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Diet and mobility in Late Antique Sicily: Isotopic data from the catacombs of Santa Lucia, Siracusa (Italy)

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ABSTRACT

The catacombs of Santa Lucia were built during the 3rd century CE in Siracusa, Sicily, Italy, as a burial site for members of the local Christian community until the early 8th century CE. This site is an important cemeterial context of the Late Roman and Byzantine periods. The tombs and artifacts found suggest that individuals of varying wealth were buried in the catacombs. Historical accounts also confirm the presence of a significant Christian community from Syria and the Levant in Siracusa during this period. The objective of this research is to investigate the life histories of the Late Antique community interred in the catacombs using stable isotope analysis. This technique aimed to clarify the dietary differences between individuals of different social status and geographical origins, in order to re-evaluate the data from historical documents. To achieve this, we conducted stable carbon, nitrogen, and oxygen isotope analyses on skeletal samples from 25 individuals recovered from the catacombs of Santa Lucia, using established methods. The results revealed significant dietary diversity among the individuals buried in the catacombs, with evidence of the consumption of both C3 and C4 plants, as well as fish from both freshwater and sea sources.

The oxygen isotopes show a particularly broad range in both the small sample set of bones and the larger set of teeth, suggesting a significant degree of mobility for most of the individuals tested. The high variability found in the diet and the evidence of mobility for most of the individuals tested not only between early age and adulthood, but also throughout their lives. It raises new questions and calls for the consideration of the archaeological and historical implications of these novel discoveries.

1. Introduction

Just as food plays a central role in our society for its social and cultural significance and economic, political, and religious implications, it was a key element of the fabric of ancient societies. The study of diet, cuisine, cooking and taste in antiquity is increasingly becoming a major arena for testing innovative approaches and breakthrough technologies that often provide revolutionary new data that help us rewrite the pages of human history. While archaeology, art history and history are critical to interpreting the material dimension of food preparation, the social phenomenon around food consumption, and shedding light on the enigmatic taste of our ancestors, dietary habits can only be studied through the lens of the biomolecular analysis of those nutrients trapped as residue inside ancient pottery or assimilated by human skeletons. When the reconstruction of ancient diet focuses on the latter case, the combined application of staple isotopes analysis and aDNA study offers invaluable new information on ancient mobility, another area of research that is gaining momentum in Mediterranean archaeology. Unfortunately, despite being the cradle of Classical civilizations, not much scholarly work has been done in Italy in this regard, and the situation is even more dire for ancient Sicily.

Studies of dietary practices and mobility in ancient Sicily through the

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lens of biomolecular archaeology are so far quite limited. Specifically, only three works focusing on stable isotopes studies are available for the Greek Archaic and Classical periods (Tanasi et alii 2017a; Reitsema et alii 2020; Reitsema et alii 2022). For the Roman and Late Antique periods, the paucity of information regarding dietary habits and living standard offered by the ancient sources combined with the lack of specific archaeometric studies leaves a multitude of research questions up for speculation, while issues related with mobility are primarilyy addressed through epigraphic and onomastic perspectives.

New research was designed in the context of the Mediterranean Diet Archaeology Project, developed within the University of South Florida's Institute for the Advanced Study of Culture and the Environment (https://www.usf.edu/arts-sciences/institutes/iasce/research/med-diet-arch.aspx) and spearheaded by two of authors, to tackle the open issue of the dietary and culinary habits of ancient communities of the Mediterranean region and the impact on their living standards and health (Tanasi et alii 2017a; Tanasi et alii 2021a; Tanasi et alii 2021b; Tanasi et alii 2018; Tanasi et alii 2017b). Through stable isotope analysis, this present study aims to evaluate individual life-histories of a Late Antique Sicilian community that orbited around the catacombal complex of Santa Lucia in Siracusa between the first half of the 5th and the early 8th century CE to shed light on differential dietary habits between individuals of diverse status and place of origin and on mobility patterns of individuals moving over time into the community, focusing on new contexts from recent excavations conducted by two of the authors.

2. The case study of the catacombs of St. Lucia at Siracusa

The development of labyrinthine underground Christian cemeteries, commonly known as catacombs, increased in the 4th century CE by the promulgation of two Roman imperial edicts, that of Milan (313 CE), issued by Constantine I (272–337 CE), officially ending the persecution of Christians and that of Thessalonica (380 CE), promulgated by Theodosius I (347–395 CE), which made Christianity the sole admissible state religion of the Roman Empire. From that time onward, catacombs became the quintessential representation of the community cemetery, especially in Italy, Sicily, Malta, Tunisia, and Turkey, representing the funerary counterpart of the society of the living (Stevenson 1978). The grand scale and monumentality of catacombs of Siracusa in Sicily -Vigna Cassia, Santa Lucia and San Giovanni- testifies to the size and relevance of the Christian community of the city between the late 3rd and the 5th century CE (Sgarlata 2016). After the fall of the Roman empire in 476 CE, Sicily remained in an administrative limbo, at times disrupted by occasional raids of the Vandals, until the end of Gothic war (535–554 CE), when Sicily was incorporated, alongside the rest of Italy, to the Byzantine empire by Emperor Justinian I (482–565 CE), of which it remained a part of until the long-lasting invasions from Muslim North Africa (827–965 CE). During the Byzantine period, Sicilian catacombs continued to be used for funerary purposes, although with occasional transformations of certain sectors into cult places to accommodate pilgrims at the tombs of saints and martyrs.

The Catacombs of Santa Lucia are among the most significant and ancient monuments linked to the Christian communities of Sicily in the Late Roman period and serve as an emblematic example of the prolonged use and vital role of such complexes during Late Antiquity. This extensive subterranean burial ground was established between the 3rd and 5th centuries CE, and was constructed on earlier structures utilized for funerary, religious and manufacturing purposes, which were then converted into monumental burial chambers (Agnello, 1954; Agnello, 1955). The presence of the tomb of Santa Lucia ensured the popularity of the complex, even after its use as a cemetery ended in the 6th century CE. In at least two regions (A and C), oratories were established, possibly by local monastic groups. Frescoes, lapidary inscriptions, and devotional graffiti attest to continued use until the late 13th century (Sgarlata and Salvo, 2006). The division of the cemetery into four areas, identified by the first letters of the alphabet (A-D) as suggested by Führer (Führer, 1897) following his initial explorations, does not correspond to the original topography of the catacomb but instead reflects the layout resulting from the construction of the church-mausoleum of Santa Lucia by Giovanni Vermexio in 1630. The new building destroyed a significant portion of the cemetery to isolate and incorporate the revered tomb of the martyr into the monument.

The first systematic investigations of the cemetery date to the early 20th century, when the archaeologist Paolo Orsi (1918, 1920) greatly expanded the knowledge on the topography of the northern area of the catacomb and specially of region A, where the first Byzantine oratory was identified (Oratory of the Forty Martyrs of Sebaste). The topography of the cemetery was later further compromised by a second traumatic event in the early 1940s, when the catacomb was used as an air raid shelter during World War II. In these circumstances, the Unione Nazionale Protezione Antiaerea (UNPA) – the Italian National Authority for Anti-Aircraft Protection – created new connecting tunnels to facilitate the flow of refugees from one sector to another, as well as large rooms for people to take shelter in. The only positive effect of UNPA intervention was the creation of new access points to hitherto unexplored areas, subsequently identified as regions B and C.

The archaeologist Santi Luigi Agnello was responsible for the subsequent systematic investigations of the cemetery in the 1950s. On behalf of the Vatican Pontifical Commission for Sacred Archaeology, the tunnels of region C were excavated, uncovering the central axis of the entire area formed by the double North-South galleries of A and B, accompanied by cubicula, which represents the largest district of the whole complex. Within the southern area of region C, several structures were discovered that date back to the Greek and Roman periods and were buried by a catastrophic cave-in that presumably occurred at the end of the Early Roman Empire. These structures include the "Pagan Shrine," a place of worship dedicated to Zeus Peloros and dated to the 2nd-1st century BCE, a columbarium with cinerary urns from the 1st-2nd century CE, and several rooms related to a large, Late Hellenistic pottery workshop. Additionally, another Pagan Shrine, similar to the first one but in a much worse state of preservation, was found in the south-eastern part of region C, in an area referred to as Sector F.

The religious purpose of the room was determined by Agnello (1955) based on the architectural similarities between the Shrine of Zeus Peloros, which had a trapezoidal plan and a pillar with evidence of a frontal niche, and on of the discovery of some terracotta figurines of sailors in two small votive pits (*thysiai*) dug into the floor level, interpreted as ex-votos. Unlike the Shrine of Zeus Peloros, which remained mostly intact in its perimeter and was exploited by the Christian cemetery by simply opening burial niches along the walls, this second room went through much more complex phases of use, significantly altering its original appearance (Gradante & Tanasi 2016).

In the same years (1952–1953), Agnello also explored the northern sector of region C, corresponding to Oratory C. Over the centuries this area was affected by transformations and demolitions related to the construction of the upper basilica and the church-mausoleum of Santa Lucia and was massively occupied by alluvial debris. The new rooms brought to light testify a series of architectural and monumental transformations that occurred when the cemetery fell into disuse in the late 6th century and it was turned it into a true place of martyrial worship. The walls of the hypogeum are completely adorned with frescoes that, in certain areas, are superimposed upon one another to form four layers (palimpsests) that date back to different periods from the Byzantine (around the 8th century CE) and Norman (around the 13th century CE) periods (Arcidiacono 2016). Pilgrims who visited the hypogeum left devotional graffiti on the walls that bear witness to the attraction of the venerated tomb of Santa Lucia until the 11th century CE.

In addition, another significant complex that Agnello uncovered along gallery B is Crypt VI (Agnello 1955), which consists of a group of cubicula arranged on different levels and accessed through a single grand entrance with a sequence of three framed arches. A lower level, connected to the rest of the complex via a staircase, was excavated in a later phase. Portions of frescoes from the last period of use are still visible on the walls. In one room, massive sarcophagi carved into the bedrock indicate the high status of the patrons of this complex. The excavation of the crypt in the early 1950 s yielded numerous architectural elements and plastering pieces in colored marble, providing evidence that this funerary space was designed for an elite group.

After a long hiatus in archaeological investigations, those three major areas of Region C, Sector F, Oratory C and Crypt VI were subject to new investigations by two authors of the current research, between 2013 and 2015, which provided the materials to conduct the isotopic study that will be illustrated in the following sections (Gradante & Tanasi 2016; Gradante et al. 2016; Gradante & Tanasi 2017; Tanasi et al. 2019) (Fig. 1).

The sampling strategy for SIA process adhered to established protocols and guidelines (Vaiglova 2023), with careful consideration given to selecting well-preserved bones, teeth, and available anthropological information most likely to yield valuable data for analysis. Upon initial evaluation in the laboratory, it was determined that collagen was absent in a substantial number of samples, rendering them unsuitable for isotopic analysis. The sample size for the present study was subsequently adjusted accordingly.

3. Contexts and materials

For the purposes of this novel isotopic study, the focus was primarily on three excavation contexts more recently explored in Region C.

3.1. Sector F

The investigated area of Sector F, consisting of a trapezoidal-shaped room, is divided into two sub-sectors: sector α, including the whole area on the southern side of the central pillar, and sector β, including the northern side of the room and the gallery connecting the room to the adjacent oratory. The room is currently delimited on West and South by retaining walls made of blocks and fragments of limestone; on the western wall a gap in the top part reveals the landslip stretching along

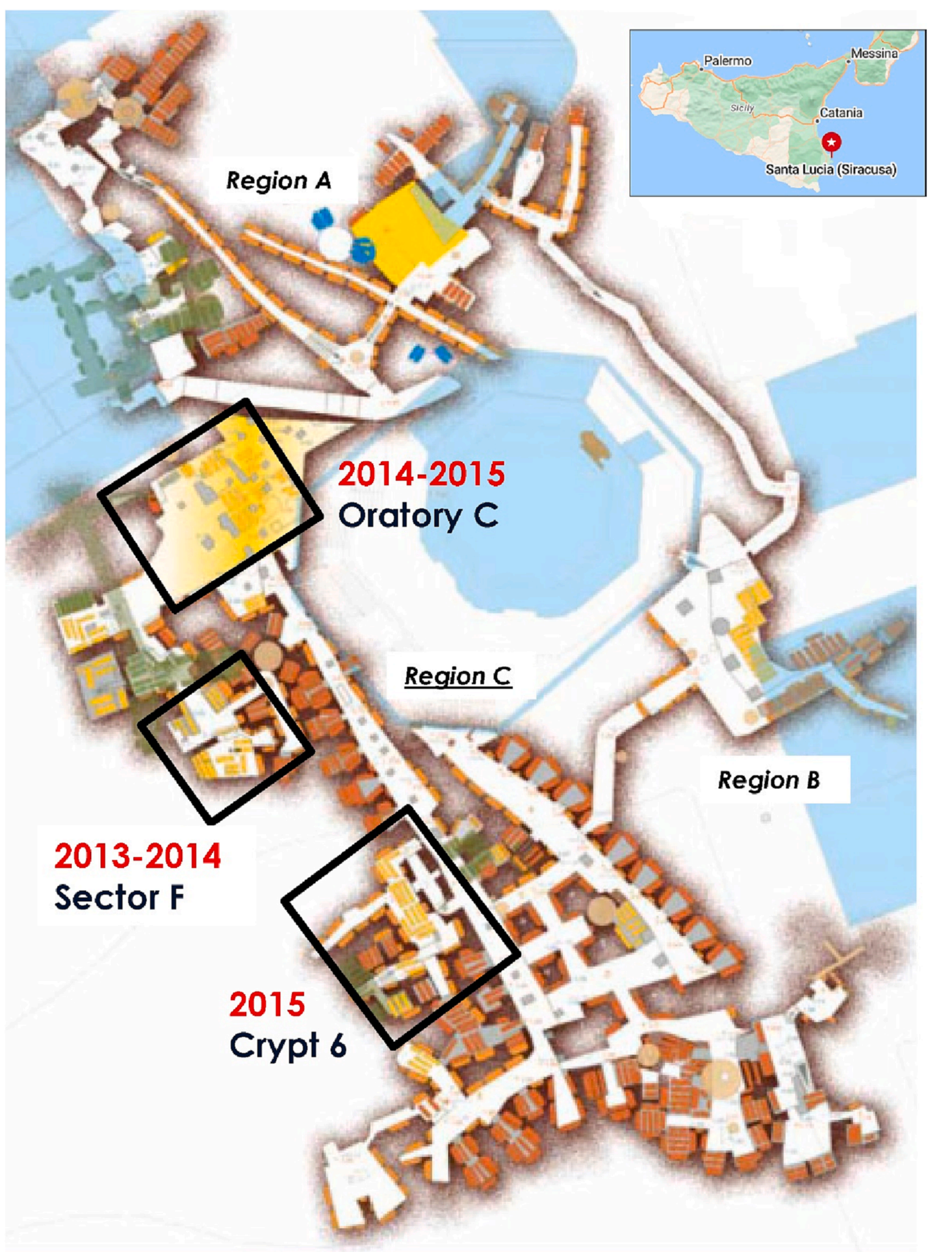


Fig. 1. Plan of the Catacombs of Santa Lucia with indications of the areas investigated in 2013–2016 in Region C (after Sgarlata & Salvo 2006).

the limit of the catacomb. The eastern wall of the room is flanked by a cubiculum and burial niches carved into the rock, broken by a passage that opens centrally towards the cistern and gallery F. On the North side, the room connects to the short gallery leading to Oratory C. The floor was intensively exploited for the cutting of *formae*, or graves carved into the bedrock; most of them do not retain their original coverings, which would have consisted of large ceramic tiles sealed with a thick layer of mortar. The graves are filled with soil mixed with debris, attributable to one or more phases in which the burials were violated. Among the 14 graves investigated in this sector, 3 have been chosen for sampling: 1008, 1065 and 1066 (Fig. 2).

Tomb 1008, located at the SW corner of the excavation area (sector α), yielded a primary burial, preserving commingled bones of a male adult individual with the cranium oriented towards the West. The bones were covered by a thick deposit of sterile soil, containing two poorly preserved bronze coins, a bronze nail, a fragment of an oil lamp, a terracotta disk and, in the lower part, large animal bones and ceramic kiln wasters (Gradante & Tanasi 2016, 45-46); no remains of the original covering have been found.

Tombs 1065 and 1066 are both *formae* carved into the bedrock, lying within the cubiculum located along the eastern wall of the pagan shrine and intensely exploited with burials both along the walls and on the floor. The former is centrally located on the cubiculum floor with E/W orientation; it was looted in antiquity disturbing a secondary burial of which scattered bones remained (individual A). A secondary burial of a young female adult was oriented with the cranium toward the West (individual B). On the opposite side, the grave, evidently too small, was enlarged by creating a small niche to allow the placing of the feet. The original covering of the grave was not preserved and was filled with a deposit of fragments of painted plaster, recalling the decoration of the complex of tombs, located at the SW corner of sector F (Gradante & Tanasi 2016, 53). Tom 1065 is located along the southern limit of the cubiculum, with E/W orientation, this tomb still retained one of the covering tiles, cemented with a thick layer of mortar along the edge. The grave was filled by a deposit of soil, building material and skeletal material, probably fallen from the niches above, and had been previously plundered. The layer also yielded a fragment of a bronze needle. Proceeding with the excavation, other disarticulated bones emerged on the western side of the grave, while on the opposite side a new layer of dark soil was identified, possibly related to the decay of a wooden artifact. The bones belong to at least three individuals, respectively named individual A, B and C. At the bottom of the tomb, the poorly preserved remains of a fourth individual (D), an infant placed with the cranium oriented to the East, were brought to light (Gradante & Tanasi 2016, 53-54).

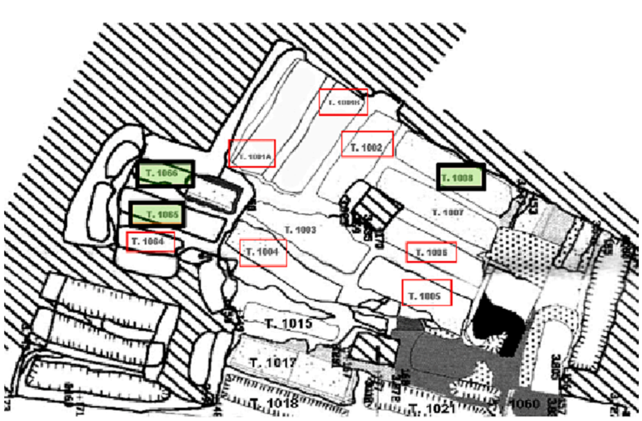


Fig. 2. Plan of the Sector F, area a with indication of the tombs sampled.

3.2. The Oratory C

The area identified as Oratory C, extending along the northern edge of the Region C, is currently accessed from East, through the staircase of the underpass built during the 17th Century to connect the southern side of the transept of the basilica with the Mausoleum of Santa Lucia. The northern limit of the area, adjacent to the foundations of the portico of the basilica, must have corresponded to the original entrance to the oratory in the Byzantine and Norman periods. On the north wall, in fact, a framed gate and some steps made of reused material (marble blocks and columns) can still be distinguished, as well as a series of architectural elements such as column drums, now incorporated into the modern retaining wall, made of limestone blocks. Its original eastern limits have been compromised by the underpass connecting the basilica to the Mausoleum and by the excavation carried out for the construction of the Mausoleum itself. The oratory connects to gallery B, while on the eastern side it preserves the original limits of the hypogeum. The space is divided into different connected rooms (distinguished by letters A-M) and delimited by architectural elements, built in masonry, or carved into the rock. The central area preserves pictorial palimpsest frescoes attributable to at least three decorative phases of the rooms, while the floor, progressively sloping downwards from East to West, was intensively exploited by graves with different orientations, all apparently plundered (Arcidiacono 2016). In Room A, located along the northern limit of the oratory, 5 graves identified on the floor level were investigated and chosen for sampling: 2041, 2044, 2045, 2046 and 2048, and one was excavated in Room F: 2169 (Fig. 3). **Tomb 2041**, located along the southern limit of the room with a E/W orientation, was filled by an 8 cm thick compact layer of soil that yielded numerous ceramic sherds, mixed bone fragments, and two bronze coins. One coin is dated to the time of the Byzantine Emperor Michael III (842–867 CE) and marks the *terminus ad quem* for the establishment of the ossuary. Removing this layer brought to light a consistent layer of disarticulated skeletal remains that continued to the bottom of the tomb. This ossuary, containing at least 48 individuals, is assumed to be the result of the violation of the burials lying on the floor of the adjacent oratory. Along the northern limit of the grave was dug a sort of recess, cutting the southern edge of the tombs 2044, 2045, 2046, located side by side in a central position in the room, probably to place the closing slabs of the ossuary. **Tomb 2044** is located close to the western limit of the room and yielded a primary

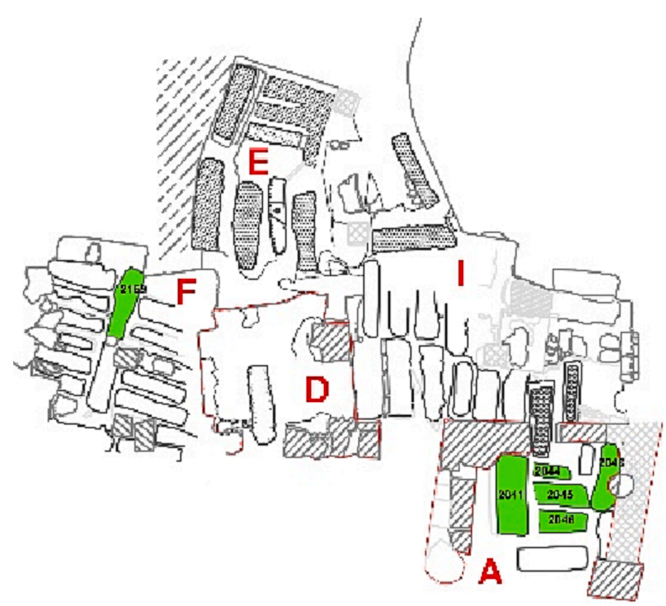


Fig. 3. Plan of the Oratory C, Room A and F, with indication of the tombs sampled.

burial of a juvenile (probably adolescent) individual devoid of a cranium, originally oriented to the North, and of foot bones, which were intercepted together with the southern limit of the grave by tomb 2041. **Tomb 2045** yielded two disturbed primary burials (A and B) and a bronze hairpin and sporadic ceramic fragments mixed with fragments of bones. **Tomb 2046** presented three overlapping burials, apparently separated from each other by a layer of lime (A, B, C,) and did not yield any artefacts. **Tomb 2048,** located along the northern limit of the room, was disturbed by the installation of a composite wall structure, made of modern limestone blocks and ancient architectural elements on its northern side, and presented remains of a primary burial of a middle or old aged male adult (A) and of sporadic skeletal materials of a second individual (B). In Room F, **tomb 2169** had a funerary cushion carved in the bedrock on the NW side, but was significantly disturbed in antiquity and yielded the skeleton of an individual (A) laying supine whose cranium was completely missing.

3.3. *Crypt 6*

With respect to the Crypt VI, just one tomb, 3020, was considered for the purpose of the isotopic study (Fig. 4). Tomb 3020 is located at the entrance to so-called corridor B1. The tomb was devoid of the original cover and yielded the disarticulated bones of a child of indeterminate sex, aged between 9 and 12 years (individual A) and the primary burial of an adult of indeterminate sex (individual B).

The chronological setting of the contexts was established via radiocarbon analyses carried out on the skeletal remains of one individual from the Sector F, area α (Tomb 1066 individual A), three individuals from the Oratory C (two from Room A: one from tomb 2046 individual C and one from the tomb/ossuary 2041 individual G; one from Room F: tomb 2169 individual A) and one from the Crypt VI (t. 3020 A) (Table 1). The analyses pointed to a substantial contemporaneity between the tombs in the rooms A and F of Oratory C and Crypt VI, suggesting a contemporaneity of the two contexts. The chronology of the latest individual (A) buried in Tomb 1066 in Sector F, Area α, is surprisingly low, a fact that urges new studies related to the use of this district of the Catacombs. Equally surprising is the later date obtained from the tomb/ossuary 2041. The initial assumption was in fact that the ossuary was established in the 9th century CE, demonstrated by the numismatic evidence, gathering skeletal remains from tombs dated to the 5th century CE being cleared out.

Therefore, taking into consideration these new chronological data, it is possible to identify: a first cemeterial phase for the individuals buried in Oratory C, Room A and F and Crypt VI (Group 1: First half of the 5th – half of the 6th century CE); a second one for those entombed in Sector F, Area α (Group 2: Middle of the 6th – beginning of the 7th century CE;) and a third for those who were translocated to the ossuary 2041 and whose primary burial location is unknown (Group 3: Middle of the 7th – beginning of the 8th century CE).

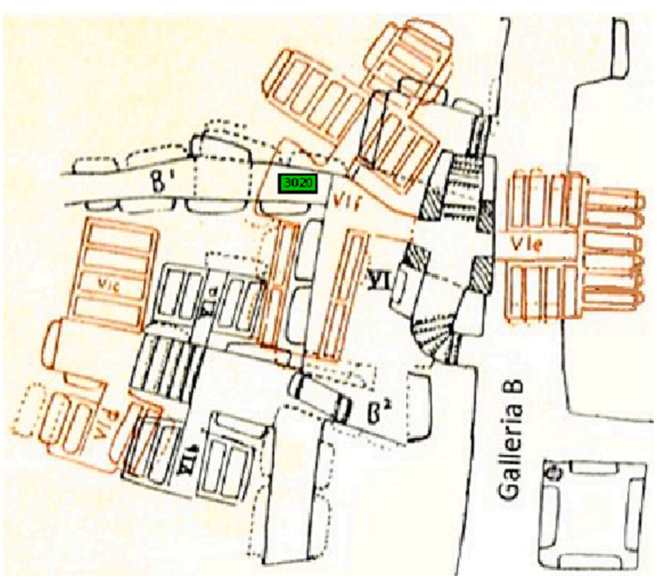


Fig. 4. Plan of the Crypt VI, with indication of the tomb sampled.

3.4. *Materials*

The poor state of preservation of the skeletons found in the investigated graves within the catacombs greatly influenced the sampling process and constrained the options available to the authors (Figs. 5-7). The adverse environmental conditions within the catacombs also limited the quality of the samples obtained and have therefore imposed certain compromises on the research team. As a result, the researchers were unable to confidently determine the sex or age at death for most of the individuals examined. The compromised state of the skeletal remains thus presented a significant obstacle to the bio-archaeological analysis of these individuals, limiting the scope and accuracy of the study.

Overall, 25 individuals were sampled according to the table that follows; the table emphasizes the different chronology of the three groups of samples (Table 2).

4. Methods

Isotopic analyses were conducted on collagen, apatite, tooth enamel, and tooth roots from 25 individuals from Santa Lucia, as shown in Tables 3-5, with the aim of obtaining dietary (C, N) and mobility (O) data. Due to preservation issues, limited anthropological information such as age and sex, and contextual information such as primary or secondary burials were available during the sampling process. This was due to the fact that the archaeological context was highly disturbed in antiquity. In some cases, duplicate samples were collected due to difficulties in separating individuals. Although radiocarbon dating was performed on several individuals, the results indicated significant differences in chronology, particularly among those entombed in Sector F, Area α, making this a particularly heterogeneous sample.

Preparation was done in the Laboratory for Archaeological Science at the University of South Florida (USF), following well established procedures (Tykot 2004, 2020) and then submitted to the Center for Applied Isotope Studies for AMS radiocarbon dating of the University of Georgia (UGA). The collagen samples underwent combustion at a temperature of 575 °C in sealed ampoules that were evacuated to create a vacuum. The combustion process involved the presence of CuO. The carbon dioxide produced during combustion was separated from other by-products using a cryogenic purification method and then catalytically converted to graphite using the technique described by Vogel et al. (1984). The ratio of ^{14}C to ^{13}C in the resulting graphite was determined using the CAIS 0.5 MeV accelerator mass spectrometer. This ratio was then compared to the ratio obtained from Oxalic Acid I (NBS SRM 4990). The $^{13}C/^{12}C$ ratios of the sample were separately measured using a stable isotope ratio mass spectrometer and expressed as $\delta^{13}C$ in reference to VPDB (IAEA-603 $\delta^{13}C = 2.46‰$), with an error margin of less than 0.1‰. The calibration was then performed using Calib Rev 7.1.0. There were insufficient yields of collagen for analysis of some of the samples, likely due to the environmental conditions of the archaeological context mentioned above. Acceptable C:N ratios and other analytical parameters have been checked to ensure that inappropriate values were discarded. The collagen from Tomb 1008 was poorly preserved, while teeth recovered from Tomb 2041 required a second analysis. Values for $\delta^{18}O$ show high variability and have not been obtained for all of the teeth.

Due to the issue with the preservation of the samples mentioned above, it was important to use different instruments to analyze the isotopic composition of various elements with high precision and

Table 1
Radiocarbon dates for the five individuals selected from the three studied contexts.

USF #	UGA #	Context	Sample	Date	2σ cal	2σ rounded
USF 38,181	UGA 51,096	Oratory C, Room A t. 2046, individual C	Bone collagen	1560 ± 20	433–567 CE	430–570 CE
USF 38,176	UGA 51,097	Oratory C, Room A t. 2041, individual G	Bone collagen	1310 ± 20	659–773 CE	650–780 CE
USF 38,185	UGA 51,098	Oratory C, Room F t. 2169, individual A	Bone collagen	1590 ± 20	425–541 CE	420–550 CE
USF 38,186	UGA 51,099	Crypt VI t. 3020, individual A		1560 ± 20	433–567 CE	430–570 CE
USF 38,177	UGA 51,336	Sector F, Area α t. 1066, individual A		1490 ± 20	549–638 CE	540–640 CE

Fig. 5. Sector F, Area α, Tomb. 1065.

sensitivity: the analyses were specifically performed using a Delta + XL continuous flow isotope ratio mass spectrometer for determining the carbon and nitrogen isotopic ratios in collagen samples, which was connected to a Carlo-Erba NA2500™ elemental analyzer for collagen samples. In addition, a ThermoFisher MAT253™ isotope ratio mass spectrometer was coupled to a GasBench-II with a continuous-flow interface to facilitate the conversion of solid samples into gaseous form for the apatite and enamel samples. The apatite and enamel samples were reacted with 600 µl of 104% H_3PO_4 at 25° C for 24 h.

Fig. 6. Sector F, Area α, Tomb. 1008.

5. Results

This is pilot study that highlights some of the challenges inherent to the assemblage under investigation. It was difficult to reliably determine the sex and age of most individuals, and it is likely that not all individuals in each of the tombs were analyzed. Moreover, the small set of bones overlaps with only a few of the sampled teeth, and the teeth are mostly different and represent different stages in the life of individuals. This is because human teeth form at different ages during youth, whereas bones typically provide information about the last 5–10 years of life. As a result, the data pertain to different moments in the life of several inhumated individuals whose only link between one another may have been their burial in the same Christian cemetery.

The oxygen isotopes ($\delta^{18}O$) exhibited a particularly broad range, both in the sample set of bones and the larger set of teeth (Figs. 8-9). This

Fig. 7. Oratory C, Room A, Tomb 2041 (ossuary).

suggests mobility in most individuals not only between their youth and adulthood, but also throughout their life, with high variability in their diet too (Fig. 10). The more relatively positive $\delta^{13}C_{ap}$ than $\delta^{13}C_{co}$ in Table 3 for a few individuals support there being a C_4 plant (probably millet) in their diet. The low $\delta^{15}N$ for individuals from T.2048A and T3020 also confirm this.

Both the distributions and the grouped graph for $\delta^{18}O$ (Figs. 8-9) show that the variability in accessing water (oxygen results are mostly affected by consumption of water of different geological origins) is so high that there is not even a distinguishable major group. The data obtained from the teeth suggest that the society during this period was highly diverse, with individuals born in various regions. These findings align with our current understanding of the Late Roman and early Byzantine Empire.

A plot of the data from the tooth roots, divided by group (Fig. 10), shows greater diversity, perhaps representing the cultural diversity of the Mediterranean societies of the time. The only distinguishing element, uncertain given the limited number of samples, is that the first group, representing the earliest period, shows some possible higher consumption of fish. However, breastfeeding may also contribute to these values.

An extended comparison with the site of St. Callixtus reported by Rutgers et al. (2009) shows that the values at Santa Lucia are within the expected range. It is a range that certainly encompassed different diets, with access to fish possibly the most distinguishing feature. It has no excesses, for instance in Archaic Siracusa (Tanasi et al., 2017a,b) some of the lower nitrogen values are strongly suggestive of a largely vegetarian diet, while here at most there is a preference by some for C4 plants (probably millet) (Fig. 11).

The paucity of studies related to catacombs and religious communities in the early Middle Ages of Italy and the relative uncertainty in the dates of the samples analyzed has prevented more specific comparisons. For bones, it is possible to compare the results with a few other sites (Fig. 12). For group 1, with only three bones available, it is only possible to see that they fit relatively well in the median of other assemblages, and therefore are not outliers (Figs. 13-14). For group 2, several sites were selected, and 8 outliers from the other sites that did not fall within the range of the materials from Santa Lucia have been removed (Fig. 15). We notice three main groups, all based mostly on $\delta^{13}C$. The first group includes Castro dei Volsci, La Selvicciola and S. Basilio with highly negative values. Bressanone, Fara Olivana, Sirmione and Spilamberto also seem to match this group from Santa Lucia. A third group represents a later moment perhaps, and certainly involves a migratory flow of Longobards from Central Europe, and includes Dueville, Sovizzo and Romans D'Isonzo, with markedly more positive values (likely due to millet). It is not possible to draw conclusions given the small sample set, but we can see that as the Roman Empire collapsed, dietary patterns in Italy changed more significantly in later times and this shift is detectable also in our samples.

Our data is compared lastly with faunal data (Fig. 16), where "Homo" are the samples from Santa Lucia. They fall confidently in the upper range of the Omnivores, and it is possibly to see that none of them ate marine seafood on a regular basis. Among the animals that match most closely are dogs (canid), chickens (phasianid) and pigs (suid). It is likely that all these animals ate some extension of the human diet, and indeed their range appears to include more meat and fish than our samples in a few cases (Fig. 17).

6. Discussion

Stable isotope analysis offers a unique dataset for archaeology, providing insights into living standards of ancient individuals at different stages. By sampling various tissues and analyzing multiple isotopes, a detailed portrait of their lives can emerge. However, the key challenge lies in the fact that such detailed information may not always serve as a reliable basis for broader inferences, considering the vast temporal and geographical scales inherent in archaeology. To mitigate this issue, adequate sample sizes and diverse isotope studies across different time periods and regions are crucial. Gathering more data would enable more robust interpretations of societal trends. Fortunately, an interdisciplinary approach can provide contextualization for the isotopic data. Osteological information encompassing sex, age, health, activity markers, and potentially ancestry determination complement isotope data and contribute to a comprehensive understanding of the circumstances of an individual's life and death. This can be further enhanced by incorporating archaeological information, such as the nature of the burial, context of the cemetery, and historical sources. Late antique and early medieval archaeology, operating within smaller timeframes and rich in contextual information, offers an excellent opportunity to leverage stable isotope analysis fully. By incorporating isotope data with historical and archaeological context, it is possible to construct interpretations about past societies from a solid foundation (Hakenbeck, 2013).

Stable isotope analyses of C, N and O were conducted on several individuals buried in the Santa Lucia catacombs of Siracusa, Italy. Due to the complex nature of the context, the sampling strategy could not target a specific type of tomb or individual. Most tombs in the catacombs were reused, and it was not possible to distinguish between primary and secondary burials. As a result, a homogeneous sample group could not be obtained in this initial stage of research. A total of 23 enamel samples, 21 root collagen samples and 8 bone samples have been analyzed for stable isotopes, representing 25 individuals. The aim of the present

Table 2
Table indicating the individuals chosen for the isotopic study and the three chronological group that they belong to.

Context	Tomb	Chronology	Individual	
Oratory C, Room A	t. 2044		Juvenile, indeterminate	
Oratory C, Room A	t. 2045 individual A		Indeterminate	
Oratory C, Room A	t. 2046 individual A		Indeterminate	**Group 1** **First half of the 5th – half of the 6th century CE**
Oratory C, Room A	t. 2046 individual B		Indeterminate	
Oratory C, Room A	t. 2046 individual C (USF 38181, UGA 51096)	cal 433—469 CE (2σ)	Indeterminate	
Oratory C, Room A	t. 2048 individual A		Middle or old aged adult, probable male	
Oratory C, Room A	t. 2048 individual B		Indeterminate	
Oratory C, Room F	t.2169 individual B		Indeterminate	
Oratory C, Room F	t. 2169 individual A (USF 38185, UGA, 51098)	cal 425—541 CE (2σ)	Indeterminate	
Crypt VI	t. 3020 individual A USF 38186, UGA 51099)	cal 433—469 CE (2σ)	Juvenile, indeterminate	
Sector F, Area α	t. 1008		Male, indeterminate	
Sector F, Area α	t. 1065 individual A		Indeterminate	**Group 2** **Half of the 6th – beginning of the 7th century CE**
Sector F, Area α	t. 1065 individual B		Female, young adult	
Sector F, Area α	t. 1066 individual A USF 38177, UGA 51336)	cal 549—608 CE (2σ)	Indeterminate	
Sector F, Area α	t. 1066 individual B		Female, young adult	
Sector F, Area α	t. 1066 individual D		Non-adult (5–7 years old), indeterminate	
Oratory C, Room A	t. 2041 individual A		Indeterminate	
Oratory C, Room A	t. 2041 individual B		Indeterminate	**Group 3** **Half of the 7th – beginning of the 8th century CE**
Oratory C, Room A	t. 2041 individual C		Indeterminate	
Oratory C, Room A	t. 2041 individual D		Indeterminate	
Oratory C, Room A	t. 2041 individual E		Indeterminate	
Oratory C, Room A	t. 2041 individual F		Indeterminate	
Oratory C, Room A	t. 2041 individual G (USF 38176, UGA 51097)	cal 659—706 CE (2σ)	Indeterminate	
Oratory C, Room A	t. 2041 individual H		Indeterminate	
Oratory C, Room A	t. 2041 individual I		Indeterminate	

Table 3
Chronology of Permanent Teeth (after Nelson 2015).

Tooth		Crown (Enamel) Completed (Years)	Root Completed (Years)
I1	8, 9	4–5	10
I2	7, 10	4–5	11
C	6, 11	6–7	13–15
P1	5, 12	5–6	12–13
P2	4, 13	6–7	12–14
M1	3, 14	2½–3	9–10
M2	2, 15	7–8	14–16
M3	1, 16	12–16	18–25
Maxillary Teeth			
Right1 2 3 4 5 6 7 8 | 9 10 11 12 13 14 15 16**Left**			
32 31 30 29 28 27 26 25 | 24 23 22 21 20 19 18 17			
Mandibular Teeth			
I1	24, 25	4–5	9
I2	23, 26	4–5	10
C	22, 27	6–7	12–14
P1	21, 28	5–6	12–13
P2	20, 29	6–7	13–14
M1	19, 30	2½–3	9–10
M2	18, 31	7–8	14–15
M3	17, 32	12–16	18–25

I1, Central incisor; *I2,* lateral incisor; *C,* canine; *P1,* first premolar; *P2,* second premolar; *M1,* first molar; *M2,* second molar; *M3,* third molar.

study was to produce pilot data to assess the homogeneity of the assemblage and its preservation, while future studies will need to carefully consider the contextual and radiometric evidence to reconstruct the contexts of individual tombs and areas of use.

The initial results suggest that individuals in the community had a high level of mobility, evident during their youth and persisting throughout life, as indicated by the oxygen isotopic data. This mobility was observed in all three main burial phases for Groups 1, 2, and 3, and is unlikely to be explainable within a non-migratory context. Among the cultural traits that define individuals, diet is likely to maintain distinct peculiarities in cases of mobility, unless diet is forced due to religious or social constraints (ritual diet, famine, forced diet for slaves, etc.). Comparing bones with teeth shows that diet hardly changed during the life of the individuals analyzed. Typically, the study of teeth can indicate small changes of diet within the lifetime of a person and can help confirm a few suspected mobile individuals. However, in this case, the scatter matrix based on the three periods recognized shows high variability, which matches the results from oxygen isotopes.

The second important result of our work was to identify three phases

Table 4
Carbon, nitrogen, and oxygen stable isotope results with elemental ratios (C:N) for bone samples. Both collagen and apatite results are given when available.

Individual	USF #	Sample #	Type	$\delta^{13}C_{co}$	$\delta^{15}N_{co}$	C:N	USF #	Sample #	Type	$\delta^{13}C_{ap}$	$\delta^{13}C_{co\text{-}ap}$	$\delta^{18}O_{ap}$
T. 1008	34,997	4	Bone collagen	−19.0	10.8	3.3	35,005	4	Bone apatite	−13.9	5.1	−2.5
T. 1065B	34,998	15	Bone collagen	−19.6	9.7	3.3	35,006	15	Bone apatite	−14.5	5.1	−3.8
T. 1066B	34,999	16	Bone collagen	−18.8	8.6	3.3	35,007	16	Bone apatite	−13.9	4.9	−2.7
T. 2044	35,000	18	Bone collagen	−18.2	10.8	3.3	35,008	18	Bone apatite	−12.8	5.4	−0.8
T. 2046A	35,001	20	Bone collagen	−18.7	8.9	3.4	35,009	20	Bone apatite	−13.4	5.3	−2.1
T. 2048A	35,002	21	Bone collagen	−19.0	8.9	3.4	35,010	21	Bone apatite	−9.8	9.0	−1.7
T. 2048A								21	Bone apatite	−10.3		−2.3
T. 3020	35,003	25	Bone collagen	−19.2	8.3	3.4	35,011	25	Bone apatite	−11.6	7.6	−0.8
T. 3020	35,004	26	Bone collagen	−18.8	10.9	3.4	35,012	26	Bone apatite	−11.6	7.2	−2.1

Table 5
Carbon, nitrogen, and oxygen stable isotope results with elemental ratios (C:N) for teeth samples. Both tooth root and enamel results are given when available and type of tooth is specified when recognized.

Context	USF #	Sample #	Type	$\delta^{13}C_{co}$	$\delta^{15}N_{co}$	C:N	USF #	Sample #	Type	$\delta^{13}C_{en}$	$\delta^{13}C_{co\text{-}ap}$	$\delta^{18}O_{en}$	Tooth
T. 1008	37,711	32	Root collagen				37,690	32	Tooth enamel	−12.4		−4.9	M1
T. 1008	38,175	33	Root collagen				38,187	33	Tooth enamel	−12.4		−3.0	M1
T. 1065A	37,712	34	Root collagen	−18.8	8.0	3.2	37,691	34	Tooth enamel	−13.1	5.7	−2.7	M3
T. 1065B	37,713	35	Root collagen	−19.4	9.4	3.4	37,692	35	Tooth enamel	−11.8	7.7	−3.3	PM
T. 1065B	38,176	36	Root collagen	−18.0	13.9	3.2	38,188	36	Tooth enamel	−12.0	6.0	−2.5	M3
T. 1066D	37,714	37	Root collagen	−18.7	7.9	3.4	37,693	37	Tooth enamel	−12.3	6.3	−3.1	M1
T. 1066B	37,715	38	Root collagen	−16.4	13.2	3.2	37,694	38	Tooth enamel	−11.1	5.3	−3.5	M1
T. 1066°	38,177	39	Root collagen	−18.5	9.8	3.3	38,189	39	Tooth enamel	−12.3	6.2	−2.3	M1
T. 2041°	37,716	40	Root collagen	−19.3	8.6	3.2	37,695	40	Tooth enamel	−12.8	6.4	−1.5	M1
T. 2041B	37,717	41	Root collagen	−18.7	10.7	3.2	37,696	41	Tooth enamel	−12.5	6.2	−3.2	M1
T. 2041C	37,718	42	Root collagen	−19.0	10.1	3.1	37,697	42	Tooth enamel	−12.4	6.6	−5.4	M1
T. 2041D	37,719	43	Root collagen	−18.4	11.1	3.5	37,698	43	Tooth enamel	−11.9	6.5	−2.4	M1
T. 2041D							37,699	44	Tooth enamel	−12.7		−2.5	M2
T. 2041E	37,720	45	Root collagen	−17.9	11.3	3.0	37,700	45	Tooth enamel	−12.7	5.2	−1.8	M1
T. 2041E	38,178	46	Root collagen	−17.9	10.8	3.3	38,190	46	Tooth enamel	−11.9	6.0		M2
T. 2041F							37,701	47	Tooth enamel	−10.6		−4.5	M1
T. 2041G							37,702	48	Tooth enamel	−12.6		−1.6	M1
T. 2041G	38,179	49	Root collagen	−18.2	9.9	3.3	38,191	49	Tooth enamel	−11.7	6.5	−1.7	M2
T. 2041H	37,721	50	Root collagen	−18.9	9.4	3.1	37,703	50	Tooth enamel	−12.7	6.1	−2.6	M1
T. 2041H	38,180	51	Root collagen	−18.9	9.9	3.3	38,192	51	Tooth enamel				M2
T. 2041I	37,722	52	Root collagen				37,704	52	Tooth enamel	−6.2		−5.0	M1
T. 2041I										−6.3		−4.5	M1
T. 2045A	37,723	54	Root collagen	−18.7	10.0	3.1	37,705	54	Tooth enamel	−12.1	6.6	−2.7	M1
T. 2046A	37,724	55	Root collagen	−18.6	8.6	3.1	37,706	55	Tooth enamel	−12.8	5.8	−2.5	M1
T. 2046B	38,181	56	Root collagen	−18.7	9.5	3.3	38,193	56	Tooth enamel	−11.3	7.4	−3.2	M2
T. 2046C	38,182	57	Root collagen	−18.6	9.8	3.3	38,194	57	Tooth enamel	−11.9	6.7	−3.1	PM
T. 2048A	37,725	58	Root collagen	−19.1	8.8	3.4	37,707	58	Tooth enamel	−11.6	7.5	−3.9	M1
T. 2048A	38,183	59	Root collagen	−18.1	12.2	3.3	38,195	59	Tooth enamel	−11.9	6.1	−1.3	M1
T. 2048B	38,184	60	Root collagen	−19.5	12.7	3.3	38,196	60	Tooth enamel	−11.6	7.8	−3.8	M2
T.2169B	37,726	61	Root collagen	−18.3	10.1	3.1	37,708	61	Tooth enamel	−12.2	6.1	−1.6	M2
T. 2169A	37,727	63	Root collagen	−18.7	8.9	3.1	37,709	63	Tooth enamel	−12.4	6.3	−2.3	M2
T. 2169A	38,185	64	Root collagen	−18.9	9.6	3.3	38,197	64	Tooth enamel	−11.6	7.3	−2.2	M3
T. 3020	37,728	65	Root collagen	−19.3	11.8	3.1	37,710	65	Tooth enamel	−13.3	6.1	−2.0	M1
T. 3020	38,186	66	Root collagen	−19.9	12.1	3.3	38,198	66	Tooth enamel	−12.2	7.7	−2.5	M2

of use in the investigated areas of the cemetery, although the few samples provide only tantalizing data about two different periods.

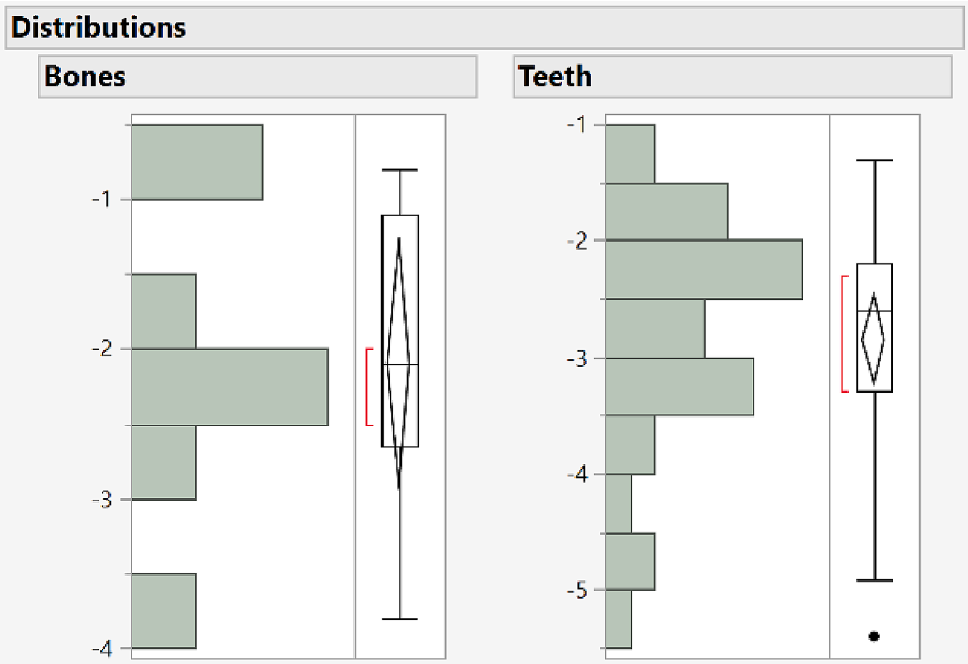
Evidence from the first phase (Group 1) revealed a consistent pattern with other Italian sites, and probably the Mediterranean, indicating that the political system was under severe stress and may have collapsed, but the economic system must have remained resilient enough to preserve food production and distribution across the former Empire. Therefore, the similarity between the catacombs of St. Callixtus and the first period of Santa Lucia should be interpreted in this light, rather than due to a specific context.

Things changed with the second phase (Group 2–3), and particularly from the 7th century CE: across Italy different diets emerged, and some communities demonstrated little cohesion due to intense migration. Santa Lucia could be compared to one of three groups that we recognize, but we have too few bone samples to suggest anything other than a possible distinctiveness that should be explored in future research. Furthermore, data from across Italy is thus far too limited to recognize broad patterns.

The role of fish in the diet was a distinguishing feature of the Christian community of the time, which was typically suggested as a staple on Fridays (see Reitsema and Vercellotti 2012 for a discussion about separating fish from millet; Ciaffi et al. 2015 discuss issues with fish in the Mediterranean with low trophic levels; Salamon et al. 2008 discusses the Church requirements for fish in the diet).

Our results suggest that fish consumption was likely low among the Christian community of the time, which contrasts with the suggested role that fish had as a staple on Fridays. It is challenging to distinguish freshwater fish, some marine fish and millet in the Mediterranean diet, but we have at least three individuals that might have consumed some fish: individual A from tomb 1065 and the individual from tomb 2048 are possible consumers of freshwater fish, while individual B in tomb 1066 might have consumed even some marine fish (positive values in both collagen and apatite). Fish may have been consumed also by individual I from tomb 2041, for which no collagen could be extracted and who is interpreted as a possible consumer of millet.

It is possible that fish consumption at Santa Lucia was mainly



Quantiles — Bones

100.0%	maximum	-0.8
99.5%		-0.8
97.5%		-0.8
90.0%		-0.8
75.0%	quartile	-1.1
50.0%	median	-2.1
25.0%	quartile	-2.65
10.0%		-3.8
2.5%		-3.8
0.5%		-3.8
0.0%	minimum	-3.8

Quantiles — Teeth

100.0%	maximum	-1.3
99.5%		-1.3
97.5%		-1.3
90.0%		-1.6
75.0%	quartile	-2.2
50.0%	median	-2.6
25.0%	quartile	-3.3
10.0%		-4.66
2.5%		-5.4
0.5%		-5.4
0.0%	minimum	-5.4

Summary Statistics — Bones

Mean	-2.1
Std Dev	0.9856108
Std Err Mean	0.348466
Upper 95% Mean	-1.276009
Lower 95% Mean	-2.923991
N	8

Summary Statistics — Teeth

Mean	-2.848387
Std Dev	1.0359765
Std Err Mean	0.1860669
Upper 95% Mean	-2.468388
Lower 95% Mean	-3.228386
N	31

Fig. 8. Distribution of $\delta^{18}O$ values for bones and teeth sampled at Santa Lucia, with summary statistics, showing a strong variability at all stages of life.

ritualistic, consumed in small quantities or shared as a staple for a few bites, rather than a regular meal in the weekly diet. The comparison of faunal remains clearly indicates that fish consumption was distinct from other animals and was consumed by all sampled individuals at Santa Lucia, both in their youth and later stages of life. The values found at Santa Lucia suggest that fish consumption was possible, and that geography was not a constraint. However, freshwater fish was preferred and always consumed with other food, indicating that it was consumed in modest quantities.

There was greater consumption of marine fish in the Imperial period and some individuals had a diet that regularly included marine fish. Despite the emphasis placed on fish consumption by Christianity and the availability of seafaring technologies, the consumption of marine fish appears to have decreased significantly in peninsular Italy and possibly Sicily after the fall of the Roman Empire (Ciaffi et al. 2015; Salamon et al. 2008). This decrease was likely due to a lack of availability. Small increases in consumption may have been culturally significant but are not distinguishable from the perspectives of isotopes in a context of very low or negligible consumption. Increased fishing produced a slow upward trend that is significant in later periods but is not necessarily true in the Mediterranean, where some fish was always available.

Additional data of great significance come from a pioneering aDNA study, in which one of the authors was involved, aimed at defining the bacteraemia of *Bartonella Quintana* in antiquity, where 36 individuals from the three chronological groups from the catacombs of Santa Lucia were tested (B-H-A Mai et alii 2020). The study found that two individuals, A from t. 2046 (Oratory C, Room A, Group 1) and E from t. 2041 (Oratory C, Room A, Group 1), both of indeterminate sex, tested

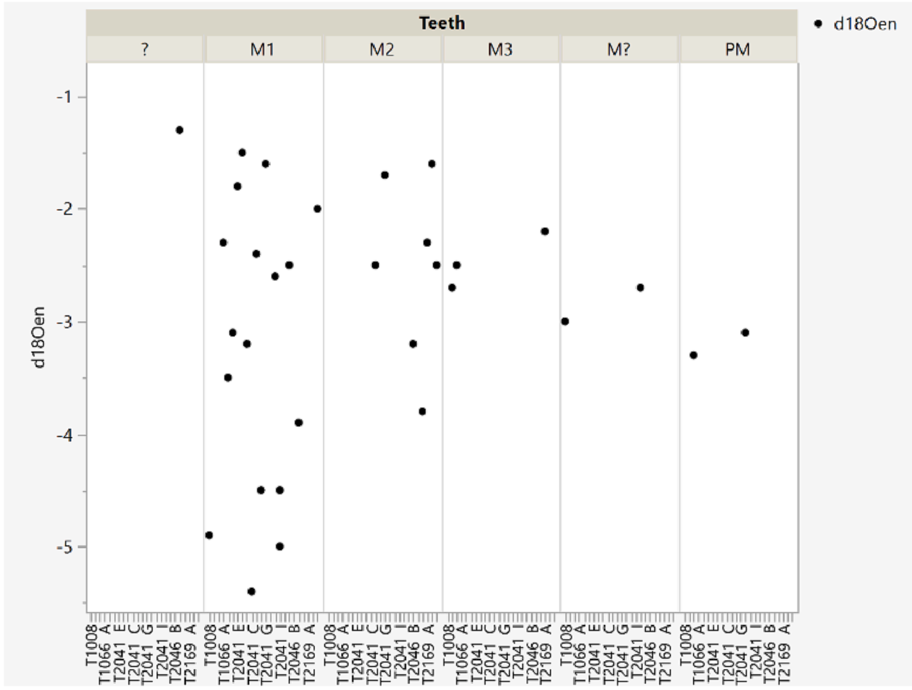


Fig. 9. Oxygen isotope results by type of tooth.

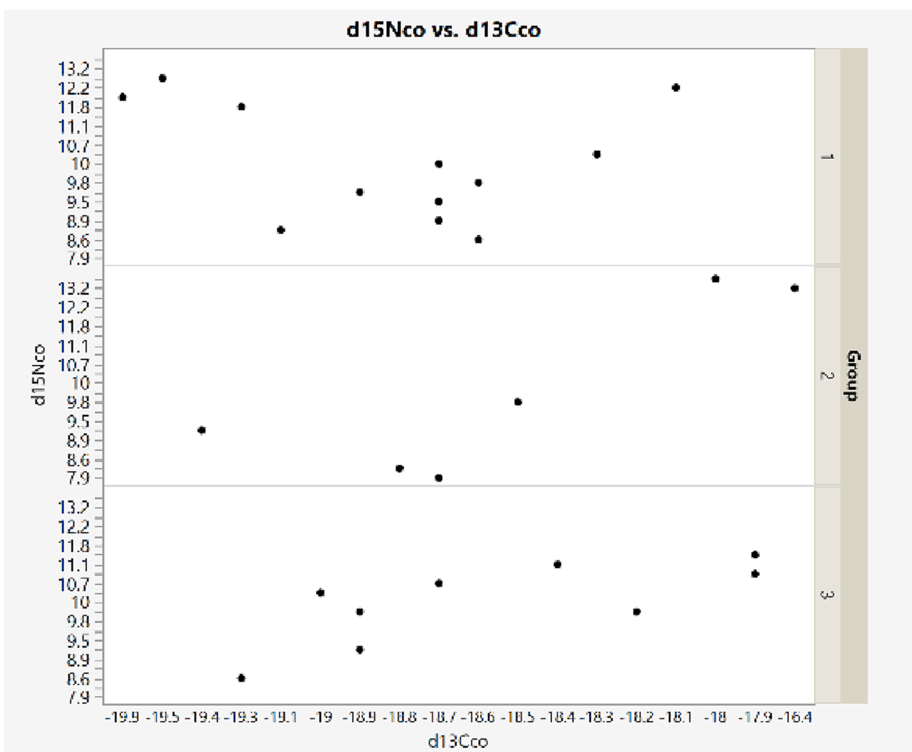


Fig. 10. Scatterplot of results from tooth roots by group. Group 1. tombs 2045, 2046, 2048, 2169 and 3020; group 2. tombs 1008, 1065, 1066; group 3. tombs 2041.

positive for the bacterium. However, these results found in just two individuals is too limited to add more context to the findings of the current research or to infer that there was a direct connection between diet and poor health standards and living conditions related to body lice infestation and outbreak of *Bartonella Quintana* epidemics.

7. Conclusions

The present study offers insight into the complexities associated with investigating the burial practices of individuals interred in Roman catacombs. One key finding from this heterogeneous sample is the high level of mobility demonstrated by these individuals, both during their youth and later stages of life. A core tenet of Christianity has been the

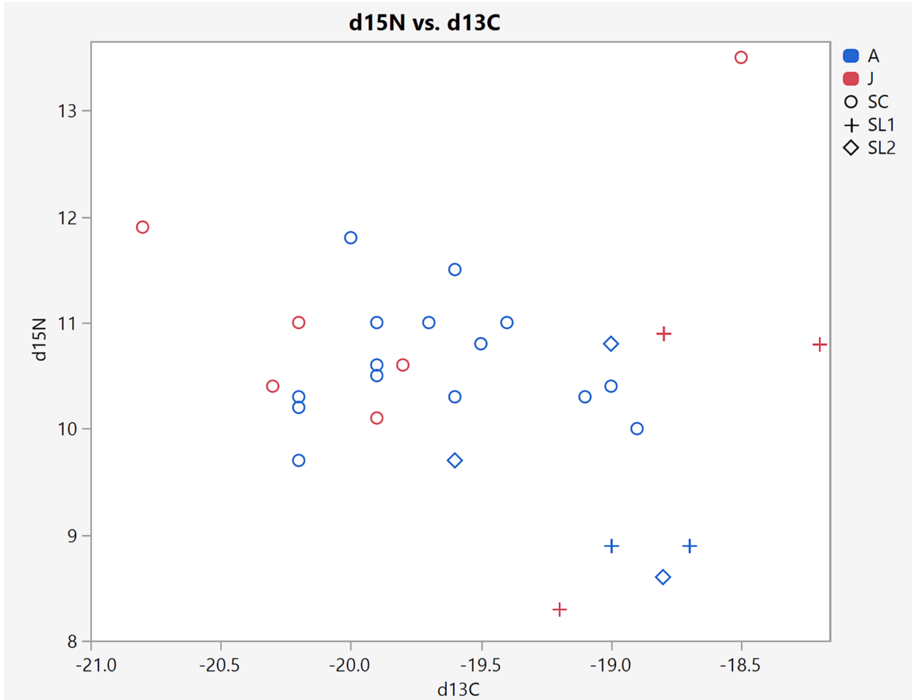


Fig. 11. Comparison of isotopes for diet between Santa Lucia (groups 1 and 2, 5th to 7th century CE) and St. Callixtus (3rd to 5th centuries CE) bones. Legend. A = adult (red), J = infant/juvenile (blue), SC = St. Callixtus (circle), SL = Santa Lucia (+and).

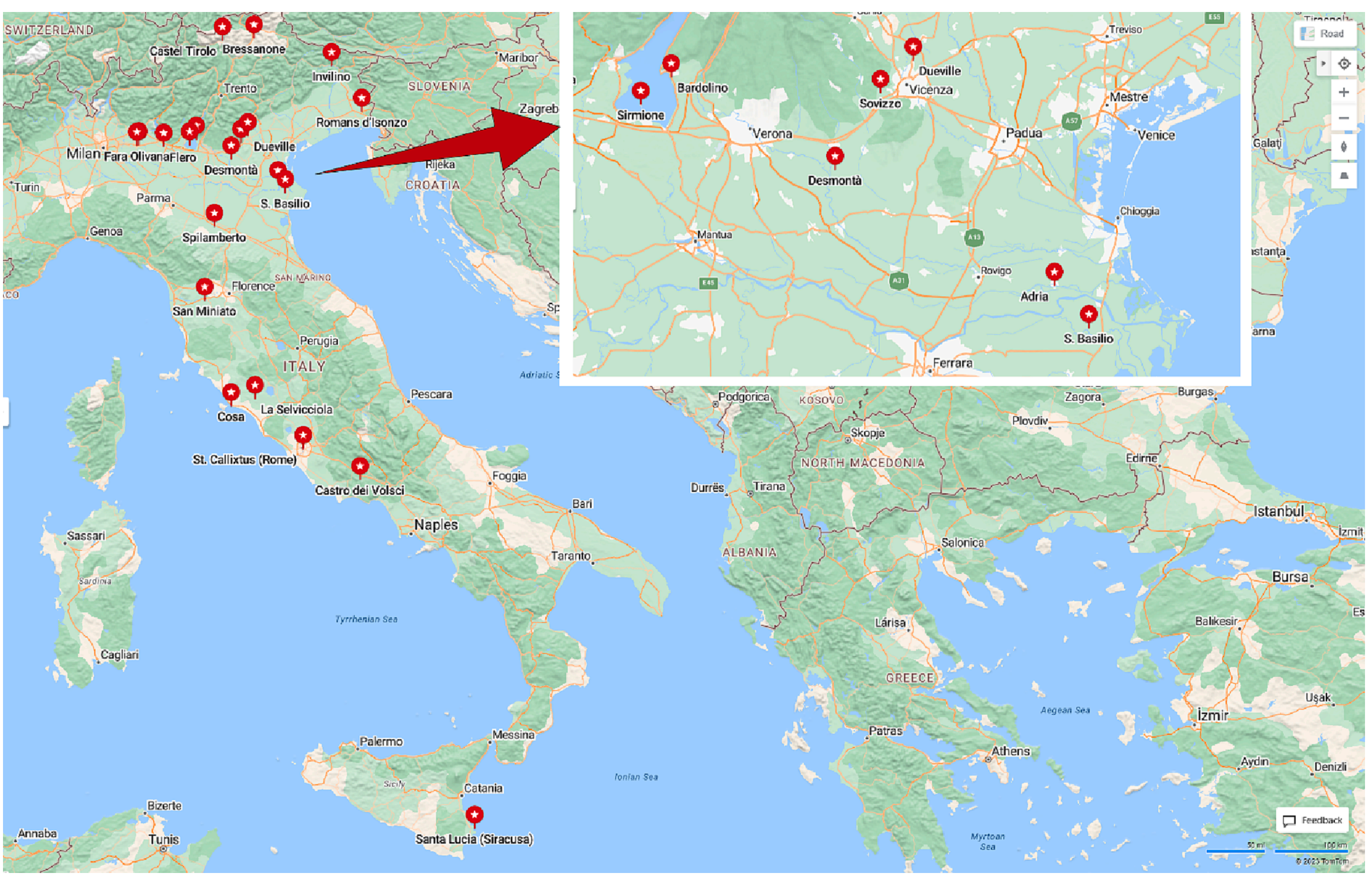


Fig. 12. Late Roman contexts offering comparative isotopic data.

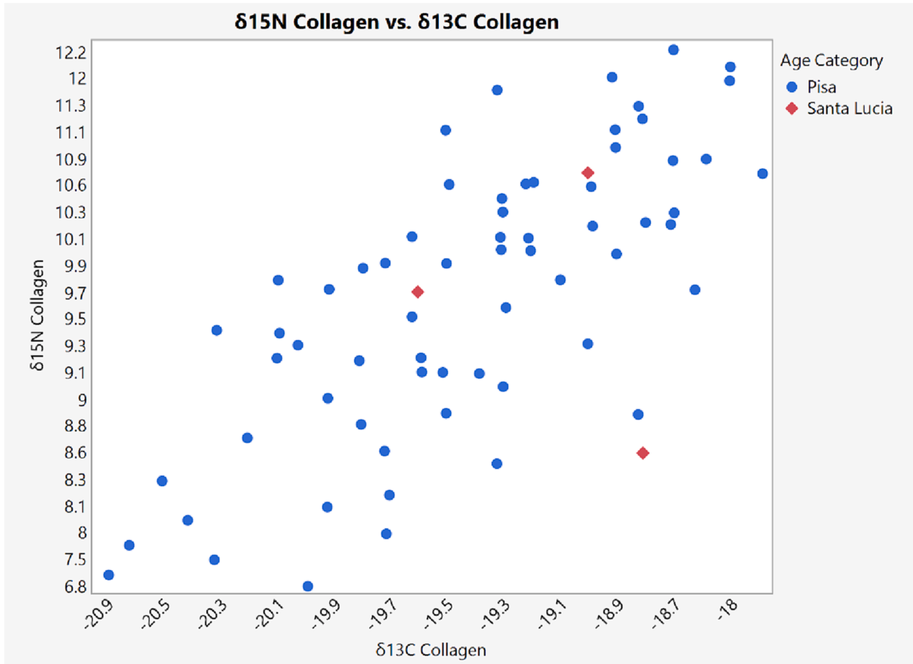


Fig. 13. Comparison of human bone samples from Santa Lucia group 1 and the sites of Pisa (Via Marche, 300–500 CE), Portus Romae (450–550 CE), Rome (Amba Aradam, 400–500 CE), Rome (Piazzale Ostiense, 300–500 CE). All sites are mixed. Data from Riccomi et al. (2020); O'Connell et al. (2019); Varano et al. (2020).

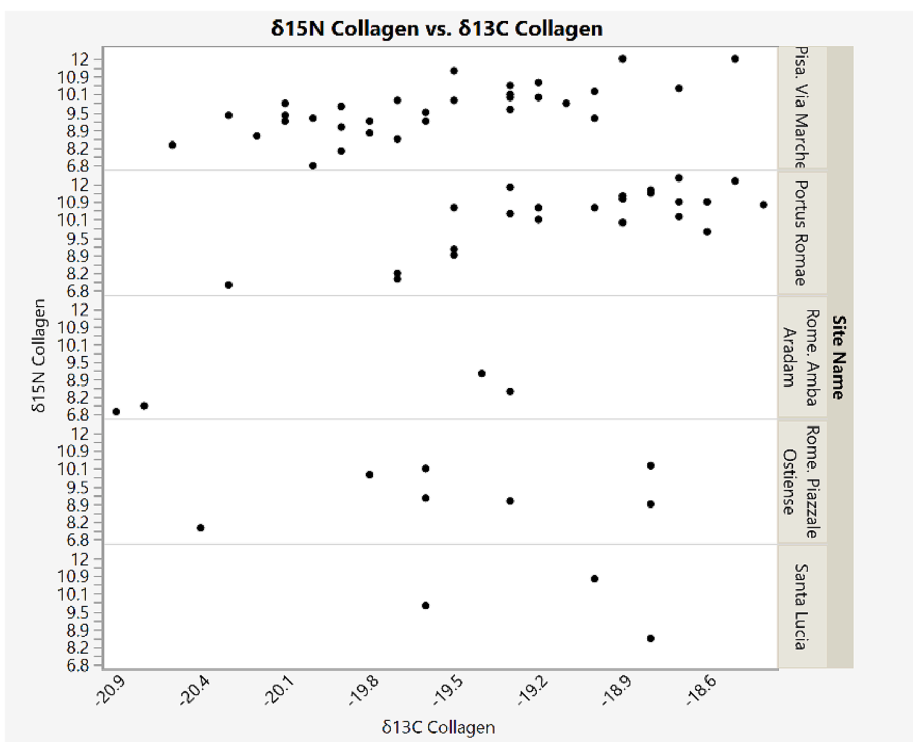


Fig. 14. Comparison of human bone samples from Santa Lucia group 1 and the sites of Pisa (Via Marche, 300–500 CE), Portus Romae (450–550 CE), Rome (Amba Aradam, 400–500 CE), Rome (Piazzale Ostiense, 300–500 CE). Divided by site. Data from Riccomi et al. (2020); O'Connell et al. (2019); Varano et al. (2020).

missionary activity of its adherents, which can be traced back to the activities of the Twelve Apostles in the first century CE. This missionary component appears to have remained active and mainstream in the 5th century CE, and it may have concentrated believers in small, highly influential groups that were engaged in professions requiring mobility, such as merchants and sailors. These mobile groups could form local communities by settling almost anywhere, creating a pattern of movement that differed significantly from the later spread of Judaism in Europe, where adherence to rigid cultural and dietary rules could single out members of the community.

Despite sharing a common belief system as demonstrated by their burial practices, early Christians led very different lives, as shown through isotopic analyses. The study highlights that they could create porous and flexible communities based on their trade, which were open

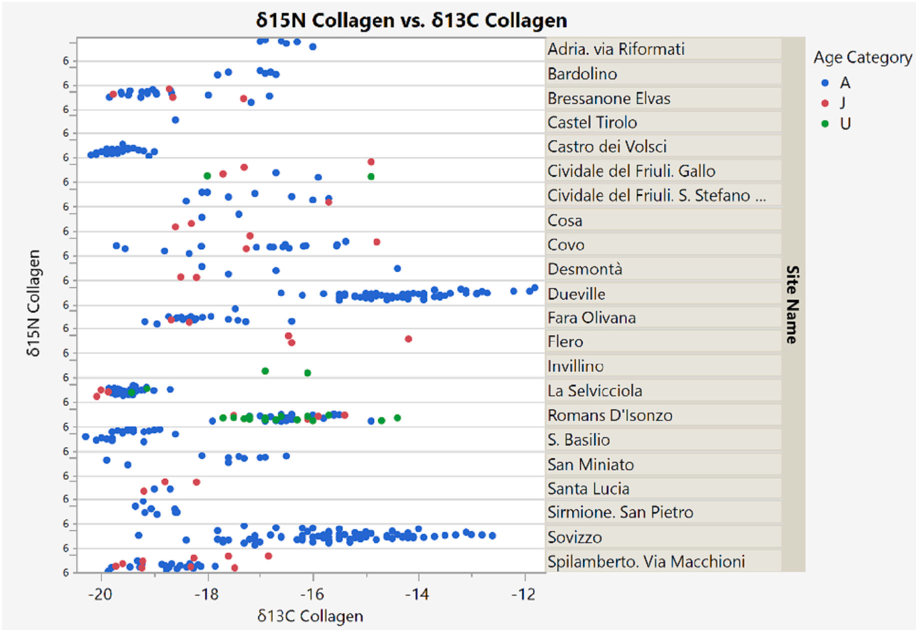


Fig. 15. Comparison of human bone samples from Santa Lucia group 2 and the sites of Adria (Via Riformati, 300–568 CE), Bardolino (568–625 CE), Bressanone Elvas (580–650 CE), Castel Tirolo (540–670 CE), Castro dei Volsci (500–600 CE), Cividale del Friuli (Gallo and S. Stefano, 568–700 CE), Cosa (500–600 CE), Covo (300–600 CE), Desmonta' (568–650 CE), Dueville (568–800 CE), Fara Olivana (500–700 CE), Flero (500–700 CE), Invillino (568–700 CE), La Selvicciola (568–700 CE), Romans D'Isonzo (568–650 CE), S. Basilio (300–568 CE), San Miniato (500–700 CE), Sirmione (San Pietro, 500–700 CE), Sovizzo (568–725 CE), Spilamberto (Via Macchioni, 300–600 CE). Data from Maxwell 2019; Paladin et al. 2020, Salamon 2008; Iacumin et al. 2014; Scorrano et al. 2014; Marinato 2014, 2018; Tafuri et al. 2018; Riccomi et al. 2020. Age category. A = Adult, J = Infant/Juvenile, U = Undetermined.

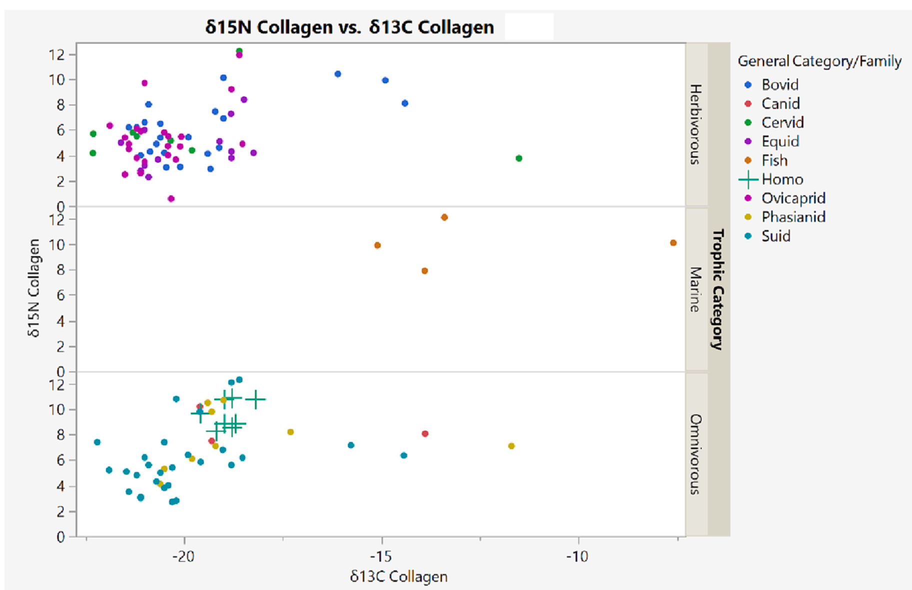


Fig. 16. Comparison of faunal data from across Italy, dated from Late Antique to Early Middle Ages. Data from publications compiled in CIMA. Compendium Isotoporum Medii Aevi (Cocozza et al. 2021). Some outliers removed.

to anyone without requiring behavioral changes in common activities such as diet. The study also suggests that diet was not a unifying element among the early Christian community, despite the later emphasis the Church placed on regulating diet. Future research could explore whether cultural traditions acquired during youth persisted into later life, and whether joining the Christian community improved or worsened nutritional values.

7.1. Ethical declaration

We, as researchers conducting an archaeological-anthropological study on human remains in catacombs, affirm our commitment to upholding the highest ethical standards (Squires et. al., 2022). Our study is characterized by respect for human dignity, cultural sensitivity, and collaboration with stakeholders. We adhere to scientific objectivity, ensure data privacy and confidentiality, and treat human remains as human subjects rather than objects. Our dissemination efforts are responsible, emphasizing public outreach, education, and respectful communication. We are accountable through the ethical review and ongoing evaluation by the *Ispettorato per le Catacombe della Sicilia Orientale of Pontificia Commissione di Archeologia Sacra* (permit n. 180/2017, December 5th, 2017), and aim to contribute to producing knowledge while preserving cultural heritage and fostering dialogue on ethical considerations in the study of human remains.

CRediT authorship contribution statement

Davide Tanasi: Conceptualization, Investigation, Formal analysis, Resources, Project administration, Supervision, Funding acquisition, Writing – original draft, Writing – review & editing. **Robert H. Tykot:**

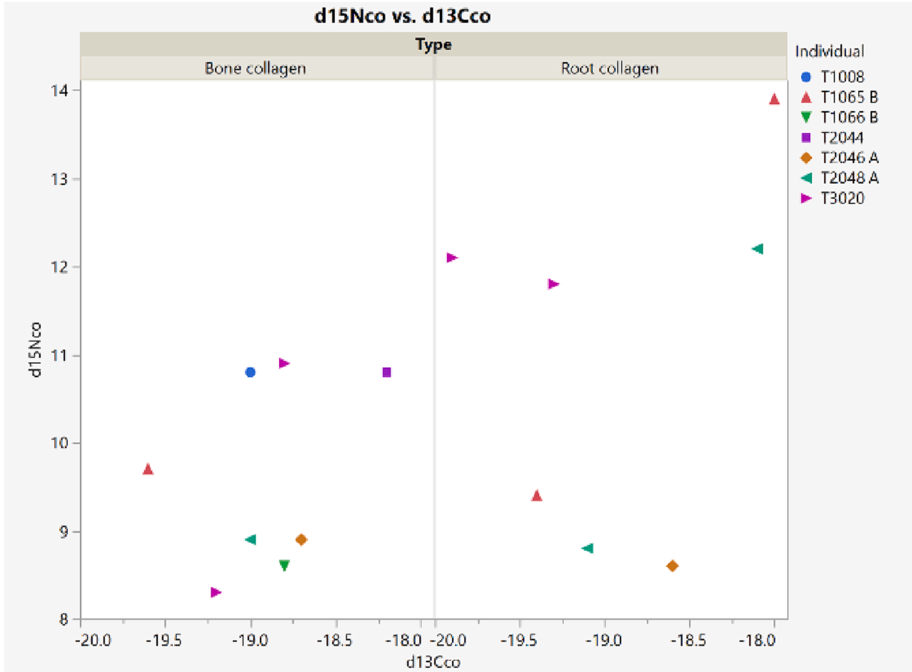


Fig. 17. A comparison of values of the same individuals, from bone collagen (left) and tooth root collagen (right), showing only small changes.

Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Andrea Vianello:** Methodology, Investigation, Formal analysis, Writing – review & editing. **Jonathan Bethard:** Methodology, Investigation, Writing – review & editing. **Ilenia Gradante:** Validation, Writing – original draft, Writing – review & editing. **Stephan Hassam:** Validation, Writing – review & editing. **Paolo Trapani:** Validation, Writing – review & editing. **Tiziana Ricciardi:** Validation, Writing – review & editing. **Enrico Greco:** Methodology, Investigation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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