There is only one animal sample from Pharsala available for study (Figures 4 and 5). The poorly preserved animal bones from Chloe do not allow comparisons between animals and humans. Therefore, we incorporate animal values from other contemporary sites of Thessaly, the sites of Kynos and Halos.[27]

The results from the isotope analysis as well as the mean values of each population are shown in Figures 4–7. The isotopic data from relevant sites, Kynos and Halos, are shown for comparison in Figure 8. The isotope analysis showed that the diet at both sites, Pharsala and Chloe, comprised largely C_3 terrestrial plant protein with elevated levels of animal protein intake (Figure 9). The inhabitants of Pharsala and Chloe exhibit enriched $\delta^{15}N$ values by 3‰ against their food because

[27] Papathanasiou *et al.* 2013; Panagiotopoulou *et al.* 2016

Sample Name	Lab number	Sex	Age	Weight (mg)	δ13C (‰)	C%	δ15N (‰)	N%	C/N
F/Ep-th1	57243	I	20–40y	7.33	-19.1	36.23	9.4	13.19	3.20
F/Ep-th2/ind1	57244	M?	20–25y	0.74	-19.2	41.11	10.4	15.41	3.11
F/Ep-th2/ind2	57245	M	40–55y	4.49	-19.5	42.63	8.6	15.33	3.25
F/Ep-th2/secA/ind1	57246	M?	24–30y	6.14	-19.1	38.06	9.2	13.85	3.21
F/Ep-th2/secA/ind2	57247	F?	>40y	5.59	-19.3	49.57	9.4	18.02	3.21
F/Ep-th2/secB	57248	F?	27–44y	6.47	-19.2	31.49	8.9	11.48	3.20
F/Per-th1/ind1	57249	I	20–35y	No collagen					
F/Per-th1/ind2	57250	I	>40y	1.45	-23.1	2.15	7.7	2.24	1.12
F/Per-th1/ind3	57251	M?	30–40y	No collagen					
F/Per-th2/indA	57252	I	YA	No collagen					
F/Per-th2/indB	57253	I	25–35y	No collagen					
F/Per-pit3	57254	I	YA	6.13	-19.4	43.23	9.7	15.48	3.26
F/Per-c4	57255	M?	20–25y	No collagen					
F/Per-c5	57256	M?	YA	0.82	-19.6	31.62	10.7	12.64	2.92
F/Per-c7	57257	F?	30–45y	6.07	-19.3	42.12	9.7	15.23	3.23
F/Per-c8	57258	F?	35–45y	7.58	-19.5	45.57	8.8	16.70	3.18
F/Od-c1	57259	F?	YA	0.87	-19.2	44.38	9.1	16.91	3.06
F/Od-c2	57260	I	20–30y	No collagen					
F/Od-c3	57261	I	Adult	No collagen					
F/Od-c4	57262	-	5–10y	No collagen					
F/Od-c5	57263	I	Adult	No collagen					
F/Od-c8	57264	-	0	0.09	-18.8	31.66	-4.4	17.68	2.09
F/Od-c9	57265	F?	40–50y	1.87	-19.9	24.09	10.4	8.52	3.30
F/Od-c13	57266	I	MA	No collagen					
F/Od-c16	57267	I	Adult	No collagen					
F/Od-be18/ind1	57268	F?	35–40y	4.13	-19.5	25.74	9.1	9.30	3.23
F/Od-be18/ind2	57269	I	20–25y	1	-19.6	45.41	10.0	16.54	3.20
F/Od-th20/#3	57270	I	35–50y	No collagen					
F/Od-c21	57271	F?	Adult	1.01	-25.2	1.56	-2.3	2.12	0.86
F/Od-c22	57272	-	3–6y	No collagen					
F/Od-c23	57273	M?	>50	No collagen					
F/Od-c24a	57274	F?	Adult	No collagen					
F/Od-c24b	57275	M?	MA	No collagen					
F/Od-c25	57276	I	30–50y	0.06	-19.2	129.59	9.4	53.38	2.83
F/Od-c26	57277	I	YA	1.19	-24.8	0.86	-	1.82	-
F/Od-c27	57278	-	7y	No collagen					
F/Od-be28/2a	57279	M	Adult	5.57	-18.8	42.22	6.5	15.45	3.19
F/Od-be28/ind1	57280	M?	Adult	5.59	-19.4	42.27	9.3	15.59	3.16
F/Od-be28/south	57281	F?	25–35y	5.73	-18.7	42.43	8.4	15.63	3.17
F/Od-be28/north	57282	I	20–30y	5.75	-19.5	42.86	9.4	15.67	3.19
F/Od-c31	57284	I	MA	No collagen					
F/Od-c32	57285	I	Adult	No collagen					
F/Od-c34	57286	M?	35–50y	No collagen					
F/Od-be28/horse	57283	-	-	5.88	-19.9	42.21	7.0	15.36	3.21

Figure 4. $\delta^{13}C$ and $\delta^{15}N$ isotope values from Pharsala, M. Male, F. Female, I. Indeterminate individuals, YA. Young adult, MA. Middle adult, Adol. Adolescent

Sample Name	Lab number	Sex	Age	Weight (mg)	δ13C (‰)	C%	δ15N (‰)	N%	C/N
C/E-th2/o1	57287	I	Adult	No collagen					
C/E-th2/cr2	57288	I	20–30y	No collagen					
C/E-th2/cr3	57289	I	I	No collagen					
C/E-th2/o4	57290	M?	Adult	No collagen					
C/E-th2/cr5	57291	F?	Adult	No collagen					
C/E-th2/cr6	57292	I	Adult	No collagen					
C/E-th2/cr7	57293	M?	Adult	0.46	-19.3	49.39	10.4	18.01	3.20
C/Z-th1/cr1	57295	F?	20–25y	5.98	-19.3	41.60	9.3	15.54	3.12
C/Z-th1/cr2	57296	I	Adult	No collagen					
C/Z-th1/cr3	57297	I	18–20y	5.83	-19.4	41.67	9.1	15.63	3.11
C/Z-th1/cr4	57298	M	20+	No collagen					
C/Z-th1/cr5	57299	F	30+	1.43	-19.2	41.33	9.9	15.35	3.14
C/Z-th1/cr8	57300	-	16–20y	No collagen					
C/Z-th1/cr10	57301	M?	Adult	0.22	-19.0	42.86	9.7	17.34	2.88
C/Z-th1/sec/north	57302	-	Adol.	5.53	-19.3	41.61	9.1	15.60	3.11
C/E-th2/P1 animal	57294	-	-	No collagen					
Chloe Th1/Z/ animal	57303	-	-	No collagen					

Figure 5. $\delta^{13}C$ and $\delta^{15}N$ isotope values from Chloe, M. Male, F. Female, I. Indeterminate individuals, YA. Young adult, MA. Middle adult, Adol. Adolescent

Pharsala	Mean δ13C (‰)	SD δ13C (‰)	Min δ13C (‰)	Max δ13C (‰)	Mean δ15N (‰)	SD δ15N (‰)	Min δ15N (‰)	Max δ15N (‰)
Adults	-19.3	0.3	-19.9	-18.7	9.3	0.9	6.5	10.7
Males	-19.3	0.3	-19.6	-18.8	9.1	1.5	6.5	10.7
Females	-19.3	0.4	-19.9	-18.7	9.2	0.6	8.4	10.4

Figure 6. $\delta^{13}C$ and $\delta^{15}N$ mean, minimum, and maximum isotope values from Pharsala

Chloe	Mean δ13C (‰)	SD δ13C (‰)	Min δ13C (‰)	Max δ13C (‰)	Mean δ15N (‰)	SD δ15N (‰)	Min δ15N (‰)	Max δ15N (‰)
Adults	-19.3	0.2	-19.4	-19.0	9.7	0.5	9.1	10.4
Males	-19.2	0.2	-19.3	-19.0	10.1	0.5	9.7	10.4
Females	-19.3	0.1	-19.3	-19.2	9.6	0.5	9.3	9.9

Figure 7. $\delta^{13}C$ and $\delta^{15}N$ mean, minimum, and maximum isotope values from Chloe

Site	Species	δ13C (‰ VPDB)	δ15N (‰ AIR)
Kynos	Turtle shell	-22.6	5.3
Kynos	Sheep/goat	-20.7	6.2
Kynos	Pig	-21.0	7.4
Kynos	Cattle	-19.4	7.7
Kynos	Sheep/goat	-18.4	5.5
Kynos	Sheep	-19.1	4.6
Kynos	Pig	-21.2	4.8
Kynos	Sheep	-18.2	5.9
Kynos	Sheep	-18.8	6. 5
Kynos	Cattle	-19.2	6.3
Halos	Herbivore	-18.6	4.1
Halos	Sheep/goat	-19.6	3.7
Halos	Herbivore	-19.5	8.0
Halos	Sheep/goat	-19.9	3.5
Halos	Cattle	-17.5	6.0
Halos	Sheep/goat	-20.1	2.6
Halos	Equine	-19.5	4.4
Halos	Cattle	-18.8	8.3

Figure 8. $\delta^{13}C$ and $\delta^{15}N$ animal isotope values from Kynos and Halos

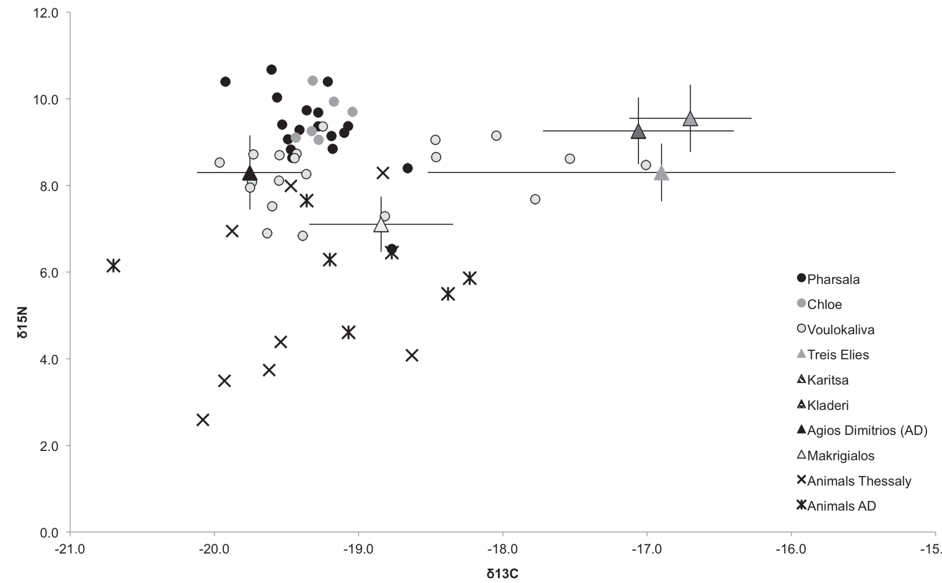

Figure 9. Isotope values $\delta^{13}C$ and $\delta^{15}N$ of human adults and animals from Pharsala and Chloe, animal isotope values from Halos, and mean isotope values of the populations from the sites Treis Elies, Karitsa, Kladeri, Makrigialos, and Agios Dimitrios

of the fractionation that occurs while ascending the food-chain.[28] Apparently animal protein – dairy products and/or meat – was a significant part of the diet at Pharsala and Chloe. The use of leguminous resources must have been negligible. Legumes exhibit low $\delta^{15}N$ values because these plants use atmospheric nitrogen (with $\delta^{15}N_{air}$ = 0‰) for the N_2-fixing nutritional processes.[29] If legumes had a significant share in the diet, then the $\delta^{15}N$ values of the humans would have clustered lower in the scale.

The isotope analysis showed that despite the diversity and differences between the cemeteries of Pharsala and Chloe indicated by the contextual analysis, diet appears to be rather homogeneous. The majority of the samples from both sites range from $\delta^{13}C$ -19‰ to -20‰, and from $\delta^{15}N$ 8.5‰ to 11‰. The standard deviation in Pharsala varies; for carbon it is very narrow showing that C_3 is the main food resource for this group. For nitrogen, on the other hand, the standard deviation is large indicating that there is varied animal protein intake. However, in general there is high proportion of animal protein as no individual exhibits $\delta^{15}N$ values low enough to infer exclusive use of plant protein. The standard deviation in the values of Chloe is very narrow indicating that the individuals included in the analysis had a very similar diet.

Let us now examine dietary variation in the group discussed above. In the plots presenting the diet between burial locations (Figure 10a) and between different grave types (Figure 10b) we see that the majority of samples from both sites cluster in a very limited area; there is much overlap with high animal protein. Diet is homogeneous, and there is no significant variation either between burial locations or between grave types, indicating that the members of the communities exhibited similar diversity within the same range of nitrogen values.

Differences between males and females are shown in Figure 11. Males from Pharsala exhibit a greater range of animal protein intake than females from the same site; females do not exhibit extreme values of very high or very low animal protein intake but lie in-between the end-members of male values. In Chloe the samples exhibit high $\delta^{15}N$ values (>9‰) and no substantial differentiation is

[28] DeNiro and Epstein 1981
[29] He *et al.* 2009

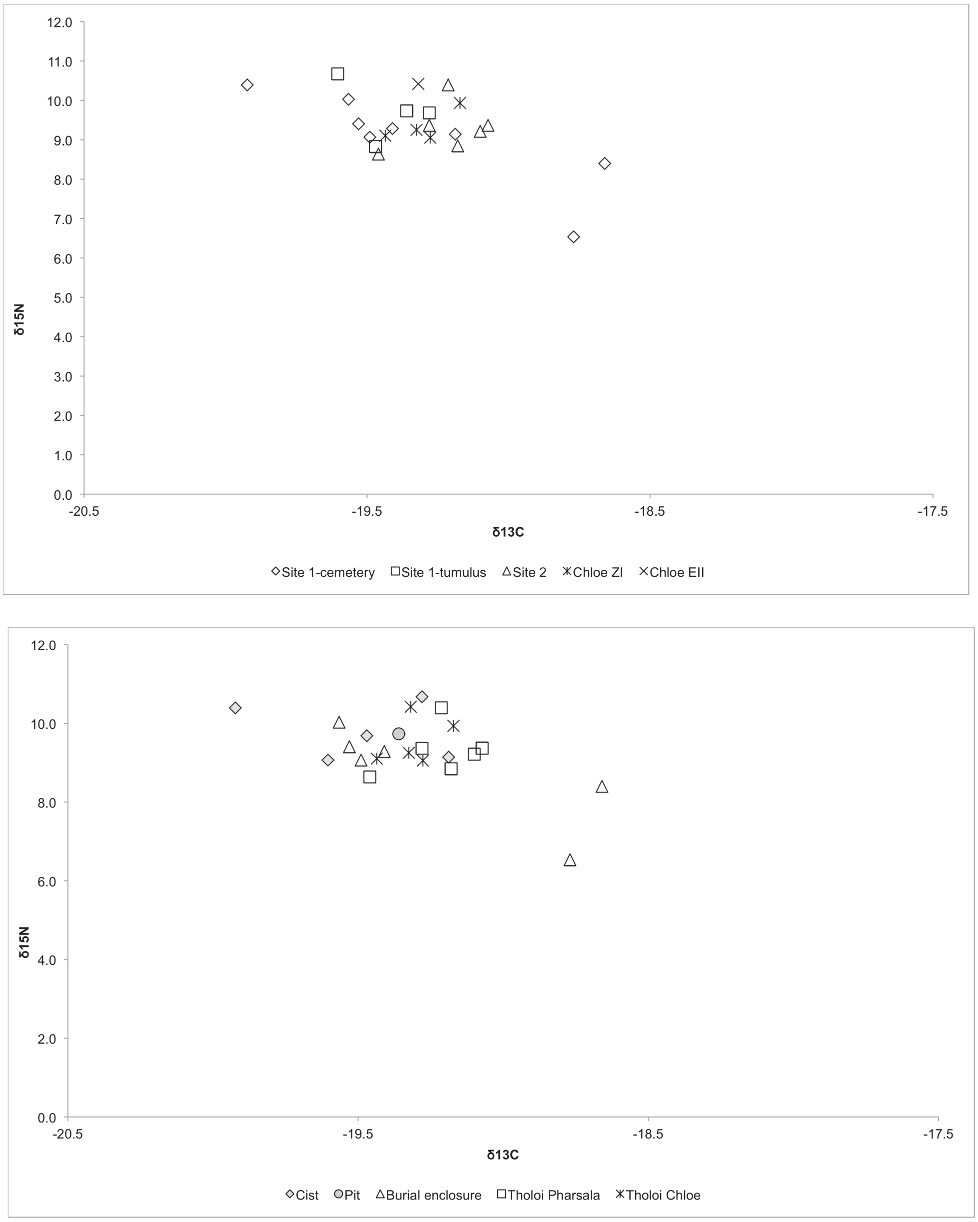

Figure 10. Isotope values $\delta^{13}C$ and $\delta^{15}N$ of human adults from a. clusters of Pharsala and Chloe and b. grave types from Pharsala and Chloe

observed between males and females. They coincide more with the higher than the lower values of Pharsala. The values of indeterminate individuals are not significantly different. They are all within the sample range of each site, and therefore indicate only minimal differentiation and strengthen the conclusion that both sexes had even access to all foodstuffs.

In Figure 12 we examine diet between different levels of wealth. There is some variation between wealthy, poor, and empty graves but no significant clustering is observed. The four samples with the higher nitrogen values – more than 10‰-, are those with the largest consumption of animal protein. However, these individuals do not show similar mortuary practices; they were buried in Pharsala and Chloe, in cists and in *tholoi*, received both rich and poor grave goods, and included both males and females. In other words, this observation suggests that diet was not connected to the social status of the individuals and that diet was not yet associated with either sex or social divisions.

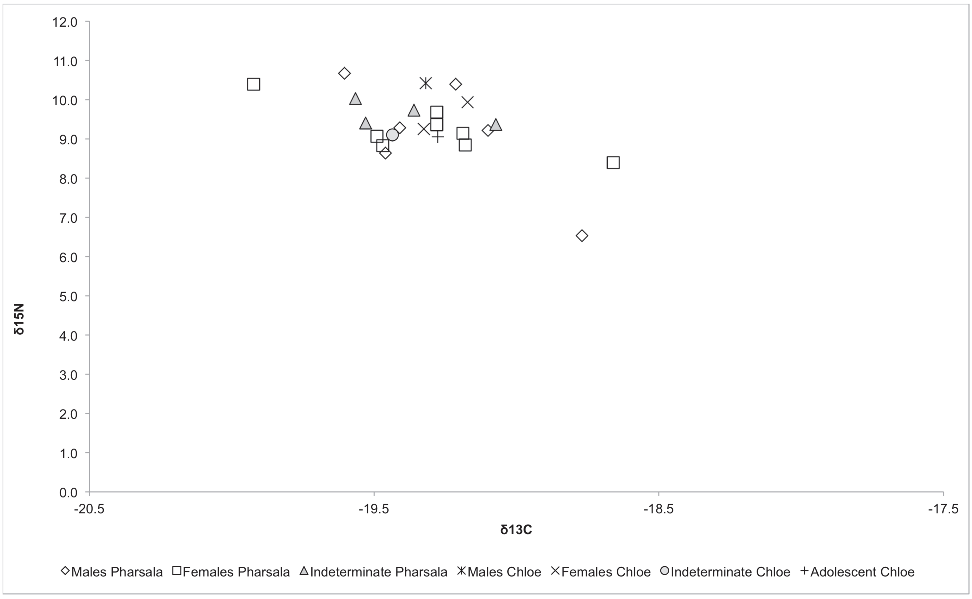

Figure 11. Isotope values δ^{13}C and δ^{15}N of males and females

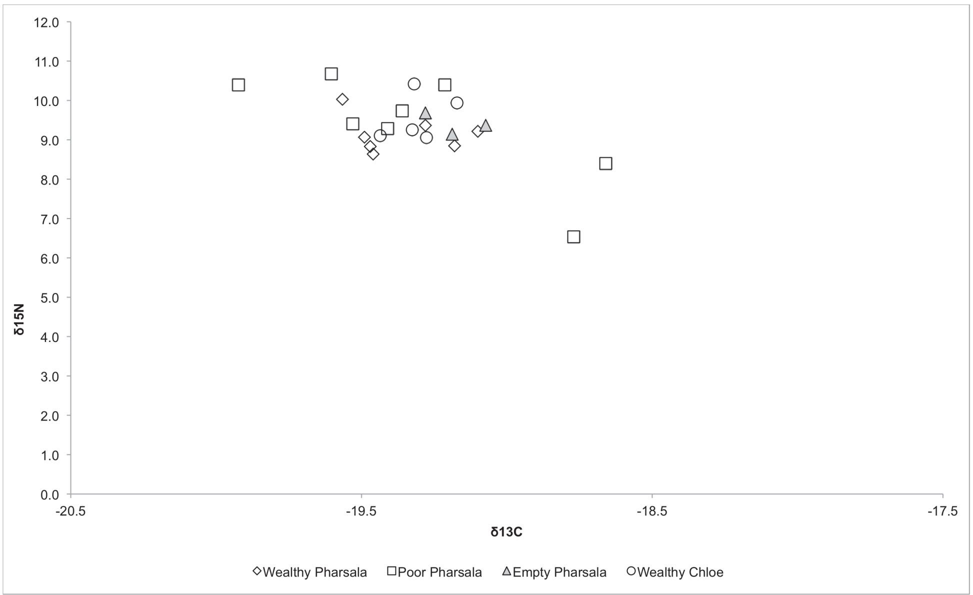

Figure 12. Isotope values δ^{13}C and δ^{15}N of human adults representing wealth groups

It is time to place these two sites in the wider context of the Early Iron Age in Greece and the Aegean. If we compare the sites of Pharsala and Chloe to other contemporary sites in Thessaly and beyond, we see the following pattern (Figure 9): sites, such as Agios Dimitrios in Central Greece,[30] Halos in Thessaly,[31] and Treis Elies, Kladeri, Karitsa, and Makrigialos in northern Greece[32] yielded low nitrogen values indicating low animal protein intake (Figure 13). The archaeological analysis of these sites showed that the cemeteries included mainly pits, cists, and tumuli. Constructions requiring certain engineering skills, like *tholoi*, were absent from all these sites; only two chamber tombs were found in the cemetery of Makrigialos along with pits and cists. In addition, these sites

[30] Papathanasiou *et al.* 2013; Panagiotopoulou and Papathanasiou 2015
[31] Malakasioti 2009; Malakasioti and Tsiouka 2011; Panagiotopoulou *et al.* 2016
[32] Pantermali 1988; Triantaphyllou 2015

Site	Mean $\delta^{13}C$ (‰)	SD $\delta^{13}C$ (‰)	Min $\delta^{13}C$ (‰)	Max $\delta^{13}C$ (‰)	Mean $\delta^{15}N$ (‰)	SD $\delta^{15}N$ (‰)	Min $\delta^{15}N$ (‰)	Max $\delta^{15}N$ (‰)
Agios Dimitrios	-19.8	0.4	-20.3	-19.0	8.3	0.9	6.3	9.2
Treis Elies	-16.9	1.6	-18.8	-15.1	8.3	0.7	7.5	9.5
Kladeri	-17.1	0.7	-18.0	-16.2	9.3	0.8	8.4	10.1
Karitsa	-16.7	0.4	-17.0	-16.4	9.6	0.8	9.0	10.1
Makrigialos	-18.84	0.50	-19.48	-17.55	7.10	0.63	5.98	8.22

Figure 13. $\delta^{13}C$ and $\delta^{15}N$ mean, minimum, and maximum isotope values from Agios Dimitrios, Treis Elies, Kladeri, Karitsa, and Makrigialos

were also less wealthy when compared to sites with *tholoi*, which incorporated more animal protein to their diet. Such practice has been attested in the Mycenaean period; in Pylos individuals buried in tholoi found to have consumed more animal protein compared to individuals buried in chamber tombs were found.[33] Could a similar practice have survived in the Protogeometric period – that is wealthier communities with tholoi using more meat or dairy products than other communities with more modest burial practices?

Further analysis of the sites of Pharsala and Chloe reveals an interesting contrast. Looking more closely at the sites, we see that some individuals from poorer graves had higher animal protein consumption than those from wealthier graves. This contrasts with the observation in the previous paragraph, where the diet of individuals from sites, where the overall wealth is lower, relied on less animal protein. Therefore, it is possible that the overall wealth of a population correlates with the diet of the population, while dietary differences within a community do not correlate with wealth divisions between individuals; here individuals from poorer graves seem to have consumed more animal protein, an observation that runs counter to the usual assumption that animal protein was consumed mainly by people of higher social status. It could be suggested that these individuals from less wealthy graves engaged with animal husbandry and reared animals themselves, and as a result their diet relied more on animal (meat or dairy) and less on plant protein.

Such inference could support Snodgrass' well-known theory that during the Protogeometric period people's economy relied more on pastoralism than on arable farming.[34] Pastoralism and meat consumption have been suggested explanations for the changes seen in the archaeological record between Late Bronze Age and Early Iron Age. Most analyses are based on the interpretation of artistic depictions on vases and figurines,[35] house plans,[36] and use of hand-made pottery and iron.[37] These have been interpreted as evidence not only for animal husbandry but also of nomadic pastoralism as Snodgrass had already argued in 1971.[38] Archaeozoological analyses have also attempted to investigate the use of animals, meat consumption, and whether there is a dietary shift through time. The analysis, so far, has not indicated the nomadic character of the economy or significant differences between the Late Bronze Age and the Early Iron Age; when there are some differences they are mostly on regional basis.[39]

Direct analyses for animal consumption have not been extensively conducted regarding the Early Iron Age. Although this study showed that meat consumption occurred in relatively high proportions, in other sites from northern Greece and southern Thessaly animal protein consumption was lower than in Pharsala and Chloe. Therefore, in order to reach more definite

[33] Schepartz *et al.* 2010; Papathanasiou *et al.* 2012
[34] Snodgrass 1971
[35] Langdon 1993: 43–4
[36] Sakellariou 1980: 118
[37] Snodgrass 2006: 134–5
[38] Snodgrass 1971: 379
[39] Halstead 1987; Dibble 2017

conclusions further systematic studies of animal and plant remains from Early Iron Age sites would need to be undertaken.

In figure 9 we also see two individuals that cluster separately from the majority of the individuals. These two individuals were buried in Pharsala and exhibit slightly less negative carbon values (F/Od-be28/2a: -18.8‰, F/Od-be28/south: -18.7‰) than the rest of the group. Their diet largely relied on C_3 terrestrial resources as was the case for the rest of the community, but they consumed less animal protein and more C_4 resources, most likely millet, which is the edible C_4 plant in Greece. The cut-off point to identify use of C_4 resources has been set at -19‰ following the study of a large number of samples from various sites in Greece;[40] carbon values less negative than -19‰ point to the presence of C_4 resources. If we compare these samples to the rest of the group from Pharsala, which exhibit only C_3 signal, we can deduce that millet was used sporadically. The two individuals, a male and a female, were buried in the same burial enclosure and both received poor grave goods; they may therefore have had some kin relation. However, more individuals were buried in this burial enclosure and they did not have C_4 resources in their diet but had more animal protein. It is not easy to answer why only these two individuals used millet. If we examine the occurrence of C_4 in other Protogeometric sites, we see that there is significant C_4 signal in all the sites where low animal protein consumption was attested, except in Agios Dimitrios, where low animal intake is present but no C_4 signal is attested. Therefore, we seem to have a correlation between C_4 plants and low animal protein. Even in Pharsala, the two individuals with C_4 signal had the lowest animal protein. Could this be incidental or does low animal intake indicate low economic status and the search for other resources? The small sample size does not let us deduce further conclusions on this correlation. Furthermore, isotopic studies have shown that the sites with more systematic C_4 signal are located mostly in northern Greece.[41] Therefore, communities or individuals with possible low economic status might have explored millet and used it as a nutritional complement. On the other hand, millet could have been obtained via contacts with northern regions or it could have been brought by individuals of non-local origin as Valamoti suggested.[42] The paper of Panagiotopoulou *et al.* explores the possibility of the presence of individuals of non-local origin in the the cemeteries under study.[43] Tooth enamel was sampled from individual F/Od-be28/south among other individuals of the same population (individual F/Od-be28/2a has not been sampled because teeth associated with this individual were not found). Strontium isotope analysis showed that individual F/Od-be28/south was of non-local origin because $^{87}Sr/^{86}Sr$ ratios were out of the local environmental range. This could be a positive first direct evidence for the suggestion proposed by Hastorf [44] and Valamoti[45] that women could have contributed to the expansion of millet. However, two issues prevent us from reaching a definite conclusion: a) C_4 signal of this female(?) is weak; and b) at this point we cannot discuss the origin of this individual but we can only identify her(?) as non-local.

Conclusions

In this paper we investigated Early Iron Age cemeteries at Pharsala and Chloe in Thessaly, central Greece. We studied dietary variation in relation to social divisions within and between communities, as well as between gender categories and wealth /status groups. We have shown that an integration of stable carbon and nitrogen isotope analysis with osteological data and the contextual analysis of mortuary practices allows us a better understanding of the social structure of Early Iron Age societies in Greece.

[40] Papathanasiou and Richards 2015
[41] Triantaphyllou 2001
[42] Valamoti 2013
[43] Panagiotopoulou *et al.* 2018
[44] Hastorf 1998
[45] Valamoti 2013: 56

The contextual analysis suggested that Protogeometric communities were characterised by differentiation between age groups, subtle variation between the sexes, and possibly some emerging divisions between wealth and status groups. We do not see the social stratification of the Mycenaean period. The stable isotope analysis indicated C_3 plant and animal protein as the main dietary resource of both populations with additions of C_4 protein. The dietary variations observed in these populations as well as the relation between diet and social divisions were examined through the integration of stable carbon and nitrogen isotope analyses for dietary reconstruction with the contextual analysis of mortuary practices.

No clear correlation between diet and social divisions appears, as there are no strict divisions between social groups in these communities during the Protogeometric period. The variation in animal protein intake observed between individuals within a community could not be explained by sex or status differentiation but rather personal preference or perhaps occupation. The two individuals (a male and a female) that showed additions of C_4 protein in their diet could have been characterised as a low status group due to the poor tomb and we could correlate this with the occurrence of C_4. However, other individuals buried in the same poor tomb did not consume millet and the female(?) has been identified as a non-local. Therefore, correlation of millet with low status cannot be established but further investigation of the correlation of millet with non-locals is needed.

Finally, we placed the populations of Pharsala and Chloe in the context of the Early Iron Age through the comparison with contemporary sites. We observed a correlation between C_4 protein consumption and low animal protein consumption, in Pharsala, which was also attested in other sites. However, this cannot yet be safely explained. We also showed that the populations of Pharsala and Chloe, whose burial practices exhibited great degree of diversity or elaboration incorporated more animal protein in their diet while those whose burial practices were modest followed a diet poorer in animal protein. Our results showed that there is no direct correlation between diet and social divisions within a population but the economic state of a community could have affected the overall dietary level and thus differences between different communities could have occurred but not on individual level.

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