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The Early Medieval Transition: Diet Reconstruction, Mobility, and Culture Contact in the Ravenna Countryside, Northern Italy

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The Early Medieval Transition: Diet Reconstruction, Mobility, and Culture Contact

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by

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Abstract

This research project evaluates the effects of increased mobility and culture contact on dietary practices, and on dietary variation among people buried at two northern Italian sites, Chiunsano di Ficarolo and Chiesazza di Ficarolo, located near the ancient Roman capital of Ravenna and dating 4^{th} to 7^{th} century CE. The Early Medieval period was a time of change, political instability, migration and invasion of the “barbarian” tribes, and diet was not unaffected. In particular, it is hypothesized that a new staple crop, millet, was introduced and that meat consumption had increased. The goal of this research is to use stable isotope analysis to reconstruct the diet of people at the Ficarolo sites, evaluate the presence and role of millet and animal protein, and assess potential influences of mobility and culture contact on dietary practices at the sites in the transitional period between Late Roman and Early Medieval times.

In this study, 49 human bone samples from Chiunsano di Ficarolo and Chiesazza di Ficarolo were used for stable isotope analyses of bone apatite and collagen. Carbon, nitrogen, and oxygen isotopes were analyzed to understand diet and mobility patterns at the sites. Additionally, 3 animal bone samples were used for baseline analysis. Previous paleodietary studies indicate that Roman diet of the Imperial period was based on C_3 plants and consumption of terrestrial protein, while one of the major incoming groups in this period, the Langobards, consumed high amounts of C_4 plants, such as millet, after migrating into northern Italy. Therefore, the diet at the Ravenna countryside was compared to the traditional Roman diet and dietary practices across the Italian peninsula during these transitional times.

The results of this study show that a mix of C_3 plants, such as barley, rye, wheat, oats, and rice, and C_4 plants, such as millet and sorghum, was detected in the diet of most individuals tested, as well as a mix of terrestrial and aquatic protein. A full reliance on millet, as was previously detected at the Langobard sites in northern Italy was not detected. On average, diet in the Ravenna countryside appeared to be similar to the traditional Roman diet, however, a higher variation in miller consumption was observed at the Ficarolo sites. Furthermore, a high number of non-local individuals have been detected at the sites. The majority of non-locals appear to have originated from the east and south coastal regions of Italy, with a few coming from drier and hotter environments, potentially North Africa. Dietary difference between local and non-local individuals was identified, with local individuals consuming more C_3 plants and freshwater fish and less millet, possibly due to difference in status and access to resources. This research is significant as it fills the gap in knowledge on the diet in the Ravenna countryside during the Migration period.

Chapter 1: Introduction

1.1 Background

This research is the investigation of diet on the cusp of the Late Roman and Early Medieval periods, 5^{th} to 8^{th} centuries CE, in northern Italy. Previous paleodietary studies have analyzed dietary change in other regions of northern Italy, however, the diet in the Ravenna countryside during Migration Period had not yet been explored. Furthermore, the migration of "barbarian" groups, especially the Langobards, has been previously examined historically, archaeologically, and paleogenomically. Yet studies disagree on the level of cultural influence that Langobards exuded on the local populations, with some scholars even stating that the Langobards sought to assimilate with post-Roman Italians and did not attempt to either hold on to their traditions or impose them of their newly acquired territories (Christie 2010; Iacumin et al. 2014; Maxwell 2019). Reconstruction of dietary and mobility patterns at the chosen sites of Chiunsano di Ficarolo and Chiesazza di Ficarolo help understand the potential change that occurred in the Ravenna countryside.

1.2. Research Questions and Theory

Through dietary analysis, my research asks how local and migrant Langobard populations interacted with each other, examines any power struggles, and explores if there was a hybridization or segregation of cultural practices. The questions of dietary change during the Migration Period could be approached from the perspective of migration theory and culture contact. The research questions this study poses are:

- What was the diet in the countryside of Ravenna in the Early Medieval period?
- Are there significant differences in diet between the sites and within the sampled population based on other factors?
- Does the diet conform to the local diet or the Langobard diet, based on staple foods such as meat and millet?
- Are there non-local individuals within the population? Where do they originate from?
- Are there differences in diet between the local and non-local populations?
- How can the observed diet inform the understanding of the social and cultural relations between the local Italian populations and the migrating group?

To interpret the data acquired through stable isotope analysis, archaeological theories of migration and culture contact are employed. Given that food is significantly related to one's identity and traditions, changes in dietary practices could indicate potential shifts in values due to economic and political circumstances, migration of people from other regions with their own dietary traditions, and possible power relationships between the interacting cultures.

1.3 Methods

49 human and 3 animal bones from Chiunsano di Ficarolo and Chiesazza di Ficarolo have been used for the analysis of stable carbon, nitrogen, and oxygen isotopes to address the research questions stated above. Carbon isotopes from bone collagen provide understanding of animal and plant consumption, specifically the role of C_3 plants, such as wheat, barley, and legumes, and C_4 plants, such as millet and sorghum, in an individual's diet. Furthermore, comparing stable carbon

isotope values from bone collagen and bone apatite allows further interpretation of the source of C_4 plant in diet, whether the individual consumed C_4 plants directly or if the C_4 plants were present in diet through secondary consumption, when livestock animals were fed C_4 resources. Nitrogen isotopes allow to evaluate the role of animal protein in diet and examine if an individual consumed terrestrial animal protein, in the form of meat and dairy, or also supplemented the diet with aquatic protein, saltwater or freshwater fish. The combination of nitrogen isotopes with carbon isotopes from both bone collagen and apatite allows to reconstruct the full picture of the diet and evaluate the role of different dietary resources.

Oxygen stable isotopes present information on individuals' mobility. Oxygen isotopes are ingested with water and given that the values of oxygen isotopes differ based on geographic location, altitude, and precipitation, different region in Italy and the Mediterranean have different established standard values of oxygen isotopes in water. Thus, the oxygen isotope values within the Ficarolo population analyzed here could be compared to the values common for the Ravenna countryside and with values outside of the region for identification of migrants.

1.4 Intellectual Significance

While this research focuses on the sites around Ravenna, it can also help understand the life of people in the capital. Information of diet from Ravenna during this historical period is currently unavailable. Furthermore, the analysis of diet change in Ravenna could be complicated by more constant political and economic transitions during the Late Roman and Early Medieval periods. The countryside of Ravenna presents more stable patterns of dietary change. Thus, this research fills the gap in knowledge on diet of people around Ravenna, presents additional insight into the life of people living in the capital, and supports further research.

Chapter 2: Culture and History

. The "Migration Age" lasting between 4th and 6th centuries CE is often regarded as the period of "Barbarian Invasions," but primarily involved sedentary peoples living to the north and east of the Roman borders moving into Italian lands, conquering them, settling in, and founding new kingdoms (Goffart 2006a). The migration of these peoples is sometimes mentioned as the cause for the "fall" of the Roman Empire, among other factors such as the climate change, disease, weakening of commercial and socio-political mechanisms, and political instability (Brooke 2014; Christie 2011; Erdkamp 2019; Gibbon 2001; Harper 2017). This period brought political change, settlement restructuring, and transition to self-sufficiency in trade and production (Christie 2011; Montanari 1999).

This study focuses on the territory around Ravenna, a major city in northern Italy in the Late Roman and Early Medieval periods (Figures 1 and 2). In 402 CE Ravenna became the capital of the Western Roman Empire (Barker 2004). Emperor Honorius and his court made the city the cultural center of the Western Empire. Its position on the shore of the Adriatic Sea and the port of Classe allowed the city to engage in extensive trade and have connections to the rest of the Mediterranean world (Christie 2011). In 476 CE, the army of the barbarian general Odovacar (Odoacer) took over the city, and Ravenna became the center of the new power in Italy (Barker 2004). In 490 Odovacar took refuge in the city, when the Ostrogothic king Theodoric invaded Italy and sieged Ravenna for three years. The local bishop of Ravenna mediated the settlement between Odoacer and Theodoric to rule equally together, but only a few days later Theodoric killed Odoacer at a banquet (Roncaglia 2018). Theodoric then ruled the new Ostrogothic Kingdom of Italy till 526 with Ravenna as a capital. The population of Ravenna was estimated to have had 10-15,000 inhabitants at the beginning of the 6th century (Christie 2011). The kingdom appears to have been stable, and the written documents from the time indicate active administration and trade, handling of internal and external issues, and marriage alliances with neighbors to the north and south (Christie 2010). Furthermore, the archaeology, architecture, and art in Ostrogothic Ravenna remained "Roman," with Roman and Byzantine designs and art styles being most prominent in urban development, except for the new Gothic churches (Christie 2010).

Figure 1. Map of Italy, with Rome and Ravenna marked. Modified from Google Maps (2021)

Figure 2. Map showing the location of Ravenna and Ficarolo. Modified from Google Maps (2021)

The relationships with the Eastern Roman Empire, however, soon declined, and the Gothic Wars of the 6th century resulted in Ravenna going under the rule of the Byzantine Empire, yet the city itself was spared the ruin and remained prosperous, with the help of the beautification program organized by the emperor Justinian (Barker 2004). The Byzantine power initially remained strong in the city. With the looming threat of the Langobards, otherwise also known as Lombards, the imperial regime in Ravenna was reorganized, and the exarchate was established. Ravenna, now the capital of this new province, also became the seat of the governors of the remaining imperial Italy (Barker 2004). Although in 579 the Langobards seized the port of Ravenna (Classe), which they controlled for ten more years, the exarch of Ravenna found other ways to support the city, such as restoring the connection with Rome through Via Flaminia. The Langobards' power in Italy was divided between the northern kingdom with Pavia as the center and the duchies further to the south (Barker 2004).

The independence of the city was only growing. However, in 709, Ravenna was devastated under the orders of Emperor Justinian II, convinced of the disloyalty of the city. The Langobard threat became more significant for Ravenna, weakened by the destruction, and in 737 the Langobards seized the city for a few years, but the exarchate, later restored, lost its control over the Byzantine Italy (Barker 2004). In 751, Langobards gained Ravenna back, although their rule in Ravenna was short, and the Langobard kingdom was annexed by the Franks in 774. As the power of the Franks faded in the 9th century, Ravenna's archbishops regained control of the city, as the neo-Langobard "kingdom of Italy" continued its history (Barker 2004).

The two sites in the countryside of Ravenna that this research looks at are Chiunsano di Ficarolo and Chiesazza di Ficarolo, both near the modern town of Ficarolo (Figure 3). Ravenna, as the capital that experienced constant short-term resettling of different groups that exercised social power, is expected to show unique patterns in dietary practices. The wider countryside population potentially represents more stable patterns of dietary changes if those occurred in this period. The Italian countryside in the Late Roman and Early Medieval times was heterogeneous, with land use, settlement, peasantry, and structure of estates varying between the territories of each city (Wickham 1981). In general, the peasantry was mostly unaffected by the decline of the Empire or the 6th century wars. While the landowning aristocracy changed from Roman to Langobard, it seems that Langobard agriculturalists did not retain their identity, and the local peasants continued to work their lands in accordance with their established traditions (Wickham 1981). The Langobards valued raising farm animals more than the Romans did, but it appears that most of the lowland Italy continued to rely on the vegetarian diet, and meat was rare. The settlement pattern in the Roman Italy was rather dispersed; under Langobards a bit more diverse pattern of villages can be observed. While disperse villages made of scatters of houses were still common, the villages resembling a more concentrated nuclei began to appear, even though the effects of these changes on the peasant everyday life are unknown (Wickham 1981). The exact way of life in the countryside of Ravenna is unclear, especially due to the city's long resistance to the Langobard control. The examination of dietary practices at Chiunsano and Chiesazza between the Late Roman and the Early Medieval periods may provide a further insight into the potential changes or continuity of peasant life in the countryside of Ravenna.

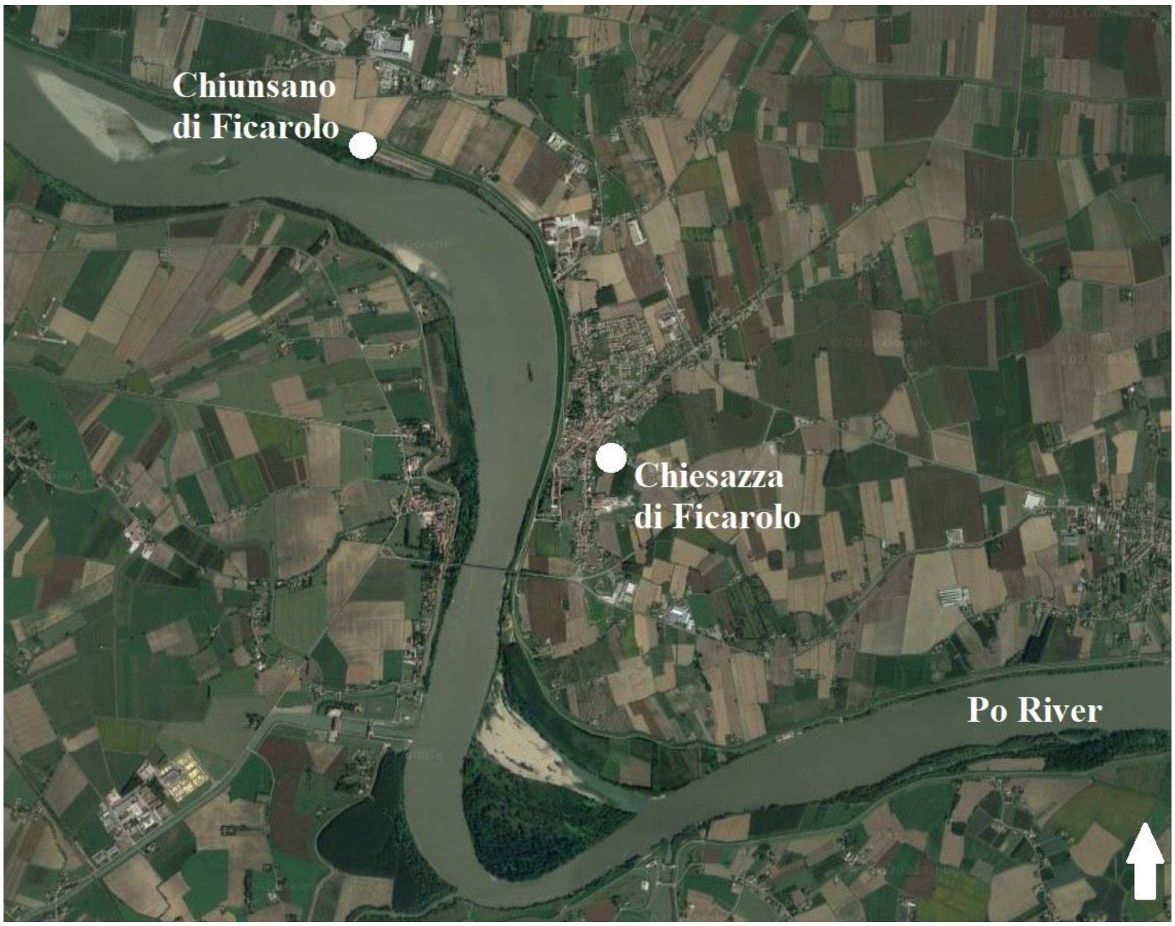

Figure 3. Relative location of the two main sites, Chiunsano and Chiesazza near the modern town of Ficarolo. Modified from Google Maps (2021)

Ravenna, its countryside, and the region of northern Italy between the Late Antiquity and Early Medieval periods, 6th-8th century, experienced the influence of Langobards, who had moved into Italy from the lower Elbe (Goffart 2006a). At the height of the Langobard rule, a large part of the Italian peninsula, including the duchies established in Benevento and Spoleto in Central Italy, was under their control. Some areas, such as Ravenna and the road connecting it to Rome, remained under Byzantines for a while (Drew 2004). The migration of the Langobards took place at the end of the Great Germanic Migration and, according to historical studies, involved a mass movement of 40 to 70,000 people but only three generations (Alt et al. 2014; Christie 2010). Some scholars (Goffart 2006a) state that Langobards, as other Germanic tribes, originated in Scandinavia, later moving through the territory of modern Germany. Before entering the Italian lands, the Langobards were stopped by the Ostrogothic Kingdom of Italy in the Danube region, the province of Pannonia, where they settled for half a century (Peters 1974). The Langobards invaded Italy in 568, after the Ostrogoths fell under the Byzantine power. For the following two centuries the Langobards expanded throughout northern Italy, and by the end of the 8th century Langobard kingdom dominated the north of the Italian peninsula (Peters 1974). Byzantine Empire finding allies among Franks and Burgundians attempted to compromise the Langobard power, and the eventual destruction of the Langobard kingdom came in 774, but not before the Langobards assimilated into the Mediterranean world, by converting to orthodox Christianity and becoming a part of the Early Medieval economic community (Peters 1974).

The impact of the Langobard presence in Italy and the relationships between the newcomers and the local Italian populations are still debated. Drew (2004) suggests that the Roman way of life in Northern Italy survived, even though the aristocracy appears to have been primarily Langobard. However, some authors (Alt et al. 2014; Iacumin et al. 2014) state that in Northern

Italy only the Langobards left a recognizable ethnic trace, while others (Goffart 2006b) question the potential bias of written sources and their exaggeration of the role that Langobard movement played in the region.

The Langobard presence in Italy is studied archaeologically through the analysis of burials and material culture. 40 cemeteries, containing around 2,000 burials are known that date to the Langobard period and have yielded information of Langobard funerary customs and migration routes (Alt et al. 2014). Langobards became archaeologically distinguished through burials in 5th-6th century, with grave goods, such as clothes, ornaments, food offerings, and military hardware, accompanying the burial, and suggesting a military ruling class (Christie 2010; De Vingo 2012). However, the researchers also note that among the Langobards who have migrated into Italy, only the first generation may have held tight to their identity as Langobards, especially the elites. Over time, however, a merging of Langobard and local Italian and Byzantine forms and designs can be observed in burial goods (Christie 2010). The religious motifs of the burials also support this claim, as Langobard aristocracy were buried in suburban cemeteries and urban early Christian Basilicas. The Christian decorations may have been used for political and social reasons, to either establish recognition or religious continuity (De Vingo 2012).

The presence and burial customs of Langobards in northern Italy has been studied also using paleogenomics. Paleogenetic analyses at the Langobard cemetery of Collegno, near Turin, showed burials organized around biological kingship, with the largest family being of central/northern European ancestry, potentially originating from the territory of modern Hungary (Amorim et al. 2018). Moreover, burial goods appear to be connected with ancestry, as individuals with northern ancestry were more often buried with grave goods than individuals of southern ancestry (Amorim et al. 2018).

Thus, we can see that historically and archaeologically, Langobards have left their mark on the region of North Italy. The dietary study in the Veneto region by Maxwell (2019) also indicates that the arrival of Langobards has affected the production and consumption in northern Italy but points out that while dietary changes occurred in the region, there were no statistically significant changes between the diet of locals and non-locals. Further investigation of dietary practices would allow a deeper understanding of diet change in Northern Italy and the influence that Langobard migration had on the lives of the local Italian people.

Chapter 3: Research Question and Theory

3.1. Introduction

Food is an important marker of social, economic, and cultural developments a society goes through. The diet of a group may change to assist the adaptation to the new way of life. The dietary strategies in Ravenna have not yet been explored, either in the Late Roman or Early Medieval periods. This study hypothesizes that migration of Langobards into northern Italy and the subsequent contact between the Langobard culture and the local Italian culture affected the diet in the Ravenna countryside. Thus, this research explores archaeological theories of migration and culture contact to evaluate the data from stable isotope analysis.

3.2 Migration Theory

A minimal definition of migration states that it is a "one-way residential relocation to a different "environment" by at least one individual" (Cabana and Clark 2011: 3). The popularity of migration as archaeological theory and a model of understanding human behavior has had its rises and declines in the past. It was widely used by anthropologists starting in the mid-19th century to study important historical events and the flow of racial, cultural, and linguistic groups across the landscape. These groups were associated with their genes, material culture, and languages, and their movement was used to explain culture change (Cabana and Clark 2011).

By the end of the 20th century, four analytical approaches to migration in anthropology began to develop. The first approach evolved from the modernization theory, which looked at the push and pull factors, leading people out of their home country and towards the host country (Brettell 2015). While some studies emphasized migration as the rational economic decision, others pointed out that often people migrate simply to places that seem familiar or offer support, recognizing that not all mobility is perfectly planned (Anthony 1997). The second approach to migration was based in historical-structuralist/political economy, which focused on the role of the global market and capitalist development in disrupting, displacing, or attracting populations to urban centers and thus generating migration streams (Brettell 2015). Such an approach, however, was criticized for focusing attention not on an individual migrant, but the macrolevel process of population movement, thus denying the migrants their agency, making them passive reactors to the system. Through this wave of criticism, the third approach emerged with the concept of the "culture of migration," defined as an ingrained part of human behavior and a part of community values (Brettell 2015). In this approach, a decision to migrate was understood as a part of people's daily experiences, with mobility not being "hard-wired" but connected to people's values and perhaps even identity. Finally, the fourth approach to mobility and migration was framed by concepts of transnationalism and diaspora. The concept of transnationalism poses that migrants act as social actors in multiple social fields, as they create new connections in the host counties but also retain their ties to the countries of origin (Brettell 2015). Thus, the proponents of transnationalism study diasporic communities, groups of people living outside their home countries. Within the study of diasporas, anthropologists have studied political and economic spaces that these communities operate in, the formation of new cultures and identities within the diasporic communities, and the creation of the collective memory about the homeland (Brettell 2015).

The study of migration has long been used to explain the special distribution of archaeological finds (Burmeister 2000). At the end of the 20th century some anthropologists working in European contexts, such as Douglas (1984) and Holmes (1983), also used a more historical perspective, while others focused on tracking movement of ethnic groups through distribution of culture traits (Brettell 2015; Burmeister 2000). The latter approach also rejected the idea that self-contained ethnic groups leave their homeland and settle in a foreign place without experiencing any cultural change, with (Burmeister 2000), with Halsall (2012: 32) even stating that migrants often do not leave a cultural trace in the host region, instead they adopt the culture of the new homeland rather fast, yet it is unclear if and how power relations between the migrant and host groups affect those culture changes.

3.2.1 Migration in the Late Roman and Early Medieval Periods

Migration in the Roman world has also been analyzed in terms of economic decisions. Migration of aristocratic lineages could be connected to politics and the goal of achieving prestige in new provinces, while at the same time migration also offered the disadvantaged groups in the Roman Empire an opportunity to improve their status in society (Anthony 1997). In Late Roman and Early Medieval European archaeology, it appears that migration was always a useful model to explain culture change, especially as it has been seen either as a cause or a result of the decline of the Western Roman Empire. Archaeological and historical studies have focused on the invasions of the “barbaric tribes” on the northern border of the Empire and their mass migration into Italy, as a force that the Western Roman Empire simply could not withstand (Grant 1998; Heather 2002; Wickham 1981). The contrary point of view sees the migration during this period as an outcome of the decline of the Roman Empire, in that the war, disease, famine, and economic collapse of the period caused the coerced displacement of communities (Anthony 1997; van Dommelen 2014).

A third way of examining the migration in the Late Roman and Early Medieval period, however, has stated that Roman Empire may not have been swept by migration, which forced the Roman provinces to succumb. According to this view, the Germanic masses involved only a few groups of people, each numbering in tens of thousands of people, who did not overturn and dispossess the local Italian communities (Goffart 2006b). Alternatively, migration involved the Barbarians lawfully purchasing land, serving as recruits in the Roman army, marrying into Roman aristocracy, and adopting the religion of the Empire, thus slowly acculturating to the already established ways of life on Roman land (Goffart 2006a). The Langobard occupation of the Italian land may have closely followed the Roman system of *hospitalitas*, which in the time of the Republic meant the system of quartering soldiers, but by the time of the Late Antiquity meant that barbarian occupants were awarded one or more personal taxpayers. Thus, while that does not mean that the local Italian landowners were free from the ruling power of the invaders, they were not turned into slaves or serfs, they were forced to pay a tax on their harvests but remained in full change of their lands and dependents (Goffart 1980). Furthermore, the studies focused on population dynamics, nutrition, and health in Italy in the Migration Period has concluded that the barbaric invasions did not significantly affect the Italian population. Particularly, some studies show that in northern Italy Langobards made up no more that 5-8 percent of the population, and that the paleopathological analysis indicates that the diet has improved and became more equal among the population from the Late Roman to Early Medieval period (Barbiera and Dalla-Zuanna 2009).

This "positive" approach to the barbarian invasions has been critiqued by scholars arguing that the Italian populations were affected by the newcomers and experienced long-term effects of the decline of the Empire (Ward-Perkins 2005). It is important to remember that war and conquest took place, and such conflicts always involve suffering. And while lawful acquisition of land probably occurred, according to Ward-Perkins (2005), some land was forcefully taken from the landowners as literary sources talk about the division of land and losses of the Roman population, not taxes. Furthermore, from the archaeological evidence scholars observe the decline in production, the number of settlements, disappearance of industries and commercial networks, potential drop in food production, and possible decline in agricultural sophistication (Ward-Perkins 2005). But were all these developments the direct result of the arriving barbarians? To investigate further the influence of migration and whether or not acculturation of the barbarians after they have migrated into Italy occurred, it is important to investigate how different cultural groups interact with each other.

3.3 Cultural Contact

Berry (1997: 7) described acculturation as "phenomena which result when groups of individuals having different cultures come into continuous first-hand contact with subsequent changes in the original culture patterns of either or both groups." According to Berry (1997), the process of acculturation depends on the power differences between the "dominant" and "non-dominant" cultures and the voluntariness, mobility, and permanence of contact. The strategies of acculturation based on these factors include assimilation, integration, separation, and marginalization. Acculturation leads to physical, biological, economic, social, and cultural changes of one or both groups. According to Berry (1997), dietary change may either involve biological changes, such as decreased or improved nutrition and hence the health of the group, or cultural changes, transforming the dietary strategies and cultural views on food.

Expanding on the acculturation approach, Phinney et al. (2001) added a theoretical framework of ethnic and national identity. This framework allows viewing acculturation as an individual experience, not just the state of a migrating group in general. Thus, an individual retaining a strong ethnic identity and embracing the new national identity could be considered integrated, while an individual accepting only their ethnic or only the new national identity would be considered separated or assimilated, respectively. An individual identifying with neither would have a marginalized identity (Phinney et al. 2001).

Within the archaeological field, Burmeister (2000) argues that migration and the cultural change related to it may only be understood through the processual perspective as an extensive socioeconomic process. The archaeological evidence may include material culture, architecture, and burial practices, although Burmeister (2000) also notes that burials reflect the social status of individuals rather than internal traditions. Not all archaeological investigations of culture contact, however, adopt the processual perspective. In the case of dietary studies a larger emphasis is put on individual agency and identity, due to the assumption that food plays a big role in the creation of personal identity. For example, Beaudry (2013), linking dietary strategies to survival, examines dietary mixture from two perspectives: incorporation and creolization. Incorporation is explained through the Inca practice of elite feasting and support of laborers from the provincial territories with state pottery, which was in turn connected with gendered labor and the domestic realm. Covertly establishing power in the domestic life of the provinces through pottery helped the Inca expansion and incorporated Andean peoples into the Inca dietary traditions (Beaudry 2013). Creolization, the process when the elements of contacting cultures blend together creating a new culture, is explained through the French colonization of the North American territories. The dietary strategy of the first generation of colonists was to replicate the food production practiced in their home country, while the second generation adapted to the new environmental conditions and began to incorporate products of the New World. This mixture of local and colonial foodways created a distinctive creole culture. However, the author notes that different colonial cultures vary in how receptive they are to culinary experimentation, which would lead to the varying success of survival (Beaudry 2013).

3.3.1 Cultural Contact in the Roman World

The study of culture contact in the Roman world is often focused on the influence that Roman culture had in the conquered provinces. The extent of Roman influence appears to have varied between the regions. Such, in the study of identity expression among the indigenous people of Gaul and Germany after the Roman conquest Wells (2015) found that based on the examination of archaeological evidence from burials and sanctuary sites, the Roman presence in those provinces had a limited impact on the identity of the conquered peoples. The dietary studies of Roman Britain showed that Roman conquest widely affected the life of local populations, but people's acceptance of Roman food and thus Roman ways varied based on their personal identity. In the study of the Roman influence on the British foodways and dietary habits, Van der Veen (2008) took the embodiment approach, stating that food is a special type of material culture, linked to the political economy and domestic sphere of human life. In the study of "Romanization" of Britain through the import and adoption of over 50 new food plants, strengthened by the archaeobotanical data, the author found that the new food broadened the British diet, potentially improved nutrition, and allowed different groups and classes in Roman Britain to be distinguished from one another. Conformity or nonconformity with the Roman foods became a part of people's identity, either by showing their status, an interest in becoming more "Roman," or rejection of foreign produce (Van der Veen 2008). Similarly, resistance to the foodways of a foreign or ruling culture has been observed in the archaeological study of Roman pans in the 1st century BCE Jerusalem and Judea. Pans, connected with Roman recipes and thus Roman culture, were potentially not of interest to Jewish people in this period, making them extremely rare in the archaeological record in Palestine (Beaudry 2013).

The majority of culture contact studies focus on Roman influence in the conquered provinces at the height of the Roman power. It is not clear what influence would an incoming group have on the local Italian populations after the decline of the Western Roman Empire. According to Ward-Perkins (2005), the Germanic tribal identity was already flexible and changeable, with individuals capable of changing their group membership between one Germanic group to another rather fast. Some studies also allude to the possibility that identity change may have occurred among the Langobards migrating into Italy. For example, according to Christie (2010: 11) "a mid-7th-century Lombard in north Italy will have talked, thought, and interacted in a quite different way from a mid-6th-century Lombard on the Danube," indicating a cultural change that the migrating groups have gone through. Paul the Deacon's Historia Langobardorum (ca. AD 787-789) tells the story of Droctulft, a man born a Sueve, or Suebi, a Germanic group of people from the region of the Elbe River, but raised among the Langobards, who abandoned his adoptive peoples to join the Byzantines in the fight against the Langobards. His Langobard identity may have been indicated by his facial hair, a long beard, a feature at the time associated with Langobards, but an epitaph at the time of his death indicated that he thought of Byzantine Ravenna as his homeland (Ward-Perkins 2005). However, it is also important to note that acculturation of migrating Langobards does not necessarily mean that they were becoming Italian. Most probably, the already established Italian traditions were strong and instead of being replaced by the migrant traditions were fused with them (Christie 2010). The mixing of the "Roman" identity and the "barbarian" identity can also be observed in the language people used at the time. The literary sources indicate that the conquered Roman people did feel an incentive to not only wear the dress of the barbarians, but also adopt a new language to show devotion to the new ruling nobility and rise in status (Ward-Perkins 2005). However, not all Romans were ready to take on the new ways due to the "centuries-old, deeply ingrained certainty that their own (Roman) ways were immeasurably superior to those of the barbarians" (Ward-Perkins 2005: 79). Perhaps this idea of the superiority of Roman culture over the rest was what helped the Roman identity to live on, as the barbarian nobility potentially took on the Roman ways in order to show prestige and culture to their new subjects (Ward-Perkins 2005).

The identity approach, given that food is closely connected with individual and communal ways of life and traditions, could possibly help to interpret the dietary change in the Early Medieval countryside of Ravenna. Potential dietary change related to foods consumed primarily by one group and not the other, could indicate either the preservation of the "Roman" identity and thus retention of the traditionally Roman or local diet, or the transition to the "Langobard" identity through the influence of the Langobards possibly establishing their diet along with their power in the region, in the Early Medieval period.

Chapter 4: Stable Isotope Analysis

4.1 Introduction

The use of stable isotope analysis for diet reconstruction began in the 1970s. The first studies focused on analyzing plant consumption based on ^{13}C levels (DeNiro and Epstein 1978; Vogel and van der Merwe 1977). In the 1980s analysis of nitrogen isotopes was added, and diet reconstruction via stable isotope analysis was implemented across various sites (Ambrose and DeNiro 1986; Farnsworth et al. 1985; Schoeninger et al. 1983; Schwarcz et al. 1985; Walker and DeNiro 1986). As the technology improved, the time required to analyze a single sample decreased. It also became possible to analyze several samples at once (Katzenberg 2008). Furthermore, researchers began studying the difference between diet reconstruction from bone collagen and bone apatite and adding oxygen and strontium isotope analyses in animal and human studies (Lee-Thorp et al. 1989; Luz and Kolodny 1985; Luz et al. 1990; Schoeninger 1979; Sealy et al. 1991; Tykot 2020; Tykot et al. 1996; Wright and Schwarcz 1998). The field and techniques continue to develop to this day; however, the principles remain the same.

4.2 Stable Isotope Principles

Isotopes are versions of the same chemical element that have the same number of protons and electrons, but differ in the number of neutrons, which affects their size and atomic mass. Stable isotopes are non-radioactive, and thus do not spontaneously go through radioactive decay. Carbon and nitrogen both have two stable isotopes: ^{12}C and ^{13}C, and ^{14}N and ^{15}N. Oxygen has three stable isotopes: ^{16}O, ^{17}O, and ^{18}O. The lightest isotopes ^{12}C, ^{14}N, and ^{16}O are the most abundant in nature, and each make up around 99% of the total amount of their respective element's isotopes (Katzenberg 2008; Tykot 2020). The heavier isotopes are measured in per mil (‰) using mass spectrometers and reported using the delta (δ) notation, which expresses the difference of the measurement from the internationally established standards. The standard for carbon and oxygen originally used to be Pee Dee Belemnite limestone in South Carolina. Given that the original stocks of this limestone are now exhausted, the new currently used standard is Vienna PDB. The standard for nitrogen is AIR, or atmospheric nitrogen (DeNiro 1987; Pollard and Heron 2008; Tykot 2020; van der Merwe 1982). The formula used to calculate the values of stable isotopes is:

$$\boldsymbol{\delta^{13}C = [(^{13}C_{sample}/^{12}C_{sample})/(^{13}C_{standard}/^{12}C_{standard}) -1] \times 1000‰}$$

where the $^{13}C/^{12}C$ ratio can be replaced with $^{15}N/^{14}N$ and $^{18}O/^{16}O$ for $\delta^{15}N$ and $\delta^{18}O$, respectively (DeNiro 1987; Pollard and Heron 2008).

The difference in isotope values between the sample and the standard is called fractionation. Fractionation occurs because the isotopes vary in size and atomic mass, and thus different chemical and metabolic processes result in varying ratios of these isotopes (van der Merwe 1982). The values of isotopes in the sample can be negative, as is the usual case for the $\delta^{13}C$ in plant tissues, which are isotopically depleted compared to the VPDB standard (Pollard and Heron 2008).

4.3 Biology

The isotopic method of diet reconstruction is based on the observation that carbon and nitrogen ratios in bones and teeth reflect the isotopic ratios from food. Bone is made of about 30% organic matrix of protein collagen, and 70% inorganic minerals, mostly hydroxyapatite, and acts as a storage for calcium and phosphate ions that are necessary for bone repair and remodeling (Katzenberg 2008; Pollard and Heron 2008). Bone collagen consists of 35% carbon, 11-16% nitrogen, hydrogen, oxygen, and sulfur, which is why it is used for stable isotope analysis. The mineral portion of the bone, bone apatite, also contains carbon in the form of carbonate (Katzenberg 2008). Bone collagen is used to analyze the dietary protein consumption, while apatite analysis also investigates carbohydrates and lipids in the diet (e.g., Waterman et al. 2017). This research is concerned with investigating both the dietary proteins from collagen and the whole diet from the apatite.

Bone is a living tissue that is constantly remodeled until the organism is dead. Remodeling of the bone allows complete regeneration of an adult skeleton every 10 years (Manolagas 2000; Pollard and Heron 2008). Specialized bone cells, osteoclasts, adhere to the bone and remove it in a target area, while osteoblasts move after the osteoclasts to a secreting osteoid that mineralizes and creates the new bone (Manolagas 2000). The rates of bone turnover vary within the skeleton, which means that different elements of the skeleton contain different information on diet. Thus, teeth that form in early childhood and do not go through major remodeling throughout life, reflect the diet in this period of life. Different bones may also show different time spans, but the general consensus is that bone reflects diet in the last 7-15 years of an individual's life (Pollard and Heron 2008; Tykot 2020). Mobility in life can also be accessed through the difference in diet between childhood and adulthood, through the comparison of stable isotopes in teeth and bone (Pollard and Heron 2008).

Furthermore, bone goes through post-mortem alterations called diagenesis. The structural relationship between the collagen and apatite, allows collagen to survive in the archaeological record for thousands of years, but degradation still occurs. Depending on the taphonomic conditions, diagenesis includes breakdown and leaching of collagen, alteration of mineral matrix, and other changes that affect the values of carbon and nitrogen stable isotopes in the analysis (Hedges 2002; Katzenberg 2008). Methods of bone preparation first developed by Lee-Thorp (1989) are aimed at removing diagenetic carbonates from bone. Diagenetic change can also be detected through several methods, including measurement of atomic carbon to nitrogen ratios and collagen concentrations in the whole bone (Ambrose 1990). The effects of diagenesis may not be detrimental to research, as according to Tykot (2020), preservation is considered reliable when collagen yield is more than 1%. Methods of contamination assessment will be discussed later in the methods section.

4.4 Diet

The values of carbon and nitrogen isotopes in human tissues depend on their values in plants and animals being consumed. Different foods have different ratios of carbon and nitrogen isotopes (DeNiro 1987).

4.4.1 Carbon

Different types of plants in the diet can be distinguished depending on the photosynthetic pathway they use and the resulting ^{13}C values in their tissues. Three types of photosynthesis have been detected in plants: C3, C4, and CAM. They differ by the type of enzyme that a plant uses to fix atmospheric CO_2 in their tissues and the amount of carbon atoms that the first product of photosynthesis has (DeNiro 1987). CAM plants grow in arid environments and are rarely included in human diet; thus, they are not discussed further. Atmospheric CO_2 has a $\delta^{13}C$ value around -7‰ (DeNiro 1987). C_3 plants, such as wheat and barley, perform the chemical reaction known as

Calvin cycle, where the initial product of CO_2 fixation contains three carbon atoms. Their $\delta^{13}C$ values measure around -26.5‰ (DeNiro 1987; Tykot 2020; van der Merwe 1982). C_4 plants, such as maize and millet, use the Hatch-Slack photosynthetic pathway, where the initial product of CO_2 fixation contains four carbon atoms. These plants have higher values of $\delta^{13}C$, around -12.5‰ (DeNiro 1987; Tykot 2020; van der Merwe 1982). During consumption, bone collagen $\delta^{13}C$ is modified by metabolically induced fractionation and enriched by about 5‰ (Pollard and Heron 2008; Tykot 2020), but the overall difference in $\delta^{13}C$ values between C_3 and C_4 plants remains, allowing researchers to evaluate the role of these plants in a person's diet. Collagen carbon reflects the ratio of carbon isotopes from the protein consumption (Pollard and Heron 2008). For a deeper understanding of C_3 and C_4 plants in the diet, stable carbon isotopes from bone apatite and/or tooth enamel are analyzed. While collagen carbon comes mainly from consumed proteins, apatite/enamel carbon comes from carbohydrates, lipids, and proteins ingested (Ambrose and Norr 1993). This reflection of a full diet allows identification of even a small percent of C_4 plants in the diet (Tykot 2020). Percentages of C_4 plants in the diet can be interpreted from the $\delta^{13}C$ collagen values, using the range of carbon isotope values from -19‰ to -5‰. Each per mil above -19‰ would indicate 7% of C_4 plant consumption (Tykot 2020).

For marine plants carbon sources include dissolved carbon dioxide, bicarbonates, and carbonates (van der Merwe 1982). The photosynthetic division of marine plants is not possible, but plankton isotopically resembles C_3 plants, while kelp and seaweed resemble C_4 plants. Overall, $\delta^{13}C$ values of aquatic organisms can vary from -7‰ to -31‰, with freshwater organisms having more negative $\delta^{13}C$ values and saltwater organisms having less negative $\delta^{13}C$ values (van der Merwe 1982).

In the bone collagen of the consumer, $\delta^{13}C$ values are metabolically enriched. Studies on mice have previously shown a +5‰ enrichment relative to the whole diet. In bone apatite enrichment was found to be about + 9.5‰ in rats, while in larger herbivores and humans it seems that bone apatite $\delta^{13}C$ are enriched by about +12‰, relative to the whole diet (Pollard and Heron 2008; Tykot 2020; van der Merwe 1982).

Data on $\delta^{13}C$ values from both bone collagen and apatite allows to calculate the $\delta^{13}C$ collagen-apatite spacing and quantify the consumption of C_3 and C_4 plants together with marine and terrestrial protein (Kellner and Schoeninger 2007; Killgrove and Tykot 2013, 2018; Waterman et al. 2017).

4.4.2 Nitrogen

Nitrogen isotope values in bone show consumption of nitrogen-fixing plants and non-nitrogen fixing plants (Pollard and Heron 2008). To form proteins, plants need nitrogen. Some plants are able to acquire nitrogen from the atmosphere, for which the standard value of nitrogen isotopes is 0‰ (Mays 2010). Many plants cannot acquire nitrogen from the atmosphere but receive it from the soil through a symbiotic relationship with the *Rhizobium* bacteria. Those plants have nitrogen values around 5‰ (Katzenberg 2008; Mays 2010). In the middle are the legumes, which use both sources of nitrogen, and their $\delta^{15}N$ values range between 0 and 4‰ (Mays 2010). In addition to the source of nitrogen, rainfall and altitude also affect the nitrogen isotope values in plant tissues.

Nitrogen isotope values in bone also indicate the role and type of protein in the diet, as almost all nitrogen in diet comes from protein consumption (Mays 2010). Flesh has a higher value $\delta^{15}N$ values than diet, thus with each trophic level, $\delta^{15}N$ values get enriched by about 3-5‰

(Hedges and Reynard 2007; Mays 2010; Tykot 2020). Marine plants also have higher $\delta^{15}N$ values because of the dissolved nitrates in water. Additionally, due to marine and freshwater environments having more trophic levels, $\delta^{15}N$ values of people consuming fish are much higher than $\delta^{15}N$ values of people eating a terrestrial diet (Mays 2010; Pollard and Heron 2008; Tykot 2020). Saltwater and freshwater fish consumption can be further differentiated through $\delta^{13}C$ values, as freshwater fish have lower $\delta^{13}C$ values than saltwater fish (Katzenberg 2008). Thus, the combination of nitrogen isotopes with both collagen and apatite carbon can provide insight into someone's dietary practices and ways of life.

4.5 Migration

Oxygen values from bone apatite and/or tooth enamel depend on the values of ingested water and thus vary between regions with different climates, humidity, and altitude (Katzenberg 2008; Tykot 2020). Based on these differences in regional values, oxygen isotopes are used to study human mobility.

4.5.1 Oxygen

Oxygen is found in bone carbonate and phosphate, and the $\delta^{18}O$ values in food depend primarily on the values of ingested water (Katzenberg 2008; Luz et al. 1990). Oxygen isotopes vary based on climate, humidity, and temperature and are implemented to analyze seasonality, human mobility and their effects on diet (Tykot 2020). $\delta^{18}O$ values tend to decrease with increasing latitude, distance from the coast, and altitude, as ^{18}O isotopes are heavier and fall with precipitation (Katzenberg 2008). Comparison of oxygen values between teeth that form early in life with values from bone apatite that is affected by bone turnover throughout life, may show a difference in the source of the ingested water and indicate mobility in life (Katzenberg 2008). While this research project does not involve the analysis of tooth enamel, it may be possible to implement the results from other studies, such as the assessment of oxygen isotope range in Europe by Lightfoot and O'Connell (2016) and the examination of Langobard diet and migration in the Veneto region of northern Italy by Maxwell (2019), which involved the analysis of oxygen isotope values from water in the contemporary, Early Medieval, period.

4.6 Conclusion

The analysis of stable nitrogen isotopes together with both bone collagen and apatite carbon can provide information on the average diet in the last decade or so of an individual's life. Carbon isotopes from collagen can help distinguish between C_3 and C_4 plant consumption and differentiate between marine and aquatic protein. Carbon isotopes from apatite allow to distinguish even the smallest amounts of C_4 plants in the diet, around a few percentages indicated by a difference in 0.5‰. Nitrogen isotopes provide information on protein consumption, allows to identify agricultural people with low animal protein intake, and people who consumed animal protein. Furthermore, if animal protein was part of the diet, differentiate which type of protein, terrestrial or aquatic, either saltwater or freshwater fish, was consumed. The additional information provided by the analysis of oxygen isotopes may add understanding of human mobility at the examined sites. In general, previous archaeobotanical and zooarchaeological studies, such as the study by Rottoli (2014), identified presence of barley, wheat, rye, einkorn, beans, lentils, chickpeas, pigs, sheep and goats, cattle, fowl, and freshwater fish in Early Medieval Northern Italy. The presence of these food sources could be expected in the countryside of Ravenna, too.

Chapter 5: Literature Review − Dietary Studies

5.1 Roman Diet

The Roman diet has been archaeologically studied in Rome, across the Italian peninsula, and on the periphery of the Roman Empire. According to the dietary studies and the Roman literary sources, the basic staples were cereals, olive oil, and wine (Craig et al. 2009; Killgrove and Tykot 2013; Prowse et al. 2004). The literary sources describing the Roman diet come from the writings of the 1^{st}-2^{nd} century Roman writers, such as Cato, Varro, and Columella. However, these sources are biased in that they primarily describe the diet of the Roman elites (Prowse et al. 2004). A typical meal of the lower classes according to Belcastro et al. (2007) consisted of bread, wine, onions, chickpeas, garlic, lard, some fruit, and olives. The amount of supplemental foods, such as meat, with pork being the most popular kind of meat, dairy, and fish, varied based on locally available resources and the socioeconomic status of the consumer.

Stable isotope analysis may help reconstruct a less biased picture of the Roman diet. Killgrove and Tykot (2013) have analyzed the remains from two Roman burial sites, one a periurban cemetery of Casal Bertone dating to 2^{nd}-3^{rd} centuries CE, another – Castellaccio Europarco, a burial area near the wall of *via Laurentina*. The overall average $\delta^{13}C_{co}$ was -18.2‰ ± 1.1‰, $\delta^{15}N$ 10‰ ± 1.5‰, and $\delta^{13}C_{ap}$ -11.8‰ ± 1.3‰. These results indicate that the diet of the studied groups relied primarily on C_3 plants and terrestrial animals, with some addition of the aquatic protein and C_4 plants (Killgrove and Tykot 2013). No significant differences were found between men and women or adults and subadults in the Casal Bertone sample. Furthermore, there were no differences between the burial sites in the mean values $\delta^{13}C_{co}$ and $\delta^{15}N$, although a significant statistical difference was detected in the mean $\delta^{13}C_{ap}$ values. The authors attribute this difference to people of Castellaccio Europarco, a suburban cemetery located in the agricultural area, consuming more millet, a C_4 plant, than people of periurban Casal Bertone (Killgrove and Tykot 2013). The authors explain it through Roman views on millet, as it was associated with the poor and famine. Thus, the reasons for the difference in $\delta^{13}C_{ap}$ values may lie in the socioeconomic inequality between the people of Rome. In a comparison with other contemporary dietary studies around Italy, the authors point out that there was no singular Roman diet. For example, the sites close to saltwater and freshwater resources, such as Portus Romae and St. Callixtus show signs of higher fish consumption, indicating the use of locally available foodstuffs (Killgrove and Tykot 2013).

At Gabii, another Imperial-Era site, located 18 km to the east of Rome, Killgrove and Tykot (2018) found that the average $\delta^{13}C_{co}$ was -18.9‰ ± 0.7‰, $\delta^{15}N$ 10.7‰ ± 0.9‰, and $\delta^{13}C_{ap}$ -12.9‰ ± 1.3‰. No significant differences were found between men and women. The diet at Gabii was found to be different from the diets at Casal Bertone and Castellaccio Europarco, due to a lower consumption of millet but a somewhat higher consumption of aquatic resources at Gabii (Killgrove and Tykot 2018). Yet the authors note that the nitrogen isotope values at Gabii are still low, suggesting a low reliance on aquatic foods. Immigration was also noted at Gabii, with one individual in the sample having a significantly lower $\delta^{18}O$ value indicating migration from a cooler, wetter area of the Empire. This individual consumed a higher amount of C_4 resources than the rest of the sample, possibly indicating a standard diet in their place of origin (Killgrove and Tykot 2018).

Located 23 km southwest of Rome is Isola Sacra, the necropolis where the inhabitants of Portus Romae were buried. Portus Romae is a coastal site; hence Prowse et al. (2004) tested the importance of marine foods in the diet at the site. The researchers found that the average $\delta^{13}C_{co}$ was -18.8‰ ± 0.3‰, $\delta^{15}N$ 10.8‰ ± 1.2‰, and $\delta^{13}C_{ap}$ -11.4‰ ± 1.2‰. The diet at Isola Sacra was concluded to have consisted out of a mixture of marine and terrestrial resources, with high-trophic level fish being consumed, not only the low-trophic level fish in the form of garum. The main source of carbon was from terrestrial foods, such as bread and small amounts of vegetables, fruits, oil, and wine (Prowse et al. 2004). The authors state that the presence of millet in the diet was possible, but not through direct consumption, which was considered less desirable, but through addition of millet as animal fodder (Prowse et al. 2004).

The diet at the Roman coastal site of Velia that dates to between 1st and 2nd centuries CE was investigated by Craig et al. (2009). It is located in Campania, southern Italy. The researchers found that the sample is divided into two distinct groups based on the nitrogen isotope values. The first group had the average $\delta^{13}C$ of -19.5‰ ± 0.2‰ and $\delta^{15}N$ of 8.2‰ ± 0.7‰. The second group had the average $\delta^{13}C$ of -19.3‰ ± 0.3‰ and $\delta^{15}N$ of 11.2‰ ± 1.3‰. The researchers did not find any further differences within the samples. The authors concluded that the first group consumed high amounts of cereals and legumes, which would explain their low nitrogen isotope values, with some addition of meat and dairy. The diet of the second group appears to have contained more marine fish (Craig et al. 2009). The clustering of the two groups does not correspond with any other archaeological information, however, the authors also propose that individuals in the second group with the higher nitrogen isotope values were immigrants. Thus, this study provides evidence for the heterogeneity of the Roman diet due to potential residential mobility.

For the purposes of this project, it is also important to look at the diet in the region close to Ravenna, in northern and northeastern Italy. Diet and mobility in northern Italy during the Roman period have been further explored by Milella et al. (2019). The authors of this study analyzed stable isotopes for both diet and mobility reconstruction at the *Nuova Stazione dell'Alta Velocit*à necropolis in Bologna dating to the 1st-4th centuries CE. The study found that the average $\delta^{13}C$ was -20.3‰ ± 0.3‰ and $\delta^{15}N$ 9.1‰ ± 1.1‰. The authors note that the $\delta^{13}C$ values at their site are lower than $\delta^{13}C$ values at Casal Bertone, Gabii, and Isola Sacra, while the $\delta^{15}N$ values are close to the $\delta^{15}N$ values at Casal Bertone, Castellaccio Europarco, and Velia, but lower than at Gabii and Isola Sacra (Milella et al. 2019). The authors conclude that the diet at Bologna in the Roman period relied on wheat with no indication of millet consumption, but with the addition of freshwater fish. Fish was concluded to comprise on average 13.2% of the diet. Three individuals in the sample were identified as possible non-locals through stable isotope analysis. For one of them, diet reconstruction was not possible due to the low collagen yield, however, the other two had $\delta^{13}C$ and $\delta^{15}N$ values within the average diet range at the site, potentially due to migration early in life (Milella et al. 2019). Even taking into account the heterogeneity of the Roman diet observed by archaeologists around Italy, the Bologna study shows in this region a distinct diet from which millet was not detected in bone collagen and was possibly excluded.

Dietary studies of Roman-period Ravenna are not currently available. However, a paleopathological study focused on analyzing human skeletal remains from three necropoleis, at Bagnacavallo, 'Le Palazzette', and 'La Marabina', was conducted by Facchini et al. (2004). Cribra orbitalia was observed in 60% of the total sample, 62.5% of subadults and 59.3% of adults. Among the subadults, the higher severity cribra orbitalia lesions were more common, while in adults, the lower severity lesions were more prevalent. Cribra cranii was observed in 44.8% of the total sample, 12.5% of subadults and 57.1% of adults. Furthermore, linear enamel hypoplasia was observed in 84% of the individuals in the sample (Facchini et al. 2004). The authors interpret these results as acquired anemia and early life nutritional stress, as pooper classes in the Roman period relied on cereals and legumes, while meat was not considered a primary food item. Thus, according to Facchini et al. (2004), the lack of iron in the diet, together with worm infestations, infectious diseases, and potential lead poisoning, may have led adults in the Ravenna to develop anemia.

5.1.1 Conclusion

The Roman diet appears to have been heterogenous and varying based on where people lived, which locally available resources individuals had access to, and their socioeconomic status. The main staples included cereals, olives, and wine, while the addition of meat and fish widely varied among populations. The role of millet, however, may allow to distinguish the "Roman diet" from dietary practices in other historical periods. The Roman views on millet associated the crop with poverty and famine, hence consumption of millet was either low, indirect through animal fodder, or absent, as was the case for Roman Bologna. No studies of Roman diet in Ravenna are available, but paleopathological studies provide evidence of potential nutritional stress, possibly due to low animal protein consumption.

5.2 Late Roman Diet

Investigations of diet at the archaeological sites in northern Italy dating to the Late Roman period are rare. The available studies, however, provide evidence to plant and animal resources that were present in the region at the time. At Modena, northern Italy, using pollen analysis, Bosi et al. (2015) investigated the decrease of cereal fields in the Late Roman period. In a later research, Bosi et al. (2019) through the analysis of pollen, non-pollen palynomorphs, seeds, and fruits preserved at Modena concluded that base cultivations of cereals, legumes, grapes, and olives remained in the Late Roman period at the expense of cultivating luxury horticultural and aromatic plants. Additionally, the carpological analysis showed a decrease in plant diversity in people's diet at Modena in the Late Roman period, which the researchers relate to climatic changes (Bosi et al. 2019).

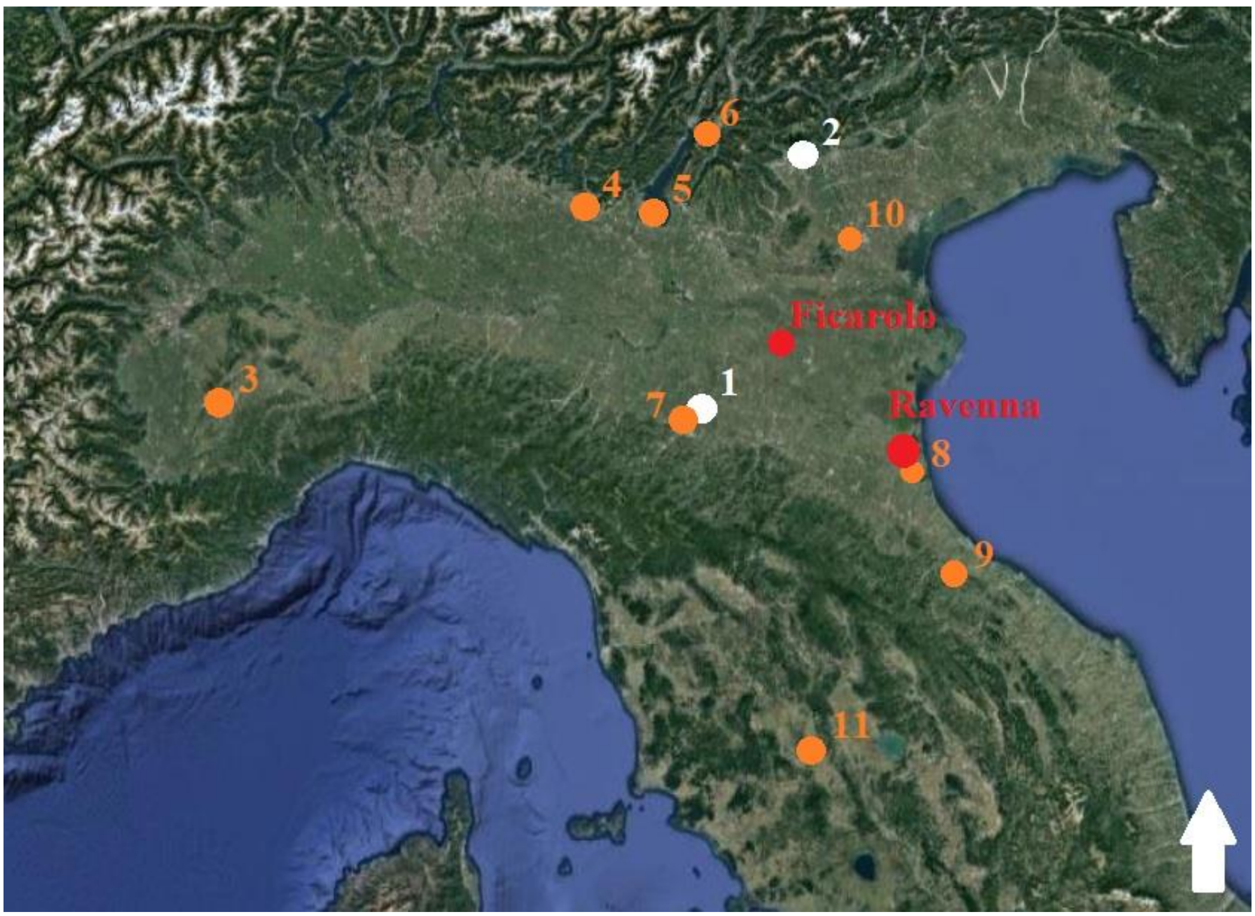

Figure 4. Map of Late Roman and Early Medieval sites. Modified from Google Maps (2021)*
*Late Roman: 1) Modena; 2) Villa Rustica of Brega, Rosà, Vicenza. Early Medieval: 3) Cherasco; 4) Brescia; 5) Sirmione; 6) Loppio; 7) Cognento; 8) Classe; 9) Domagnano; 10) Padua; 11) Pieve di Pava

The zooarchaeological analysis at a Late Roman site, Villa Rustica of Brega, near the town of Rosà in north-eastern Italy, shows which terrestrial animals were available for consumption in the region (Alhaique and Cerilli 2003). The authors report that 730 fragments of animal remains were found in a cistern at the site. The majority of all fragments were located in a single unit and had evidence of cutmarks on them, which led the authors to conclude that these animals were a part of the diet of people living at this villa (Alhaique and Cerilli 2003). Minimum number of individuals (MNI) was counted for each type of domesticated animals. The authors list 6 cows (24%), 3 boars (12%), 15 ovicaprines (60%), and 1 pig (4%) found within the unit (Alhaique and Cerilli 2003).

5.2.1 Conclusion

The Late Roman studies provide evidence for available resources and indicate some changes that occurred in northern Italy at the time. The staples, such as cereals, grapes, and olives remained, while the diversity of crops decreased, with luxury plants cultivated less. On the other hand, the animal husbandry appears to have remained the same, with ovicaprines being the predominant domesticate.

5.3 Early Medieval Diet

The Early Medieval dietary studies focus on the changes that the social and economic transformations brought to Italy. Montanari (1999) in an overview of the Early Medieval food system writes that self-sufficiency defined the food production in this period. The diet was differentiated. While the Roman market valued wheat as a high-quality crop, in the Early Medieval times people consumed cereals that were more productive and easier to cultivate for personal consumption. Thus, rye oats, barley, spelt, millet, and sorghum became more popular, along with beans and chickpeas (Montanari 1999). Food resources were also obtained from uncultivated lands, with fish caught in the local rivers and livestock raised in the wood clearings. Sheep and goat raising was most commonly practiced in Italy, while pig breeding was a distinctive trait of the Germanic peoples (Montanari 1999). Cattle raising gained importance, and, according to the author, for the first time in history beef became an important food source. Cheese, however, was primarily made not from the cow milk, but from the milk of goats and sheep. Furthermore, drinking milk was considered a sign of "barbarism." Overall, the diet in the Early Medieval period appears balanced and diverse, including comparatively more animal protein (Montanari 1999).

Millet, previously absent or very low in some of the Roman north Italian studies, shows prominently in the Early Medieval period. The carpological studies, a type of research that examines the remains of seeds and fruits in the archaeological record, from thirty-two sites in northern Italy showed that "major" cereals, such as barley, rye, wheat, oats, and rice, which originated in East Asia, but by 1st century CE has been imported as an exotic product into Italy and the Mediterranean region, are present at all of the sites. "Minor" cereals, such as millet and sorghum, are absent only from four (Castiglioni and Rottoli 2013; Livarda 2011). However, the "major" cereals are more abundant at the majority of the sites, with the exception of Cherasco, Collegno, Brescia, Sirmione, Loppio, and Cognento sites, where "minor" cereals are dominant. Among the "minor" cereals, broomcorn millet is the most common. The authors conclude that cereal cultivation in northern Italy in the Early Medieval period was based on polyculture, and cultivation of 6 to 8 different cereals was common (Castiglioni and Rottoli 2013). This observation supports the previous statements by Montanari (1999) regarding diversification of crops and the need for self-sufficiency. Millet appears to be as important as barley and wheat in northern Italy during this period. However, for the purposes of this study it is important to note that at the sites close to Ravenna, Classe and Domagnano, minor cereals are almost absent (Castiglioni and Rottoli 2013). A later publication by Rottoli (2014) added the results of the archaeozoological studies, which showed that depending on the landscape, people relied on different domesticates. Pigs appear to have been the predominant domesticate on lowland sites, while sites in mountainous areas had more sheep, goats, and cattle. Domesticated fowl, specifically roosters, geese, and ducks, were present in rather large numbers throughout, and sites close to Lake Como show significant presence of fish (Rottoli 2014).

A lipid residue analysis was also performed at the Early Medieval site of Padua in northern Italy (Ganzarolli et al. 2018). The goal of the research was to figure out which cereals were directly consumed at the site. Lipids from forty-five cooking wares and coarse-wares were extracted and analyzed, showing millet residue. The researchers state that in the majority of cases, millet was mixed with animal products and vegetables, which is supported by historical sources mentioning that millet was used to cook soups and porridges, as it was more digestible in broth or milk (Ganzarolli et al. 2018).

Several diet reconstruction studies involved examining the local Italian diet during this period. The stable isotope analysis in Early Medieval Colonna reveals that the diet in the Middle Ages may not have been the same throughout Italy. At Colonna, the average $\delta^{13}C$ was -18.9‰ ± 0.4‰ and $\delta^{15}N$ of 7.7‰ ± 0.6‰. The nitrogen isotope values were higher in men, suggesting a higher proportion of animal protein in their diet, potentially due to higher status (Baldoni et al. 2016). The authors of the study conclude that people in Early Medieval Colonna consumed a terrestrial diet with dietary protein primarily coming from C_3 plants. Millet may have been a part of the diet, due to slight elevation of $\delta^{13}C$ in some individuals (Baldoni et al. 2016). A statistical comparison of the isotopic results at Colonna were also compared to a few other Early Medieval and Medieval burials in central Italy. The authors state that the comparison with diet at Cosa and Piazza Madonna di Loreto sites showed a greater variation in diet, with higher consumption of C_4 plants and marine resources, at these sites than at Colonna (Baldoni et al. 2016). A further study of dental calculus in Colonna adds information on the dietary habits and the use of medicinal plants in Early Medieval Italy. Gismondi et al. (2018) found granules of C_4 plants in dental calculus of several individuals but noted that a minimal consumption may have not affected the isotopic values. Furthermore, markers of oil-rich seeds, fruits, and aquatic resources, such as fish, mollusks, and algae were found. The researchers point out that the markers may signify a low proportion of aquatic foods in the diet that also would not have affected the isotopic values but could be observed through the analysis of dental calculus (Gismondi et al. 2018).

An Early Medieval privileged burial in Siena was examined alongside 19 other burials at the site of Pieve di Pava through stable isotope analysis. The average isotope values for the group showed $\delta^{13}C$ of -19.1‰ ± 0.9‰ and $\delta^{15}N$ of 9.6‰ ± 0.6‰, while the privileged individual had the average $\delta^{13}C$ of -19.0‰ ± 0.1‰ and $\delta^{15}N$ of 10.1‰ ± 0.2‰. The study concluded that the privileged individual consumed more meat, compared to the rest of the group, indicating potential socioeconomic differences in diet (Ricci et al. 2012).

5.3.1 Conclusion

The decline of the Roman market led people to diversify their crops and become more self-sufficient in their food production. While in central Italy among the local populations it appears that millet still remained the less popular crop, in northern Italy millet was harvested alongside a wide range of other cereals, and at some sites even became the dominant crop for direct consumption. The protein consumption appears to have continued to rely on ovicaprines and cattle. The dietary signs of the Germanic tribes mentioned by Montanari (1999), such as reliance on pork and consumption of cow milk, may help distinguish the possible influence of the Germanic immigrants on the local Italian diet.

5.4 The Langobard Diet

In order to evaluate dietary changes and influences between the local populations and the migrants, it is necessary to determine if the migrant groups had a distinct diet themselves. A number of dietary studies in the Early Medieval period have examined the Langobard burials with the goal of reconstructing the dietary habits of the Langobard populations in Italy or assessing their health status in relation to diet.

The comparative analysis of dental health between the Roman and Early Medieval populations by Manzi et al. (1999) examined the individuals buried at the Langobard necropolis of La Selvicciola dated to the 7th century CE. Statistically significant differences in dental pathologies were detected. The Langobard populations had significantly higher rates of caries (70.8% of the Langobard and 35.9% of the Roman individuals affected), alveolar abscesses (18.7% of the Langobard and 4.7% of the Roman individuals affected), and antemortem tooth loss (60.4% of the Langobard and 43.7% of the Roman individuals affected). However, the rates of dental enamel hypoplasia were somewhat lower in Langobard populations than in Romans (75.0% of the Langobard, 81.03% of the Roman individuals affected) (Manzi et al. 1999). The study concluded that the dental health differences may have been caused by the varying socioeconomic status, with individuals from Early Medieval La Selvicciola relying primarily on cereals, thus consuming more carbohydrates and less proteins (Manzi et al. 1999).

The diet at La Selvicciola was also later analyzed through stable isotope analysis by Tafuri et al. (2018) and compared to the diet during the classical period. The results of the stable isotope analysis showed that at the Roman cemetery at Lucus Feroniae the average $\delta^{13}C$ was -19.6‰ ± 0.5‰ and $\delta^{15}N$ 10.0‰ ± 1.3‰, while at the Langobard cemetery of La Selvicciola the average $\delta^{13}C$ was -19.4‰ ± 0.3‰ and $\delta^{15}N$ 9.1‰ ± 0.7‰. Both sites show a C_3 plant-based diet. The authors point out the difference in isotopic distribution at the two sites, stating that the Roman diet appears to have been more heterogeneous, as people relied on different sources of protein with potential addition of marine foods, while the Langobard diet had a more homogeneous pattern, indicating a restricted protein source (Tafuri et al. 2018). However, the researchers also note that protein at both sites was likely derived from plant sources, not meat, which potentially indicates a progressive impoverishment in the diet (Tafuri et al. 2018).

A health comparison study between the Roman necropolis of Quadrella and the Early Medieval necropolis of Vicenne-Campochiaro also found significant differences in health between the periods (Belcastro et al. 2007). The study focused on dental pathologies and skeletal health markers, such as cribra orbitalia and periostitis. At Vicenne the researchers found higher levels of heavy wear, calculus, and interproximal chipping, which the authors attributed to consumption of fibrous foods, such as meat. Protein consumption at Vicenne according to Belcastro et al. (2007) was higher and corresponds to the dietary model of Germanic peoples. The comparison of cribra orbitalia rates between the Vicenne sample and the Ravenna sample studied by Facchini et al. (2004) showed a higher frequency of this skeletal pathology in Ravenna, potentially due to a difference in climate and a worse health status at Ravenna with the spread of malaria (Belcastro et al. 2007).

A zooarchaeological analysis conducted on the Langobard faunal remains in the area of S. Giulia monastery in Brescia showed presence of butchery marks on a high proportion of bone refuse from domestic animals (Baker 1996). 90% of the faunal remains at the site were mammal bones and teeth, with caprines being the dominant taxa (65%), followed by cattle (15-20%) and pigs (15-20%). The author specifically notes that contrary to the idea that pigs were the most popular domesticate in northern Italy, the amount of pig bones in Langobard Brescia was rather low, but that contemporary assemblages from neighboring sites show a wide range of caprines and pigs butchered, suggesting a diverse set of dietary strategies (Baker 1996).

Iacumin et al. (2014) studied diet at six northeastern Italian sites, five of which date to the Early Medieval period and are connected through archaeological evidence to the Langobard culture. The stable isotope analysis results showed a mixed C_3/C_4 diet with low animal protein intake, and the potential addition of low trophic level marine proteins. The authors note that C_4 plants (foxtail, millet, and broomcorn) were consumed directly, not through animal consumption. However, some individuals in the study showed an almost pure C_3 diet (Iacumin et al. 2014). The authors propose that these individuals from the site of St. Stefano were the upper-class people and perhaps the real Langobards, who unlike the locals consumed more wheat. The local lower-class individuals were hypothesized to be enslaved by the Langobards. A statistical comparison between the diet at the northeastern Italian sites studied by Iacumin et al. (2014) and the diet at Early Medieval Colonna in central Italy showed a statistically significant difference for both $\delta^{13}C$ and $\delta^{15}N$ isotope values, which may further indicate a difference between the local Italian and the Langobard dietary practices (Baldoni et al. 2016).

Two more Langobard cemeteries, at Sovizzo and Dueville in Vicenza, were investigated by Maxwell (2019). These cemeteries are located in the Veneto region and date to the 6^{th}-8^{th}

century CE. Here, however, a C_4-based diet can be observed. At Sovizzo, the average $\delta^{13}C_{co}$ was -15.5‰ ± 1.2‰, $\delta^{15}N$ 9.1‰ ± 0.8‰, and $\delta^{13}C_{ap}$ -9.1‰ ± 0.9‰. At Dueville, the average $\delta^{13}C_{co}$ was -14.5‰ ± 0.8‰, $\delta^{15}N$ 8.5‰ ± 0.5‰, and $\delta^{13}C_{ap}$ -6.9‰ ± 0.9‰ (Maxwell 2019). The author states that millet was a staple crop in the Veneto during the Bronze Age but decreased in its popularity during Roman times. With the breakdown of trade in the Late Antique period, however, the region returned to self-sufficient production. Millet, which used to be a staple crop in the Veneto from the Bronze Age but lost its prominence during the Roman period potentially due to social stigma, returned into the diet of people (Maxwell 2019). However, the C_4-based diet, as shown in this study, was a local diet, not the Langobard diet. The Langobard migrants integrated into the local community, taking on the local dietary practices (Maxwell 2019).

Outside of Italy, the diet of the Langobards was also analyzed. The dietary study of the Moravian Langobard population during the Migration period showed that the average $\delta^{13}C$ was -19.4‰ ± 0.6‰ and $\delta^{15}N$ 9.6‰ ± 0.7‰ (Plecerová et al. 2020). The study shows a mixed diet of animal and plant proteins, with some addition of the freshwater resources, and a low consumption of millet, and relates it to the agricultural traditions of the Langobards and the Germanic tribes in general (Plecerová et al. 2020). A similar diet was found among the contemporary Langobard population in Hungary, suggesting a low significance of millet among Langobards of Central Europe (Alt et al. 2014).

5.4.1 Conclusion

It appears that the diet of the Langobard groups in Italy also varied based on the site, the socioeconomic status, and the local resources. In central Italy, the Langobard groups, while consuming more animal protein, seem to have relied on a particular source of meat, perhaps pork, instead of diversifying diet on ovicaprines and cattle, as the local Italian populations. Furthermore, in some areas the dominant position of the Langobards can be observed, such as at St. Stefano, where the Langobards seem to have enjoyed a more protein-rich diet, than the local populations, hypothesized to be enslaved. On the other hand, in areas like the Veneto, Langobards do not appear to have had a great influence on the diet, having assimilated into the local dietary strategies. Thus, the dietary changes may have also depended on the power dynamic between the local and migrant groups. Finally, millet does not appear to have been a part of the Langobard diet but was widely practiced in northern Italy by the locals. Identifying the role of millet in the diet at Ravenna may help reconstruct the relationships between the local and migrant groups and evaluate the potential influences.

Chapter 6: Methods

6.1 Introduction

A total of 49 human bones, including 38 ribs and 11 long bones (8 fibulae, 1 femur, and 2 unknown), and 3 animal bones for baseline analysis, were sampled for carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and oxygen ($\delta^{18}O$) stable isotope analysis.

6.2 Sample Pretreatment

Bone collagen and apatite samples were prepared and purified at the Laboratory for Archaeological Sciences at the University of South Florida using the following established protocols (Tykot 2020).

6.2.1 Bone Collagen

For each studied individual, a piece of bone of about 3-4 grams was taken from a larger bone sample for collagen analysis, and bone powder was drilled out for the apatite analysis. Both the bone piece and the bone powder were weighed, and their mass was recorded. Collagen samples were then processed according to the following processing method:

1. Collagen samples were soaked in 50 ml of 0.1 M NaOH solution for 24 hours to remove humic acids.
2. After 24 hours, the NaOH solution was poured off, and the samples were thoroughly rinsed in distilled water. The samples were cut into smaller pieces.

3. 50 ml of 2% HCl were added to remove bone mineral, and the samples were soaked in the solution for 24 hours.
4. After 24 hours, HCl was poured off, and the samples were rinsed in distilled water. HCl was replaced and the samples were again soaked for 24 hours. This process was repeated until bone was totally demineralized, the acid solution was no longer yellow, and there were no bubbles on the surface.
5. HCl was poured off, and the samples were thoroughly rinsed in distilled water. 50 ml of 0.1 M NaOH solution were added, and the samples were soaked for 24 hours to remove any remaining humic acids.
6. After 24 hours, NaOH solution was poured off, and the samples were thoroughly rinsed in distilled water.
7. Rinsed samples were transferred to 2-dram glass vials. The vials were labeled with indelible marker and placed in the drying oven (60° C) overnight.
8. Dried samples were weighed to determine collagen yield (Figure 5). Then, for each sample, two 0.9-1.2 mg samples were collected and wrapped into tin cups for preparation for the mass spectrometer.

6.2.2 Bone Apatite

Bone apatite samples were drilled using a handheld Dremel microdrill from bone samples used for collagen analysis and processed according to the following steps:

1. Approximately 10 mg of bone powder were drilled and soaked in 1 ml of 2.0% bleach solution for 72 hours to remove collagen, bacterial proteins, and humates.

2. After 72 hours, the bleach solution was pipetted out, and the samples were rinsed using deionized water and centrifuged four times.
3. Samples were placed in a drying oven (60° C) overnight.
4. Dried samples were weighed and pre-treated with 1 ml of 1 M acetic/sodium acetate buffer solution for 24 hours to remove non-biogenic carbonate contaminants.
5. The acetic/sodium acetate buffer solution was pipetted out, and samples were rinsed using deionized water and centrifuged four times.
6. Samples were placed in a drying oven (60° C) overnight.
7. Samples were weighed to get a total weight, and then a smaller sample (0.9-1.1 mg) was weighed into 2-dram glass vials for preparation for the mass spectrometer (Figure 6).

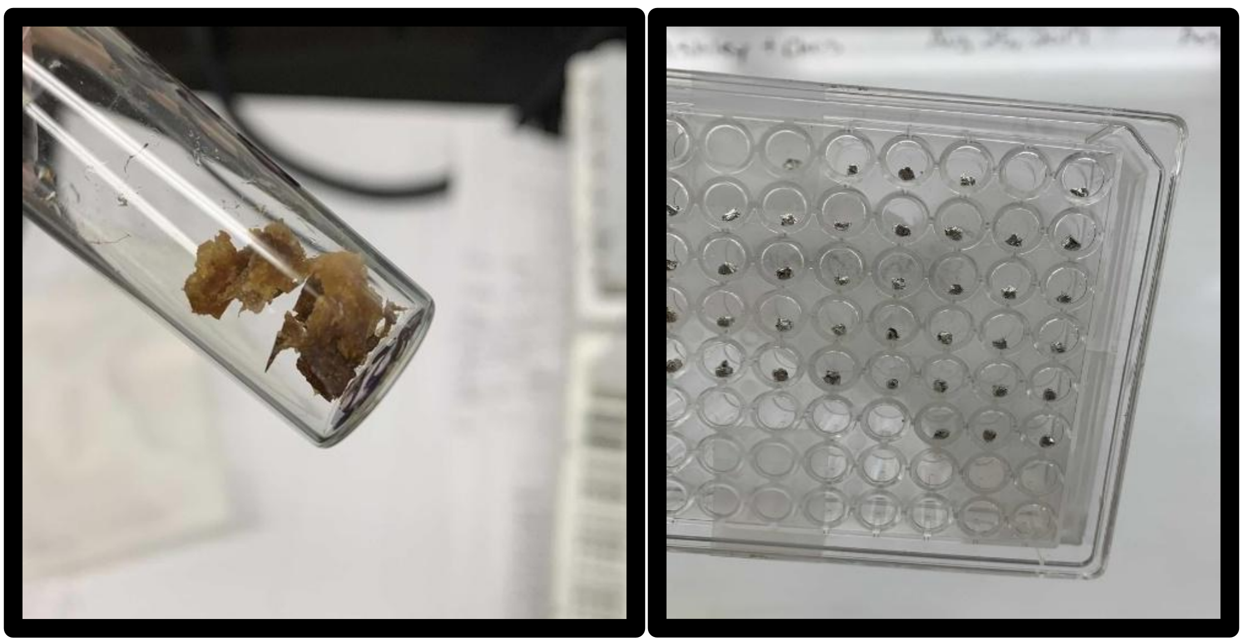

Figure 5. Dried collagen samples (left); samples wrapped in tin capsules (right), photographed by A. Temkina.

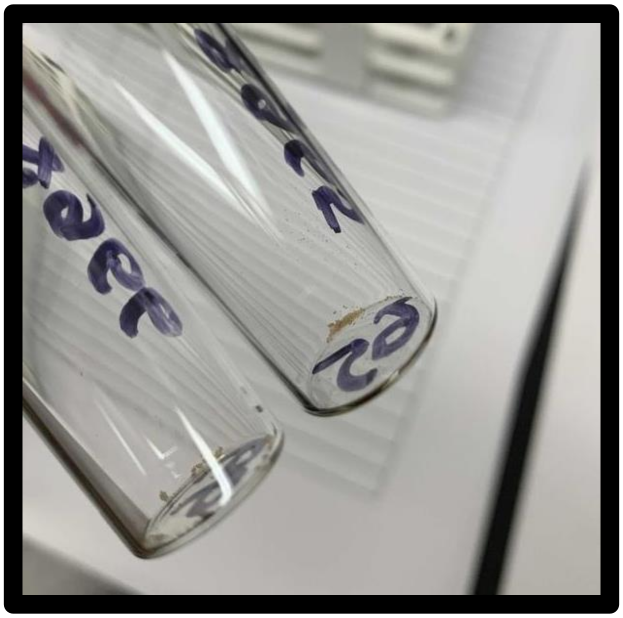

Figure 6. Bone apatite prepared samples, photographed by A. Temkina.

6.3 Analytical Methods

6.3.1 Collagen

Preservation of collagen was essential during sample preparation. A yield of less than 1% can skew the results, due to potential loss of amino acids that contain varying values of carbon and nitrogen isotopes (Tykot 2020). The yield of collagen was calculated by taking the final weight of prepared collagen, dividing it by the original weight of the bone sample and multiplying it by 100%. The majority of the collagen samples produced a collagen yield more than 1%.

The additional reliability precautions implemented was the calculation of the carbon to nitrogen gas ratio and duplication of 1 mg collagen pseudomorphs that were analyzed using the mass spectrometer (Ambrose 1990; Tykot 2020). Ratios of 2.9-3.6 between carbon and nitrogen gases are considered reliable (Katzenberg 2008). All achieved ratios in this analysis ranged between 3.2 and 3.6.

Collagen samples in tin capsules were analyzed using a Carlo-Erba NA2500-II EA with a Costech Zero-Bank autosampler coupled with a Thermo Delta + XL stable isotope ratio mass spectrometer at the USF St. Petersburg laboratory. Collagen samples in tin capsules were placed into a sample tray, which then dropped samples into the furnace, where N_2, CO_2, and H_2O were produced (Katzenberg 2008). The N_2 and CO_2 gases were then separated and analyzed by the mass spectrometer through the measurement of the ion beam intensity. These measurements were then reported as rations of carbon and nitrogen isotopes relative to the standards of Vienna Pee Dee Belemnite (VPDB) and AIR. The $\delta^{13}C$ measurements have the precision of ± 0.1‰, and the $\delta^{15}N$ values measurements have the precision of ± 0.2‰ (Tykot 2020).

6.3.2 Apatite

The preservation of apatite samples is assessed throughout the pretreatment process by measuring yields and the final CO_2 yield during the mass spectrometry analysis. $\delta^{13}C$ and $\delta^{18}O$ isotopes were assessed from 1 mg apatite samples analyzed on a ThermoFisher MAT253 IRMS coupled to a GasBench-II + continuous-flow interface (Tykot 2020). The measurements of both carbon and oxygen isotopes were reported as standards of Vienna Pee Dee Belemnite (VPDB) and AIR. The $\delta^{13}C$ and $\delta^{18}O$ measurements from bone apatite have the precision of ± 0.1‰ (Tykot 2020).

6.4 Sample Reporting

All standard delta notation results for bone collagen ($\delta^{13}C_{co}$ and $\delta^{15}N$) and bone apatite ($\delta^{13}C_{ap}$ and $\delta^{18}O$) were recorded in a Microsoft 365 Excel spreadsheet. The spreadsheet included the sample context, bone type, notes on the sample, USF collagen and apatite ID numbers, isotope values, and C:N ratio, %C and %N, and % yield. Collagen-apatite spacing was calculation by subtracting collagen value from apatite value. The complete data are provided in Appendix A.

6.5 Statistical Analysis

All statistical analyses were performed using SPSS v.26. Isotope values were illustrated using graphs and charts made in RStudio. The normality of the samples was tested using a Shapiro-Wilk test. The nitrogen isotope samples for both sites had the only normally distributed values. To analyze and compare nitrogen values between the sites, a parametric independent-samples t-test was used. For the analysis of the non-normal samples, the non-parametric Mann-Whitney U test was used. The standard alpha level of 0.05 was used for all statistical testing.

Several outliers have been detected within the samples. While their presence is explored within the results, they were excluded from the samples before the statistical testing. Outliers were identified using a 2 SD method, meaning the values were considered outliers if they were two standard deviations higher or lower than the sample mean.

Chapter 7: Results

7.1 Introduction

Among the collagen samples, 47 out of 49 human samples produced sufficient collagen yields and presented reliable data. Among the apatite samples, all 52 (49 human bone samples and 3 animal bone samples) were available for analysis of the carbon isotopes, and 49 (45 human bone samples and 3 animal bone samples) produced oxygen isotope analysis data.

7.2 Diet

Averaged collagen isotope data from both sites are presented in Table 1. The average group $\delta^{13}C_{co}$ of the 47 individuals ranges between -19.6‰ and -16.9‰ (mean -18.2 ± 1.3, 1σ) and average $\delta^{15}N$ ranges between 10.1‰ and 12.7‰ (mean 11.4 ± 1.3, 1σ). Carbon and nitrogen values for human bone collagen together with faunal bone collagen are shown on Figure 7. Apatite carbon isotope data from both sites are presented in Table 2. The average group $\delta^{13}C_{ap}$ of the 49 individuals ranges between -12.2‰ and -9.8‰ (mean -11.0 ± 1.2, 1σ).

Table 1. Human and faunal bone collagen descriptive statistics for $\delta^{13}C_{co}$ and $\delta^{15}N$

		δ^{13}Cco				δ^{15}N			
Site	n	Min	Max	Mean	SD	Min	Max	Mean	SD
Total Human	47	-19.6	-16.9	-18.2	1.3	10.1	12.7	11.4	1.3
Chiesazza	26	-19.4	-17.0	-18.2	1.2	11.0	12.4	11.7	0.7
Chiunsano	21	-18.9	-17.1	-18.0	0.9	10.3	12.3	11.3	1.0
Fauna	2	-23.9	-19.7	-21.3	1.6	5.4	9.0	7.2	1.8

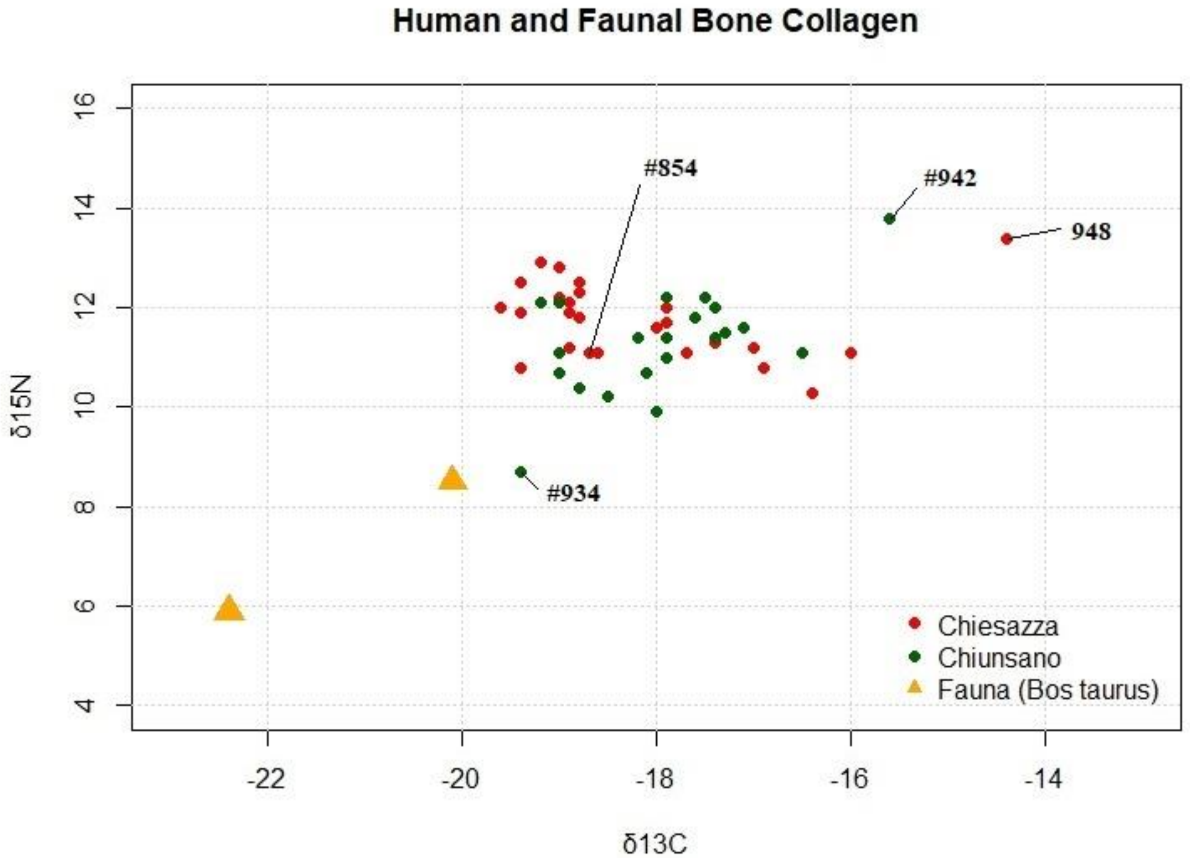

Figure 7. Carbon and nitrogen values for human and faunal bone collagen

Table 2. Human and faunal bone descriptive statistics for $\delta^{13}C_{ap}$

		δ^{13}Cap			
Site	n	Min	Max	Mean	SD
Total Human	49	-12.2	-9.8	-11.0	1.2
Chiesazza	26	-12.1	-9.5	-10.8	1.3
Chiunsano	23	-12.2	-10.1	-11.2	1.0
Faunal	3	-11.2	11.0	-11.1	0.1

Overall, among the humans the $\delta^{13}C_{co}$ values range from the most negative of -19.6‰, which suggests complete reliance on C_3 resources, to the most positive of -15.6‰, suggesting about 25% of dietary protein coming from C_4 sources.

Three individual outliers can be observed on Figure 7. One outlier from Chiunsano di Ficarolo (#934) has a $\delta^{15}N$ value of 8.7‰, more than two standard deviations lower than the average. This individual consumed primarily C_3 plants and had low amounts of animal protein in the diet. Another individual from Chiunsano di Ficarolo (#942) has an elevated $\delta^{15}N$ value of 13.8‰, two standard deviations higher than average, and one individual from Chiesazza di Ficarolo (#948) has both elevated $\delta^{13}C_{co}$ and $\delta^{15}N$ values of -14.4‰ and 13.4‰, respectively, with both values being over two standard deviations higher than the average. For both #942 and #948 about 30% of their dietary protein came from millet. Additionally, these two individuals consumed a high amount of animal protein, with addition of seafood. Given that both sites are located near the Po River, but far from the coast of the Adriatic Sea, approximately 80 km (50 miles) away, seafood consumption indicates either a higher status of these individuals allowing seasonal travel or access to coastal resources, or a recent migration before death from near a coastal region.

A special case that is not the outlier in the sample, but a potential outlier in lifestyle is the Ficarolo Dame, individual #854. This individual had an elaborate burial, compared to the rest of the individuals, which included luxury artifacts (Dr. Andrea Vianello, communication via email, April 7, 2020). The remains of the dame had $\delta^{13}C_{co}$ and $\delta^{15}N$ values similar to the average range of the rest of the sample. Given that she is hypothesized to be an outsider from more northern regions outside of the Italian territories, who was traveling through the countryside of Ravenna right before she died, her diet being similar to the diet of the local population is an interesting finding. However, the full exploration of her circumstances may be addressed by strontium isotope analysis, currently not available for this research project.

With the outliers excluded, the $\delta^{13}C_{co}$ values range from -19.6‰ to -16‰, indicating a range from no presence of C_4 dietary proteins to 20% of C_4 dietary proteins. Furthermore, the independent-samples Mann-Whitney U test showed that there is no statistically significant difference between $\delta^{13}C_{co}$ of human bone samples at Chiunsano di Ficarolo and Chiesazza di

Ficarolo (U = 301.000; p-value = 0.131). Similarly, no significant difference was detected for the $\delta^{13}C_{ap}$ (U = 192.000; p-value = 0.378) values between the sites. The independent-samples t-test also showed no statistically significant difference between the $\delta^{15}N$ values (F = 0.005; t = 1.666; df = 42; p-value = 0.103). However, several trends within the group can be observed. The whole sample can be divided into two major groups based on their C_4 plant consumption (Figure 8). The individuals with $\delta^{13}C_{co}$ less than -18.5‰ have a low if any amount of dietary proteins coming from millet consumption (yellow circle), and individuals with $\delta^{13}C_{co}$ more than -18.5‰ whose dietary proteins came partially from millet (blue circle).

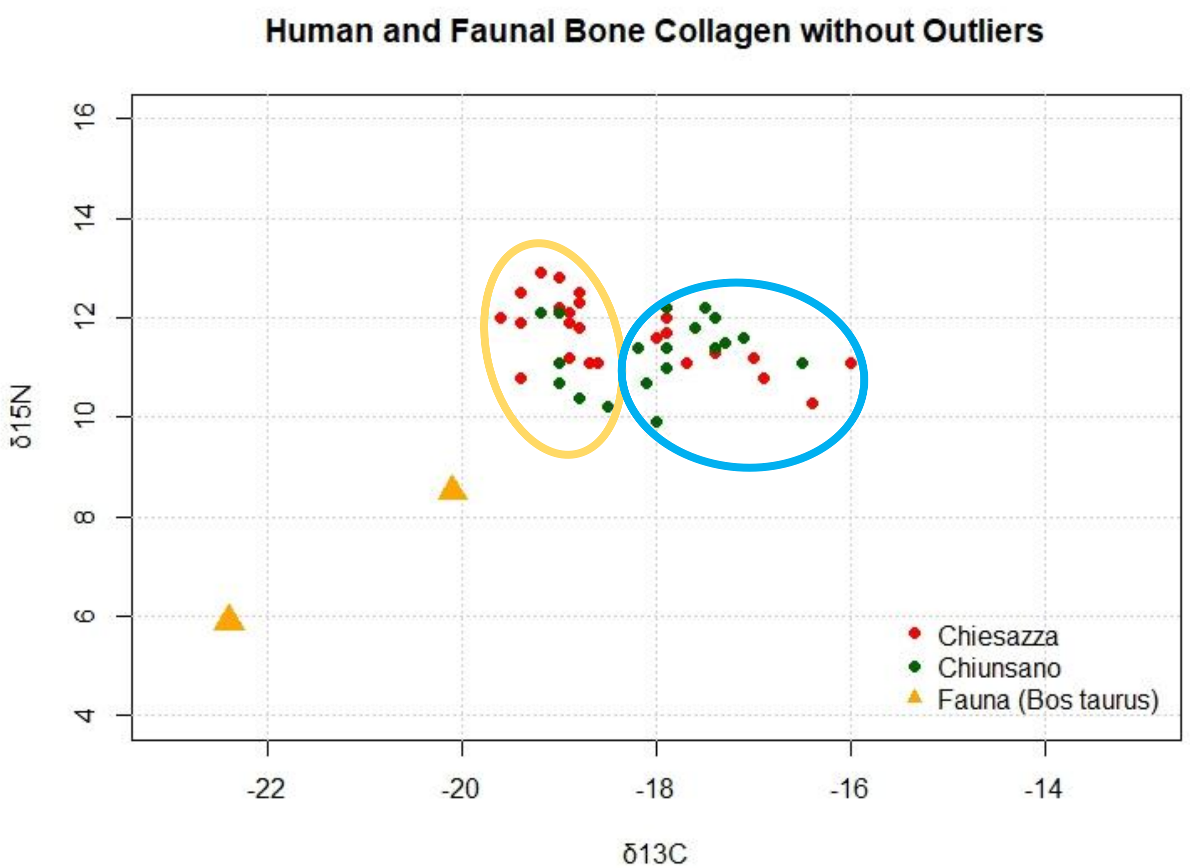

Figure 8. Low millet vs. high millet consumption for human carbon and nitrogen values

The average values for $\delta^{13}C_{co}$ and $\delta^{15}N$ calculated without the outliers are presented on Table 3. The mean $\delta^{13}C_{co}$ at Chiesazza is slightly lower than at Chiunsano, suggesting a slightly higher millet consumption at Chiunsano. The mean $\delta^{15}N$ at Chiesazza is slightly higher than at Chiunsano, suggesting a slightly higher animal or aquatic protein consumption at Chiesazza.

Table 3. Human bone collagen descriptive statistics for $\delta^{13}C_{co}$ and $\delta^{15}N$, no outliers

		$\delta^{13}C_{co}$				$\delta^{15}N$			
Site	n	Min	Max	Mean	SD	Min	Max	Mean	SD
Total	44	-19.1	-17.3	-18.2	0.9	10.8	12.2	11.5	0.7
Chiesazza	25	-19.4	-17.4	-18.4	1.0	11.0	12.4	11.7	0.7
Chiunsano	19	-18.7	-17.3	-18.0	0.7	10.6	12.0	11.3	0.7

Looking at the Chiesazza sample, a declining linear relationship between the $\delta^{13}C_{co}$ and $\delta^{15}N$ values can be observed (Figure 9). It appears that individuals who consumed more freshwater fish have less millet consumption, and individuals who consumed more millet had less freshwater fish.

Overall, a 1‰ enrichment in $\delta^{13}C_{co}$ and 3‰ enrichment of $\delta^{15}N$ indicates consumption of herbivorous animals or their milk/cheese. The average $\delta^{13}C_{co}$ and $\delta^{15}N$ values for herbivores at the Chiesazza di Ficarolo site were -21.3‰ and 7.2‰, respectively. The individuals at the Ficarolo sites were on average 3.1‰ higher for $\delta^{13}C_{co}$ and 4.2‰ higher for $\delta^{15}N$ than the herbivores. The consumption of herbivores alone would not account for the elevated $\delta^{13}C_{co}$ and $\delta^{15}N$ values, which indicates the addition of C_4 and marine resources. It appears that some individuals within this population have consumed more C_4 foods than others.

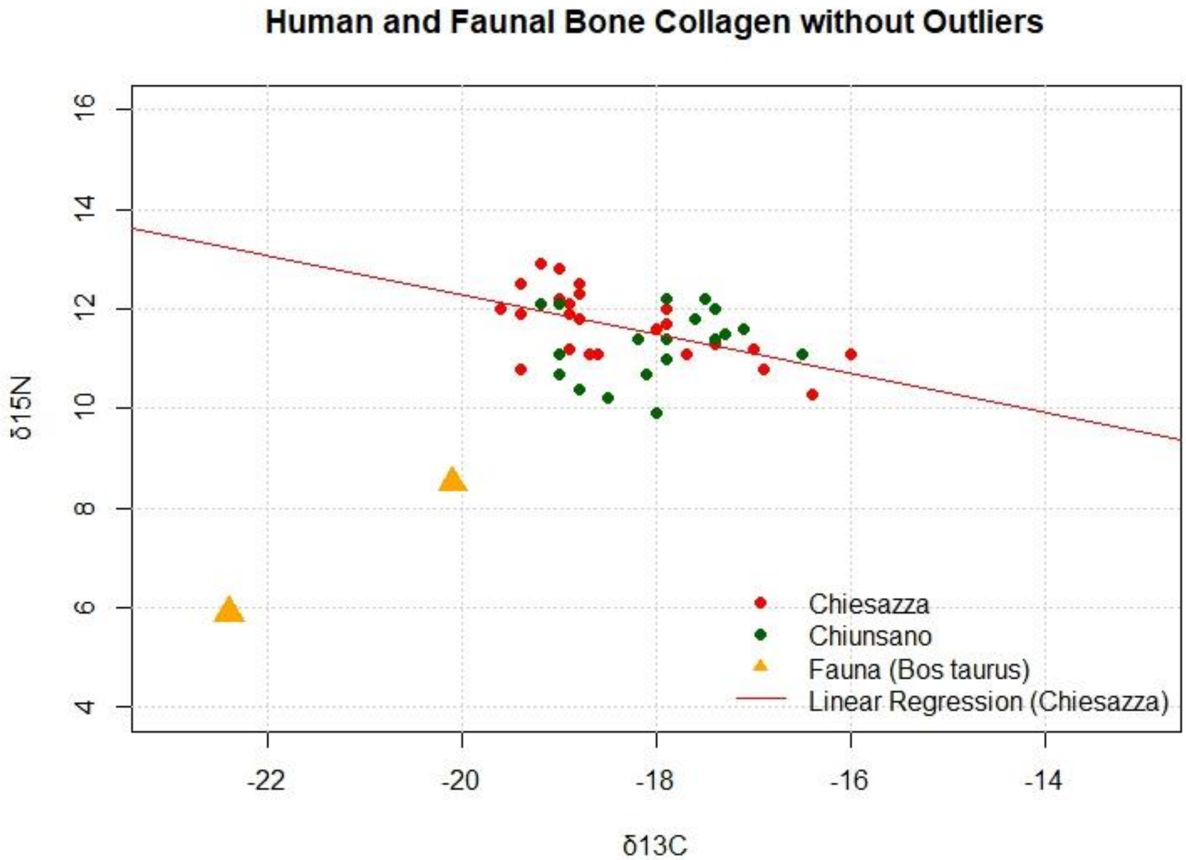

Figure 9. Carbon and nitrogen values for Chiunsano and Chiesazza with linear relationship for freshwater fish and millet consumption at Chiesazza highlighted

Collagen carbon and apatite carbon values for human bone together with C_3 protein and C_4 protein lines, following the method of Kellner and Schoeninger (2007), are shown on Figure 10. Overall, $\delta^{13}C_{ap}$ values in the sample range from the most negative -13.5‰, representing almost no millet in their diet, to the most positive -7.4‰, representing 40% of millet in the overall diet. Two individuals have significantly higher $\delta^{13}C_{ap}$, indicating higher direct millet consumption, around 40% of the whole diet. Without the two individuals with two high $\delta^{13}C_{ap}$ values, the most positive $\delta^{13}C_{ap}$ value is -9.3‰, indicating around 30% of millet in the overall diet. Thus, the consumption of millet at the Ficarolo sites ranges from virtually no millet consumption to millet comprising around 30% of the whole diet. This range of values is present at both sites. At this moment it is not possible to state if there were social or economic differences between people who did not consume millet at all and people who consumed it. However, it is important to note that even people with the highest amounts of millet in their diet relative to the sample, 40%, did not rely exclusively on millet.

Furthermore, the majority of the individuals roughly follow the C_3 protein line. A few individuals move towards the C_4 protein line, indicating higher millet consumption from both direct sources, plants themselves, and indirect sources, through millet-fed domesticated animals. These individuals have high $\delta^{13}C_{co}$ values but relatively lower $\delta^{15}N$, suggesting that individuals who did not consume freshwater fish, or did not have access to it, supplemented their diet with millet-fed domesticates.

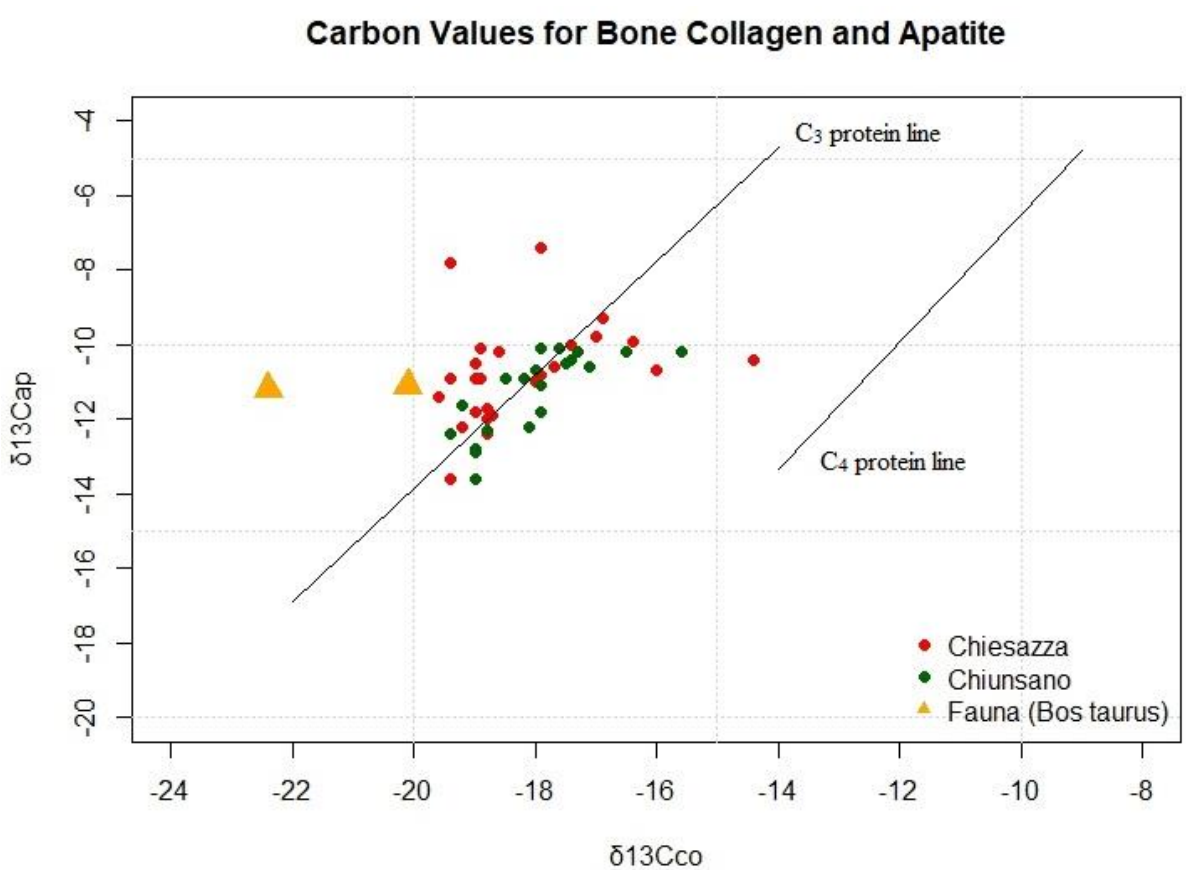

Figure 10. Carbon values for human and faunal bone collagen and apatite. Protein lines after Kellner and Schoeninger (2007)

Additionally, the comparison between the $\delta^{13}C_{co}$ and $\delta^{13}C_{ap}$ values allows to analyze the collagen-apatite spacing for each individual. Following the method proposed by Krueger and Sullivan (1984), the $\Delta^{13}C_{ap\text{-}co}$ values for Ficarolo individuals range from 4.0‰ to 11.6‰. The majority of the individuals at Chiunsano and Chiesazza, 71%, have $\Delta^{13}C_{ap\text{-}co}$ values around 5-7‰, showing an omnivorous, monoisotopic diet. Slightly higher $\Delta^{13}C_{ap\text{-}co}$ values, 8-9‰, according to Krueger and Sullivan (1984) represent a diet that includes C_3 terrestrial protein and C_4 plant diet, which is present among 18% of the Ficarolo sample. Lower $\delta^{13}C_{co}$ are correlated with the higher $\Delta^{13}C_{ap\text{-}co}$ value, supporting the idea that the diet of these individuals was more based on C_3 protein. Furthermore, two individuals in the sample (#848 and #852) show high $\Delta^{13}C_{ap\text{-}co}$ values, around 10-11‰, indicating a diet based on terrestrial protein and C_4 plants. One individual (#948) stands out among the group with the $\Delta^{13}C_{ap\text{-}co}$ of 4.0‰, potentially indicating a significant addition of marine protein in the diet. The correlation between nitrogen isotope values with $\Delta^{13}C_{ap\text{-}co}$ values was not detected within the sample, possibly indicating different amounts of animal protein consumption among all the diet groups.

7.3 Mobility

The average group $\delta^{18}O$ of the 45 individuals ranges between -5.5‰ and -3.1‰ (mean -4.3 ± 1.2, 1σ). The distribution for both sites combined is shown on Figure 11. The average $\delta^{18}O$ for Chiesazza di Ficarolo ranges between -6.1‰ and -3.9‰ (mean -5.0 ± 1.1, 1σ), and the average $\delta^{18}O$ for Chiunsano di Ficarolo ranges between -4.8‰ and -3.1‰ (mean -3.9 ± 0.8, 1σ). The Mann-Whitney U test detected a significant difference between $\delta^{18}O$ values at the sites (U = 450.000; p-value < 0.001).

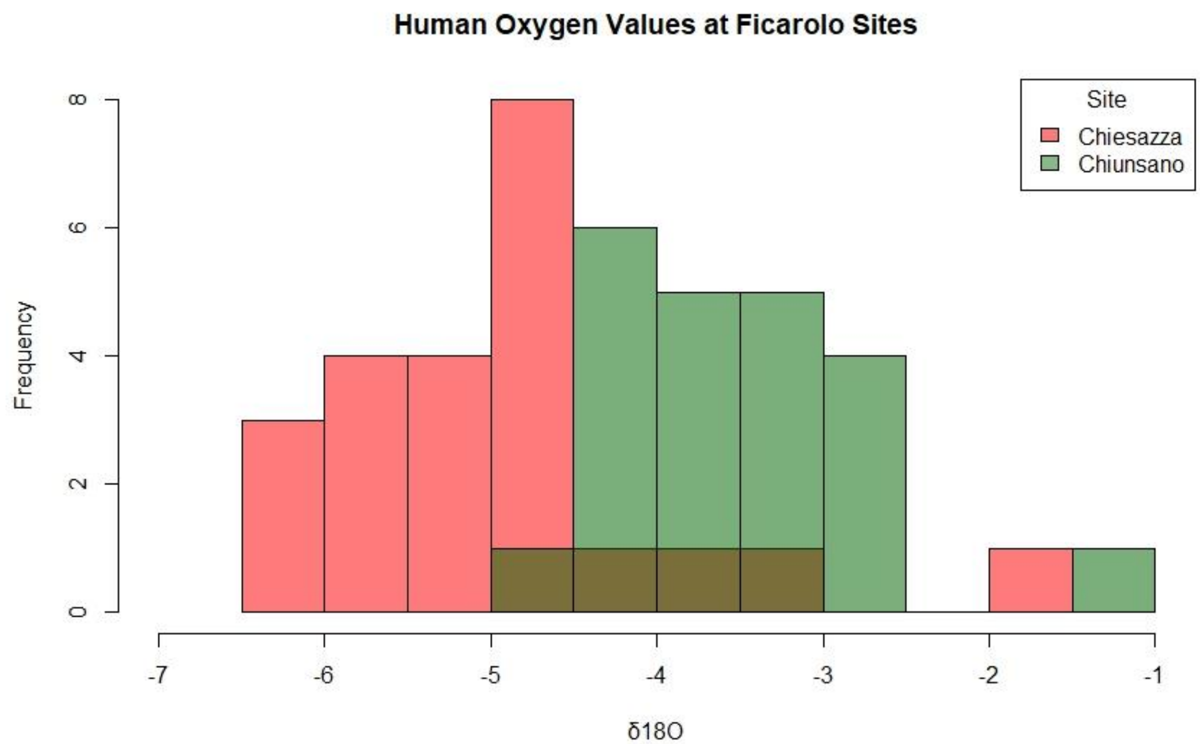

Figure 11. Histogram of the oxygen isotope values at both Ficarolo sites combined

The $\delta^{18}O$ for the region, according to the data by Longinelli and Selmo (2003) is -6.8‰. This data point was reported at the sampling station of Comacchio, located around 50 miles away from Ficarolo. The difference between this regional value and the average $\delta^{18}O$ for the sample may have occurred due to the difference of water sources at the sites, with Comacchio located closer to the Adriatic Sea, and Chiunsano di Ficarolo and Chiesazza di Ficarolo located near the Po River. The three animal samples in this study, that also would be expected to represent the values associated with local water sources, have $\delta^{18}O$ values of -1.3‰, -3.7‰, and -5.2‰. These values present a wide range of oxygen values. Thus, perhaps the human values are appropriate for the range of values in the region.

Another more recent study of oxygen isotope values among the Langobard populations near Verona reports mean $\delta^{18}O$ value from human bone of -6.4‰ ± 1.1 (Francisci et al. 2020). Yet the mean oxygen value at the Ficarolo sites is still significantly lower.

According to the data collected by Longinelli and Selmo (2003) the relatively higher oxygen values come from the sampling stations of Sabaudia and S. Giorgio Ionico, located significantly further east and south from the Ficarolo region. The explanation for some individuals in the sample having higher $\delta^{18}O$ values may be that before their death they had relied on a different source of water and were potentially capable of seasonal mobility to more eastern or southern regions of Italy or even outside of the Italian peninsula. Then individuals with lower $\delta^{18}O$ values, corresponding with the values common for the region were more stable, relying on the local source of water. The significant difference between $\delta^{18}O$ values at the two sites may potentially indicate a different status of individuals living there. Individuals at Chiunsano di Ficarolo, who on average have higher $\delta^{18}O$ values, potentially experienced higher mobility in their life, than more sedentary individuals from Chiesazza di Ficarolo.

Similar results of elevated oxygen values have been observed at the northern Italian sites by Maxwell (2019). The mean $\delta^{18}O$ values at Sovizzo and Dueville, located close to Vicenza, were -4.2‰ and -3.8‰, respectively. The comparison between oxygen values of local and non-local individuals at the Ficarolo sites and individuals at the Vicenza sites is shown on Figure 12.

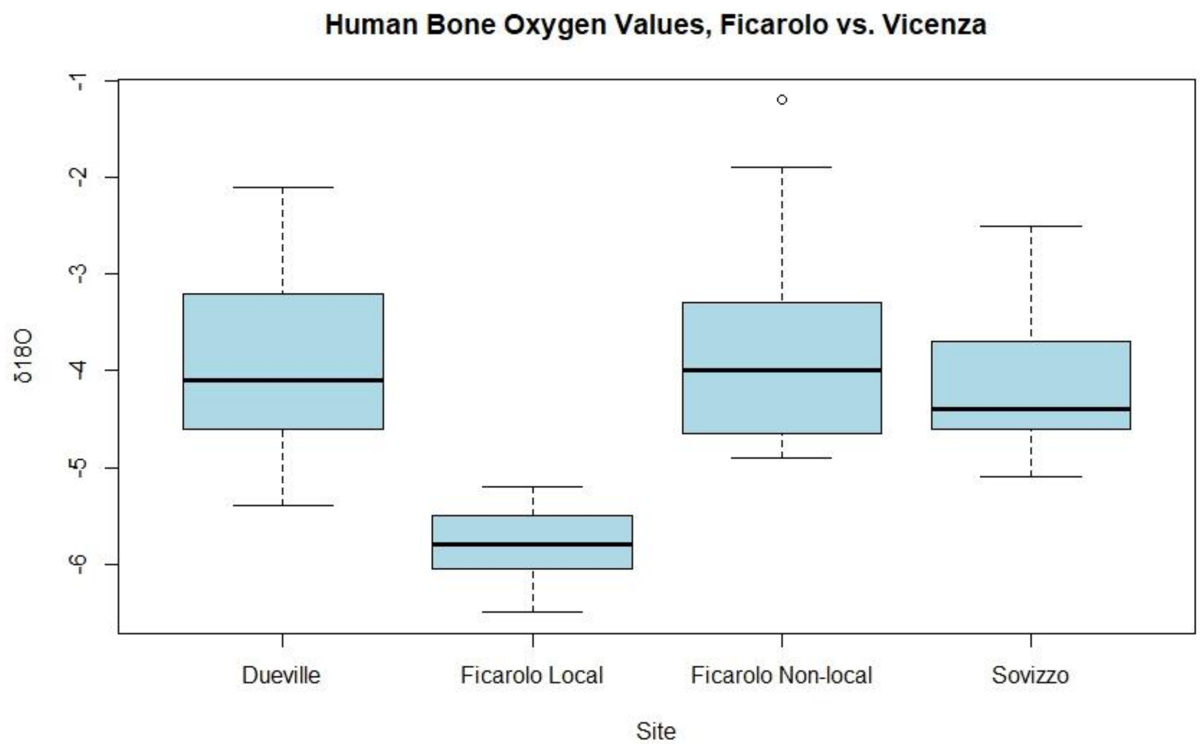

Figure 12. Oxygen isotope boxplot for local and non-local individuals at the Ficarolo sites and individuals at Vicenza sites, Sovizzo and Dueville. Sovizzo and Dueville oxygen data from Maxwell (2019)

Maxwell (2019) notes that such high oxygen values are more indicative of the coastal regions of Italy, Greece, and North Africa, and interprets that these individuals with elevated oxygen values could have been migrants or refugees from other parts of the Byzantine Empire. Given that in the 7th century CE Ravenna and the territories around the city were under the control of the Byzantine Empire, it is possible that migration into Ravenna occurred during that period and that Chiunsano di Ficarolo sample represents these migrating individuals.

To analyze potential differences in diet between locals and non-locals, an approximate point of difference may be set at -5‰ (the highest range point common for the region). Assigning a local and non-local status to individuals in the Ficarolo sample, it is possible to compare the diets of local and non-local individuals (Figure 13).

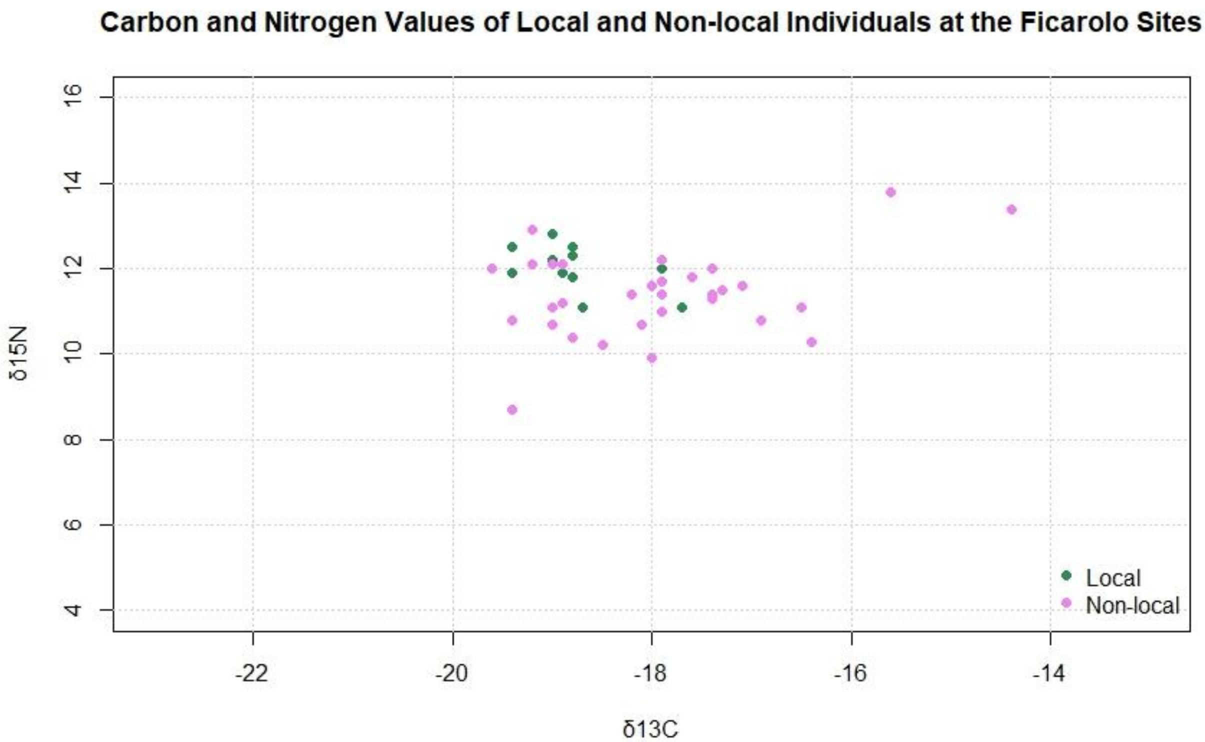

Figure 13. Carbon and nitrogen values of locals and non-locals at the Ficarolo site. Distinction made using oxygen values

For the local group, the mean $\delta^{13}C_{co}$ is -18.8‰ ± 0.5, mean $\delta^{15}N$ is 12.0‰ ± 0.5, and mean $\delta^{13}C_{ap}$ is –11.2‰ ± 1.5. For the non-local group, excluding the outliers, the mean $\delta^{13}C_{co}$ is -18.2‰ ± 0.9, mean $\delta^{15}N$ is 11.3‰ ± 0.7, and mean $\delta^{13}C_{ap}$ is –11.0‰ ± 1.2. The difference between the diets of locals and non-locals analyzed using the Mann-Whitney U test, chosen due to small sample of local individuals, shows no statistically significant difference for $\delta^{13}C_{co}$ values (U = 214.500, p-value = 0.096) and $\delta^{13}C_{ap}$ values (U = 188.000, p-value = 0.402), but a statistically significant difference in $\delta^{15}N$ values (U = 70.000, p-value = 0.006). The p-value of 0.096 for the comparison of carbon isotopes from bone collagen is very close to the significance level of 0.05 and indicates some difference between the local and the non-local samples, even if less strong. The analysis shows that the local individuals consumed significantly more animal protein, specifically freshwater fish, and slightly less millet and more wheat than the non-local individuals. The diet of non-local individuals also has greater variation.

It is notable that all three outliers have the $\delta^{18}O$ values of potential migrants. The individual with low $\delta^{15}N$ values (#934) has the lowest $\delta^{18}O$ value among the three, as well, -3.5‰. Two other individuals with elevated $\delta^{13}C$ and $\delta^{15}N$ values (#942 and #948) have $\delta^{18}O$ of -4.1‰ and -4.8‰. The significant difference in the two types of outlier diets together with varying $\delta^{18}O$ values may indicate that the individual who consumed a more vegetarian diet came from a different region of the Byzantine Empire than the two individuals who have consumed more saltwater fish and millet.

The lowest oxygen values belong to two individuals whose diets go along with the mean carbon and nitrogen values of the group, within one standard deviation range. These individuals are #939 ($\delta^{13}C$ = -17.4‰, $\delta^{15}N$ = 11.8‰, $\delta^{18}O$ = -1.2‰) and #954 ($\delta^{13}C$ = -19.2‰, $\delta^{15}N$ = 12.9‰, $\delta^{18}O$ = -1.9‰). Their oxygen values indicate that they potentially migrated to the Ravenna countryside from a region with an even hotter and drier climate than the rest of the possible non-locals, but their diet fits the Ficarolo averages. Perhaps, their diet, as their oxygen values, represent the life circumstances in their home region, and migration did not affect their diet significantly.

Regarding the special case of the Ficarolo Dame (#854), her $\delta^{18}O$ values are on the higher range point for the local regional values ($\delta^{18}O$ = -5.9‰). According to data by Giustini et al. (2016), the territories to the north of Italy have significantly lower $\delta^{18}O$ values, ranging between -10 and -12‰ and even lower, due to ^{18}O depletion at higher altitudes. Thus, if the dame was traveling from her home region up north, her expected $\delta^{18}O$ values would be significantly lower. Potentially, other natural factors have elevated her oxygen values, although it is hard to evaluate with the currently available data.

It is also important to note that, outside of the outliers, around half of the individuals who have elevated $\delta^{18}O$ values, indicating their potential migrant status in the countryside of Ravenna, have consumed the same diet as people hypothesized to be local. It appears that the majority of the individuals had access to the same food resources, whether local or non-local.

7.4 Conclusion

Overall, the diet of individuals is highly similar within both sites, although some slightly different trends can be observed at Chiesazza di Ficarolo. A few outliers have been identified, as well as the dietary difference between local and non-local individuals, and the reason for their different diets may require additional information on the gender, status, health, or other aspects of the lifestyle of these individuals, which is currently unavailable. A significant difference in water source has also been observed between the sites, which may indicate relatively recent migration to the Ravenna countryside, specifically, the Chiunsano di Ficarolo site from more southern coastal regions of the Byzantine Empire. The further examination of potential mobility of the population would also require additional data.

The identification of whether the diet observed for the majority of the population at the Ficarolo sites resembles more the Roman, Late Roman, or Langobard diet is explored in the next chapter.

Chapter 8: Discussion

8.1 Diet

In order to understand what diet people in the countryside of Ravenna consumed, it is important to compare it to the diets of contemporary populations in and outside of northern Italy, the Roman era populations, and the incoming Langobards. The results of the stable isotope analysis at Chiunsano di Ficarolo and Chiesazza di Ficarolo show elevated $\delta^{13}C_{co}$ and $\delta^{15}N$ values, indicating the addition of C_4 plants like millet into the diet and consumption of terrestrial and aquatic animal protein. The overview of the political, economic, and cultural changes suggests that the role of millet and the consumption of animal protein could serve as two main points of dietary comparison.

8.1.1 Millet

During the Roman period, diet in northern Italy appears to be based on consumption of C_3 plants, such as wheat, with millet being absent from the diet (Milella et al. 2019). This may be related to Roman views on millet. According to Tafuri et al. (2009) cultivation of millet in Italy occurred first in the northern region, from where it spread later to the southern territories. It is possible, however, that due to the strong cultural association of millet with famine and poverty, cultivation of millet in its place of origin slowed down and the crop was not used for human consumption.

Millet is seen in the diet of people outside of northern Italy in the Roman period, but primarily through indirect consumption. At the sites of Casal Bertone ($\delta^{13}C_{co}$ = -18.3‰ ± 0.7, $\delta^{13}C_{ap}$ = -12.3‰ ± 0.8), Gabii ($\delta^{13}C_{co}$ = -18.9‰ ± 0.7, $\delta^{13}C_{ap}$ = -12.9‰ ± 1.3), and Isola Sacra ($\delta^{13}C_{co}$ = -18.8‰ ± 0.3, $\delta^{13}C_{ap}$ = -11.4‰ ± 1.2), the presence of millet in the diet is observed, but the C_4 resources are hypothesized to have come through feeding domesticated animals with millet (Craig et al. 2009; Killgrove and Tykot 2013, 2018; Prowse et al. 2004). The direct consumption of millet is higher at the Ficarolo sites ($\delta^{13}C_{co}$ = -18.2‰ ± 0.9, $\delta^{13}C_{ap}$ = -11.0‰ ± 1.2) than at Casal Bertone, Gabii, and Isola Sacra. However, millet consumption overall, through direct and indirect means, at the Ficarolo sites is similar to the diet at Castellaccio Europarco. Castellaccio Europarco is hypothesized to represent individuals of lower status living in the Roman suburbs (Killgrove and Tykot 2013). However, a higher variation in $\delta^{13}C_{ap}$ at Ficarolo sites than at Casal Bertone indicates a wider variability in millet consumption in the Ravenna countryside.

The role of millet in Late Roman times is unclear, but in northern Italy millet becomes one of the most common crops in the Early Medieval period, according to carpological and lipid residue studies in the region (Castiglioni and Rottoli 2013; Ganzarolli et al. 2018). Outside of northern Italy, at sites like Sienna ($\delta^{13}C_{co}$ = -19.1‰ ± 0.9) and Colonna ($\delta^{13}C_{co}$ = -18.9‰ ± 0.4, presence of millet is lower than at the Ficarolo sites (Baldoni et al. 2016; Ricci et al. 2012).

Millet in the diet of Langobards appears to vary. Langobards outside of northern Italy show low consumption of millet and higher reliance on wheat (Alt et al. 2014; Plecerová et al. 2020). However, in northern Italy Langobard populations show high consumption of millet through direct means, and sometimes even very high reliance on millet (Iacumin et al. 2014; Maxwell 2019). Maxwell (2019) hypothesized that as millet returned to the status of a staple crop in northern Italy, the migrating Langobards integrated into the local practice of millet consumption. Such high reliance on millet is observed among some of the individuals in the countryside of Ravenna, ranging between 20 and 40%. Full reliance on millet was not observed. Diet at Ficarolo sites is based on a mix of C_3 and C_4 plants, with the difference in millet consumption potentially depending on socioeconomic factors.

8.1.1.1 Conclusion

While stable isotope studies from Early Medieval north Italian sites are not available for direct comparison, it appears that as consumption of millet decreased outside of northern Italy, it increased at the Ficarolo sites. However, the full reliance of millet, as what the Langobards who had migrated to northern Italy practiced, did not take place around Ravenna for most individuals, with the highest percentage of millet in diet being around 40%. Millet consumption at Chiunsano di Ficarolo and Chiesazza di Ficarolo more closely resembles the diet at Casal Bertone, a site in the Roman suburbs, during the Imperial period, but with a higher variation in direct millet consumption.

8.1.2 Protein

The investigations of the role of meat in Ravenna and a few other northern Italian sites during the Roman period shows that meat was not a staple food but was included in the diet when possible. At the sites of Barnacavallo, ‘Le Palazzette’, and ‘La Marabina’ Facchini et al. (2004) note the prevalence of anemia and signs of early life nutritional stress. The authors conclude that people at these sites relied primarily on lentils and cereals. At Bologna, similar low consumption of animal protein could be observed due to low $\delta^{15}N$ values ($\delta^{15}N = 9.1‰ \pm 1.1‰$). However, Milella et al. (2019) hypothesize that freshwater fish was a minor part of people’s diet.

Outside of northern Italy, significant consumption of animal protein has been detected at the Roman sites of Casal Bertone ($\delta^{15}N$ = 9.8‰ ± 1.5), Castellaccio Europarco ($\delta^{15}N$ = 10.1‰ ± 1.4), and Gabii ($\delta^{15}N$ = 10.7‰ ± 0.9) . Sites that are located geographically close to various bodies of water tend to demonstrate diet that includes saltwater or freshwater fish, such as Isola Sacra ($\delta^{15}N$ = 10.8‰ ± 1.2) (Killgrove and Tykot 2013, 2018; Prowse et al. 2004). Thus, it seems that animal protein has been a part of the Roman diet when accessible and the type of animals consumed depended on the locally available resources. Access to animal protein appears to vary potentially due to status. At the coastal site of Velia, Craig et al. (2009) identified two distinct groups: people who consumed more fish ($\delta^{15}N$ = 11.2‰ ± 1.3), and people who primarily consumed terrestrial animals ($\delta^{15}N$ = 8.2‰ ± 0.7). No data are available to how these two groups were otherwise different, but the authors suggest that people who consumed more fish were immigrants. Further interpretation depends on the cultural views on fish consumption, but possibly fish was considered more affordable and thus accessible to the lower-class individuals (Marzano 2018).

By the Early Medieval period consumption of animals in the local Italian diet continues to vary based on status with high status individuals being able to add terrestrial animals into their diet, but otherwise animal protein consumption appears to have decreased (Baldoni et al. 2016; Ricci et al. 2012). Langobards, according to historians, seem to have valued raising and consuming animals more than the local Italians, and the stable isotope reconstructions support this notion, indicating that while the local populations diversified their diet with affordable fish, Langobards focused on consuming a restricted terrestrial protein source (Maxwell 2019; Montanari 1999; Tafuri et al. 2018).

In the Ravenna countryside, consumption of both terrestrial and aquatic protein is observed ($\delta^{15}N$ = 11.5‰ ± 0.7). Given that Langobards, even those who have settled in northern Italy, do not appear to have focused their diet on fish, yet fish appears in the diet of local individuals, people living at Chiunsano di Ficarolo and Chiesazza di Ficarolo seem to retain the local diet. Addition of terrestrial protein in their diet appears to resemble consumption patterns at the Imperial era sites, located closer to Rome. As Ravenna became the capital, it gained more significance and prosperity, which potentially gave people access to some more expensive terrestrial protein. Consumption of fish, however, also continued, which may indicate that differences in status among the people at Ficarolo sites played some role in their dietary practices.

8.1.2.1 Conclusion

In the Early Medieval period, people in the countryside of Ravenna appear to have followed primarily the established local diet. Both terrestrial and aquatic protein is present in the diet of individuals at Chiunsano di Ficarolo and Chiesazza di Ficarolo. The majority of the individuals have elevated $\delta^{15}N$ values, indicating fish consumption, possibly a more affordable and locally accessible resource, among most of the sampled people. Less individuals focus only on terrestrial protein. Additionally, people in the Ficarolo group who have consumed less freshwater fish have also incorporated more millet into their diets through indirect sources. Thus, it appears that millet-fed domesticated animals may have been a dietary substitute for freshwater fish. A difference in status within the sample based on the type of animal protein consumed is possible, but investigation of this hypothesis would require further data.

8.2 Migration

The analysis of oxygen isotopes helps to identify the primary source of water people used within the approximately last decade of their life and thus their place of origin if they moved from one region to another within that decade. Comparing the oxygen values from human bone apatite to the common values established for the region through precipitation and drinking water studies highlights individuals who migrated recently. For full interpretation of migration, a drinking water standard at the site and oxygen isotopes from tooth enamel should be analyzed, together with strontium isotopes. Presented here are preliminary findings only from bone apatite.

The $\delta^{18}O$ values for the region range between -7‰ and -5‰ (Longinelli and Selmo 2003). Although this segregation is a bit arbitrary and variation on the higher and lower borders of this range is possible, for the purposes of the research people whose oxygen values fall within the common range are considered local, and individuals whose values fall above -5‰ are analyzed as non-local. Within the Ficarolo sample, 34 individuals (76%) were identified as non-local, while 11 individuals (24%) appear to have been local. Interestingly, all local individuals have been buried at Chiesazza di Ficarolo, while non-local people were present at both sites.

8.2.1 Locals

The oxygen values from bone apatite of local individuals range from -6.5‰ to -5.2‰. The data indicate that for the period of approximately 7 to 15 years before death, these individuals have lived at the Ficarolo sites or nearby, within the area of these oxygen values. Whether they were born locally or migrated earlier in life is unclear. To identify where these individuals were born, strontium isotope analysis is necessary. However, based on diet reconstruction, these individuals consumed a C_3 based diet with high amounts of animal protein, with addition of freshwater fish.

This focus on wheat together with diversification of protein sources more closely resembles a Roman diet, than a Langobard diet. Thus, so far based on dietary data, it appears that these individuals represent the local Italian population.

8.2.2 Origin of Non-Locals

The oxygen values from bone apatite of non-local individuals range from -4.9‰ to -1.2‰. Non-local individuals could be separated further into regional and non-regional migrants. Regional migrants are people who possibly migrated either from other regions of the Italian peninsula or from close up areas with similar climates, such as the Mediterranean. There are 27 potential regional migrants and 5 possible non-regional migrants. Regional migrants have $\delta^{18}O$ values ranging approximately from -4.9‰ to -3.1‰. These elevated oxygen values are more common for the eastern and southern outer borders of the Italian peninsula, the island of Sicily, southern Spain, and Greece (Dotsika et al. 2010; Emery et al. 2018; Prowse et al. 2007; Stark et al. 2020). Among the non-regional migrants, $\delta^{18}O$ values range between -2.7‰ and -1.2‰. These significantly elevated values are more common in very dry hot climates, for example in North Africa (Prowse et al. 2007). Milella et al. (2019) hypothesize that high frequency of non-locals may indicate the presence of military personnel from across the Empire at a site. Given the political changes and history of wars for power over the northern Italian territories between the Byzantine Empire, Goths, Langobards, and other migrating peoples, it is possible that some of the non-local individuals in the countryside of Ravenna were involved in the military.

8.2.3 Dietary Differences between Locals and Non-Locals

When compared based on the burial site, the majority of the individuals at the Ficarolo sites were consuming the same diet. Minor differences have been detected between the sites, and there may be a correlation between these minor differences and migration status. When migration status is taken into account, dietary differences appear. All individuals identified as local come from Chiunsano di Ficarolo, and their diet contains slightly less millet and significantly more freshwater fish than the non-locals. Non-local individuals come from both Chiunsano di Ficarolo and Chiesazza di Ficarolo. Some of them consumed the same diet as the local population, some consumed more millet and less freshwater fish, instead potentially substituting with millet-fed domesticated animals. Because of the variation among the diet of non-locals, and many non-locals consuming the same diet as locals, a difference in status was potentially present between non-locals.

The three outliers who have consumed significantly different diets than the rest of the Ficarolo individuals appear to be regional migrants, coming from either eastern and southern Italy or elsewhere in the Mediterranean. The exact origins are difficult to pin down, but the two individuals who consumed significant amounts of saltwater fish potentially migrated from coastal Italian areas close to the sea.

8.3 Conclusion

Because bone collagen and apatite indicate isotopes that the body received in the last decade or so of life, only recent diet and mobility before death can be analyzed. Diet appears to be the same for the majority of the individuals. A mix of C_3 and C_4 resources, wheat and millet, was detected in the diet of most individuals tested, as well as a mix of terrestrial and aquatic protein.

Such dietary patterns resemble the local Roman diet, supplemented by locally available resources, but have a higher variation in direct millet consumption than at the Imperial Roman sites. The similarities in diet among the locals and some of the non-locals possibly indicate integration of migrants into the local dietary practices or a variation in status among the migrants, which allowed people access to different food resources. At the Ficarolo sites, migrants originated from regions with drier hotter climates inside and outside Italy, while the presence of Langobards or people who have moved to the Ravenna countryside from more northern regions was not detected.

Chapter 9: Conclusions and Future Directions

Ravenna became a political, cultural, and economic center of the Western Roman Empire in the beginning of the 5th century CE. The city itself and the territories around it gained significant prosperity during the transitional period between the Late Roman and the Early Medieval periods (Barker 2004; Christie 2011). Ravenna resisted the force of migrating and settling in the region of norther Italy Langobards until the middle of the 8th century (Barker 2004). The cultural influence that Langobards had on the city of Ravenna and the territories around it is still debated (Drew 2004; Goffart 2006a; Peters 1974).

The goal of this study was to reconstruct the diet of people buried at Chiesazza and Chiunsano, two sites located near the modern town of Ficarolo in northern Italy. Dietary reconstruction provides an insight into the daily life of people in the past, cultural and economic changes, and interactions between different individuals within the group. As these two sites in the past were within the territory of the Ravenna countryside, the dietary data from Ficarolo sites in this study was used to understand the more stable patterns of potential dietary change around Ravenna, during the period of significant political and economic transitions. The diet was then compared to the traditional "Roman" diet in the region and the diet of the Langobards, in order to evaluate potential Langobard influence on the local diet. Previous studies by Alt et al. (2014), Iacumin et al. (2014), and Maxwell (2019) along many others have performed diet reconstruction through stable isotope analysis in the neighboring regions. The diet in the Ravenna countryside on the cusp of the Late Roman and Early Medieval periods has not been evaluated previously.

The results of this research show that local diet was in part preserved in the Ravenna countryside, although with some changes relative to the Roman diet. People at Chiunsano and Chiesazza consumed a mix of C_3 resources, such as wheat and barley, and C_4 resources, such as millet and sorghum, as well as a mix of terrestrial and aquatic protein. Previous dietary studies have indicated that the local north Italian populations during this period relied on a higher diversity of plans and animal resources (Montanari 1999; Castiglioni and Rottoli 2013; Livarda 2011; Rottoli 2014), while Langobards primarily relied on C_3 resources (Iacumin et al. 2014; Tafuri et al. 2018) and in northern Italy potentially assimilated into the local dietary practices (Maxwell 2019). Thus, it appears that at the Ficarolo sites people continued following the local diet, but with higher variability in resources than the "Roman" diet, and the Langobard influence in diet was not observed.

Recent mobility of the individuals has also been analyzed. A high percentage of migrants has been detected at the Ficarolo sites. Migrants primarily originated from regions with drier hotter climates inside and outside Italy, with a small number of people also possibly coming from the region of North Africa. Migrants from northern territories have not been identified in this research, thus recently migrated Langobards were not observed. Several of the non-local individuals appear integrated into the local diet as well, indicating strong influence of the local dietary practices.

These findings are important for the interpretations of the influences of migration during this period and the preservation of culture and identity through dietary practices. As posed by Ward-Perkins (2005: 79), the "centuries-old, deeply ingrained certainty that their own (Roman) ways were immeasurably superior to those of the barbarians" may have played a significant role in the continuation of local traditions, ways of live, and diet. The observed integration of migrant individuals at the Ficarolo sites into the local dietary practices may signify the power of the local "Roman" ways even in the post-Roman times.

This anthropological research of the diet in the Ravenna countryside has been affected by the COVID-19 pandemic, and essential information about the studied individuals, such as age, gender, health status, etc. was not available. Future study of the dietary change in the Ravenna countryside should prioritize combining the dietary reconstruction data with the analysis of the skeletal data in order to gain further insight into the lives of these individuals.

Furthermore, given the large percentage of non-local individuals at the Ficarolo sites, a larger sample of the local population should be investigated in the future for a more in-depth comparison of the dietary similarities or differences between locals and migrants. The investigation of oxygen and strontium isotopes from the dental enamel of the people in the countryside of Ravenna would assist in identifying more precise places of origins for the migrants and show if mobility in early stages of life occurred among the population identified as local. Ravenna and the territories around it, being the center of political and economic changes at the time, presents ample opportunities to investigate the life circumstances of people in the middle of these dramatic transitions. Further investigations of dietary change due to migration in the past also would provide a chance to investigate intercultural relationships, power balance between locals and migrants, and the ways people have adapted to change in the past.

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Appendix A: Isotope Data

Table A1. Isotope data from Chiunsano di Ficarolo and Chiesazza di Ficarolo sites

Context	#	Bones	Collagen	$\delta^{13}C_{co}$	$\delta^{15}N$	% Yield	C:N	%N	%C	Apatite	$\delta^{13}C_{ap}$	$\delta^{18}O$
Ficarolo superficie	954	long bone	38954	-19.2	12.9	4.2%	3.6	17.1	51.9	38986	-12.2	-1.9
Ficarolo 3	836	rib	37836	-18.9	11.2	14.1%	3.3	14.9	42.0	37856	-11.8	-4.6
Ficarolo 3	837	rib	37837	-19.4	12.5	8.3%	3.2	14.4	40.2	37857	-13.6	-5.2
Ficarolo 5	838	rib	37838	-17.7	11.1	6.4%	3.5	10.9	32.9	37858	-10.6	-5.5
Ficarolo 6	839	rib	37839	-18.8	12.5	9.1%	3.3	10.2	29.1	37859	-12.0	-6.4
Ficarolo 7	840	rib	37840	-19.0	12.2	1.6%	3.4	15.1	44.0	37860	-10.5	-5.8
Ficarolo 9A	841	rib	37841	-19.6	12.0	6.7%	3.4	14.9	43.9	37861	-11.4	-4.7
Ficarolo 9B	842	rib	37842	-18.9	12.1	5.9%	3.3	13.5	38.4	37862	-10.1	-4.8
Ficarolo 12	843	rib	37843	-19.4	11.9	12.1%	3.5	11.6	34.4	37863	-10.9	-6.1
Ficarolo 13	844	fibula	37844	-16.9	10.8	5.2%	3.4	17.9	51.9	37864	-9.3	-4.9
Ficarolo 16	845	rib	37845	-18.8	12.3	9.1%	3.3	13.6	38.2	37865	-12.4	-5.5
Ficarolo 19	846	rib	37846	-17.9	11.7	5.6%	3.3	14.9	42.6	37866	-10.8	-4.7
Ficarolo 20	847	rib	37847	-18.9	11.9	1.5%	3.4	9.7	28.3	37867	-10.9	-5.6
Ficarolo 21	848	rib	37848	-17.9	12.0	4.7%	3.3	14.3	40.6	37868	-7.4	-6.5
Ficarolo 22	849	rib	37849	-19.0	11.1	12.2%	3.3	11.5	32.4	37869	-11.8	-4.9
Ficarolo 22A	850	rib	37850	-18.0	11.6	1.2%	3.4	9.4	27.1	37870	-11.0	-4.9
Ficarolo 23	851	rib	37851	-19.0	12.8	5.2%	3.4	9.5	27.5	37871	-10.9	-6.0
Ficarolo 28	852	rib	37852	-19.4	10.8	13.6%	3.5	8.7	26.0	37872	-7.8	-4.0
Ficarolo 29	853	rib	37853	-18.8	11.8	14.3%	3.3	11.1	31.5	37873	-11.7	-5.3
Ficarolo Dama	854	rib	37854	-18.7	11.1	5.3%	3.2	12.7	35.1	37874	-11.9	-5.9
Chiunsano 1/2000	924	rib	38924	N/A	N/A	0.0%	N/A	N/A	N/A	38956	-10.7	-3.0
Chiunsano 1/92	925	rib	38925	-17.3	11.5	0.4%	3.5	10.0	29.5	38957	-10.2	-4.1

Table A1 (continued)

Context	#	Bones	Collagen	$\delta^{13}C_{co}$	$\delta^{15}N$	% Yield	C:N	%N	%C	Apatite	$\delta^{13}C_{ap}$	$\delta^{18}O$
Chiunsano 1/93	926	fibula	38926	-19.0	10.7	3.5%	3.3	17.5	49.9	38958	-12.8	-3.2
Chiunsano 1/97 bis	928	fibula	38928	-18.0	9.9	1.9%	3.4	11.3	32.5	38960	-10.7	-4.3
Chiunsano 1/98	929	rib	38929	-17.4	11.4	0.5%	3.4	13.0	38.2	38961	-10.4	-3.3
Chiunsano 1/99	930	rib	38930	-17.5	12.2	3.0%	3.4	13.5	38.8	38962	-10.5	N/A
Chiunsano 2/92	931	fibula	38931	-19.0	11.1	6.9%	3.4	14.2	41.2	38963	-12.9	-4.2
Chiunsano 2/93	932	rib	38932	-19.0	12.1	5.5%	3.3	13.0	37.0	38964	-13.6	-2.7
Chiunsano 2/97	933	rib	38933	-18.5	10.2	3.5%	3.4	9.5	28.1	38965	-10.9	-4.0
Chiunsano 2/99	934	fibula	38934	-19.4	8.7	9.5%	3.4	11.3	32.4	38966	-12.4	-3.5
Chiunsano 2+3/2000	935	fibula	38935	-18.8	10.4	8.6%	3.4	12.7	36.8	38967	-12.3	-4.0
Chiunsano 3/92	936	rib	38936	-17.9	12.2	1.6%	3.3	10.3	29.3	38968	-10.1	-4.2
Chiunsano 3/95	937	rib	38937	-17.9	11.0	3.4%	3.4	13.2	38.4	38969	-11.1	-1.2
Chiunsano 3/97	938	fibula	38938	-18.1	10.7	1.9%	3.4	12.1	35.1	38970	-12.2	-4.0
Chiunsano 4/2000	939	rib	38939	-17.6	11.8	3.0%	3.5	13.9	41.3	38971	-10.1	-3.3
Chiunsano 4/95	940	rib	38940	-17.1	11.6	2.6%	3.4	13.2	38.6	38972	-10.6	-4.1
Chiunsano 5/2000	941	rib	38941	-17.4	12.0	3.6%	3.4	11.4	33.7	38973	-10.4	-2.7
Chiunsano 5/95	942	rib	38942	-15.6	13.8	1.2%	3.5	6.9	20.7	38974	-10.2	-4.7
Chiunsano 6/95	943	rib	38943	-18.2	11.4	2.6%	3.5	11.4	34.1	38975	-10.9	-3.4
Chiunsano 7/95	944	rib	38944	-19.2	12.1	8.6%	3.4	15.7	46.4	38976	-11.6	-4.0
Chiunsano A/82	945	rib	38945	-17.9	11.4	1.4%	3.5	16.3	48.4	38977	-11.8	N/A
Chiunsano sporadico e alfa	946	long bone	38946	-16.5	11.1	8.1%	3.5	20.0	59.7	38978	-10.2	-4.8
Ficarolo 10	947	rib	38947	-17.0	11.2	4.6%	3.6	14.2	43.7	38979	-9.8	N/A
Ficarolo 14	948	rib	38948	-14.4	13.4	2.8%	3.5	16.7	50.2	38980	-10.4	N/A
Ficarolo 15	949	femur	38949	-18.6	11.1	8.3%	3.5	15.2	45.3	38981	-10.2	-3.1
Ficarolo 18	950	fibula	38950	-160	11.1	11.0%	3.5	18.1	54.2	38982	-10.7	-4.1
Ficarolo 2	951	rib	38951	-17.4	11.3	4.5%	3.6	17.2	52.4	38983	-10.0	-3.1
Ficarolo 26	952	rib	38952	-16.4	10.3	0.4%	3.5	11.3	34.0	38984	-9.9	-4.1

Table A1 (continued)

Context	#	Bones	Collagen	$\delta^{13}C_{co}$	$\delta^{15}N$	% Yield	C:N	%N	%C	Apatite	$\delta^{13}C_{ap}$	$\delta^{18}O$
Ficarolo 1	835	Bos taurus	37835	-22.4	5.9	2.7%	3.4	19.1	55.8	37855	-11.2	-5.2
Ficarolo 31	953	Bos taurus	38953	-20.1	8.5	1.1%	3.4	14.6	43.2	38985	-11.1	-1.3
Padovetere 3	955	Bos taurus	38955	N/A	N/A	0.0%	N/A	N/A	N/A	38987	-11.0	-3.7