Nourishing urban development: A palaeodietary study of Archaic Gabii, Italy (6th–5th c BCE)

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A R T I C L E   I N F O

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Latium

A B S T R A C T

Gabii was established around the 8th century BCE in the province of Latium and was considered to be a sister city to Rome. In an effort to learn more about its settlers and their dietary patterns, stable isotope analysis was conducted using skeletal remains from eight individuals found in chamber tomb burials dating to the Archaic period (6th–5th centuries BCE). The δ15N (9.3‰ to 11.5‰) and δ 13Cco (−20.5‰ to −18.9‰) from bone collagen as well as the δ13Cap (−13.2‰ to −9.5‰) from the bone apatite demonstrate that Archaic Gabines’ diet consisted mainly of terrestrial protein in conjunction with C3 plants. In comparing the Archaic diet with the earlier Iron Age and later Imperial diets, a shift towards more positive carbon and nitrogen values is seen through time, suggesting both the introduction of new foods and the correlative relationship between foodways and the rise of urbanism in Latium.

1. Introduction

The Archaic period (6th to 5th centuries BCE) in west-central Italy is conventionally known as a short era between the end of the pre-urban Iron Age and the rise of the Roman Republic. This was a time of rapid social change as Rome began to separate itself from the powerful Etruscan city-states to its north and, along with nearby settlements, began to undertake more substantial building projects, formalize social roles, increase population density, and increase both economic complexity and centralization (Terrenato, 2010; Smith, 2005; Momigliano, 2008; Hopkins, 2016). The site of Gabii, an ancient town located 18 km east of Rome in the province of Latium, demonstrates this sociocultural elaboration in its Archaic era burial forms, where rock-cut chamber tombs and grave goods were found, and in its monumental fortifications and orthogonal city planning (Mogetta and Becker, 2014). Since foodways were a major cultural signifier in the Roman Republic and the Roman Empire, the Archaic period in the province of Latium effectively laid the groundwork for what it meant to be “Roman” in diet. Before the poet Horace (Satire 1.3) penned the phrase ab ovo usque ad mala (literally: from the egg to the apple) as shorthand for the courses of a traditional Roman meal, the food system of Latium evolved during the critical period of Archaic urban development.

Although Archaic Italy, including the Etruscans and the Latins, was a literate society, only a handful of examples of Old Latin date to before the 3rd century BCE, and they are inscriptions on pottery, grave markers, and other public monuments (found in the Corpus Inscriptionum Latinarum). Due to this lack of historical records from the Archaic period, the contemporary understanding of the Roman diet comes from later classical sources on how and what the Romans were eating in the Republican and Imperial periods. Archaeologically, for example, botanical evidence from the Palatine hill in Rome shows that domesticated plants, including primarily cereals with some legumes and fruit, were processed and stored in an increasingly centralized way during the Archaic era urbanization of the city (Motta, 2002).

While the classical Roman diet is often said to have consisted of a Mediterranean triad of grain, grapes, and olives (Lo Cascio et al., 2015; Virlouvet, 2005), protein sources such as legumes and meat were also regularly consumed. The common archaeobotanical remains found in Latium are grains such as emmer, einkorn, oats, rye, and millet, which were used to make bread, porridge, stews, and flat-cakes (Garnsey, 1988; Garnsey and Scheidel, 1998; Garnsey, 2009; Powell, 2003; Thurmond, 2006). Peas, chickpeas, lentils, and broad beans were some of the preferred pulses (Thurmond, 2006).

Due to the cost of production, fish and meat were not accessible to
most of the population, even in classical times. However, there is zooarchaeological evidence from Iron Age central Italy for meat consumption as well as for secondary products; sheep and goats were raised for wool, milk, and cheese, and oxen were used as work animals (Minniti, 2012). Pigs were also raised for consumption, and the wild boar was eaten then as it is today (Garnsey and Scheidel, 1998). Across western central Italy from the Bronze Age through the Archaic period, the zooarchaeological data indicate controlled animal husbandry and the increased production of meat over time necessary to feed an urban population, a trend that would continue and intensify throughout Roman Italy (De Grassi Mazzorin and Minniti, 2017; Mackinnon, 2004; Minniti, 2012). Archaic era foodways in Latium were therefore a complex system of agriculture and pastoralism.

While recent studies are filling in gaps in our knowledge of early Roman foodways, there are still few archaeobotanical and zooarchaeological studies from this period and even fewer isotopic studies. In order to contribute new data to a growing understanding of the Archaic diet, we employed a palaeodietsary study of stable light isotopes of carbon and nitrogen on human skeletal remains from the site of Gabii. Human bone is composed mostly of inorganic hydroxyapatite, while the organic portion is largely made up of collagen. Carbon atoms in collagen ($^\delta^{13}$C$_{coll}$) come mainly from dietary proteins, while carbon atoms in apatite ($^\delta^{13}$C$_{apat}$) derive from all ingested macronutrients (Fernandes et al., 2012; Katzenberg, 2008; Krueger and Sullivan, 1984). Measuring the range of stable carbon isotopes can discriminate between plants with different photosynthetic pathways; the C$_3$ pathway is characteristic of most plants found in Europe, and the C$_4$ pathway is more common in succulents and grasses in hot and dry climates (Pollard et al., 2007). The range of C$_3$ plants is from −15% to −10%, while C$_4$ plants range from −35% to −22% (Ambrose, 1993). These ranges, although not absolute, provide a distinctive scale to distinguish C$_3$ plants such as wheat and barley from C$_4$ plants which include maize, millet, and sugar cane (Kellner and Schoeninger, 2007; Pollard et al., 2007). When a population is suspected to have consumed aquatic resources as part of the diet, however, analysis of nitrogen isotope ratios can discriminate among diets at different trophic levels, distinguishing between marine (+17 to +20‰) and terrestrial protein (+6 to +12‰) consumed (Katzenberg, 2008; Larsen et al., 1992; Pollard et al., 2007; Schoeninger et al., 1983). Nitrogen isotopes ($^\delta$N) therefore help locate an individual’s place in the food chain (Hedges & Reynard, 2007; Schoeninger and DeNiro, 1984). By obtaining $^\delta^{13}$C$_{apat}$, $^\delta^{15}$C$_{coll}$, and $^\delta$N data from human tissue, it is therefore possible to reconstruct the main protein and carbohydrate components of a diet. Moreover, because of their ability to distinguish trophic level, nitrogen isotopes are particularly useful for identifying breastfeeding and weaning practices, because nursing infants are often one trophic level higher than their mothers in nitrogen (Fuller et al., 2006; Katzenberg et al., 1996; Katzenberg, 2008).

Although stable light isotopes analysis on Archaic period Italian bone samples has, to our knowledge, never been done before, the use of stable isotopes to reconstruct the Roman diet is not a new technique. In Rome, Imperial era sites such as Isola Sacra ($^\delta^{13}$C$_{coll}$ mean = −18.8 ± 0.3‰; $^\delta^{15}$N mean = 10.8 ± 1.2‰) (Prowse, 2001; Prowse et al., 2004, 2005; Prowse et al., 2008), Casal Bertone ($^\delta^{13}$C$_{coll}$ mean = −18.2 ± 0.6‰; $^\delta^{15}$N mean = 10.0 ± 1.5‰) and Castellaccio Euraparco ($^\delta^{13}$C$_{coll}$ mean = −18.5 ± 0.6‰; $^\delta^{15}$N mean = 9.5 ± 1.3‰) (Kilgrove and Tykot, 2013), and the catacombs of St. Callixtus ($^\delta^{13}$C$_{coll}$ mean = −19.8 ± 0.4‰; $^\delta^{15}$N mean = 10.6 ± 0.8‰) (Rutgers et al., 2009) and Saints Peter and Marcellinus ($^\delta^{13}$C$_{coll}$ mean = −19 ± 0.3‰; $^\delta^{15}$N mean = −11.2 ± 1.1‰) (Salesse et al., 2014; Salesse, 2015) show a wide range of dietary patterns determined by the different grains and protein resources available and by socially constrained access to them (Kilgrove and Montgomery, 2016). For example, the isotopic data from Casal Bertone and Castellaccio Euraparco revealed differential carbohydrate consumption based on social class, and Isola Sacra showed that diet changed with the life course. Moreover, the low carbon isotope ratios at the catacombs of St. Callixtus point to a freshwater fish diet that may be due to early Christian asceticism. While all of these studies help contextualize what people were eating near Rome in Imperial times, it is unclear whether they reflect the diet of the Archaic period.

The findings of this palaeodietsary analysis of Archaic Gabii are important both because of the new information provided in the absence of historical records, and because we are able to compare these carbon and nitrogen isotope values to data from the same geographic area prior to and after its urbanization. The increase in urban development from the Iron Age to the Imperial era, once clear archaeologically, is now paralleled by the isotopic change in dietary resource use.

2. Materials and methods

The city of Gabii (WGS 84: 41.886944° N, 12.715833° E) lies 18 km east of Rome, Italy, in the province of Latium. Early settlement around Lago di Castiglione, a volcanic crater lake, dates to at least the 10th century BCE, with proto-urban development beginning in the 8th century BCE. At its height, Gabii was only about two square kilometers, overshadowed in many ways by Rome to its west. Nevertheless, Gabii had a reputation as a religious center, with Romulus and Remuslegendarily educated there (Plutarch VI Life of Romulus). Little is known from historical records about Gabii, but large-scale archaeological work has been carried out by The Gabii Project, headed by Nicola Terrenato at the University of Michigan, since 2007.

The archaeological investigation of Gabii over the past decade has found evidence of initial settlement in permanent huts from the late 8th century BCE, expansion and urbanization in the form of orthogonal planning by the 6th–5th centuries BCE, and increasing population density during the late Archaic and early to middle Republican periods (6th-2nd centuries BCE). Gabii ceased to be an important settlement area by the early Imperial period (1st century BCE to 1st century CE), particularly after quarrying activity increased and aqueduct creation led to the draining of the volcanic lake by the 3rd century CE (Becker et al., 2009; Mogetta and Becker, 2014; Farr, 2014). Land use patterns, however, suggest that Gabii continued to be important for agricultural production in the area into the early Medieval period (Zapelloni Pavia et al., 2017).

Burials found at Gabii date to three general temporal phases: Orientalizing (8th–6th century BCE), Archaic (6th–5th century BCE), and Imperial (1st–4th centuries CE). While research into the Imperial and Orientalizing burials has previously been published (Becker and Nowlin, 2011; Kilgrove and Tykot, 2018), the Archaic grave styles have only recently been investigated (Evans, 2017), and the osteological analysis of the demographics of the Archaic skeletons is in press (Kilgrove, forthcoming).

The Archaic period graves involve three underground rock-cut chamber tombs, as well as a simple infant burial (Fig. 2). These chamber tombs or hypogea were well-preserved by a substantial silt layer above which the Gabines appeared not to have developed further (Mogetta and Becker, 2014). The central location of these burials within the urban area of the site and the amount of work needed to create them suggest these individuals were part of the elite social order (Farr, 2014). This burial area appears to have been abandoned by the early 5th century BCE.

Seven skeletons were recovered from three chamber tombs by Gabii Project team. Tomb 25 is a double tomb cut into the rock that contained one individual (25A) in a tuff (volcanic rock) sarcophagus and one individual (25B) placed directly in a niche next to it. Based on the fill, it is assumed that the two burials were made at the same time, and a fragment of pottery dates it to the early to mid 5th century BCE (Evans 2018:30). A second semi-chamber tomb was discovered nearby, with three niches containing skeletons 38, 39, and 40. A number of artifacts were found on top of and around individual 38, and all three individuals were likely placed on wooden biers or in wooden coffins that...
have since decayed. This tomb dates to between 525 and 400 BCE based on stratigraphy (Evans 2018:32). Another semi-chamber tomb contained two individuals, 41 and 42, who were placed in niches on either side of a deep cut into the bedrock. Nails recovered from the burials suggest each individual was placed in a wooden coffin or bier, and ceramics date the tomb to the late 6th to early 5th century BCE (Evans 2018:35). A final skeleton, 48, has been included in this analysis because it dates to the early Archaic period. However, this individual may belong to the end of an earlier tradition of burying nonadults near house walls (Mogetta and Cohen, forthcoming; Killgrove, forthcoming).

Standard osteological methods were used to estimate sex and age-at-death for all skeletons found at Gabii by Kristina Killgrove (2011, 2015, forthcoming). The age-at-death of adults was determined by the scoring of the pubic symphysis, the auricular surface, and cranial suture closure based on Brooks and Suchey (1990), Buckberry and Chamberlein (2002), Todd (1921a, 1921b), Lovejoy et al. (1985), and Meindl and Lovejoy (1985). Adults were placed into age categories defined by Buikstra and Ubelaker (1994) of young adult (20–35), middle adult (35–50), and older adult (50+). Using the Phenice (1969) method in conjunction with Acsádi et al.’s (1970) cranial features, the sex of adults was estimated as female (F), probably female (PF), indeterminate (I), probably male (PM), or male (M). The age-at-death of nonadults was estimated using dental development and epiphyseal closure techniques by Moortree et al. (1963a, 1963b), White and Folkens (2005), Gustafson and Koch (1974), Anderson et al. (1976), and Baker et al. (2005). Using Baker et al.’s (2005) age grouping techniques, nonadults were put into the following categories: infant (0–12 months), young child (1–6 years), older child (6–12 years), and adolescent (12–20 years).

Between 2 and 6 g of rib samples were taken from the six adult skeletons: 25A, 25B, 39, 40, 41, and 42. Human ribs were chosen for their high surface-to-volume ratio of trabecular bone and because they remodel quickly (Meier-Augenstein, 2011; Hill, 1998), allowing us to investigate the foods consumed in the last years of the Gabines’ lives. Because commingling of bones in the second chamber tomb meant an inability to confidently assign ribs to individual 38, a humeral epiphysis was tested instead, and the ilium of individual 48 was sampled because of a lack of ribs present.

The Archaic faunal remains from Gabii are currently under study by Victoria Moses, with most of the remains coming from domesticated animals, including sheep/goat, pig, and cattle, with some wild animals like hare, fox, and deer. Very few fish remains have been recovered. The zooarchaeological sampling strategy of the Gabii Project includes full screening and soil sampling of the Archaic layers to provide a unique dataset on subsistence economy and foodways. Six faunal bone samples were chosen from the Archaic phase for isotope analysis in order to help establish a trophic baseline in this project, including three pigs and three ovicaprids.

Initial processing of the animal bone samples took place at Kristina Killgrove’s former lab space at the University of West Florida (UWF), and processing of the human bone happened at Bethany Turner’s stable light isolate prep lab at Georgia State University (GSU), both using methods by Turner et al. (2005), adapted from Tykot and der Merwe (1996), Ambrose (1990), and Schoeninger and DeNiro (1984). The 14 total bone samples were cut using a dental drill to expose the trabecular bone. Once the cortical bone was exposed, it was cleaned mechanically with a dental drill and sonicated in vials filled with double-distilled water (ddH₂O). The samples were left to dry, were crushed in an agate mortar and pestle, and were sieved through a 120-mesh (125μm) screen to obtain the portions to be used for collagen and apatite analysis.

At GSU, the human and animal collagen samples were soaked for 4 h in an annealed thimble in a Soxhlet apparatus in 10:5:1 Methanol: Chloroform: ddH2O. The collagen portions were soaked in 0.5 M HCl every 48 h for 14 days and then rinsed to pH neutral and freeze dried. Reliability of collagen yields was confirmed through carbon and nitrogen abundances as well as C:N ratios.

The human apatite samples were further crushed into fine powder, which was soaked in a mixed solution of 2% NaOCl and distilled water for 24–72 h to ensure all the organic material was removed. The samples were centrifuged and rinsed with ddH₂O to pH neutral and then soaked in 0.2% acetic acid solution at 4°C for 2–4 h. The isolated carbonate samples were centrifuged, rinsed to pH neutral, and freeze-dried before being digested in 100% phosphoric acid (Turner et al., 2005). Faunal samples were not subjected to apatite analysis.

The collagen and carbonate samples were sent to the Center for Isotope Geoscience at the University of Florida, where they were digested on an automated prep system in a Thermo Delta V isotope ratio mass spectrometer. Analytical precision based on standard USGS40 is ± 0.06‰ for δ¹³C, reported with respect to AIR, and ± 0.04‰ for δ¹⁵N, reported with respect to the VPDB standard. Precision of the bone apatite values is based on the NBS-19 standard reported with respect to VPDB; this yielded both δ¹³C values (± 0.04‰) and δ¹⁵N values (± 0.07‰). In the interest of fully reporting available data, the oxygen isotope values are included in Supplementary File 1; however, we do not discuss them further due to the dietary focus of this article.

Isotopic data, together with associated chronological and other supporting information from this study, have been added in the IsoArcH database (Salesse et al., 2018; Salesse et al., 2019).

3. Results

3.1. Isotope ratios of human bone collagen and apatite

This study used stable isotope analysis to reconstruct the Archaic dietary patterns of eight people buried at Gabii: two adult females, four adult males, one adolescent, and an infant of about 3 months at the time of death. These demographics are presented in Table 1, along with the measured δ¹³Cc, δ¹⁵N, and δ¹⁵Cc values. Also provided are the C:N ratio, carbon and nitrogen abundances, and collagen yield as

<table>
<thead>
<tr>
<th>Individual</th>
<th>Sex</th>
<th>Age Category (age in years)</th>
<th>Sample</th>
<th>δ¹³Cc (%)</th>
<th>δ¹⁵N (%)</th>
<th>δ¹⁵Cc (%)</th>
<th>C:N Ratio</th>
<th>%C</th>
<th>%N</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 A</td>
<td>PF</td>
<td>Middle Adult (20–35)</td>
<td>Rib</td>
<td>−19.8</td>
<td>9.7</td>
<td>−13.2</td>
<td>3.3</td>
<td>45.63</td>
<td>16.10</td>
</tr>
<tr>
<td>25 B</td>
<td>M</td>
<td>Adolescent (16–20)</td>
<td>Rib</td>
<td>−20.5</td>
<td>9.3</td>
<td>−12.3</td>
<td>3.4</td>
<td>45.58</td>
<td>16.00</td>
</tr>
<tr>
<td>38 I</td>
<td></td>
<td>Adolescent (12–14)</td>
<td>Humeral epiphysis</td>
<td>−19.5</td>
<td>10.2</td>
<td>−12.3</td>
<td>3.4</td>
<td>27.80</td>
<td>9.64</td>
</tr>
<tr>
<td>39 M</td>
<td></td>
<td>Middle Adult (20–35)</td>
<td>Rib</td>
<td>−19.9</td>
<td>10.9</td>
<td>−12.5</td>
<td>3.3</td>
<td>44.76</td>
<td>15.82</td>
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<tr>
<td>40 M</td>
<td></td>
<td>Middle Adult (20–35)</td>
<td>Rib</td>
<td>−19.8</td>
<td>10.3</td>
<td>−13.1</td>
<td>3.5</td>
<td>44.64</td>
<td>15.11</td>
</tr>
<tr>
<td>41 M</td>
<td></td>
<td>Middle Adult (20–40)</td>
<td>Rib</td>
<td>−19.8</td>
<td>9.8</td>
<td>−11.6</td>
<td>3.3</td>
<td>40.27</td>
<td>14.31</td>
</tr>
<tr>
<td>42 F</td>
<td></td>
<td>Older Adult (50+)</td>
<td>Rib</td>
<td>−19.6</td>
<td>10.3</td>
<td>−11.1</td>
<td>3.4</td>
<td>50.53</td>
<td>17.69</td>
</tr>
<tr>
<td>48 I</td>
<td></td>
<td>Infant (c. 3 months)</td>
<td>Ilium</td>
<td>−18.9</td>
<td>11.5</td>
<td>−9.5</td>
<td>3.4</td>
<td>37.60</td>
<td>13.15</td>
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<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>−19.7</td>
<td>10.3</td>
<td>−12.0</td>
<td>3.4</td>
<td>45.05</td>
<td>17.69</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
<td>0.45</td>
<td>0.70</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
indications of the reliability of the δ13C and δ15N sample collagen measurements. Based on the C:N molar ratios that fall between the canonical range of 2.9–3.6 (DeNiro, 1983), the likelihood that the collagen in the samples is well preserved is high. (See Table 2.)

The δ13C ranges from −20.5‰ to −18.9‰, with a mean of −19.7‰ and a standard deviation of 0.45. Individual 48 presents a carbon isotope value nearly two standard deviations higher than the mean, while individual 25B has a carbon isotope value similarly far removed but in the lower direction. The δ15N values of the sample range from 9.3‰ to 11.5‰, with a mean of 10.3‰ and a sdeve of 0.70. Individual 25B is again anomalous, with the lowest nitrogen value of the sample, and individual 48 has the highest. All of the data points, however, fall within a range that suggests the diet of the Archaic Gabines consisted mostly of C3 pathway plants like wheat along with terrestrial protein (Fig. 3).

Analysis was also run on the apatite portion of the human bones in order to extrapolate overall dietary information. The δ13C ranges from −13.2‰ to −9.5‰ for the Archaic Gabines, with a mean of −12.0‰ and a standard deviation of 1.2. In this case, individual 25A is one standard deviation lower than the mean, while 48 is two standard deviations higher. Plotting the carbon isotope values from both collagen and apatite can provide an alternate visualization of carbohydrate energy versus protein. Fig. 4 shows that the Archaic Gabines all fall along the C3 protein line and that they consumed more C3 than C4 carbohy-

Finally, because of its anomalous values in all isotope ratios measured (cf. Supplementary File 1 for δ18O value), individual 48 will be excluded from all statistical analyses in the remainder of this paper. However, this infant will be further discussed below in reference to evidence for breastfeeding and weaning at Gabii.

3.2. Comparisons with faunal results

The inclusion of faunal samples is key in the reconstruction and understanding of the different trophic levels of the Gabine diet. On average, there is a 2–3‰ increase in δ15N as one goes up the food chain, from nitrogen-fixing plants at the low end of the nitrogen range, to carnivores as well as some marine creatures at the high end (Tykot, 2004). Thus, establishing what the animals themselves were eating at Gabii can help refine our interpretation of the isotopic signatures obtained from the human bones.

Animal bone has been excavated and collected by the Gabii Project since its inception, although most of the zooarchaeological data has yet to be published as researchers continue to analyze them (Alhaique, 2016; Alhaique et al., 2016). It is clear, however, that Archaic faunal remains follow expectations derived from other contemporaneous sites in western central Italy in that sheep/goat are the most abundant, followed by pig and cattle. Some wild resources, such as hare and butchered tortoise, were likely part of the Gabine diet. Although animal remains have been found in graves at Gabii, most of the bones are associated with domestic activities, namely disposal of bone following consumption. However, the Archaic area also has a very high density of wool working tools such as spindle whorls and loom weights, under study by J. Troy Samuels, so it is possible that the animals may represent raising sheep for wool more so than for consumption. Additionally, the palaeobotanical remains, currently being analyzed by Laura Motta, show a range of C3 and C4 crops such as wheat and millet, which may have been for animal fodder or for human consumption.

Among the domesticated animals in the Archaic Gabii faunal sample, the average δ13C value is −20.1‰ and the δ15N average is 6.2‰. The Archaic people were, on average, 0.3‰ higher in δ13C and 3.9‰ higher in δ15N than the terrestrial animals. As predicted, the humans are approximately one trophic level above these often-consumed domesticated animals.

Variation within the faunal sample, however, is intriguing. The pigs do not form a clear cluster, and the sheep and goat are also heterogeneous in their isotope values. Even adding in faunal isotopes from Imperial-era Isola Sacra (Fig. 3) simply underscores the variability in animals' diets. This scatter of faunal data may reflect differences in how the animals were raised, either through specifically providing fodder using more C4 crops or allowing grazing in different areas that were primarily C3 or C4 plants, since some millet types native to Italy may have grown naturally in the area.

The faunal sample from Gabii is useful in visualizing the alimentary resources available for both animals and humans, but more work needs to be done in the future on the foodweb of Archaic Latium, particularly since this time period represents the beginning of urban development in the area.

3.3. Dietary variation in the Archaic Gabines

Due to the small sample size, hypothesis testing of intra-site differences was not able to be conducted; however, descriptive statistics are included here to explain the overall patterns of variation seen in the Gabine diet based on sex and age.

Out of the six adult individuals, two were assessed as female or probably female (42 and 25A, respectively). There is only a 0.2‰ difference between their δ13C signatures, and a distance of just 0.6‰ between them in δ15N, suggesting they consumed similar diets. However, the two females establish the minimum and maximum limits of the Archaic δ13C range, with 25A at the low end (−13.2‰) and 42 at the high end (−11.1‰). Four of the adults were estimated to be male: 25B, 39, 40, and 41. The δ13C range for males is −20.5‰ (25B) to −19.8‰ (40, 41); with a difference of only 0.7‰, the δ13C ratios suggest a homogeneous diet among males. A similar observation is noted with the δ15N signatures, which ranged from 9.3‰ to 10.9‰. There is, however, a 1.5‰ difference in the δ13C range (−13.1‰ to −11.6‰), reflecting overall dietary differences between male individuals 40 and 41. Females and males at Gabii therefore overlap in their isotope ranges, suggesting these adults were all consuming similar

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Species</th>
<th>δ13C (‰ VPDB)</th>
<th>δ15N (‰ AIR)</th>
<th>C:N ratio</th>
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</thead>
<tbody>
<tr>
<td>3040</td>
<td>Goat</td>
<td>−19.1</td>
<td>5.2</td>
<td>3.3</td>
</tr>
<tr>
<td>3077</td>
<td>Sheep</td>
<td>−21.3</td>
<td>7.1</td>
<td>3.3</td>
</tr>
<tr>
<td>3135</td>
<td>Sheep/goat</td>
<td>−19.4</td>
<td>7.3</td>
<td>3.3</td>
</tr>
<tr>
<td>3153</td>
<td>Sheep/goat</td>
<td>−19.9</td>
<td>6.5</td>
<td>3.3</td>
</tr>
<tr>
<td>3153</td>
<td>Sheep/goat mean</td>
<td>1.2</td>
<td>1.2</td>
<td>3.3</td>
</tr>
<tr>
<td>3077a</td>
<td>Pig</td>
<td>−18.7</td>
<td>6.7</td>
<td>3.3</td>
</tr>
<tr>
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<td>Pig</td>
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<td>Pig</td>
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<td>6.1</td>
<td>3.3</td>
</tr>
<tr>
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<td>Pig mean</td>
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<td>5.8</td>
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<td>Pig SD</td>
<td>1.3</td>
<td>1.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>
foods in the last few years of their lives.

The two nonadults in the Archaic sample represent different bone types tested and different ages at death. Individual 38 was approximately 12–14 years old at the time of death and buried in one of the underground chamber tombs. Because the individual’s sex cannot be determined based on macroscopic examination, skeleton 38 is not included in the sex-specific descriptive statistics above. However, several characteristics warrant its inclusion with the adults in nonparametric hypothesis testing below. First, the nonadult’s biological age places him or her within a Roman social age category similar to that of an adult. If social norms based on written records from the later Republican and Imperial periods are taken in consideration and assumed to be applicable to the Archaic period, girls could marry as young as 12, while boys transitioned to manhood at puberty. Between 10 and 14 years of age, children could be found guilty of crimes but also were often judged unable to have the same criminal intent as an adult (Laes, 2006). Second, this nonadult's burial in an elite tomb suggests an inherited social status that may have conferred some rights and privileges of adulthood. And finally, skeleton 38’s carbon and nitrogen isotope values are similar to those of the adults from Archaic Gabii and dissimilar to the other nonadult, infant 48. For these reasons, we are comfortable including skeleton 38 among the adults in inter-site and temporal comparisons provided below.

Individual 48, however, an infant of about 3 months old, cannot be included further in hypothesis testing because its isotopic signatures are all anomalous compared to the rest of the population. Specifically, its δ15N and δ13Cco signatures are both approximately two standard deviations higher than the population average. It is unsurprising to see a trophic difference in this nonadult, given that the infant was likely breastfeeding at the time of its death (Katzenberg et al., 1996; Fuller et al., 2006). According to early Imperial era medical sources such as Galen, the recommendation for mothers in ancient Rome was to breastfeed for at least six months and to wean the child completely by age two (Green, 1951). Isotopic studies by Tracy Prowse (2001) and Prowse et al. (2004, 2007, 2008) on skeletons from the cemetery of Isola Sacra at coastal Portus Romae have provided strong evidence to confirm this custom, and studies by Rutgers et al. (2009) and Killgrove and Tykot (2013) on Imperial era skeletons have produced a handful of similar results. More isotopic studies concentrating on weaning in ancient Rome are still needed, however, to examine the variation in breastfeeding and weaning compared to advice found in the historical record.

3.4. Dietary changes through time in the Lake Castiglione Area

Highlighted in Fig. 3 are comparative palaeodietary data from the later Imperial phase of Gabii and from the earlier Iron Age cemetery of Castiglione (see Fig. 1 map). This cemetery, excavated in the 1980s by Anna Maria Bietti Sestieri (1992) lay just to the west of Gabii and it, along with Osteria dell’Osa, may have been the main burial location for the inhabitants of Gabii and the surrounding area in the Iron Age. The 11 skeletons that were tested from Castiglione date to 830–770 BCE and thus form an earlier, proto-urban comparative sample (Bietti Sestieri, 1984; Schwarz and Knyf, 1992). The 18 adult skeletons from Imperial Gabii date to the 1st-3rd centuries CE (Killgrove and Tykot, 2018), or a time when Gabii’s settlement was in decline. Together, the three sample populations can be investigated for change in the adult diet over time in the Lago di Castiglione area.

The 11 Castiglione samples included ten adults and one older adolescent, with an overall δ13Cco mean (n = 11) of −19.8 ± 0.75‰ and δ15N mean (n = 10) of 8.7 ± 0.59‰. Adult Gabine results (n = 7) included a mean of −19.8 ± 0.45‰ in δ13Cco and a mean of 10.1 ± 0.70‰ for δ15N. Finally, the Imperial adult Gabine sample (n = 18) produced means of −18.8 ± 0.7‰ δ13Cco and 10.7 ± 0.9‰ δ15N. There are clear differences in the means that are worth exploring statistically for significance and directionality.

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Fig. 1. Map of sites with human and faunal isotope values used in this article. The walls of Imperial period Rome, the Imperial period site of Isola Sacra, the late Iron Age cemetery at Castiglione, and the Archaic era burials at Gabii are highlighted on this modern map of Rome. (Base map tiles © OpenStreetMap.org contributors, available for use under the open database license CC BY-SA 2.0.)
When comparing the Iron Age samples from Castiglione with the Archaic Gabii samples, the δ15N signatures were found to be significantly different (Mann-Whitney U = 1, z = −3.269, p < 0.01), with the Castiglione skeletons having a lower average nitrogen isotope value. This hints at increased consumption of higher trophic value protein among the Archaic Gabines. A comparison of the δ13Cco values between Castiglione and Archaic Gabii, however, was not significantly different (Mann-Whitney U = 22.5, z = 1.4, p = 0.16), suggesting similar carbohydrate resource consumption.

Archaic and Imperial Gabii were also compared, resulting in significant differences in both δ13Cco (Mann-Whitney U = 0, z = 3.78, p < 0.001) and δ15N (Mann-Whitney U = 26.5, z = 2.178, p < 0.05). The δ13Cep values were also significantly different (Mann-Whitney U = 26, z = −2.095, p < 0.05). These results indicate that Archaic
Gabii had significantly lower carbon and nitrogen isotope values than did Imperial Gabii, but higher carbon apatite values. The Gabines were likely consuming more C3 foods and lower trophic level protein in the Archaic period, and had added some C4 resources and higher trophic level food in the Imperial phase.

Finally, Castiglione was compared to Imperial Gabii, yielding statistically different results in both the δ13C (Mann-Whitney U = 3, z = -4.29, p < 0.001) and δ15N (Mann-Whitney U = 12, z = 3.72, p < 0.001) ratios. The Castiglione individuals show lower carbon and nitrogen ratios than do the Imperial Gabines, pointing at not only a difference in animal protein intake, but also in carbohydrate choice and reliance.

Although the sample sizes are small, both Fig. 3 and the Mann-Whitney U statistics illustrate a significant change in alimentary resources from the proto-urban Iron Age to the urban development of the Archaic to the decline of the settlement of Gabii in the Imperial era.

4. Discussion

With this study, we sought to reconstruct the dietary patterns of Archaic Gabines using biochemical data obtained from skeletons found in chamber tomb burials. Light isotope analysis of carbon and nitrogen was conducted to understand the composition of the Archaic diet. Specifically, we expected to see change through time in dietary resource use in this geographic area due in part to the changes in urban development and subsistence economy known archaeologically. Carbon and nitrogen values from the seven Archaic chamber tomb burials suggest that people were eating mainly C3 plants in addition to terrestrial protein. Furthermore, the carbon and nitrogen levels of the terrestrial fauna align with the human values, indicating that these taxa were likely consumed by the Gabines.

Overall, Archaic males and females at Gabii were eating similar protein and carbohydrate sources. The same homogeneous dietary pattern was found among the Imperial period by Killgrove and Tykot (2018), suggesting that the adult population at Gabii had access to similar resources and practiced the same foodways regardless of biological sex. Nonetheless, when examining the isotopic signatures closely, the female individuals 42 and 25A make up the minimum and maximum δ13Cap ranges, respectively. This might suggest a different diet between the females possibly tied to their ages. Individual 42 is an older adult (50+ years old), who, besides suffering from significant tooth wear, presented antemortem tooth loss and showed degenerative joint disease in her spine and hips. In contrast, individual 25A exhibited the expected tooth wear for a middle-aged adult. It is possible that individual 42 had a distinct diet to help her consume softer or even medicinal foods for her ailments. Monitoring one’s diet was vital in helping balance the four humors, a theory to which influential physicians such as Galen subscribed (Galen, 2000). These interpretations, however, are very preliminary, as the pattern observed might simply be related to the small sample size.

Individual 25B, an older adolescent or young adult male buried together with the middle-aged female 25A, presents intriguing isotope values as well. With a δ13C value two standard deviations lower than the adult mean and the lowest δ15N value of the entire sample, individual 25B may have been consuming a largely vegetarian diet. Further, his skeletal and dental pathologies were surprisingly numerous for his young age. Schmorl’s nodes suggestive of disc herniation were present in his spine, linear enamel hypoplasia on both maxillary and mandibular canines point at developmental stress around 2–3 years of age, and periodontal disease was indicated by reduction of the height of the dental alveoli. The combination of dental issues and carbon and nitrogen signatures could convey that 25B consumed a strict or deficient diet. Finally, the burial of 25B next to an older woman (25A) is not a common Archaic Roman burial practice. However, it is difficult to extrapolate the sociocultural significance of the burial without further analysis. For example, future DNA testing may be able to establish whether these individuals were genetically linked, perhaps as mother and son.

In a broader perspective, in comparing diet in the Lago di Castiglione area over time, statistically significant differences were found, providing temporal evidence that animal protein consumption increased gradually and that C4 resources, likely millet, also became more common in the diet over time. The Castiglione individuals presented lower nitrogen signatures than did the Archaic Gabines suggesting that they were less dependent on animal protein than were the Archaic period individuals or, perhaps, that the Archaic Gabines introduced occasional marine resources into their diet. Given the discovery of several fish hooks at Gabii (Alhaïque et al., 2016) along with a few fish bones in the zooarchaeological assemblage, aquatic resources were almost certainly consumed; however, the extent to which they made up the diet in any period is unclear but appears to have been small. A further increase in nitrogen isotope averages between Archaic...
and Imperial Gabii could also be related to an increased use of aquatic resources in the area. Alhaique et al. (2016) suggest that in the Republican era, when the settlement of Gabii was at its largest, fish remains are few but also, surprisingly, the species they identified are mainly marine (e.g., moray and mackerel) and not freshwater species that would have been living in the Lago di Castiglione.

The dietary shift evident in both carbon and nitrogen suggests a change towards a more varied, heterogeneous diet that incorporated new resources such as fish and millet over time. Historically, this dietary shift is not surprising, as the Imperial period marks Rome's expansion geographically and culturally (Palmer, 1970). An increase in resource variety is attested through archaeobotanical evidence in areas of the Empire such as Roman Britain (Van der Veen, 2008). A greater variety of foods were available to more people, and this may be reflected at Gabii in the form of a more “Roman” diet. However, as Killgrove and Tykot (2013, 2018) have argued previously, while some patterns in resource use exist for the Imperial period in Rome, the diet is more intriguing for its heterogeneity, varying based on sex, age, social class, religion, and migration status.

The addition of Archaic Gabii and Iron Age Castiglione, however, provides us with a new perspective on the Imperial Roman diet: one with intriguing time depth. Knowing what the people of Latium ate prior to the rise of the Empire is an important key to tracing the evolution of the subsistence economy. Yet Archaic foodways are only recently becoming understood. For example, a chemical study of food remnants conducted by Notarstefano et al. (2011) used pottery vessels dating to the 6th century BCE from San Vito dei Normanni in south-eastern Italy. This analysis revealed that the residue found in the cooking vessels primarily consisted of products derived from boiled meat and vegetables, while the cookware itself was of Greek import, particularly the pots used to cook meat. The results of Notarstefano et al.’s (2011) study highlight not only the types of food eaten in the Archaic period, but also the fact that exchange of goods and customs was common. This increase in exchange, though, reflects a bigger pattern in Archaic Italy: the rise of urban centers.

One possible explanation for the change in diet over time at Gabii is the effect of urbanism on foodways. The shifting political economy from the Archaic through the Imperial periods was characterized by massive increases in population density, formalization of social roles, centralization of authority, economic intensification, and increase in connections across the Empire. In complex societies, the links between diet (especially meat production) and power, economy, religion, and other important aspects of social life are well attested (e.g., DeFrance, 2009).

The shift to either more millet consumption or more meat from animals fed with millet seen in the early Imperial period can similarly be linked to the increased demands of the population. Although Imperial Gabii was not as large or as densely settled as it had been in the Republican era, the growth of Rome and its suburbs meant constant use of land around Lago di Castiglione. Because millet is a hearty crop that grows well and frequently throughout Italy, it could more effectively feed hungry residents or, more likely given ancient authors' disdain for millet as a food, could feed animals that would provide sustenance for people.

At Gabii, the Archaic individuals show an increased consumption of meat from earlier time periods, possibly tied to their elite status and perhaps related to their authority to control the distribution of meat. Eating meat could therefore have been a way to signify elite status for these Gabines. Nevertheless, while the fish remains and fishing hooks show aquatic sources were at least occasionally part of the diet during some periods at Gabii, the low number of fish remains despite careful sampling might instead mean that adding manure to agricultural fields affected the nitrogen values. An historical treatise by the Roman agricultural writer Columella, de Re Rustica (Book II), spells out the kinds of manure favored in the 1st century CE as well as methods of application. Columella notes that bird dung from pigeons, hens, and other fowl is the best for manuring fields, followed by human manure, and then manure from cattle, sheep, goats, and pigs. His suggestions for manuring involve its application on plots of wheat, barley, as well as legumes and pulses. As manuring of agricultural fields can increase the nitrogen values of crops, and therefore the trophic level of the humans and animals that consume those crops (Bogaard et al., 2007; Fraser et al., 2011), it is entirely possible that the upward shift in nitrogen values over time in the Lago di Castiglione area represents an increase in crops produced through manuring. If this is the case, manuring would further support our argument for an increased intensity in agricultural production that would have accompanied the increased demands of an urban populace. Whether the nitrogen shift we are seeing relates to manuring or a change in consumption of protein sources is currently unclear; more work on palaeodiet and palaeobotany in the Archaic period is needed.

While isotopic analysis of animals and humans from Gabii provides some clues to the prehistoric and pre-Roman diet of west-central Italy, the observed patterns raise more questions than can be answered with a small sample. Additional research into the Archaic diet and into the Iron Age to Archaic transition would be most welcome.

5. Conclusions

This study found through a combination of historical sources, archaeological information, and isotopic data that there was an increase in consumption of higher trophic level foods and of millet through time at Gabii and in the Lago di Castiglione area just east of Rome, Italy. This palaeodietary study indicates that a shift occurred between the Archaic (6th–5th c BC) and Imperial (1st–3rd c CE) periods at Gabii, with the latter consuming more or different animal protein and more C4 resources. We suggest that the increasingly varied diet seen isotopically and archaeologically from the Iron Age through the Imperial era may be related to urban development and concomitant changes to the local subsistence economy. Nonetheless, due to the small sample sizes in this work, additional research is needed to investigate whether the identified dietary shift is a pattern that obtains elsewhere in ancient Italy.

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