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Stable Isotope Analysis of Human and Faunal Remains. A Palaeodietary Investigation into Chalcolithic and Bronze Age Cyprus.

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Abstract:

This study focuses on the Chalcolithic and Early to Middle Bronze Age periods of Cypriot prehistory (ca. 3900-1650 BC) and utilises stable light isotope analysis of bone and teeth to explore issues of diet and subsistence economy. A total of 100 human and animal skeletal samples from eight archaeological sites pertaining to the investigated period have been processed. Measurements were conducted either on bone and dentine collagen (C, N) or on tooth enamel carbonate (C, O). The new isotopic dataset is discussed within the frame of three main research aims: 1) to investigate possible dietary differences among the selected prehistoric communities, distinguishing between the Chalcolithic and the Early to Middle Bronze Age periods; 2) to clarify whether the pre and proto-historic inhabitants of Cyprus also relied on freshwater and marine foods; 3) to identify possible individual patterns of consumption, especially gender-related differences in the diet.

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Contents

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

Situated in the north-east corner of the Mediterranean basin, the island of Cyprus boasts a rich prehistoric past and a unique landscape and natural environment. Once regarded as no more than a peripheral area of the ancient Near East, Cyprus developed its own distinctive prehistoric culture and increasingly gained influence over the Mediterranean world.

This study focuses on the Chalcolithic and Early to Middle Bronze Age periods of Cypriot prehistory, from the early 4th to mid-2nd millennia BC, and utilises stable light isotope analysis of bone and teeth to explore issues of diet and subsistence economy. Over the entire period, archaeological evidence attests to a series of major changes in social structure, technology and economy that transformed the self-sufficient, rural communities of the Chalcolithic into more cooperative, proto-industrial centres during the subsequent Early and Middle Bronze Ages (Held 1993; Steel 2004; Knapp 2008, 2013). Of crucial importance is the advent, at the transition from the Late Chalcolithic to the Early Bronze Age, of a new cultural system – the Philia facies – characterised by a completely diverse suite of technologies and associated beliefs. How to explain the origin of the Philia Bronze Age system still represents a controversial issue that revolves around two contrasting positions: one theory suggests that the Philia facies followed a migration and inherent transfer of goods and ideas from Anatolia (Webb & Frankel 1999, 2007, 2011; Frankel 2000), whilst the other model interprets it as the result of internal changes and developments on Cyprus (Knapp 2008: 110-130; 2013: 263-277). Without entering the debate, it is important to notice that "many of the innovations which characterise the Early Cypriot Bronze Age and distinguish it from the earlier Chalcolithic cultural system fall within the domestic sphere, indicating major changes in patterns of life and the ways in which everyday tasks were carried out" (Webb & Frankel 2007: 189). In the realm of subsistence, hoe-based agriculture, herding of pigs and – to a lesser extent – caprines, along with intensive hunting of fallow deer constituted the economic mainstay of the isolated Chalcolithic villages of the island (Croft 1991, Hansen 1991). With the advent of the Philia culture, patterns in animal exploitation changed dramatically and significant innovations were introduced. These include for example: the inauguration of plough agriculture, the re-appearance of domestic cattle after about three millennia of absence, the increased exploitation of secondary products and the utilisation of new cooking equipment and domestic technologies (Webb & Frankel 1999, 2007). The success of these innovations is further demonstrated in the socio-cultural and economic developments of the subsequent Early and Middle Bronze Ages, characterised by a substantial intensification and extensification of farming activities along with the gradual emergence of new forms of diversification and proto-specialization and more complex systems of labour control. The final stage of the Middle Bronze Age is characterised by the development of proto-urban centres, the creation of an organised internal and international trading system, and the first signs of a possible formal social or economic hierarchy of settlements.

In this scenario, the lack in the current literature of specific studies concerning the reconstruction of dietary patterns in Cyprus during the Chalcolithic and the Bronze Age is somehow surprising, as it is very likely that the above described transformations would have had an effect on the food system. Indeed, not only food is essential for human survival but it is influenced by a complex suite of environmental, economic and socio-cultural constraints that determine both food choices, thus diet and nutrition, and food ways, that is, how food items are procured, prepared and consumed. Food-related activities, concepts and cultural beliefs together contribute to shape the cultural identity of a community and for this reason they should constitute an integral part of archaeological investigation.

With reference to Cyprus, general trends on dietary patterns during the examined period have routinely been inferred from faunal and botanical data, and within the context of broader research focused on subsistence strategies (see, for example, Croft 1991, 2002; Keswani 1994; Button 2010; Spigelman 2006). Although crucial to assessing which plant and animal resources were available to prehistoric people, zoo-archaeological and archaeobotanical analyses present methodological limitations when applied to the reconstruction of past diets. In the first place, due to a number of preservation and recovery biases, the relative proportions of plant and animal species retrieved during archaeological excavations are not necessarily representative of the diet of the investigated community (Papathanasiou 2015: 25-27).

In Cyprus prehistoric contexts, both the sample size and the number of archaeobotanical plant remains vary greatly from site to site, mainly because of a combination of natural (e.g. different diagenetic patterns) and artificial factors, including variations in excavation, sampling and processing techniques (Lucas 2014: 33). Similarly, taphonomic processes and different recovery techniques (e.g. water flotation and/or sieving) are likely to affect the composition of the faunal assemblage, usually at the expenses of smaller bones such as birds and fish. At Kissonerga *Mosphilia*, Croft (1998: 207-209, 212) estimated that the vast majority (97%) of bird bones had been probably overlooked, and assumed that "birds would have constituted a far more significant resource than appearance might suggest". With regard to fish remains, Button (2010: 365, but applying a ratio like in Croft's 1998: 212) suggested that the amount of fish bones ordinarily missed in Cypriot archaeological excavation might be of the order of 90% or more in terms of elements identified. Further limitations to the reconstruction of past diet include the difficulties in establishing a clear correlation between the archaeobotanical and faunal deposits and the patterns of consumption. For example, in palaeobotanical analyses, it is not always possible to discern whether botanical remains represent food items intentionally gathered for human consumption and/or plants consumed by animals (e.g. Adams & Simmons 1996: 223-224; Murray 1998a: 222). On the other hand, with regard to animal bones, it can be hard – if not impossible – to determine whether the formation of a faunal deposit is the product of long-term household activities or of episodes of ceremonial food consumption and feasting. Furthermore, archaeobotanical and faunal data provide information on the varieties of foods available to the whole community, but inevitably fail to assess the relative importance of these resources in the diet of the single individual. As a consequence, socio-cultural dynamics influencing the patterns of food consumption, like status- or gender-related differences in the diet, cannot be accurately investigated.

Given these premises, it seems evident that our knowledge of the dietary habits of the people living in Cyprus throughout the period from the Chalcolithic to the Early and Middle Bronze Ages is still vague and incomplete. In particular, there are a number of relevant questions that need to be addressed:

1) What was the role of marine and freshwater resources in the subsistence economy of these communities?

2) At a diachronic level, which dietary shifts occurred between the Chalcolithic and the Early to Middle Bronze Age periods?

3) Are there gender-related differences in food acquisition and consumption within each period?

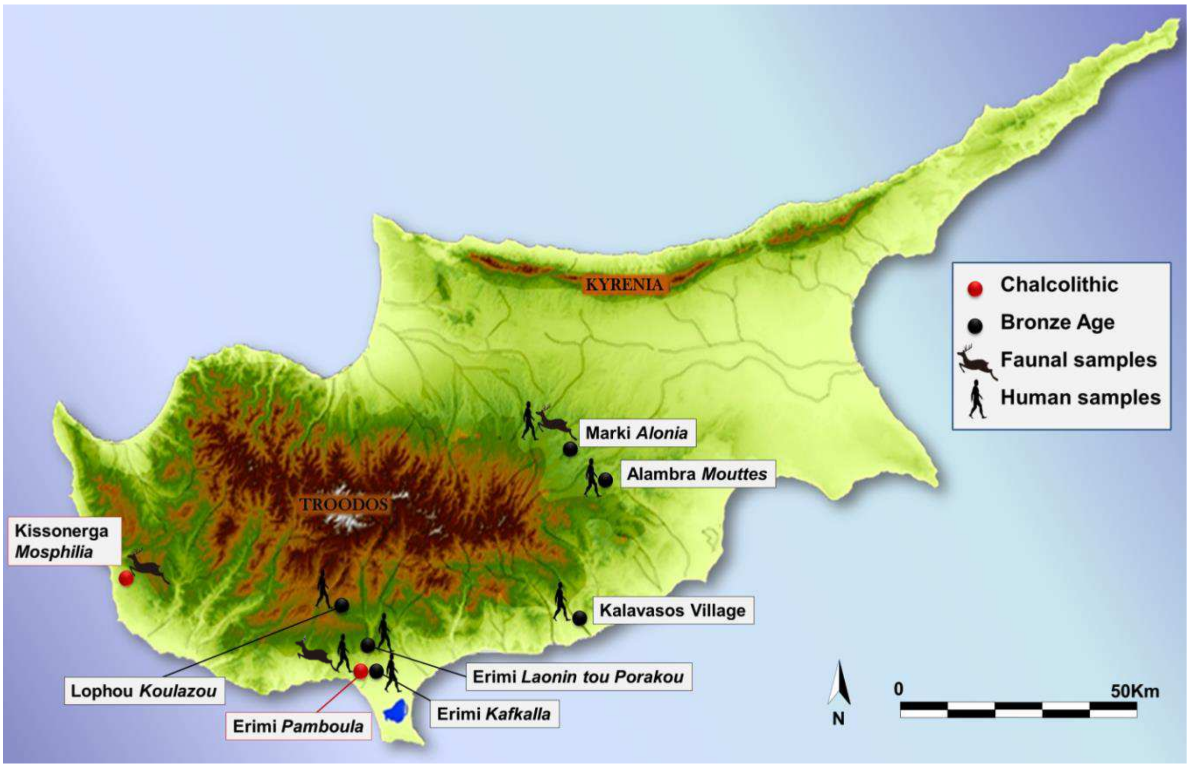
In order to tackle these problems, this study uses stable carbon and nitrogen isotope analysis of archaeological skeletal material to reconstruct the palaeodiet of the inhabitants of Cyprus from the Chalcolithic through the Early and Middle Bronze Ages (ca. 3900-1650 BC). Although minimally applied in Cyprus, light stable isotope analysis for palaeodiet reconstruction represents one of the best established applications of bone chemistry for reconstructing the diet of ancient communities (Ambrose 1993; Pate 1994; Sealy 2001; Tykot 2006; Lee-Thorp 2008; Schoeninger 2011). The technique is based on the premise that the carbon and nitrogen isotopic composition of skeletal tissues reflects that of the nutrients assimilated through the diet. Depending on which component of bone and teeth is utilised for the analysis, specific aspects of the diet can be investigated. In particular, measurements conducted on collagen – a fibrous protein dominating the organic fraction of bone and tooth dentine – will mainly reflect the dietary proteins; on the other hand, analysis of the inorganic matrix of bone and tooth enamel will provide estimates of the whole diet (Ambrose & Norr 1993). In general, due to the patterns of stable carbon and nitrogen isotope distribution in the biosphere, measurements of stable carbon and nitrogen ratios in archaeological bones and teeth allow to 1) identify the consumption of plants belonging to different photosynthetic pathways, namely, C_3 (like wheat and barley) versus C_4 (like millet) plants; 2) assess the kinds of proteins consumed in the diet, distinguishing between terrestrial (pulses and terrestrial animals), freshwater and marine resources; 3) estimate the relative importance of these food groups to the diet. The methodology is thus appropriate to the research questions addressed here.

In total, eight archaeological sites have been investigated within this research (Figure 1.1). From a chronological point of view, the Chalcolithic period is represented by the two settlements of Erimi *Pamboula* and Kissonerga *Mosphilia*, while for the Bronze Age, skeletal material from Marki *Alonia*, Alambra *Mouttes*, Kalavasos Village tombs, Lophou *Koulazou*, Erimi *Laonin tou Porakou* and Erimi *Kafkalla* was analysed. As typical for the period, the two Chalcolithic settlements of Erimi *Pamboula* and Kissonerga *Mosphilia* are located near coastal areas, respectively to the south and west of Cyprus. Differently, the Bronze Age villages of Marki *Alonia*, Alambra *Mouttes* and Erimi *Laonin tou Porakou* are situated more inland and in close proximity to important river courses. The remaining

Bronze Age sites of Kalavasos Village, Lophou *Koulazou* and Erimi *Kafkalla* are necropolises.

The selection of sites is the result of a long process of evaluation of the osteological collections designed to target the most suitable and more reliable skeletal material to be utilised for the analysis. In this regards, it should be underlined that the collections of human remains pertaining to the Chalcolithic and the Bronze Age are not numerous in Cyprus, and those that have been fully studied and published are even less. About ten years ago, Harper & Fox (2008: 2) emphasised that only about 36% or 9 of 25 reported Early and Middle Cypriot cemeteries had undergone anthropological study. Unfortunately, with a few exceptions, the situation has changed very little and most of the skeletal material excavated during rescue operations remains largely unstudied.

Figure 1.1 Map of Cyprus showing the archaeological sites investigated within this study and the distribution of the faunal and human samples.



Another frequently encountered problem is the accessibility of the material. This is partly due to the island's political division, following which the sites and inherent findings located in the northern sector of Cyprus cannot be accessed, and partly to the earlier custom of foreign archaeological missions to bring the bulk of the finds to their home country. This is the case, for example, of the human remains recovered from the necropolises of Karmi *Lapatsa* and *Palealona* (see map in Figure 3.2), a selection of which was brought by J.R.B Stewart to Australia in 1961, and it is now stored at the Nicholson Museum at the University of Sidney (Webb *et al.* 2009). A further limiting factor in the selection of sites was the general poor preservation of the osteological collections. In Cyprus, environmental conditions, such as high summer temperatures and the alkaline pH of the soils, may greatly affect the survival of collagen (Scirè Calabrisotto *et al.* 2013). The situation appears further exacerbated by the peculiar funerary customs of the Chalcolithic and Bronze Age periods. Funerary architecture typically consists of limestone rock-cut tombs which fill with water in the winter and dry in the summer, thus enhancing chemical degradation and displacement of the skeletal material (Harper & Fox 2008: 3). Also, mortuary rituals involving multiple opening and closing of the tombs along with secondary treatments of the dead allowed multiple stages of bone manipulation (Keswani 2004; Crewe *et al.* 2005).

Within this framework, preference was given to published osteological collections so as to have the possibility to integrate relevant anthropological data (like sex, age at death and palaeopathologies) to the results of the isotopic study. In addition, an effort was made to select archaeological sites where both animal and human remains had been excavated, so as to obtain a faunal isotopic baseline specific to each site and to which the human values could be referred. Depending on the preservation state of the skeletal material available from each site, either bone and dentinal collagen or tooth enamel was utilised for the analysis. In the latter case, additional information on the place of residence of the analysed animals and individuals was obtained through the measurement of stable oxygen isotope ratios of tooth enamel carbonate. In addition, radiocarbon dating of selected samples and Bayesian modelling of radiocarbon datasets were employed to get chronological control over the investigated sites and materials. Finally, complementary data derived by palaeobotanical, zoo-archaeological and anthropological studies were merged with the isotopic dataset in the attempt to better define the socio-cultural and environmental factors influencing the dietary choices of the investigated communities.

This thesis is structured as follows. Chapter 2 gives a general introduction to the environmental context of this research. After e brief discussion of the physiographic and climatic features of Cyprus, the text proceeds with a review of the existing palaeoenvironmental and palaeoclimatic data relevant to the reconstruction of the environmental conditions during the Chalcolithic and the Bronze Age, followed by a general description of the regions where the sites investigated within this research are located. Chapter 3 presents the historical and archaeological context for the work and provides basic background information about the socio-cultural and economic traits characterising the communities of the island during the Chalcolithic and the Early-Middle Bronze Age. Chapter 4 provides general information on the reconstruction of palaeodiet through carbon and nitrogen stable isotope analysis and define the methods and instruments utilised in this research. In Chapters 5 and 6, the isotopic investigation of archaeological sites pertaining to the Chalcolithic and to the Bronze Age periods, respectively, is presented. Each site is described also in terms of its location, excavation history, chronology, available natural resources and mortuary population. Chapter 7 provides a preliminary synthesis and discussion of the data gathered in this work and finally Chapter 8 discusses the value of this study in relation to the study of palaeodiet in prehistoric Cyprus and suggests potential avenues for future research.

CHAPTER 2
ENVIRONMENTAL CONTEXT

2.1. Introduction

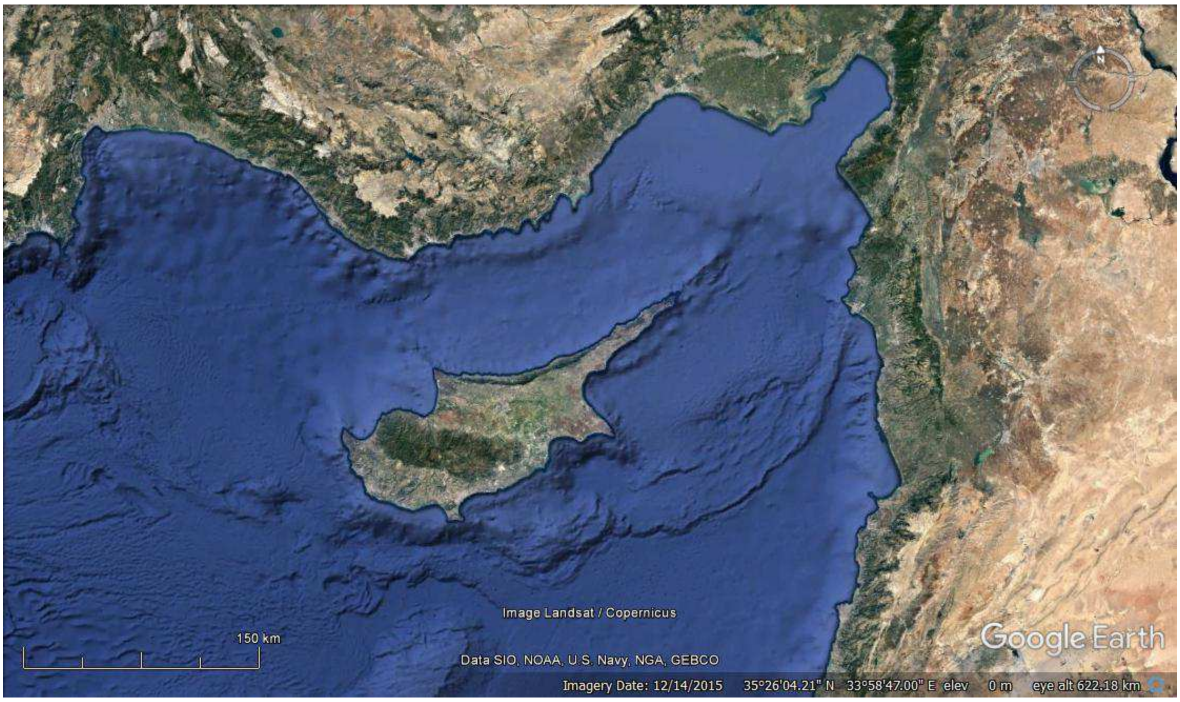
A complete understanding of the archaeological context cannot be achieved without the assessment of past environmental conditions and the dynamic interactions taking place between human groups and their ecosystems. In particular, the features and processes of the biophysical environment provide a background for and interact with human socio-economic and cultural systems, affecting also subsistence strategies and dietary patterns. Food systems are embedded into a variety of landscapes which differ according to several factors – such as topography, climate and availability of natural resources – that often act as environmental constraints and contribute to shape the dietary habits of a community.

This chapter is meant to provide an environmental framework within which to discuss the isotopic data presented in Chapters 5 and 6. Accordingly, the first section describes the general physiography and the current climatic conditions of the island of Cyprus. The second part reviews the palaeoenvironmental and palaeoclimatic data relevant for the reconstruction of the environmental conditions during the Chalcolithic and the Bronze Age. Finally, the last section offers a general description of the three regions where the sites investigated within this research are located: the Ktima lowlands, the Kouris River and Vasilikos River valleys (both part of the Southern Chalk Plateaus) and the upper catchment of the Yialyas River in the Central lowlands.

2.2. The island of Cyprus

With an area of 9.251 km^2, Cyprus is the third largest island of the Mediterranean, after Sicily and Sardinia. Situated in the north-eastern corner of the Mediterranean basin, it lies only some 70 km south of Turkey, 95 km west of Syria, and 400 km north of Egypt. The island of Rhodes in the Aegean Sea lies nearly 500 km west (Knapp 2013: 3).

Figure 2.1 Satellite image showing the location of Cyprus in the Mediterranean Sea. Source: Google Earth 7.1.8, Cyprus 35°26'04.21"N, 33°58'47.00"E, eye altitude 622.18 km, imagery date 12/14/2015.



2.2.1. Topography and geology

The landscape of Cyprus displays a general east/west trend (Figure 2.1). The topographic features reflect the underlying geology and are usually grouped into four principal units (Zohary 1973; Meikle 1977; Rapp 2003). In the south-west, almost one third of the island (3200 km^2) is occupied by the Troodos Mountain Range, a dome-shaped massif rising from about 700 to 2,000 m above sea level, with its highest peak (Mt. Olympus) attaining an altitude of 1,952 m. On a geological ground, the Troodos Terrane is unique and consists of the stratified ophiolite complex, that is, an uplifted piece of oceanic crust aged 92 million years resulted from the collision of the African and Eurasian lithospheric plates (Tsintides *et al.* 2002; Zomeni 2012). Originally mapped by the members of the Geological Survey Department of Cyprus (published during the years 1959-1967), the Troodos ophiolite is one of the best exposed and most thoroughly studied ophiolite in the world, characterised by a sequence of plutonic rocks (i.e. basalt, gabbro and dolerite) overlaid by a sheeted dike complex, pillow lavas, and pelagic sediments (Thy & Esbensen 1993). In cultural and social terms, the importance of the Troodos Range lies in the massive copper sulphide deposits hosted in the pillow lavas, which have constituted the mainstay of Cypriot economy over the past 4,000 years (Knapp 2013: 3). Also relevant, especially for the Chalcolithic prehistory of Cyprus, is picrolite, a soft light-green stone contained in the outcrops of pillow lavas and used in the past to manufacture an extensive repertoire of decorative objects like figurines, pendants, beads and vessels (Xenophontos 1991).

In the north, the Kyrenia Range, also called *Pentedaktylos*, is a narrow mountain chain (5 km at its widest point) extending along the coast in a series of rocky peaks that rise abruptly from the surrounding lowlands. It has an average height of 600 m and consists of an assemblage of allochthonous crystalline limestone blocks and thick sandstone beds (Tsintides *et al.* 2002; Zomeni 2012).

Between these principal formations lies the central low plain, also known as *Mesaoria* ("between the mountains"), extending from Famagusta Bay on the east to Morphou Bay on the west. These central lowlands vary in elevation between 0 and 230 m above sea level and mainly consist of alluvial deposits, silt, and a central limestone plateau overlaid especially in its eastern sectors with a hard calcareous crust (locally termed *kafkalla*) occasionally covered by thin layers of terrarossa soils (a red soil produced by the degradation of limestone and dolomite formations) (Knapp 2013: 4-5).

Finally, a narrow coastal belt, varying from 0.5 to 5 km wide, surrounds most of the island and it is characterised by fertile, tilled land along with uncultivated land, mostly rocky shores with some sandy bays and salt pans (Meikle 1977; Rapp 2003).

2.2.2. Hydrology

The extreme hydrologic situation of Cyprus is one of the most salient characteristics of the island for there are several rivers but, due to arid climatic conditions, none of them has perennial flow along its entire length. Also, there are no freshwater lakes, only salt lakes at Larnaca and Limassol. Fortunately, groundwater bodies are frequent in Cyprus and help to restore the balance of water supply. Important aquifers are located in the western and south-eastern deltaic deposits of the *Mesaoria*, in the area south-west of Limassol and in the Kyrenia Range. These aquifers generate springs, most of which take water from the joints and fissures in the rocks. Nevertheless, most springs are small, the largest being issued from the Kyrenia Range and south of the Troodos Range (Christodoulou 1959: 36-40; UNDP 1970: 4; Water Development Department 2005).

The largest rivers on the island drain radially from the Troodos massif and receive water only from rainfall (concentrated in autumn and winter) and from melting of winter snow on the top of the Troodos Range. As a consequence, rivers are mostly active in the winter season, when, as noted by Christodoulou (1959: 39), water is least wanted, but they become virtually dry in summer. Precipitation patterns also determine the seasonal distribution of surface runoff, with minimum values during the summer months and maximum values during the winter months (Water Development Department 2005).

Of crucial importance in the study of the landscape of Cyprus is that the seasonal or episodic nature of stream flow (occasionally punctuated by catastrophic floods) and the pronounced gradient of the rivers stemming from the two mountain ranges have favoured violent erosion and deposition of heavy materials along river courses and floodplains. This is evident both in the geomorphology of the deeply incised river valleys surrounding the Troodos massif and in the deposition of thick alluvial fans on the lowlands, where the most productive and cultivated soils are located (Stanley Price 1979: 7-9; Knapp 1994: 390-397; Butzer & Harris 2007; Zomeni 2012, Figure 4.5).

2.2.3. Vegetation

Due to its varied climate and geology, and to the proximity to Asia, Africa and Europe, the island of Cyprus is characterized by a variety of landscapes. In addition, both its size and isolation (at least since the Miocene salinity crisis) have contributed to support high species and habitat diversity (Delipetrou *et al.* 2008).

The present vegetation of Cyprus consists of a mosaic of six general groups of wild plants and natural habitats: pine forests, maquis[1] and garigue[2], rocky areas, coastal areas, wetlands, and cultivated land (Tsintides 1998: 11-20). Forests cover about 20% of the island and extend mainly on the Troodos massif, on the mountains of the Akamas peninsula in the west and on the northern Kyrenia Range. About 66% of forest land is constituted by thermophilous pine forests of *Pinus brutia*, occurring at various elevations (from sea level up to 1,400 m) and from dry to sub-humid climate. At the highest elevations of the Troodos Range (between 1,200 and 1,900 m), a restricted area with higher precipitation and lower temperatures in winter is characterised by forests of black pine (*Pinus nigra*). In the Kyrenia range, pines are locally mixed with cypress (*Cupressus sempervirens*). The most humid and coolest areas of the Troodos Range host also montane

[1] *Maquis:* forest vegetation that has not fully regenerated and is comprised of evergreen shrubs or small trees (up to 3–5 m high) (Fall 2012: 80).

[2] *Garigue:* vegetation composed of low-growing evergreen shrubs up to about 50 cm high (Fall 2012: 80).

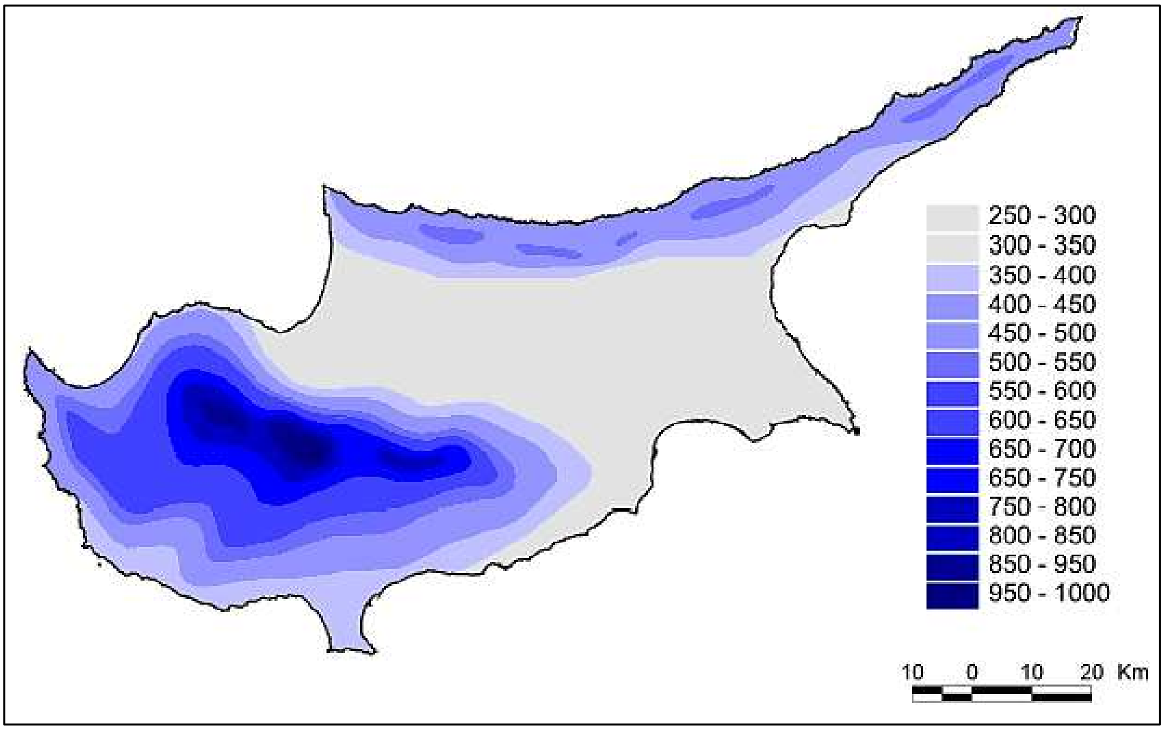
conifers, junipers, and the endemic evergreen golden oak (*Quercus alnifolia*). The endemic Cyprus cedar (*Cedrus brevifolia*) is found only in the Paphos Forest, from 900 to 1400 m of elevation. Descending the slopes of the Troodos massif, the forest coverage is gradually replaced by various types of evergreen, sclerophyllous Mediterranean shrubs of different heights, subshrubs, herbs and isolated trees that form the largest continuum of natural biotopes on the island. These plants cover a considerable portion of the island (about 30%) and constitute the garigue and maquis vegetation zones. Here the floral array is formed by rare communities of olive (*Olea europea*), carob (*Ceratonia silique*), lentisc (*Pistacia lentiscus*) and kermes oak (*Quercus coccifera*) alternated to drier and grazed areas occupied by garigue formations. The vegetation of both rocky and coastal areas is sparse and respectively characterised by chasmophytic vegetation and plants that tolerate high salinity of soils and air. Although water courses in Cyprus are not perennial, narrow and discontinuous lines of riparian shrub and forest develop along the numerous streams of the island, especially where slopes are gentle. Representative species are for example *Alnus orientalis*, *Platanus orientalis* and *Nerium oleander*. Finally, cultivated lands cover about 45% of the island and, apart from the vast cultivated areas of the fertile *Mesaoria* plain, they are found among the mountains and, occasionally, within the forested areas (Tsintides 1998; Tsintides *et al.* 2002; Delipetrou *et al.* 2008; Fall 2012).

2.2.4. Climate

According to current bioclimatic classifications, Cyprus shows a prevailing Mediterranean semiarid climate close to aridity (Pantelas 1996; Andreou & Panagiotou 2004). Winters are rainy, rather variable, and go from November to mid-March while summers are dry and hot, lasting from mid-May to mid-September; they are separated by short autumn and spring seasons characterized by sudden changes in weather conditions (Department of Meteorology 2006-2016).

Due to its position, the island of Cyprus is visited by predominantly continental or modified continental air masses; most of the low pressure systems are deviated by the south-west corner of Turkey thus affecting the rainfall potentialities on the island (Christodoulou 1959: 19). The distribution of the mean annual precipitation on the island is shown in Figure 2.2. Generally speaking, precipitation levels are associated with elevation: at the peak of the Troodos massif, the average annual total precipitation is nearly 1,100 mm, but decreases steadily to 450 mm towards the western sector of the island, and between 300 and 350 mm towards east, in the central plain and the flat south-eastern areas of the island. Along its narrow ridge, the Kyrenia range is characterised by a relatively small increase of rainfall to nearly 550 millimetres at about 1,000 m. Precipitations are usually concentrated from October through May, with about 60% of the average annual total precipitation for the island (465 mm) occurring from December to February. Rainfall in the warmer months is rare and rarely effective, as the small amounts of rain are rapidly absorbed by the very dry soil and soon evaporated in hot temperatures (Water Development Department 2005; Pashiardis 2013).

Figure 2.2 Distribution of the mean annual precipitation in Cyprus (mm). Source: Water Development Department (2005, Figure 2-3).



As far as temperature variation is concerned, the major factors controlling it are elevation and the proximity to the sea. In general, altitude lowers temperatures by about 5°C per 1,000 m while the influence of the sea produces cooler summers and warmer winters near most of the coastline and especially on the west coast. The seasonal difference between mid-summer and mid-winter temperatures is quite large, corresponding to 18°C inland and about 14°C on the coasts. Differences between day maximum and night minimum temperatures are also quite large, especially in the interior and during summer. In July and August the mean daily temperature ranges between 29°C on the central plain and 22°C on the Troodos mountains, while the average maximum temperature for these months ranges between 36°C and 27°C respectively. In January the mean daily temperature is 10°C on the central plain and 3°C at the higher elevations of the Troodos Range with an average minimum temperature of 5°C and 0°C, respectively (Department of Meteorology, 2006-2016; Pashiardis 2013).

The island of Cyprus is characterized by a critical deficit of precipitation over atmospheric water demand. The UNESCO (1979) aridity index has been used to quantify this deficit and map the severity of dryness based on the ratio of annual rainfall to annual potential evapotranspiration during the period 1980-2010. Accordingly, nearly 80% of the island is semi-arid (aridity index between 0.2 and 0.5). Sub-humid or humid areas are found only in the Troodos massif, above 800 m of elevation. These results highlight the severe negative balance between water supply from precipitation and the evaporative demand of the atmosphere (Pashiardis 2013).

2.3. Palaeoenvironment

In spite of a long tradition of archaeological research, an accurate reconstruction of the environmental history of Cyprus has not yet been accomplished and the palaeoenvironmental record of the island is still fragmentary and incidental. In particular, the nature of the evidence is biased in favour of geology, the discipline which currently provides the largest amount of palaeoenvironmental data (Geological Survey Department 2005-2016).

Besides some recent survey expeditions and geoarchaeological studies that have shed new light on the environmental changes taking place in certain areas of the island (see, for example, Deckers 2005; Deckers *et al.* 2005; Devillers 2008; Iacovou 2008, 2014; Given *et al.* 2013a, 2013b; Kinnaird *et al.* 2013), the few environmental proxies from Cyprus are mainly the result of research undertaken in conjunction with archaeological excavations and are thus limited to the site area and its immediate surroundings. Recent efforts have been made by Lucas (2014) to produce a comparative quantitative analysis of the Cypriot archaeobotanical record, and by Griggs *et al.* (2013) to provide the first dendroclimatic record of long-term annual precipitation and drought assessment at low to mid-elevations in Cyprus. However, the current state of environmental research is far from exhaustive and more systematic studies are needed in order to fully understand the complex environmental history of the island.

2.3.1. Climatic reconstruction

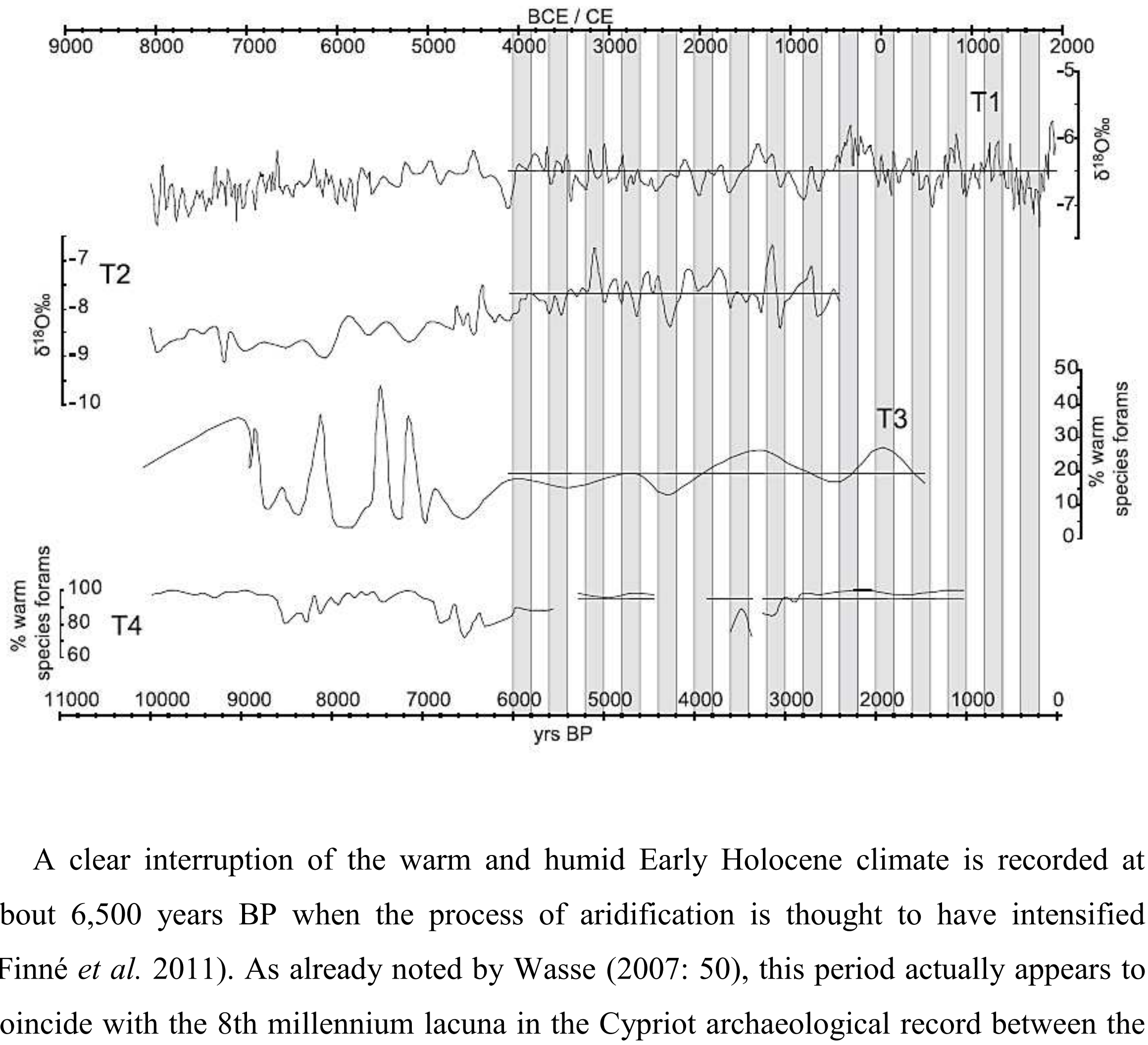
As already stressed before, the lack of systematic investigation of multiproxy-data from Cyprus affects the Holocene palaeoclimatic record of the island which presently consists of few palynological, paleolimnological and dendroclimatic studies (cf. Finné *et al.* 2011: Fig. 1; Luterbacher *et al.* 2012 : 98-103). With reference to prehistoric times, pollen analyses have been conducted at the Neolithic site of Khirokitia (Renault-Miskovsky 1989), the Chalcolithic site of Lemba *Lakkous* (Renault-Miskovsky 1985) and the Late Bronze Age sites of Kalopsidha (Bottema 1966) and Hala Sultan Tekke (Bottema 1976; Kaniewski *et al.* 2013), though the pollen cores retrieved from archaeological excavations have often shown problems of bad preservation (Bottema 1966, 1976; King 1987). On the other hand, dendroclimatic sampling has been made on large populations of different species of pine and cedar trees, although it should be underlined that the tree-ring sequences do not cover a sufficient time span to investigate climatic conditions before the 15th century AD (see for example Touchan *et al.* 2005; Rich *et al.* 2012; Griggs *et al.* 2013). Finally, only very preliminary results have been published concerning the analysis of lake sediments from the Akrotiri salt lake and, unfortunately, they are not linked to a temporal scale (Reed 2009).

As a consequence of this lacuna, the reconstruction of the Cypriot palaeoclimate usually relies on palaeoclimatic evidence from the Eastern Mediterranean and the surrounding regions, following the basic assumption that climatic events occurring in the Levant could also have included the island of Cyprus (see, for example, Wasse 2007). This supposition is probably valid in the case of major climatic episodes affecting the whole Mediterranean, but clearly becomes less accurate when trying to describe the island-specific climatic variations on a high resolution temporal scale. Indeed, the latest reviews of palaeoclimate in the Levant and the Eastern Mediterranean clearly show that superimposed on the long-term trend is short-term variability, both in time and space, resulting in a climatically complex Holocene (Robinson *et al.* 2006, 2011; Finné *et al.* 2011).

Within these premises, the following discussion aims at presenting the principal climatic events that affected the climate in the Levant and Eastern Mediterranean during the Early-Middle Holocene (c. 9,500-2,250 years BP), as this temporal span also includes the period investigated within this work of thesis (see Figure 2.3).

There is general consensus in the literature that the cool, dry conditions of the last Ice Age were replaced by a wetter and warmer climate starting around 9,500 years BP and covering about the first half of the Holocene. Considering Cyprus archaeological record, this climatic amelioration would have corresponded to the socio-cultural intensification represented by the later Cypro-PPNB and Khirokitian (see Table 3.1). Towards this purpose, the presence of *Pistacia* species at *Shillourokambos* and Khirokitia (see map in Figure 3.1) seems consistent with this scenario (Wasse 2007: 49).

Figure 2.3 Collection of proxy-based paleoclimate data showing warmer (up) and cooler (down) conditions. T1-T4 represent data from north-eastern Italy, south-western Romania, Adriatic Sea and Aegean Sea, respectively. Grey bars mark interval of 200-years. Horizontal black bars in graphs show calculated average proxy value for the period 6000-0 years BP. Please note the difference between the upper (BCE/CE) and lower (yrs BP) time scales, grey bars are set after the yrs BP scale. From Finné *et al.* 2011: 3159, Fig. 3.



A clear interruption of the warm and humid Early Holocene climate is recorded at about 6,500 years BP when the process of aridification is thought to have intensified (Finné *et al.* 2011). As already noted by Wasse (2007: 50), this period actually appears to coincide with the 8th millennium lacuna in the Cypriot archaeological record between the Khirokitian and the Ceramic Neolithic. The drier conditions of the Mid-Holocene seem to have been temporally replaced by more humid conditions around 5,000 years BP (Robinson *et al.* 2006, 2011; Finné *et al.* 2011). With reference to Cyprus, that period of moister climate would have covered the greater part of the Chalcolithic (ca. 4,000/3,900-2400 BC). Actually, the results of palynological analysis from Lemba *Lakkous* seem consistent with the evidence of a more humid climate, as suggested by the presence of *Alnus* and aquatic plants in the pollen cores (Renault-Miskovsky 1985: 306-311). The Mid-Holocene time interval also encompasses a rapid climate anomaly apparent in many paleoclimate records, mainly from the northern hemisphere, and occurring at about 4,200 years BP, often referred to as the 4.2 event. The spatial extent and the properties of this climate anomaly are still debated but it has been proposed that a volcanic eruption and/or a severe drought could have affected the eastern Mediterranean (Finné *et al.* 2011). Within this framework, it should be noticed that the pollen samples from Lemba *Lakkous* dated to the mid-third millennium BC seem to indicate climatic deterioration with lowering of the water table and a temporary cessation of dependable stream flows (Renault-Miskovsky 1985, 306-311).

Throughout the latter part of the Mid-Holocene, a general drying trend seems to have prevailed and climatic fluctuations had probably been less extreme until about 3,200 years BP, when a severe drought event is thought to have affected the whole Eastern Mediterranean. This period actually corresponds to the end of the Bronze Age (ca. 1050 BC) and many authors have related this climatic shift to the Late Bronze Age crisis (see, for example, Kaniewski *et al.* 2013).

2.3.2. Sea-level fluctuations

Besides climatic variations, sea level fluctuations are mainly governed by eustatic changes and tectonic events. Concerning the western and central Mediterranean basin, several scholars have tended to consider tectonically-induced submergence as subordinate to eustatic changes in sea-level, and the coastline is assumed to have reached its present configuration in the early Holocene (ca. 9000 BP). However, studies conducted in the eastern Mediterranean have often underlined the difficulty of clearly understanding the role of localized tectonic activity on the configuration of the coastline during the Holocene. That issue would be particularly important for Cyprus, as the island is located just at the border between the African Tectonic plate and the Anatolian tectonic microplate, and it has been frequently affected by tectonic movements such as earthquakes (Gomez & Pease 1992). In addition, as suggested by Deckers (2002: 35-36), sea-level fluctuations could also have affected the fluvial system causing either alluvial erosion and river aggradation or sedimentation in the coastal areas. Unfortunately, these local dynamics have been poorly investigated and the reconstruction of sea-level fluctuations have been mainly derived from the study of tectonic and eustatic components.

In general terms, after the Late Glacial Maximum (around 18,000 BP) the mean sea level of the Mediterranean basin was about 120 m lower than at present day. By ca. 9000 BP mean sea level had risen to about -35 m and by ca. 5000 BP it was within about 1 m of its present elevation. As a consequence, the Chalcolithic inhabitants of Cyprus would have experienced a sea level only moderately lower than today and with a slightly more extensive coastline, about 1-2 km seaward in the south and 1 km in the north. During the Bronze Age, the coastline was probably very similar to the present one. However, between 5,000 and 3,500 BP the mean sea level probably fell slightly, until it was about 2 m lower than present day around 3,500 BP, that is, at the end of the Bronze Age (Deckers 2002: 34).

2.3.3. Flora and Fauna

Archaeobotanical data from the Early Aceramic Neolithic (see Table 3.1) suggest that cultivated (if not domesticated) plants were brought to Cyprus by the island's earliest settlers at ca. 8500 BC (Colledge *et al.* 2004; Peltenburg *et al.* 2000; Willcox 2003). Among the principal founder cereal crops, only wild barley (*Hordeum spontaneum*) is indigenous to Cyprus, whilst the wild progenitors of einkorn wheat (*Triticum boeoticum*) and emmer wheat (*Triticum dicoccoides*) are not attested on the island. The main founder pulses include wild lentil (*Lens orientalis*), wild pea (*Pisum elatium* and *Pisum humile*), wild chickpea (*Cicer echinospermum* and *Cicer reticulatum*), and wild bitter vetch (*Vicia ervilia*), among which only lentil and pea are indigenous to the island. Flax (*Linum bienne*) is also indigenous to Cyprus (Lucas 2014: 40).

Plant remains from Aceramic Neolithic levels include three domesticated cereals (einkorn wheat, emmer wheat and hulled barley) supplemented by legumes (lentil, pea) and fruits (pistachio, fig, plum, pear and grape). Bread wheat first appears on Cyprus during the Ceramic Neolithic together with chickpea and domesticated flax. The Chalcolithic and the Early/Middle Bronze Ages do not have further crop or pulse introductions but domestication of grape likely begins in the Chalcolithic and that of almond in the Early/Middle Bronze Ages. Conversely, wild herbaceous taxa increase through time from the Aceramic Neolithic to the Bronze Age, reaching the maximum peak during the Chalcolithic with 18 new species appearing in the archaeobotanical record of the period. This result has been taken as an evidence for agricultural intensification and extensification (Lucas 2014: 71-75).

Although limited, pollen and anthracological analyses suggest that the island of Cyprus was once more densely forested than today, especially in the northern coast, the coastal areas to the west and south-west of Larnaca, and around Paphos and Limassol, where both rainfall and temperature range would have supported thick forests in antiquity (Zohary 1973; Knapp 1994: 395; Adams & Simmons 1996: 20; Burnet 2004). Vegetation cover would have included dense forests of typical Mediterranean trees and shrubs – such as carob (*Ceratonia siliqua*), cypress (*Cupressus sempervirens*), juniper (*Juniperus* sp.), oak (*Quercus coccifera* and *Quercus infectoria*), bay laurel (*Laurus nobilis*), olive (*Olea europaea*) – as well as thick riparian forests (Burnet 2004; Delipetrou *et al.* 2008, with references).

Since the island of Cyprus was never connected to the mainland, prior to human occupation (i.e. before about 11,000 BC), the terrestrial mammalian fauna was reduced to only four or five endemic species: mouse (*Mus cypriacus*), genet (*Genetta plesictoides*), and dwarf forms of elephant (*Elephas cypriotes*) and hippopotamus (*Phanourios minutus*) which both became extinct at the end of the Pleistocene (Simmons 1999; Vigne *et al.* 2011). As noted by Croft (2002: 172), the disappearance on the island of these large mammals left Cyprus with no mammalian herbivore larger than the mouse.

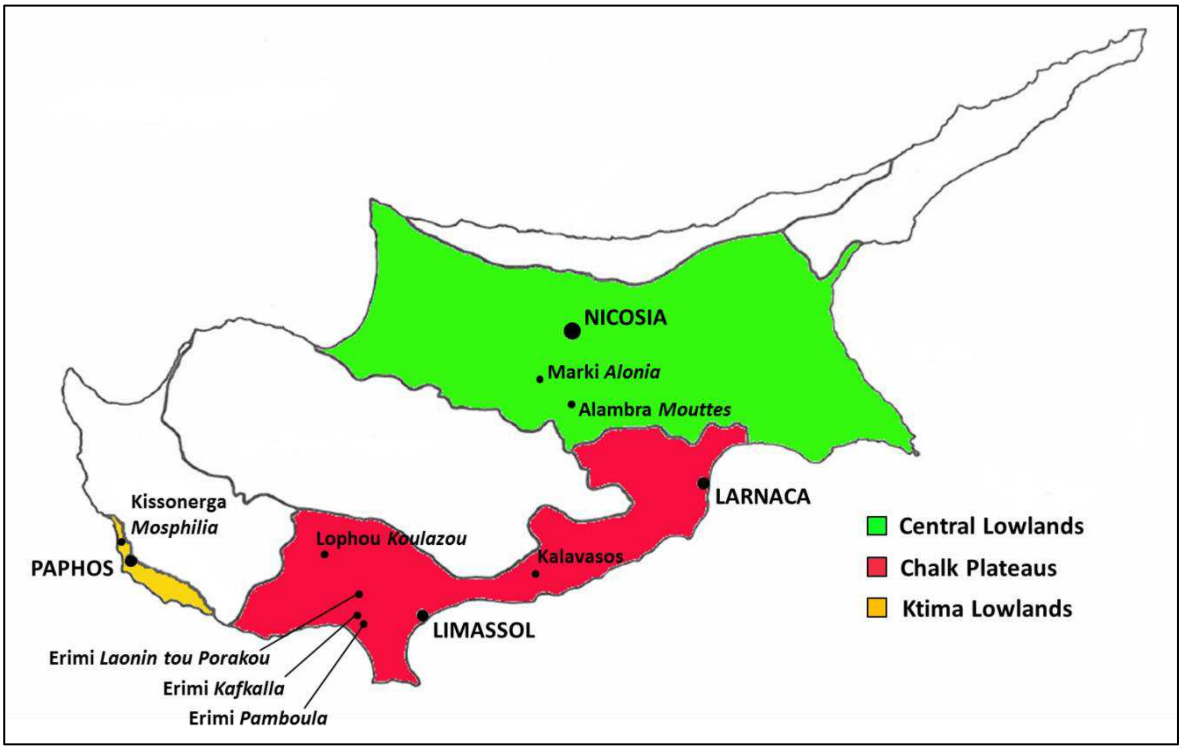
By the Late Aceramic Neolithic, all animal species regularly represented in the faunal assemblage of prehistoric Cyprus are present, including sheep, goat, cattle, fallow deer (*Dama mesopotamica*), dog, fox and cat. Since these animals apparently have no ancestors on the island, it is believed that they were brought to Cyprus during multiple episodes of introduction along with the range of cultigens mentioned above (Peltenburg *et al.* 2000, 2003; Vigne *et al.* 2000, 2011, 2016). With the exception of fallow deer, the domestication status of the other introduced ungulate species at the time of import is currently a point of debate (e.g. Horwitz *et al.* 2004; Vigne *et al.* 2011).

Interestingly, cattle disappears from the Cypriot faunal record after the Late Aceramic Neolithic and it is found again only by the onset of the Bronze Age. During the same period, equid (most likely donkeys) and screw-horned goats were also introduced to Cyprus (Croft 1996; Knapp 2013: 11-12).

2.4. Investigated regions

The sites investigated within this study are located in three main regions: the Ktima lowlands; the Southern Chalk Plateaus, including the Kouris River and the Vasilikos River valleys, and the Central lowlands (Figure 2.4).

Figure 2.4 Map of Cyprus showing the regions investigated within this study. Adapted from Stanley Price 1979: 4, Fig. 3.



2.4.1. The Ktima lowlands

The region of the Ktima lowlands is defined here after Christodoulou (1959: 18) as the narrow strip of land running along the west coast of Cyprus for about 25 km, from the modern village of Kissonerga, located just south of the Akamas peninsula, to the modern village of Kouklia, situated at the border between the Paphos and Limassol districts. The coast is rocky and the morphology of the area is that of a series of raised beaches backed by steep cliffs.

On a geological ground, the low coastal areas predominantly consist of Pleistocene terrace deposits of calcarenites, sands and gravels, surrounded by Mamonia rocks in the west and the Pakhna formation in the east (Geological Map of Cyprus 1995; Christodoulou 1959: 18). The most recent, lowest, raised beaches typically show soils which are gravelly and of rather good fertility although the best soils are the calcareous, alluvial deposits located on river deltas or lower terraces (Christodoulou 1959: 45).

The region is intersected by five main rivers flowing into the sea: the Cha-Potami, Dhiarizos, Xeros, Ezousa and Yeroskipou basins. In addition, the calcarenite deposits along the coast represent good aquifers (UNPD 1970: 97-99).

The area of Kissonerga *Mosphilia* is currently under banana cultivation although cereal crops and isolated vineyards were presented until 1975. The climax vegetation includes maritime scrub forest with lentisc, juniper and carob under a localised Aleppo Pine canopy. A minor stream, probably once perennial, is located adjacent to the site (Peltenburg *et al.* 1998: 1).

2.4.2. The Southern Chalk Plateaus

The wide region of the Southern Chalk Plateaus extends along the south coast of Cyprus from the gulf of Episkopi to the area of Larnaca which, although part of a distinct drainage unit, share the same geology (Christodoulou 1959: 16-18).

From a geomorphological point of view, the region is defined by low, gentle dip-slopes descending gradually to the sea, ending sometimes in raised beaches and, rarely, in narrow coastal plains. A series of deeply-incised, canyon-like valleys cut through these plateaus towards the sea. Among these are the Kouris River and the Vasilikos River valleys, where the sites of Erimi *Pamboula*, Erimi *Kafkalla*, Erimi *Laonin tou Porakou*, Lophou *Koulazou* and the village of Kalavasos are located (see Figure 2.4).

a. Kouris River valley

Located in the southwestern region of Cyprus, the Kouris catchment is the major drainage system of the island. It covers an area of 300 km^2 and extends from the southern side of the Troodos Massif to the Mediterranean Sea. Most of the area is drained by the Kouris, Limnatis and Kryos Rivers and their tributaries, originating in the Troodos Mountains and in the sedimentary hills. Flow in the Kouris and Limnatis Rivers is continuous throughout the year, consisting of spring water during the dry season, while the Kryos River is normally dry in summer. The transition from the Troodos Mountains to the hilly area occurs at an elevation of about 800 m and is marked by a rather striking valley; then, the hilly area merges gently with the coastal plain.

The Kouris drainage encompasses two main geological zones: the Troodos Terrane (or Troodos Ophiolitic complex) in the north and the Circum Troodos Sedimentary Succession in the south. The first one is characterised by strong lithologic heterogeneity and comprises the ultramafic (harzburgite, periodotite, dunite, serpentinite and picrolite) and gabbros cumulates of the plutonic complex on the highest elevations, followed by the volcanic and intrusive series of the diabase sheeted dykes, the basal group and the outer arc of upper and lower pillow lavas. On the other hand, the sedimentary complex includes river alluvium and consolidated sediments mainly represented by chalks, marls, calcarenites and limestones of the Lefkara and Pakhna formations (Boronina *et al.* 2003).

Surface elevation within a distance of about 30 km ranges from about 2000 m north to sea level in the south, thus giving rise to very high slopes and pronounced gradients (Boronina *et al.* 2003). Such conditions and the frequent occurrence of sudden and violent rainstorms during the winter months have been deemed responsible for intense fluvial activity, with alternating or concurrent episodes of strong erosion and subsequent deposition of heavy materials that have gradually created a mountainous landscape made of steep, canyon-like valleys alternating with isolated plateaux with a null or low gentle slope (Stanley Price 1979: 7–9). In the Kouris valley the debris is then carried through the river channel and deposited on either side of the stream following linear arrangements. Alluvial sediments formed during this process usually accumulate in the lower reaches of the valley where the terrain is relatively flat and soils retain moisture more effectively than they do on the steep chalky slopes to the east and west (Bolger 1988: 18). Following Christodoulou (1959), soils in this region tend to be thin and not so well suited to dry farming except in valleys and depressions. The belt of alluvial deposits along the river banks carry good red loamy soils; shallow valleys, especially if terraced, carry stiff, light-coloured soils of relatively good fertility. Away from the river, to the east and west, marls give stiff and compact soils difficult to work and red loams develop mainly on the tops of lime plateaus where erosion rates are low (Christodoulou 1959: 45; Bolger 1988: 18).

Another important source of fresh water is represented by groundwater bodies. Besides the contribution of the Kouris, Limnatis and Kryos Rivers, the region is indeed well irrigated by aquifers that constitute one of the richest hydrogeological areas of southwestern Cyprus. In general, the Kouris catchment can be divided into two main aquifers: a sedimentary aquifer (chalks, marls, calcarenites) and an igneous rock aquifer (ophiolites) consisting of mantle, plutonic and intrusive sequences. Several springs characterise the upper part of the catchment as they are mainly associated with plutonic and intrusive rocks (gabbro, sheeted dykes). In total, 64 springs have been mapped within the Kouris drainage and 14 of the largest have been monitored monthly since 1986 by the Water Development Department (Boronina *et al.* 2003).

b. Vasilikos River valley

The Vasilikos River valley is aligned approximately NW-SE. The village of Kalavasos, where the skeletal material analysed in this study has been recovered, is located where the valley is particularly narrow, just north of the point where it widens out toward the coastal zone. What follows, is a brief review of the geomorphological features of the valley, taken from the more detailed work by Gomez *et al.* 2004.

From the geological point of view, the upper part of the catchment (total area 151.4 km^2) is characterised by igneous rocks of the Troodos Ophiolite complex of Upper Cretaceous age (andesitic, diabase rocks and an outer arc of pillow lavas); the lower part comprises sedimentary rocks: sandstone of the Alassa formation, marls and sandy limestones with gypsum (Dhali Group) and chalk (Lefkara Group) of Upper Cretaceous to Pliocene age. In the northern sector, dry, humus-carbonate soils are more frequent while on the lower hills of the Lefkara Group coarser and thin calcareous soils (difficult to cultivate) have developed. The most fertile alluvial soils are mainly found in the floodplain of the Vasilikos River and, to a lesser extent, behind artificial terraces in the side valleys. Besides good agricultural potential, the Vasilikos valley was exploited for the massive bodies of copper disseminated in the pillow lavas. Gypsum, limestone and other local stones for building as well as local clay for pottery must also have been of considerable importance.

As typical in Cyprus, flow in the Vasilikos catchment is not perennial and depends almost exclusively on rainfall. Three aquifers are present in the area, located in the gypsum and Athalassa sandstones and in the more recent gravels.

2.4.3. Central lowlands

The region of the Central Lowlands includes all the territories lying between the Troodos and the Kyrenia Ranges and it is sometimes erroneously called *Mesaoria* plain (Christodoulou 1959: 12). It is characterised by a very diverse pattern of landforms but the main features are the eastern and western alluvial fan regions, sided by limestone plateaus and, to the southwest, the Troodos Range. The geological formations of the Central

Lowlands are the youngest of Cyprus and include Pleistocene fanglomerates, limestone-capped plateaus with marl (Nicosia and Athalassa formations), and Upper Miocene-Pliocene marls (Stanley Price 1979: 6).

Of interest here is the upper catchment of the Yialyas River, at the interface of the igneous formations of the northern Troodos and the sedimentary deposits of the central plain, where the sites of Marki *Alonia* and Alambra *Mouttes* are located (see Figure 2.4). At Marki, the most prominent source of water supply, although not perennial, is the drainage system of the Alykos River and its tributaries. Here the valley is characterised by small streams that cross the chalk escarpment in several places and flow south to join the main river before it also joins the Yialyas River further north-east (Xenophontos 1996). While the copper ores of the Troodos are close to the site, the agricultural potential of the area of Marki is rather low, and productivity is limited by the poor quality of the soils (Frankel & Webb 2006: 306-307). The area of Alambra is crossed by two rivers: the Yialyas, to the north, flows towards north-east, while the Tremithos and its tributaries, to the south-east, drains towards the south coast near Larnaca. The most fertile soils are located to the north of Alambra, close to the Yialyias River, although the area of upper pillow lavas to the south and west of the village is also farmed (Coleman *et al.* 1996: 1).

CHAPTER 3
HISTORICAL AND ARCHAEOLOGICAL CONTEXT

The skeletal material analysed in this work of thesis originates principally from archaeological sites pertaining to the Chalcolithic and the Early to Middle Bronze Age periods of Cypriot prehistory (ca. 3900-1650 BC)[3]. During that time, significant social, economic, and cultural changes radically transformed the prehistoric communities of Cyprus from isolated, rural villages into proto-industrial, increasingly complex centres.

In order to place the palaeodietary data presented in Chapters 5 and 6 within their historical and archaeological contex, this chapter provides basic background information about the socio-cultural and economic traits characterising the communities of the island during the investigated period. More exhaustive overviews can be found in Steel (2004) and Knapp (2008, 2013).

3.1. Chalcolithic

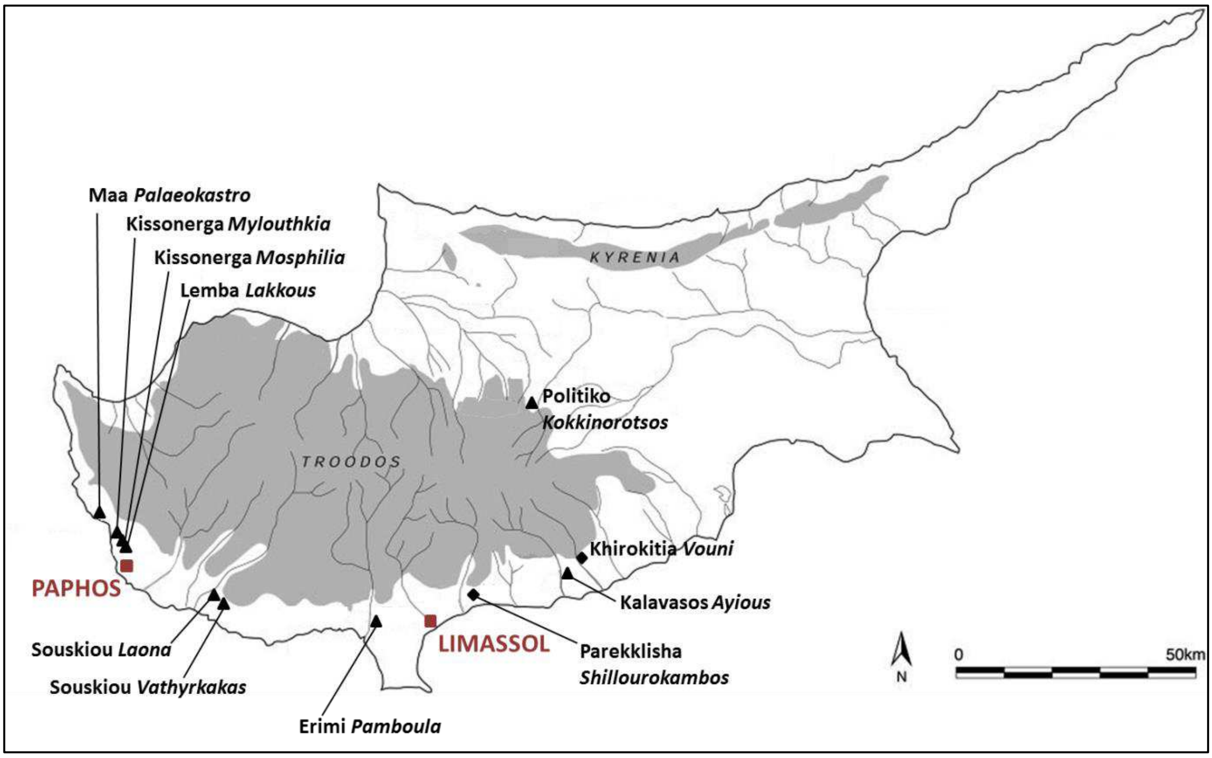
The Chalcolithic period in Cyprus lasted for some 1500 years, from ca. 4000/3900 to 2400 BC. According to the latest terminology, the Chalcolithic is subdivided into three main phases - Early, Middle and Late - sometimes referred to as the “Erimi Culture”, from the eponymous site of Erimi *Pamboula* (see Figure 3.1) where the first attestations of the Chalcolithic occupation were found.

Although a significant amount of new data has been produced over the last three decades, the archaeological record of the Chalcolithic period is still incomplete and unbalanced. The situation is particularly worse in the northern sector of the island, where

[3] Since it is uncertain whether the skeletal material from the Bronze Age necropolis of Erimi *Kafkalla* (Chapter 6.2.6) belongs to the transitional Middle to Late Bronze Age phase or to the full Late Bronze Age, the latter period is not discussed in this chapter.

political occupation has made this territory inaccessible since 1974 and no major excavations of Chalcolithic sites had been made before that date. As a matter of fact, our knowledge of the Chalcolithic society mainly derives from the south-west and west of the island, where the major excavated settlements are located (Figure 3.1).

Figure 3.1 Map of Neolithic and Chalcolithic sites mentioned in the text.



3.1.1. Settlements, architecture and material culture

The transition from the Ceramic Neolithic to the Chalcolithic is characterised by a widespread abandonment of the Late Neolithic villages and the establishment of new settlements, especially on richer, better watered coastal regions. At least 125 sites of the period are known, and further 48 yielded material indicators of both the Ceramic Neolithic and the Chalcolithic (Knapp 2013: 197). This major island-wide reorganisation of settlement patterns has been explained as the result of an indigenous process of settlement abandonment, dislocation and fissioning, probably linked to increasing demographic pressure (Peltenburg 1993, 2014; Knapp 1994).

From the architectural point of view, the Early Chalcolithic is marked by the transition from the rectangular stone buildings of the Neolithic to the use of circular, timber-framed structures and semi-subterranean spaces, including elaborated tunnel complexes.

Ephemeral, circular *pisé* structures of similar design existed at Kissonerga *Mylouthkia* (Period 2), Kalavasos *Ayious* and Erimi *Pamboula* (Layers I-II), as attested by the presence of several post-holes and the recovery of daub inside some of the excavated pits (Peltenburg 2003, 2014; Todd & Croft 2004; Dikaios 1962: 113-116). At Kissonerga *Mylouthkia*, Kissonerga *Mosphilia*, Maa *Palaeokastro*, Kalavasos *Ayious* and Erimi *Pamboula*, the excavated pits and semi-subterranean areas display different shapes and characteristics, suggesting that they could have served multiple functions besides storage or discard, possibly including temporary shelter or dwelling (Knapp 2013: 198-204). For instance, at *Mylouthkia*, the excavation of pit 1 evidenced a sequence of four light, artefact-rich timber structures and the presence of secondary burials (Peltenburg *et al.* 2003: 261-263). Differently, bell-shaped pits at Kissonerga *Mosphilia* have been interpreted as installations for communal grain storage (Peltenburg *et al.* 1998). At a later stage of the Early Chalcolithic, light timber structures were substituted by mud-walled round houses with stone foundations, as indicated by the stratigraphic sequences of architectural remains recovered at Kissonerga *Mylouthkia*, Kissonerga *Mosphilia* and Erimi *Pamboula*. The circular building tradition lasted until the start of the Bronze Age and is often considered a sign of consolidation of new cultural conventions (Knapp 2013: 205). At the same time, strong signs of continuity with the Late Neolithic are visible in the recurrence of the same type of installations, tunnels, wall-and-ditch enclosures, ceramics and in the gradual evolution of artefacts types. For instance, figurines evolve from the cylindrical phallus-shaped examples of the Late Neolithic into more rounded cylinders with opposing, short, armlike projections and breasts (Peltenburg 2014). Although still produced at the household level, Red-on-White pottery (first appeared during the Ceramic Neolithic) continue to develop and diversify, with ceramic vessels often painted all over with more detailed geometric designs (Bolger 1991). At this time, the first picrolite objects started being manufactured, a genre destined to become one of the most famous expressions of Cypriot prehistoric art, the cruciform figurine.

During the subsequent Middle Chalcolithic, the population continued to expand and the communities tended to relocate, probably driven by the necessity to find new resources to exploit. The best known excavated sites are still located in the south-west or in the southern coastal regions, although circular, monocellular structures have been found also in the north coast of Cyprus (Peltenburg 2014: 255).

The sites of Kissonerga *Mosphilia* and *Mylouthkia*, Lemba *Lakkous*, Souskiou *Laona* and Erimi *Pamboula* attest to an increase in the size of the settlements (up to 15 ha for

Erimi *Pamboula)* and the importance of curvilinear architecture, along with innovations in the use of internal spaces. The typical Chalcolithic house was circular in plan and divided into four areas arranged in a clockwise fashion around a central, white-plastered, circular hearth. Each space appears to have been designed for a specific function: workplace/tool storing, cooking and storing, sleeping and reception. High concentrations of equipment found in the middle of the floor suggest that much work was carried out indoor, around the central hearth. Pits and communal installations like the grain silos of Kissonerga *Mosphilia* disappeared during the Middle Chalcolithic and were replaced by large storage pots. Similarly, public facilities were enclosed and privatized. Taken together, all these transformations have been interpreted as evidences of a more autonomous household behaviour and of the development of a new system of property and inheritance rights, accompanied by the emergence of social inequalities (Peltenburg *et al.* 1998: 237-240; Peltenburg 2003: 266-272; Knapp 2013: 206-207). In this regards, the clearest evidence comes from Kissonerga *Mosphilia* (Period 3B), where a group of imposing, more refined houses was erected around an open court and separated from the rest of the community by a wall and ditch. For the first time, rooms were partitioned by internal walls creating a more formal segregation of activities according to which reception and sleeping areas were separated from work and storage zones. In Peltenburg's opinion, the structures characterising this sector of the settlement can be associated to the emergence of an élite group, probably linked to a ritual authority (Peltenburg *et al.* 1998).

Ritual activities, feasting and symbolic display become especially important during the Middle Chalcolithic. The most significative example comes again from Kissonerga *Mosphilia* where a non-mortuary deposit consisting of a Red-on-White painted house model and some fifty objects, including for example pottery and stone anthropomorphic figurines (likely associated to birthing rituals), a model stool, various stone tools and a triton shell, was found (Peltenburg 1991). This ceremonial area (as defined by the excavators) was accessed by a paved track and enclosed by the group of monumental buildings described above; here, the open courtyard was characterised by several large earth ovens presumably used for the preparation of food during special celebrations.

The Middle Chalcolithic is also characterised by impressive developments in all sectors of material culture, especially picrolite, pottery and the earliest use of copper. The production of picrolite objects grows in importance and diffusion, and figurines become more varied in size and style, with an emphasis on the human (cruciform) form and the representation of sexuality and procreativity (Knapp 2013: 238). The variety of motifs that decorate Red-on-White pottery increases and becomes more distinctive, suggesting the emergence of local production centres (Bolger 1991). Finally, the first attempts of copper mining and smelting are attested in the form of a chisel, two needles and two uncertain pieces from Erimi *Pamboula* and two spiral ornaments, two amorphous fragments and a possible blade from the Souskiou complex (Knapp 2013: 229-230).

The transition to the Late Chalcolithic is marked by dramatic changes in the Cypriot society, some of which foreshadow those of the subsequent Bronze Age. The archaeological record of the period is quite limited and incomplete so that continuity of site-use is by no means certain. At Erimi *Pamboula*, Kissonerga *Mosphilia* and Lemba *Lakkous* there is a gap in evidence between the Middle and Late Chalcolithic, possibly lasting about 200 years.

From the architectural point of view, the circular building form continues also during the Late Chalcolithic, although with less formally segregated internal divisions. At Kissonerga *Mosphilia*, the Late Chalcolithic is characterised by two phases. During the earlier one, only a group of dispersed structures was recovered, including the remarkable Pithos House, so called after the thirty storage vessels found inside. In addition, this household was equipped with a possible rudimentary oil press and its floor was littered with over 300 objects, including copper slags and metal products, faience beads, triton shells and shell and picrolite working debris. According to the excavators, this was a privileged household, implying the existence of a group that managed and controlled labour and economic surpluses. A more egalitarian social structure reappears in the later phase of the settlement and seems to follow the probable deliberate destruction of the Pithos House, interpreted as a violent response to the concentration of power and economic resources in a single group (Peltenburg *et al.* 1998).

One of the most striking changes in material culture is the disappearance of the cruciform pendants, interpreted as a sign of profound ideological transformation and an alteration in exchange networks since the raw material for the cruciforms (picrolite) could only be found only in central and southern locations (Peltenburg 1982). Other innovations are evident in pottery, probably as a result of increasing contacts with West Anatolia and the East Aegean, as suggested by the inception of elaborately spouted pouring vessels, the careful deployment of red and black burnished surfaces and the embellishment of those surfaces with plastic decoration (Bolger 2007). Within this frame, stamp seals and faience disc beads constitute other Late Chalcolithic introductions.

Although limited, archaeological evidence indicates that during the Late Chalcolithic Cyprus was participating in long-distance trade routes involving both the Near East and the Aegean. As a result, a complex system of new interactions and negotiations with exotic peoples, travellers and traditions began, a process that marks the beginning of the Bronze Age.

3.1.2. Subsistence economy

Information on the subsistence economy characterising the Chalcolithic has been mainly extrapolated from the floral and faunal assemblages retrieved at the major excavated sites of the period. Accordingly, some important economic changes are evident throughout the course of the Chalcolithic and these are briefly summarised below.

Starting from the Early Chalcolithic, relevant data derive from the analysis of the plant and animal remains recovered at Kissonerga *Mylouthkia* and *Mosphilia* and Kalavasos *Ayious*, added to a fragmentary faunal sample from Erimi *Pamboula* (Murray 1998b; Colledge 2003; Hansen 2004; Lucas 2014; Croft 1991). Palaeobotanical evidence attests to the presence of a various array of domesticated crops (rye, oat, wheat, barley) and legumes (chickpea, pea, bitter vetch and lentil), supplemented by fruits (olive, grape, fig, pistachio, hackberry and juniper). Concerning animal economy, pigs, caprine and, most notably, fallow deer (*Dama Mesopotamica*) dominate the faunal assemblage. Although faunal evidence is limited to the three above mentioned sites, the high frequency of deer with respect to the other species (between 63% and 78%) has been interpreted as a sign of strong reliance on deer hunting, a trend already observed during the preceding Ceramic Neolithic (Croft 1991; Knapp 2013: 215). Although rarely mentioned, excavations at Kissonerga *Mylouthkia* also yielded a noteworthy amount of fish remains (50 fragments) attesting to the practice of at least three different methods of marine fishing at this site (Ceròn-Carrasco 2003: 256).

Palaeobotanical and faunal data for the subsequent Middle and Late Chalcolithic principally come from Kissonerga *Mylouthkia* and *Mosphilia*, Lemba *Lakkous*, Souskiou *Laona* and Prastio *Agio Savvas* (Lucas 2014: 37-38; Knapp 2013: 215-217). While the array of plant remains is similar to the precedent phase, the faunal assemblage related to the Middle and Late Chalcolithic periods reveals a trend towards an increasing consumption of pigs at the expenses of both deer and caprines. For instance, at Kissonerga *Mylouthkia*, between the Early and Middle Chalcolithic, deer and caprine meat consumption decreased from almost 75% to 56% and from 8% to 2.2%, respectively, while pig meat supply rose from 17% to 41% (Croft 2003a). Similarly, at Kissonerga *Mosphilia* the contribution of dear to the meat supply fell from 67.8% during the earlier Middle Chalcolithic (Period 3A) to 38.1% in the Late Chalcolithic (Period 4), while over the same period pigs meat supply fraction increased from 23.8% to 54.1% (Croft 1998b: 315, Table 22.14). Finally, at Lemba *Lakkous*, the consumption of deer declined from 71.4% during the Early/Middle Chalcolithic (Period I) to 41.3% during the Late Chalcolithic (Period III), whilst pigs and caprines rose from 29.4% to 49.1% and from 6.3% to 9.4%, respectively (Croft 1991: 71, Table 3). As far as marine resources are concerned, a substantial assemblage of marine molluscs was recovered at Kissonerga *Mosphilia* during the Middle and Late Chalcolithic periods, with limpets and topshells the most frequent edible species (Ridout-Sharpe 1998). Conversely, only a small sample of marine shells was instead recovered at the nearby site of Lemba *Lakkous* (Ridout-Sharpe 1985).

As far as possible economic models are concerned, the frequent dislocation of settlements and the exceptionally high proportion of fallow deer bones recovered at several Chalcolithic sites, especially during the earlier stage of the period, have been interpreted as evidence for a more mobile subsistence strategy involving a process of de-intensification of agricultural practices alongside increasing reliance on deer hunting, probably favoured by an accelerated process of aridification (Clarke *et al.* 2007). The hypothesis of a possible decrease in agricultural practices has been recently contradicted by Lucas (2014: 73), according to whom the substantial increase in the number of weed taxa attested during the Chalcolithic and its correlation with the decline in fallow deer hunting should be seen as evidence for agricultural intensification, extensification and crop diversification. Moreover, the archaeobotanical evidence seems paralleled by the increase, from the Early to Late Chalcolithic periods, in the numbers of storage facilities and groundstone tools used in crop processing, including rubbers, pestles, querns, pounders and sickle blades (Knapp 2013: 217).

An alternative economic model for the Chalcolithic period is that of a mixed economy combining agro-pastoralism and controlled hunting of fallow deer, in which settlement relocation represented a self-regulating response to ecological stresses (Held 1993; Knapp 1994). Within this framework, the decline in the importance of deer hunting alongside the increasing exploitation of domesticated animals (pigs and caprines) starting from the Middle Chalcolithic has been interpreted as a reflection of growing nutritional demand by an expanding population, possibly correlated to a reduction of deer habitat due to woodland clearance (Croft 1991). Alternatively, Keswani (1994: 265) has suggested that this evolution in subsistence strategies could be linked to the intensified ritual consumption of domesticated livestock, itself related to population growth and to the increasing reliance on ritual celebrations and social exchanges.

3.2. Transition to the Bronze Age: the Philia phase

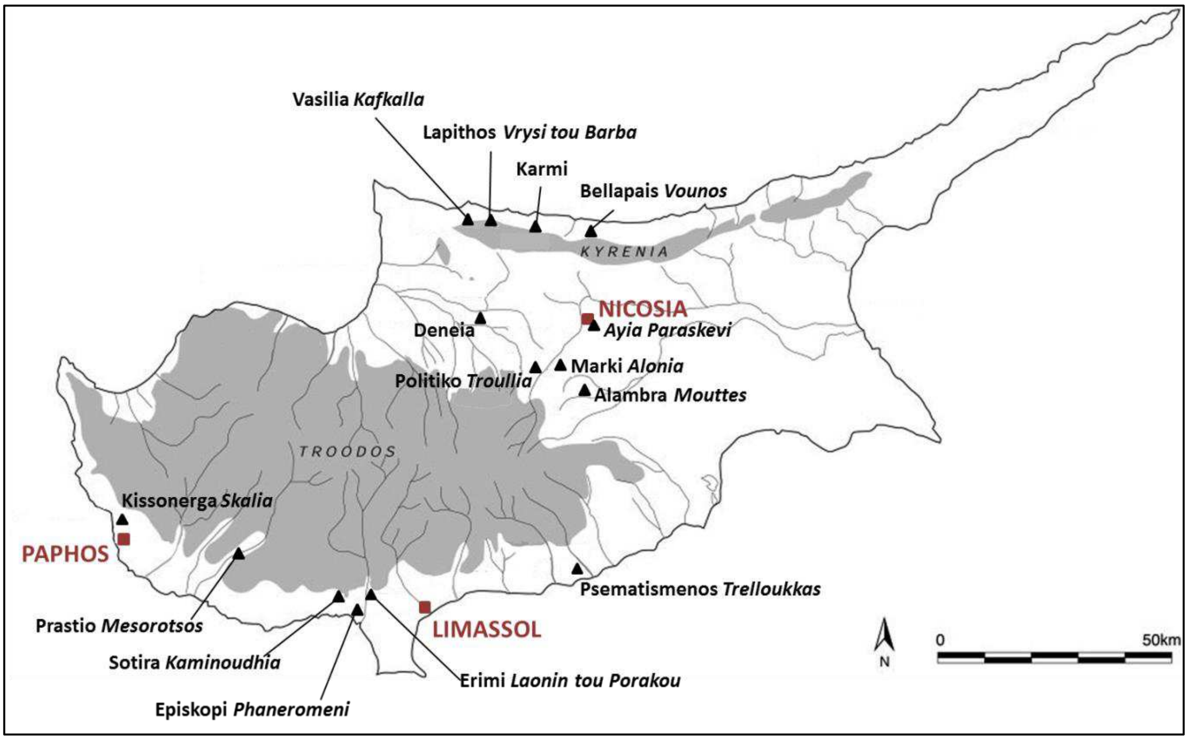
The issue of the origin and diffusion of the so called Philia *facies* (ca. 2400-2250 BC) is particularly controversial, as this phase seems intermediate between the Chalcolithic and the fully developed Early Bronze Age communities (Webb & Frankel 1999). In particular, it is generally accepted that the chronological phases Late Chalcolithic, Philia and Early Cypriot I-II, though consecutive, are affected by overlapping, with certain Philia material features attested also in the Late Chalcolithic and Early Bronze Age archaeological records. Generally speaking, Philia sites are characterized by innovations in architecture (adoption of rectilinear versus circular forms), the ceramic record (e.g. the presence of distinctive forms of food preparation and consumption like hobs, baking pans and cooking pots), in technology (e.g. metal artefacts), in the variety of animals (e.g. the reintroduction of cattle and its use also for traction and secondary products) and in mortuary behaviour (introduction of chamber tombs), just to cite the most relevant ones. These important changes have been variously interpreted, and scholars still adopt opposite views of this phenomena, either considering the Philia culture as the result of internal processes operating independently (e.g. Knapp 2008: 110-130; 2013: 263-277), or as an evidence of contacts, influences or migrations, in particular from Anatolia. Among supporters of the latter theory, J. Webb and D. Frankel have long tried to demonstrate the validity of this interpretation with a series of intriguing publications (see, for example, Webb & Frankel 1999, 2007, 2008, 2011). Within this framework, of particular interest is the issue of how to distinguish two possible ethnical groups within a community (as in the case of Kissonerga *Mosphilia*, Webb & Frankel 2007) but, most of all, how to describe social interactions and a possible co-presence of indigenous people and newcomers. In this regards, Knapp's opinion is that a possible distinction between Anatolian migrants or colonists and indigenous Cypriotes should be treated very carefully and, rather than talking about concepts of acculturation, reaction and assimilation, preferably considers the material innovations and associated social changes of the Philia phase as a manifestation of hybridisation practices between distinct cultures (Knapp 2013: 263-277).

3.3. The Early and Middle Bronze Ages

In Cyprus, the Early and Middle Bronze Ages are usually referred to as Early Cypriot (EC) and Middle Cypriot (MC), respectively. Conventionally, each period is further subdivided into three sequential phases: EC I, EC II, EC III for the Early Cypriot and MC I, MC II, MC III for the Middle Cypriot. The appropriateness of this traditional tripartite scheme for the study of the cultural and socio-economic developments of the communities of Bronze Age Cyprus has been often questioned as this sequence is almost entirely based on pottery recovered from mortuary contexts (e.g. Catling 1973: 165-166; Knapp 1990: 148-149, 1994: 274-276). More recently, an alternative periodisation scheme – based on cultural stages rather than pottery classifications – has been proposed (Knapp 2013: 25-28). Accordingly, the Bronze Age is subdivided into two major phases (see also Table 3.1):

- the Prehistoric Bronze Age (ca. 2250-1700 BC) encompasses the Philia *facies* and the Early and Middle Cypriot and it is further subdivided into two phases: EC I-II (PreBA I) and EC III-MC II (PreBA II);
- the Protohistoric Bronze Age (ca. 1700-1100) spans from the Middle Cypriot III to the Late Cypriot IIIA; here the MC III-LC I interface is lumped into a unique transitional phase (ProBA I) while the subsequent LC II and LC III are assigned to ProBA II and ProBA III, respectively.

Figure 3.2 Map of Bronze Age sites mentioned in the text.



3.3.1. Settlements, architecture and material culture

Attestation of the Philia *facies* in the archaeological record of Cyprus are found either within the context of phenomena of restructuration of Late Chalcolithic communities (e.g. at Kissonerga *Mosphilia*) or in association with the establishment of new settlements, like at Marki *Alonia* (see Figure 3.2). Unfortunately, very few Philia settlements have been excavated and Philia burials, although more numerous (see Webb & Frankel 1999: 7-12), do not help clarifying the background of the appearance of this new cultural system. In general, the distribution of Philia settlements suggest that these communities were targeting the cupriferous deposits of the north-western Troodos as well as areas of good agricultural land, along transportation routes and in proximity to the sea or to reliable water sources (Knapp 2013: 279; Webb 2014: 356-357). Some of them were occupied for a rather short period while other settlements like Marki *Alonia* show evidence of long-term occupation during which the distinctive traits of the Philia *facies* (pottery, metallurgical production, agricultural and mortuary practices) were consolidated and developed into those characteristic of the Early Cypriot. The ceramic record of the Philia *facies* is quite uniform and characterised by the introduction of a common set of high quality, similarly decorated, handmade eating and drinking vessels in Red Polished Philia ware and other minor wares (Webb 2014: 359).

During the subsequent stages of the Early Cypriot, new settlements were established along the south coast and, by EC III, in other coastal areas, copper-bearing zones and the eastern and western regions. According to a recent survey by Georgiou (2007), 44 sites dating to EC I-II and 345 to EC III and MC I-II have been identified, attesting to significant population growth during the whole period. However, only two Early Cypriot settlements have been excavated: Marki *Alonia* was occupied from the Philia phase to the MC II while Sotira *Kaminoudhia* principally dates to the EC III (Webb 2014). Our knowledge on the use of domestic space mainly derives from these sites, where rectilinear buildings made entirely of stone or of mould-made mudbricks set on stone foundations, densely packed arrangements and the accretive nature of settlement architecture remain a constant throughout the Early and Middle Cypriot periods. Although the two settlements display some differences in both the layout and the construction of the architectural units (Papaconstantinou 2013), common features like the size of the households, the presence of indoor facilities and the lack of communal enterprises are generally regarded as evidence of "autonomous communities in which both the land and its products were owned by extended family units, rather than collectively or by outsiders" (Webb 2014: 358). At the same time, the material culture (especially the ceramic record) suggests that the autonomous villages of the Early Cypriot were also dependent on a system of intra- and inter-regional exchanges, probably organised along household and kin-based lines (Driessen & Frankel 2012; Webb 2014: 359). The characteristic pottery of the Early and Middle Cypriot is the Red polished ware (RP), a fabric covered with an iron-rich red slip, usually burnished to a high lustre and often decorated with incised patterns. Although clearly inspired to the Philia tradition and developing in rather similar ways across the island, the EC I-II pottery vessels display regional trends visible both in the fabric (e.g. the Red Polished I South Coast ware typical of the south-west) and in the different forms and decorations. In addition, other types of objects appeared during the Early Cypriot, including zoomorphic figurines (mostly representations of bull) and human figurines primarily depicting females and infants, possibly to be associated to the themes of fertility and reproduction (Webb 2014: 363). By EC III, the regional ceramic styles appear to have been largely replaced by common forms of Red Polished Ware, mainly of north coast origin. Concurrently, several metal goods and a small quantity of imported objects are found in the necropolises of the north coast, possibly attesting to the role played by the communities of this part of the island in establishing new contacts and trade routes which would have enabled the transport of copper from mining and production sites to coastal areas (Webb 2014: 361).

The following Middle Cypriot is characterised by significant changes in settlement patterns as population rose steadily and tended to concentrate in larger centres. Some villages originally founded earlier in the Bronze Age continued in use for many generations but were abandoned during MC II. Concurrently, an increase in the size of cemeteries like Deneia, Lapithos *Vrysi tou Barba* and Nicosia *Ayia Paraskevi* suggests a process of nucleation into larger villages and towns. Some of these began to decline towards the end of the Middle Cypriot when new settlements were established on the coastal fringe – probably in response to an increasing external demand for Cypriot copper and other products, like perfumed oil – and in the central lowland. Differently, some of the sites already occupied during the initial phase of the Middle Cypriot (MC I-II) were not abandoned, but were subject to a more complex reorganisation and functional redefinition of the settlement space, as seen for example at Erimi *Laonin tou Porakou* (Bombardieri 2014).

Information on MC I-II domestic architecture is primarily derived from excavations at Marki *Alonia* (Frankel & Webb 2006) and Alambra *Mouttes* (Coleman *et al.* 1996). At

Marki, households are the result of a long process of rebuilding and renovation in new open terrain. In spite of some variations in the layout, the majority of households retained the traditional form of rectilinear multi-room compounds already seen in the preceding Early Cypriot. Differently, the row of rectangular houses brought to light at Alambra shows little evidence of renovation and modification and a more uniform layout (Frankel 2014). Red Polished ware continued to be the dominant fabric (although most common at northern, central and south-eastern sites) together with White Painted wares, usually regarded as the hallmark of the Middle Cypriot. Concurrently, the material record indicates an increase in craft specialization, including metal artefacts, beads, shell and picrolite ornaments and pendants, gaming stones, jewellery, terracotta and antigorite figurines, new pottery shapes and styles and new terracotta models.

3.3.2. Subsistence economy

The picture emerging from the analysis of the archaeological, archaeobotanical and faunal records of the Early and Middle Cypriot periods is that of an essentially conservative society, still relying on a mixed agro-pastoral economy. At the same time, the data attest to a series of radical changes in agricultural and herding practices which developed in parallel with an increasing process of diversification and proto-specialization (Knapp 1990: 69, 2013: 303-307; Keswani 1994). These transformations are currently considered within the frame of the so-called Secondary products Revolution (Sherratt 1981, 1983), whose material indicators are first seen on Cyprus at the transition from the Chalcolithic to the Bronze Age.

Concerning agricultural production, there are several lines of evidence consistent with an intensification and extensification of agricultural practices throughout the period. The most fundamental innovation within the secondary-products package was the introduction of the cattle-drawn plough, which allowed to cultivate greater stretches of land and substantially increased agricultural yields. The high frequency of grain harvesting and processing equipment (querns, pounders and grinders), along with the development of a kit of metal tools related in part to forest clearance, further support this scenario (Knapp 2013: 304). Archaeobotanical data from the Early/Middle Cypriot settlements of Marki *Alonia* (Adams & Simmons 1996), Sotira *Kaminoudhia* (Hansen 2003), Politiko *Troullia* (Falconer & Fall 2013), Kissonerga *Skalia* (Lucas 2014) and Erimi *Laonin tou Porakou* (Scirè Calabrisotto *et al. forthcoming*) indicate no further crop or pulses introductions with respect to the preceding Chalcolithic period. The only exception is represented by the appearance of almond (*Amygdalus communis*) at Marki *Alonia* and Sotira *Kaminoudhia*, probably attesting to the domestication of this species (Lucas 2014: 41). At the same time, evidence for extensification is reflected in the increased numbers of weeds in the Leguminosae family, a trend which, in Lucas' opinion (2014: 73), correlates well with the settlement patterns of the Early/Middle Cypriot and with an expansion of cultivated fields in newer areas that receive less rainfall and have poorer quality soils.

The Early and Middle Cypriot periods witnessed important changes also in the faunal record. Zoo-archaeological analyses conducted on the faunal assemblages of Marki *Alonia* (Croft 2006), Sotira *Kaminoudhia* (Croft 2003b), Alambra *Mouttes* (Reese 1996) and Politiko *Troullia* (Falconer & Fall 2013) indicate a preponderance of sheep and goat remains (up to 61% at Alambra *Mouttes*), followed by various proportions of cattle (up to 32% at Sotira *Kaminoudhia*), fallow deer and pig bones. An apparent exception is represented by the site of Prastio *Mesorotsos*, where pig and deer bones from Middle Cypriot levels (respectively 39.2% and 32.7% of the total faunal remains) outnumber those of caprines (28.1%) (McCarthy *et al.* 2010: 64). Also, at the MC III-LC IA site of Episkopi *Phaneromeni* almost equal proportions of cattle (31%) and caprines (32%) were recovered, followed by pigs (26%) and deer (11%) (Swiny1989). As far as herding practices are concerned, after analysing species diversity and killing patterns at Marki *Alonia*, Sotira *Kaminoudhia* and Alambra *Mouttes*, Spigelman (2006) concluded that the inhabitants of these villages were practicing a diversified faunal strategy centred on the exploitation of both domesticated and wild animals to provide buffering mechanisms against resource failure. In addition, killing patterns of sheep and goats are consistent with the exploitation of these animals both for meat and secondary products, in particular wool, hairs and milk.

According to Knapp (2013: 305) the rising importance of cattle and caprines coupled with the less frequent exploitation of pigs and fallow deer is to be linked to the social, material and environmental changes brought by the Secondary Products Revolution. The relevance of these transformations is reflected also in the material culture, for example in terracotta models depicting the elbow plough, draft animals, pack animals and other agricultural and pastoral scenes (Knapp 2013: 304). From an environmental point of view, progressive land clearance and deforestation would have contributed to the creation of more open environments, usually better suited to sheep and goats. In addition the new farming techniques would have led to the reorganisation of agricultural work – probably involving the subdivision of labour practices – and favoured the emergence of new types of specialised production, including metalworking. Although the organisation of the copper industry is still poorly understood, metallurgical technology was well known, as attested by the quality and quantity of metal products recovered in several tomb deposits along or near the north coast (e.g., Lapithos *Vrysi tou Barba*, Bellapais *Vounos*, Vasilia *Kafkalla*). In addition, the recovery of ingot moulds in recent excavations at Marki demonstrates that copper from nearby ore bodies was being processed and distributed across the island. In this sense, the increasing exploitation and distribution of copper resources was probably facilitated by the introduction of cattle and equids and their use as pack and transport animals.

3.4. Chronology

Over the past few decades the chronological record of pre- and proto-historic Cyprus has been constantly enhanced by the combination of new fieldwork documentation and the availability of new absolute dates from radiocarbon dating of archaeological materials. In addition, the widespread use of Bayesian modelling of radiocarbon data, as an analytical tool for improving the accuracy of the results, has contributed to the refinement of current chronologies, both through dedicated projects (Bietak & Czerny 2007; Peltenburg *et al.* 2013) and single contributions (Manning 2013a, 2013b, 2014). Even so, the chronological dataset defining the period from the Epipalaeolithic to the end of the Bronze Age is still limited and uneven, with some major lacunae affecting some phases more than others (for more details see Manning 2013a; Peltenburg *et al.* 2013). In particular, the assessment of the chronology of the Early-Middle Cypriot seems quite problematic, owing to several factors: 1) the scarcity of long sequenced excavated sites spanning the whole period; 2) the patchy nature of the radiocarbon record across the island; 3) the lack of good chronological definition, especially in the final MC III, with Episkopi *Phaneromeni* being the only excavated settlement providing a set of three (too early) dates for this cultural horizon (Carpenter 1981: 4) and the difficulties in distinguishing ceramic assemblages within the EC III/MC I and MC III/LC I transitional phases. Conversely, the chronology of the Chalcolithic period relies on a good body of published radiocarbon data covering Early to Late Chalcolithic contexts, although there is some level of uncertainty where the Middle Chalcolithic ends (Manning 2013a).

In this study, the radiocarbon based chronological framework outlined in Knapp (2013: 25-28) and Manning (2013a) has been taken as reference (see Table 3.1).

Table 3.1 Chronological framework of Prehistoric Cyprus. From Knapp 2013: 27, Table 2.

PERIODS	PHASE/CULTURE	DATES BC
Late Epipalaeolithic	Akrotiri Phase	11,000-9,000
Initial Aceramic Neolithic	Cypro-PPNA	9000-8500/8400
Early Aceramic Neolithic (EAN)	Cypro-EPPNB	8500/8400-7900
	Cypro-MPPNB	7900-7600
	Cypro-LPPNB	7600-7000/6800
Late Aceramic Neolithic (LAN)	Khirokitia	7000/6800-5200
Ceramic Neolithic	Sotira	5200/5000-4500-4000
Chalcolithic	Early Chalcolithic	4000/3900-3600/3400
	Middle Chalcolithic	3600/3400-2700
	Late Chalcolithic	2700-2500/2400
	Philia phase	2400/2350-2250
Prehistoric Bronze Age	Early Cypriot I-II	2250-2000
	Early Cypriot III -Middle Cypriot I-II	2000-1750/1700
Protohistoric Bronze Age	Middle Cypriot III-Late Cypriot I	1700-1450
	Late Cypriot IIA-IIC early	1450-1300
	Late Cypriot IIC Late-IIIA	1300-1125/1100
Early Iron Age	Late Cypriot IIIB	1125/1100-1050
	Cypro-Geometric I	1050-1000

CHAPTER 4
METHODOLOGY

4.1. Introduction

To reconstruct the palaeodiet of a community basically means to identify the types and amounts of food that a group of individuals habitually ate in the past. Until some decades ago, the reconstruction of prehistoric diets exclusively relied upon the various food-related artefacts and ecofacts recovered during archaeological excavations, with inherent difficulties and limitations. Although ubiquitous in the archaeological record, biological materials such as floral and faunal remains rarely reflect the proportions of dietary components, and only limited information on the diet can be extrapolated from the recovery of food processing tools and installations, as well as from the analysis of palaeopathologies, dental microwear and functional anatomy. As a matter of fact, most of this evidence is indirect and fails to provide direct information at the individual level of analysis.

Within this frame, the development of light stable isotope analysis of skeletal remains for palaeodiet reconstruction has allowed archaeologists to significantly increase the quantity and quality of palaeodietary data. Since this approach allows to identify the foods actually eaten by an individual, socio-cultural determinants of dietary choices can be investigated using stable isotopes, including for example gender-related differences in the diet. The disadvantage is that, even under the best circumstances, only information on the relative consumption of general food groups can be obtained, as the isotopic variability of the dietary items is limited. The best way to overcome this limitation and try to increase the accuracy of our palaeodietary investigation is to adopt a multidisciplinary approach, where any available form of evidence is integrated. This methodology becomes especially important when considering archaeological research and the difficult task of reconstructing past lifeways from a complex and often fragmentary archaeological record.

In this palaeodietary study, information on the dietary patterns of the Chalcolithic and Bronze Age communities of Cyprus was primarily derived from stable carbon and nitrogen isotope analysis of animal and human skeletal remains excavated at relevant archaeological sites of the period. Depending on the preservation state of the skeletal material available from each site, either bone and dentinal collagen or tooth enamel was utilised for the analysis. In the latter case, additional information on the place of residence of the analysed animals and individuals was obtained through the measurement of stable oxygen isotope ratios of tooth enamel carbonate. In this chapter, a basic coverage of the fundamentals of stable isotope analysis for palaeodiet reconstruction is provided, followed by more detailed information on the research methods used to conduct the present study.

4.2. Stable isotopes: terminology, notation and measurement

Isotopes are forms of the same element (e.g. carbon) with the same number of electrons and protons but different numbers of neutrons. By definition, *stable* isotopes are not radioactive, that is to say, they do not decay or change in abundance through time. For instance, carbon occurs in three main isotopic forms: ^{12}C and ^{13}C, both stable, and the radioactive ^{14}C which is used for radiocarbon dating.

Since chemical reactions largely depend on electron configurations, isotopes of the same element display almost the same chemical properties but the different numbers of neutrons in their nuclei result in different atomic masses. They also vary in their terrestrial abundance, with the lighter form usually being the most abundant (Table 4.1).

Table 4.1 Average terrestrial abundances of carbon, nitrogen and oxygen. The atomic mass of each isotope is represented by the superscript numbers to the left of the element symbol. Extracted from Table 13.1, Katzenberg & Saunders (2008).

ELEMENT	ISOTOPE	ABUNDANCE (%)
Carbon	^{12}C	98.89
Carbon	^{13}C	1.11
Nitrogen	^{14}N	99.63
Nitrogen	^{15}N	0.37
Oxygen	^{16}O	99.759
Oxygen	^{17}O	0.037
Oxygen	^{18}O	0.204

As a consequence of their different atomic masses, molecules containing different isotopes of the same element (for instance $^{13}CO_2$ versus $^{12}CO_2$) react at different rates and form bonds of variable strengths. The effects are most evident among the light elements (e.g. carbon, nitrogen and oxygen), because mass variation between the isotopes is large compared with the average mass of the element. In general, the heavier isotopes are characterised by slower rates of movement and diffusion with respect to lighter isotopes (kinetic isotope effects) and by different rates and temperatures of melting, freezing, crystallization, condensation and evaporation (equilibrium isotope effects). These differences in the rates of movement, chemical reaction and state transition lead to the separation or *fractionation* of the isotopes of an element during naturally occurring processes, thus affecting their relative abundances. As the isotopes within an element circulate in the biosphere, fractionation accounts for stable isotope variation in biological and geochemical systems and actually constitutes the basic requirement for investigations through stable isotope analysis. More detailed information on isotope effects and fractionation can be found for example in Hoefs (1997) and Fry (2006).

Because differences in the natural abundance of stable isotopes are usually very small, on the order of a few thousandths of a percent, the absolute abundance of each isotope is not actually determined. Instead, stable isotope abundances are reported as ratios of the heavier to the lighter isotope (e.g. $^{13}C/^{12}C$), with respect to the ratio of a standard reference material.

The measured isotopic ratios are thus expressed using the delta (δ) notation in parts per thousand (‰), based on the following relation:

$$\delta^{X}A(‰) = ((R_{sample}/R_{standard}) - 1) \cdot 1000$$

where A is the element in question, X is the atomic mass of the heavier isotope and R is the ratio of the heavier isotope with respect to the lighter isotope. For instance, in the case of carbon:

$$\delta^{13}C(‰) = ((R_{sample}/R_{standard}) - 1) \cdot 1000 \quad \text{where } R = {}^{13}C/{}^{12}C$$

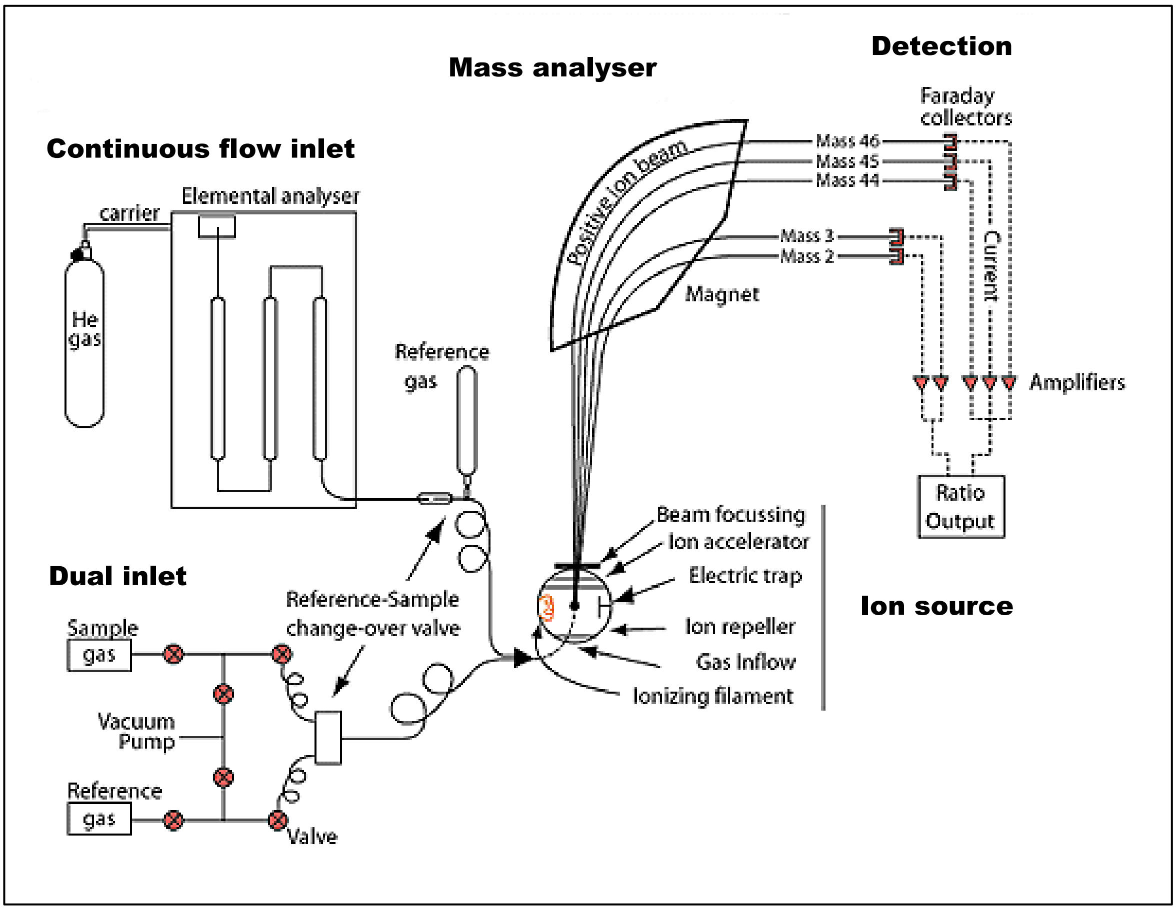
Because of the above, if a sample has proportionally more heavy isotopes than in the standard, then its isotope value is positive and the sample is said to be “enriched” in the heavy isotope. Differently, when the isotope value is negative, the sample is "depleted" in heavy isotope compared to the reference material.

The standard reference material for carbon and oxygen isotope ratios in carbonates and organic matter was originally derived from the Peedee formation *Belemnitella americana* marine fossil limestone (PDB) in South Carolina (Craig 1957). Because the original material is no longer available, stable carbon isotope ratios are now reported relative to Vienna Peedee belemnite (VPDB), with raw values typically calibrated using the National Bureau of Standards (NBS) reference sample so as to allow for reliable comparisons between the results produced by different laboratories (Coplen 2011). Atmospheric N_2 (AIR – Ambient Inhalable Reservoir) is the standard reference material for nitrogen (Mariotti 1983).

Stable isotope abundance ratios are measured in isotope ratio mass spectrometers (IRMS). Mass spectrometers are analytical instruments that have many uses in chemistry, biochemistry, geochemistry, and ecology. Here I provide a brief description of how an isotope ratio mass spectrometer works. For a more detailed account see for example Platzner *et al.* (1997).

Isotope ratio mass spectrometers consist of four main components: an inlet system (dual inlet or continuous flow inlet), an ion source, a mass analyser, and a series of ion detectors (Figure 4.1). Because most elements of interest (including carbon and nitrogen) are usually introduced to the mass spectrometer as a gas (CO_2 and N_2, respectively) this instrument is sometime combined with combustion furnaces and elemental analysers that allow the conversion of the solid sample into the requisite gaseous form (continuous flow inlet). In such a setup, the sample is weighed into tin capsules and placed into an automated sample tray that sequentially drops the capsules into the furnace where the sample is converted into gas. This gas is carried into the mass spectrometer through a gas carrier (helium) from which it is separated before entering the instrument. Once in the mass spectrometer, the gas of interest is let into the ion source to be converted into ions, usually by electron bombardment. Because ions are charged particles, they can be accelerated and directed into the mass analyser. Here, the ions are sorted out according to their mass-to-charge ratio and the intensity of each ion beam is determined in the ion collector section of the instrument. The relative intensities of the individual isotope ion beams are then reported as isotope ratios, for example, $^{13}CO_2/^{12}CO_2$. To report a ratio of the stable isotopes in the sample relative to that same ratio in the standard, the mass spectrometer alternately analyses aliquots of the unknown sample and a known standard gas.

Figure 4.1 Schematic representation of the main components of an isotope ratio mass spectrometer. Adapted from http://www.gwadi.org/tools/tracers/methods.



4.3. Palaeodiet reconstruction with carbon and nitrogen stable isotopes

The first applications of light stable isotope analysis to the field of palaeodietary research date back to the 1970s and are related to the work of Vogel and van der Merwe (1977; van der Merwe and Vogel 1978) who first reported the use of stable carbon isotope ratios in bone collagen as a tool for quantifying maize consumption in the diet of prehistoric populations of North America. These pioneering studies stemmed from a series of important advances concerning carbon isotope pathways in plant photosynthesis (Calvin

& Benson 1948; Ransom & Thomas 1960; Hatch & Slack 1966) and its fractionation effects in plant tissues (Hall 1967; Bender 1968; Smith & Epstein 1970), along with the knowledge gained from radiocarbon dating of bone collagen (e.g. Tamers & Pearson 1965; Longin 1971) and from stable carbon isotope analysis on free-ranging animals (Vogel 1978). Almost in the same years, measurements of stable carbon and nitrogen isotope ratios were conducted on animals raised on controlled diets (DeNiro & Epstein 1978; 1981) and effectively demonstrated that the isotopic composition of animal tissues is largely dependent on that of the diet.

In the early 1980s, stable isotope analysis of nitrogen further developed evidencing a clear relationship with trophic levels, especially in marine vs. terrestrial ecosystems (e.g. DeNiro & Schoeninger 1983; Schoeninger & DeNiro 1983, 1984; Minagawa & Wada 1984; Schwarcz *et al.* 1985; Ambrose & DeNiro 1986).

Over the past 40 years, applications of stable isotope analysis for palaeodiet reconstruction have significantly increased and much progress has been made in addressing a great variety of issues including for example the nutritional, physiological and environmental factors influencing isotope fractionation (e.g. weaning effects, Katzenberg *et al.* 1996), the kinds of materials to be analysed (e.g. carbonised encrustations on potsherds, Hastorf & DeNiro 1985) and their diagenetic alteration (e.g. reliability of fossil bone and enamel isotope signals, Lee-Thorp & Sponheimer 2003), compound specific analysis (e.g. Fogel & Tuross 2003), changes in the diet throughout human evolution (Lee-Thorp & Sponheimer 2006) and the potential of other light stable isotopes for palaeodietary studies (e.g. sulphur, Nehlich 2015).

Only a minor part of the above mentioned topics will be discussed in the next sections. More comprehensive reviews and overviews of stable isotope analysis of skeletal material can be found in Schwarcz & Schoeninger (1991), Ambrose (1993), Pate (1994), Sealy (2001), Tykot (2006), Katzenberg and Saunders (2008) and Lee-Thorp (2008).

4.3.1. Principles of diet reconstruction from stable carbon and nitrogen isotope ratios

Palaeodiet reconstruction with stable carbon and nitrogen isotope analysis is based on two main assumptions: 1) the carbon and nitrogen isotopic composition of our body tissues largely reflects that of the foods consumed during our lifetimes 2) different food resources have distinctive carbon and nitrogen isotopic signatures that allow us to make inferences about the kinds of foods from which these elements were taken. These assumptions work on the premise that in general most animals (including humans) are close to a steady-state condition in which the overall isotopic composition of the body is the result of a net balance between inputs (mostly dietary intake) and outputs (urine, feces, expired CO_2 and H_2O) (DeNiro & Epstein 1978; Schwarcz & Schoeninger 1991; Hedges 2003). If an animal has been eating a uniform diet for a period of time that is longer than the rate of turnover of a specific tissue, then the carbon and nitrogen isotope ratios of each body tissue and biochemical fraction will reach steady state values. Thus, by measuring stable isotope values in that specific tissue or biochemical fraction – and taking into account the fractionation factors occurring during the incorporation of dietary carbon and nitrogen in the body – it is possible to estimate the isotopic composition of the diet.

To summarise, an accurate palaeodietary reconstruction with stable carbon and nitrogen isotopes necessitates knowledge of 1) the isotopic composition of the dietary resources that may have been available to the investigated human populations; 2) the fractionation between the diet and the consumer tissues or biochemical fractions analysed (e.g. bone collagen); 3) the factors affecting both the isotopic composition of foodstuffs and the diet-tissue relationship.

a. Stable carbon and nitrogen isotopes in terrestrial and aquatic ecosystems

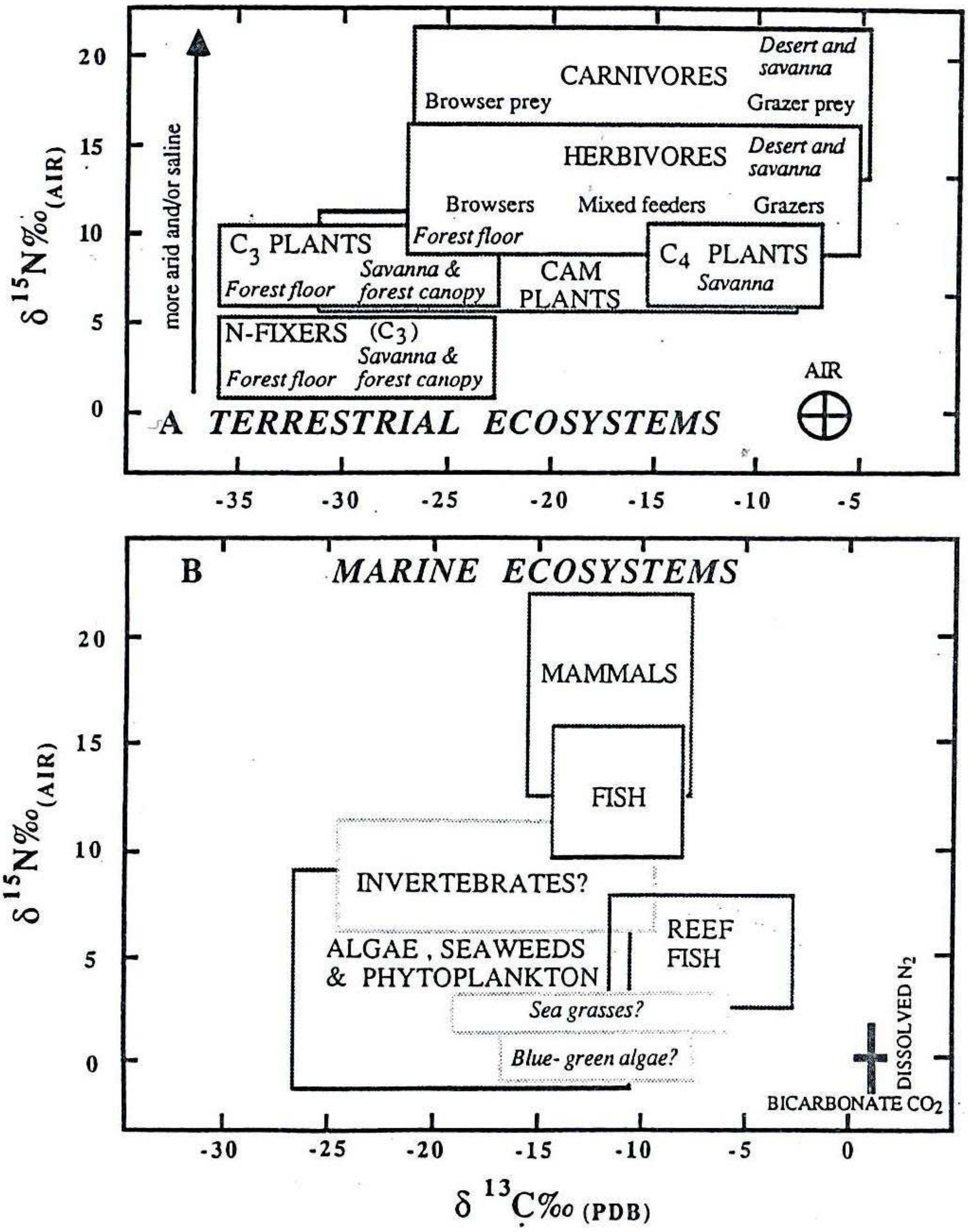
The type of habitat – terrestrial, freshwater or marine – is one of the major causes of variation in the $\delta^{13}C$ and $\delta^{15}N$ values of dietary items.

In terrestrial foodwebs, the main source of carbon is atmospheric CO_2 whose $\delta^{13}C$ values typically ranges between -7 and -8‰. Atmospheric carbon first enters the terrestrial biological system through plant photosynthesis, a biochemical process that allows plants to fix the carbon dioxide in their leaves and convert it into simple sugars like glucose. Depending on the plant's particular photosynthetic pathway, plant tissues discriminate against the heavier ^{13}C isotope to different degrees, thus acquiring different $\delta^{13}C$ values. There are two basic photosynthetic pathways, named C_3 and C_4 according to the number of carbon atoms that appear after CO_2 fixation; a third system, called CAM photosynthesis (Crassulacean Acid Metabolism), includes the plants that are capable to switch between C_3 and C_4 depending on their actual location and environmental conditions. Most food plant products are C_3 and include for example cereals like wheat, barley and rice, all root crops, vegetables, legumes, nuts, most fruits and forest and wetland grasses. Economically important C_4 plants are cereals like sorghum, millet and maize, sugar cane, some amaranths, chenopods, setaria millets and tropical pasture grasses. In general, the distribution of C_3 and C_4 plants across the geosphere varies according to environmental circumstances, with C_3 plants favoured in shaded, more humid environments and C_4 plants growing best in hot and dry habitats. CAM plants are typical of arid or tropical environments and include for example pineapple, cacti and agave (Ambrose 1993; Schwarcz & Schoeninger 1991). Since C_3 plants discriminate against atmospheric $^{13}CO_2$ more than C_4 plants, their $\delta^{13}C$ values are more depleted compared to those of C_4 plants. Specifically, C_3 plants show $\delta^{13}C$ values typically ranging between -36.0 and -24.0‰, (global mean -26.5‰) while C_4 plants have $\delta^{13}C$ values between -14.0 and -9.0‰ (averaging about -13‰) (O'Leary 1981; Smith & Epstein 1971; van der Merwe & Medina 1991). Because these differences in the $\delta^{13}C$ values are maintained through every stage of the terrestrial food chain, it is usually possible to distinguish whether the diet of primary consumers like herbivores is principally based on C_3 or C_4 plants, or if they are intermediate feeders (see Figure 4.2A). At higher trophic levels, the $\delta^{13}C$ values of the tissues of carnivores and omnivores track the values of the animals that they feed on. In the case of humans, the isotopic composition of the diet can reflect the isotopic signatures of C_3 and C_4 plants by consumption of plant foods and/or flesh and secondary products of herbivores.

Nitrogen enters the terrestrial foodweb mostly from soil nitrates, ammonia and ammonium, animal urea and plants that show simbiose with nitrogen-fixing bacteria. In vascular plants, nitrates are produced and decomposed through a series of steps involving nitrification and denitrification, finally resulting in varying isotopic fractionations. Most terrestrial plants have $\delta^{15}N$ values close to atmospheric N_2 although these can vary considerably depending on environmental conditions. In addition, plants like legumes which obtain most of their nitrogen through bacteria fixation show lower $\delta^{15}N$ values than the other terrestrial plants (Virginia & Delwiche 1982). Through plants, nitrogen is incorporated into the tissues of herbivores, omnivores, and carnivores following the trophic chain (see Figure 4.2B).

Aquatic plants from freshwater habitats like lakes and rivers take carbon mainly from inorganic carbon dissolved in the water; the latter originates principally from the dissolution of atmospheric CO_2, the decomposition of terrestrial plants and reaction with limestone in the bedrock. As a consequence, the $\delta^{13}C$ values of freshwater plants and of the fish and animals that feed on them may vary widely, depending on the contribution of local carbon sources (Schwarcz & Schoeninger 1991). Freshwater ecosystems also produce high variability in the nitrogen isotope ratios, with values for inorganic nitrogen ranging from 0.6‰ to 40‰ (Mariotti *et al.* 1984; Cifuentes *et al.* 1989).

Figure 4.2 Distribution of stable carbon and nitrogen isotopes in terrestrial and marine foodwebs. From Ambrose (1993: 87, Figure 2).



In the case of marine ecosystems, the main source of carbon is dissolved bicarbonate (HCO_3) in the ocean, showing a $\delta^{13}C$ value of ~ 0‰. Thus, the initial carbon source used by marine organisms is less negative than that used by terrestrial ones. In fact, primary producers like marine plants tend to have higher $\delta^{13}C$ values averaging -19‰, although interspecific differences and variable environmental conditions account for a wide range of variability. For instance, estuarine sea grasses have $\delta^{13}C$ values around -13‰ while phytoplankton has produced $\delta^{13}C$ values ranging from about -30‰ at 0°C to -19‰ at 30°C (Ambrose 1993, with references).

As far as nitrogen isotope ratios are concerned, the principal source of available nitrogen is bacterial and algal fixation which results in the production of N-containing compounds (nitrates and ammonia) with higher $\delta^{15}N$ values than dissolved N_2. As a consequence, the $\delta^{15}N$ values of marine plants are about 4‰ higher than those of terrestrial ones, although in cases where there is a significant contribution of N-fixing blue-green algae, like in tropical marine reef and mangrove ecosystems, the $\delta^{15}N$ values may be similar to those of terrestrial plants (Ambrose 1993).

The tissues of most marine vertebrate and of consumers of marine food are generally enriched in the heavier ^{13}C isotope and therefore have less negative $\delta^{13}C$ values. In addition, the marine food chain is longer than the terrestrial food chain and that causes a great deal of variability among the various animal species, as there are continuous increases in both carbon and nitrogen isotope ratios from one trophic level to the next. In coastal and island environments where C_4-based foods are uncommon it is usually possible to differentiate marine and terrestrial components of human diets. However, given the systematic differences within and between marine foodwebs discussed above, a careful characterisation of the isotopic composition of the local resources exploited by humans should be first made. In places where the presence of C_4 plants is attested, the sole information provided by stable carbon isotope values does not make it possible to distinguish between the contribution of C_4 plants and marine foods. In this case, it is also necessary to evaluate information derived from nitrogen isotopes.

b. Factors affecting $\delta^{13}C$ and $\delta^{15}N$ values of dietary resources

Several environmental factors influence the carbon isotope ratios of C_3 plants and these differences are reflected in the $\delta^{13}C$ values of their consumers (Ambrose 1993; van Klinken *et al.* 2000). In particular, light intensity, water availability, changes in the $\delta^{13}C$ of atmospheric CO_2 and soil nutrient content are among the principal causes of variation in the $\delta^{13}C$ values (Ambrose 1993: 89, with references). In general, C_3 plants from closed and humid environments will show lowest $\delta^{13}C$ values compared to those living in hot, dry ones. In fact, it has been shown that $\delta^{13}C$ values are higher in plants with higher water use efficiencies and plants subjected to water stress. Conversely, plants growing in locations characterised by reduced light intensity and absence of rapid mixing of atmospheric and biogenic CO_2 (such as forest understories) result in more negative $\delta^{13}C$ values. The depletion in the heavier carbon isotope occurring in plants from closed environments is usually referred to as the "canopy effect" and has been widely invoked in archaeology to explain the observation of lower $\delta^{13}C$ values in herbivores living in densely forested environments (e.g. Drucker *et al.* 2008; Bonafini *et al.* 2013). Temporal and spatial variations in the isotopic composition of atmospheric CO_2 also influence that of plants. For instance, burning of fossil fuel during the last centuries has led to a steady decrease (about -1.5‰) in the $\delta^{13}C$ value of atmospheric CO_2 since 1800 AD and this should be taken into account when comparing the values obtained from modern foods to those deriving from ancient skeletal tissues. Variations in the $\delta^{13}C$ values of C_4 plants are not well understood although these plants seem not be affected by environment-related isotope effects such as humidity, light intensity and temperature. Carbon isotope variation in CAM plants is related to environmental conditions (salinity, day lengths, night temperature and water stress). In hot, arid environments, the $\delta^{13}C$ values are similar to those of C_4 plants whilst in cooler environments CAM plants shift to C_3 photosynthesis and have more negative $\delta^{13}C$ values (Ambrose 1993).

Variations in the nitrogen isotope values of soils, plants and animals are due to several factors. In cool, moist soils where N-fixation is higher as well as the rate of mineralization, the $\delta^{15}N$ values are usually lower. Conversely, hot, dry soils like savanna and deserts show higher $\delta^{15}N$ values. In addition, saline and fertilized soils show the highest nitrogen isotope ratios and these values affect also the plants growing on them.

4.3.2. Stable isotope analysis of bone and teeth

Any human and animal tissue or metabolic product that contains carbon and/or nitrogen can be utilised for palaeodietary isotopic analysis, including for example breath CO_2, blood and other fluids, keratinous tissues such as hair and nails, and calcified tissues like bone and teeth. Archaeological applications of stable isotope analysis for palaeodiet reconstruction are usually restricted to bone and teeth, as they are by far the most common vertebrate tissues to be recovered during excavations.

Bones and teeth are composite materials made up of complex organic molecules and minerals organised into various hierarchical levels (Weiner & Wagner 1998; Weiner *et al.*

1999; Weiner 2010: 99-134). Briefly, the basic components of bone are a mineral phase called carbonate hydroxyapatite, an organic matrix mainly composed of a structural protein, that is, collagen, and water. In general, dry bone is considered to be approximately 70% inorganic and 30% organic by weight, although the relative proportions of these fractions vary somewhat across species, among bone types, and throughout the lifetime of an individual (Schwarcz & Schoeninger 1991: 291). In mature bone, the crystals of hydroxyapatite (also known as dahllite) are mostly plate-shaped and extremely small, with average dimensions of 50 × 25 × 2–4 nm. The small size of the crystals is one of the causes for atomic disorder in the mineral phase, resulting in higher solubility and hence instability. As already specified, most of the organic fraction of bone (about 90% by weight) is constituted by type I collagen, a fibrous protein also found in skin and other soft tissues in vertebrates. The remaining 10% is a complex suit of other proteins (often termed as NCPs, namely, noncollagenous proteins), proteoglycans (proteins associated with polysaccharide chains), and various lipids. After type I collagen, the second most abundant protein in bone is osteocalcin. Vertebrate teeth show different morphologies that reflect the different functions they perform during food processing (Lowenstam & Weiner 1989; Lucas 2004; Weiner 2010: 99-134; Nanci 2013). In brief, the bulk of vertebrate teeth is composed of a relatively plastic material named dentin while the outer surface consists of a very hard and stiff material called enamel. Two types of dentin are present in teeth: intertubular dentin (found in the bulk of the tooth and in the tooth root) and peritubular dentin (a hard and relatively collagen-free material found only in the tooth crown). In all respects, the basic constituents of intertubular dentin resemble those of bone: plate shaped crystals of carbonate hydroxyapatite, type I collagen, and water. The major difference between intertubular dentin and bone is in the suite of noncollagenous proteins, as some of these are present in intertubular dentin but not in bone. Enamel is a unique material that differs largely from bone. About 99% by weight of mature enamel consists of the same mineral that is present in bone and dentin – carbonate hydroxyapatite – although enamel crystals are very long and have widths and thicknesses in the range of 20 to 60 nanometres.

Stable isotope analysis of bone and teeth should take several factors into account. First, it is important to know that these tissues form during different timespan: bone is a living tissue that remodel regularly within an individual’s life while tooth enamel and dentine are incremental tissues that form during a limited period of the life of an individual. As a consequence, isotope values of bone are the product of long-term averages (usually depending on the age of the individual) whilst isotope ratios measured on teeth reflect the condition of the individual while that specific tissue was forming (Sealy *et al.* 1995; Lee-Thorp 2008). Secondly, depending on which component of bone and teeth is utilised for the analysis, specific aspects of the diet can be investigated. In particular, measurements conducted on collagen will mainly reflect the dietary proteins whilst analysis of the inorganic matrix of bone and tooth enamel will provide estimates of the whole diet (Ambrose & Norr 1993). Thirdly, the $\delta^{13}C$ value of bone collagen is approximately 5‰ more positive than that of the diet, while in the case of apatite, the diet-tissue fractionation is estimated to be at least 9.5‰ and as much as 11 to 12‰ (Lee-Thorp *et al.* 1989; Ambrose & Norr 1993; Hedges 2003). Finally, since bone and teeth are subjected to *post mortem* and *post-burial* alteration, it is fundamental to assess that the original isotopic composition of these tissues has not changed. A description of the patterns of diagenesis of bone and teeth is out of the scope of this thesis but useful reviews and information can be found in Collins *et al.* (2002), Hedges (2002), Lee-Thorp (2002, 2008), Berna *et al.* (2004), Nielsen-Marsh *et al.* (2007).

4.4. Materials and methods

A total of 100 skeletal samples from eight archaeological sites dating to the Chalcolithic and the Bronze Age were analysed in this study (see Table 4.2).

Table 4.2 Faunal and human skeletal samples analysed within this study.

Faunal samples	**Chalcolithic**	**Bronze Age**
bone	n = 15	n = 25
teeth	n = 2	n = 4
TOTAL	n = 17	n = 29
Human samples	**Chalcolithic**	**Bronze Age**
bone	n = 2	n = 42
teeth	n = 0	n = 10
TOTAL	n = 2	n = 52

As anticipated in Chapter 1, the selection of sites from the Chalcolithic period was limited by issues of poor preservation of the skeletal material. Previous feasibility tests involving collagen extraction in bones and teeth from Kissonerga *Mylouthkia* (Goude *et al.* 2010) and Souskiou Laona (G. Cook *personal communication*) showed that the Chalcolithic skeletal remains from that sector of the island were particularly low in collagen content and no useful analysis could be undertaken. A similar result was obtained in this research at the site of Kissonerga *Mosphilia*, although the successful extraction of collagen in two animal teeth raises the possibility that these tissues could be used for future palaeodietary investigations (see Chapter 5.2.2). Differently, feasibility tests made on the skeletal remains from Erimi *Pamboula* revealed an exceptional preservation of the bone material (see Chapter 5.2.1). Concerning the Bronze Age period, skeletal material from three settlements and three cemetery areas was included in this study. In particular, the settlements of Marki *Alonia*, Alambra *Mouttes* and Erimi *Pamboula* were chosen because of the presence of both animal and human remains although, unfortunately, only the faunal assemblage from Marki *Alonia* was sufficiently well preserved for the analysis (cf. Chapters 6.2.1, 6.2.2 and 6.2.5).

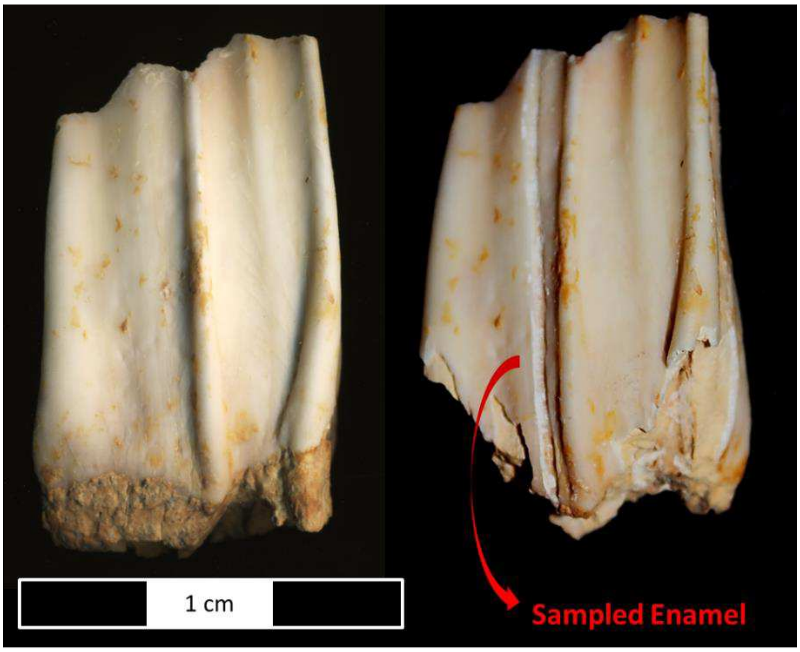
The sampling strategy was clearly intended to select the best preserved material. With reference to the bone samples, sampling was preferably conducted within the shaft of long bones like femurs or humeri, as they are normally less depleted in collagen content. In addition, each element was visually inspected in order to avoid porous, brittle bones and to favour hard, dense ones. If the cross section was visible, as in the case of fragmented elements, then the bones showing a powdery or chalky matrix were rejected. As far as the number of human samples is concerned, during the sampling procedure, an effort was made to examine every single bone and tooth within the osteological collection in order to try to collect as many well-preserved samples as possible. Differently, in the case of the animal remains, a fixed number of samples was analysed from the sites of Erimi *Pamboula,* Kissonerga *Mosphilia* and Marki *Alonia*, as agreed with the Department of Antiquities of Cyprus.

The skeletal samples were prepared and measured either at the IRMS Laboratory of the DiSTABiF – Dipartimento di Scienze e Tecnologie Ambientali Biologiche e Farmaceutiche – of the Seconda Università di Napoli (Caserta, Italy) or at the RLAHA – Research Laboratory for Archaeology and the History of Art – of the University of Oxford (UK). Measurements were conducted either on bone and dentine collagen or on tooth enamel carbonate.

Concerning collagen extraction, two slightly different protocols were adopted. At the RLAHA, bone samples and teeth were first shot-blasted with aluminium oxide to remove dirt and any visible incrustation. Then, approximately 500-750 mg of bone chunks, or tooth root pieces in the case of animal teeth, were used for collagen extraction. The material was treated with a solution of HCl 0.5 M and left for 2–5 days to demineralize at 5°C. The solution was then discarded and the residue was rinsed three times in deionised MilliQ water and ultrasonic bath for 30 minutes at 0°C. The gelatinization of the residue was then achieved in a pH 3 HCl solution at 75°C for at least 48h. Subsequently, the supernatant was filtered with a 5-8 mm Ezee filter® (Elkay Laboratory Products) and the soluble gelatine freeze-dried for 48h. Insoluble residues were discarded. In the case of the three human teeth from Tombs 53 and 60 of Kalavasos Village, they were cut in the half with a diamond saw and only one half of each tooth was used for collagen extraction. The halves were placed in a test tube with a solution of HCl 0.5 M at 5°C until CO_2 ceased to evolve. Then the pre-treatment followed the same steps described above for the other samples.

At the DiSTABiF laboratory, after mechanical cleaning, about 1 g of the bone samples was weighed and subsequently pulverized using a mortar and pestle. Demineralization of the material was achieved adding a solution of HCl 0.6 N at room temperature for 2 hours and then, after the solution of HCl 0.6 N was changed, overnight. Then the residue was treated with 0.1M NaOH at room temperature for 30 minutes in order to remove humic acids, and again with HCl 0.6 N for 30 minutes at room temperature so as to remove any CO_2 possibly absorbed from atmosphere during the precedent step. The gelatinization of the residue was achieved in a pH 3 HCl solution at 70°C for about 24 hours. Subsequently, the supernatant was filtered with a 5-8 mm Ezee filter® (Elkay Laboratory Products) and the soluble gelatine freeze-dried for 48h.

Figure 4.3 Maxillary left M_3 of a caprine from Kissonerga *Mosphilia* before and after the sampling of roots for collagen extraction and of enamel.



Tooth enamel was sampled and prepared at the RLAHA. Enamel was sampled from the bulk of the tooth so as to obtain an average of diet over several years. In order to do this, the best preserved surface of the tooth was drilled along a vertical line from the neck to the occlusal surface, using a mounted Dremel variable speed drill with a 0.5 mm diamond tip (see Figure 4.3). A minimum of 5 mg of enamel powder was then collected on clean aluminium foil and transferred into a microcentrifuge tube. Powders were reacted in a 1:1 mixture of 1.5% sodium hypochlorite and distilled water for 30 min to remove organics. The samples were then washed to a neutral pH by with distilled water, and then treated with 0.1M acetic acid for 10 min, in order to remove soluble diagenetic carbonates. Finally, they were rinsed again three times and then freeze dried.

As far as measurements are concerned, at the RLAHA collagen and enamel isotope values were determined on SERCON 20-22 IRMS system coupled to a SERCON GSL elemental analyser running in continuous flow mode with a Helium carrier gas. Together with the collagen samples, the following laboratory standard reference materials were measured: Alanine, modern cow collagen, marine seal collagen (all calibrated to the VPDB and AIR scales using the USGS40 and USGS41 glutamic acid standards). Together with the enamel samples, CO-1 (*Calcite* - International Standard), mammoth enamel and wildebeest enamel (all calibrated to IAEA CO-1 and NBS 19) were measured. At the DiSTABiF laboratory, the weight fraction of N and C expressed in % of the sample dry weight was measured with a Flash EA 1112 elemental analyser (from Thermo Finnigan) while the carbon and nitrogen isotope ratios were measured with a Delta V Advantage isotope ratio mass spectrometer (from Thermo Scientific). Together with the collagen samples, six standard reference materials were measured: IAEA-USGS-34 (*Potassium Nitrate*), IAEA-N-2 (*Ammonium Sulfate*), IAEA-CH-3 (*Cellulose*), IAEA-CH-6 (*Sucrose*), Sirfer Yeast and the internal laboratory standard dried yeast (calibrated to the VPDB and AIR scales using IAEA-N-2 and IAEA-N-1 standards).

The quality of the collagen extracts was assessed by evaluation of the collagen yield (weight percentage), the molar ratio of carbon to nitrogen (C/N) and the measured carbon and nitrogen percentages (%C, %N). While there is general agreement that bones with very low collagen yields should be considered suspect for isotopic analysis, conclusions regarding the point at which samples should be rejected have varied. According to van Klinken (1999), collagen yields down to 0.5% should still contain well preserved collagen, although it is recommended that the integrity of collagen samples with very low yields (between 2% and 0.5%) is further checked by means of other quality indicators. On the other hand, a number of studies have demonstrated that the measure of the C/N ratio is an extremely robust indicator of collagen integrity, with values expected to fall within the range of 2.9-3.6 in well preserved collagen samples (DeNiro 1985; Schoeninger *et al.* 1989; Ambrose 1990; van Klinken 1999). Ambrose (1993) recommended as additional criteria the determination of the percent of carbon (%C) and nitrogen (%N) in the collagen extract, with concentrations being expected to be above 3% and 1%, respectively. In this study, the collagen extracts were considered as well-preserved and accepted if they had a minimal weight percentage of 0.5% collagen, C/N ratio between 2.9 and 3.6 and minimum carbon and nitrogen contents of 3% and 1%, respectively. Only two exceptions were made: sample AL_1 from Alambra *Mouttes* (Chapter 6.2.2) and sample T328_B2 from Erimi *Laonin tou Porakou* (Chapter 6.2.5). In these two cases, the collagen yield was lower than 0.5% but both the collagen extracts showed acceptable C/N ratios and %C and %N close to that of collagen from fresh bone. For these reasons, they were believed to contain intact collagen.

CHAPTER 5
DIET IN THE CHALCOLITHIC: STUDY OF ARCHAEOLOGICAL SITES

5.1. Introduction

The Chalcolithic period (ca. 4000/3900-2400 BC) witnessed the floruit of one of the most distinctive societies of prehistoric Cyprus. Although biased towards the southern and south-western sectors of the island, archaeological evidence points to a series of common trends and innovations: style of architecture, exceptional arts and crafts, first use of copper, appearance of an island-wide symbolic system, signs of social disparities and the inauguration of important contacts with the neighbouring regions, especially Anatolia (Peltenburg 2012, 2014).

At the beginning of the Early Chalcolithic, the increasing demographic pressure and consequent resource stress have deemed responsible for a process of community fissioning and settlement relocation towards coastal areas, where the presence of more fertile, alluvial soils would have favoured land cultivation (Peltenburg 1993, 2014). During the Middle and Late Chalcolithic periods population growth continued and was accompanied by innovations in technology and social structure that together contributed to bring changes also in the field of subsistence economy. Palaeobotanical data suggests that, throughout the period, the subsistence economy was based on hoe cultivation of various species of cereals and pulses, supplemented by the collection of fruits and wild plants. As noted by Murray (1998a) and Lucas (2014: 73), the archaeobotanical record indicates that processes of agricultural intensification, extensification (expansion into new areas) and varietal diversification occurred during this period. On the other hand, the faunal data collected from the main Chalcolithic sites of the island suggest that hunting of fallow deer continued to predominate during the Early Chalcolithic, accounting for the highest proportion of meat supply, but gradually declined during the subsequent Middle and Late Chalcolithic and was steadily replaced by herding of pigs and caprines (Croft 1991).

Although attested at certain Chalcolithic sites of the island (Kissonerga *Mylouthkia*, Kissonerga *Mosphilia* and Lemba *Lakkous*, see Chapter 3) marine foods have been seldom considered as a component of the subsistence economy of the Chalcolithic communities of Cyprus. However, the fact that the majority of Chalcolithic settlements were located in coastal regions prompts the question of how intensive and specialized fishing was and how strongly the communities might have depended on it as a component of their diet or to protect against resource stresses. In this regards, Button (2010: 323) noted that the expansion of human population attested by growth in both the size and the number of Chalcolithic sites, coupled with the apparent crucial role played by wild resources throughout the period, "will almost certainly have resulted in greater total human pressure on wild animal populations, primarily fallow deer, feral caprines and wild pigs, but also including coastal stocks of fish and mollusks".

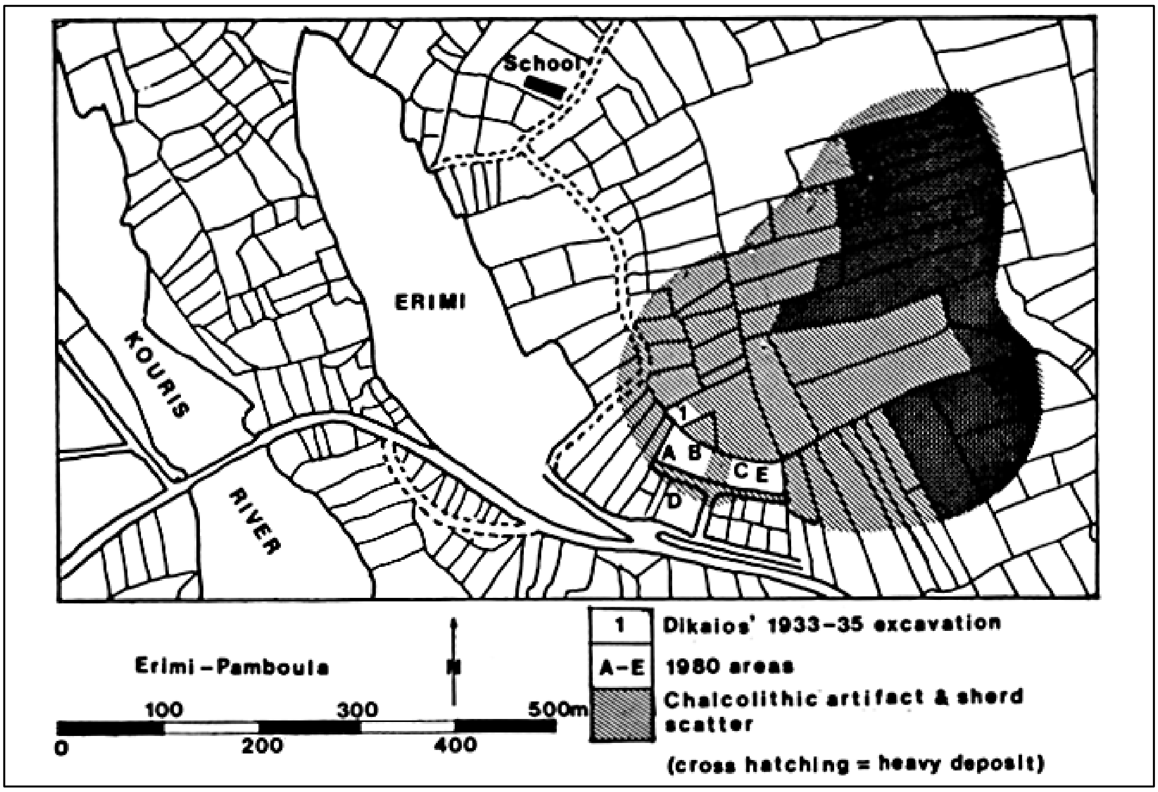
In order to test the importance of marine resources in the diet of the Chalcolithic communities of Cyprus and improve our knowledge of individual patterns of consumption during this period, stable isotope analysis has been conducted on skeletal material from the two Chalcolithic sites of Erimi *Pamboula* and Kissonerga *Mosphilia* (see Figure 1.1). This chapter is intended to present the comprehensive palaeodietary investigation undertaken at these Chalcolithic settlements within the frame of this study. Accordingly, the most relevant information on the location, excavation history, chronology as well as palaeobotanical, faunal and anthropological data will be first provided, followed by a detailed account of the isotopic study, including a description of the sampled materials, preservation state and discussion of the faunal and human isotopic data.

5.2. Investigated sites

5.2.1. ERIMI-PAMBOULA

Erimi *Pamboula* is located in southern Cyprus, close to the modern village of Erimi and about 20 km west of the modern town of Limassol (Figures 1.1 and 3.1). The site is situated at the northern edge of an alluvial plain, on the east bank of the Kouris River, about 3.5 kilometres from the sea.

Figure 5.1 Site plan of Erimi *Pamboula* showing the excavated areas and the presumed extent of the Chalcolithic settlement. From Heywood *et al.* (1981: 24).



The Chalcolithic settlement of Erimi *Pamboula* was first identified by P. Dikaios, who discovered it in 1933 while he was excavating in the Kourion area (south-west of modern Erimi) on behalf of the Cyprus Museum. He soon realised the potentialities of this site and, from 1933 to 1935, conducted a small trial excavation at *Pamboula* with the purpose of making a preliminary study of the settlement and its culture (Dikaios 1938, 1962: 113-132). According to Dikaios, his trench was backfilled after the excavation and the field was put under cultivation again. Then, in 1980, due to building activities in the area, the site was re-examined under the supervision of H. and S. Swiny, who carried out a surface survey and a small excavation, just 50 m south of Dikaios' original sounding (Heywood *et al.* 1981) (Figure 5.1).

In 1982, D. Bolger studied and relocated some of the unpublished materials excavated by Dikaios and stored at the Cyprus Museum in Nicosia (Bolger 1988). More recently, in 2010-2012, the Department of Antiquities of Cyprus undertook a series of rescue excavations at Erimi *Pamboula* (plots 47, 122, 125-127, 250, 278, 279, 279Γ, 319, 330, 569 and 760) whose findings have not yet been studied (Y. Violaris and P. Christofi *personal communication*).

a. Chronology

Dikaios recorded thirteen occupation levels at Erimi *Pamboula* and subdivided them into two periods on the basis of a copper chisel found in level IX. Accordingly, levels I-VIII were included in the earlier Period 1 while levels IX-XIII were assigned to Period 2 (Bolger 1988: 25). Conventionally, the thirteen levels are ascribed to the Early and Middle Chalcolithic, though occupation during the Late Chalcolithic at another part of the site has also been suggested (Peltenburg *et al.* 2013: 320).

Dating materials

Dikaios' excavation of Erimi *Pamboula* by artificial stratigraphy prevents the possibility to establish accurate spatial and temporal correlations between ceramics from different areas and levels of the site. In her revision of the pottery from Erimi, Bolger (1988: 35-42) divided the ceramic assemblage recovered by Dikaios into two major groups: the first one included the most abundant Red-on-White ware (RW), Red Slip ware (RS), Red Lustrous ware (RL) and their variants; the second one comprised minor wares such as Black Topped ware (BTW), Combed ware (Cb) and Coarse ware (CW).

Radiocarbon dating

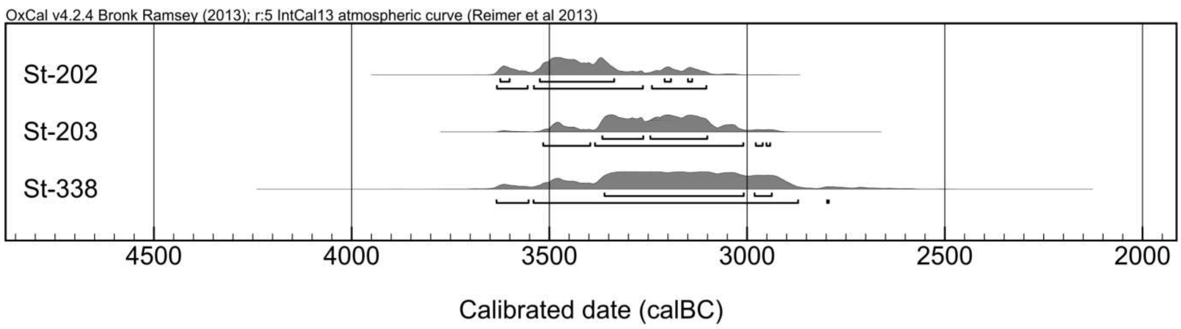
In the 1950's, three charcoal samples which had been kept in the Cyprus Museum were submitted to the Stockholm Laboratory for radiocarbon dating (Östlund 1957, 1959). More recently, the three radiocarbon determinations have been re-evaluated by Peltenburg *et al.* (2013) within the ARCANE (Associated Regional Chronologies for the Ancient Near East) research program. As already noted by the authors, the context of provenance of the charcoals is not clear. Östlund (1957: 496) reported that they originated from levels II and III which, according to Dikaios' ultimate phasing, would correspond to the bottom layers. At the same time, Dikaios (1962: 129, 198) stated that they were collected from the excavation upper's levels. In treating the radiocarbon data from Erimi *Pamboula*, Peltenburg *et al.* (2013: 320) decided to arbitrarily associate them to Period 2, probably towards the end of the sequence of layers attributable to the Middle Chalcolithic. While it is clearly impossible to trace back the original location of the three charcoals, it should be noticed that, in his earlier report, Dikaios utilised a reversed order for numbering the excavated layers and originally associated the bare rock to layer X (Dikaios 1936: 8), not to layer I as in the final report (Dikaios 1938: 8, 1962). Considering that the three charcoal samples were submitted to the Stockholm Laboratory almost 20 years after being recovered, it is possible that they were still labelled with the old numbering, and that would explain the inconsistency in the context of provenance reported by Östlund (1957: 496) and Dikaios (1962: 129, 198).

In this study, the radiocarbon ages yielded by the three charcoals have been calibrated anew taking the latest calibration curve as a reference (IntCal 13, Reimer *et al.* 2013). The results are summarised in Table 5.1 and shown in Figure 5.2.

Table 5.1 Radiocarbon ages and calibrated ages of the three charcoal samples from Erimi *Pamboula.*

SAMPLE NAME	MATERIAL	RADIOCARBON AGE (years BP)	CALIBRATED AGE (68% confidence level)	CALIBRATED AGE (95% confidence level)
St-202	charcoal	4630 ±80	3630-3130 BC	3640-3100 BC
St-203	charcoal	4540 ± 80	3370-3100 BC	3520-2940 BC
St-338	charcoal	4480 ± 150	3370-2930 BC	3640-2790 BC

Figure 5.2 Calibrated radiocarbon dates from Erimi *Pamboula* calibrated in OxCal 4.2.4 using the IntCal13 calibration curve.



Generally speaking, the dates span within the interval 3630-2930 BC (at 68% level of probability) and seem to confirm occupation at Erimi *Pamboula* during the Early-Middle Chalcolithic. However, the lack of more precise information concerning the context of recovery and the botanical species of the charcoals hamper an accurate interpretation of these results and further investigations would be needed to better define the chronological framework of this Chalcolithic site.

b. Site description

Erimi *Pamboula* is the largest Chalcolithic settlement currently identified in Cyprus, extending over an area of about 15 ha, as estimated from surface scatter of Chalcolithic pottery and lithic artefacts (Heywood *et al.* 1981:28).

The area excavated by Dikaios was much smaller, covering ca. 150 m^2 and reaching a maximum depth of about 5.5 m in the north-east part, where a large depression in the bedrock was recorded (Dikaios 1938: 2-3). The earlier excavations revealed a superimposed sequence of circular buildings (that Dikaios described as huts) and an amazing quantity of artefacts, especially pottery. These architectural remains were subdivided according to three chronological phases and four building types: Phase 1 (levels I-IV) was characterised by buildings of light timber construction and a brushwood superstructure; in Phase 2 (levels V and V/VI), buildings with and without stone foundations were recognised; Phase 3 (levels VI-XIII) yielded the remains of more solid constructions exclusively with stone foundations (Dikaios 1962: 128; Bolger 1988:25; Knapp 2013: 208).

The remains of other features like thresholds, partitions, benches hearths and grinding installations were evidenced, especially during Phase 3. Unfortunately, the lack of information concerning the precise provenance of the artefacts makes it difficult to clearly associate spatial units with different kind of activities. In Bolger's opinion, the general arrangement of the finds does not seem to indicate any evidence of differentiated places of activity. For example, cooking was probably done outdoors, indoors or in some of the small ancillary units characterising the two-roomed buildings (Bolger 1988: 29).

c. Flora and Fauna

Palaeobotanical remains

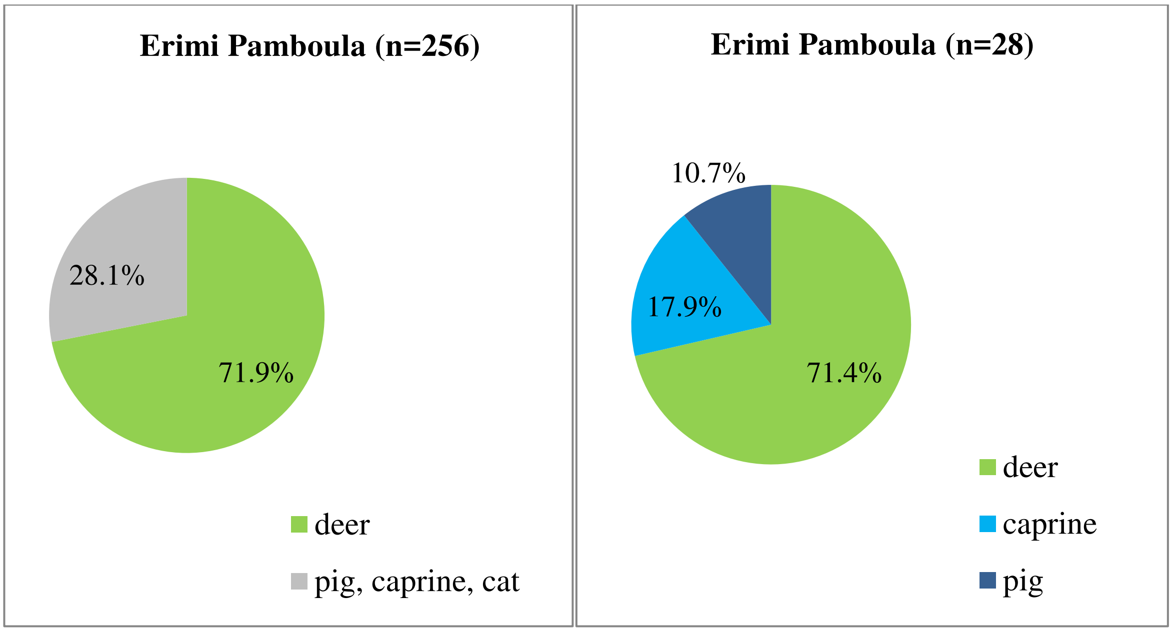
No information about palaeobotanical remains possibly recovered during excavations at Erimi *Pamboula* is currently available (Bolger 1988: 29). Soil samples recovered during the 2011-2012 rescue excavations are currently being analysed by Dr. Evi Margaritis of the Cyprus Institute (Nicosia) and will hopefully provide some information about the vegetation surrounding the ancient settlement.

Faunal remains

Animal bones recovered during Dikaios excavations were first studied by King (1953) and subsequently re-examined by Ducos (1965). The faunal remains from the 1980 trial excavation were instead analysed by Croft (1981).

The composition of the two faunal assemblages in terms of identifiable animal remains is similar and includes fallow deer (*Dama Mesopotamica*), sheep/goat and pig. In her report, King (1953) also refers to the presence of the fragmentary skeleton of a cat. The comparative frequencies of identified mammalian bones from the earlier faunal sample have not been reported, let alone the number of deer fragments which, according to Ducos (1965), amounted to 71.9% of the total remains. A similar figure is given by Croft (1981), who found that deer represented 71.4% of the remains, while pig and caprines accounted for 10.7% and 17.9%, respectively (Figure 5.3). Among the caprine remains, only goat was specifically identified both by King (1953) and Croft (1981), leading the latter to hypothesise that caprine exploitation was possibly more focused on goats rather than sheep.

Figure 5.3 Identified mammalian bone fragments from Erimi *Pamboula*: a) considering all faunal remains (from Croft 1991, Table 2: 71); b) considering only the faunal remains recovered in 1980 (from Croft 1981, Table 4: 41).



A further assemblage of faunal remains was recovered during the 2011-2012 rescue excavations. A considerable amount of material originates from plot 330, located on the southern border of the Chalcolithic settlement and assumed to be part of its catchment area.

This plot is only meters away from the circular buildings excavated by Dikaios and probably represents an area devoted to outdoor activities, including butchering or meat processing, as evidenced both by the high density of animal bones and the vast number of stone tools collected such as grinders, pounders, axes (P. Christofi, *personal communication*). The faunal assemblage has not yet been studied but preliminary observations made by the author within the context of this research point to a heavy predominance of fallow deer.

Molluscs and fish

A small assemblage of shells was recovered at Erimi *Pamboula* during Dikaios excavations and was studied by Wilkins (1953). Edible species included *Charonia lampas*, *Cassis sulcosa*, *Patella* (limpets) and *Cardium* (cockles) but all the shells from Erimi appeared to be recent in Wilkins opinion.

The later 2011-2012 excavations by the Department of Antiquities of Cyprus produced a greater quantity of invertebrate remains, amounting to 116 marine shells and 2 fossils, recently studied by D. Reese (*forthcoming*). According to the author, this later assemblage mainly consists of ornamentals items, with few examples of the edible species *Phorcus*, *Patella* and *Cerastoderma* (cockles), possibly indicating limited consumption of this kind of foods.

d. Human remains

Four burials found in stratigraphic succession with the circular buildings were excavated by Dikaios at Erimi *Pamboula* (Dikaios 1938). Only one burial belongs to the earlier Period 1 (level V) while the other three were assigned to Period 2 (levels VIII-IX). The human remains were examined by Guest (1938), with the exception of Skeleton N°2 which was first described by Rix (1938) and subsequently by Angel (1953: 420, 428 n. 10; 1961: 228, Table 2 and Pl. 119). Later on, these burials were reviewed by Niklasson (1991). According to publications, the four burials represent the single interments of two adult males, one female adolescent and one child.

The osteological collection of Erimi *Pamboula* is currently stored at the Limassol District Archaeological Museum (Limassol) let alone Skeleton No. 2 which was moved intact to the Cyprus Museum in Nicosia where it is still on exhibition (Guest 1938: 59) (Figure 5.4).

Figure 5.4 Photo of the reconstruction of the Chalcolithic burial from Erimi *Pamboula* on exhibition at the Cyprus Museum in Nicosia. Courtesy of the Department of Antiquities, Cyprus.

Health status

Some information about the health status of the buried individuals can be extrapolated from the dental pathological conditions reported by Guest (1938). According to the author, Skeleton No.1, identified as an old male adult, showed ante mortem tooth loss (right P_2, M_1 and M_3) and traces of old inflammatory change associated with the sockets of the lower canines. The adolescent, Skeleton No.4, had several teeth with carious spots and Skeleton No.3, belonging to a child about 10 years old, displayed very worn milk molars and incipient wear of the permanent molars. As far as Skeleton No. 2 is concerned, Rix (1938) reported that this adult male had a complete and good dentition but the wear on teeth was consistent with an edge-to-edge bite.

e. Isotopic study

Materials

A total of 12 bone samples were analysed from the site of Erimi *Pamboula*. Ten samples were taken from the faunal assemblage recovered in plot 330 during the 2011-2012 rescue excavations and stored at the Kourion Archaeological Museum in Episkopi village (Table 5.2). The remaining two bone fragments were sampled from the human remains excavated by Dikaios in the 1930s (Table 5.3), though it should be specified that one sample (EPAM_UN) was taken from a left femur found within a small assemblage of adult-sized commingled remains which is not mentioned in the anthropological report of Guest (1938). Examination of the sampled femur and its comparison with the photos of the burials in Dikaios final report suggest that it could originate from the same context of the child burial (Skeleton No. 3; Dikaios 1938, Pl. XIV, 1) (P. Chrysostomou, *personal communication*).

As mentioned above, because Erimi *Pamboula* was excavated by artificial stratigraphy and because of the paucity of radiocarbon dates, the sequence of 13 layers identified by Dikaios cannot be anchored to an absolute chronology. If comparing the architectural remains of *Pamboula* with those found at other Chalcolithic sites of the island (especially Kissonerga *Mylouthkia* and *Mosphilia* and Kalavasos *Ayious*, see Figure 3.1), it seems reasonable to ascribe the burial in layer V and the burial in layer IX to the Early/Middle and Middle Chalcolithic, respectively, although this assumption would need to be confirmed by radiocarbon dating. As for the faunal remains excavated by the Department of Antiquities of Cyprus, it is currently not possible to ascribe them to a specific phase of the Chalcolithic.

Table 5.2 Faunal bone samples collected from Erimi *Pamboula*.

SAMPLE NAME	CONTEXT	PHASE/ CHRONOLOGY	SPECIES	ANATOMIC ELEMENT	NOTES ON COLLOCATION
EPAM_1	Plot 330, Layer 2	Chalcolithic	pig	right humerus	Tray 316
EPAM_2	Plot 330, Layer 2	Chalcolithic	pig	left mandible	Tray 316
EPAM_3	Plot 330, Layer 2	Chalcolithic	fallow deer	left humerus	Tray 316
EPAM_4	Plot 330, Layer 4	Chalcolithic	fallow deer	left humerus	Tray 332
EPAM_5	Plot 330, Layer 4	Chalcolithic	fallow deer	right humerus	Tray 332
EPAM_6	Plot 330, Layer 4	Chalcolithic	fallow deer	left humerus	Tray 333
EPAM_7	Plot 330, Layer 4	Chalcolithic	fallow deer	left humerus	Tray 333
EPAM_8	Plot 330, Layer 5	Chalcolithic	fallow deer	right humerus	Tray 343
EPAM_9	Plot 330, Layer 5	Chalcolithic	fallow deer	right humerus	Tray 343
EPAM_10	Plot 330, Layer 5	Chalcolithic	pig	right humerus	Tray 343

Table 5.3 Human bone samples collected from Erimi *Pamboula*.

SAMPLE NAME	CONTEXT	PHASE/ CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE	NOTES ON COLLOC.
EPAM_SK 1	Skeleton 1* Layer V under the floor of Hut VIA	Period 1 Early/Middle Chalcolithic	right femur	M	old adult	Bones 4, Box 2
EPAM_UN	Unidentified ** Layer IX pit below hut A	Period 2 Middle Chalcolithic	left femur	unknown	adult	Bones 8

* The remains of this individual are currently located in a box labelled "Skeleton 3" but are referred to as "Skeleton 1" in the anthropological report by Guest (1938).

** This sample originates from a pool of commingled bones recovered together with the remains of the child referred to as "Skeleton 3" in Guest (1938).

Results

All the 12 samples were prepared and measured for their carbon and nitrogen isotopic ratios at the IRMS Laboratory of the DiSTABiF - Dipartimento di Scienze e Tecnologie Ambientali Biologiche e Farmaceutiche - of the Seconda Università di Napoli (Caserta, Italy).

The stable isotope values yielded by the animal and human samples are reported in Tables 5.4 and 5.5, respectively, together with the collagen quality indicators obtained from each collagen extract.

Table 5.4 Collagen stable isotope values obtained from the faunal samples. Analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values. Acceptable samples based on collagen yield, C/N ratio and %C, %N appear in bold.

SAMPLE NAME/SPECIES	CONTEXT	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ (PDB, ‰)	$\delta^{15}N$ (AIR, ‰)
EPAM_1 pig	**Plot 330, Layer 2**	**1.2%**	**29.0**	**9.7**	**3.5**	**-20.3**	**6.4**
EPAM_2 pig	Plot 330, Layer 2	0.8%	2.2	0.6	4.0	-20.2	2.2
EPAM_3 deer	**Plot 330, Layer 2**	**1.2%**	**17.5**	**5.9**	**3.5**	**-20.2**	**5.8**

EPAM_4 deer	Plot 330, Layer 4	1.8%	26.5	9.3	3.3	-19.9	5.5
EPAM_5 deer	Plot 330, Layer 4	1%	12.6	4.3	3.4	-20.4	4.9
EPAM_6 deer	Plot 330, Layer 4	2%	34.4	11.8	3.4	-20.4	7.2
EPAM_7 deer	Plot 330, Layer 4	1.5%	18.8	6.4	3.4	-20.1	6.0
EPAM_8 deer	Plot 330, Layer 5	2.5%	27.6	9.5	3.4	-19.6	7.0
EPAM_9 deer	Plot 330, Layer 5	1%	11.7	3.9	3.5	-20.4	6.6
EPAM_10 pig	Plot 330, Layer 5	1.4%	26.0	8.7	3.5	-21.0	7.6

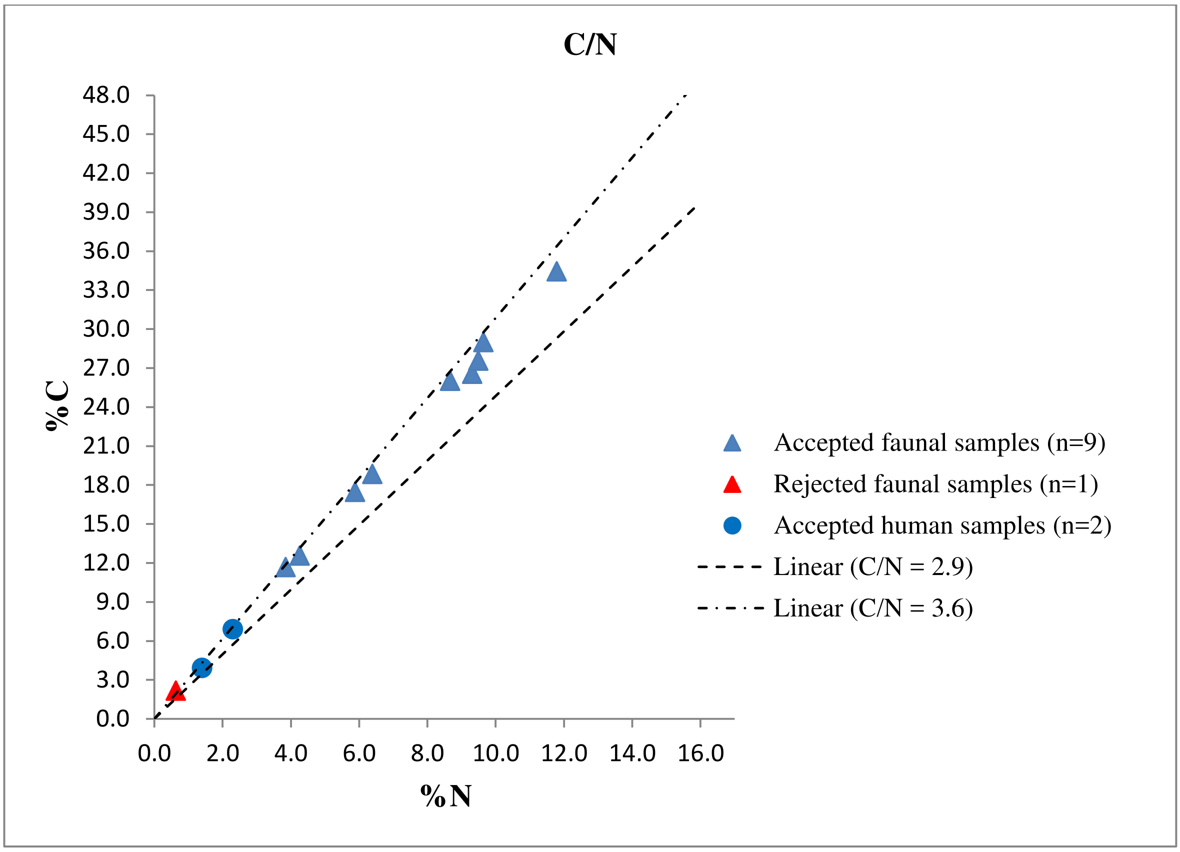
Table 5.5 Collagen stable isotope values obtained from the human samples. Analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values. Acceptable samples based on collagen yield, C/N ratio and %C, %N appear in bold.

SAMPLE NAME	CONTEXT	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ (PDB, ‰)	$\delta^{15}N$ (AIR, ‰)
EPAM_SK1	Skeleton 1, Layer V, under the floor of Hut VIA	0.9%	3.9	1.4	3.3	-21.1	6.2
EPAM_UN	Unidentified Layer IX, pit below hut A	0.7%	6.9	2.3	3.4	-21.2	7.4

Preservation State

The human and animal remains from Erimi *Pamboula* appeared exceptionally well preserved and collagen was successfully extracted from all the 12 samples. Collagen yields were generally higher in the faunal samples, with a mean collagen content of 1.4% ±0.005 (at 1 SD), while the two human samples produced lower weight percentages of collagen amounting to 0.7% and 0.9%. Similarly, carbon and nitrogen contents were higher in the animal collagen samples, but very low in the human remains, suggesting a more advanced stage of diagenesis (Figure 5.5). Only the collagen extracted from the pig mandible (sample EPAM_2) yielded unacceptable values of %C, %N and C/N ratio and was thus rejected.

Figure 5.5 Elementary contents (C, N) in the validated collagen extracts and the C/N range proposed by DeNiro (1985).



Faunal Isotope Values

The isotope values obtained for both the two animal species suggest the exploitation of a mainly C_3 ecosystem.

The deer group is quite homogeneous and shows mean $\delta^{13}C$ and $\delta^{15}N$ ratios of -20.1±0.3‰ and 6.1±0.8‰, respectively (Table 5.6). As for the two pig samples, they show slightly different isotope ratios: EPAM_1 yielded $\delta^{13}C$ and $\delta^{15}N$ values which are near to those of deer (-20.3‰ and 6.4‰, respectively); EPAM_10 has a lower $\delta^{13}C$ of -21‰ and a more positive $\delta^{15}N$ of 7.6‰.

Table 5.6 Summary of the $\delta^{13}C$ and $\delta^{15}N$ values yielded by the deer samples.

DEER	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C$ (‰)	-20.1	-20.2	0.3	0.8	-20.4	-19.6	7
$\delta^{15}N$ (‰)	6.1	6.0	0.8	2.3	4.9	7.2	7

Human Isotope Values

The $\delta^{13}C$ and $\delta^{15}N$ ratios obtained for the two human samples indicate a dominant terrestrial-based diet, apparently characterised by a significant contribution of proteins from C_3 plants and legumes. The $\delta^{13}C$ values of the two individuals are almost identical (-21.1‰, -21.2‰) and appear more depleted in ^{13}C than those of deer but very close to the carbon isotopic ratio of the pig sample EPAM_10. On the other hand, the $\delta^{15}N$ ratios slightly differ from each other (6.2‰, 7.4‰) and are quite similar to those of the animals, probably indicating a low contribution of animal proteins in the diet of these two individuals and/or an important consumption of pulses.

Summary and Discussion

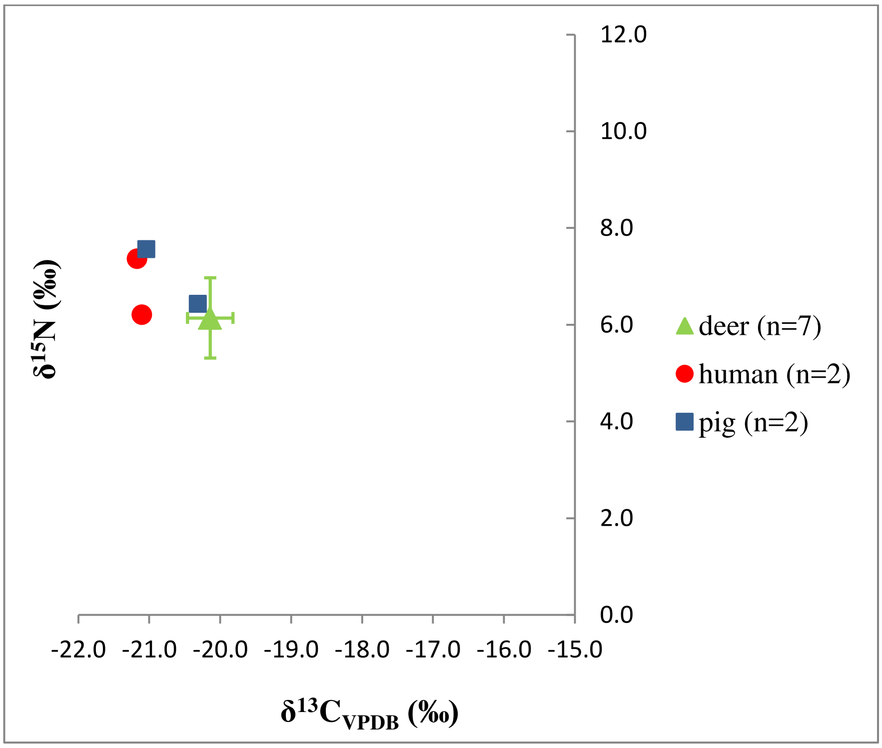
Stable isotope analysis of humans and fauna from Erimi *Pamboula* has provided us with preliminary information on the diet of fallow deer, pigs and adult humans (Figure 5.6).

The faunal samples from Erimi *Pamboula* show $\delta^{13}C$ and $\delta^{15}N$ values which appear consistent with the exploitation of a mainly C_3 ecosystem. The group of fallow deer is quite uniform, as might be expected from animals with a limited dietary choice, eating primarily grasses and, occasionally, trees and dwarf shrub shoots (Chapman & Chapman 1975). Little can be said about the two pigs apart from the fact that their isotope values suggest a diet based on terrestrial C_3 foods.

The two humans display similar isotope values that point to a dominant terrestrial-based diet, generally devoid of marine foods. More specifically, we can hypothesise a diet characterised by a significant proportion of terrestrial C_3 plants and pulses and likely a low contribution of animal proteins, as indicated by the low $\delta^{13}C$ and $\delta^{15}N$ values. The isotopic evidence obtained from the two humans appears in contrast with the analysis of the faunal remains which instead points to a subsistence economy heavily oriented towards deer hunting (Croft 1981; 1991). In this regards, it should be recalled here that ante mortem tooth loss was recorded in Skeleton 1 (associated to sample EPAM_SK1), while the other three individuals showed either several carious spots or remarkable tooth wear. Taken together, these dental diseases might be indicative of a diet rich in carbohydrates and coarse, abrasive items like raw vegetables, pulses and dirty foods (see, for example, Hillson 1979; Eshed *et al.* 2006; Alt & Rossbach 2009; Esclassan *et al.* 2009; Masotti *et al.* 2017). As mentioned before, direct archaeobotanical evidence for crops at Erimi *Pamboula* is currently lacking. However, Bolger (1988: 18) suggested that cultivation of fruit and vegetable crops would have been possible, even without irrigation, in the lower reaches of the Kouris River valley, where the soils of the alluvial belt retain sufficient moisture.

Although limited to two individuals, these results are important and hint at the possibility that the exceptional numbers of fallow deer bones recovered at Erimi *Pamboula* might not be related to the heavy consumption of deer meat, at least on a regular basis. What may this imply about the subsistence economy of the Chalcolithic communities is further discussed in Chapter 7.2.1, where also other kinds of evidences are taken into account.

Figure 5.6 Collagen stable isotope values of human and animal samples from Erimi *Pamboula*.

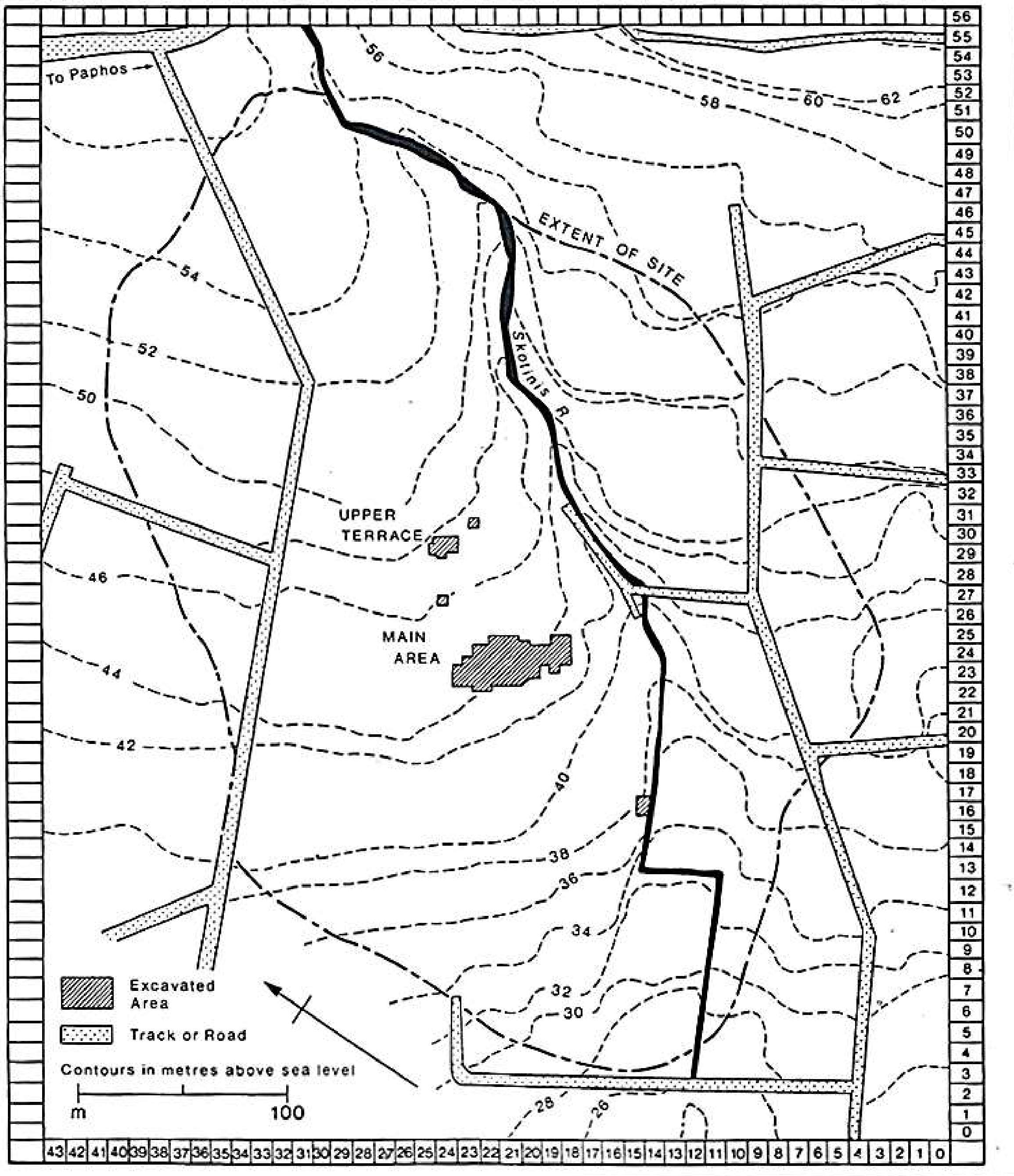


5.2.2. *KISSONERGA-MOSPHILIA*

Kissonerga *Mosphilia* is a multi-period site located in the south-western coast of Cyprus (Figures 1.1 and 3.1), about 6 km north of the modern town of Paphos (Cadastral Sheet XVII/45, plots 157-158). The site lies along the northern bank of the Skotinis stream and currently represents the largest Chalcolithic settlement in the Ktima lowlands (Figure 5.7).

The existence of a prehistoric site at Kissonerga *Mosphilia* was first reported by A.H.S. Megaw (1952: 113). In 1975, the archaeological area was surveyed in detail by Hadjisavvas (1977) and then almost annually from 1976 to 1982 within the Lemba Archaeological Project. LAP excavations started in 1979 and continued until 1992, under the direction of E. Peltenburg of the University of Edinburgh (Peltenburg *et al.* 1998).

Figure 5.7 Site plan of Kissonerga *Mosphilia* showing the excavated areas and the approximate extent of the site. From Peltenburg *et al.* 1998, Fig. 15.



a. Chronology

The site of Kissonerga *Mosphilia* is characterised by a remarkably long sequence of occupation extending from the Late Aceramic Neolithic to the Philia phase (late 7th-mid 3rd millennium BC). According to Peltenburg *et al.* (1998: 240-260), five main occupational periods could be discerned: Periods 1A-1B yielded the remains of Neolithic activities; Periods 2, 3A-3B and 4 correspond to the Early, Middle and Late Chalcolithic, respectively; Period 5 refers to the Philia phase. In common with several other prehistoric sites in Cyprus, the Aceramic Neolithic (Period 1A) is followed by a lengthy gap in settlement evidence, and occupation during the Late Neolithic period (Period 1B) is currently attested only by pottery. Differently, the interpretation of the stratigraphic deposits from the subsequent Periods 2-5 suggests general occupational stability.

Dating materials

Kissonerga units were allocated to Periods 1-5 according to their stratigraphic position and associated assemblages, especially their ceramics. Six key sequences (one from the Upper Terrace and five from the Main Area) provided the best stratigraphic evidence for the popularity of specific wares at different periods and contributed to the construction of a relative chronology. Besides Period 1A (Aceramic Neolithic) for which pottery is obviously not attested, the following ceramic phases were detected: Period 1B is poorly defined and characterised by the occurrence of Combed ware (Cb) and Red-on-White Banded Ware/Band and Line Ware (RWB/BL); in Period 2, Glossy Burnished Ware (GBW) predominates, with small proportions of RWB/BL and possibly Red Monochrome Painted-A Ware (RMP-A); Period 3A is distinguished by large amount of RMP-A with small percentages of GBW and RWB/BL that continue in small numbers also in Period 3B, dominated by RMP-A, Red Monochrome Painted-B Ware (RMP-B) and Red-on-White Lattice Ware (RWL); in Period 4, all wares but Cb and RMP-A are attested but a new ware, Red and Black Stroke-Burnished Ware (RB/B), dominates the assemblage; Period 5 is poorly defined but characterised by the appearance of small proportions of Red Polished (Philia) Ware (RP) (Bolger *et al.* 1998: 8).

Despite several minor incongruities, this ceramic sequence confirms the division of Chalcolithic habitation at Kissonerga into three periods (Early, Middle and Late Chalcolithic) with ceramic breaks occurring between each period and, to a lesser extent, between Periods 3A-3B (Bolger *et al.* 1998: 102).

Radiocarbon dating

A total of 31 radiocarbon determinations are available from Kissonerga *Mosphilia*, the majority of which (26 dates) belongs to Periods 3 and 4 (Table 5.7). Most dates originate from charcoals probably derived from structural timbers and only six short-lived samples were radiocarbon dated (Table 5.7 in bold). The complete datelist was first published in Peltenburg *et al.* (1998: 12-21). Most recently, the radiocarbon data from Kissonerga *Mosphilia* have been re-evaluated through Bayesian analysis by Manning (2013a, 2013b, 2014) and Peltenburg *et al.* (2013: 313-348). In the first case, the dates have been arranged into a Bayesian model including all the radiocarbon data available for prehistoric Cyprus, in the attempt to define a radiocarbon-based chronology for the whole period from the Late Epipalaeolithic to the Late Bronze Age. In the second instance, Peltenburg *et al.* (2013) have considered only the dates from Kissonerga *Mosphilia* Periods 3B, 4 and 5 as the research program was restricted to the third millennium BC.

Table 5.7 List of radiocarbon determinations from Kissonerga *Mosphilia*. Dates from short-lived samples are evidenced in bold.

SAMPLE NAME	MATERIAL	CONTEXT	PERIOD	RADIOCARBON AGE (years BP)
AA-10495	charcoal	Pit Complex 1667	1A	7255 ± 60
GU-3397	charcoal	Pit 1659 Fill 1666	2	5320 ± 90
OxA-2965	*Gramineae*	Pit 1149	2	5100 ± 80
OxA-2964	charcoal	Pit 1132 Fill 1147	2	4860 ± 80
GU-2967	charcoal	Surface 1541	3A	5540 ± 110
AA-10497	*Vitis vinifera*	General 1571	3A	4605 ± 55
AA-10496	*Lens*	Grave 551	3A?	4285 ± 60
GU-2537	charcoal	Pit 1012	3A/4	4020 ± 110
BM-2526	*Pinus*	Building 206, Fill 196	3B	4690 ± 70
BM-2528	*Pinus, Olea*	Building 206, Fill 626	3B	4600 ± 60
OxA-2963	charcoal	Building 994, Pit 1202	3B	4520 ± 80
BM-2568	*Pinus*	Building 855, Fill 936	3B	4490 ± 50
OxA-2962	*Lens / Gramineae*	Building 1161, Oven fill 1265	3B	4370 ± 70
OxA-2961	seed	Building 4, Fill 278	3B	4310 ± 75
OxA-2162	*Morus*	Pit 1015	3B	4300 ± 80
OxA-2161	*Morus*	Pit 1015	3B	4290 ± 80
GU-2968	charcoal	General 2060	3B	4240 ± 100
GU-2168	*Pinus*	Building 855, Fill 935	3B	4210 ± 105
GU-2426	*Morus*	Pit 1015	3B	3880 ± 100
GU-2536	similar to *Pistacia*	Fireplace 1242	3/4	4170 ± 80

GU-2966	*Pistacia*	Fireplace 849	4	5620 ± 60
GU-2155	charcoal	Unit 240, contam by B 3 found tr 392	4	4250 ± 170
GU-2158	*Pinus*	Stakescape 821	4	4220 ± 75
OxA-2960	*Gramineae*	Building 834, Fill 1138	4	4220 ± 70
BM-2279R	charcoal	Building 3, Fill 52	4	4180 ± 130
BM-2529	*Morus*	Building 3, Timber 461	4	4160 ± 50
BM-2527	*Morus*	Building 493, Fill 478	4	4130 ± 50
GU-2535	*Pistacia / Pinus*	Pit 1284	4	4070 ± 130
BM-2530	*Morus*	Building 3, Fill 384	4	3960 ± 80
GU-2157	*Morus*	Building 3, Fill 384	4	3900 ± 50
GU-2167	*Morus*	Pit 916	5	3990 ± 50

In order to offer a complete and updated description of the chronological framework provided by ^{14}C dating, all the radiocarbon determinations from Kissonerga *Mosphilia* have been re-evaluated within the context of this study. Specifically, the unique Period 1A date (AA-10495) has been re-calibrated individually while the radiocarbon data from the consecutive Periods 2-5 have been treated through Bayesian analysis. Because of their uncertain stratigraphic allocation, samples AA-10496, GU-2537 and GU-2536 were excluded from the Bayesian model as well as sample GU-2167 which originates from a plough damaged context (Peltenburg *et al.* 2013: 324). The remaining 26 dates were arranged into a Bayesian model taking their stratigraphic succession into account and allowing the formation of a chronological sequence of four contiguous phases: Period 2, Period 3A, Period 3B and Period 4. Period 5 was excluded from the sequence as the only radiocarbon determination referring to this phase, sample GU-2167, had been rejected.

The 26 radiocarbon data were first evaluated through a General Outlier Model (Bronk Ramsey 2009b) so as to target probable and/or definite outliers. The statistical analysis resulted in the identification of two definite outliers (samples GU-2967 and GU-2966) and five probable outliers (samples GU-3397, AA-10496, GU-2526, GU-2426 and GU-2157) which are almost the same as in Manning (2014). These samples were rejected and the model was run again with a unique modification: the two dates originating from the same context Pit 1015, namely, samples OxA-2162 and OxA-2161, were combined using the function “R_Combine” in OxCal program. Towards this purpose, it should be noticed that, in treating the two dates from Pit 1015, Peltenburg *et al.* (2013, Fig. 9.3: 323) made a mistake and erroneously combined samples OxA-2962 and OxA-2161 instead of OxA-2162 and OxA-2161.

The results of the final model are shown in Figure 5.8 while the overall calibrated dates are reported in Table 5.8. The agreement index A_{MODEL} is 78.7% meaning that there is good consistency between the radiocarbon data and the stratigraphic constraints.

Figure 5.8 Modelled calibrated dates from Kissonerga *Mosphilia* arranged in a chronological graph. OxCal 4.2.4 was used, with IntCal13 as the reference calibration curve. The grey distributions represent the non-modelled calibrations while the solid distributions show the results after Bayesian modelling. The bars beneath the distributions indicate the 68% and 95% probability ranges obtained from the analysis.

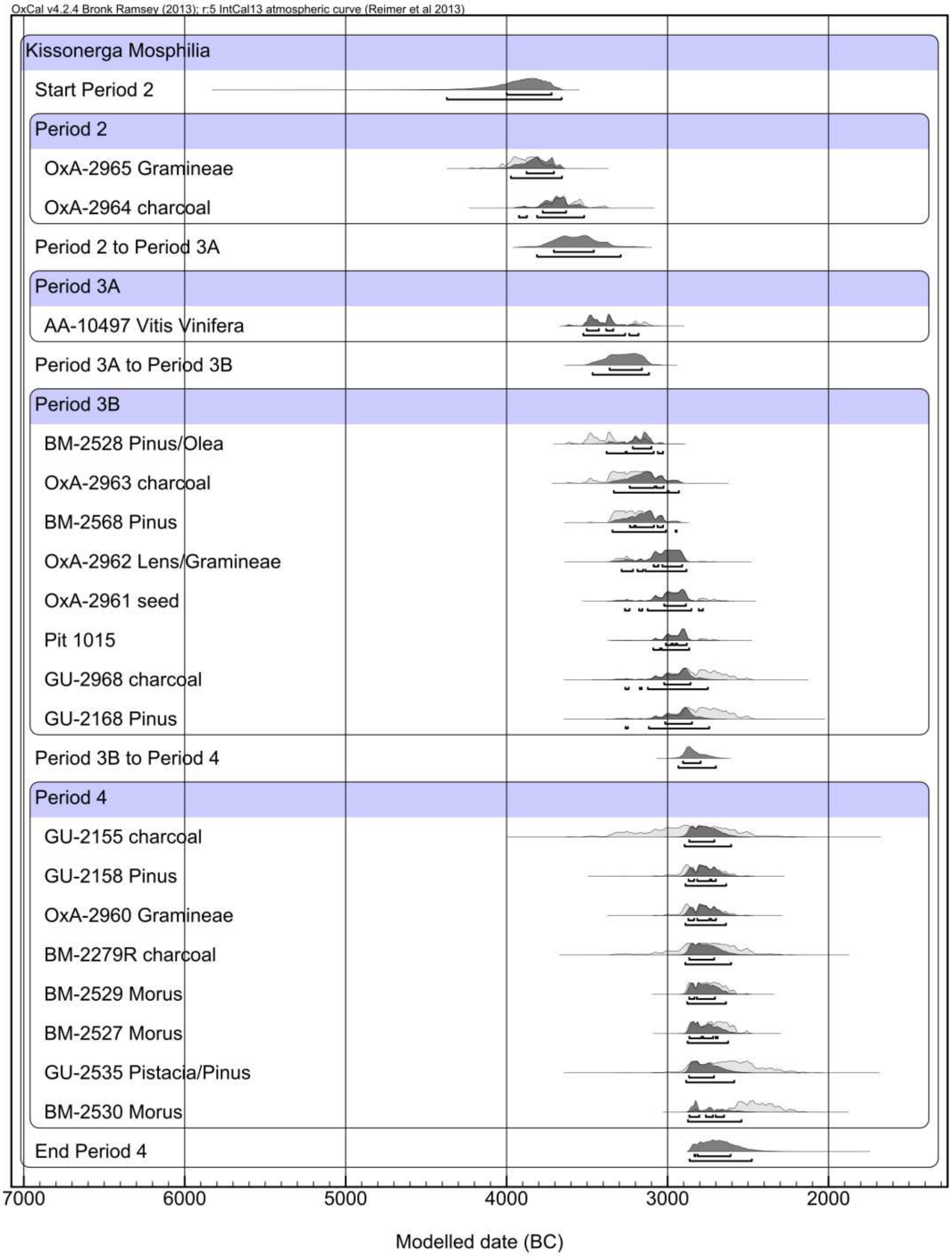


Table 5.8 Calibrated dates from Kissonerga *Mosphilia* calibrated using OxCal 4.2.4 and IntCal13 as the reference calibration curve.

Kissonerga *Mosphilia* Period 1A	**Calibrated dates (BC) 68% level of probability**	**Calibrated dates (BC) 95% level of probability**
AA-10495	6220-6060	6240-6010
Kissonerga *Mosphilia* Periods 2-4	**Modelled dates (BC) 68% level of probability**	**Modelled dates (BC) 95% level of probability**
Start Period 2	4000-3720	4380-3650
Period 2		
OxA-2965 *Gramineae*	3880-3700	3980-3650
OxA-2964 charcoal	3780-3630	3930-3510
Period 2 to Period 3A	3710-3450	3820-3290
Period 3A		
AA-10497 *Vitis Vinifera*	3510-3330	3530-3180
Period 3A to Period 3B	3370-3150	3470-3110
Period 3B		
BM-2528 *Pinus/Olea*	3220-3100	3380-3020
OxA-2963 charcoal	3240-3020	3350-2940
BM-2568 *Pinus*	3240-3020	3350-2940
OxA-2962 *Lens/Gramineae*	3090-2900	3290-2880
OxA-2961 seed	3030-2880	3270-2780
Pit 1015	3020-2880	3090-2860
GU-2968 charcoal	3030-2850	3270-2750
GU-2168 *Pinus*	3020-2840	3270-2740
Period 3B to Period 4	2910-2790	2940-2700
Period 4		
GU-2155 charcoal	2870-2700	2900-2600
GU-2158 *Pinus*	2870-2700	2890-2630
OxA-2960 *Gramineae*	2880-2700	2890-2630
BM-2279R charcoal	2870-2710	2890-2600
BM-2529 *Morus*	2870-2700	2880-2630
BM-2527 *Morus*	2870-2680	2880-2620
GU-2535 *Pistacia/Pinus*	2870-2710	2890-2580
BM-2530 *Morus*	2870-2640	2880-2540
End Period 4	2840-2600	2870-2470

As shown in Table 5.8, the single Period 1A date obtained from sample AA-10495 points to a range between 6220-6060 BC (at 68% level of probability) which is consistent with occupation at Kissonerga *Mosphilia* during the Late Aceramic Neolithic (Table 3.1). Concerning the sequence from Period 2 to Period 4, the Bayesian model suggests that occupation during the Chalcolithic started between 4000-3720 BC (Start Period 2 = Start

Early Chalcolithic) and ended between 2840-2600 BC (End Period 4 = End Late Chalcolithic) at 68% confidence level. Broadly speaking, the calibrated ranges confirm occupation during the whole Chalcolithic, that is, from the beginning of the 4^{th} millennium BC to the mid-3^{rd} millennium BC (Table 3.1). Nevertheless, as in previous analyses (Peltenburg *et al.* 2013: 321-324; Manning 2013a, Manning 2014), several issues like the paucity of short-lived samples, the old wood factor and large standard measurement errors limit the accuracy of the results and the calibrated ranges appear rather wide and somewhat biased towards older ages.

b. Site description

The Lemba Archaeological Project exposed a total of 1,358 m^2. The largest excavated areas are the Main Area (1,126 m^2) and the Upper Terrace (132 m^2), followed by three soundings (100 m^2) located in the Upper Terrace and beside the Skotinis stream (Figure 5.7) (Peltenburg *et al.* 1998: 3).

The Upper Terrace displays the earliest *in situ* evidences of occupation at Kissonerga *Mosphilia*, dating back to the Late Aceramic Neolithic (Period 1A). These consist of two main features: a pit (1680), filled with degraded colluvium and fist-sized stones, and a hollow (1667) interpreted as a *havara* quarry and filled with several broken objects, but no pottery. The earliest architectural evidence, dating to the Early Chalcolithic (Period 2), also occurs in the Upper Terrace and corresponds to three curvilinear depressions (Buildings 2178-2180) with a peripheral setting of posts: B 2178 was interpreted as a probable work hollow while the other two as living hollows. Outside of these buildings, several pits were found filled with food processing and cooking equipment (rubbers, pounders, cupped stones, stone bowl fragments) likely indicating that these activities were principally done out-of-doors. Among pits, bell-shaped ones like those surrounding B 2178 were regarded as probable communal fixtures for storing processed crops (Peltenburg *et al.* 1998: 240-260; Knapp 2013: 203-210, 248-250).

The subsequent Middle Chalcolithic (Periods 3A, 3B) is well represented both in the Main Area and in the Upper Terrace and is distinguished by the erection of stone-based structures. In the Main Area, rather poorly built rectilinear buildings constitute the principal evidence for the initial Period 3A. Worth of notice are Building 1016, with its decorative limestone white orthostats, and Ridge Building 1547, interpreted as a pendant-maker's workshop and characterised by formalised internal divisions of space and a redtinted floor. Differently, on the Upper Terrace, Period 3A architectural remains correspond to well-built circular buildings. In particular, successive pairs of large and small structures like Building 1547/1590 and Building 1016/1565 contained hearths and well-demarcated living areas and have been interpreted as the domestic dwellings of high-status individuals. Private storage areas (with large storage jars) were built over earlier, communal storage pits. Living areas were clearly distinguished from storage or work areas, and the production of pottery, pendants and ceramic/stone discs intensified, with increased diversity in most artefact types. During the subsequent Period 3B significant changes took place that point to a remarkable cultural florescence and the development of a centrally organised settlement. During this period, the Upper Terrace was abandoned and the community moved to the Main Area, towards the sea. Settlement expansion is attested by the dramatic increase of roofed space at the site, and in the establishment of separate activity zones, most notably a ceremonial area characterised by distinctive architectural forms and four large structures grouped around it (Buildings 2, 4, 206, 1000). These buildings were built with calcarenite stone and distinguished by unique cement-plastered floors, hearths and radial partition walls that represent the first enclosed spaces within Cypriot structures, designed to separate storage and work activities from the living/sleeping room. The earliest forms of *pithoi* (storage vessels) are also associated to this period. Towards the end of Period 3B, several signs of decline and abandonment were noticed that were interpreted as a possible dissolution of the centralised power and the beginning of a process of fission that led to the abandonment of the high sector for about 200 years (Peltenburg *et al.* 1998: 240-260; Knapp 2013: 203-210, 248-250).

The arrival of new settlers during the Late Chalcolithic (Period 4) is characterised by the erection of smaller structures of circular plan, lacking built spatial partitions, and a significantly different material culture. The initial Phase 4a is marked by a few isolated structures among which the most peculiar is Building 3, named the “Pithos House” and designed as an élite residence whose wealthy occupants possessed control over productive labour. Among the activities presumably taking place in the Pithos House were bulk food and liquid storage, tool storage, food processing, metal working, axe and adze caching, redistribution, working of ornamental artefact and possible olive oil processing. During the subsequent Phase 4b, Building 3 was destructed and other structures were built over and south of it. In the whole area several smaller buildings proliferated and the community apparently reached its maximum extent. The new settlement layout had three distinct zones consisting of small groups of autonomous households. Communal facilities disappear from the archaeological record, ovens are no longer found outside and there is evidence for more cooking indoors (Peltenburg *et al.* 1998: 240-260; Knapp 2013: 203-210, 248-250).

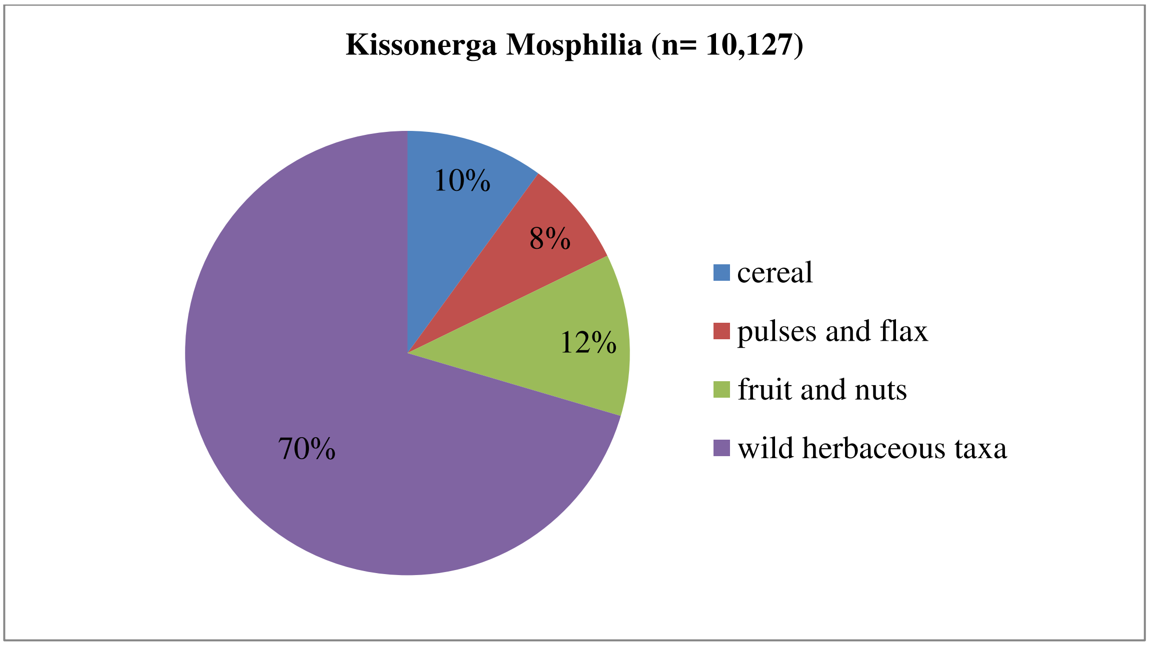
Because of poor preservation, little can be said about the nature of Period 5 occupation, mainly attested by RP (Philia) and BSC pottery, with no upstanding architectural remains. Generally speaking, the transition to the Philia phase has been interpreted as a peaceful transformation, probably involving a group of immigrants (Peltenburg *et al.* 1998: 240-260; Knapp 2013: 203-210, 248-250).

c. *Flora and Fauna*

Palaeobotanical remains

Excavation at Kissonerga *Mosphilia* yielded a considerable quantity of botanical remains mainly consisting of weed seeds (especially wild grasses), fruit and nuts, cereal, pulses and flaxes (Figure 5.9).

Figure 5.9 Identified flora taxa from Kissonerga Mosphilia. Data were extrapolated from Murray (1998b, Table 23.2: 319). The following items have not been included: awns and culms for cereal; *Ficus carica* seeds, *Vitis vinifera* fruit fragments and stems for fruit and nuts; uncharred Boraginaceae and Cyperaceae for the wild herbaceous taxa.



Small quantities of root/tubers (2 items) and dung (5 items) were also recovered. According to Murray (1998a: 216), most items were probably derived from crop processing waste, including cereal chaff, cereal grains and weed seeds. Some of this material was probably used as fuel in domestic fires and successively discarded, as attested by the high density of items per litre and the great range of taxa recovered from pit contexts. The author could not find any correlation between context type and activity areas in terms of archaeobotanical composition, even from obvious features like ovens and hearths. Closely examination of contexts with associated artefacts such as ground stone mortars and querns also brought similar conclusions and it was not possible to associate the botanical remains to particular domestic activities such as pounding or grinding. Among the cereals, barley grains were always more numerous than barley chaff and glume wheat chaff was always more abundant than glume wheat grain. This uniform trend could be explained as a consistent processing of cereals over time but may also derive from the use of barley grain together with cereal processing wastes (including chaff) as animal fodder, and the subsequent use of animal dung as fuel. The palaeobotanical remains indicate a considerable availability of wild plant resources at Kissonerga *Mosphilia* and it is almost certain that wild fruits like fig, grape, olive, pistachio, hackberry, juniper and possibly caper were collected for food. Wild legumes were moderately present in the assemblage but, according to Murray (1998a: 222), the extent to which they may have been used for human consumption is not clear. They undoubtedly represented an important grazing component of the animal diet and the presence of grass peas and vetch hint at the possibility that these taxa could have been grown deliberately for fodder. Similarly, among the wild/weed species, some taxa may have been grazed by livestock (arriving on site in animal dung used as fuel) or collected deliberately for food or other uses, even though most of them resemble a typical Eastern Mediterranean assemblage of crop weeds.

In an isotopic perspective, the botanical remains from Kissonerga *Mosphilia* are dominated by C_3 plants. Among the wild/weed species reported by Murray (1998b, Table 23.2: 319), 20.3% and 7.6% belong to the Cyperaceae and Chenopodiaceae families, respectively, which are known for having several C_4 members (see for example Pyankov *et al.* 2010). However, only two seeds (0.3%) recognised as *Suaeda cf. fruticosa* (Chenopodiaceae family) can be clearly designated as C_4 (Elmore & Paul 1983, Table 1) and almost half of the seeds of the Cyperaceae family have been identified as *Schoenus nigricans* which is not C_4.

Faunal remains

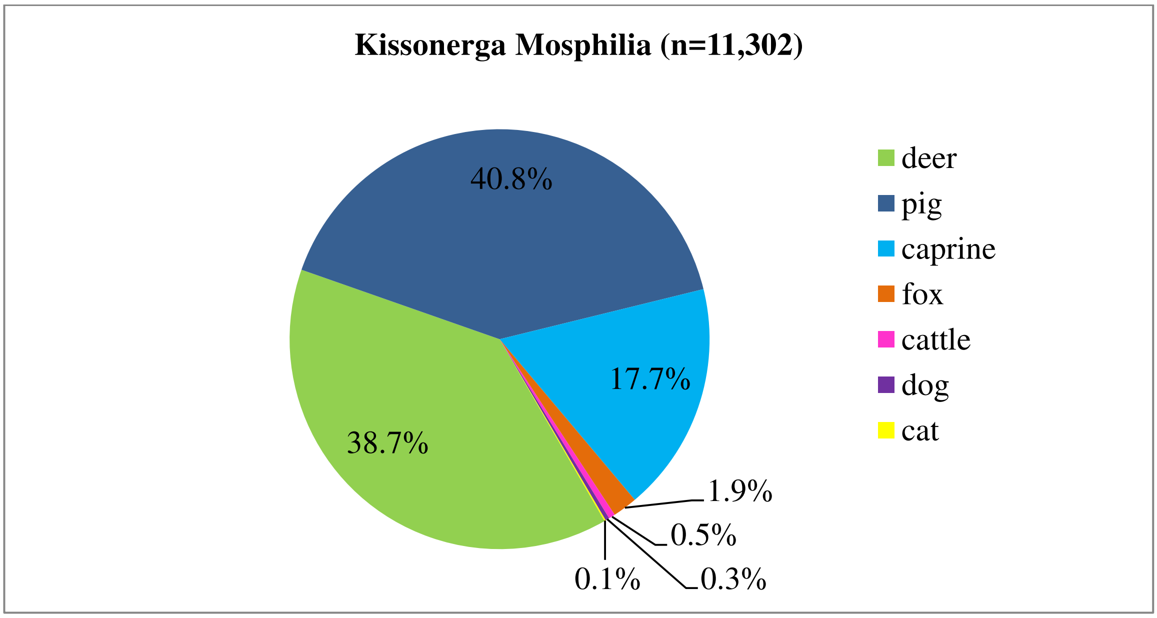
A total of 11,302 fragments of mammalian bone (excluding mice and shrews) were retrieved at Kissonerga *Mosphilia* (Croft 1998). As shown in Figure 5.10, the majority of the faunal remains were identified as fallow deer (*Dama mesopotamica*), pig and caprine (total of 97.2%), followed by fox (1.9%), cattle (0.5%), dog and cat (together accounting for 0.4%). Moderate quantities of bird remains (107 fragments) were also recovered many of which (48 fragments) were identified and attributed to various species of pigeon (e.g. *Columba palumbus*, *Columba livia* and *Streptopelia turtur*), ducks (e.g. *Anas platyrynchos*), song thrush (*Turdus philomelos*), quail (*Coturnix coturnix*), coot (*Fulica atra*) and jay (*Garrulus glandarius*). An upper molariform tooth of equid from a contaminated context and a semi-fossilized lower first molar tooth of pigmy hippopotamus (clearly brought to the settlement as a fossil) complete the picture.

Despite suggestions that the fallow deer of Early Prehistoric Cyprus were, in some sense, domesticated, in Croft's opinion they were free-living, hunted creatures (Croft 1991). However, the non-domestic status of the deer should not be taken to imply that their exploitation was a random, unstructured affair. On the contrary, culling patterns deduced from the deer remains of Kissonerga *Mosphilia* and other Cypriot sites show very clearly that a system of game management must have existed amongst the human communities as their subsistence depended heavily upon deer over several millennia (Croft 1991, 2002).

As for the other two most attested species, it is assumed that both pig and caprines were domestic animals. Specifically, epiphyseal fusion data of pig bones indicate a high incidence of infant slaughter that suggests human control of pigs for increasing productivity. As for the caprines, epiphyseal fusion data indicate that more than half of these animals survived beyond 2.5-3.5 years of age to be slaughtered as adults. However, because among the caprine postcranial fragments 88% were identified as goat and only 12% as sheep, Croft (1998: 209) hypothesised that the epiphyseal fusion data observed in the caprine assemblage most likely reflect goat mortality patterns. Within this context, the author also observed the presence of a considerable high proportion of adult males among the goat assemblage. These males would have represented a surplus to breeding requirements, suggesting that neither meat nor milk production was of some concern for this community. The possibility that these goats, or at least a proportion of them, were not herded but feral, hunted animals has also been hypothesised.

Finally, the few cattle remains recovered at Kissonerga *Mosphilia* must be related only to occupation during Period 5, that is, during the Philia phase when, as attested at other sites of Cyprus, this animal was reintroduced to the island to become an important component of the Bronze Age animal economy.

Figure 5.10 Identified mammalian bone fragments from Kissonerga *Mosphilia* according to Croft (1998, Table 10.1: 207).



Molluscs and fish

Almost one thousand (999) samples of Mollusca have been examined from excavations at Kissonerga *Mosphilia* (Ridout-Sharpe 1998). Of particular interest is the range of freshwater and brackish water species, which confirm the presence of a permanent water source in the past. Large deposits of molluscan refuse were absent and the remains of food species were thinly spread throughout the site. Among them, limpets (*Patella* spp.) and topshells (*Monodonta* spp.) were quite numerous, amounting to 28.13% and 26.29% of the total, respectively. According to the author, nearly all had been collected in a "fresh" or live condition. The topshells had almost all been smashed, presumably to extract the meat, but the smaller shells were left intact and may have been discarded.

A small assemblage of fish remains was also recovered at Kissonerga *Mosphilia*. These were studied by Irving (1998) who recognised a total of ten taxa, five of which proved identifiable to species level. The most represented species were *Clupidae* (herring family), *Sardina pilchardus* (pilchard or sardine) and *Sparidae* (bream family), all species which can be found close off the shores of Cyprus also at present time. The only taxon within the assemblage which is indicative of a single habitat is the parrot fish *Scarus* sp. which occurs exclusively on coral reefs. According to the author, the range of species and their sizes reveal no specialized fishery practices and the fishing techniques employed may have been with nets, traps or hooks.

d. Human remains

A total of 73 burials stratified within settlement deposits were recovered from periods 3A, 3B, 4 and 5 at Kissonerga *Mosphilia*. The site yielded a mortuary population of 89 individuals (mostly children) and further 107 records of fragmentary human bone were retrieved from general habitation deposits (Lunt *et al.* 1998: 65-92). Unfortunately, it was not possible to include this osteological collection within this research as only the sampling of a small set of faunal samples could be arranged. As a consequence, the description of the human remains from Kissonerga *Mosphilia* is not discussed here in details.

e. Isotopic study

Materials

A total of 7 animal samples (five bone fragments and two teeth) were collected from the faunal assemblage of Kissonerga *Mosphilia* stored at the Paphos Archaeological Museum (Table 5.9).

Table 5.9 Faunal bone samples collected from Kissonerga *Mosphilia*.

SAMPLE NAME	CONTEXT	PHASE/ CHRONOLOGY	SPECIES	ANATOMIC ELEMENT
KM_68CAPR	Main Area Unit 68	Period 4 Late Chalcolithic	caprine	tooth max left M^3
KM_72PIG	Main Area Unit 72	Period 4 Late Chalcolithic	pig	left humerus
KM_101CAPR	Main Area Pit 101	Period 4 Late Chalcolithic	caprine	left tibia
KM_101DEER	Main Area Pit 101	Period 4 Late Chalcolithic	deer	left radius
KM_109FOX	Main Area Unit 109	Period 4 Late Chalcolithic	fox	tooth mand left M_1
KM_127GOAT	Main Area Unit 127	Period 4 Late Chalcolithic	goat	left radius
KM_127DEER	Main Area	Period 4	deer	right tibia

	Pit 127	Late Chalcolithic		

Results

The five animal bone samples were prepared and measured for their carbon and nitrogen isotopic ratios at the DiSTABiF Laboratory of the Seconda Università di Napoli (Caserta, Italy). The two sampled teeth (KM_68CAPR and KM_109FOX) were analysed at the RLAHA – Research Laboratory for Archaeology and the History of Art – of the University of Oxford, where stable isotope analysis was conducted both on the collagen extracted from the tooth dentine (carbon and nitrogen) and on tooth enamel (carbon and oxygen). The overall results are reported in Table 5.10.

Table 5.10 Stable isotope values yielded by the faunal samples. For measurements made on bone collagen, analytic error is 0.1‰ for δ^{13}C and 0.2‰ for δ^{15}N values; for dentine collagen, analytic error is 0.2‰ for both δ^{13}C and δ^{15}N values. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. For measurements made on enamel, analytical precision as indicated by multiple replicates was better than 0.1‰ for both δ^{13}C and δ^{18}O values.

SAMPLE	COLLAGEN YIELD	%C	%N	C/N	δ^{13}C collagen (PDB, ‰)	δ^{15}N collagen (AIR, ‰)	δ^{13}C enamel (PDB, ‰)	δ^{18}O enamel (PDB, ‰)
KM_68CAPR caprine	**3.0%**	**17.2**	**5.8**	**3.4**	**-20.1**	**7.1**	**-8.8**	**-4.6**
KM_72PIG pig	0.4%	2.2	0.4	6	-25.3	n	/	/
KM_101CAPR caprine	0.4%	3.9	0.9	5.2	-23.1	n	/	/
KM_101DEER deer	0.4%	3.7	1.0	4.5	-22.8	n	/	/
KM_109FOX fox	0.3%	41.1	12.6	3.8	-20.5	9.3	**-10.4**	**-4.3**
KM_127GOAT goat	0.5%	3.1	1.1	3.3	-21.9	0.6	/	/
KM_127DEER deer	0.4%	3.3	0.8	4.5	-22.3	n	/	/

Preservation state

Notwithstanding the intact and hard appearance of the skeletal material selected for stable isotope analysis, collagen was quite degraded in all the bone samples, with yields ranging from 0.4% to 0.5%, very low carbon and nitrogen percentages and too high C/N ratios (Table 5.10). Differently, the collagen extracted from tooth dentine seemed better preserved although sample KM_109FOX had do be rejected due to its slightly higher C/N ratio (3.8), possibly indicating contamination by organic carbon.

Faunal Isotope Values

Different studies have shown that, in the case of medium to large-bodied herbivorous mammals, the $\delta^{13}C$ values of collagen and tooth enamel are enriched in ^{13}C by a consistent amount, about +5‰ and +14‰, respectively, relative to the diet (Cerling & Harris 1999; Passey *et al.* 2005). Accordingly, the caprine tooth from Kissonerga M*osphilia* produced collagen and enamel isotope ratios consistent with a diet mainly characterised by C_3 plants. The carbon isotope ratio measured on the fox tooth enamel also indicates the exploitation of a mainly C_3 ecosystem and a prevalent terrestrial-based diet. In addition, the tooth enamel $\delta^{13}C$ of the fox is lower than that of the caprine and reflect the different kind of nutrients characterising the diet of the two animals, respectively an herbivore and a generalist carnivore.

As for the oxygen isotope ratios, both the fox and the caprine exhibit very similar $\delta^{18}O$ values possibly indicating that they were sharing the same environment.

Summary and Discussion

Only faunal remains were analysed from the site of Kissonerga *Mosphilia*. The few samples collected for isotope analysis revealed a bad preservation state and only two molar teeth, respectively of a sheep/goat and a fox, were successfully analysed. In keeping with the archaeobotanical remains retrieved from this site, the isotope results obtained from the two animals indicate the exploitation of a mainly C_3 ecosystem. A $\Delta^{13}C$ spacing of 1.6‰ was observed between the enamel carbon isotope ratios of the caprine and the fox which is consistent with the different trophic level occupied by the two animals and with their different dietary habits. In fact, while sheep and goats are obligate herbivores, the fox is a generalist carnivore that usually preys upon small mammals like birds and reptiles, though occasional scavenging as well as the consumption of various plant matter and invertebrates is also common (Lariviere & Pasitschniak-Arts 1996).

CHAPTER 6

DIET IN THE BRONZE AGE: STUDY OF ARCHAEOLOGICAL SITES

6.1. Introduction

The Early and Middle Bronze Ages represent one of the most formative periods in Cypriot prehistory. Of crucial importance is the appearance on the island of a completely new set of innovations at the transition from the Late Chalcolithic to the Early Bronze Age, that is, during the so called Philia phase (see Chapter 3). Chief among these transformations were the introduction of the cattle-and-plough complex and the expansion of copper metallurgy, both of which played a major role in the subsequent development of the island's economy (Steel 2004: 125). In the realm of subsistence, new technologies and the transformation of arable practices increased productivity and fostered more complex social interactions. The animal economy also dramatically changed and, besides the introduction of cattle, caprines raised in importance at the expenses of fallow deer and pigs. Archaeobotanical evidence indicates that the same array of cultigens were exploited: the staples were cereals like wheat and barley, supplemented by pulses (mainly chickpeas and lentils) and fruit, the latter possibly derived also from orchard husbandry (Steel 2004: 131). In terms of meat consumption, Croft (2003b, 2006) estimated that, both at Marki *Alonia* and Sotira *Kaminoudhia*, cattle and deer would have accounted for the highest supply of total meat, thus exceeding the importance of caprines. At the same time, caution is required when evaluating the relative value of domesticated animals within the subsistence economy and dietary patterns of the period. In fact, we should also consider that – contrary to pigs and deer – cattle, sheep and goat all yielded valuable secondary products like wool, hairs and, in a dietary perspective, milk (the latter possibly associated with specific pottery shapes such as Red polished "milk" and "cream" bowls, Knapp 2013: 304). Besides molluscs, attestation of fish remains are practically absent at the main excavated settlements of the period, although small amounts of freshwater crabs have been recovered at Marki *Alonia* (Croft 2006), Sotira *Kaminoudhia* (Croft 2003b) and Prastio *Mesorotsos* (McCarthy *et al.* 2010). This pattern seems consistent with a subsistence pattern largely based on farming and herding, with aquatic resources playing a minor role (if any) to the economy of the Early and Middle Bronze Ages communities. According to Swiny (1981), settlement location was mainly determined by access to water supply and arable land, a further confirmation of the importance of the arable economy during this period.

In order to improve our knowledge of the dietary habits and of individual patterns of consumption during the Bronze Age in Cyprus, stable isotope analysis has been conducted on skeletal material from six archaeological sites of the period (see Figure 1.1): Marki *Alonia*, Alambra *Mouttes*, Kalavasos village (the Bronze Age cemetery), Lophou *Koulazou*, Erimi *Laonin tou Porakou* and Erimi *Kafkalla*. This chapter is intended to present the comprehensive palaeodietary investigation undertaken at these sites within the frame of this study. Accordingly, the most relevant information on the location, excavation history, chronology as well as palaeobotanical, faunal and anthropological data will be first provided, followed by a detailed account of the isotopic study, including a description of the sampled materials, preservation state and discussion of the faunal and human isotopic data.

6.2. Investigated sites

6.2.1. MARKI-ALONIA and MARKI-DAVARI

The site of Marki is located in central Cyprus, south of the Alykos River, at a distance of about 15 km from the modern town of Nicosia (Figures 1.1 and 3.2). Investigations in the area have revealed the presence of a large Bronze Age complex characterised by a main settlement at the locality of *Alonia*, surrounded by five discrete burial grounds. Among them is the cemetery area of Marki *Davari*, extending on a long narrow spur about 500 m north of the settlement (Figure 6.1).

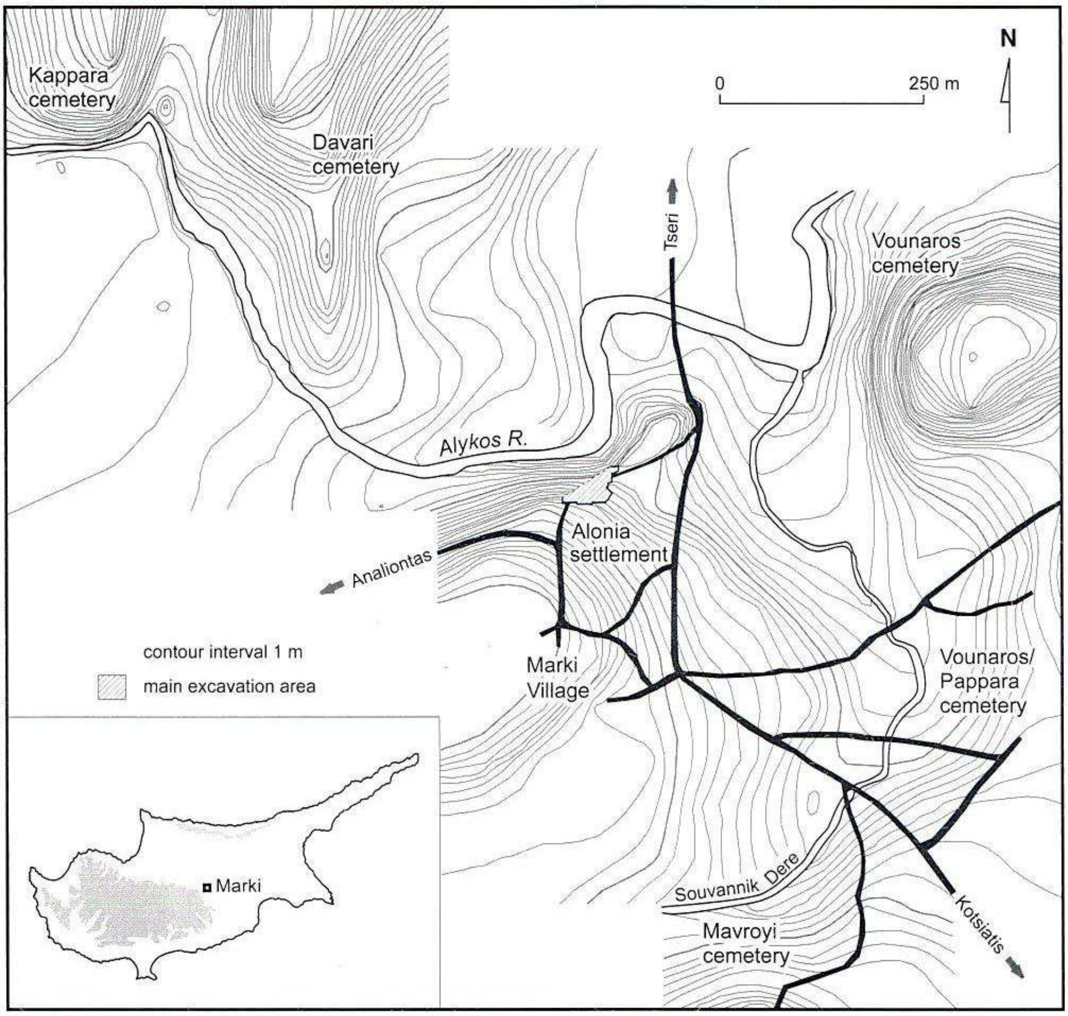
The archaeological potential of this site has been recognised at least since 1940, when the Department of Antiquities of Cyprus was informed of the accidental discovery and looting of tombs that were part of the extensive cemeteries surrounding the settlement

(Karageorghis 1958). Subsequent mentions of Marki can be found in the gazetteer of sites by Catling (1962) and Stanley Price (1979), respectively, who reported the presence of Early and Middle Bronze Age material at *Alonia*.

The cemetery of Marki *Davari* was initially considered by Karageorghis (1958) and Catling (1962: 152, No. 110) to be part of the same necropolis as *Kappara*, while Held (1992: 82-83) later distinguished it as a separate burial area.

From 1990 to 2000, the site was surveyed and excavated by the Australian Cyprus Expedition, under the co-direction of D. Frankel and J.M. Webb of La Trobe University (Frankel & Webb 1996, 2006). Marki *Davari* was first surveyed in 1994 by the Australian Cyprus Expedition (Frankel & Webb 1996: 11-15) while in 1999 a more detailed survey of this cemetery area was carried out by A. Sneddon (2002). Among the tombs that had been identified, only three were excavated by the Australian Cyprus Expedition (Frankel & Webb 2006: 285-286).

Figure 6.1 Site plan and excavated area of Marki *Alonia*. From Frankel & Webb 2006, Fig. 1.1.



a. Chronology

Archaeological evidence at Marki *Alonia* points to a long period of occupation, from the foundation of the village in the earlier stages of the Bronze Age to its abandonment during the Middle Bronze Age. This full, continuous temporal sequence has been divided into nine Phases (A-I), each one assigned to a conventional Cypriot archaeological period on the basis of stratigraphy and associated ceramic. Accordingly, Phases A-B corresponds to the Philia phase, Phases C-D to the Early Cypriot I-II, Phases E-F to the Early Cypriot III, Phases G-H to the Middle Cypriot I, Phase I to the Middle Cypriot II (Frankel & Webb 2006: 35, Table 3.2).

Dating materials

The full material assemblage of Marki *Alonia* consists of 206,996 sherds and other ceramic artefacts, 5.5% of which (corresponding to 16,880 sherds) were considered as diagnostic (Frankel & Webb 2006: 89-154). According to typological and contextual aspects, the ceramic assemblage was subdivided into three main chronological categories: Philia, EC I-II and EC III to MC I-II.

Philia ceramics were mainly recovered from Phases A-B deposits at *Alonia* and also in Tombs 6 and 7 at *Davari*. The most represented wares comprised Red Polished Philia (RPP) and Philia Red Slip (PRS), while only smaller quantities of Red Polished Coarse Philia (RPCP), White Painted Philia (WPP) and Black Slip and Combed (BSC) were recorded. Concerning the EC I-II period, Phases C and D deposits were dominated by Red Polished I-II (RP) wares, including over 900 diagnostics and a small number of almost complete vessels. Minor quantities of Red Polished Coarse ware (RPC) and imported ceramics including early RP and Black Polished (BP), Red Polished South Coast (RPSC) and Brown Polished (BrP) wares were also found. Finally, the ceramic assemblage associated to Phases E-F (EC III) and G-I (MC I-II) was almost exclusively characterised by Red Polished III (RP III), including over 9000 diagnostic materials and 130 complete or near complete vessels. Residual sherds of Philia fabrics, RP I-II and few minor wares complete the assemblage related to this period. In particular, small quantities of Early Red Slip ware (ERS) appeared in EC III and became more common in MC I (Phases G and H); similarly, small amounts of Black Slip ware (BS) were present in Phase G but became more frequent in Phases H and I. Within the red monochrome assemblage, an evolution in the typology of small bowls was also observed: during the EC III, RP I and II bowl types continued in use alongside new RP III types while by MC I these were replaced by bowls with rounded knob-lugs at the rim and bowls with horizontal handles.

Radiocarbon dating

A total of 21 radiocarbon dates of reasonable reliability are available from the site of Marki *Alonia*. All but two dates were obtained from short-lived remains (Table 6.1). Six additional radiocarbon determinations were assumed to be clearly unreliable or unusable and are not considered here (Frankel & Webb 2006: 37, Table 3.3b).

Table 6.1 List of radiocarbon determinations from Marki *Alonia*.

SAMPLE NAME	MATERIAL	CONTEXT	PHASE	RADIOCARBON AGE (years BP)
Beta 138630	1 seed	Unit XCIX-12 context 2554	A	3780 ± 30
Beta 138629	1 seed	Unit XCIX-12 context 2554	A	3780 ± 30
Beta 100553	1 seed	Unit LXV-8 context 1274	B	3810 ± 50
OZA 338	1 seed	Unit C-4 context 1780	C	3770 ± 50
Wk 166434	1 seed	Unit XCIII-8 context 2964	C	3597 ± 39
OZA 344	1 seed	Unit CV-3 context 1931	C	3770 ± 50
OZA 339	1 seed	Unit CII-5 context 1789	D	3720 ± 50
OZA 342	1 seed	Unit CIIA-1 context 1857	D	3700 ± 40
OZA 337	1 seed	Unit C-3 context 1761	D	3670 ± 50
OZA 336	1 seed	Unit C-3 context 1755	D	3650 ± 50
OZA 334	1 seed	Unit C-2 context 1734	E	3550 ± 50
OZB 162	1 wheat seed	Source γ Unit XX-2 context 370	F	3892 ± 39
OZB 161	1 wheat seed	Source γ Unit XX-2 context 370	F	3888 ± 42
OZB 163	1 wheat seed	Source γ Unit XX-2 context 370	F	3834 ± 42
OZA 340	1 seed	Unit CII-3 context 1804	F	3740 ± 40
OZB 160	1 wheat seed	Source γ Unit XX-2 context 336	F	3675 ± 118
OZA 279U	2 wheat seed	Source γ Unit XX-2 context 343	F	3645 ± 95
OZA 345	1 seed	Unit CIII-2 context 1844	H	3730 ± 50
OZB 159	1 wheat seed	Unit LI-2 context 763	H	3764 ± 50
Beta 50747	charcoal	Unit IV-1 context 212	I	3460 ± 90
Beta 50746	charcoal	Unit IV-1 context 212	I	3480 ± 80

This set of radiocarbon data represents the largest series for any single site of the Early to Middle Cypriot in Cyprus and it has proved crucial for the definition of the EC-MC chronology (see for example Manning 2013a, 2014). The complete datelist was first discussed in Frankel & Webb (2006: 35-37). Most recently, Peltenburg *et al.* (2013) have re-considered the 17 dates referring to the third millennium BC, that is, to the period spanning from the Philia phase to the EC III, and Manning (2013b) has re-evaluated the whole dataset focusing in particular on the beginning of the Philia phase.

In this study, the radiocarbon data from Marki *Alonia* have been arranged into a Bayesian chronological model following the periodisation shown in Table 6.1 and grouping the Phases A-F as in Peltenburg *et al.* (2013: 325-327). Phases H and I were also added to the sequence. Because of their unsecure context of provenance, the dates ascribed to Source γ and associated to levelling fill re-deposited in Unit XX were preferably discarded; only the date from sample OZB-160 was included following the assumption that its higher stratigraphic position might have separated it from the rest of secondary or tertiary dumping in Unit XX (Peltenburg *et al.* 2013: 327 and n. 41; Manning 2013b: 6).

The radiocarbon determinations were first evaluated through a General Outlier Model (Bronk Ramsey 2009b) resulting in the identification of two probable outliers: samples Wk 166434 and OZA 334. The model was thus run again omitting the two outliers and combining the two dates from context 2554 in Unit XCIX-12 (samples Beta 138630 and Beta 138629, function R_Combine in OxCal). The final results are summarized in Table 6.2 and shown in Figure 6.2.

The agreement index of the model (A_{MODEL}) is 82% meaning that a good level of consistency between the *a priori* archaeological information and the dating evidence has been obtained.

Table 6.2 Calibrated dates from Marki *Alonia*. OxCal 4.2.4 was used, with IntCal13 as the reference calibration curve.

Marki *Alonia* Sequence	Modelled dates (BC) 68% level of probability	Modelled dates (BC) 95% level of probability
Start Marki Alonia	2290-2150	2330-2140
Phases A-B = Philia		
Context 2554	2270-2140	2280-2140
Beta 100553	2270-2140	2290-2140
End Phases A-B = Philia	2230-2130	2270-2130
Start Phases C-D = EC I-II	2210-2120	2220-2080
Phases C-D		
OZA 338	2200-2110	2200-2080
OZA 344	2200-2110	2200-2080
OZA 339	2200-2110	2200-2080
OZA 342	2200-2110	2200-2080

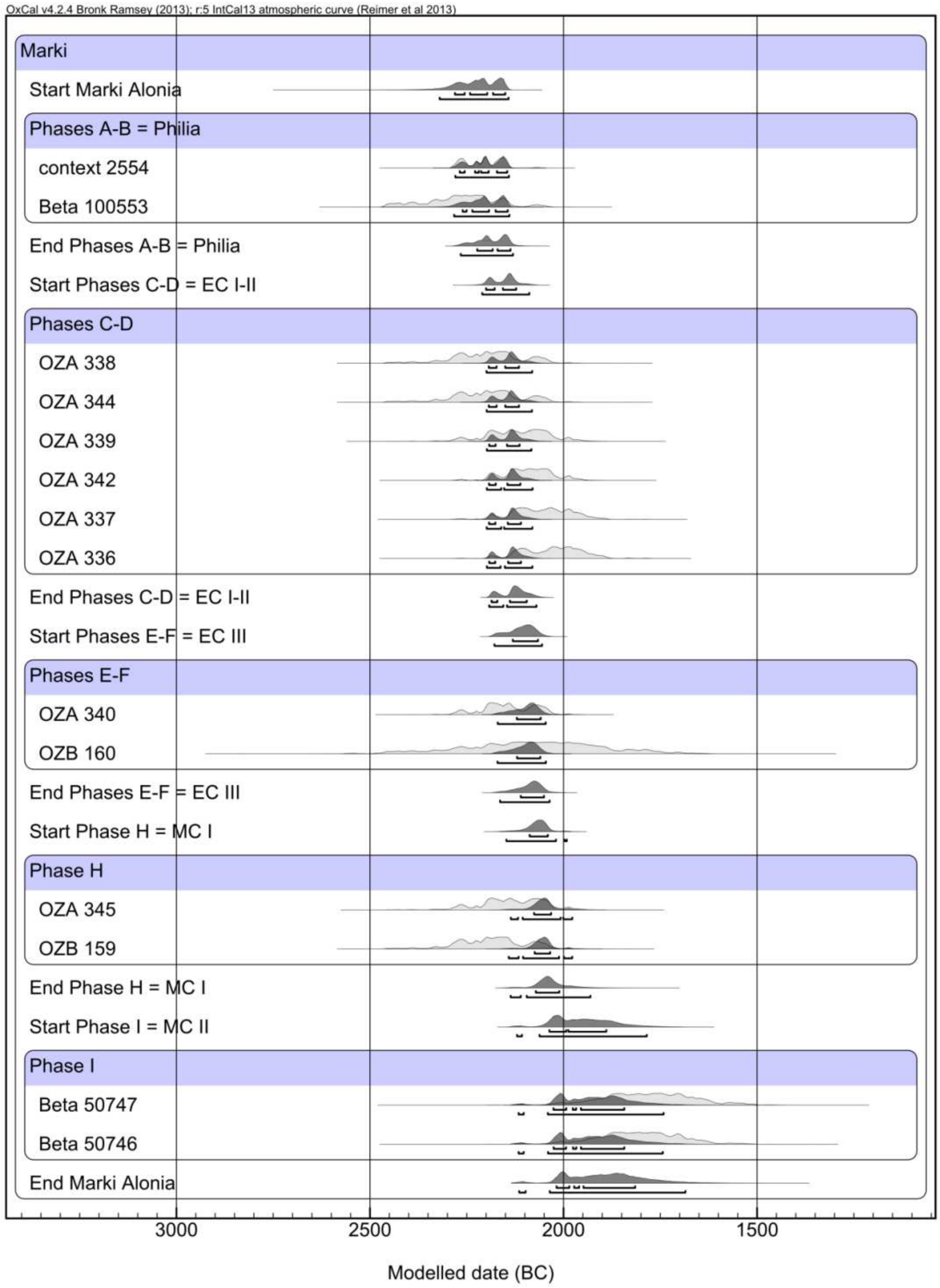
OZA 337	2200-2110	2200-2080
OZA 336	2200-2110	2200-2080
End Phases C-D = EC I-II	2190-2090	2200-2070
Start Phases E-F = EC III	2140-2060	2180-2050
Phases E-F		
OZA 340	2130-2050	2180-2040
OZB 160	2130-2060	2180-2040
End Phases E-F = EC III	2120-2050	2170-2030
Start Phase H = MC I	2090-2040	2150-1990
Phase H		
OZA 345	2080-2030	2140-1970
OZB 159	2080-2030	2150-1970
End Phase H = MC I	2080-2010	2140-1930
Start Phase I = MC II	2040-1890	2130-1780
Phase I		
Beta 50747	2030-1840	2120-1740
Beta 50746	2030-1840	2120-1740
End Marki Alonia	2020-1810	2120-1680

As shown in Table 6.2, the Bayesian model suggests that the settlement of Marki *Alonia* was occupied from 2290-2150 BC to 2020-1810 BC (at 68% level of probability). In terms of equivalent Cypriot chronology, this temporal span corresponds to the period from the Philia phase to the MC I-II (Table 3.1) and it is thus in good agreement with the ceramic chronology described above. Nevertheless, within this temporal sequence, the calibrated ranges associated to the start and end boundaries of consecutive phases generally overlap. As noted by Frankel & Webb (2006: 35), this lack of chronological precision can be related to a series of intrinsic and extrinsic factors including the paucity of organic remains, the integrity of the samples, their timing of deposition and subsequent taphonomic processes, along with the peculiar structure of the calibration curve and the relatively fine-scale chronology of the Bronze Age in Cyprus.

For the sake of completeness, we also report the attempt made within this research to radiocarbon date three bone samples taken from the skeletal remains recovered in Tombs 5-7 of Marki *Davari*. These are actually the same samples utilised also for palaeodiet reconstruction, named MD_T5, MD_T6 and MD_T7 (Table 6.5).

The three bone samples were prepared at the INFN-LABEC Laboratory of the University of Florence following the methodology described in Scirè Calabrisotto *et al.* 2013. Unfortunately, as in the case of stable isotope analysis, almost no collagen was recovered after the pre-treatment procedure thus preventing the acquisition of radiocarbon data from this burial area.

Figure 6.2 Modelled calibrated dates from Marki *Alonia* arranged in a chronological graph. The grey distributions represent the non-modelled calibrations while the solid distributions show the results after Bayesian modelling. The bars beneath the distributions indicate the 68% and 95% probability ranges obtained from the analysis.



b. Site description

Marki *Alonia*

From 1990 to 2000, The Australian Cyprus Expedition cleared an area of about 2000 m^2, the largest of any EC-MC settlement in Cyprus. The site is characterised by 33 architectural compounds varying through time in use, size and structure (Frankel & Webb 2006: 30, 37-41, 305-319). These architectural complexes usually consisted of two or three roofed interior rooms and an associated walled courtyard, although also single room units and compounds with no courtyard were also attested. Concerning materials and techniques, walls consisted of several courses of stone and an upper section realized in mudbricks; the roofs were probably flat, with wooden beams to support layers of matting and packed earth. Floors were not formally constructed and were made up of mud or clay.

The evolution of the settlement of Marki *Alonia* throughout the nine phases of occupation is evidenced in the development of the built-up area and in the continuous process of renovation and/or reorganisation characterising the various compounds (Frankel & Webb 2006: 37-41, 308-319). The initial phase of the settlement (Phases A-B) comprised a small cluster of compounds located in the north-western sector of the exposed area. Among them, Compounds 3 and 4 have been interpreted as two mutually dependent residential units sharing a common courtyard where different kind of activities were accomplished. Courtyards appear to have been defined by light fences, animal pens or similar informal demarcations.

During the subsequent Phases C-F, the settlement expanded to the east and south with increasing building activities in this sector of the site. The communal character of the earlier compounds was replaced by new independent and more spatially segregated households, with access through narrow entrances or internal passage ways. In Phase C, courtyards were partially enclosed by substantial stone walls and by Phase E they were fully enclosed. In some circumstances, earlier structures were renovated and replaced by individual compounds, as in the case of Compounds 3 and 4 which were replaced by two equally-sized, non-communicating households, Compounds 6 and 7. This new arrangement of the architectural space has been interpreted as an increased emphasis on private property, probably related to intergenerational inheritance and the control and manipulation of space.

During Phase G, the centre of the settlement gradually moved towards south-east: new compounds were built, but others were reduced in size or abandoned. By Phase H the density of occupation was significantly lower in this part of the settlement and by Phase I only three compounds were still utilized, suggesting a gradual decline of the village prior to final abandonment.

Domestic technologies

During Philia phases A and B several production-related activities appear to have taken place in the courtyards. A set of facilities and associated artefacts like chipped stone, bone, antler and shells were recovered in the communal yard of Compounds 3 and 4, suggesting that this space was used as a common work place with shared resources. Worth of notice is the presence of a large bread oven, likely utilised for large-scale production, and a freestanding, dedicated storeroom where cereals were stored both above and below ground, in *pithoi* and clay-lined pits. This room produced also vat-like vessels with basal holes which have been linked to processing activities perhaps involving olives, wine or cheese production.

During the subsequent EC-MC period, the number and variety of activities carried out in courtyards decreased through time, and from Phase C onward installations like ovens were only found in interior rooms. Inner spaces, especially those furnished with a hearth, produced the great majority of complete or near complete artefacts, suggesting that a wide range of tasks were carried out indoor, while other interior rooms were probably destined to storing and sleeping. In particular, the interpretation of the different sets of discarded artefacts and associated facilities and structures attest to household-level activities like cereal processing, spinning and weaving, chipped and ground stone tool production, along with the preparation, serving and consumption of food. At this time, staples were either stored above ground in fully enclosed courtyards or in storing bins in interior rooms.

Marki *Davari*

In spite of over 60 years of extensive looting, the abundant scatters of pottery surrounding the exposed tombs of Marki *Davari* has allowed the estimation of the major period of use of this cemetery area, that is, during the Early-Middle Cypriot. *Davari* is a limestone ridge almost 200 m long and 150 m wide, lying about 500 m north of the settlement of Marki *Alonia*. At least 324 tombs were identified and over 12,500 sherds were collected, of which 1,500 pieces were recognised as diagnostic (Sneddon 2002).

The Australian Cyprus Expedition excavated three tombs: Tombs 5 and 6 dated to the Philia phase and the EC-MC Tomb 7 (Frankel & Webb 2006: 285-286). Tomb 5 is a roughly circular chamber tomb (about 2.8 m in diameter) carved into the sloping limestone of the central ridge of *Davari*. It is characterised by a relatively shallow entrance located about 1.4 m above the floor of the chamber and an oval or rectilinear *stomion* originally closed with a large limestone block. Tombs 6 and 7 are shallow, roughly circular pit tombs (about 2.5 m in dimeter) located on the northern fringe of the cemetery.

c. Flora and Fauna

Palaeobotanical remains

A total of 235 litres of soil collected from 52 contexts were processed during the 1991-1993 excavation seasons at Marki *Alonia* (Adams & Simmons 1996). The botanical remains recovered at this site were preserved both in charred and mineralized form. Recognised species of economic importance include *Hordeum* (barley) and *Triticum dicoccum* (emmer wheat) for cereals, *Cicer* (chick pea), *Lens* (lentil), *Vicia* and *Lathyrus* species (peas) for legumes, *Ficus* (fig), *Prunus dulcis* (almond), *Pistacia* sp. (pistachio), *Olea* (olive) and *Vitis vinifera* (grape) for fruits and nuts. A wide range of weed species commonly found in association with cultivated plants was also found: *Asphodelus* sp. (asphodelus), Boraginaceae, numerous mineralised seeds of *Buglossoides arvensis* (gromwell), *Centaurea* spp. (thistle), Chenopodiaceae (goosefoot), Compositae (thistle, daisies), *Cyperus* sp. (nutgrass), *Galium* sp (bedstraw), Gramineae (grass), *Heliotropium* sp. (heliotrope), *Malva* sp. (mallow), *Medicago* sp. (medic), *Oxalis* sp. (soursob), *Picris* sp. (ox tongue), *Polygonum* sp. (knotweed) and *Solanum* sp. (nightshade). The precise number of identified taxa has not been reported for all species but it is generally very low (1-3 seeds) for cereals and pulses while it amounts to several seeds for the wild herbaceous taxa (Adams & Simmons 1996, Table 9.13: 322).

Faunal remains

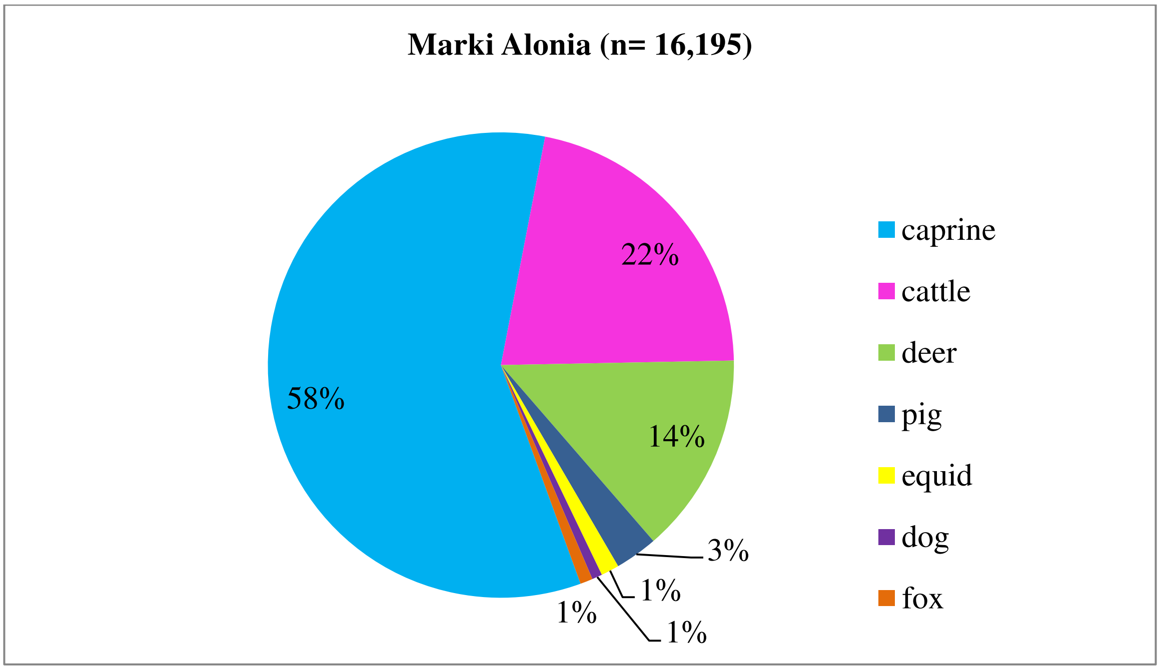
A total of 17,696 fragments pertaining to the larger mammals were identified at Marki *Alonia* (Croft 2006). Remarkably, the distribution of the faunal remains covers the entire span of occupation of the settlement, from the Philia phase throughout the Early and Middle Cypriot. The amount of identified fragments for each period is more or less similar, ranging from 2,546 pieces in the EC III to 5,381 in the Philia phase; only the small MC II sample represents an exception with its 297 identified pieces (Table 6.3).

Table 6.3 Number of identifiable pieces of larger mammals for each period. Data from Croft (2006, Table 9.1: 263).

Period	PHILIA	EC I-II	EC III	MC I	MC II	TOTAL
TOTAL	5381	3561	2546	4410	297	16,195

Generally speaking, the relative frequencies of identified animal bones associated to each species appear stable throughout the whole sequence of occupation: sheep and goat remains are invariably the most numerous, followed by cattle and fallow deer. Smaller percentages of pig, equid (most likely donkey) and fox are also constantly present in the bone assemblage of each period and dog remains are absent only in the small MC II sample. Cat remains are rare and occur only sporadically. The overall estimation of the proportions of larger mammalian bones recovered at Marki *Alonia* is represented in Figure 6.3. Additionally, small amounts of avian, micromammalian, amphibian and reptilian bones were found.

Figure 6.3 Identified mammalian bone fragments from Marki *Alonia*. Material that could not be attributed to a chronological period has been excluded. Data from Croft (2006, Table 9.1: 263).



According to Croft (2006), the animal economy of Marki *Alonia* was characterised by a high degree of underlying conformity, although some trends are apparent in the data which could indicate some kind of evolution in the ways animals were exploited through time.

Between Philia times and MC I, caprine remains always heavily outnumber those of the other animals accounting for 57 to 61% of the identified bone fragments. At the genus level, sheep and goats were probably present in roughly balanced proportions, although a gradual decrease in the frequency of sheep compared with goat might be hypothesised. Throughout the same period, equid and, possibly, cattle appear to have declined somewhat, from 2% to less than 1% and from 24% to 19%, respectively. Conversely, the relative frequencies of the remains of deer and pig seem distinctly to have increased through time, from 9% to 16% and from 1% to 4%, respectively. During MC I, a decline in the relative frequency of caprines (54%) seems apparent, whilst deer (19%) and pig (5%) continued to increase, reaching their highest ever levels at this time.

The above described faunal data clearly attest to the crucial importance of sheep and goats at Marki *Alonia*. Nevertheless, the numerical predominance of caprine remains in the bone assemblage should not be overestimated. Indeed, caprines are small animals and typically yield far less meat per head than larger mammals like cattle and deer (Croft 2006: 265). In fact, the evaluation of data derived from the weights of identified fragments point to a far less caprine orientated economy in favour of the more productive cattle. These estimates indicate that during the Philia phase as much as two third of all meat consumed at Marki *Alonia* would have been beef, while in subsequent periods the proportion was slightly lower but always over half. From the weight perspective, deer remains also appear more prominent in the assemblage: the representation of deer gradually increased from Philia and EC times, and came to exceed that of the caprines during the MC period.

Despite these differences, both the methodological approaches described above suggest similar patterns of exploitation through time, namely, a decline in the significance of cattle and equid and an increase in the importance of deer and pig.

As far as herding practices are concerned, the following data where obtained by Croft (2006). The overall evaluation of fusion- and dental-based patterns of mortality for caprines suggests that the majority of sheep and goats died by approximately two years of age. Survivorship curves obtained from mortality data of caprine teeth point to an exploitation oriented towards meat production. Secondary products like milk and wool were probably considered valuable goods but they appear not to have been the focus of caprine exploitation. Patterns of mortality for cattle, as deduced from epiphyseal fusion, indicate that they usually lived until 2 to 4 years of age. Besides producing considerable amounts of meat and milk, cattle were likely used for traction and transport. The overall evidence obtained by combining all of the available fusion data of deer suggests that only a small minority of these animals were killed as infants whilst most deer reached adulthood. This pattern might appear in contrast with the exploitation of deer for meat production, although the possibility that young males were allowed to live longer for the purpose of collecting antlers should also be considered. In fact, this secondary product was recovered in great quantities at Marki *Alonia* suggesting that its acquisition was a matter of considerable significance to the inhabitants of the village. Finally, epiphyseal data obtained from the less abundant pig remains indicate that most pigs were killed prior to adulthood, around 3-3.5 years of age. However, Croft (2006: 274) noted that this figure is probably distorted by the fact that unfused bones of immature pigs are very fragile and thus hardly found on excavations. According to the author, heavy culling of young pigs was the most probable herding strategy adopted at Marki *Alonia*, as that would have increased meat production.

Molluscs and fish

A rather small assemblage of marine and freshwater invertebrates was recovered at Marki *Alonia* (Reese & Webb 2006). Among the 74 marine shells, the following edible species were recognised: *Charonia* (trumpet or triton shell), *Patella* (limpet), *Murex* (murex), *Cerastoderma* (cockle) and *Eriphia verrucosa* (crab). It is possible that these marine invertebrates could have been eaten at the site but the overall assemblage of marine shells point to collection for ornamental purposes. Concerning freshwater remains, a total of 14 *Potamon* crabs and two *Melanopsis praemorsa* gastropods were recovered. Freshwater crab remains are regularly present on ancient settlements in Cyprus and, according to Croft (2006: 275) they were undoubtedly eaten.

As far as fish remains are concerned, a unique bone of a substantial marine fish was recovered from a MC I context (Croft 2006: 275), attesting, along with the above mentioned marine invertebrates, regular contacts with the coastal area.

d. Human remains

Although burial in pit or chamber tombs in cemeteries set some distance from the settlements was the norm during the Early and Middle Bronze Age, six cases of intra-mural burial were reported at Marki *Alonia*, particularly in the later phases of occupation. As for the identified *extra moenia* cemeteries, all the three tombs excavated at the nearby cemetery of Marki *Davari* yielded a small amount of human remains (Frankel & Webb 2006: 285-286).

As far as intra-mural burials are concerned, the remains of eight individuals, corresponding to two adults, one adolescent and five juveniles were recovered. Specifically, four individuals were identified among the remains collected from LVII-1, contexts 963 and 1015; these include one middle adult female approximately 30 years at death and three juveniles whose deaths occurred in the range of 5.5 to 8 years of age (Moyer 2006: 286-290). Units XIII-3 and XCVIII-3 (context 1910 and 1879) yielded the almost complete skeleton of a female individual aged 21-33 years and the relatively complete body of a late adolescent/young adult, respectively (Fox 2006: 290-291). Finally, a subadult individual between 2 and 3 years old was recovered in Unit XCIX-12, context 2482, and the incomplete remains of a single immature individual between 7 and 8 years old were found in Unit XCIX-6, contexts 2397 and 2326 (Lorentz 2006: 293-296).

Between 1991 and 2000, various contexts yielded further fragmentary human skeletal remains assumed to come from secondary or tertiary depositional contexts. At least eleven (possibly fifteen) individuals are represented among this fragmentary and incomplete assemblage which probably includes an adult male, three adults of unknown sex, an adolescent/young adult male, an adolescent/young adult of unknown sex, a 2 to 10 years subadult of unknown sex, a subadult of unknown sex, a foetus close to term, a child possibly between 5 to 8 years old and a slightly older subadult (Fox 2006: 291-293, Lorentz 2006: 296-297).

Concerning the human remains recovered from Tombs 5-7 at Marki *Davari*, only the skeletal assemblage from Tomb 7 has been published (Lorentz 2006: 297). This material was extremely fragmented and incomplete thus severely limiting the anthropological analysis. Personal examination of the skeletal remains from Tombs 5 and 6 revealed a similar condition, with the remains from Tomb 5 being somewhat better preserved, although fragmentary.

Health status

The most complete burials yielded the remains of eight individuals, corresponding to two adults, one adolescent and five juveniles. None of the preserved skeletal elements pertaining to this small population displayed lesions indicative of osseous pathology. As far as dentition is concerned, the general fragmentary state of the alveoli did not allow to obtain information on periodontal health. However, the recovered teeth were in general good condition and caries is reported only for one primary tooth from burial in Unit LVII-1, context 963. A single instance of enamel hypoplasia was observed on both maxillary central incisors of the subadult in Unit XCIX-6, contexts 2397 and 2326. Cases of severe dental attrition have not been reported. Concerning the pool of commingled fragmentary remains, no pathological lesions were found.

e. Isotopic study

Materials

A total of 29 faunal and 6 human samples were taken from the osteological collection of Marki *Alonia* and Marki *Davari*. Concerning the sampling of the faunal remains, the best preserved elements were mostly found in Philia and Early Cypriot contexts (Table 6.4). As for the human bone assemblage, samples were preferably collected from the most complete intramural burials recovered at Marki *Alonia*. Three additional human samples were also chosen among the skeletal remains recovered at Marki *Davari*, Tombs 5-7 (Table 6.5).

Table 6.4 Faunal samples collected from Marki *Alonia*.

SAMPLE NAME	CONTEXT	PHASE/ CHRONOLOGY	SPECIES	ANATOMIC ELEMENT	NOTES ON COLLOCATION
MARKI_1	unit L context 989	Phase A Philia	dog	left mandible	Tray 189
MA_989CAPR	unit L context 989	Phase A Philia	caprine (goat?)	mand right M_3	Tray 189
MA_989EQ	unit L context 989	Phase A Philia	equid	mand left M_3	Tray 189
MA_989BOS	unit L context 989	Phase A Philia	cattle	max right molar (M^1?)	Tray 189
MARKI_5	unit L context 989	Phase A Philia	caprine	left humerus	Tray 189
MARKI_6	unit L context 989	Phase A Philia	caprine	left tibia	Tray 189
MARKI_7	unit L context 989	Phase A Philia	cattle	left tibia	Tray 189
MARKI_8	unit L context 989	Phase A Philia	equid	radius	Tray 189
MARKI_9	unit L context 989	Phase A Philia	deer	right femur	Tray 189

MA_1466BOS	unit IX context 1466	Phase D EC I-II	cattle	mand right molar M_1	Tray 191
MARKI_11	unit IX context 1466	Phase D EC I-II	cattle	possible radius	Tray 191
MARKI_12	unit IX context 1466	Phase D EC I-II	caprine	right radius	Tray 191
MARKI_13	unit IX context 1466	Phase D EC I-II	deer	left tibia	Tray 191
MARKI_14	unit IX context 1466	Phase D EC I-II	dog	right tibia	Tray 191
MARKI_15	unit IX context 1466	Phase D EC I-II	equid	right femur	Tray 191
MARKI_16	unit IX context 1466	Phase D EC I-II	pig	right humerus	Tray 191
MARKI_17	unit XVI context 605	Phase F EC III	cattle	right humerus	Tray 181
MARKI_18	unit L context 999	Phase A Philia	caprine	tibia	Tray 189
MARKI_19	unit L context 999	Phase A Philia	cattle	humerus	Tray 189
MARKI_20	unit L context 1053	Phase A Philia	dog	left mandible	Tray 184
MA_1534CAPR	unit XIII context 1534	Phase B Philia	caprine	right humerus	Tray 193
MA_1490CAPR	unit X context 1490	Phase E EC III	caprine	right humerus	Tray 195
MA_1490DE	unit X context 1490	Phase E EC III	deer	right mandible	Tray 195
MA_1565EQ	unit XIII context 1565	Phase A Philia	equid	femur (left)	Tray 197
MA_1565CAPRm	unit XIII context 1565	Phase A Philia	caprine	right mandible	Tray 197
MA_1565DE	unit XIII context	Phase A Philia	deer	right radius	Tray 197

	1565				
MA_1565CAPRh	unit XIII context 1565	Phase A Philia	caprine	right humerus	Tray 197
MA_2196CAPR	unit CIII context 2196	Phase A Philia	caprine	left humerus	Tray 209
MA_2418DE	unit XCVII context 2418	Phase A Philia	deer	right humerus	Tray 215

Table 6.5 Human samples collected from Marki *Alonia* and Marki *Davari*.

SAMPLE NAME	CONTEXT/TOMB	PHASE/ CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
MA_1379	XIII-3 context 1379	Phase H MC I	fragment of right femur shaft	F	21-33
MA_1910	XCVIII-3 context 1910	Phase I MC II	fragment of right femur shaft	M	15 ± 3
MA_1879	XCVIII-3 context 1879 associated with Skull in XCVIII-3 context 1910	Phase I MC II	mand right M_3 tooth # 32		
MD_T5	Tomb 5 Marki *Davari*	EC-MC	fragment of femur shaft	Cba	adult
MD_T6	Tomb 6 Marki *Davari*	Philia	long bone fragment	Cba	adult
MD_T7	Tomb 7 Marki *Davari*	Philia	long bone fragment	Cba	adult

Results

All the faunal bone fragments from Marki *Alonia* and the human bone samples from Marki *Davari* were prepared and measured for their carbon and nitrogen isotope ratios at the DiSTABiF laboratory of the Seconda Università di Napoli. All the teeth (faunal and human) and the two human bone samples from Marki *Alonia* were prepared and measured at the RLAHA of the University of Oxford. In the case of animal teeth, stable isotope analysis (C, N, O) were conducted both on the collagen extracted from the dentine and on tooth enamel carbonates, whilst the single human tooth was analysed only for its carbon and oxygen isotope ratios. The overall isotope results obtained from the faunal and human samples are reported in Tables 6.6 and 6.7, respectively.

Table 6.6 Stable isotope values yielded by the faunal samples. For measurements made on collagen, analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values; for dentine collagen, analytic error is 0.2‰ for both $\delta^{13}C$ and $\delta^{15}N$ values. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. For measurements made on enamel, analytical precision as indicated by multiple replicates was better than 0.1‰ for both $\delta^{13}C$ and $\delta^{18}O$ values. Abbreviation n = not measured.

SAMPLE	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ collagen (PDB, ‰)	$\delta^{15}N$ collagen (AIR, ‰)	$\delta^{13}C$ enamel (PDB, ‰)	$\delta^{18}O$ enamel (PDB, ‰)
MARKI_1 dog	1.1%	2.7	1.0	3.1	-20.7	6.1	/	/
MA_989CAPR caprine (goat?)	**1.2%**	**15.6**	**5.3**	**3.4**	**-19.6**	**8.6**	**-10.0**	**-4.6**
MA_989EQ equid	3.9%	2.7	0.8	4.2	-21.6	2.5	-8.6	-3.9
MA_989BOS cattle	**2%**	**21.3**	**7.2**	**3.5**	**-21.0**	**5.8**	**-10.5**	**-6**
MARKI_5 caprine	**1.2%**	**21.1**	**7.7**	**3.2**	**-19.8**	**8.3**	/	/
MARKI_6 caprine	0.4%	1.6	0.3	5.6	-25.4	n	/	/
MARKI_7 cattle	**0.5%**	**13.1**	**4.6**	**3.3**	**-20.7**	**5.6**	/	/
MARKI_8 equid	0.5%	3.4	0.9	4.3	n	n	/	/
MARKI_9 deer	0.4%	1.6	0.6	3.0	-21.9	4.8	/	/
MA_1466BOS cattle	2.5%	2.8	0.8	4	-21.8	5.1	**-7.7**	**-4.6**
MARKI_11 cattle	**0.5%**	**9.4**	**3.2**	**3.4**	**-21.2**	**6.4**	/	/
MARKI_12 caprine	**0.5%**	**44.0**	**15.2**	**3.4**	**-18.4**	**7.7**	/	/
MARKI_13 deer	**0.9%**	**7.9**	**3.2**	**2.9**	**-20.7**	**6.7**	/	/
MARKI_14 dog	**0.5%**	**4.3**	**1.5**	**3.4**	**-20.5**	**7.8**	/	/
MARKI_15 equid	**0.9%**	**31.1**	**11.4**	**3.2**	**-18.2**	**7.7**	/	/
MARKI_16 pig	**0.6%**	**11.1**	**3.6**	**3.5**	**-20.6**	**5.2**	/	/

MARKI_17 cattle	0.5%	1.9	0.4	5.8	n	n	/	/
MARKI_18 caprine	0.2%	2.2	0.6	4.7	n	n	/	/
MARKI_19 cattle	0.3%	2.3	0.0	0	n	n	/	/
MARKI_20 dog	**0.7%**	**11.0**	**4.2**	**3.1**	**-19.8**	**10.1**	/	/
MA_1534CAPR caprine	1%	1.4	0.3	6.7	-22.4	4.1	/	/
MA_1490CAPR caprine	**1.9%**	**26.5**	**9.2**	**3.4**	**-19.2**	**8.2**	/	/
MA_1490DE deer	**2.8%**	**18.5**	**6.3**	**3.4**	**-20.0**	**6.2**	/	/
MA_1565EQ equid	**3.4%**	**30.3**	**10.6**	**3.3**	**-20.6**	**8.5**	/	/
MA_1565CAPRm caprine	**3.4%**	**26.3**	**9.2**	**3.3**	**-18.8**	**7.0**	/	/
MA_1565DE deer	**3.7%**	**34.9**	**12.5**	**3.3**	**-20.7**	**5.7**	/	/
MA_1565CAPRh caprine	**5.5%**	**26.9**	**9.6**	**3.3**	**-19.6**	**5.9**	/	/
MA_2196CAPR caprine	**2.3%**	**21.8**	**7.4**	**3.4**	**-20.9**	**7.3**	/	/
MA_2418DE deer	**2.2%**	**29.7**	**10.2**	**3.4**	**-20.1**	**8.1**	/	/

Table 6.7 Stable isotope values yielded by the human samples. For measurements made on collagen, analytic error is 0.2‰ for both $\delta^{13}C$ and $\delta^{15}N$ values. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. For measurements made on enamel, analytical precision as indicated by multiple replicates was better than 0.1‰ for both $\delta^{13}C$ and $\delta^{18}O$ values. Abbreviation n = not measured.

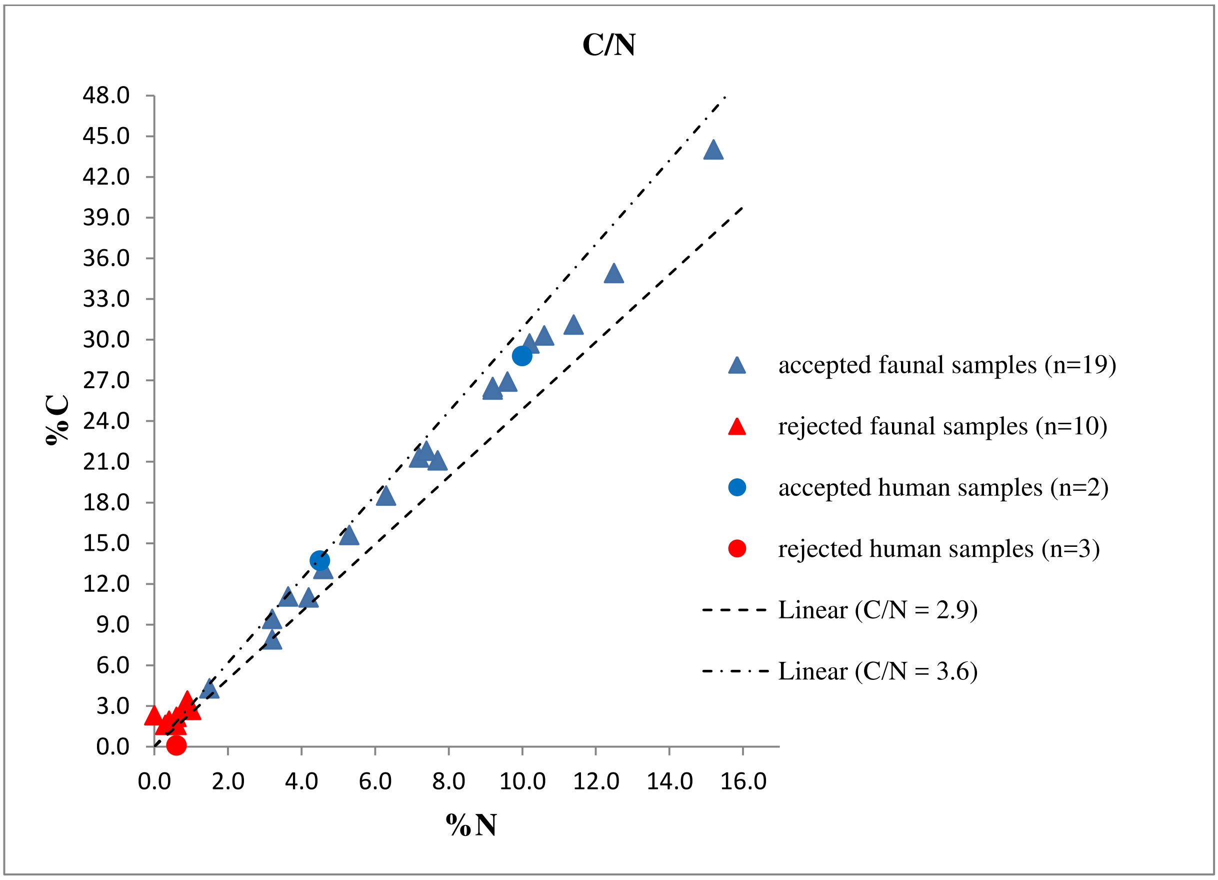
SAMPLE	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ collagen (PDB, ‰)	$\delta^{15}N$ collagen (AIR, ‰)	$\delta^{13}C$ enamel (PDB, ‰)	$\delta^{18}O$ enamel (PDB, ‰)
MA_1379	**2.4%**	**28.8**	**10**	**3.3**	**-19.7**	**11.8**	/	/
MA_1910 and MA_1879	**0.8%**	**13.7**	**4.5**	**3.6**	**-20.7**	**11.9**	**-11.3**	**-6.5**

MD_T5	0.4%	0.1	0.6	0.2	n	n	/	/
MD_T6	0.4%	1.1	0.0	0.0	n	n	/	/
MD_T7	0.4%	1.4	0.0	0.0	n	n	/	/

Preservation state

The preservation state of the faunal remains from Marki *Alonia* was quite variable, probably because of the changing soil conditions of the individual find contexts. Overall, the faunal material was quite well preserved and collagen was recovered in all the animal samples with a mean collagen yield of 1.6% (n=29). Accordingly, %C, %N and C/N ratios were also quite different and ten samples had to be rejected due to their outside values (Figure 6.4).

Figure 6.4 Elementary contents (C, N) in the collagen extracts and the C/N range proposed by DeNiro (1985).



The sampled human remains from Marki *Alonia* were in quite good condition: the skeleton of the adult female (burial in XIII-3, context 1379) was well preserved, with bone integrity intact and recovery of almost all elements; the adolescent skeleton (burial in XCVIII-3, context 1910 and 1879) was less well preserved but almost complete. Collagen was recovered in both the bone samples collected from these two burials with yields of 2.4% and 0.8%, respectively, and acceptable %C, %N and C/N ratios (Figure 6.4). Differently, the human remains from Marki *Davari* showed very poor preservation and no intact collagen was recovered in the three samples taken from Tombs 5-7, as suggested by the anomalous values of %C, %N and C/N ratio.

Faunal Isotope Values

Before proceeding with a description of the faunal data, it seems appropriate to specify that all the isotope values referred to the same animal species have been grouped together regardless of their association to a different phase of the Bronze Age. This decision was taken after considering both the small size of the faunal isotopic dataset and the apparent lack of phase-related discrepancies in the isotope ratios of animals of the same species.

The collagen isotope ratios obtained from the four herbivores (sheep/goat, cattle, deer and equid) range from -21.2‰ to -18.2‰ and seem to indicate a diet principally based on C_3 plants. Within this framework, caprines and cattle, that is, the two most represented livestock within the faunal record, display quite different mean $\delta^{13}C$ and $\delta^{15}N$ values that suggest diversified dietary habits and/or herding practices. In fact, cattle have more negative mean $\delta^{13}C$ and $\delta^{15}N$ ratios of -21.0±0.3‰ and 5.9±0.4‰, respectively, while caprines show higher mean $\delta^{13}C$ and $\delta^{15}N$ ratios of -19.5±0.8‰ and 7.6±0.9‰, respectively (Table 6.8).

Table 6.8 Summary of the $\delta^{13}C$ and $\delta^{15}N$ values yielded by the caprine, cattle and deer samples.

CAPRINE	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C$ (‰)	-19.5	-19.6	0.8	2.5	-20.9	-18.4	7
$\delta^{15}N$ (‰)	7.6	7.7	0.9	2.7	5.9	8.6	7
CATTLE	**Mean**	**Median**	**SD**	**Range**	**Min**	**Max**	**Count**
$\delta^{13}C$ (‰)	-21.0	-21.0	0.3	0.5	-21.2	-20.7	3
$\delta^{15}N$ (‰)	5.9	5.8	0.4	0.8	5.6	6.4	3
DEER	**Mean**	**Median**	**SD**	**Range**	**Min**	**Max**	**Count**

$\delta^{13}C$ (‰)	-20.4	-20.4	0.4	0.7	-20.7	-20.0	4
$\delta^{15}N$ (‰)	6.7	6.5	1.0	2.4	5.7	8.1	4

The more negative and more homogeneous isotope values of cattle may indicate that these animals were living in a restricted environment and were possibly foddered by humans with a more monotonous diet, perhaps involving leafy crops and some legumes. Differently, the more positive and more spread values of sheep and goats suggest that caprines were exploiting larger C_3 biomasses and feeding in more open and drier habitats.

The two equid samples, most likely donkeys, show similar $\delta^{15}N$ values of 7.7‰ and 8.5‰ but quite different $\delta^{13}C$ ratios of -18.2‰ and -20.6‰, respectively (Table 6.6). These results are near to the range of values covered by the caprines and may indicate the exploitation of an analogous wide and arid territory. In this regard, it should be noted that, similarly to sheep and goats, donkeys are water-conserving species and thus are more likely to adapt to dry environments, compared for example to cattle (Smith & Pearson 2005).

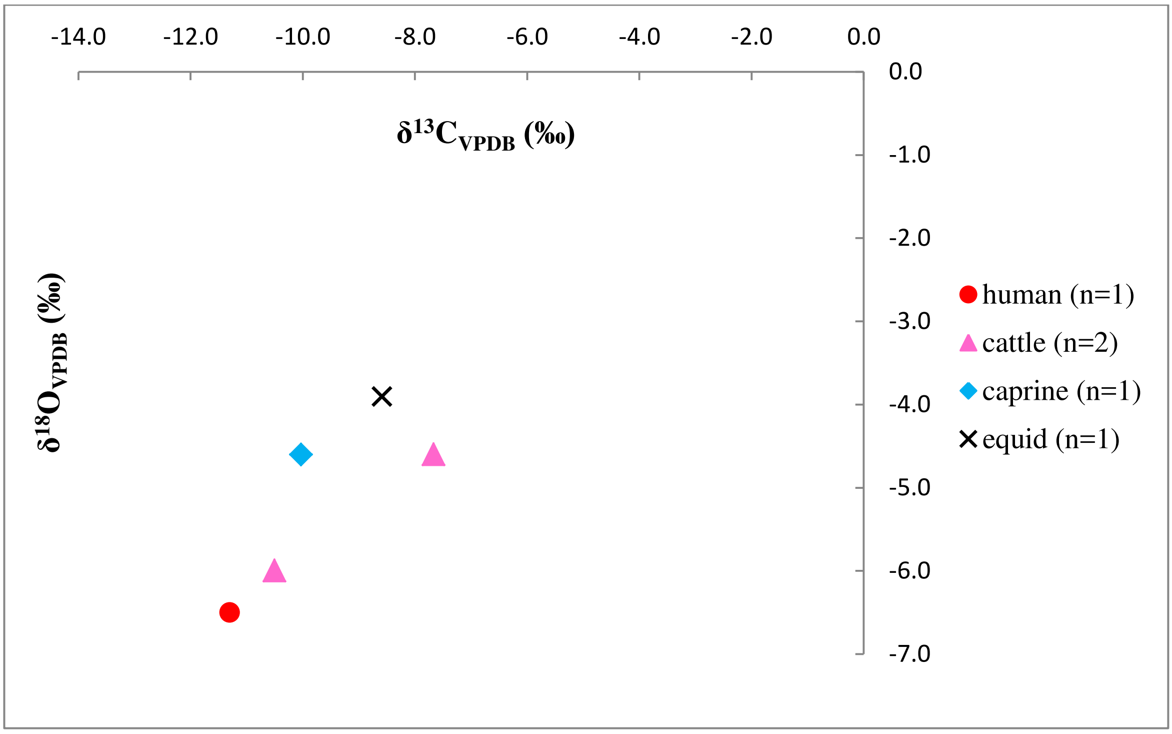
Finally, the fourth group of herbivores is represented by fallow deer (*Dama Mesopotamica*), a wild species intensively hunted throughout the prehistory of Cyprus (Croft 2002). The mean collagen $\delta^{13}C$ and $\delta^{15}N$ values of deer are -20.4±0.4‰ and 6.7±1‰, respectively (Table 6.8). These results appear intermediate between those of cattle and sheep/goat, possibly indicating a higher contribution of browse plants to the diet and the exploitation of more shaded environments like forests.

The remaining analysed animals (one pig and two dogs) also display collagen isotope values consistent with a diet based on C_3 foods. More specifically, the $\delta^{15}N$ value of the pig sample, the lowest within the whole faunal dataset, might indicate a prevalent vegetal diet also rich in legumes. On the other hand, the two dogs have similar $\delta^{13}C$ values but quite different $\delta^{15}N$ ratios that suggest a certain degree of variability in the proportion of animal proteins to their diet.

The few isotopic data obtained from the four animal teeth (samples MA_989CAPR, MA_989EQ, MA_989BOS and MA_1466BOS) seem to further support the evidence gathered from the collagen values. Specifically, the three molars of caprine, equid and cattle originating from context 989 display similar enamel $\delta^{13}C$ values indicating a prevalent consumption of C_3 plants (Table 6.6 and Figure 6.5). In addition, while the cattle show a lower $\delta^{18}O$ of -6‰, the caprine and the equid have more positive $\delta^{18}O$ values of -

4.6‰ and 3.9‰, respectively. Considering that these animals lived during the same period (Philia phase), this discrepancy in the $\delta^{18}O$ values could well reflect the different drinking habits characterising these species. In fact, while cattle require constant access to water, caprines and donkeys are more tolerant to draught conditions.

Figure 6.5 Tooth enamel stable isotope values of faunal samples from Marki *Alonia*.



The fourth animal tooth (sample MA_1466BOS) corresponds to a cattle first molar from an EC I-II context. As shown in Figure 6.5, both the $\delta^{13}C$ and $\delta^{18}O$ values yielded by this animal are more positive with respect to the other cattle (sample MA_989BOS). In this regards, it is possible to hypothesise that this discrepancy in the $\delta^{18}O$ values of the two animals could depend either on climatic changes or on the effect of breastfeeding in the diet of the cattle with the higher $\delta^{18}O$ value (sample MA_1466BOS), as breast milk is more enriched in ^{18}O. In fact, cattle first molars usually form in utero and fully develop by 2-3 months when the calf is still assuming milk (Brown *et al.* 1960).

Human Isotope Values

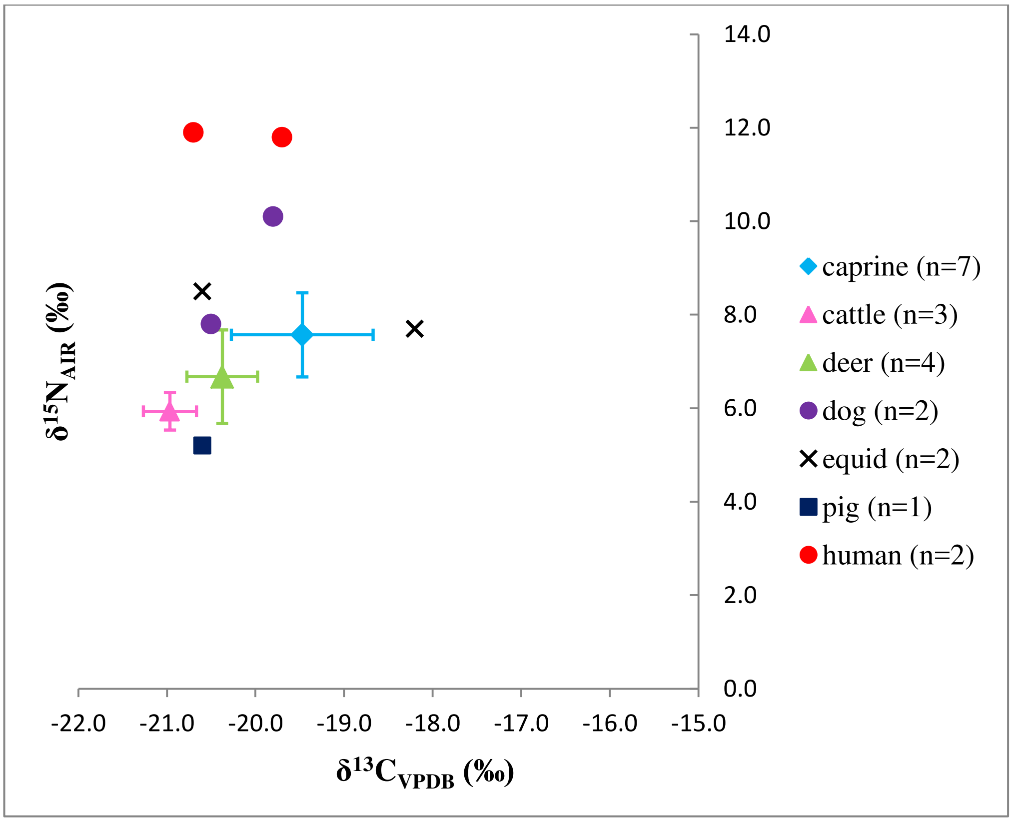
The two human collagen samples show similar $\delta^{13}C$ values of -19.7‰ and -20.7‰, and almost identical $\delta^{15}N$ ratios of 11.8‰ and 11.9‰ that altogether point to a terrestrial-based diet (Table 6.7). The tooth enamel $\delta^{13}C$ measured on the third molar of the male adolescent (sample MA_1879) is also consistent with the prevalent consumption of C_3 foods. Compared to the animals, the two humans display higher $\delta^{15}N$ values resulting in a $\Delta^{15}N$ spacing ranging from about +6.6‰, with respect to the pig sample, to about +4.2‰, if considering the mean $\delta^{15}N$ value of the caprines. If accounting for a mean $\Delta^{15}N$ spacing of +3‰ between two consecutive trophic levels, the apparently higher $\Delta^{15}N$ yielded by these two individuals can possibly be explained with a contribution of freshwater foods to their diet.

Summary and Discussion

The general good state of preservation of the faunal and human skeletal material recovered at Marki *Alonia* allowed to obtain the most complete isotopic dataset within this study.

The three most represented herbivores in the faunal record, namely caprines, cattle and deer, are quite well defined from the isotopic point of view, showing mean $\delta^{13}C$ and $\delta^{15}N$ values of -19.5±0.8‰ and 7.6±0.9‰, -21±0.3‰ and 5.9±0.4‰, 20.4±0.4‰ and 6.7±1‰, respectively (Table 6.8 and Figure 6.6).

Figure 6.6 Collagen stable isotope values of faunal and human samples from Marki *Alonia*.



The different isotope values yielded by cattle and caprines have been interpreted as a consequence of possible differences in herding practices and thus in the diet of these two domestic species. Specifically, the more negative and more homogeneous isotope values of cattle may indicate that they were kept by humans in a restricted environment and were possibly foddered with a more monotonous C_3 diet, perhaps involving leafy crops and legumes. Differently, the more positive and more spread values of sheep and goats suggest that caprines were exploiting larger C_3 biomasses, such as we might expect from animals herded in more open and drier habitats. As for deer, their isotope values seem to indicate that they were feeding on C_3 plants from a more temperate location compared to the caprines, probably woodlands and forest edges, as suggested by their ecological behaviour (Chapman & Chapman 1975).

The isotope values yielded by the two equid samples (probably donkeys) have been interpreted as indicative of the exploitation of a range of diversified, including more arid, habitats. This hypothesis would be consistent with the assumption that donkeys were primarily kept as working animals and probably utilised for transportation (Croft 2006: 274), a practice that would have implied moving across different and distant areas, perhaps using donkey caravans like those attested in the southern Levant during the Chalcolithic and the Early Bronze Age (Grigson 2012).

Little can be said about the unique pig sample apart from the fact that this animal displays the lowest nitrogen isotope ratio within the faunal dataset, possibly indicating a prevalent vegetal diet, and a quite negative carbon isotope value that may reflect dwelling in a temperate location, as required by its ecological needs (see for example Grigson 2007). Finally, the isotope values of the two dogs indicate a carnivorous, terrestrial-based diet, although the discrepancy in their nitrogen isotope ratios hints at the possibility that they were not fed on a regular diet, but obtained their food also from scavenging.

As for the two humans from Marki *Alonia*, a mixed terrestrial-based diet with probable contribution of freshwater resources has been hypothesised. In keeping with the archaeological, archaeobotanical and faunal record, cereal and pulses together with animal products from a range of domesticated (caprines, cattle and pig) and hunted (deer) animals likely constituted the basis of the diet of these two individuals. In addition, the occasional consumption of freshwater food seems further supported by the remains of freshwater crab identified within the faunal assemblage. Although the single contribution of different animal products to the diet of the two humans cannot be reliably estimated, the hypothesis derived from weights of animal bones - following which cattle and deer could have been preferentially eaten - seems not in contrast with the isotope results. The human isotope values appear to be in good agreement also with the evaluation of the dental health of the two individuals. Remarkably, both of them showed a complete dentition and a moderate tooth wear that, combined with the absence of caries and periodontal diseases, might indicate a diet less sticky, less soft and less rich in carbohydrates (Moyer 2006: 290), as also confirmed by the high nitrogen isotope ratios discussed before.

Unfortunately, possible inferences about the diet of the whole community of Marki *Alonia* are limited by the very small number of analysed individuals. From the anthropological point of view, the small group of individuals recovered from intra-mural burials does not seem to show particular health or nutritional problems and only one case of enamel hypoplasia was identified. However, we should also recall that this kind of burials were not the rule during the Bronze Age in Cyprus, and Frankel & Webb (2006: 283) have suggested that they could represent an alternative mortuary treatment destined to certain individuals of the community who were probably discriminated because of their age, sex or other social factors. Although the material remains of Marki *Alonia* do not point to significant systemic differences in the wealth and status of the occupants, it would be interesting to investigate whether such a dietary pattern, rich in animal proteins and characterised by the occasional consumption of freshwater food, was the norm for the community or a diet restricted to a an élite of individuals.

6.2.2. ALAMBRA-MOUTTES

The archaeological area of Alambra *Mouttes* is located in central Cyprus, less than 10 km south-east of Marki *Alonia* (Chapter 6.2.1) and about 20 km south of the modern town of Nicosia (Figures 1.1 and 3.2).

This site has been known at least since the second half of the 19th century, when P. Di Cesnola, Ohnefalsch-Richter and Sir R.H. Lang reported and partially documented the excavation of at least 100 tombs in the Alambra area (Coleman *et al.* 1996: 7, with references). In 1924, E. Gjerstad excavated the remains of a small Middle Cypriot house at the locality of *Mavroyi*, approximately 160 m south-west of *Mouttes* (Gjerstad 1926: 19-27). In 1974, an archaeological mission led by the Cornell University conducted a preliminary surface survey of the Alambra area; formal archaeological excavations, alternated to study seasons, lasted from 1976 to 1985 and brought to light the remains of a

Middle Cypriot settlement and several clusters of tombs scattered around it (Coleman *et al.* 1996).

Investigations at Alambra *Mouttes* have been recently resumed by the University of Queensland Alampra Archaeological Mission (UQAAMP), under the co-direction of A. Sneddon, G. Deftereos and T. Rymer. The project started in 2012, when the UQAAMP undertook rescue operations in the area of Alambra under license from the Department of Antiquities of Cyprus. In the same year, a geophysical survey was carried out that allowed the identification of an area of high archaeological potential, located about 100 m north-east of the Middle Cypriot structures exposed by the Cornell University (Figure 6.7). UQAAMP excavations in that area began in 2014 and continue today. Since preliminary results have not yet been published, all the information presented in the next sections is based on unpublished excavation reports.

Figure 6.7 Satellite image showing the location of the area exposed by the Cornell University and the area investigated in 2015 by the University of Queensland. Source: Google Earth 7.1.8, Alambra, 34°59'04.66"N, 33°23'47.81"E, eye altitude 519 m, imagery date 2/16/2015.

a. Chronology

Permanent occupation at Alambra Mouttes is first attested in the Early Cypriot but, as evidence only come from tombs, very little about this earlier phase of habitation is currently known. Differently, the architectural and stratigraphic deposits excavated in the ancient settlement attest to continuous occupation during the Middle Cypriot I-II, probably related to a single episode of dwelling (Coleman *et al.* 1996: 327). Ongoing investigations by the UQAAMP further support these findings as the several test pits excavated in the targeted area have brought to light the remains of further Middle Cypriot structures, more or less contemporary with the settlement excavated by the Cornell University.

Dating materials

The material assemblage recovered by the Cornell University archaeological mission comprises a great amount (99%) of Red Polished ware (RP) and a small percentage of White Painted ware (WP) – the second most important ceramic type in the Middle Cypriot period – and Black Polished ware (BP) (Coleman *et al.* 1996: 237-240).

The ceramic assemblage recovered from the UQAAMP is almost exclusively Red Polished ware, with only a handful of White Painted fragments. The pottery recovered from secure contexts dates to the ECIII to MCII period and it is thus consistent with the dating proposed by Coleman for the ancient settlement, with abandonment occurring before the MCIII period.

Radiocarbon dating

Four radiocarbon dates obtained from two ashes and two charcoal samples are currently available from Alambra *Mouttes* (Coleman *et al.* 1996: 339-340). The samples were analysed in 1983 by the Eidgenössische Technische Hochschule (ETH) of Zürich, and in 1995 by Beta Analytic Inc.

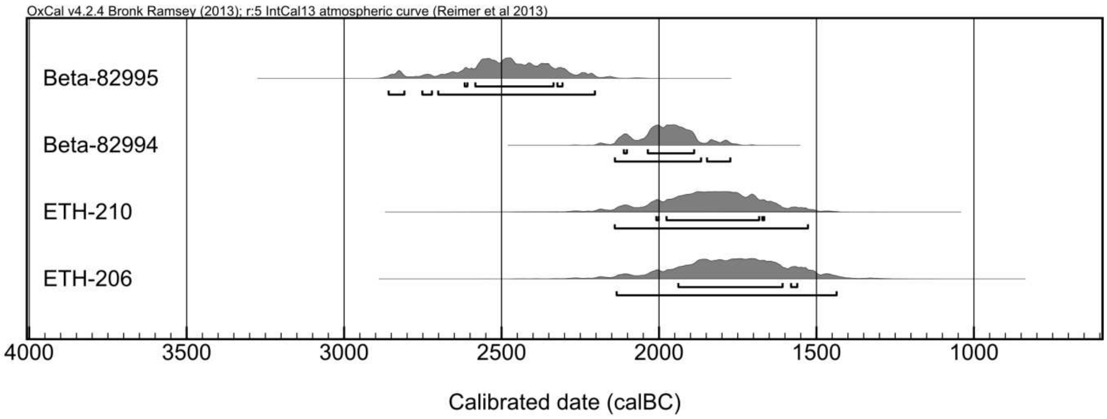
In this study, the radiocarbon ages yielded by the four samples have been calibrated anew taking the latest calibration curve as a reference (IntCal 13, Reimer *et al.* 2013). The results are summarised in Table 6.9 and shown in Figure 6.8.

Table 6.9 Radiocarbon ages and calibrated ages of the samples from Alambra *Mouttes*. OxCal 4.2.4 was used.

SAMPLE NAME	CONTEXT/ MATERIAL	RADIOCARBON AGE (years BP)	CALIBRATED AGE (68% confidence level)	CALIBRATED AGE (95% confidence level)
Beta-82995	Building III Room 19 carbon	3970 ± 90	2620-2300 BC	2860-2200 BC
Beta-82994	Building IV Room 13 carbon	3610 ± 60	2120-1880 BC	2150-1770 BC

ETH-210	Building II Room 2 ash	3500 ± 120	2010-1660 BC	2150-1520 BC
ETH-206	Building IV Space 27 ash	3440 ± 140	1940-1560 BC	2140-1430 BC

Figure 6.8 Calibrated radiocarbon dates from Alambra *Mouttes* calibrated in OxCal 4.2.4 using the IntCal13 calibration curve.



As shown in Figure 6.8, the absolute date of sample Beta-82995 is much earlier than the other three, an occurrence which was already noted by Coleman *et al.* (1996: 339-340) and possibly ascribed to the specific context of recovery, namely, a hearth that probably predates the major activity recorded in Area A (the settlement). As for the other three radiocarbon determinations, the measurements have large error spans and do not form a tight grouping; in fact, their calibrated ages cover a quite large temporal span, ranging from 2120 BC to 1560 BC, at 68% level of probability.

All the four radiocarbon determinations from Alambra *Mouttes* have been recently re-evaluated by Manning (2013a, 2014) through Bayesian analysis, and arranged within a comprehensive chronological model of Cypriot pre- and proto-history. Accordingly, occupation at Alambra *Mouttes* has been estimated to start at about 2090 BC and to end at about 1800 BC, in agreement with the ceramic chronology (see Manning 2013a: 512, Figure A10 with caption).

b. Site description

The Bronze Age settlement excavated by the Cornell University is situated on the north-east slopes of the *Mouttes* hill. The settlement is believed to have reached an extension of over 6 ha. It was built directly onto the limestone bedrock and consists of seven rectangular buildings extending over the sloping terrace of the hill. From the architectural point of view, most of the walls were constructed of sedimentary stones and in conjunction with bedrock scarps of different heights, thus obtaining variations in the surface elevation within the rooms. Also, evidence for the use of a clay material (defined by the excavators as "mud-plaster") has been found on the lower surfaces of the standing walls. Inside the buildings, hearths and bedrock depressions, associated or not with mud-plaster, were recovered, as well as a wide range of movable finds attesting to different activities like food storing, cooking and spinning (Coleman *et al.* 1996: 327-328).

A series of tombs, clustered in six different areas, occupy the sloping terraces around the settlement, generally separated from the habitation area. Tombs are all rock-cut types and can be divided into two main groups: chamber tombs, consisting of a single chamber and a *dromos*, and pit tombs. They are scattered around the settlement but seem not to indicate a preconceived plan of cemetery areas or to be deliberately destined to different members of the community.

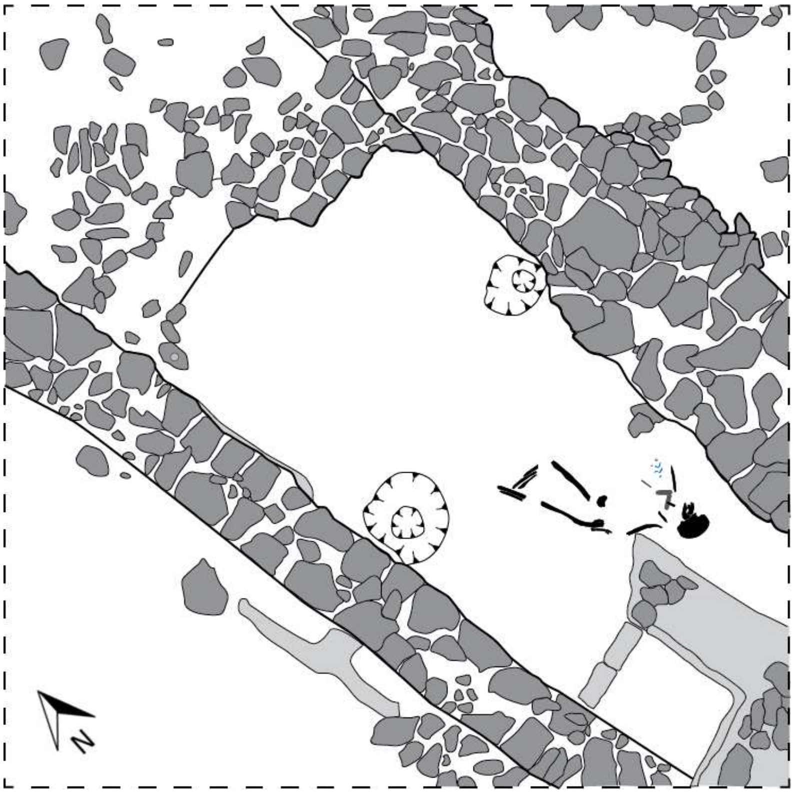
As far as UQAAMP excavations are concerned, only a brief description of Trench 2 is given, as the skeletal material sampled for this study originates from this area.

Trench 2

Trench 2 is a 5 x 5 m excavation square situated in a location that geophysical survey and 2014 test excavation had identified as a rectangular structure. During the 2015 excavation season, a narrow rectangular room contained within four walls was exposed, the internal space measuring 2.20 x 4.20 m, oriented lengthways N-S (Figure 6.9).

Excavations in this room revealed the presence of a layer of mudbrick fill which in turn overlaid a thick ashy deposit that has been interpreted as evidence for fire destruction, probably following the abandonment of the structure. The southern end of the room had been divided lengthways by a low mudbrick wall into two alcoves. The alcove on the east side was 570 mm wide and about 1.30m long, and contained a burial (Context 0116, see Figure 6.11), resting on the floor surface.

Figure 6.9 Plan of Trench 2. Courtesy of A. Sneddon.



c. Flora and Fauna

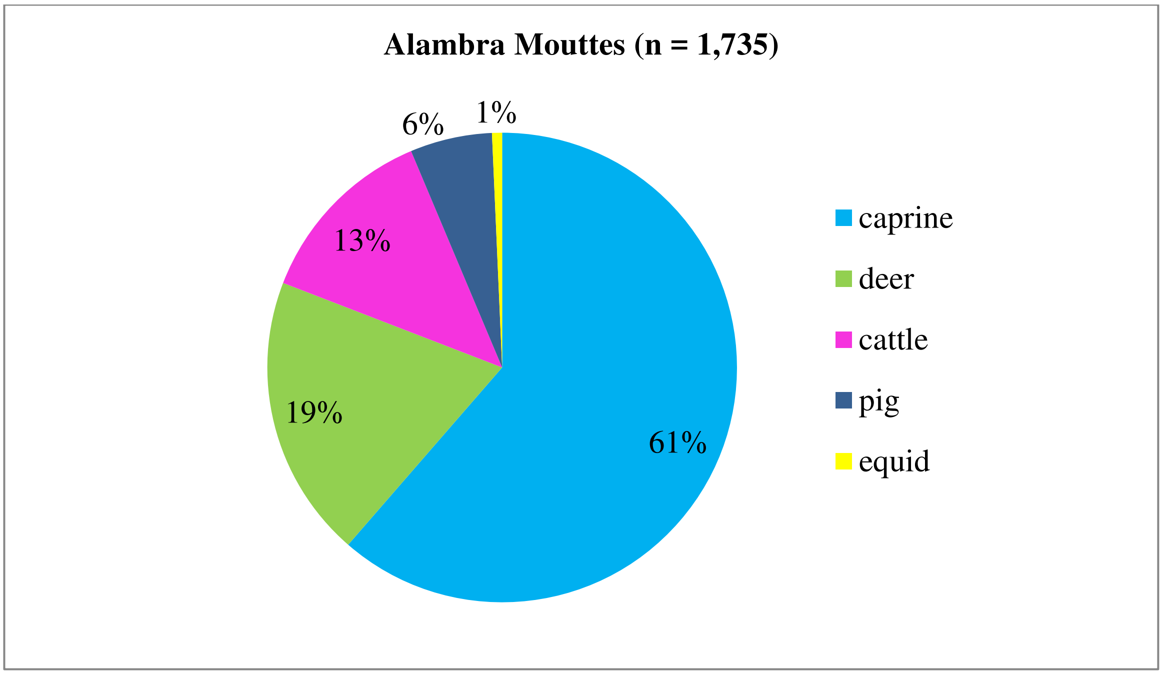
Palaeobotanical remains

A griddle and a juglet bearing leaf impressions on the base and on the shoulder, respectively, represent the only botanical evidence currently available from Alambra *Mouttes*. The first was recognised as a grape leaf while the second was tentatively identified as a young cultivated olive leaf or, more likely, a mature olive leaf (Coleman *et al.* 1996: 325).

Faunal remains

Excavations at Alambra *Mouttes* by Cornell University yielded a total of 8,809 animal bone fragments of which 1,735 proved identifiable (Reese 1996). Among them, caprines were more abundant, followed by similar proportions of fallow deer (*Dama Mesopotamica*) and cattle, pig and a few fragments of equid (either horse or ass) (Figure 6.10).

Figure 6.10 Identified mammalian bone fragments from Alambra *Mouttes*. Data extrapolated from Reese (1996).



The bones were not evenly distributed along the site but concentrated in certain buildings, probably indicating that only certain rooms were dedicated to certain activities. As far as herding practices are concerned, aging evidence for sheep and goats suggests that these animals were kept as long as possible, possibly because of the importance of milk and wool/hair. Cattle remains mainly pertained to adult individuals and towards this purpose Reese (1996: 479) hypothesised that these animals were also used for transport and traction, not only for meat and milk. No evident culling patterns were recognised in the ages of the few recovered pigs while, concerning the remains of equids (all adults), the author commented that they were probably used to carry or pull burdens. Differently, fallow deer was a free-living, hunted species and the large number of deer bones recovered at Alambra *Mouttes* suggests that the animal was a significant source of meat for the community. No animal bones have yet been recovered during UQAAMP excavations.

Molluscs and fish

A small assemblage of marine shells and two fossils (possibly originating from the bedrock) was recovered at Alambra *Mouttes*. According to Reese (1996: 484), there is no evidence to suggest that marine shells were eaten; instead, they were probably used as ornaments (*Dentalium* and *Murex*) and utilitarian objects (*Charonia*).

d. Human remains

The Cornell University excavated six tombs all of which contained human remains (Coleman *et al.* 1996: 113-128; Domurad 1996). Unfortunately, all the tombs but Al. 102 and Al. 105 were found looted. Despite the poor condition of the remains, a total of 4 adult males and 3 adult females were identified. Tomb Al. 102 was the only one with a MNI of 2, though the two burials were interpreted as not contemporaneous.

An intra-mural burial was recovered in Trench 2 by the UQAAMP (Figure 6.11). Preliminary observation of the cranium and the dental characteristics allowed to estimate an age at death of approximately 15-30 years and sex likely female. Preservation was poor, but the individual appeared to have been placed partially on its right side/back, with the left hand and arm behind the back and the right hand and arm to its right side. The right leg was bent and rested below the left tibia and fibula. According to the excavators, this burial probably post-dates the occupation of the room.

Figure 6.11 Skeleton recovered in Trench 2, Context 0116. Courtesy of A. Sneddon.

Health status

The seven individuals recovered by the University of Cornell show a general poor dental health with a great incidence of ante mortem tooth loss. The individual from tomb Al. 103 also shows hypoplastic lines indicating ill health or malnutrition. According to Domurad (1996), tooth loss may have been related more to wear and heavy mechanical use rather than caries and infection. As far as postcranial remains are concerned, arthritis was identified in 3 people and seemed particularly accentuated in the individual from tomb Al. 101.

As for the skeleton excavated by the UQAAMP, the skeletal remains have not yet been fully studied and information on possible palaeopathologies is currently not available.

e. Isotopic study

Materials

The animal and human remains recovered during Coleman excavations are currently stored at the Cyprus Museum in Nicosia. Regrettably, personal examination of the skeletal material revealed a poor preservation state as the bones were generally quite degraded and chalky in appearance. In addition, most of the human remains had been treated with polyvinyl acetate on the whole bone surface, thus severely limiting the sampling procedure. For these reasons, it was decided not to take any sample from these osteological collections, due to low chances of collagen preservation and/or potential contamination from restoration glues. Instead, one sample was collected from the skeleton recently excavated in Trench 2 by the University of Queensland, also allocated at the Cyprus Museum (Table 6.10). Much of this bone material was quite fragmentary and not well preserved but it was assumed that, due to the small amount of time elapsed from excavation to sampling, the more compact long bone could still contain sufficient collagen for the analysis.

Table 6.10 Human bone sample collected from Alambra *Mouttes*.

SAMPLE NAME	CONTEXT	PHASE/ CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
AL_1	Trench 2, 0116	Middle Cypriot	right femur	probably female	15-30 years

Results

The bone sample was prepared and measured for carbon and nitrogen stable isotope analysis at the DiSTaBiF Laboratory of the Seconda Università di Napoli (Italy). The results are shown in Table 6.11.

Table 6.11 Collagen stable isotope values yielded by the human sample. Analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values.

SAMPLE	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ collagen (PDB) (‰)	$\delta^{15}N$ collagen (AIR) (‰)
AL_1	0.2%	22.1	7.1	3.6	-20.8	9.5

Preservation state

The bone fragment yielded a very low collagen yield of 0.2% that confirms the poor preservation of the human remains. However, because this sample displays an acceptable C/N ratio and carbon and nitrogen percentages very close to that of intact collagen (cf. van Klinken 1999), it is preliminary accepted here.

Human Isotope Values

The $\delta^{13}C$ and $\delta^{15}N$ values yielded by sample AL_1 appear consistent with a mainly terrestrial-based diet of C_3 plants (cereal and pulses) and animals fed in a C_3 ecosystem, with no evidence of heavy marine food consumption.

Summary and Discussion

A unique bone sample was successfully analysed from the Middle Cypriot village of Alambra *Mouttes*. The isotope values indicate a mainly terrestrial-based diet of C_3 plants (cereal and pulses) and proteins from animals fed on C_3 resources, with no evidence of regular freshwater or marine food consumption. Information on the dental health of this (probably female) individual are not available although the very poor preservation of the teeth, as revealed from personal examination of the skeletal material, casts some doubts on the possibility of deriving some useful clues about dietary habits.

6.2.3. THE BRONZE AGE CEMETERY OF KALAVASOS VILLAGE

The modern village of Kalavasos is located in the Vasilikos River Valley, along the west bank of the Vasilikos River, about 30 km east of Limassol (Figures 1.1 and 3.2).

The evidence of Bronze Age tombs within the confines of the village has been known since 1940, when the first archaeological discoveries were reported to the authorities, although the existence of tombs in the central area of the village must have been known for a very long time (Todd 2007: 1). Most of the Bronze Age tombs identified in the village have been excavated by the members of the Vasilikos Valley Project (VVP), under the direction of A. South and I. Todd.

Figure 6.12 Plan of Kalavasos village showing the location of sites where the Bronze Age tombs were found. Scale: 1: 5,000. From Todd 2007, Fig. 3.

Particularly significant from the archaeological point of view is the area where the Panayia Church is presently located (Figure 6.12); here several tombs pertaining to an important cemetery dating principally to the Early/Middle Cypriot were found (Todd 2007: 1). More specifically, an important series of tombs (T. 13-20) was discovered in 1949 during the construction of the Kalavasos Cooperative shop near the Panayia Church. A further series of tombs was brought to light in 1978 (T. 36-48) when a row of shops and offices was constructed immediately below the east end of the Panayia Church; these tombs were excavated by VVP in conjunction with the Department of Antiquities of Cyprus and the results were published in Todd (1986).

Set at a short distance from the Panayia Church area, the Mosque/Mavrovouni area (Figure 6.13) also yielded evidences of the existence of a Bronze Age cemetery and some tombs were excavated in 1950-1951. A further area of the village of Kalavasos where Bronze Age tombs have been found is the plot where the Cinema is presently located (Figure 6.13); here in 1961 and 1962 nine tombs were excavated.

In 1984 and 1987 further building episodes caused accidental discovery of several other tombs (T. 52-79) in all the three areas of Kalavasos village; these tombs were excavated by the VVP and published in Todd (2007).

a. Chronology

The chronology of the tombs excavated at the village of Kalavasos derives from the analysis of the funerary assemblages. Specifically, the Panayia Church cemetery area was used predominantly in the Early/Middle Cypriot (Tombs 1, 3, 5, 13-20, 36-48, 54-55, 57-72) with only very limited use being evidenced during the Late Cypriot (Tomb 2 and some sherds found in Tombs 46, 47 and 57). In the Mosque/Mavrovouni area, three tombs (T. 52, 53, 56) belong to the Early Cypriot III/Middle Cypriot I, while other four to the Late Bronze Age (T. 10-11, 22, 51). Finally, in the Cinema area, nine Early/Middle Cypriot tombs were found (T. 23-31).

b. Site description

The Panayia Church is situated at a short distance to the south of the centre of Kalavasos village, overlooking the main square. The Mosque lies approximately in the centre of the village, just west of the main north-south road which crosses the entire village, c. 90 m NNW of the Panayia Church. The relationship between these two cemetery areas is uncertain since no tombs have yet been found in the intermediate space. Finally, the Cinema area is located at the south end of the village, immediately east of the road leading up to the main square.

No conclusive evidence has yet been found for an Early/Middle Cypriot settlement within the confines of the village, although one wall exposed in 1978 below the east end of the Panayia Church might belong to this period (Todd 2007: 2).

c. *Flora and Fauna*

Palaeobotanical remains

No palaeobotanical remains were recovered from the excavations of the Bronze Age cemetery areas of Kalavasos village, the only exception being represented by one grain of wheat and several seeds of *Lithospermum arvense*, all assumed to be modern (Hansen 1986).

In geographic terms, the closest archaeobotanical evidence comes from the near Neolithic site of Kalavasos *Tenta*, located just 4 km south of the village (Todd 2005). According to Hansen (2005), this site yielded 175 identifiable remains including three domesticated cereals (einkorn wheat, emmer wheat and barley), two domesticated pulses (lentil and pea) four tree/shrub species (caper, fig, pistachio and pear/apple) and 24 wild herbaceous taxa.

Faunal remains

A considerable quantity of animal bones was recovered in the Panayia Church area during the rescue excavations in 1978. Faunal remains were present in Tombs 40, 43, 44, 46 and 48 including caprines, equid, dogs and a pig. However, following Croft (1986), various factors suggest that the great majority of the bone material was intrusive and not contemporary to the time the tombs were built.

A small assemblage of animal bones (all identified as sheep/goat) was recovered in Tombs 57, 59, 62, 67, 69-72 during later excavations at Panayia Church; a single bone of frog was found in Tomb 70 (Todd 2007: 5-25).

d. Human remains

The Bronze Age tombs excavated at the three localities of Kalavasos village contained a significant quantity of ancient human remains, resulting in one of the largest collections of MC human remains in Cyprus. The skeletal material was studied by J. Moyer who identified a minimum number of 78 individuals from a total sample of 41 tombs (Moyer 2007). Most recently, the osteological collection has been re-examined by A. Osterholtz (2015) utilising different methodologies.

In this study, only the human remains from Tombs 36, 59, 60, 61, 63, 65 and 67 of Panayia Church and Tomb 53 of Mosque/Mavrovouni Area were sampled. The next section offers a brief description of these tombs, including the results of the anthropological analysis made by Moyer (2007). Indeed, the sampling of the human remains was done following the indications of sex and age at death found in this publication.

Panayia Church

Tomb 36

Tomb 36 was one of the largest (about 3.1 × 1.95 m) and better preserved tombs excavated at Kalavasos. One peculiar feature of this tomb is the presence of a niche along the northern wall containing a bowl. Based on stratigraphic evidence within the tomb, the excavators hypothesised at least two phases of tomb use separated by approximately 10 cm of inwashed fill (Todd 1986: 25). According to Moyer (2007, Table 28: 310-311), Tomb 36 contained a minimum number of seven individuals among whom one female 28-30 years old, one female of 23-30 years of age, one adult male, two probably female adults, one probable male adult and one child 5.5 ± 9 months years old were identified.

Tomb 59

Tomb 59 measures 1.8 × 1.78 m with a height of 1.53 m and shares a *dromos* with Tombs 61 and 62. Human remains were scattered throughout the tomb and intermixed with ceramic vessels (Todd & Pearlman 2007). Moyer (2007: 278) identified a total of three individuals, including one female 18-23 years old, one male 35-45 years old and an adult of unknown sex.

Tomb 60

Tomb 60 measures 2.0 × 1.84 m with a height of 1.35 m. According to the excavators, this tomb was probably looted in antiquity, leading to the disarticulation and commingling of the human remains within the tomb (Todd & Pearlman 2007). Moyer (2007: 280) recognised two individuals: one female 18-19 years old and one middle adult male.

Tomb 61

Tomb 61 shares the *dromos* with Tombs 59 and 62. This tomb measures 1.63 × 1.5 m with a height of 1.33 m. Fragments of the *stomion* were recovered from within the tomb chamber. The human remains were recovered in two concentrations, on the south-east and west sides of the tombs (Todd & Pearlman 2007). A minimum number of three individuals, including one female 35-39 years old, one probably male adult and one probably female adult, was identified by Moyer (2007: 282).

Tomb 63

Tomb 63 shares the *dromos* with Tombs 57 and 58. This tomb measures 1.52 × 1.18 m with a height of 1.29 m (Todd & Pearlman 2007). Moyer (2007: 285) identified a minimum number of two individuals, including one female of 19-24 years of age and a middle adult female.

Tomb 65

Tomb 65 measures 2.23 × 2.22 m with a height of 1.43 m. The exact nature of the *dromos* is uncertain. The tomb was discovered by mechanical cutting and so was entered through one of the walls. Despite modern disturbance caused by electrical wire, there doesn't appear to have been looting. This tomb exhibits reuse, with earlier burials pushed to the back of the tomb when a new interment was made (Todd & Pearlman 2007). According to Moyer (2007: 291), a minimum number of four individuals was present: one female 25-30 years old, one male 50+ years old, one male 45-50 years old and one male 22-25 years old.

Tomb 67

Tomb 67 measures 2.9 × 2.85 with a height of at least 1.45 m. Most of the remains were disarticulated and commingled, indicating probable tomb reuse (Todd & Pearlman 2007). A minimum number of five individuals, including one middle adult female, one male of 22-24 years of age, one middle adult female, one female 35-39 years old and one male 20-30 years old, were identified by Moyer (2007: 296).

Mosque/Mavrovouni Area

Tomb 53

Tomb 53 measures 2.88 × 2.74 m with a height of 1.68 m (Pearlman & Todd, 2007, p. 31). Moyer (2007: 268-269) identified a minimum number of six individuals, including one male 18-20 years, one male 17-19 years, one young/middle adult male, one middle adult male, one young/middle adult female and one child of 4-10 tears of age.

e. Isotopic study

Materials

The osteological collection from Kalavasos village tombs was in quite poor condition and the skeletal material was generally very fragile and chalky. For this reason, teeth were preferentially selected. In total, three bone fragments and nine teeth were collected from Tombs 36, 59, 60, 61, 63, 65 and 67 of Panayia Church and Tomb 53 of Mosque/Mavrovouni Area (Table 6.12).

Table 6.12 Human bone samples collected from Kalavasos Village tombs.

SAMPLE NAME	PROVENANCE	CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
KL_T36_16	Panayia Church, Tomb 36	MC II	skull 4 tooth # 16	M	adult
KL_T36	Panayia Church, Tomb 36	MC II	fragment of left rib	M?	adult
KL_T53_30	Mosque/Mavrovouni Area Tomb 53	EC III-MC I	skull B associated with skeleton 2 tooth # 30	M	17-19 years
KL_T53_31	Mosque/Mavrovouni Area Tomb 53	EC III-MC I	skull B associated with skeleton 2 tooth # 31		
KL_T59	Panayia Church Tomb 59	EC III-MC I	fragment of right humerus	F?	adult

KL_T60	Panayia Church Tomb 60	MC I	fragment of left femur	F	18-19 years
KL_T60_19	Panayia Church Tomb 60	MC I	tooth # 19		
KL_T61_18	Panayia Church Tomb 61	MC I-II	skull 1 tooth # 18	F	35-39 years
KL_T63_17	Panayia Church Tomb 63	EC III-MC I	skull 1 tooth # 17	F	19-24 years
KL_T65_30	Panayia Church Tomb 65	MC I	skull 3 tooth # 30	M	45-50 years
KL_T65_14	Panayia Church Tomb 65	MC I	skull 2 tooth # 14	M	50 + years
KL_T67_15	Panayia Church Tomb 67	EC III-MC II	tooth # 15	unknown	middle adult

Results

All the samples from Kalavasos village tombs were prepared and measured at the RLAHA of the University of Oxford. Specifically: the three bone fragments were analysed for their carbon and nitrogen isotopic ratios; both the collagen extracted from tooth dentine and the carbonates from tooth enamel were measured on the teeth from Tombs 53 and 60, as they were better preserved; the remaining teeth were analysed only for carbon and oxygen isotopic ratios. The overall results are reported in Table 6.13.

Table 6.13 Stable isotope values yielded by the human samples. For measurements made on collagen, analytic error is 0.2‰ for both $\delta^{13}C$ and $\delta^{15}N$ values. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. For measurements made on enamel, analytical precision as indicated by multiple replicates was better than 0.1‰ for both $\delta^{13}C$ and $\delta^{18}O$ values.

SAMPLE	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ collagen (PDB, ‰)	$\delta^{15}N$ collagen (AIR, ‰)	$\delta^{13}C$ enamel (PDB, ‰)	$\delta^{18}O$ enamel (PDB, ‰)
KL_T36_16	/	/	/	/	/	/	**-11.4**	**-6.5**
KL_T36	**2%**	**30.5**	**10.4**	**3.4**	**-21.1**	**10.7**	**/**	**/**
KL_T53_30	**> 1%***	**16**	**5.4**	**3.4**	**-20**	**10.5**	**-12.3**	**-6.5**
KL_T53_31	**> 1%***	**19.1**	**6.6**	**3.4**	**-20.6**	**9.5**	**-11.5**	**-4.6**
KL_T59	1.4%	2.1	0.6	4.1	-21.3	6.7	/	/
KL_T60	0.8%	2.1	0.2	11.6	-27.2	2.4	/	/
KL_T60_19	1.2%	n	n	n	n	n	**-11.6**	**-5.1**
KL_T61_18	/	/	/	/	/	/	**-12.2**	**-5.1**

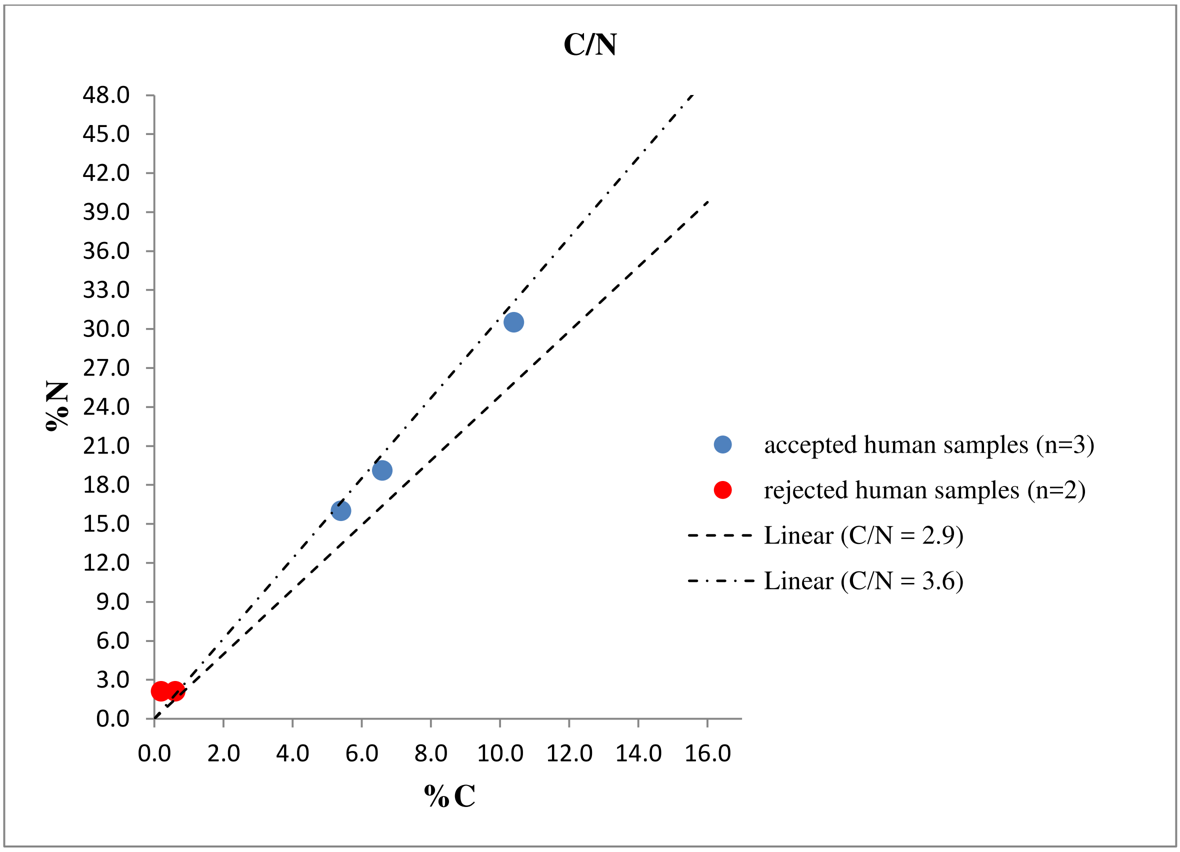
KL_T63_17	/	/	/	/	/	/	**-12.1**	**-6.6**
KL_T65_30	/	/	/	/	/	/	**-12.8**	**-3.6**
KL_T65_14	/	/	/	/	/	/	**-12.9**	**-3.4**
KL_T67_15	/	/	/	/	/	/	**-11.8**	**-5.5**

*Collagen yield could not be precisely calculated as the tooth dentine was not separated from the enamel during the pre-treatment procedure.

Preservation state

The three bone fragments selected for the analysis displayed a somewhat better preservation state within the skeletal assemblage from Kalavasos village tombs. Collagen was successfully extracted from all the three bone samples with quite good yields of 0.8%, 1.4% and 2%. However, both samples KL_T59 and KL_T60 displayed unacceptable values of C/N, %C and %N and were thus rejected (Figure 6.13).

Figure 6.13 Elementary contents (C, N) in the validated collagen extracts and the C/N range proposed by DeNiro (1985).



The two teeth from the individual of Tomb 53 were in good condition and collagen was successfully extracted in both cases, with yields greater of 1% and acceptable collagen quality indicators. Differently, the tooth from Tomb 60 gave a very degraded and probably contaminated collagen extract.

Human Isotope Values

The three collagen samples obtained from the two individuals of Tombs 36 and 53 yielded similar $\delta^{13}C$ and $\delta^{15}N$ values pointing to a prevalent terrestrial-based diet. In addition, it should be noticed that the nitrogen ratio measured on the first molar (tooth #30) of the adolescent of Tomb 53 is more enriched in ^{15}N (+1‰) with respect to the second molar (tooth #31), possibly because of the influence of breastfeeding. Indeed, first molars are earlier-forming permanent teeth and could retain some isotopic signal from the mother, as demonstrated for example by Dupras & Tocheri (2007).

Concerning the isotope values obtained from tooth enamel, the results have been subdivided into two groups, depending on the time of formation of the teeth: Table 6.14 summarises the isotope values obtained from second and third molars, that is, later-forming teeth; Table 6.15 summarises the isotope ratios obtained from the first molars which, on the other hand, are earlier-forming teeth. The two series of data are also shown in Figure 6.14.

Table 6.14 Summary of the enamel isotope values of second and third molars.

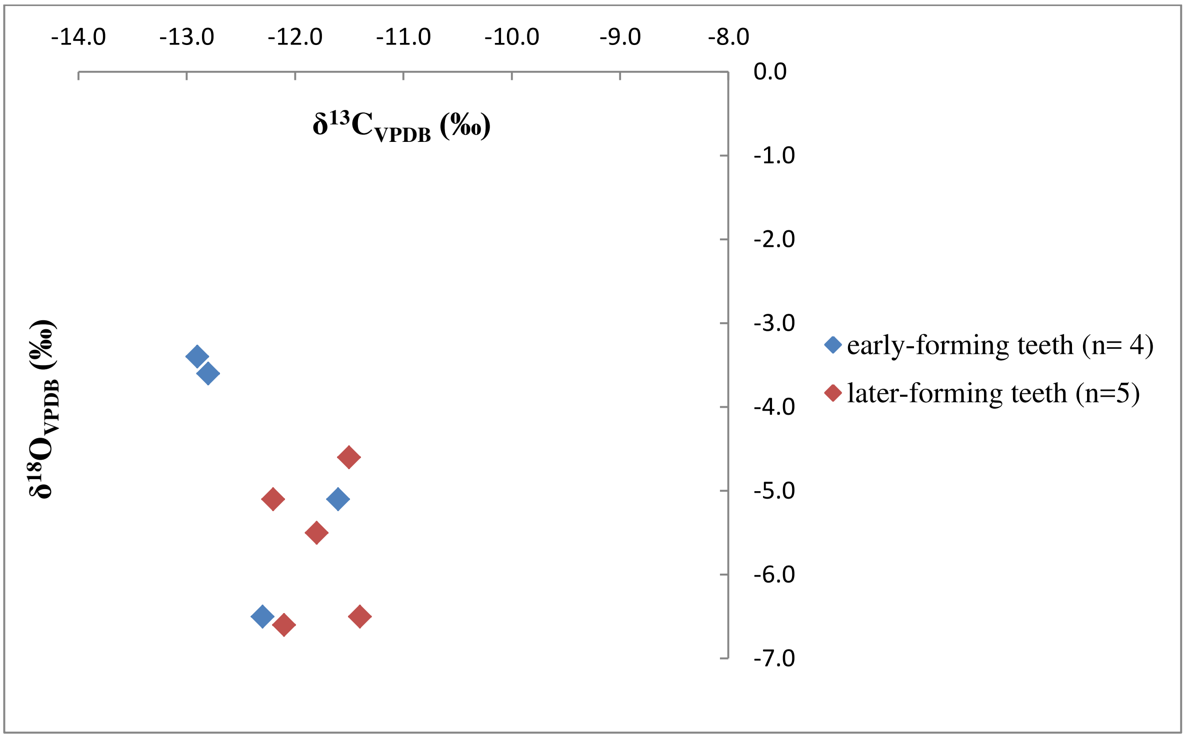
HUMAN	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C_{ENAMEL}$ (‰)	-11.8	-11.8	0.4	0.8	-12.2	-11.4	5
$\delta^{18}O_{ENAMEL}$ (‰)	-5.7	-5.5	0.9	2.0	-6.6	-4.6	5

Table 6.15 Summary of the enamel isotope values of first molars.

HUMAN	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C_{ENAMEL}$ (‰)	-12.4	-12.6	0.6	1.3	-12.9	-11.6	4
$\delta^{18}O_{ENAMEL}$ (‰)	-4.7	-4.4	1.4	3.1	-6.5	-3.4	4

As shown in Table 6.14, the mean $\delta^{13}C_{ENAMEL}$ of the later-forming teeth is -11.8‰ ± 0.4‰ while the mean $\delta^{13}C_{ENAMEL}$ of the earlier-forming teeth is -12.4‰ ± 0.6‰. Both these ranges are consistent with a diet dominated by C_3 foods. The $\Delta^{13}C$ spacing of 0.6‰ obtained for the two series of data might be due to the influence of breastfeeding; this value actually coincides with the one found by Dupras & Tocheri (2007) when comparing the $\delta^{13}C_{ENAMEL}$ values of earlier-forming teeth versus later-forming teeth in a Roman population of Egypt. This trend is also apparent in Figure 6.15, where the first molars tend to be more negative than the values obtained from the second and third molars, the only exception being sample KL_T60_19.

Figure 6.14 Tooth enamel isotope values from Kalavasos village tombs.



As far as oxygen isotope ratios are concerned, the mean $\delta^{18}O_{ENAMEL}$ values of earlier-forming and later-forming teeth are -4.7‰ ±1.4‰ and -5.7‰ ±0.9‰, respectively. If considering only the mean values, a $\Delta^{18}O$ spacing of 1‰ is observed between the earlier-forming and the later-forming teeth. This value would appear consistent with the findings of Wright & Schwarcz (1998), according to whom an enrichment of up to 0.7-1‰ was observed in enamel that mineralizes in early childhood. Nevertheless, as also shown in Figure 6.14, the $\delta^{18}O_{ENAMEL}$ values of earlier-forming teeth are much more spread than the ratios obtained from the later-forming teeth. In particular, while the first molars KL_T60_19 and KL_T53_30 show $\delta^{18}O_{ENAMEL}$ values which are similar to the mean $\delta^{18}O_{ENAMEL}$ of later-forming teeth, the two first molars KL_T65_30 and KL_T65_14 (both originating from Tomb 65) seem to form a separate group. More specifically, their $\delta^{18}O_{ENAMEL}$ values show an enrichment in ^{18}O of about +2.7‰ with respect to the mean

$\delta^{18}O_{ENAMEL}$ values of the later-forming teeth. This value appears somewhat too positive to be ascribed entirely to the effect of breastfeeding; instead, it is possible that these two individuals had lived their infancy in a more arid location compared to the rest of the community. The fact that both of them were buried in the same tomb probably further supports this hypothesis.

If considering samples KL_T65_30 and KL_T65_14 as two outliers, a quite different picture emerges and the difference between earlier-forming and later-forming teeth is not so well demarcated. In fact, as shown in Table 6.16, the $\Delta^{13}C_{ENAMEL}$ spacing between the first molars (excluding samples KL_T65_30 and KL_T65_14) and the second and third molars is only -0.2‰ while the $\Delta^{18}O_{ENAMEL}$ spacing is -0.1‰. Preliminary, it would appear that breastfeeding is not significantly affecting the results although the small size of the isotopic dataset clearly hampers the accuracy of the interpretation.

Table 6.16 Summary of the enamel isotope values of first molars after exclusion of samples KL_T65_30 and KL_T65_14.

HUMAN	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C_{ENAMEL}$ (‰)	-12.0	-12.0	0.5	0.7	-12.3	-11.6	2
$\delta^{18}O_{ENAMEL}$ (‰)	-5.8	-5.8	1.0	1.4	-6.5	-5.1	2

Summary and Discussion

The collagen and enamel isotope values obtained from Tombs 36, 59, 60, 61, 63, 65 and 67 of Panayia Church and Tomb 53 of Mosque/Mavrovouni Area all point to a diet dominated by C_3 foods. If comparing the isotopic dataset from Kalavasos with the faunal collagen and enamel isotope values from Marki *Alonia* (Chapter 6.2.1), a regular consumption of animal proteins seems also probable. No faunal remains apart from a few bones of caprines (probably offering goods for the funerary rituals) were recovered at Kalavasos village as the settlement has not been precisely located. However, we can probably presume that the same range of animals exploited in Cyprus during the Bronze Age was also consumed at this locality.

Further interesting information about the burials from Kalavasos village comes from the enamel oxygen isotope values according to which the two adult male individuals buried in Tomb 65 might have spent their childhood in a different, more arid, locality. Available architectural and archaeological data about this tomb, and the funerary assemblage contained within the chamber, do not suggest particular outstanding characteristics. The most peculiar feature about the two individuals is probably represented by their age at death which, according to the estimates of Moyer (2007), would be of 45-50 years and 50+ years, thus quite above the average for Bronze Age Cyprus.

6.2.4. LOPHOU-KOULAZOU

The site of Lophou *Koulazou* is situated in the upper Kouris River valley, about 20 km north-west of Limassol (Figures 1.1 and 3.2).

The archaeological area first became known from accidental discoveries occurred in 1983 during the construction of the road linking the villages of Lophou and Alassa (Violaris *et al.* 2013, with references). The rescue operations carried out by the Department of Antiquities of Cyprus revealed a necropolis in the areas of *Vournia* and *Chomatsies*, both dated to the Early and Middle Bronze Age. At the beginning of the 1990s, E. Herscher and S. Swiny (1992: 77-81) conducted further analyses on the funerary assemblages recovered from *Vournia* and *Chomatsies*, although the archaeological material turned out to be deficient and heavily disturbed by systematic clandestine digging, which has been going on in the Lophou area for decades.

The cemetery area of Lophou *Koulaouzou* was identified in 2010, after the Department of Antiquities was informed of the presence of several tombs, recognised during illegal construction operations for a road. According to Violaris *et al.* (2013), the site of *Koulaouzou* seems to form the same cemetery with *Vournia*, which in turn is an extension of the cemetery at *Chomatsies*, reaching a total extension of about 1 km in length (Figure 6.15).

The tombs at *Koulaouzou* and *Vournia* extend over a series of limestone terraces, sloping on both banks of the same steep gully, while the cemetery at *Chomatsies* is separated from them because of the peculiarities of the local topography, and it occupies a nearby slope situated immediately to the north of the steep gully. Since the area has not yet been systematically surveyed, we only have pieces of the complete picture at our disposal, and one must also take the effects of looting, erosion and land improvement through systematic terracing into account.

Figure 6.15 General view of the cemetery area of Lophou.

a. Chronology

The preliminary overall analysis of the funerary assemblages and architectural types hints at the utilization of the cemetery from the beginning of the Early Cypriot to the end of the Middle Cypriot (EC-MC II/III).

Dating materials

The preliminary analysis of the material assemblage from Lophou *Koulaouzou* revealed two chronological extremes represented by Tomb 13, which at the moment may be considered the oldest one, and by Tomb 8, which is likely to be the most recent. The offering deposit of the oldest Tomb 13 includes a Red Polished I (RP) globular jug showing an applied lunette on the shoulder and a downward curving loop on the neck which can be compared with types of the EC I-II period. A smaller assemblage was found in Tomb 8 where, together with a huge RP double-handled amphora, a fragmentary Drab Polished (DB) handled jug was recovered that is comparable with more recent MC III-LC I examples from other areas of Cyprus (Violaris *et al.* 2013: 334-335).

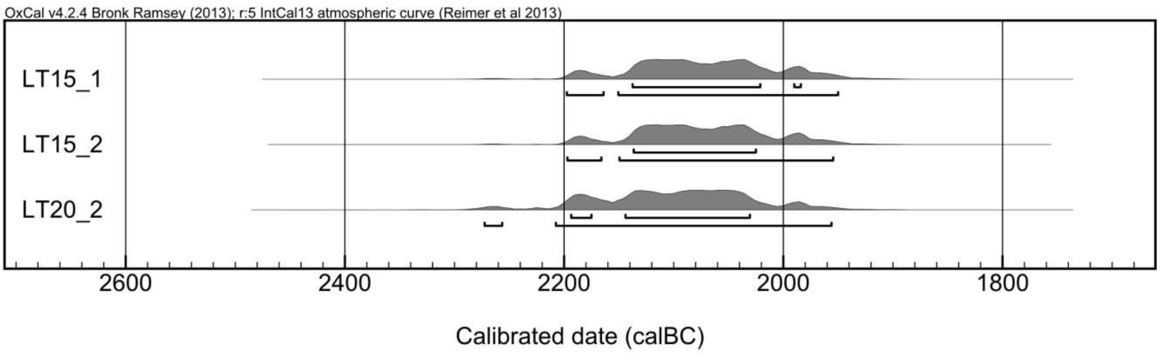
Radiocarbon dating

A total of eleven bone samples were collected from the human remains found in Tombs 8, 13, 15, 17-21 for radiocarbon purposes (Violaris *et al.* 2013: 335-336). Collagen was successfully extracted in six out of 11 samples, but three collagen extracts had to be rejected due to their unacceptable C/N ratios. The final results are summarised in Table 6.17 and shown in Figure 6.16.

Table 6.17 Calibrated radiocarbon dates from Lophou *Koulaouzou* calibrated in OxCal 4.2.4 using the IntCal13 calibration curve.

SAMPLE NAME	TOMB	RADIOCARBON AGE (years BP)	CALIBRATED AGE (68% confidence level)	CALIBRATED AGE (95% confidence level)
LT15_1	Tomb 15	3684 ± 42	2140-1980 BC	2200-1950 BC
LT15_2	Tomb 15	3686 ± 39	2140-2020 BC	2200-1950 BC
LT20_2	Tomb 20	3707 ± 46	2200-2030 BC	2280-1950 BC

Figure 6.16 Probability density distributions of the three bone samples from Lophou *Koulaouzou*. OxCal 4.2.4 was used.



As shown in Figure 6.16, samples LT15_1, LT15_2 and LT20_2 produced similar calibrated dates ranging from 2200 to 1980 BC (at 68% confidence level), corresponding to the ECI-MCI period and thus consistent with the chronology proposed for this cemetery area.

b. Site description

In 2010, a total of 16 rock-cut chamber tombs were excavated at Lophou *Koulazou* by the Department of Antiquities of Cyprus, under the direction of Y. Violaris. Most of these tombs were either disturbed by clandestine digging or by recent bulldozing operations, or both. The tombs exhibit the standard form of a single, irregularly rounded to ovoid chamber, with a cave-like section and a wide dimensional variability. Usually the *stomion* and the *dromos* area were disturbed but in at least one case where the tomb was intact, a vertical rounded *stomion* was revealed, as well as a short, generally rectangular *dromos* (Violaris *et al.* 2013).

c. Flora and Fauna

Archaeobotanical remains were not retrieved during rescue operations. As far as faunal remains are concerned, personal examination of the skeletal material from Lophou *Koulazou* did not reveal the presence of animal bones in the tombs containing human remains.

d. Human remains

A small assemblage of very fragmented and poorly preserved human remains was recovered from Tombs 8, 9, 13, 15, 17, 18-21 of Lophou *Koulazou*. Although the skeletal material has not been fully studied yet, the general fragmentary state of the human remains is likely to severely limit the anthropological investigation.

Health status

Personal examination of the human remains from Lophou *Koulazou* revealed the presence in Tomb 15 of two fragments pertaining to the same mandible (Figure 6.18); among the 7 *in situ* teeth (3 incisive, 2 canine and 2 first premolars), the right incisive and the right canine show possible evidence of enamel hypoplasia.

Figure 6.17 Photo of mandible recovered in Tomb 15 at Lophou *Koulazou*. Photo by author.

Personal examination of the human remains from Lophou *Koulazou* revealed the presence in Tomb 15 of two fragments pertaining to the same mandible (Figure 6.18); among the 7 *in situ* teeth (3 incisive, 2 canine and 2 first premolars), the right incisive and the right canine show possible evidence of enamel hypoplasia.

e. Isotopic study

Materials

A total of five bone samples were collected from Lophou *Koulazou* for conducting stable isotope analysis (Table 6.18). The same bone samples previously used for radiocarbon dating were chosen for sampling.

Table 6.18 Bone samples analysed from Lophou *Koulaouzou*. Abbreviation: cba = cannot be assessed

SAMPLE NAME	TOMB	CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
LT15_2	Tomb 15	EC I-MC I*	femur shaft	cba	adult
LT17	Tomb 17	EC-MC**	femur shaft	cba	adult
LT19	Tomb 19	EC-MC**	humerus shaft	cba	adult
LT20_2	Tomb 20	EC I-MC I*	femur shaft	cba	adult
LT21	Tomb 21	EC-MC**	femur shaft	cba	adult

*From radiocarbon dating

**From analysis of ceramic assemblages

Results

The bone samples were prepared and measured for stable isotope analysis (carbon and nitrogen) at the DiSTaBiF Laboratory of the Seconda Università di Napoli (Italy). The results are shown in Table 6.19.

Table 6.19 Stable isotope values yielded by the human samples of Lophou *Koulazou*. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. Analytic error is 0.1‰ for δ^{13}C and 0.2‰ for δ^{15}N values. Abbreviation: n = not measured

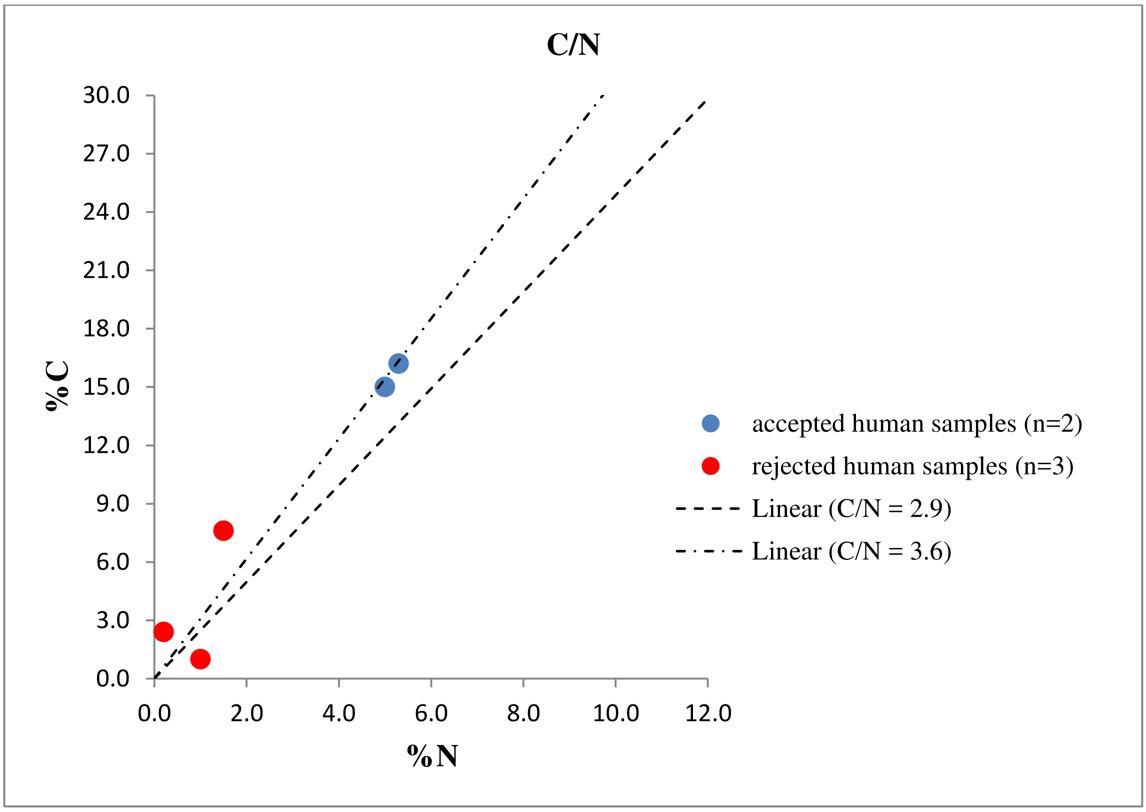
SAMPLE	COLLAGEN YIELD	%C	%N	C/N	δ^{13}C collagen (PDB, ‰)	δ^{15}N collagen (AIR, ‰)
LT15_2	**0.5%**	**16.2**	**5.3**	**3.6**	**-19.8**	**7.2**

LT17	0.4%	2.4	0.2	15.2	n	n
LT19	0.3%	1.0	1.0	1.2	n	n
LT20_2	**0.5%**	**15.0**	**5.0**	**3.5**	**-19.7**	**8.6**
LT21	0.2%	7.6	1.5	6.0	-20.1	6.1

Preservation state

The analysed bone samples yielded very low collagen yields ranging from 0.2% to 0.5% and attesting to the poor preservation of the skeletal material. The samples with collagen yields below 0.5% also showed unacceptable values of C/N ratio, %C and %N and were thus rejected (Figure 6.18).

Figure 6.18 Elementary contents (C, N) in the validated collagen extracts and the C/N range proposed by DeNiro (1985).



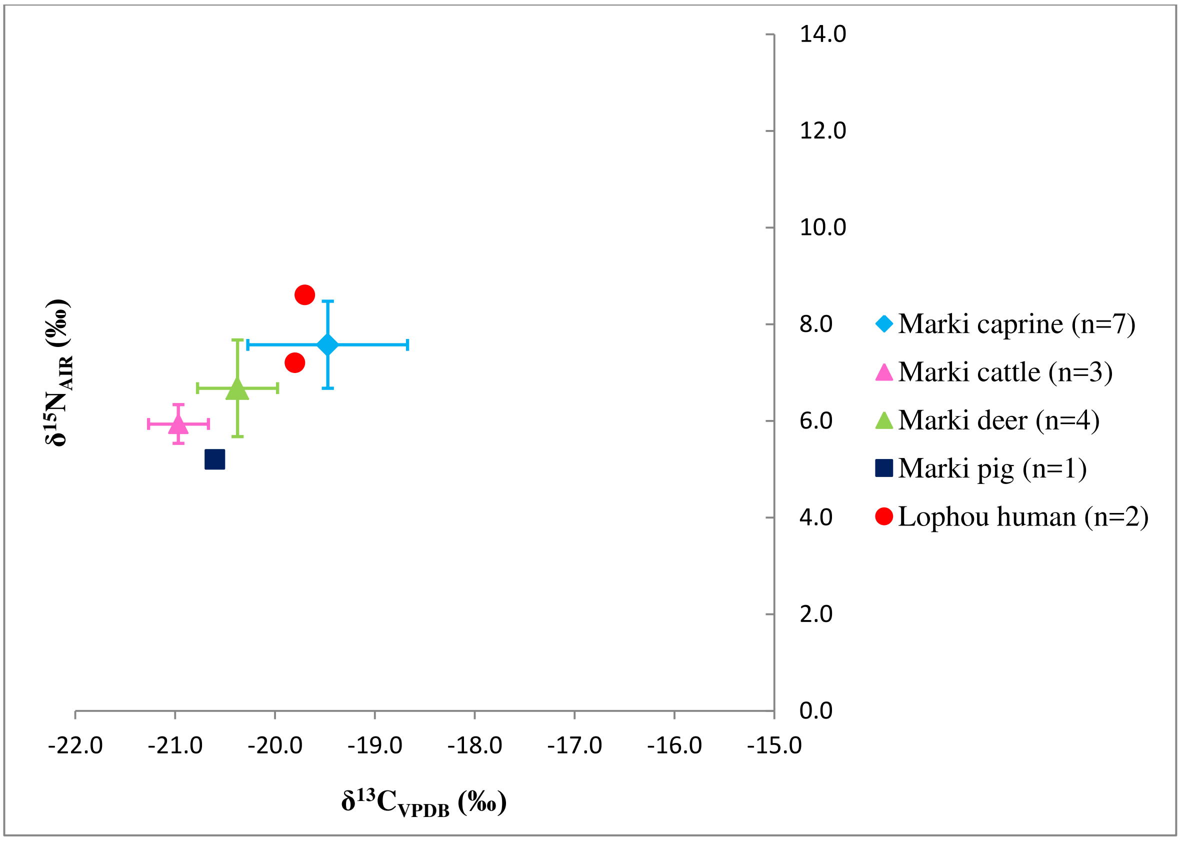
Human Isotope Values

The two individuals from Tombs 15 and 20 yielded isotope values pointing to a mainly terrestrial-based diet. While their $\delta^{13}C$ values are almost identical, their nitrogen isotope ratios are rather different, possibly indicating a different diet.

Summary and Discussion

Only two bone samples were successfully analysed from the cemetery area of Lophou *Koulaouzou*. Both the individuals show isotope values consistent with a mainly terrestrial-based diet. In view of the absence of faunal isotopic data referring to the area of the Kouris River valley during the Bronze Age, the isotope results from Lophou have been preliminary referred to the faunal isotopic dataset from Marki *Alonia* (Chapter 6.2.1). Accordingly, it would seem that both these two individuals had a diet not very rich in animal proteins (Figure 6.19).

Figure 6.19 Collagen stable isotope values of the individuals from Lophou *Koulazou* plotted against the mean collagen faunal isotope values of caprines, cattle, deer and pig from Marki *Alonia*.



6.2.5. ERIMI-LAONIN TOU PORAKOU

Erimi *Laonin tou Porakou* is located in the middle Kouris River valley, at a distance of about 10 km from the sea (Figures 1.1 and 3.2). The archaeological area lies on the highest hilltop of the eastern riverbank, facing southward the modern Kouris dam, on the border between the modern villages of Ypsonas and Erimi.

The site was first identified in 2007 as a result of a survey project conducted in the middle and lower Kouris River valley, with the purpose of outlining the landscape use and the sequence of ancient occupation in the Kourion region (Jasink *et al.* 2008; Bombardieri 2010). Since 2009, the site has been systematically investigated under the direction of L. Bombardieri, as a joint project of the Universities of Torino and Firenze in collaboration with the Department of Antiquities of Cyprus. The six-years excavation program carried out at Erimi *Laonin tou Porakou* has brought to light the remains of a Middle Cypriot settlement and a contemporary necropolis, whose findings are soon to be published in a first comprehensive volume of the site (Bombardieri *forthcoming*).

a. Chronology

The general chronology of Erimi *Laonin tou Porakou* points to two main periods of occupation (Periods 1 and 2). The earlier Period 2, dating to the Middle Bronze Age, is currently the best documented one with two phases (Phases A and B) attested stratigraphically. The following Period 1 occupation follows a lengthy *hiatus*, and it is related to a sporadic use of the area during the Hellenistic and Roman periods (Bombardieri 2014).

Dating materials

The pottery from Erimi *Laonin tou Porakou* originate from three different areas described in details further below: Areas A and B of the settlement and Area E, the necropolis. The ceramic assemblage has been recently studied by J. Webb (*forthcoming*). It is comprised mainly of local variants of Red Polished (RP) and Drab Polished (DP) wares, added to a number of imported fine quality vessels of RP III and several imported DP vessels of probably west coast origin. Generally speaking, diagnostic materials from Phases A and B of the settlement are not markedly different and there seems to be little variation in ceramic wares, styles and forms during the period in which the site was occupied. On a chronological basis, the ceramic assemblage point to a short period of occupation embracing the whole Middle Cypriot.

Radiocarbon dating

A five-years program dedicated to the accurate selection of samples to be destined to radiocarbon dating has been carried out at the site of Erimi *Laonin tou Porakou* in order to obtain a reliable ^{14}C-based chronology (Scirè Calabrisotto & Fedi *forthcoming*). In total, 7 charcoal samples[4] and 17 bone fragments collected during the 2010-2014 field seasons from Area A and Area E, respectively, were collected for radiocarbon dating. Charcoal samples to be dated were selected either from primary deposits within a well-defined stratigraphy or from secondary deposits for which a clear interpretation had been made. On the other hand, prior to the collection of the bone samples, a preliminary anthropological analysis finalized to the identification of the minimum number of individuals (MNI) of each tomb was performed, so as to collect at least one bone sample from each individual.

All the samples were prepared and measured by Accelerator Mass Spectrometry (AMS) at the LABEC Laboratory - Laboratorio di tecniche nucleari per l'Ambiente e i BEni Culturali - of INFN – Istituto Nazionale di Fisica Nucleare - in Florence (Italy). Prior to the AMS measurement, specific procedures were adopted for charcoals and bones to prepare the samples to be dated: after mechanical cleaning, charcoal samples were chemically pre-treated following the so-called conventional ABA method, the main steps of which can be seen for example in Cartocci *et al.* 2007. Concerning the bone samples, radiocarbon measurements were conducted on the collagen residues extracted following the procedure described for example in Scirè Calabrisotto *et al.* 2013. All the successfully extracted collagen residues were also analysed for their C/N atomic ratio in order to check the quality of collagen (see Table 6.21). Specifically, at INFN-LABEC, the cut-off points indicated by DeNiro (DeNiro 1985) are taken as reference: C/N ratios should not fall outside the recommended range of 2.9-3.6, otherwise indicating a probable contamination of the sample. As a consequence, all the collagen extracts showing outsider values of C/N atomic ratio have been considered as not reliable and discarded.

Collagen was successfully extracted in 12 out of 17 bone samples (about 70% of the processed bones), with collagen yields ranging between 0.5% and 5% in relation to the mass of the whole bone sample. Evaluation of the C/N ratio measured on the 12 collagen residues resulted in the rejection of two samples from Tomb 228 (Tomb228_4 and Tomb228_sub) as they displayed unacceptable C/N values outside the recommended range of 2.9-3.6 (within the experimental uncertainty of 0.2). In general, collagen was better preserved in the bone samples collected from the two chamber tombs (248 and 428) while the highest degree of collagen degradation was recorded in those samples taken from the

[4] A further radiocarbon date comes from a charcoal sample, named Ch_us394, collected from a superficial archaeological layer of Area A (see Scirè Calabrisotto *et al.* 2012). However, given the ambiguous provenance of that material and the very late date obtained (Byzantine period), this evidence has not been considered in this chapter.

two looted tombs (228 and 230) and the pit tomb (328). Preliminarily, we can ascribe this evidence to several factors like the burial mode, the different exposure of the skeletal remains to weathering agents and bone manipulation probably occurred during looting activities. In any case, further research would be needed to clearly identify the diagenetic patterns affecting the archaeological area of Erimi *Laonin tou Porakou*.

The measured radiocarbon ages of the charcoals and of the validated collagen extracts are displayed in Tables 6.20 and 6.21, respectively.

Table 6.20 Measured radiocarbon ages and stratigraphic context of the charcoal samples.

Sample name	Radiocarbon Age (years BP)	Phase (as from stratigraphy)
Ch_us636	3900 ± 35	SA III, US 636 phase B
Ch_us459B	3720 ± 35	SA I, us 459 phase B
Ch_us391	3750 ± 30	WA V, US 391 phase A
Ch_us392	3795 ± 35	WA V, US 392 phase A
Ch_us630	3730 ± 35	SA III, US 630 phase A
Ch_us423	3645 ± 35	SA IIa, US 423 phase A
Ch_us427	3450 ± 70	SA IIa, US 427 phase A

Table 6.21 Measured radiocarbon ages and C/N ratios of the bone samples.

Tomb id. Number	Sample name	C/N (± 0.2)	Radiocarbon Age (years BP)
228	T228_1	3.4	3145 ± 30
230	T230_1_f	3.4	3500 ± 65
230	T230_1_o	3.5	3450 ± 55
230	T230_2	3.4	3240 ± 40
248	T248_1	3.7	3620 ± 40
248	T248_2	3.8	3570 ± 55
248	T248_3	3.3	3470 ± 70
328	T328_B2	3.4	3340 ± 100
428	T428_1	3.3	3730 ± 50
428	T428_2	3.2	3540 ± 45

In order to allow for an overall description of the temporal relationship between Area A and Area E, the radiocarbon data from Erimi *Laonin tou Porakou* have been evaluated through Bayesian analysis with OxCal software (Bronk Ramsey 2009a; 2009b) and IntCal

13 (Reimer *et al.* 2013) as the reference calibration curve. Specifically, when arranging the radiocarbon measurements into the Bayesian chronological model, the following information, based on *a priori* archaeological evidences, have been incorporated:

1. Considering that the workshop complex and the Cemetery had been utilized within the same cultural horizon, the charcoal samples from Area A and the bone samples from Area E have been arranged in two separate but overlapping sequences.
2. The sequence of the workshop complex has been subdivided into two phases (phase B and phase A) and the charcoal samples have been disposed according to their stratigraphic context.
3. Tombs 228 and 230 have been found looted and thus constitute a dubious context. Hence, the radiocarbon data from these two tombs have been excluded from the model.
4. The sequence of utilization of Tombs 248, 328 and 428 cannot be independently assessed therefore the bone samples have been arranged into a unique phase named "all tombs".

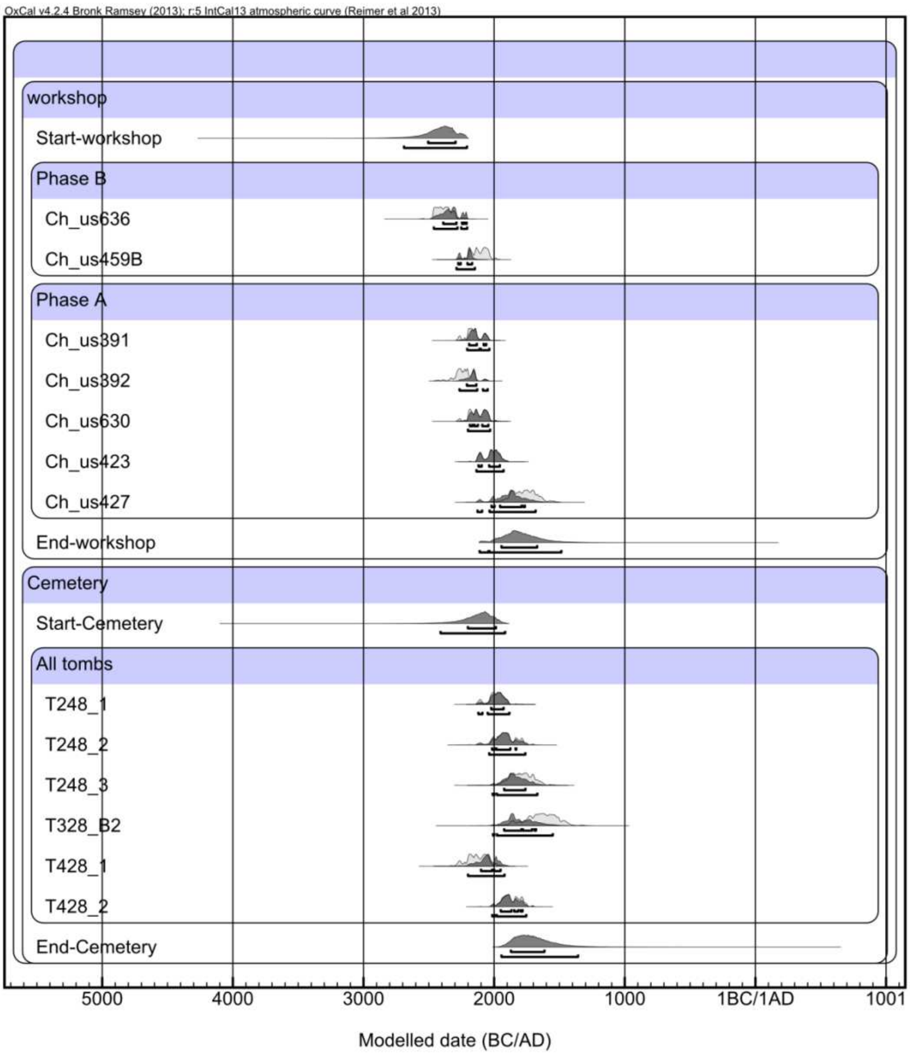
The results of the Bayesian model are summarised in Table 6.22 and displayed in Figure 6.20. The reliability of the model was evaluated via the so-called agreement index (A) which, according to Bronk Ramsey, should not fall below 60%. In this case, the agreement index has been calculated as 62%, meaning that a satisfying agreement between the *a priori* archaeological information and the radiocarbon data has been obtained.

Table 6.22 Modelled dates indicating the calibrated ages of each sample and the ranges estimated for the Start and End boundaries of the workshop and the Cemetery sequences.

Area A and Area E Sequences	Modelled dates (BC) 68% level of probability	Modelled dates (BC) 95% level of probability
Start workshop complex	*2510-2290*	*2710-2200*
Phase B		
Ch_us636	2400-2210	2470-2200
Ch_us459B	2280-2160	2290-2140
Phase A		
Ch_us391	2200-2060	2210-2030
Ch_us392	2210-2130	2270-2050
Ch_us630	2190-2040	2210-2030
Ch_us423	2120-1950	2140-1920
Ch_us427	2020-1760	2130-1680

End workshop complex	*1950-1670*	*2120-1460*
Start Cemetery	*2200-1980*	*2410-1910*
All tombs		
T248_1	2030-1920	2130-1880
T248_2	2020-1830	2040-1760
T248_3	1940-1760	2020-1670
T328_B2	1940-1710	2020-1550
T428_1	2110-1940	2200-1920
T428_2	1960-1780	2020-1750
End Cemetery	*1880-1610*	*1960-1370*

Figure 6.20 Modelled calibrated dates arranged in a chronological graph. The grey distributions represent the non-modelled calibrations while the solid distributions show the results after Bayesian modelling. The bars beneath the distributions indicate the 68% and 95% ranges obtained from the analysis.



As evidenced in Table 6.22, the Bayesian model seems to suggest that the workshop complex was realised some time before the utilization of the Cemetery and that they were abandoned more or less during the same period. However, because the sequence of radiocarbon data from Area A is dominated by long-lived materials, this information should be considered with caution. Indeed, as already noticed before, it is probable that the calibrated ranges of the charcoals could be biased towards older ages owing to old wood issues. This problem has been frequently encountered also in other prehistoric sites of Cyprus and in this regards Manning noted that the radiocarbon dates on long-lived samples sometime show substantial and varying inbuilt ages probably due to sampling of inner tree-rings from reasonably old trees or re-used wood (Manning 2013b: 3).

Unfortunately, the current evidence from Erimi *Laonin tou Porakou* do not allow for the accurate estimation of the age offset possibly associated to the charcoal samples and only some preliminary considerations on the maximum lifespan of identified timber species can be made. Specifically, we can notice that the oldest estimates were obtained from sample Ch_us636, recognised as *Olea* species. In general, olive trees are not suitable for dendrochronology (on that problem see for example Cherubini *et al.* 2014) but some studies exist that have estimated a maximum age range of around 700 years for this species (Thomas 2003; Arnan *et al.* 2012). On the other hand, samples Ch_us459B, Ch_us391, Ch_us392 and Ch_us630, identified as *Pinus* sp., produced calibrated ages only a century or so older than the bone samples. In this case, we can report the data obtained from Griggs *et al.* 2013 who found that a maximum lifespan of about 150-300 years is usually observed in *Pinus Brutia*, the most common pine tree found at lower to mid elevations in Cyprus.

With reference to Area E, the dates produced by the short-lived bone samples appear more uniform although they seem to suggest a slightly earlier utilization of Tomb 428. Indeed, taking the 68% confidence intervals into consideration, Tomb 428 would have been used between the EC III and MC III period while Tombs 248 and 328 have been dated to the MC I-III.

In the light of these considerations, the estimated Start of the workshop complex between 2510-2290 BC, corresponding to the Late Chalcolithic and Philia phase, seems unreliable and only future research intended to collect further radiocarbon data from short-lived remains will help to better define the chronology of Area A. On the other hand, the 2200-1980 BC range obtained for the Start of the Cemetery, referring to the period between EC I and MC I, appears more accurate and consistent with the archaeological evidence. As for the End of the two sequences of Area A and Area E, the estimated ranges are more similar and point to the MC I-III in the case of the workshop complex and MC II-III for the Cemetery (at 68% level of probability).

For the sake of completeness, I comment here the radiocarbon ages obtained from Tombs 228 and 230 which have been excluded from the Bayesian model. The corresponding calibrated ranges were published in Scirè Calabrisotto *et al.* 2012 and Scirè Calabrisotto *et al.* 2013 but they are reconsidered here in the light of new archaeological and radiocarbon data. In terms of Cypriot chronology, sample T228_1 from Tomb 228 yielded dates pointing to the Late Cypriot while samples T230_1 and T230_2 from Tomb 230 were dated to the Middle Cypriot and to the Late Cypriot, respectively. While the dates of sample T230_1 are consistent with the radiocarbon evidence from Tombs 248, 328 and 428, the LC ranges of samples T228_1 and T230_2 seem anomalous. Towards this purpose we should recall that Tombs 228 and 230 were found looted and thus represent unsealed archaeological contexts where intrusive material could potentially have been introduced. The possibility that the pre-treatment procedure could have failed to remove all the contaminations might also be hypothesized though it should be noticed that both samples T228_1 and T230_2 yielded C/N ratios within the acceptable range of 2.9-3.6 (see Table 6.21). Ultimately, current evidence do not allow for a clear explanation of the later dates of samples T228_1 and T230_2 and more research is needed in order to better interpret these results.

b. Site description

Excavations at Erimi *Laonin tou Porakou* have revealed the presence of a Bronze Age settlement organised into three discrete areas destined to a different use and function (Figure 6.21): Area A, located on the top of the hill, and Area B, on the first lower terrace, were occupied by a workshop complex and a domestic quarter, respectively; Area E, extending over two terraces sloping toward south, corresponded to the southern cemetery (Bombardieri 2013, 2014, *forthcoming*).

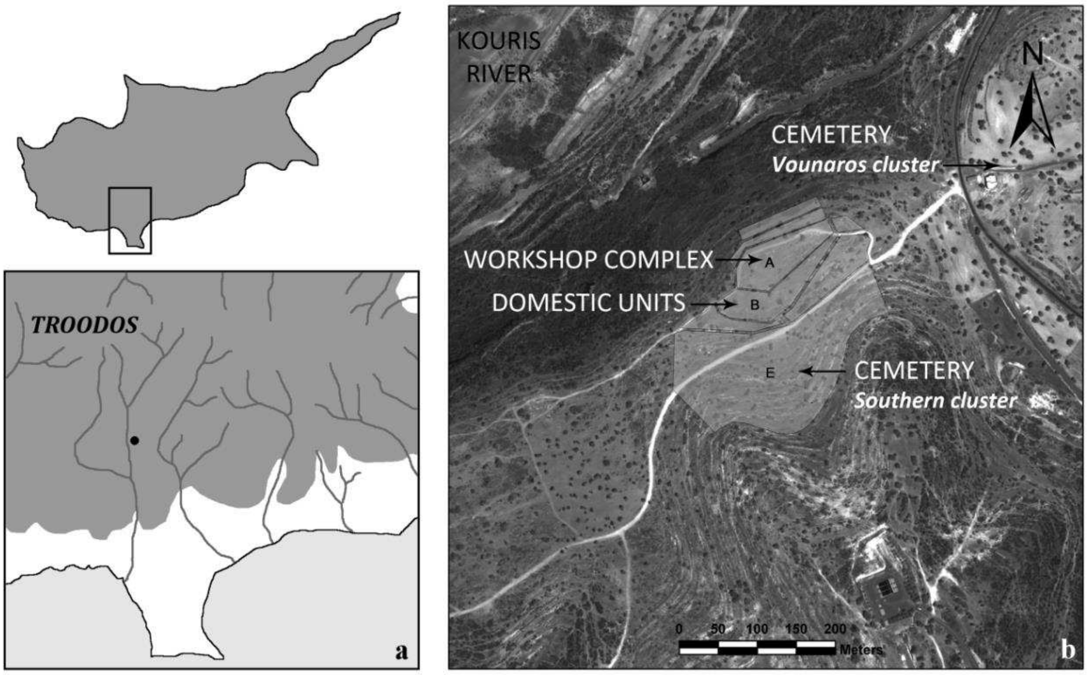
A further funerary cluster contemporary to the settlement and located eastward of it was identified in 2012 during rescue-excavations carried out by the Department of Antiquities of Cyprus in the area of Ypsonas *Vounaros* (Christofi *et al.* 2014).

Area A: the workshop complex

Located on the top of the hill, Area A corresponds to the productive complex of the settlement, organised with a distinctive layout made of open spaces and roofed units (Bombardieri 2013, *forthcoming*). The workshop complex currently extends over an area of 625 m^2 and it is functionally arranged into 12 discrete units/spaces: five open spaces (WA I - WAV), four roofed units (SA I-SA III, SA VI) and three additional units/spaces as yet not fully excavated, respectively to the north-east (SA IV-V) and south-west (SA VII) of the actual extension of the complex. The structural elements (installations and work places) and residual artefacts (tools, containers, special purpose vessels) connected with storage and working activities, and their spatial distribution within the complex, helped to characterise and understand the nature and development of this productive complex, presumably devoted to the textile production (Bombardieri 2014).

Two main phases of utilization have been evidenced within Area A. The earlier phase B corresponds to the beginning and progressively increasing workshop activity, which led to the first installation of an organized complex dedicated to. The more recent phase A is marked by a new occupation of the settlement and a re- organisation of workshop activity, during which some of the former installations were reused while others were built as new.

Figure 6.21 Location and site plan of Erimi *Laonin tou Porakou* showing the three main investigated areas. Courtesy of Luca Bombardieri.



Area B: the domestic quarter

Investigations in Area B have exposed the foundations of what has been interpreted as a large housing space, extending over an area of 20 x 15 meters currently investigated. A series of five roofed domestic units (Rooms 1-3, 5, 7) is organized around open rectangular courts (Courts 4, 6), where small working installations such as pots emplacements and basins carved into the limestone bedrock have been recovered. Three large rooms extend to the north (Rooms 2, 3 and 5) and all overlook Court 4, which appears to have been functionally associated with several roofed spaces. Overall, the domestic quarter seems to correspond to a complex of roofed spaces and open areas, linked by entrances and passages, and characterized by a continuous sequence of occupation, as attested for example in Room 2, where rock-cut and clay features pertaining to the earlier phase B had been later reused in phase A with only minor renovations or the addition of new structures built with stone slabs (Bombardieri 2013). With reference to the material culture, only few attestations of domestic installations (fire places, hearts and mealing bins) and related cooking equipment (pots, processing stone tools like pestles, rubbers and querns) have been recovered (Bombardieri *forthcoming*).

Worth of mention is the recent excavation of Area T2, located to the south-west of the workshop complex (Area A) and to the east of the already excavated residential area (Area B) (Bombardieri 2016, unpublished site excavation report). Here a large pit directly carved into the bedrock and presumably used as a domestic dump structure was recovered, filled in with a deposit of discarded ground stone tools, fragmentary clay mealing bins, palaeobotanical remains and a few animal bones.

Area E: the southern cemetery

As mentioned above, an *extra moenia* cemetery area extends towards the east and south of the Bronze Age settlement, including two distinct and contemporary tomb clusters (Bombardieri 2014, *forthcoming*). The southern funerary cluster extends immediately outwards from the settlement along two of the natural limestone terraces sloping towards southeast, where a series of eleven rock-cut tombs (Tombs 228-232; 240-241, 248, 328, 427 and 428) were excavated during the 2008-2014 seasons.

As to the funerary architecture, three major types of tombs were identified: pit tombs (T427, T240, T328), chamber tombs (T228-230, T232, T248, T428) and pit/chamber tombs (T231, T241). Pit tombs have elliptical or irregularly rounded plan and have been carved within the natural flat surface of the lowest identified terrace. Chamber tombs are more elaborated tombs and have single or double irregularly rounded chambers with a cave-like section. A short *dromos* leads to the grave chamber of tombs 228-230, located on the upper terrace and unfortunately found looted; differently, deeper shaft *dromoi* were cut in the lower terrace where the entrances of tombs 232, 248 and 428 were roughly outlined by regularizing the terrace façade.

c. Flora and Fauna

Palaeobotanical remains

During the 2010-2012 excavation campaigns, soil samples were collected from the filling of specific archaeological features and from the inside of ceramic vessels (from both Areas A and E). Preliminary morphological observations and analyses allowed the identification of abundant mineralised nutlets, rare seeds of a few other plant species and a mixture of charcoal and small snails. The small number of the finds is probably attributable to the chemical composition of the sediments which has proved particularly aggressive on all types of organic materials. The identified carpological remains comprise rare diaspores of taxa: *Anchusa* cf. *officinalis*, *Echium plantagineum*, *Galium* sp., *Onopordum* sp., *Illyricum cyprium*, *Ajuga chamaepitys*, cf. *Medicago* sp., cf. *Calendula* sp. and cf. *Leontodon* sp. representing a taphonomical/artificial selection of the vegetation growing in the surroundings of the archaeological area. These taxa are all wild species and no evidence of food plants has been found. Mineralisation is the most frequent type of preservation and only one charred fragment belonging to *Galium* sp. was recovered (Vassio & Bombardieri *forthcoming*).

Most recently, archaeobotanical material retrieved from soil samples collected from Area T2 has provided some information on the crops possibly cultivated in the vicinity of the site. The plant remains are badly preserved, consisting mainly of fragments of seeds, due to post depositional processes. However, it was possible to identify cereals such as barley and emmer wheat, lentils, grape and fig. Fragments of emmer wheat chaff were also found. The presence of chaff in the assemblage is interesting, as it provides information for crop processing activities. The chaff is removed for the glume wheats, such as emmer, only if it is going to be used for human consumption. In addition, the presence of chaff suggests that at least the later stages of crop processing, like the removal of the chaff by light pounding or charring, was undertaken in the settlement (Scirè Calabrisotto *et al. forthcoming*).

Faunal remains

A small assemblage of faunal remains was recovered during the 2016 archaeological campaign in Area T2 (Bombardieri 2016, unpublished site excavation report). Preliminary examination of the material has led to the identification of one molar of a goat and one incisive of a sheep/goat. The remaining skeletal remains (10 pieces in total) are quite fragmentary and they have not yet been fully studied.

d. Human remains

Human remains were recovered in Tombs 228, 229, 230, 248, 328, 427 and 428, all containing collective burials. A minimum number of 21 individuals resulted from the anthropological analysis (Albertini *forthcoming*). Specifically, the analysis of the skeletal remains from Tomb 228 revealed at least 4 individual (MNI=4): one subadult between 3 and 12 years old and three adults among whom at least one male is present. The osteological remains recovered from Tomb 230 point to at least 2 adult individuals, including one adult, probably female, fairly represented and a further individual attested only by two humeral shafts. The scant remains of 4 individuals were identified in Tomb 328, including at least one adult probable female; the analysis of tooth wear suggest the presence of a young adult, a juvenile individual of more than 15 years of age, and two subadults, one with an age ranging from 8 to 11 years and the other of 3 ± 2 years old. Tomb 248 contained the skeletal remains of at least 4 individuals: two middle adults possibly male, one female of young age and an individual of an age range straddling the boundary between adolescence and young adult age. As far as Tomb 428 is concerned, a minimum number of four individuals has been estimated on the basis of two pairs of femurs to be possibly connected to a male and a female adults, one additional right femoral shaft relating to a third adult, and a further right femur combined with two postcranial elements (clavicle, radial shaft) pertaining to one subadult individual.

During the 2016 archaeological campaign, the anthropological analysis of the skeletal remains recovered in Tomb 427, excavated in 2014, and Tomb 429, excavated in 2016, was also completed. However, because this material was not included within this study, it is not described here.

Health status

Concerning dental pathologies calculus formations were recorded only on five teeth, all showing a low expression degree. The low incidence of calculus is commonly connected with a diet poor in sugar and starches. It is worth mentioning that, since the calculus is a calcified deposit, its presence and identification is conditioned by the calcareous depositional soil. Only in 9 cases (i.e. 6.9% of the recovered teeth), the presence of a caries was also identified. The low prevalence of these lesions could be also linked to nutritional factors. At Erimi, hypoplasia has been documented in two individuals, both from chamber Tomb 228. Thus, it seems plausible to argue for a hereditary origin in the manifestation of this anomaly. On the post-cranial skeleton remains, arthropathic alterations were observed on all the vertebral elements recovered from Tombs 230 and 248 although it is not possible to associate these elements to a specific individual with an assigned age at death. As to the enthesopathies, some alterations were identified on anatomical elements from Tombs 228, 248 and 428 (Albertini *forthcoming*).

e. Isotopic study

Materials

In total, 14 bone samples taken from the osteological collection of Tombs 228, 230, 328, 248 and 428 were analysed (Table 6.23). As in the case of Lophou *Koulaouzou*, the same anatomic elements chosen for radiocarbon dating were chosen for conducting stable isotope analyses.

Table 6.23 Bone samples analysed from Erimi *Laonin tou Porakou*.

SAMPLE NAME	TOMB	CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
T228_1	Tomb 228	LC*	right femur	M	adult
T228_2	Tomb 228	MC**	right femur	unknown	adult
T228_3	Tomb 228	MC**	left femur	unknown	adult
T228_4	Tomb 228	MC**	left femur	unknown	adult
T230_1_f	Tomb 230	MC*	left femur	F	adult
T230_2	Tomb 230	LC*	right humerus	unknown	adult
T248_1	Tomb 248	EC III-MC I/II*	left femur	M?	adult
T248_2	Tomb 248	EC III-MC I/II*	left femur	unknown	adult

T248_3	Tomb 248	EC III-MC I/II*	left femur	unknown	adult
T328_B1	Tomb 328	MC**	left femur	unknown	adult
T328_B2	Tomb 328	EC III-MC I/II*	right femur	unknown	adult
T328_B3	Tomb 328	MC**	right femur	unknown	adult
T428_1	Tomb 428	EC I/II-MC I/II*	right femur	F	adult
T428_2	Tomb 428	EC III-MC I/II*	right femur	M	adult

*From radiocarbon dating; **From ceramic chronology

Results

All the samples were prepared and measured for their carbon and nitrogen isotopic ratios at the IRMS Laboratory of the DiSTABiF laboratory of the Seconda Università di Naples (Caserta, Italy). The results are shown in Table 6.24.

Table 6.24 Stable isotope values yielded by the human samples of Erimi L*aonin tou Porakou*. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. Analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values.

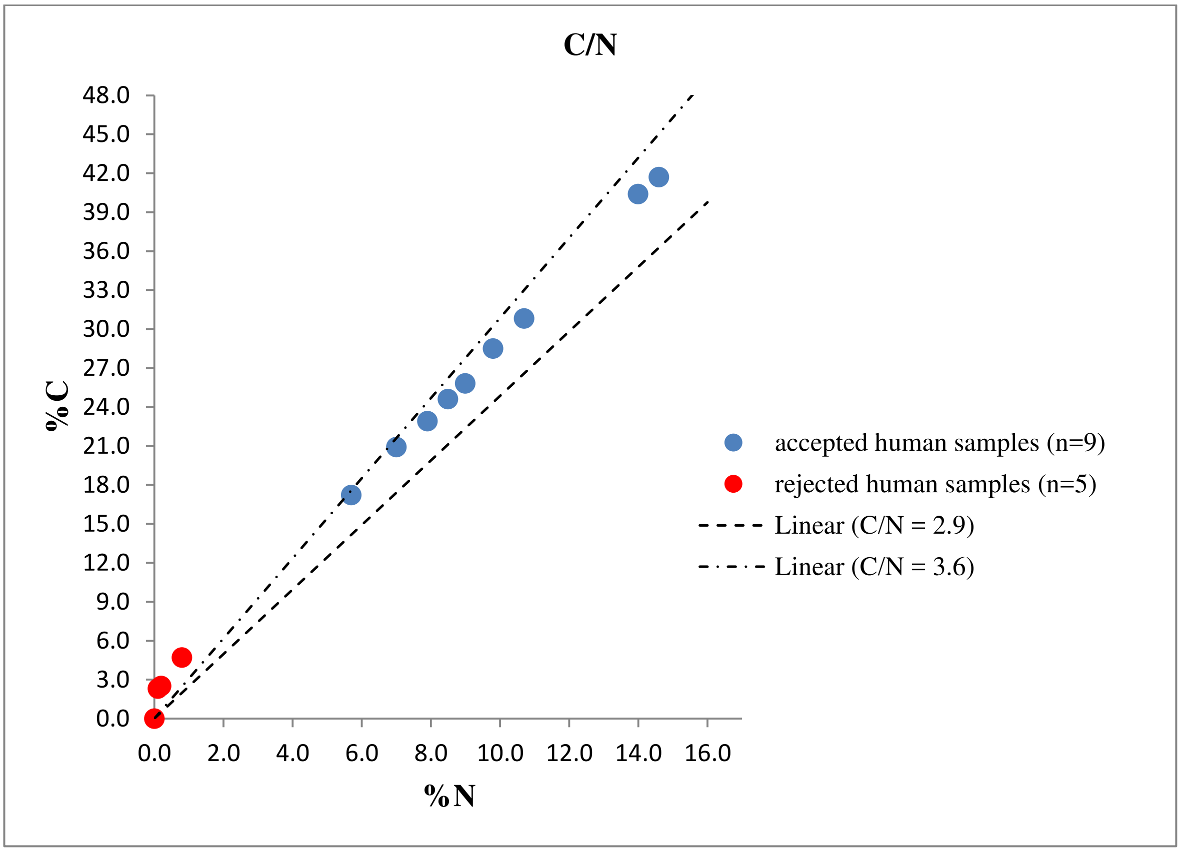
SAMPLE	COLLAGEN YIELD	%C	%N	C/N	$\delta^{13}C$ collagen (PDB, ‰)	$\delta^{15}N$ collagen (AIR, ‰)
T228_1	**0.5%**	**17.2**	**5.7**	**3.5**	**-19.7**	**9.6**
T228_2	0.3%	2.5	0.2	16.9	-21.0	8.3
T228_3	0.2%	2.3	0.1	24.1	n	8.1
T228_4	0.3%	0.9	-0.4	-2.7	n	n
T230_1_f	**0.5%**	**22.9**	**7.9**	**3.4**	**-20.0**	**9.5**
T230_2	**0.3%**	**28.5**	**9.8**	**3.4**	**-19.7**	**10.0**
T248_1	**1.3%**	**30.8**	**10.7**	**3.4**	**-20.2**	**10.2**
T248_2	**0.5%**	**25.8**	**9.0**	**3.4**	**-19.6**	**9.2**
T248_3	**0.5%**	**24.6**	**8.5**	**3.4**	**-18.0**	**8.4**
T328_B1	0.2%	n	n	n	n	n
T328_B2	**0.5%**	**20.9**	**7.0**	**3.5**	**-19.8**	**8.1**
T328_B3	0.3%	4.7	0.8	6.6	-19.6	12.5
T428_1	**2.6%**	**41.7**	**14.6**	**3.3**	**-19.8**	**9.7**
T428_2	**1.5%**	**40.4**	**14.0**	**3.4**	**-19.7**	**9.8**

Preservation state

Collagen yields ranged from 0.3% to 2.6% with lowest masses occurring in the samples collected from the two looted tombs (T. 228 and 230) and from the pit tomb (T. 328). Collagen samples with yields of 0.5% and higher produced acceptable values of C/N ratio, %C and %N and they were thus considered well-preserved. A further sample, T230_2, showing a very low collagen yield of 0.3% but acceptable C/N ratio and carbon and nitrogen percentages very close to that of fresh bone collagen was also believed to contain intact collagen.

Ultimately, nine bone samples were deemed acceptable for this study and for discussing the palaeodiet of the community of Erimi *Laonin tou Porakou* (Figure 6.22).

Figure 6.22 Elementary contents (C, N) in the validated collagen extracts and the C/N range proposed by DeNiro (1985).



Human isotope values

The δ^{13}C and δ^{15}N values of the validated collagen extracts are summarised in Table 6.25. In brief, the δ^{13}C values range from -20.2‰ to -18‰ with a mean δ^{13}C value of -

19.6‰; on the other hand, the $\delta^{15}N$ values span from 8.1‰ to 10.2‰ with a mean $\delta^{15}N$ value of 9.4‰. Due to the unavailability of contemporary faunal isotopic data from the area of the Kouris River valley, these results have been preliminarily compared to the isotopic ranges obtained from a set of faunal samples from Marki *Alonia* (Chapter 6.2.1). Accordingly, a predominantly terrestrial-based diet characterised by C_3 plants and proteins derived from C_3-feeding animals, with no evidence of regular fresh water or marine food consumption, can be suggested for the people of Erimi. Samples T228_1, T230_1 and T230_2 originating from the looted Tombs 228 and 230 yielded isotope values consistent with the data obtained from the other individuals. However, palaeodietary information related to these samples should be considered with caution due to the fact that Tombs 228 and 230 represent unsealed contexts.

Table 6.25 Summary of the isotope values of Erimi *Laonin tou Porakou*.

HUMAN	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C$ (‰)	-19.6	-19.7	0.6	2.2	-20.2	-18.0	9
$\delta^{15}N$ (‰)	9.4	9.6	0.7	2.1	8.1	10.2	9

Notwithstanding the small size of the dataset, the isotope values seem to suggest that the people of Erimi *Laonin tou Porakou* may have had differential access to certain resources. In particular, samples T328_B2 and T248_3 show the most negative $\delta^{15}N$ values (8.1‰ and 8.4‰ respectively), suggesting that these two individuals either had minor access to animal proteins or were consuming a higher quantity of pulses and/or animals fed with legumes. Worthy of note also is the most positive $\delta^{13}C$ of -18‰ yielded by sample T248_3. Unfortunately, the cause of ^{13}C-enrichment in this individual cannot be exactly determined on the basis of current isotopic evidence. Indeed, the data seem to suggest that neither the consumption of marine food nor the contribution of C_4 resources – so far not evident in the human and animal isotopic data analysed within this study – might be taken into account.

Summary and Discussion

Preliminary isotopic evidence obtained from the human skeletal remains recovered in the southern funerary cluster (Area E) points to a prevalent terrestrial-based diet with consumption of C_3 plants and a variable intake of terrestrial animal proteins from animals feeding in a C_3 ecosystem.

As for the exploitation of aquatic resources, there is no isotopic evidence for heavy fresh water or marine consumption. The Kouris River most likely represented a source of freshwater food like fishes, snails and crabs and the recovery in Areas A and B of 26 marine shells implies that the sea coast was occasionally frequented. However, this kind of resources was probably overlooked in favour of more continuous supplies derived from livestock-based agro-pastoralism. Such hypothesis seems further supported by the analysis of the marine shell assemblage which has revealed that they were most likely collected dead on the beach and not utilized for dietary purposes (Reese & Yamasaki *forthcoming*).

Further useful information about the dietary habits of the community of Erimi *Laonin tou Porakou* derives from dental analysis. Specifically, the low frequency of caries attested in the analysed individuals can probably indicate an abrasive diet made of tough, unrefined and fibrous foods and/or a significant consumption of dairy products (Albertini *forthcoming*). Both the hypotheses are consistent with the isotopic results and would fit well into an agro-pastoral food system.

6.2.6. ERIMI-KAFKALLA

The wide cemetery area of Erimi *Kafkalla* is located about 3 kilometres north of the modern village of Erimi (Figures 1.1 and 3.2).

Two large necropolises have been identified at the localities of *Kafkalla* and *Pitharka* that share many features and both show a long period of utilization, from the Bronze Age to the Roman period. It is probable that these two areas once formed a vast and unique cemetery, later encompassed within the settlement area of *Pitharka* which became a complex centre during the LC II/III period and lasted until the Hellenistic and Roman Age (Flourentzos 2010).

The Department of Antiquities of Cyprus excavated over 150 tombs in the last decade, mainly through rescue operations due to the building development of the area. Unfortunately, a large number of the excavated tombs were found looted (Y. Violaris *personal communication*).

a. Chronology

As far as chronology is concerned, exhaustive analysis of the funerary assemblages recovered by the Department of Antiquities of Cyprus in the necropolis of Erimi *Kafkalla* has not yet been performed. After an extensive survey of the area, Swiny (1979) argued that the large cemetery area of *Kafkalla* was in use throughout the Middle Cypriot, with a few burials dating early in the Late Cypriot, possibly reusing older chambers. However, recent excavations undertaken by the Department of Antiquities in the southern area of the necropolis have revealed the presence of tombs that are mainly at least up to LCII in date, with several cases of reuse of older ones (D. Aristotelous *personal communication*). In addition, as stated above, Hellenistic and Roman utilization of the area is also attested.

Radiocarbon dating

Only one radiocarbon date obtained from a bone samples taken from Tomb 80 of Erimi *Kafkalla* is currently available (Scirè Calabrisotto *et al.* 2013). This determination yielded calibrated ranges referring to the Hellenistic and Roman periods and further attests to the common phenomenon of reutilisation of Bronze Age tombs during later periods.

b. Site description

The necropolis of *Kafkalla* occupies a large area on the plateau which defines the east bank of the river Kouris. The cemetery area extends from the point where the plateau is cut by the modern motorway up to plot no. 429, thus stretching over an area of about 500 x 200 m. As implied by the toponymal, the overall site is geologically formed of a surface layer of hard limestone, referred to as *kafkalla* in Greek. However, under this calcareous layer, the rock is soft and easy to be carved, that is where the tombs were hewn. In his survey, Swiny (1979: 257) recorded 227 *dromoi* giving access to a minimum of 260 burials. In his view, this huge cemetery area probably served a large settlement throughout its existence, or a smaller one for a longer time span.

The skeletal material analysed within this study originates from a series of tombs excavated in 2012 and 2013 by D. Aristotelous (Department of Antiquities of Cyprus) during rescue operations linked to construction works in plot 408 of Erimi *Kafkalla*. The tombs were tightly clustered; in the majority of cases, a common shallow *dromos* (narrow or circular in shape) allowed for many funeral chambers to be carved on either sides of it (see Figure 6.23).

Figure 6.23 Photo showing the layout of tombs in plot 408 at Erimi *Kafkalla*. Courtesy of Demetra Aristotelous.

c. Flora and Fauna

Palaeobotanical remains were not retrieved from the tombs of Erimi *Kafkalla*. As far as animal bones are concerned, personal examination of the skeletal material recovered in the tombs located in plot 408 revealed the presence of some faunal remains though at that time they were not precisely identified.

d. Human remains

The tombs excavated at Erimi *Kafkalla* yielded an impressive amount of skeletal remains. Unfortunately, this material has not yet been studied.

e. Isotopic study

Materials

A total of 14 bone samples were collected from the skeletal material recovered from Tombs 291, 312, 358, 361, 362, 365, 386 and 390 in plot 408 at Erimi *Kafkalla* (Table 6.26).

Table 6.26 Bone samples analysed from Erimi *Kafkalla*. Abbreviation n.a. = not analysed

SAMPLE NAME	TOMB	CHRONOLOGY	ANATOMIC ELEMENT	SEX	AGE
EKT291	Plot 408 Tomb 291	MC-LC	fragment of femur	n.a.	adult
EKT318	Plot 408 Tomb 318	MC-LC	fragment of femur	n.a.	adult
EKT358	Plot 408 Tomb 358	MC-LC	fragment of femur	n.a.	adult
EKT361	Plot 408 Tomb 361	MC-LC	fragment of femur	n.a.	adult
EKT362_1	Plot 408 Tomb 362	MC-LC	fragment of femur	n.a.	adult
EKT362_2	Plot 408 Tomb 362	MC-LC	fragment of femur	n.a.	adult
EKT365_1	Plot 408 Tomb 365	MC-LC	fragment of femur	n.a.	adult
EKT365_2	Plot 408 Tomb 365	MC-LC	fragment of femur	n.a.	adult
EKT386_1	Plot 408 Tomb 386	MC-LC	fragment of femur	n.a.	adult
EKT386_2	Plot 408 Tomb 386	MC-LC	fragment of femur	n.a.	adult
EKT390_1	Plot 408 Tomb 390	MC-LC	fragment of femur	n.a.	adolescent
EKT390_2	Plot 408 Tomb 390	MC-LC	fragment of femur	n.a.	adolescent
EKT390_3	Plot 408 Tomb 390	MC-LC	fragment of femur	n.a.	adolescent
EKT390_4	Plot 408 Tomb 390	MC-LC	fragment of femur	n.a.	adult

Results

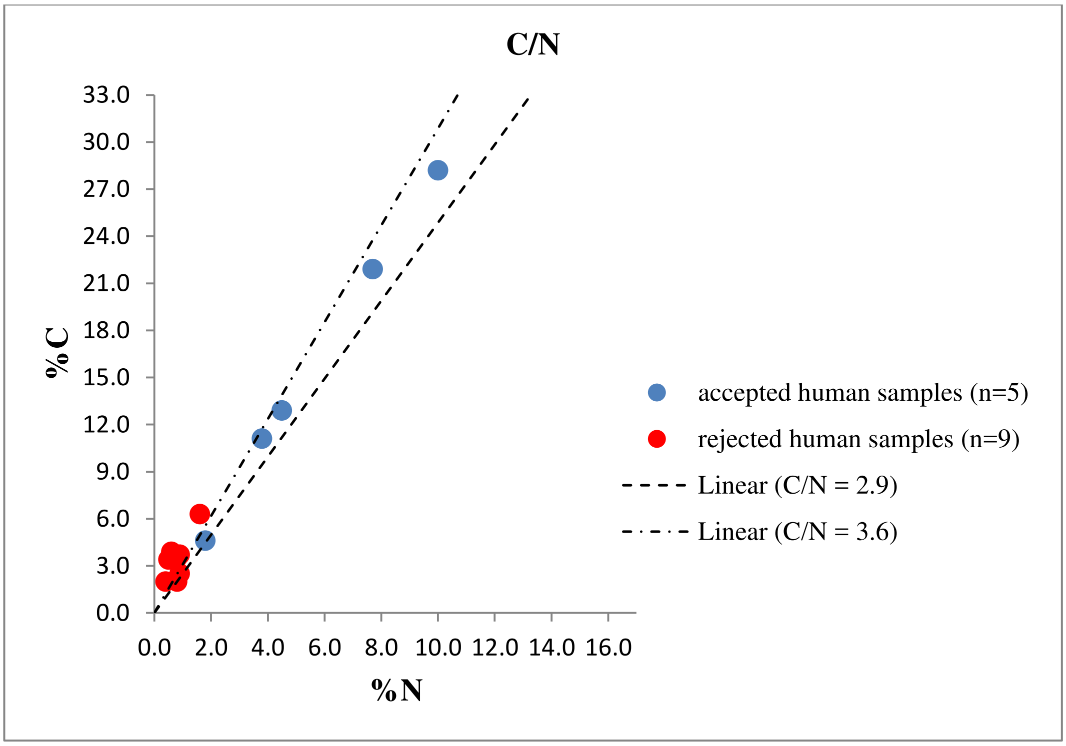
All the samples were prepared and measured for their carbon and nitrogen isotopic ratios at the IRMS Laboratory of the DiSTABiF laboratory of the Seconda Università di Napoli (Caserta, Italy). The results are shown in Table 6.27.

Table 6.27 Stable isotope values yielded by the human samples of Erimi *Kafkalla*. Acceptable collagen samples based on collagen yield, C/N ratio and %C, %N appear in bold. Analytic error is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$ values.

SAMPLE	COLLAGEN YIELD	%C	%N	C/N	δ13C collagen (PDB) (‰)	δ15N collagen (AIR) (‰)
EKT291	0.3%	3.9	0.6	7.2	n	n
EKT318	0.1%	3.5	0.8	4.9	n	n
EKT358	0.4%	2.5	0.9	3.4	-21.1	10.7
EKT361	0.1%	3.4	0.5	7.8	n	n
EKT362_1	0.4%	6.3	1.6	4.6	-20.3	4.1
EKT362_2	0.3%	3.7	0.9	4.8	n	n
EKT365_1	0.5%	2.0	0.8	3.0	n	n
EKT365_2	0.5%	2.0	0.4	6.3	n	n
EKT386_1	**0.5%**	**12.9**	**4.5**	**3.3**	**-20.2**	**9.1**
EKT386_2	**0.6%**	**11.1**	**3.8**	**3.4**	**-20.3**	**9.6**
EKT390_1	0.6%	2.0	0.0	0	n	n
EKT390_2	**2.0%**	**21.9**	**7.7**	**3.3**	**-20.1**	**10.7**
EKT390_3	**0.4%**	**4.6**	**1.8**	**3.0**	**-21.4**	**8.2**
EKT390_4	**1.0%**	**28.2**	**10**	**3.3**	**-19.9**	**10.8**

Preservation state

Figure 6.24 Elementary contents (C, N) in the validated collagen extracts and the C/N range proposed by DeNiro (1985).



The skeletal material from Erimi *Kafkalla* was generally poorly preserved. Collagen was successfully extracted from almost all the samples although the quantity and quality of the extracts was different. As for the bone samples collected from the tombs in plot 408, collagen yields ranged from 0.1% to 2% indicating a quite variable preservation state of the skeletal remains. With the exception of EKT390_3, all the samples producing collagen yields below 0.5% yielded also unacceptable values of C/N ratio, %C and %N and were thus rejected (Figure 6.24).

Human Isotope Values

The isotope values obtained from the validated collagen extracts are summarised in Table 6.25. Specifically, the mean $\delta^{13}C$ and $\delta^{15}N$ obtained from the four individuals of Erimi *Kafkalla* are -20.1‰ ±0.2‰ and 10.1‰ ±0.8‰, respectively. The small isotopic dataset is very uniform and indicate a diet principally based on C_3 foods with no evidence of regular consumption of aquatic resources.

Table 6.28 Summary of the isotope values of Erimi *Kafkalla*.

HUMAN	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C$ (‰)	-20.4	-20.2	0.6	1.5	-21.4	-19.9	5
$\delta^{15}N$ (‰)	9.7	9.6	1.1	2.6	8.2	10.8	5

Summary and Discussion

The skeletal material of Erimi *Kafkalla* displayed a very poor preservation state and only five samples yielded acceptable results. These four individuals show isotope ratios consistent with a prevalent terrestrial-based diet. Unfortunately, no anthropological information is currently available for this osteological collection, as well as archaeobotanical and faunal data specific of that area and referring to the Bronze Age. If comparing the isotope value with the faunal isotopic dataset of Marki *Alonia* (Chapter 6.2.1), a regular consumption of animal proteins can probably be suggested.

CHAPTER 7
SYNTHESIS AND DISCUSSION

7.1. Introduction

This chapter summarises the results of the isotopic analysis of palaeodiet and discusses them within the frame of the research questions addressed in this research. After a brief discussion on the preservation of collagen in the samples, the diet and the subsistence economy characterising the Chalcolithic and Early-Middle Bronze Age communities of Cyprus are reviewed in relation to the isotopic evidence.

In discussing the palaeodietary data from Cyprus, I have omitted the site of Erimi *Kafkalla* as the chronology of the skeletal material analysed within this study is – unfortunately – uncertain (see Chapter 6.2.6). Instead, I have included three skeletal samples from the Chalcolithic site of Souskiou *Laona* (see map in Figure 3.1) and the EC I-II cemetery of Psematismenos *Trelloukkas* (see map in Figure 3.2) which had been successfully analysed by Goude *et al.* (2010) within a pilot isotopic study conducted on a selection of prehistoric sites in Cyprus. The isotope results from these two sites are summarised in Table 7.1 and reviewed here in the light of the new isotopic evidence obtained in this study.

Table 7.1 Skeletal samples from Souskiou *Laona* and Psematismenos *Trelloukkas* successfully analysed by Goude *et al.* 2010.

Site	Chronology	Provenance	Anatomic element	$\delta^{13}C$ collagen (PDB) (‰)	$\delta^{15}N$ collagen (AIR) (‰)
Souskiou *Laona* Operation A	Middle Chalcolithic	Grave 815	left M_3	-19.0	7.6
Psematismenos *Trelloukkas*	Early Cypriot I-II	Tomb 123	right P^1	-19.1	11.0
Psematismenos *Trelloukkas*	Early Cypriot I-II	Tomb 123	right tibia	-18.9	10.1

At Kissonerga *Mosphilia*, Marki *Alonia* and Kalavasos, preliminary indications on the place of residence of six animals and ten humans were obtained from the measurement of oxygen isotope ratios on tooth enamel samples (Chapters 5.2.2, 6.2.1 and 6.2.3). However, since the analysis of migration patterns was out of the scope of this thesis, these results are not considered in this chapter.

7.2. Collagen preservation

As already mentioned in Chapter 1, collagen preservation was expected to be quite low in the skeletal material analysed within this study. Unfortunately, specific research concerning the mechanisms at the basis of collagen diagenesis in Cyprus has not been undertaken so far. It is generally accepted that time, temperature, hydrology and pH of the soils concur (among other factors) to enhance the degradation of collagen (e.g. Hedges 2002; Nielsen-Marsh 2007). In this regards, the prevailing arid climatic conditions of Cyprus certainly do not favour collagen preservation, and the prehistoric habit of burying the dead in tombs cut in the limestone bedrock – which are often subject to erosion, roof collapse and especially seasonal flooding (Keswani 2013: 161) – also plays an important role in accelerating the rate of collagen diagenesis. Moreover, the situation is further complicated by the peculiar burial practices adopted in Cyprus during the Chalcolithic and the Bronze Age, involving tomb re-use and several stages of bone manipulation (Keswani 2004).

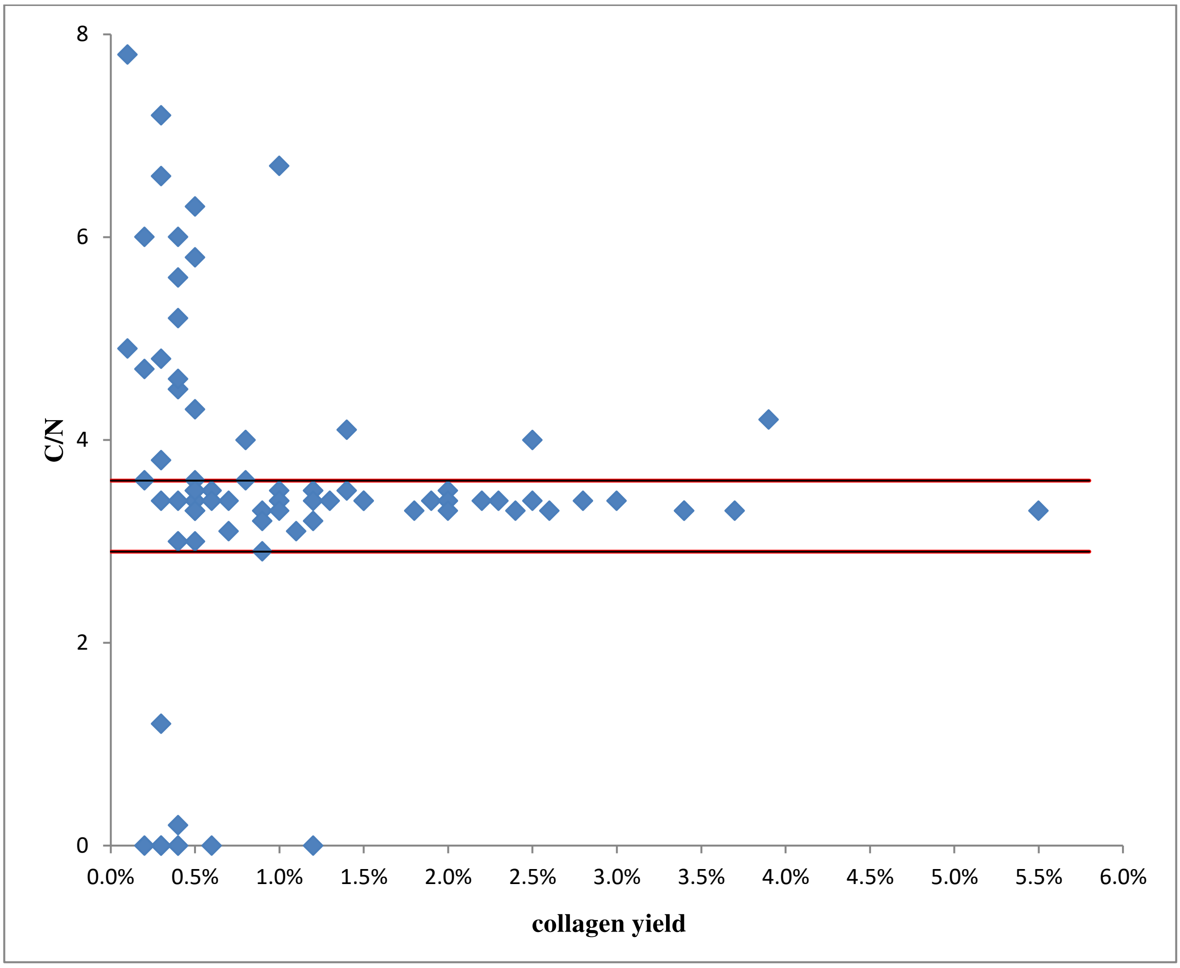
Within these premises, I comment here on the preservation state of collagen evidenced within this study. As shown in Table 7.2, a total of 93 skeletal samples were treated for collagen extraction. Since only 9 teeth were processed, bone and dentine collagen are considered together.

Table 7.2 Descriptive statistics of the values of collagen yield, %C, %N and C/N ratio obtained from all the residues extracted from bone and teeth.

COLLAGEN QUALITY INDICATORS	Mean	Median	SD	Range	Min	Max	Count
yield	1.1%	0.6%	1.0%	5.4%	0.1%	5.5%	93
%C	13.6	11.1	12.1	44.0	0.0	44.0	93
%N	4.6	3.8	4.3	15.2	0.0	15.2	93
C/N	4.1	3.4	3.3	24.1	0.0	24.1	93

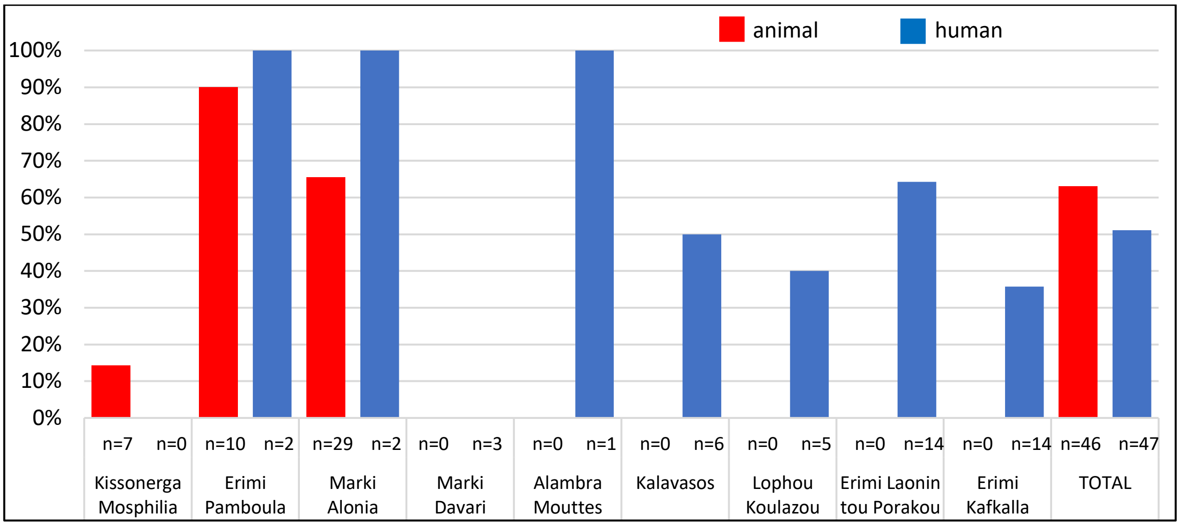
The yield of extracted residue was quite variable and ranged from 0.1% to 5.5% with an average value of 1.1%. The C/N ratio tended to be higher than the accepted range of 2.9-3.6, showing a mean value of 4.0. If plotting the percentage of collagen yield against the C/N ratio of the collagen extracts, the greatest amount of aberrant values (i.e. outside of the range of 2.9-3.6) is found below the threshold of 0.5% collagen yield (see Figure 7.1).

Figure 7.1 C/N ratio of the residues extracted from bone and teeth plotted against collagen concentration, expressed as % of bone weight. Note that the values of four extracts showing a C/N ratio above 8 are not shown. Red lines represent the 2.9-3.6 range for well-preserved collagen suggested by DeNiro (1985).



In order to investigate inter-site differences in collagen preservation, the relative frequencies of acceptable animal and human collagen extracts obtained from the skeletal remains of each site and from the whole assemblage of the Chalcolithic and the Bronze Age periods have been calculated (see Figure 7.2). The criteria adopted in this study for accepting or rejecting the collagen samples have already been explained in Chapter 4.4 and will not be iterated here. In total, 29 out of 46 animal and 24 out of 47 human bone samples yielded well-preserved collagen extracts, corresponding to 63% and 51% of the processed material, respectively. If considering only the sites where more than 5 samples were analysed, collagen was better preserved in the skeletal remains from Erimi *Pamboula* and Erimi *Laonin tou Porakou*, both located in the Kouris River valley, and from the settlement of Marki *Alonia*. The reasons for this inter-site variability are not readily understandable and further research would be needed to better clarify the situation.

Figure 7.2 Bar chart showing the relative frequencies of well-preserved collagen extracts obtained from animal and human bone samples dated to the Chalcolithic and the Bronze Age periods.

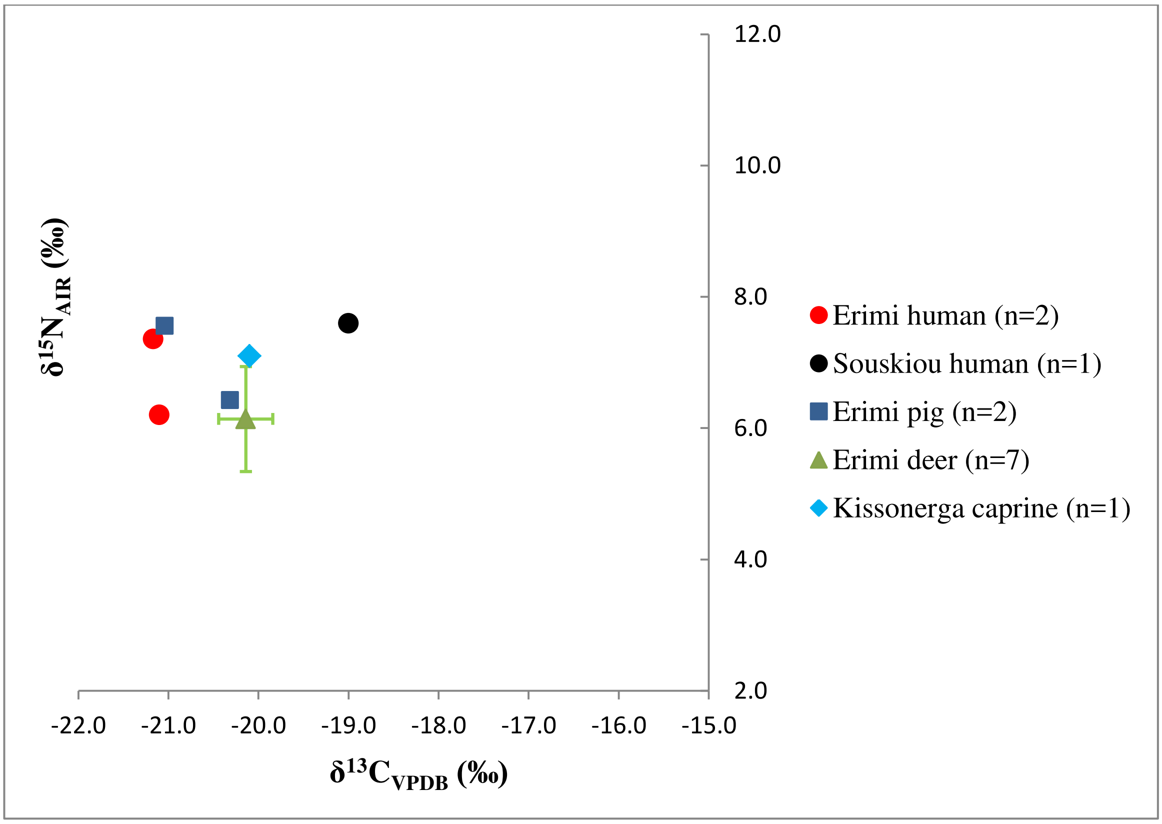


7.3. Dietary patterns and subsistence economy in Chalcolithic and Bronze Age Cyprus: the isotopic evidence

7.3.1. Chalcolithic

The palaeodietary investigation undertaken at the archaeological sites of Erimi *Pamboula* and Kissonerga *Mosphilia* (Chapters 5.2.1 and 5.2.2) has provided preliminary isotopic evidence for the study of the dietary patterns during the Chalcolithic in Cyprus. The overall presently available isotopic data for the Chalcolithic period are shown in Figure 7.3, including also the human sample from Souskiou *Laona* analysed by Goude *et al.* (2010).

Figure 7.3 Collagen isotope values of fauna and humans from Chalcolithic Cyprus. In the case of deer, the mean $\delta^{13}C$ and $\delta^{15}N$ values (± 1 standard deviation) have been considered. Data from Souskiou *Laona* are taken from Goude *et al.* (2010).



a. Faunal data

The small set of collagen isotopic data (n=10) obtained from the Chalcolithic fauna of Erimi *Pamboula* and Kissonerga *Mosphilia* comprehends all the three animal species mostly represented in the faunal record of the period, that is, fallow deer, pigs and caprines (see Figure 7.1). In general, the faunal collagen values obtained from all the animals point to the exploitation of a mainly C_3 ecosystem. At Kissonerga, two molars belonging to a sheep/goat and a fox, respectively, were also analysed for their enamel $\delta^{13}C$ ratios, and these values too indicate that the two animals were feeding chiefly on C_3 resources (Chapter 5.2.2). While no archaeobotanical evidence is currently available from Erimi *Pamboula*, palaeobotanical data from Kissonerga *Mosphilia* confirm this scenario as the great majority of identified botanical remains is indeed C_3 (Murray 1998a, 1998b). Unfortunately, the small number of isotopic data per species limits the identification of possible differences in the diet of the three animals, as only the deer group is better defined from the isotopic point of view.

b. Human data

The two humans from Erimi *Pamboula* display collagen $\delta^{13}C$ and $\delta^{15}N$ values pointing to a prevalent terrestrial-based diet, with no evidence of a regular intake of freshwater or marine foods. As shown in Figure 7.1, the $\delta^{13}C$ values of the two individuals are slightly lower than those of the animals, while the nitrogen isotope ratios are included within the range of $\delta^{15}N$ values of the analysed fauna. Such results have been taken as evidence of a diet probably characterised by a significant proportion of C_3 plants and legumes, and a likely low contribution of animal proteins. Dental diseases like ante mortem tooth loss, caries and heavy tooth wear reported in the four individuals of Erimi *Pamboula* might confirm this dietary profile (see Chapter 5.2.1).

The isotope values of the individual from Souskiou *Laona* were interpreted as indicative of the preferential exploitation of food resources from a C_3 terrestrial environment (Goude *et al.* 2010). Recently published archaeobotanical data from this site further support this hypothesis and attest to the presence of cereals (emmer wheat and hulled barley), pulses (lentil), fruit trees (fig, pistachio and grape) and wild herbaceous taxa commonly found in association with cultivated crops (Lucas 2014: 51-52). Unfortunately, faunal isotopic data from the area of Souskiou are not presently available. A preliminary estimation of the relative importance of terrestrial animal proteins in the diet of this individual can be obtained by referring its $\delta^{13}C$ and $\delta^{15}N$ values to the isotope values of the Chalcolithic fauna analysed in this study. As shown in Figure 7.1, the $\delta^{13}C$ value of this individual is more positive than those of the animals, while its $\delta^{15}N$ value is the same as one of the two pigs and only slightly higher than the other animals. Specifically, a $\Delta^{15}N$ spacing ranging from +0.5‰, if referred to the caprine, to +1.5‰, if compared to the mean isotope values of deer, can be observed. If accounting for an average incremental ^{15}N-enrichment of 3‰ at each stage of the food chain, the small differences noted between the $\delta^{15}N$ value of this individual and the nitrogen isotope ratios of the Chalcolithic fauna seem to indicate a probable low intake of animal proteins and/or a significant consumption of pulses.

c. Diet and subsistence economy

Archaeobotanical and faunal data from Chalcolithic sites in Cyprus point to a mixed subsistence economy centred on agro-pastoralism and hunting of fallow deer. A varied array of cereals (emmer wheat, einkorn wheat, bread wheat, barley, rye) and pulses (lentil, pea, bitter vetch, chickpea) supplemented by wild grasses and fruits (olive, grape, fig, pistachio, juniper berries and capers) likely constituted the core of the diet along with animal products obtained from husbandry of pigs and caprines and, most notably, hunting of fallow deer.

The preliminary human isotopic data presented in this study indicate a diet chiefly based on terrestrial C_3 foods, in keeping with the range of floral and faunal remains attested in the archaeological record of the Chalcolithic period. In addition, the isotope values of the three individuals from Erimi *Pamboula* and Souskiou *Laona* suggest a likely low consumption of animal proteins in their diet. As anticipated in Chapter 5.2.1, this result appears rather unexpected. Indeed, although limited to a small faunal assemblage, the high frequency of fallow deer bones recovered at Erimi *Pamboula* (about 71% of the total skeletal remains) has been interpreted as a sign of an animal economy heavily oriented towards deer exploitation, with caprines and pigs playing a minor role (Croft 1981: 40, 1991:70).

The apparent heavy exploitation of deer observed throughout the course of the Chalcolithic period deserves further attention. Following Croft's analysis (1991), deer contributed a significant proportion of the overall meat supply of the communities of southern and south-western Cyprus (up to 86% at Early Chalcolithic Kalavasos *Ayious*). In spite of the long-term decline in deer consumption attested at the villages of Kissonerga *Mylouthkia*, Kissonerga *Mosphilia* and Lemba *Lakkous*, by the end of the Chalcolithic "deer hunting was still providing almost a half of all meat consumed" (Croft 1991: 75). Further important data on the patterns of exploitation of fallow deer come from the small Late Chalcolithic site of Politiko *Kokkinorotsos*. Here the excavators recovered an exceptional amount of fallow deer bones which, along with other lines of evidence, support the hypothesis that this site was a special-purpose station mainly devoted to seasonal hunting (Webb *et al.* 2009; Frankel *et al.* 2013). In addition, the presence at this site of an earth oven has been associated with possible forms of feasting and public display, involving the preparation and consumption of special foods, most notably meat (Frankel *et al.* 2013: 108; Peltenburg 1991: 88-89, 1993: 14). As far as the spatial distribution of the faunal remains is concerned, Button (2010: 330-331) noted that deer bones are predominantly found outside of house contexts, the most evident exception being the Pithos House at Kissonerga *Mosphilia* (Period 4). This evidence might indicate specific butchery patterns following which deer meat was mainly processed and discarded in more general contexts, but may also imply that deer was not a food item regularly consumed within the domestic sphere. In this sense, the unusual concentration of deer bones found in the Pithos House – regarded as a special, élite residence with substantial storage facilities – may be considered further evidence that these animals were a source of , perhaps included within a system of control and distribution of specific resources. In mortuary contexts, possible ritual activities associated with fallow deer are attested by the presence of deer antlers in two Early Chalcolithic graves at Erimi *Pamboula* and Karavas *Gyrisma* (Keswani 1994, with references). In the subsequent Middle and Late Chalcolithic periods antlers occur with less frequency in the burials, although a unique jasper adze with an antler haft was recovered near the hands of a child buried at Kissonerga *Mosphilia* (Period 4) (Keswani 2013: 178, 186, with references).

Taken together with the isotopic data discussed above, these evidences raise the possibility that fallow deer might not have represented a staple in the diet of the Chalcolithic communities of Cyprus but rather a food occasionally consumed within the context of feasting and/or ritual activities or, perhaps, a resource destined to an élite group who was also controlling its distribution. If we accept this line of reasoning, we might start thinking of the practice of deer hunting not only as an economic response to resource stresses (Croft 1991) but as a more complex, possibly exclusive, activity associated with specific conventions of ritual and feasting (on this issue see also Knapp 2013: 248-249). As noted by Keswani (1994: 257), "patterns of animal exploitation and consumption in pre-state, pre-market (or extra-state, extra-market) societies are strongly influenced by social considerations and ritual practices which current utilitarian models do not take into account. The socioideological variables may be the principal determinants of the types and quantities of species consumed and the timing, scale, and age-sex profiles of animal 'harvests' in pre-state agricultural societies".

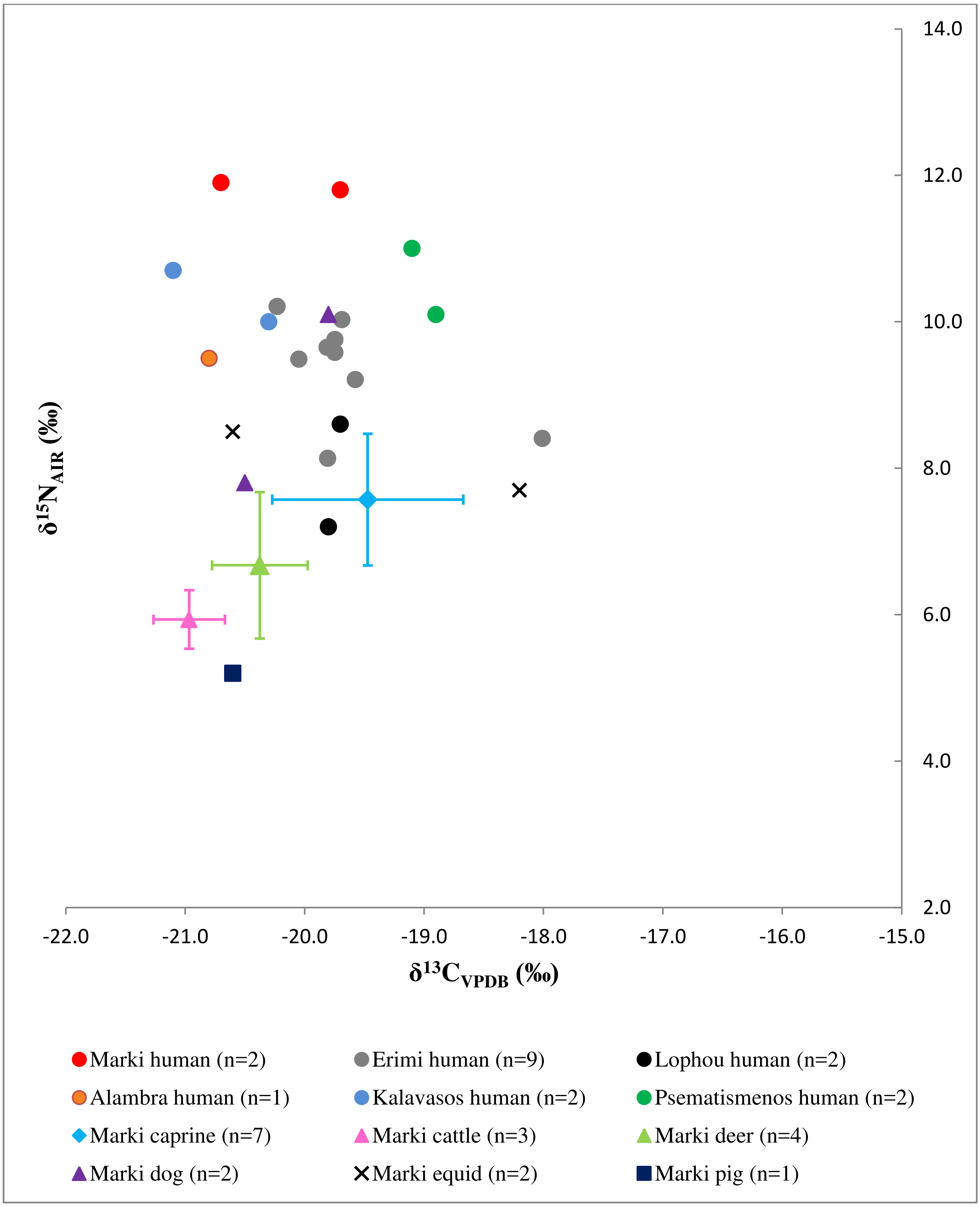
7.3.2. Early-Middle Bronze Age

The isotopic dataset obtained from the investigation of the archaeological sites of Marki *Alonia*, Alambra *Mouttes*, Kalavasos village, Lophou *Koulazou* and Erimi *Laonin tou Porakou* (Chapters 6.2.1 to 6.2.5) has allowed to make preliminary inferences on dietary patterns during the Early-Middle Bronze Age in Cyprus. In total, this study has produced acceptable carbon and nitrogen collagen isotope values from 16 human and 19 animal (caprines, cattle, deer, equid, pig and dogs) samples, and carbon enamel isotope ratios from 9 human and 5 animal teeth (caprines, cattle, equid). The overall presently available collagen isotopic data for the Early-Middle Bronze Age are shown in Figure 7.3 including also the two human samples from Psematismenos *Trelloukkas* analysed by Goude *et al.* (2010).

a. Faunal data

Information on the diet of domesticated (pig, cattle, caprines, equid, and dog) and hunted (fallow deer) animals during the Early-Middle Bronze Age has been obtained only from the site of Marki *Alonia*. The isotope values have been fully discussed in Chapter 6.2.1 and are briefly summarised here. In general, both the collagen isotope values and the enamel isotope ratios indicate a prevalent consumption of C_3 resources, in keeping with the archaeobotanical record from this area. As shown in Figure 7.4, the two groups of domestic herbivores (cattle and caprines) form separate clusters, with cattle showing lower mean collagen $\delta^{13}C$ and $\delta^{15}N$ values than sheep and goats. This result has been taken as evidence for possible differences in herding practices and in the diet of these two species. Specifically, the more negative and more homogeneous isotope values of cattle may indicate that they were kept by humans in a restricted environment and were possibly foddered with a more monotonous C_3 diet, perhaps involving leafy crops and legumes. Differently, the more positive and more spread values of sheep and goats suggest that caprines were exploiting larger C_3 biomasses, such as we might expect from animals herded in more open and drier habitats. Although limited to two samples, the isotope values of equid (probably donkeys) show similar $\delta^{15}N$ values but quite different $\delta^{13}C$ values that might indicate the exploitation of a range of diversified, including more arid, habitats, a pattern possibly correlated to their use for pack and transport. To complete the discussion on herbivores, the group of fallow deer, a free-living hunted species, has produced mean collagen isotope values which are a bit lower than those of caprines, as might be expected from animals dwelling in more temperate locations like woodlands and riparian forest thickets. Little can be said about the unique pig sample apart from the fact that this animal displays the lowest nitrogen isotope ratio within the faunal dataset, possibly indicating a prevalent vegetal diet. Finally, the isotope values of both the two dogs are consistent with a carnivorous, terrestrial-based diet, although the discrepancy in their nitrogen isotope ratios suggests that they were not fed on a regular diet, but obtained their food also from scavenging.

Figure 7.4 Collagen isotope values of fauna and humans from Early-Middle Bronze Age Cyprus. In the case of cattle, deer and caprines from Marki *Alonia*, the mean $\delta^{13}C$ and $\delta^{15}N$ values (± 1 standard deviation) are represented. Note that the isotope values of one human from Tomb 53 of Kalavasos derive from the average isotope ratios of samples KL_T53_30 and KL_T53_31, since they belong to the same individual on anthropological basis (see Chapter 6.2.3). Data from Psematismenos *Trelloukkas* are taken from Goude *et al.* (2010)



b. Human data

Information on the dietary habits of a total of 23 individuals living in Cyprus during the Early and Middle Bronze Ages have been collected through stable isotope analysis of either collagen or tooth enamel. Only in two cases it was possible to analyse the isotopic composition of both collagen and tooth enamel from the same individual: these are the male adolescent from Marki *Alonia* (Chapter 6.2.1) and the male juvenile from Tomb 53 of Kalavasos (Chapter 6.2.3).

As shown in table 7.3, if considering the whole collagen isotopic dataset, the carbon isotope ratios range from -21.1‰ to -18‰, with a mean $\delta^{13}C_{COLLAGEN}$ value of -19.9‰ ± 0.7‰; on the other hand, the nitrogen isotope ratios range from 7.2‰ to 11.9‰, with a mean $\delta^{15}N_{COLLAGEN}$ value of 9.6‰ ± 1.2‰. As for the carbon isotope ratios obtained from the analysis of tooth enamel carbonate, the values range from -12.9‰ to -11.3‰, with a mean $\delta^{13}C_{ENAMEL}$ value of -12.0‰ ± 0.6‰. If comparing the mean carbon isotope value of the human collagen samples with those of cattle, deer, sheep/goats and pig from Marki *Alonia*, a $\Delta^{13}C$ spacing of +1‰, +0.5‰, -0.5‰ and +0.7‰, respectively, is observed. The same calculation for the mean nitrogen isotope values result in a $\Delta^{15}N$ spacing of +3.7‰, +3.0‰, +2.1‰ and +4.4‰, respectively.

Table 7.3 Summary of collagen and enamel isotope values obtained from all the Early and Middle Bronze Ages individuals. Enamel oxygen isotope values are not considered.

HUMAN DATA	Mean	Median	SD	Range	Min	Max	Count
$\delta^{13}C_{COLLAGEN}$ (‰)	-19.9	-19.8	0.7	3.1	-21.1	-18.0	16
$\delta^{15}N_{COLLAGEN}$ (‰)	9.6	9.6	1.2	4.7	7.2	11.9	16
$\delta^{13}C_{ENAMEL}$ (‰)	-12.0	-11.9	0.6	1.6	-12.9	-11.3	9

Taken together, these values suggest that the diet of these individuals was mainly based on terrestrial foods, with proteins derived both from C_3 plants and from animals (pig, cattle, deer and caprines) fed chiefly on C_3 resources. Heavy consumption of aquatic foods has not been evidenced although a possible minor contribution of freshwater resources may be hypothesised for the two individuals from Marki *Alonia* (cf. also Chapter 6.2.1). With reference to individual patterns of consumption, a certain degree of variability is observed in the isotope values that suggests the presence of possible differences in the diet and/or possible differential access to specific resources. For instance, the range of 4.7‰ observed in the nitrogen isotope ratios might be indicative of a diverse contribution of animal proteins to the diet and/or the preferential consumption of proteins from different animals. In particular, the humans showing a very low nitrogen isotope ratio (e.g. the two individuals from Lophou *Koulazou* and the two individuals from Erimi *Laonin tou Porakou* with the most negative $\delta^{15}N$ values) apparently had little access to proteins from sheep and goats and/or were consuming a higher amount of pulses. In this regards, it would be very interesting to explore possible regional differences in the diet, as the environmental setting of the Early-Middle Bronze Age sites investigate within this study is different. Unfortunately, the very small numbers of samples successfully analysed from each site do not allow for reliable comparisons.

In concluding this discussion, I briefly comment on the results from Psematismenos *Trelloukkas* which were interpreted by Goude *et al.* 2010 as pointing to a prevalent terrestrial-based diet. Comparison with the faunal isotopic baseline available from Marki *Alonia* further supports this interpretation although it should be observed that both the $\delta^{13}C$ and $\delta^{15}N$ values of the two collagen samples from Psematismenos are slightly more positive than those of all the humans analysed in this study, with the exception of one individual from Erimi *Laonin tou Porakou* showing the highest $\delta^{13}C$ within the dataset (cf. Chapter 6.2.5). Since the settlement of Psematismenos *Trelloukkas* is likely to have been located on the hilltop immediately to the west of the cemetery, i.e. about 4 km from the coast (Georgiou *et al*. 2011: 340), the possibility of a minor consumption of fish resources might not be excluded.

c. Diet and subsistence economy

The transition from the Chalcolithic to the Early Bronze Age is marked by the appearance of technological innovations and new farming techniques that radically transformed the socio-economic organisation of the prehistoric villages of Cyprus. Several lines of evidence suggest that the Early and Middle Cypriot communities of the island strongly relied on agriculture and livestock to ensure local needs and generate possible surpluses. In particular, the gradual shift from a household-level mixed economy to intensive and extensive agricultural practices probably represented the first step towards the emerging of social complexity. Archaeobotanical data from the Early and Middle Bronze Ages are quite limited but – together with the large numbers of grinding stones, pounders and querns recovered at the main settlements of the period – seem to indicate a diet dominated by cereals (emmer wheat, bread wheat) and pulses (lentil, vetch, chickpea), supplemented by wild grasses and fruits (olive, grape, fig, pistachio, and almond). Faunal data are more abundant and attest to the growing importance of cattle, sheep and goats, both for meat and secondary products. On the other hand, pigs seem to have been of variable economic importance, probably depending on the different location of the settlements and the availability of adequately moist environment. Hunting of fallow deer, although significantly reduced with respect to the precedent Chalcolithic period, still played a significant role in the subsistence strategy of the Early and Middle Bronze Age communities, and it is likely that this activity was linked to complex social or ritual practices, as also suggested by the high frequency of Early Cypriot vessels with protomes, reliefs or depictions of these animals (Flourentzos 2002). As suggested by Steel (2004: 132), "the continuation of the hunting ethos is a common thread throughout Cypriot prehistory and serves to link the inhabitants of prehistoric Bronze Age Cyprus to their forbears of the Neolithic and Chalcolithic periods".

The human isotopic dataset of the Early and Middle Bronze Ages presented in this study indicates the prevalent exploitation of terrestrial-based C_3 resources and seems consistent with an emphasis on cereals and domestic animals, as attested by the archaeological, palaeobotanical and faunal records. At the same time, a close examination of individual isotope values has revealed variable consumption practices, especially in the levels of animal and fish protein in the diet. Towards this purpose, gender-related differences in the diet have been investigated in order to check if differential access to animal resources might be correlated with sex. Table 7.4 shows the mean $\delta^{13}C$ and $\delta^{15}N$ values (± 1 SD) obtained for the few individuals that could be sexed on anthropological basis. Apparently, no differences in the diet of male and female individuals are observed although further research is needed to investigate this issue more definitely.

Table 7.4 Mean collagen isotope values of males and females from the Early and Middle Bronze Ages.

SEX	$\delta^{13}C$ (± 1 SD)	$\delta^{15}N$ (± 1 SD)
Male (n=6)	**-20.3 ± 0.5**	**10.4 ± 0.8**
Female (n=4)	**-20.0 ± 0.5**	**10.2 ± 1.1**

CHAPTER 8
CONCLUSIONS

Many important aspects of the socio-economic and cultural behaviour of a population can be understood through the analysis of the food culture and the related subsistence economy. Within this frame, the application of stable isotope analysis for palaeodiet reconstruction represents a well-established method and an essential instrument for the study of ancient food systems, providing direct information on the dietary preferences of the investigated communities and a chance to reveal possible differences in the forms of individual consumption. From the archaeological point of view, this field of research is particularly significant when applied to prehistoric contexts, especially those ones for which textual sources are entirely absent, and all information needs to be extrapolated from the archaeological record.

The palaeodietary research outlined in this work of thesis has focused on the investigation of ancient food webs during the Chalcolithic and the Early and Middle Bronze Ages in Cyprus (ca. 3900-1650 BC). The main goals of this study were: 1) to investigate the subsistence strategies and the possible dietary differences among the selected prehistoric communities, distinguishing between the Chalcolithic and the Early to Middle Bronze Age periods; 2) to clarify whether the pre and proto-historic inhabitants of Cyprus also relied on freshwater and marine foods; 3) to identify possible individual patterns of consumption, especially gender-related differences in the diet.

The human isotope values presented in this study indicate for both Chalcolithic and Early to Middle Bronze Age Cyprus a diet principally based on terrestrial C_3 resources. The diachronic analysis of dietary patterns is currently limited by the small size of the Chalcolithic isotopic dataset although a possibility exists that the intake of animal proteins could have increased during the Early and Middle Bronze Ages. More specifically, a $\Delta^{15}N$ spacing of 2.6‰ has been observed between the mean nitrogen isotope values of the Chalcolithic and Bronze Age human individuals which appears consistent with the consumption of resources from different trophic levels. As previously noted by Keswani

(1994), ethnographic evidence from various parts of the world suggests that the consumption of animal products in pre-state societies is predominantly related to ritual occasions and these items do not represent staples in the diet of these communities. It is possible that the rural Chalcolithic communities of Cyprus were more reliant on vegetal proteins from cereals and legumes while the increasingly complex and specialised economic system of the Early and Middle Bronze Ages – prompted by the innovations of the Secondary Product Revolution – would have sustained a major consumption of animal resources, including dairy foods. Within this frame, another interesting issue concerns the evaluation of the contribution of fallow deer hunting to the subsistence economy of the Chalcolithic and Early to Middle Bronze Age periods. As fully discussed in Chapter 7, the preliminary isotopic evidence for the Chalcolithic seems in contrast with the results of the conventional methods of dietary reconstruction, following which the exceptional amount of deer bones recovered at the Chalcolithic settlements of the island is to be interpreted as a sign of heavy reliance on deer meat. Conversely, the isotopic data raise the possibility that fallow deer might not have represented a staple in the diet of the Chalcolithic communities of Cyprus, but rather a food occasionally consumed within the context of feasting and/or ritual activities or, perhaps, a resource destined to an élite group who was also controlling its distribution.

As far as the issue of freshwater and marine foods consumption is concerned, the individuals analysed in this study have not produced evidence for the regular consumption of these items. Again, the small size of the Chalcolithic isotopic dataset does not allow for a clear estimation of the importance of marine resources during this period. Preliminarily, it can be hypothesised that molluscs and fish from low tropic levels (such as sardines and breams) were probably occasionally consumed, especially on coastal sites, but fishing appears to have been subsidiary to animal husbandry and agriculture. The same trend continued also during the Early and Middle Bronze Ages when the subsistence economy became increasingly centred on agro-pastoral practices.

Finally, concerning individual patterns of consumption, the isotopic data from the Early and Middle Bronze Ages suggest a certain degree of variability in the dietary habits, probably due to a variable intake of fish and animal products. A preliminary evaluation of the possible differences in the diet of males and females suggests that gender was not the cause for these discrepancies. Besides personal taste, other factors like environmental constraints, possible status-related differences or differential participation in feasting might be taken into account, although further data are needed in order to investigate this issue more definitely.

In concluding, the data produced for this thesis are important in two respects. Firstly, they have contributed to improve our knowledge of human dietary patterns during the Chalcolithic and the Early to Middle Bronze Age periods of Cypriot prehistory. Secondly, they form the basis for future isotopic work on the island of Cyprus. In fact, further applications of stable isotope analysis in Cypriot prehistoric contexts have much to offer. The isotopic investigation of faunal skeletal material can offer insights into herding practices and animal feeding strategies in the past, as preliminary evidenced at the Bronze Age settlement of Marki *Alonia* (see Chapter 6.2.1). More extensive sampling of human and animal remains from the Chalcolithic settlements of the Ktima lowlands – especially teeth which are usually better preserved and allow to conduct measurements of stable isotope ratios on tooth enamel – would permit to better define the contribution of animal resources to the diet and clarify the importance of fallow deer hunting, as well as possible gender- or status-related differences in the diet. With respect to the Early and Middle Bronze Ages, additional human skeletal material which is both well-preserved and fully published is very rare. Hopefully, future excavations will enable us to increase the size of the human isotopic dataset for this period and interpret more clearly the small variations evidenced at the individual level of analysis. Also, it would be interesting to extend the palaeodietary study into the Late Cypriot.

APPENDIX 1
PHOTOGRAPHIC DOCUMENTATION OF TEETH

The human and animal teeth collected from the skeletal assemblage of Kissonerga *Mosphilia*, Marki *Alonia* and Kalavasos village were scanned with scanner Epson perfection 4490 so as to document their preservation state before collagen extraction and/or the sampling of enamel.

Kissonerga *Mosphilia*

Animal teeth

Sample KM_68CAPR, caprine tooth, max. left M^3

KM_109FOX, fox tooth, mand. left M_1

Marki *Alonia*

Human teeth

MA_1879, human tooth, mand. right M_3

Faunal teeth

MA989_BOS, cattle tooth, max right molar (M^1?)

MA989_CAPR, caprine tooth, mand. right M_3

MA989_EQUID, equid tooth, mand left M_3

Kalavasos Village Tombs

Human teeth

KL_T36_16, human tooth, max. left M^3

KL_T53_30, human tooth, mand. right M_1

KL_T53_31, human tooth, mand. right M_2

KL_T60_19, human tooth, mand. left M_1

KL_T61_18, human tooth, mand. left M_2

KL_T63_17, human tooth, mand. left M_3

KL_T65_30, human tooth, mand. right M_1

KL_T65_14, human tooth, max. left M^1

KL_T67_15, human tooth, max. left M^2

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