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BIOARCHAEOLOGY AT A RESCUE SITE: STABLE ISOTOPE ANALYSIS OF THE IOULIOPOLIS (JULIOPOLIS) NECROPOLIS

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This pilot study applies light stable isotope analysis of human bone collagen (n = 7) to complement archaeological and anthropological data at the rescue site of Iouliopolis (Juliopolis) in the Ankara province, one of the largest excavated necropoleis in Anatolia in use between the Hellenistic and the Byzantine periods. The means obtained from the Roman-period graves, $\delta^{13}C$ averaging -18.8 ± 0.5‰ and $\delta^{15}N$ averaging 8.6 ± 0.7‰, reflect reliance on C3 plants and terrestrial animal protein, consistent with isotopic data from contemporaneous Anatolian sites. Despite the significant reduction of the initial dataset (n = 42) due to poor collagen preservation, the study demonstrates the value of the approach for rescue contexts and offers opportunities for limited interpretation of observed age- and sex-based differences. It is foundational for the Ankara province in the Roman period, enabling broader research in the future.

Keywords: Stable isotope analysis, Bioarchaeology, Funerary site, Roman Anatolia, Rescue archaeology.

BİR KURTARMA KAZISINDA BİYOARKEOLOJİ: IOULİOPOLİS (JULİOPOLİS) NEKROPOLÜNDE KARARLI İZOTOP ANALİZİ

Bu ön çalışma, Ankara ilindeki kurtarma kazısı alanı Iouliopolis (Juliopolis) nekropolünde arkeolojik ve antropolojik verileri tamamlamak amacıyla insan kemik kolajenine ait hafif kararlı izotop analizini (n = 7) uygulamaktadır. Hellenistik dönemden Bizans dönemine kadar kullanılmış olan, Anadolu'nun en geniş kazılmış nekropollerinden biri olan bu alandan elde edilen Roma dönemi mezarlarına ait ortalama $\delta^{13}C$ (-18.8 ± 0.5‰) ve $\delta^{15}N$ (8.6 ± 0.7‰) değerleri, çağdaş Anadolu yerleşimlerinden bilinen izotopik verilerle uyumlu olarak C3 bitkilerine ve karasal hayvan proteinine dayalı bir beslenme modelini yansıtmaktadır. Kötü kolajen korunumu nedeniyle başlangıçtaki örnek sayısının (n = 42) önemli ölçüde azalmasına rağmen, çalışma bu yöntemin kurtarma kazıları bağlamında değerini ortaya koymakta ve gözlemlenen yaş ve cinsiyet temelli farklılıkların sınırlı da olsa yorumlanmasına imkân sağlamaktadır. Araştırma, Roma dönemine ait Ankara ili için temel bir veri kaynağı sunarak ileride daha kapsamlı çalışmaların yapılmasına zemin hazırlamaktadır.

Anahtar kelimeler: *kararlı izotop analizi, biyoarkeoloji, mezar alanı, Roma Anadolusu, kurtarma arkeolojisi.*

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INTRODUCTION

Over the last 20 years, the fields of Roman and Byzantine funerary archaeology have seen the growing influence of bioarchaeological research. This has enabled examination of skeletal remains beyond retrieving basic osteological data to explore broader questions about past human lives and experiences (Rose 2017, 15; Sołtysiak 2021). Among these methods, stable isotope analysis is a widely adopted technique for investigating subsistence strategies, differential access to food, and physical well-being. However, these developments have been non-uniform, with monumental sites (for exceptions in Türkiye, see Ekinci, Kübra, and Unur 2025; Özdemir 2018; Özdemir et al. 2025) and particular regions, such as Roman-period Britain (e.g., Chenery et al. 2010; Cummings 2009; Moore et al. 2020; Müldner, Chenery, and Eckardt 2011; Pollard et al. 2011; Redfern, Hamlin, and Athfield 2010; Richards et al. 1998) and Italy (e.g., Baldoni et al. 2019; Craig et al. 2013; Crowe at al. 2010; Killgrove 2010; Killgrove and Montgomery 2016; Killgrove and Tykot 2018; Prowse 2011; Prowse et al. 2004, 2005, 2008) and Byzantine-period Greece (e.g., Bourbou 2009, 2013; Bourbou et al. 2013; Bourbou and Garvie-Lok 2009, 2015; Bourbou and Richards 2007; Garvie-Lok 2001; McConnan Borstad, Garvie-Lok, and Katsonopoulou 2018), being in the avant-garde of multidisciplinary funerary research and methodological advances of archaeological science. In contrast, only a limited number of Roman and Byzantine sites in Türkiye have applied stable isotope analysis to human remains (e.g., Cleymans 2019; Lösch et al. 2014; Propstmeier et al. 2017; Wong et al. 2017, 2018).

This pilot study expands the isotopic dataset for Anatolia, focusing on the necropoleis at Iouliopolis, a rescue site in the Ankara province, a region not yet explored through stable isotope analysis. Given the limited historical information about diets of people on the periphery of the Roman Empire, as well as those of lower social classes, women, and children, it integrates bioarchaeological data with archaeological context to explore how factors such as sex, age, and burial type may correlate with dietary variation among the Roman-period individuals in the dataset (n = 7). The approach is particularly important given that the town of Iouliopolis itself is not accessible for comprehensive archaeological research due to its submerged state, which prevents zooarchaeological and archaeobotanical analyses. More broadly, current work offers perspectives on the viability of data from rescue contexts and from underexplored provincial and rural settlements, contributing to the growing body of bioarchaeological data from historical sites in Türkiye.[1] Isotopic values from other contemporaneous sites in Anatolia allow exploring whether the preliminary results from Iouliopolis follow similar dietary patterns, specifically the predominance of C3 plants and terrestrial animals.

Significantly, this work pivots towards the study of rural agricultural economies of the eastern Mediterranean in the Roman period, which remain poorly understood, with a relatively limited number of sites offering a holistic exploration of faunal and botanical remains (Çakırlar and Marston 2019, 91). Classical sites in the macroregion of Ioulipolis, such as Ankyra, Pessinus, and Daskyleion, provide limited data. While the agricultural economies of Roman Gordion have been examined (Çakırlar and Marston 2019), isotopic data and its integration with bioarchaeology is yet to be explored. The study is foundational to building a regional isotopic dataset that enables broader research on gender and socioeconomic diversity and comparison with other sites in Anatolia.

1 It was also among the first conducted at the Turkish Energy, Nuclear and Mining Research Institute (TENMAK) in Ankara. Until then, all stable isotope analyses published on sites in Türkiye had been carried out in foreign laboratories, before restrictions on the export of biological samples were introduced (Irvine and Özdemir 2020, 186–87). Since that time, two local facilities, TÜBİTAK MAM and TENMAK, have begun processing bone collagen samples for carbon and nitrogen stable isotope analysis.

THE SITE OF IOULIOPOLIS

Iouliopolis is located near the former villages of Sarılar and Yardibi in the Çayırhan municipality of the Nallıhan district, approximately 122 km northwest of Ankara, at the confluence of the Aladağ Çayı (ancient Skopas) and the Sakarya River (ancient Sangarios) (French 1981, 29; Fig. 1). The main information about the settlement comes from historical sources such as itineraries, ecclesiastical records, administrative documents, inscriptions, and milestones (Devecioğlu 2024; Onur 2014). It was a small town in the province of Bithynia-Pontus, whose regional importance stemmed from its location at the entrance to the province and its role as a midway station on the route from Constantinople to Ankyra (Ramsay 1890, 244–45). There are no confirmed records of the settlement after the late eleventh century CE, marked by the Seljuk expansion into Byzantine territories.

The site was partially submerged in 1954 after the construction of the Sarıyar Dam. The 1991 rescue excavations by the Anatolian Civilizations Museum uncovered a necropolis, with work resuming in 2009 to protect the site from looting (e.g., Arslan et al. 2011; Cinemre 2014; Sağır, Metin, and Cinemre 2015; Günel, Yurttagül, and Yağcı 1992; Sağır, Metin, and Çelik 2016). In 2017, Hacettepe University launched the Juliopolis Anthropological Research project (JAR), led by Ali Metin Büyükkarakaya of the Department of Anthropology, in collaboration with the Koç University Vehbi Koç Ankara Studies and Research Center (VEKAM). The project investigates the lifestyles, paleo-demography, and paleopathology of the local population (Büyükkarakaya et al. 2018). Its focus lies in multidisciplinary bioarchaeological research on human remains, combining methods from anthropology, archaeometry, archaeological chemistry, and digital bioarchaeology (3D imaging and reconstruction) to integrate the resulting data with material records, as well as literary and epigraphic sources. This approach is particularly relevant given the limited information available about the site, whose extent and layout re-

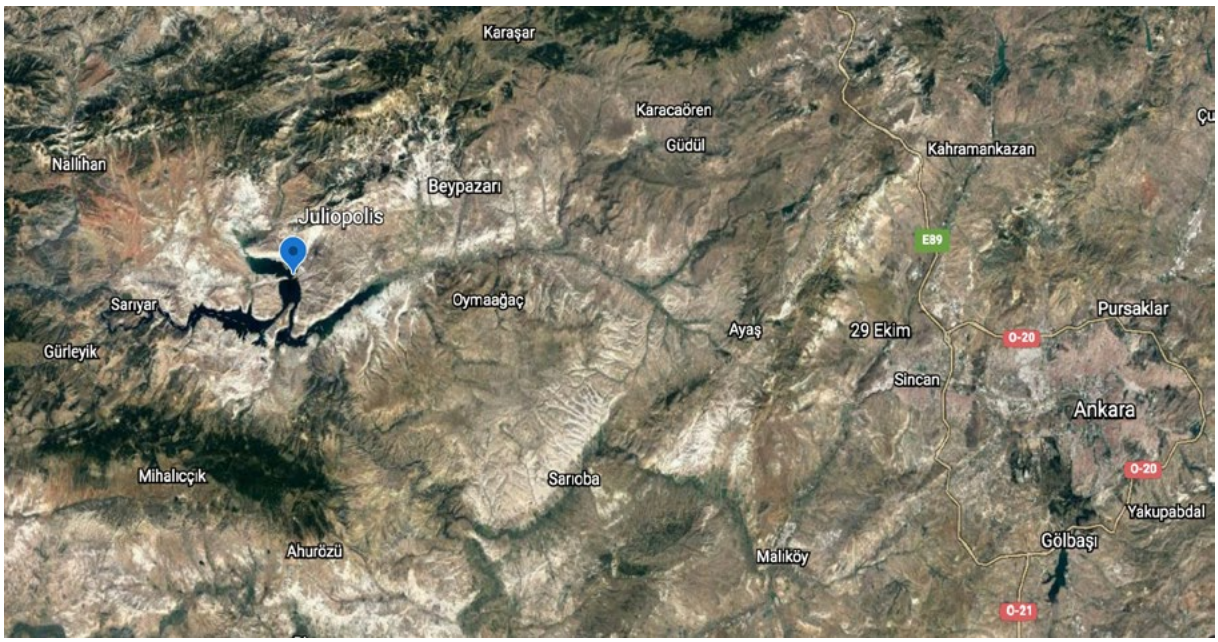

FIG. 1

Location of Iouliopolis in relation to Ankara (Google Maps).

main largely unknown, apart from its necropolis and two architectural features. By involving advanced scientific techniques and an interdisciplinary team, typically reserved for large-scale projects at monumental sites, the project shifts the scope of inquiry from broad population-level trends to the health, physical well-being, and life histories of individuals.

Salvage work has focused on the East Necropolis (Fig. 2), prioritized over the West Necropolis on the opposite shore of the Aladağ Çayı, a defensive wall, and an Early Byzantine church. With 781 graves excavated as of 2022 (Büyükkarakaya 2024, 9), the two necropoleis constitute one of the largest burial grounds excavated in Anatolia (Sertalp et al. 2023, 180). Their use spanned from the Hellenistic period to the Byzantine period, roughly between the fourth century BCE and the seventh century CE (Büyükkarakaya et al. 2018, 112, 114; Metin et al. 2021, 134), with a peak in the second–third centuries CE, indicated by coinage and other grave goods (Devecioğlu 2024, 28). The first set of radiocarbon dates supports this timeframe, confirming the use of the East Necropolis between at least the second century BCE and the sixth–seventh centuries CE (Figs. 3–7).[2]

The long-term use of the necropoleis reflected the settlement's sustained occupation, tied to its location at the confluence of the Sangarios (Sakarya) and Skopas (Aladağ Çayı) rivers, with opportunities for food production, irrigation, and communication. The proximity to three rivers—the Siberis being the third—was likely a decisive factor in establishing a settlement in this fertile area. Epigraphic evidence and coins from

FIG. 2

Location of the West and East Necropoleis.

2 Radiocarbon dating was conducted at TÜBİTAK MAM following the protocol described in Doğan, İlkmen, and Kulak 2023. Of the five samples analyzed, three were processed under the GABAM grant awarded to Inge Uytterhoeven (Department of Archaeology and History of Art, Koç University), and the remaining two as part of the *Scales of Fragmentation* project funded by the University of Warsaw.

the reigns of Maximus Caesar (236–238 CE) and Gordianus III (238–244 CE) indicate that Dionysos Kallikarpos ("bearing good fruit") had a local following, likely connected to the fertility of soil and the area's suitability for viticulture (Avcu and Doğan 2014, 86–87; Devecioğlu 2021, 76). Equally important was its strategic position on the Bithynia-Galatia border and along the Pilgrim's Road linking Constantinople, Ankyra, and the Levant (Onur 2014, 65, 67). Survey data and hagiographic sources confirm the vitality of this micro-region in Late Antiquity (The Princeton University Tahirler Project 1998; The Tahirler Project 2001; Walker 2003). Numismatic finds from Nikaia, Prusias ad Hypium, Krateia (Flaviopolis), and Amastris further attest to the town's regional connectivity through the local road network (Arslan 2012, 28; Arslan et al. 2012, 178).

Iouliopolis was also embedded within broader regional patterns of agricultural production. Galenos (aliment. 6.515, second century CE) records the cultivation of a grain whose modern equivalent is not known, zeopyros, grown in cold parts of Bithynia and considered "inferior to naked wheat as it is superior to Thracian rye" (Powell 2003, 51–53). It was grown in Iouliopolis and surrounding areas, extending into Dorylaion in neighboring Phrygia and "some other cities on its border" (Powell 2003, 53). This landscape of northwestern Anatolia was characterized by a warm temperate climate favorable to cold-resistant C3 plants (Budd et al. 2018, 2125). Other examples of regional cultivars are einkorn (tiphê) and emmer (olyra and zeia), considered inferior to naked wheat and barley but indispensable in harsher climates. This rare literary reference provides the only direct testimony regarding subsistence strategies at the site.

Given the availability of skeletal material from diverse burial contexts, the necropoleis of Iouliopolis provide a rare opportunity to move beyond limited textual references. Carbon and nitrogen stable isotope analysis, the most effective method for reconstructing individual dietary histories, allows for the diachronic examination of local food practices, the comparison of dietary patterns across different segments of the population, and the placement of Iouliopolis within broader regional frameworks.

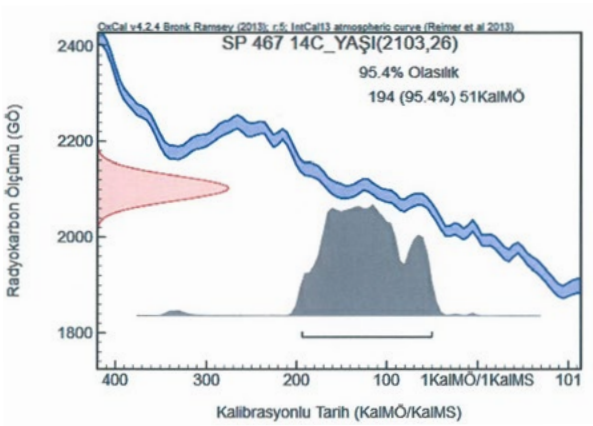

FIG. 3

Radiocarbon calibration curve and calibrated date range for an adult (30–44.5 years) from cist grave M 467 (TÜBİTAK-1380; 2103 ± 26 BP: 194–51 CE, 95.4% probability, calibrated in IntCal20). Juliopolis Necropolis Digital Collection, https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/3128/rec/400.

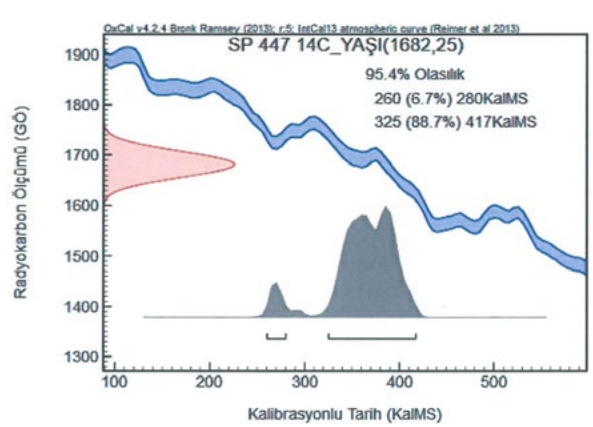

FIG. 4

Radiocarbon calibration curve and calibrated date range for an adult (30–44.5 years) from cist grave M 447, located in the northeastern corner of the nave (TÜBİTAK-1378; 1682 ± 25 BP: 325–417, 88.7% probability, calibrated in IntCal20). Based on the in situ marble inscription, the burial is attributed to the demarch Lykos, son of Leon, and his wife Photine (Onur 2014, 107). Juliopolis Necropolis Digital Collection, https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/3017/rec/378.

CARBON AND NITROGEN STABLE ISOTOPE ANALYSIS

Stable isotope analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) is a widely applied bioarchaeological method that provides direct insights into diet, health, mobility, and aspects of social life in past populations (Katzenberg 2008; Somerville, Fauvelle, and Froehle 2013; Makarewicz and Sealy 2015; Bleasdale et al. 2019). It measures the ratio of the heavier, less abundant stable isotope to the lighter, more common one for carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) in archaeological bone proteins (Schwarcz and Schoeninger 1991, 288). These signatures are incorporated into body tissues along with dietary components, such as amino acids, carbohydrates, and lipids, used to build and repair tissues, thereby linking isotope values directly to nutrition and health (Schoeninger and Reitsema 2023, 511).

Carbon isotope values distinguish between plants, the basic source of nutrients for other species, which use different photosynthetic pathways (Keegan 1989, 226–27; Schwarcz and Schoeninger 1991, 303). C3 plants, typical of temperate regions, display more negative $\delta^{13}C$ values (between –19 and –35‰), while C4 plants such as millet and sorghum show less negative values (between –8 and –13‰) (Bleasdale et al. 2019, 6163). Marine resources also tend to be enriched in ^{13}C relative to terrestrial C3 plants (Schwarcz and Schoeninger 2011, 730). Because these signals are passed on to consumers, the analysis of $\delta^{13}C$ in bone collagen allows evaluation of the relative contribution of C3 versus C4 and marine inputs (Schoeninger, DeNiro, and Tauber 1983, 1382). Since carbon data alone provides information only about the proportions of carbon from C3 and C4 sources, rather than the resources consumed (Lee-Thorp 2008, 942), it is commonly analyzed together with nitrogen isotopes.

Nitrogen isotope analysis complements carbon by reflecting the trophic level of an individual organism. $\delta^{15}N$ values increase stepwise through the food chain, with an average enrichment of about 2–5‰ at each

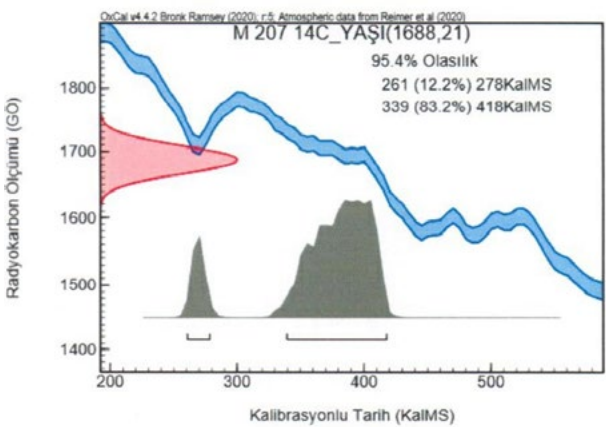

FIG. 5

Radiocarbon calibration curve and calibrated date range for an individual from cist grave M 207 (TÜBİTAK-1536; 1688 ± 21 BP: 339–418 CE, 83.2% probability, calibrated in IntCal20). Juliopolis Necropolis Digital Collection, https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/1235/rec/126.

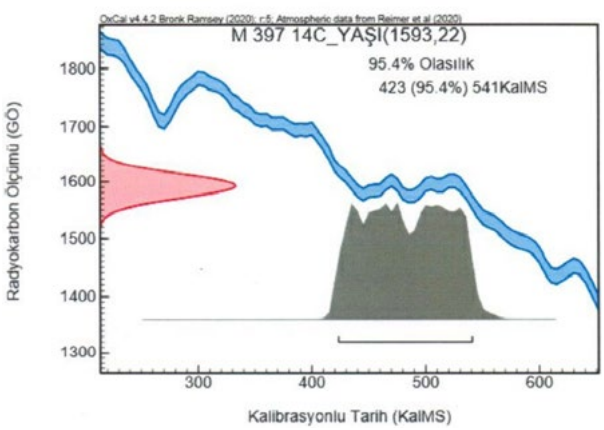

FIG. 6

Radiocarbon calibration curve and calibrated date range for an individual from cist grave M 397 (TÜBİTAK-1537; 1593 ± 22 BP: 423–541 CE, 95.4 % probability, calibrated in IntCal20). Juliopolis Necropolis Digital Collection, https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/2725/rec/326.

trophic level (Bocherens and Drucker 2003, 47).[3] Herbivores exhibit lower $\delta^{15}N$ values than omnivores or carnivores, and populations consuming significant amounts of aquatic protein often show higher values still due to the longer food chains in aquatic ecosystems (Schwarcz and Schoeninger 1991, 305). Because of this relationship, nitrogen isotopes are key for identifying the main sources of dietary protein and distinguishing between plant- and animal-derived inputs (Larsen 2015, 321). They have also been used to investigate breastfeeding and weaning practices, since infants typically display 3–4‰ enrichment in $\delta^{15}N$ values and around 1‰ enrichment in $\delta^{13}C$ relative to their mothers (DeNiro and Epstein 1978, 495; Fogel, Tuross, and Owsley 1989, 114; Schoeninger and DeNiro 1984, 625).

Stable isotope analysis can be applied to different human tissues that reflect diet over distinct periods of life. Bone remodels continuously at a rate which varies according to the type of bone tissue, skeletal element, time of life, diet, and health of an individual (Sealy, Armstrong, and Schrire 1995, 291). The cortical portion of long bones captures diet over a decade or more (Reitsema and Holder 2018, 67), while trabecular bone, such as ribs, reflects shorter periods of roughly 2–5 years (Cox and Sealy 1997, 212; Lamb et al. 2014, 560). Because bone turnover is relatively slow, stable isotope analysis captures long-term dietary patterns rather than short-term or occasional consumption (McCormack et al. 2021, 2; Müldner and Richards 2006, 229). It also cannot identify individual food items, e.g., meat versus secondary animal products, but it can reliably distinguish major food groups and broad dietary regimes (Bleasdale et al. 2019, 6162; Keegan 1989, 224). This challenge is often solved through an established baseline, in which local faunal and floral isotope values are determined to provide comparative frameworks for interpreting human data (Schwarcz and Schoeninger 1991, 312; Sealy et al. 1987, 2707).

Beyond reconstructing diet, stable isotope analysis enables examining inter- and intra-group demographic variations of diet in order to get more information about social structures, economic histories, political organization, and culture of human groups (Makarewicz and Sealy 2015, 148; Reitsema 2013, 452–53). Detectable differences in isotope values between individuals reflect significant dietary variation (Müldner and Richards 2006, 234) and can reveal variation in food access depending on such factors as age, biological sex, or social status, providing insights into inequality, household economies, and cultural practices. When combined with other archaeological and historical evidence, this method helps address questions of mobility, crop and animal management, and identity, allowing more nuanced understandings of individual life histories and community organization (Baker and Agarwal 2017, 5; Salesse et al. 2018, 1050; Sołtysiak 2021).

Research on food production and consumption in the Roman and Byzantine worlds illustrates the breadth of these possibilities. Diet serves as a proxy for health and physical well-being (Koepke 2016, 71), while also reflecting environmental adaptation, agricultural regimes, trade and migration networks, and social dynamics (Bourbou 2020; Fernandes and Chowaniec 2018). In the Roman period, the movement of armies and expansion of commerce significantly reshaped agricultural practices and increased the scale of food translocation (van der Veen 2018, 64), while in the Byzantine era diet continued to intersect with regionalism and local ecological conditions (Haldon 2009, 171; Bourbou 2020). Both Roman and Byzantine states encompassed diverse climatic zones and social structures, which produced variability in food sources, access, and consumption patterns

3 Different studies give slightly different values for this enrichment, but all are generally between 2 and 6‰ (e.g., Killgrove and Tykot 2013, 29; Lee-Thorp 2008, 928; Richards et al. 2003, 69; Hedges and Reynard 2007, 1241; Bonsall and Pickard 2015, 136; Jaouen and Pons 2017, 1395; Budd et al. 2018, 2127).

across regions, classes, sexes, and age groups. Stable isotope analysis provides a more direct, semi-quantitative approach to reconstructing individual diets (Sealy, Armstrong, and Schrire 1995, 294), in contrast to the group-level patterns discernable through written records, archaeobotanical, and zooarchaeological data. It clarifies the contribution of particular dietary components, such as cereals, legumes, meat, and fish, to everyday subsistence and enables comparisons of individuals and groups across sites and regions, which reveal sociodemographic, socioeconomic, and regional differences (Bourbou et al. 2011, 569; Killgrove and Tykot 2013, 28–29; Martyn et al. 2018, 1023), and highlight how foodways were embedded within broader processes of social behavior, political power, and cultural connections (Rose 2017, 14).

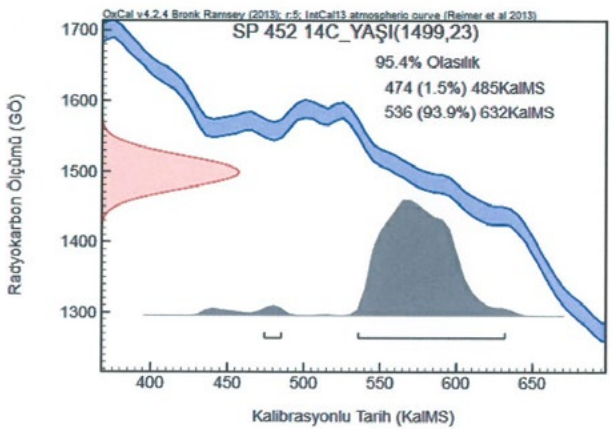

FIG. 7

Radiocarbon calibration curve and calibrated date range for an individual from cist grave M 452, located on the northern side of the main church entrance (TÜBİTAK-1379; 1499 ± 23 BP: 536–632 CE, 93.9% probability, calibrated in IntCal20). Juliopolis Necropolis Digital Collection, https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/3044/rec/384.

MATERIALS AND METHODS

Sample set

The initial sample set comprised 42 individual bone samples from 39 burials in the East Necropolis (Table 1). Only bone collagen was targeted in this study due to its robustness under poor preservation conditions, the established quality-control protocols that exist (Lee-Thorp 2008, 928, 930–31; Tykot 2014, 934),[4] and the opportunity for comparison with published isotopic data from other sites in Anatolia and across the Roman Empire. Faunal samples that could have provided site-specific isotopic baselines for interpreting human diets were not analyzed due to the absence of systematic palaeobotanical and zooarchaeological research at the site or in Roman-period Bithynia and Galatia. Another constraint is the lack of detailed information on C4 plant distribution in Anatolia. Fuller et al. (2012, 166) suggest that C4 taxa, primarily thermophilous grasses (*Poaceae*) and sedges (*Cyperaceae*) associated with wetlands, may have spread during periods of increased humidity and temperature between 800 BCE and 300 CE. However, the region of northwestern Anatolia, with its warm temperate climate, is predominantly characterized by cold-resistant C3 vegetation (Budd et al. 2018, 2125).

Anthropological assessment of the sampled individuals—age-at-death and sex estimation—was conducted by Büyükkarakaya following established standards (for further details, see Büyükkarakaya et al. 2018). The dataset consists of 10 males and 13 females, with young adults (15–30 years) and adults (30–45 years) forming the largest age categories (Table 1).[5] Because skeletal preservation at Iouliopolis was poor due to the site's geological conditions, samples were selected based on availability and visual assessment of preservation. This limitation confined the dataset to burials previously examined for

4 The C:N atomic ratio is measured to determine whether a collagen sample is sufficiently preserved in order to reflect *in vivo* $\delta^{13}C$ and $\delta^{15}N$ values, with an accepted range of 2.9–3.6 (DeNiro 1985, 808).

5 Poor preservation, especially in chamber tombs, limited the precision of sex and age estimates: sex could not be determined for about one-third of adult and young adult individuals (15 cases) and four younger subadults, and age determinations for nine individuals remained imprecise.

paleo-demographic studies (Büyükkarakaya et al. 2018) and reduced the number of individuals suitable for isotopic analysis. Ribs and long bones were mainly used for the analysis.

The archaeological context of the sample set encompasses details about location, period, burial type, orientation, and grave goods (Table 2). The minimum number of individuals (MNI) per grave ranges from one or two—the most common occurrence—to as many as 23 in the rock-cut cist grave M 452 near the church entrance. All samples derive from the East Necropolis, with two notable church-related burials: M 447, the grave of the demarch Lykos, son of Leon, and his wife Photine, in the church's northeastern corner, and M 452, the mass grave of 23 individuals interred near the western entrance. Radiocarbon dating places M 447 in 325–417 CE (Figure 4) and M 452 in 536–632 CE (Figure 7). Because of the commingled nature of M 452, it is uncertain whether the isotopic sample corresponds to the same individual dated by radiocarbon, and similar uncertainty applies to M 207 (339–418 CE; Figure 5) and M 397 (423–514 CE; Figure 6), each containing two individuals. For the remaining burials, chronological attribution relies on museum records that divide them into the Roman, Late Roman/Early Byzantine, or Byzantine periods, primarily based on coinage deposited in graves.

Cist graves dominate the sample set, consistent with their overall prevalence in the necropoleis. They are followed by chamber tombs and simple inhumations, while rock-cut cist graves—both associated with the church—are given a separate category, based on excavation records. The distribution of grave goods was evaluated relative to MNI. Three categories emerged: graves without gifts (mostly cists), graves with one or two gifts per individual (also mostly cists), and graves with more than two gifts per individual (cists and chamber tombs).

Collagen preparation

The samples were transferred from Hacettepe University to the Archaeology Laboratory of Koç University, where they were subjected to collagen extraction under the supervision of R. Özbal. Since the procedure was relatively new to the lab, we applied the protocols used by the British Geological Survey (Nottingham, UK) and shared with Özbal by A. Lamb. All steps of collagen preparation—namely, demineralization, gelatinization, filtration, and freeze-drying—were carried out in the lab. Final encapsulation was performed at the Koç University Surface Science and Technology Center (KUYTAM).

Collagen was extracted using a modified version of the Longin (1971) method. This protocol is straightforward and requires minimal laboratory infrastructure, though the progress of demineralization can be difficult to assess (Schwarcz and Schoeninger 1991, 293; Sealy et al. 2014, 65). Whole bone samples weighing 0.5–1.3 mg were placed in test tubes loosely covered with tinfoil to prevent contamination and demineralized in ~10 ml of 0.5 M hydrochloric acid at 4°C to slow the reaction (Tykot 2004, 436; Sealy et al. 2014, 64–67).[6] The acid was replaced daily or every other day depending on sample response. Prior to each replacement, tubes were centrifuged to ensure the retention of all organic material. Demineralization took between 1 and 24 days depending on bone density. Once decalcified, samples were rinsed three times in double-distilled water with centrifugation between rinses.[7]

Decalcified samples were then filled with pH 3 water, sealed with tinfoil, and placed on a hot block at 70°C for 48 hours to gelatinize. The resulting solutions were transferred into freeze-dry-proof polyethylene vials through Ezee® filters to remove insoluble residues. Vials were sealed with parafilm and frozen

6 The exact concentration of acid is not of critical importance, and various values, e.g., 0.05–0.2 M in Pestle (2010) and 1 M in the Max Planck protocol, are considered acceptable. However, more dilute acid ensures a more gradual demineralization, preferable for poorly preserved or smaller samples (Sealy et al. 2014, 65).

7 Samples were not treated with NaOH, as it was not a required step of the protocol followed and due to the poor state of collagen preservation (for further discussion of the detrimental effect of strongly alkaline solutions on collagen, see Guiry and Szpak 2021).

TABLE 1

Dataset of the δ13C and δ15N analysis. Age categories: I = Infant (0–2.4 years), C = Child (2.5–14.9 years), YA = Young Adult (15–29.9 years), A = Adult (30–44.5 years), OA = Older Adult (45+ years). Sex categories: M = Male, F = Female, N/A = Undetermined. %C and %N values are rounded to two decimal places; full values were used to calculate C:N ratios, which are likewise rounded to two decimals. Samples meeting quality criteria are shown in **bold.**

Lab ID	Grave No.	Bone Type	Sample Weight	Age	Sex	$\delta^{13}C$ ($‰_{VPDB}$)	$\delta^{15}N$ ($‰_{AIR}$)	%C	%N	C:N
KU-071	M 195	Rib	0.8536	A	M	-18.8	6.9	9.79	3.07	3.71
KU-072	M 169	Ulna	0.9793	YA	F	-21.9	4.5	0.35	0.05	8.87
KU-073	M 154	Femur	1.1938	YA	N/A	-18.9	8.9	6.61	1.74	4.43
KU-074	M 142	Femur	0.779	YA/A	F	-23.3	4.2	0.48	0.05	12.52
KU-075	M 63	Rib	0.8841	YA/A	N/A	-18.6	8.4	36.19	11.65	3.62
KU-076	M 34	Rib	0.585	I	N/A	-17.4	12.8	42.45	13.22	3.74
KU-077	M 33	Rib	0.6385	C	N/A	-18.6	9.5	40.56	12.27	3.86
KU-078	M 89	Rib	1.1316	YA/A	F	-18.9	8.1	35.64	11.06	3.76
KU-079	M 33	Femur	1.1042	YA	F	-18.7	7.0	23.25	7.12	3.81
KU-080	M 194	Tibia	1.0338	YA	M	-20.7	5.8	0.59	0.07	10.56
KU-081	M 87	Rib	0.8975	C	N/A	-18.3	7.6	22.67	5.2	5.09
KU-082	M 148	Femur	0.7479	YA/A	F	-20.1	4.1	0.5	0.08	7.61
KU-083	M 161	Rib	0.628	A/OA	M	-18.3	12.9	43.51	13.9	3.65
KU-084	**M 164**	**Rib**	**0.7894**	**YA**	**F**	**-19.8**	**7.5**	**41.14**	**13.53**	**3.54**
KU-085	**M 237**	**Rib**	**0.787**	**YA/A**	**F**	**-18.6**	**7.9**	**40.64**	**13.44**	**3.53**
KU-086	M 195	Rib	0.9018	YA	F	-19.3	7.1	36	11.42	3.68
KU-087	M 258	Clavicula	1.1122	YA	M	-19.1	9.2	32.29	10.01	3.76
KU-088	M 276	Rib	0.6511	YA/A	F	-18.7	9.3	43.21	13.77	3.66
KU-089	M 243	Rib	0.901	YA/A	F	-18.9	7.9	11.01	4.47	2.87
KU-090	**M 257**	**Rib**	**0.7957**	**YA**	**N/A**	**-18.4**	**8.7**	**28.53**	**9.7**	**3.43**

Lab ID	Grave No.	Bone Type	Sample Weight	Age	Sex	$\delta^{13}C$ ($‰_{VPDB}$)	$\delta^{15}N$ ($‰_{AIR}$)	%C	%N	C:N
KU-091	**M 248**	**Rib**	**0.9188**	**YA**	**N/A**	**-18.8**	**8.9**	**39.03**	**12.95**	**3.51**
KU-092	M 93	Rib	0.9113	YA/A	N/A	-18.9	8.7	40.43	13.16	3.58
KU-093	M 103	Rib	0.819	OA	M	-18.4	9.8	37.21	10.97	3.97
KU-094	M 221	Radius	1.0688	A	F	-19.7	-33.9	1.91	1.3	1.71
KU-095	M 34	Rib	0.7324	YA	F	-18.5	9.5	34.12	10.85	3.67
KU-096	M 88	Rib	0.7628	C	N/A	-18.3	9.0	27.58	7.42	4.34
KU-097	**M 116**	**Rib**	**0.9567**	**A**	**M**	**-18.4**	**9.6**	**22.25**	**7.25**	**3.58**
KU-098	**M 247**	**Rib**	**0.9206**	**A**	**M**	**-18.6**	**9.1**	**29.09**	**9.47**	**3.58**
KU-099	M 209	Parietal	1.0471	A	N/A	-22.0	-59.3	0.35	1.39	0.3
KU-100	M 208	Femur	1.758	A	N/A	-21.8	N/A	0.37	N/A	N/A
KU-101	M 207	Femur	1.0651	A	N/A	-18.7	10.2	5.77	1.96	3.44
KU-102	M 204	Femur	N/A	A	N/A	-20.0	6.3	0.8	0.11	8.81
KU-103	M 84	Rib	0.8801	A	N/A	-18.9	8.0	28.03	6.9	4.74
KU-104	M 447	Femur	0.6827	A	N/A	-19.0	9.4	4.53	1.11	4.74
KU-105	M 450	Rib	0.9372	A	M	-22.8	-52.0	0.9	1.13	0.93
KU-106	M 371	Tibia	1.2878	A	F	-22.0	6.5	0.81	0.13	7.52
KU-107	M 368	Humerus	0.8628	A	N/A	-22.9	-49.4	0.64	0.64	1.16
KU-108	M 484	Rib	1.1044	A	M	-18.4	11.0	9.93	3.35	3.47
KU-109	M 355	Humerus	0.7886	A	N/A	-21.4	-52.8	0.83	1.32	0.73
KU-110	M 392	Femur	0.769	A	N/A	-23.9	0.2	0.43	0.1	5.01
KU-111	M 452	Rib	0.7903	A	M	-18.5	11.7	29.4	9.35	3.67
KU-112	M 397	Rib	0.6219	A	N/A	-19.2	8.6	4.01	1.33	3.52

TABLE 2

Archaeological context of the dataset. Samples meeting quality criteria are shown in **bold**.

Lab ID	Grave No.	Grave Type	MNI	Grave Gifts Present
KU-071, KU-086	M 195	Chamber	5	Yes
KU-072	M 169	Cist	1	No
KU-073	M 154	Chamber	11	Yes
KU-074	M 142	Cist	1	No
KU-075	M 63	Chamber	N/A	Looted
KU-076, KU-095	M 34	Cist	3	No
KU-077, KU-079	M 33	Cist	3	No
KU-078	M 89	Cist	1	Yes
KU-080	M 194	Chamber	2	Yes
KU-081	M 87	Simple inhumation	1	Yes
KU-082	M 148	Cist	3	Yes
KU-083	M 161	Chamber	6	Yes
KU-084	**M 164**	**Chamber**	**2**	**Yes**
KU-085	**M 237**	**Cist**	**3**	**Yes**
KU-087	M 258	Cist	1	Yes
KU-088	M 276	Chamber	3	Yes
KU-089	M 243	Chamber	2	No
KU-090	**M 257**	**Cist**	**1**	**Yes**
KU-091	**M 248**	**Chamber**	**7**	**Yes**

Lab ID	Grave No.	Grave Type	MNI	Grave Gifts Present
KU-092	**M 93**	**Cist**	**2**	**Yes**
KU-094	M 221	Simple inhumation	1	No
KU-096	M 88	Chamber	N/A	Yes
KU-097	**M 116**	**Cist**	**1**	**Yes**
KU-098	**M 247**	**Chamber**	**4**	**Yes**
KU-099	M 209	Cist	1	No
KU-100	M 208	Cist	2	No
KU-101	M 207	Cist	2	No
KU-102	M 204	Chamber	N/A	No
KU-103	M 84	Simple inhumation	1	Yes
KU-104	M 447	Cist (church)	1	Yes
KU-105	M 450	Cist	2	Yes
KU-106	M 371	Cist	1	No
KU-107	M 368	Cist	1	No
KU-108	M 484	Cist	2	Yes
KU-109	M 355	Cist	4?	Yes
KU-110	M 392	Chamber	2	Yes
KU-111	M 452	Cist (church)	23	Yes
KU-112	M 397	Cist	2	No

TABLE 3

The final dataset.

Lab ID	Grave No.	Sex	$\delta^{13}C$ ($‰_{VPDB}$)	$\delta^{15}N$ ($‰_{AIR}$)	Z-score 1	Z-score 2
KUA-084	M 164	F	-19.8	7.5	-2.27	-1.65
KUA-085	M 237	F	-18.6	7.9	0.31	-1.04
KUA-090	M 257	N/A	-18.3	8.7	0.85	0.14
KUA-091	M 248	N/A	-18.8	8.9	-0.08	0.43
KUA-092	M 93	N/A	-18.9	8.7	-0.29	0.12
KUA-097	M 116	M	-18.4	9.6	0.87	1.51
KUA-098	M 247	M	-18.6	9.1	0.32	0.78
Mean			-18.8	8.6		
Standard Deviation			0.5	0.7		

for 24 hours at -18°C before lyophilization in a LYOQUEST-55 freeze dryer for 48 hours. Prepared collagen was stored in 1.5 ml vials at KUYTAM. Based on the anticipated poor preservation of collagen and the state of some samples after demineralization, such as flaking and lack of pseudomorphs,[8] it was initially expected that approximately 24 of them (slightly less than 60%) would provide isotopic values.

Stable isotope and statistical analyses

Isotope-ratio mass spectrometry (IRMS) was carried out at the Turkish Energy, Nuclear and Mining Research Institute (TENMAK) in Ankara.[9] Archaeological samples were analyzed in duplicate using a Flash EA 1112 elemental analyzer coupled to a Delta V Plus mass spectrometer (Thermo Scientific). Two external standards were employed for carbon (IAEA-CH-3 cellulose and B2215 fish gelatin) and two for nitrogen (IAEA-N-1 ammonium sulfate and B2215 fish gelatin). Analytical error was less than 0.1‰ for $\delta^{13}C$ and 0.4‰ for $\delta^{15}N$.[10] For each sample, results from the two analytical runs were averaged. Collagen quality was assessed based on carbon and nitrogen contents[11] and the atomic C:N ratio[12] of the gas-

8 The presence of a pseudomorph can signify structural integrity of the bone, since the collagen chains continue to be bonded together (Sealy et al. 2014, 64–65). Therefore, in poorly preserved samples, with significant diagenesis, the demineralization stage does not yield pseudomorphs, but rather "amorphous globules or wisps of gelatinous material," which indicate degradation of the collagen molecules, as was the case for many of the Iouliopolis samples.

9 Because at the time of the study, the laboratory was relatively new to stable isotope analysis of carbon and nitrogen, a trial run was conducted on non-archaeological bone samples prior to processing the archaeological material. Results were verified by comparison with international standards through the British Geological Survey, confirming the laboratory's reliability.

10 The analytical error of 0.4‰ for $\delta^{15}N$ could result from the fact that this study was the first such nitrogen analysis conducted at the TENMAK lab, employing a new standard. Hannon and Böhlke (2008, 2) consider this error acceptable.

11 "The amount of carbon and nitrogen measured by the mass spectrometer, relative to the size of the sample put in for analysis" (van Klinken 1999, 694). Commonly accepted intervals are 10–47% for %C and 5–17% for %N (Irvine and Özdemir 2021, 42).

12 C:N ratios were calculated by multiplying the molecular C:N (%C divided by %N) by the ratio of the average atomic masses of carbon and nitrogen (14.007/12.011) (Guiry and Szpak 2020, 1051).

TABLE 4

Mean δ13C and δ15N values from Iouliopolis compared with other Anatolian sites, based on the data published on IsoArch and by Lösch et al. (2014; for Ephesos) and Fuller et al. (2012; for Sagalassos).

Stable Isotope Ratio	Iouliopolis (n = 7, first–fourth century CE)	Sagalassos (n = 3; 300–450 CE)	Ephesos (n = 40, second–third century CE)	Pergamon (first–fourth century CE; Late Byzantine)[15]	Hierapolis (n = 9, first–seventh century CE; ninth–thirteenth century CE)	Kovuklukaya (n = 21; 770–970 CE)	Boğazkoy (n = 33; first century BCE–fifth century CE)
$\delta^{13}C$ ($‰_{VPDB}$)	-18.8 ± 0.5	-19.2 ± 0.2	-18.9 ± 0.4	-18.4 ± 0.3 (n = 20); -18.9 ± 0.6 (n = 55)	-18.9 ± 0.4	-19 ± 0.2	-18.7 ± 0.5
$\delta^{15}N$ ($‰_{AIR}$)	8.6 ± 0.7	10.1 ± 0.7	9.3 ± 0.8	9.9 ± 0.8 (n = 20); 9.9 ± 0.9 (n = 55)	9.4 ± 1.0	8.9 ± 0.5	8.9 ± 1.1

es produced (2.9–3.6), consistent with the amino acid composition of collagen in living organisms (DeNiro 1985, 808; Ambrose 1990, 447; Guiry and Szpak 2021).[13] Because information on peak areas was unavailable, k-values were calculated from peak amplitude values. Quality assessment reduced the dataset from 42 samples to seven individuals (Table 3). Descriptive and visual statistical analyses were carried out in Microsoft Excel and SPSS. No statistical outliers—defined as $\delta^{13}C$ or $\delta^{15}N$ values more than three standard deviations from the mean—were identified using z-scores. Owing to the small sample size, tests of statistical significance (t-test, Mann–Whitney U, ANOVA, etc.) and associations between variables (Chi-squared, Fisher's exact, etc.) could not be applied.

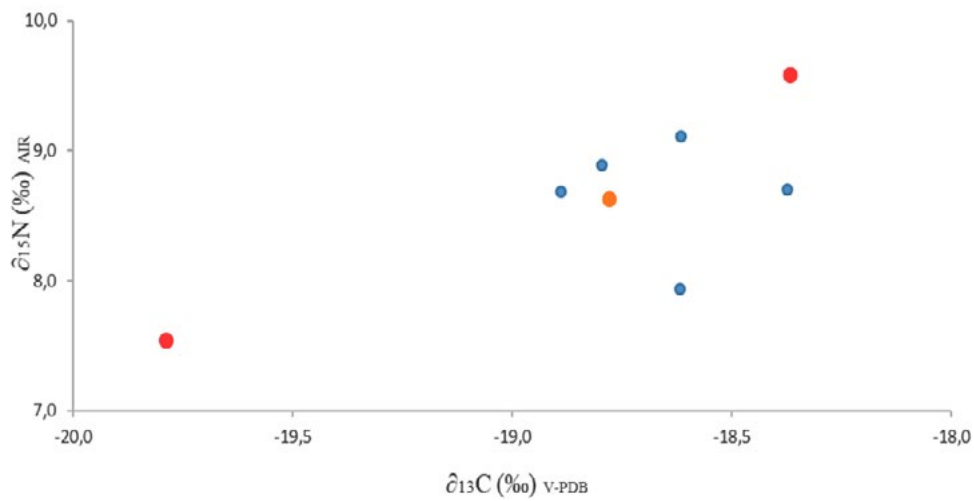

FIG. 8

Scatter plot of individual $\delta^{13}C$ and $\delta^{15}N$ values, with extreme observations marked in red and the mean value in orange.

13 Collagen yields were not measured at the time of sample preparation. However, the main quality criteria have been employed (Sealy et al. 2014, 67).

RESULTS AND DISCUSSION

The $\delta^{13}C$ values range from -19.8 to -18.4‰, with a mean of -18.8 ± 0.5‰ (95% CI [-19.2, -18.3], SD = 0.5, 95% CI [0.3, 1.1]), while $\delta^{15}N$ values range from 7.5–9.6‰, averaging 8.6 ± 0.7‰ (95% CI [8.0, 9.2], SD = 0.7, 95% CI [0.5, 1.5]) (Fig. 8; Table 3). These mean values indicate a diet dominated by terrestrial resources, particularly C3 plants, such as wheat and leguminous crops, and animals with C3 plant-based diets. Less negative $\delta^{13}C$ values might suggest limited contributions of C4 plants through direct or indirect consumption, considering the threshold of -19‰ for determination of C4 input suggested by Fuller et al. (2012, 157) for Sagalassos in southwestern Anatolia. The archaeobotanical assemblage at Roman Gordion in the macroregion of Ioulopolis indicates a focus on irrigated wheat agriculture, substituted by hulled barley, as well as presence of foxtail millet (Çakırlar and Marston 2019), which could be a potential C4 source. Variation in $\delta^{15}N$ values may reflect differential access to animal protein, as well as diachronic differences in it, given that this access to animal protein among individuals is reflected by a necropolis that was used over three centuries in the Roman period.[14]

There is no regional dataset for the Ankara province available to substitute for local isotopic baselines. Geographically close faunal isotopic datasets are available for two sites (Çamlıbel and Boğazköy) in the Çorum province, but they come from earlier periods (Pickard et al. 2016, 2017). Sagalassos (Fuller et al. 2012) provides the most comprehensive faunal isotopic dataset (n = 100) for the Roman period (300–450 CE), consisting predominantly of domestic animals (cattle, pig, sheep, and goat). Zooarchaeological research at Roman Gordion falls into a similar pattern, with the assemblage dominated by cattle and sheep/goat bones (Çakırlar and Marston 2019). These data offer a window into local animal consumption diets.

Overall, the isotopic values are similar to those reported from other contemporaneous sites in Anatolia, although Iouliopolis' $\delta^{15}N$ mean is slightly lower compared to most published datasets (Fig. 9; Table 4). It is important to note that only individuals aged between 15 and 44.5 met the collagen quality criteria. Children, older adults, and individuals from simple inhumations and rock-cut cist graves near the church were excluded. Despite this small and selective dataset, some preliminary observations can be made. The two identified adult males have the highest $\delta^{15}N$ values, while the two identified females—a young adult and a young adult/adult—have the lowest. In terms of sex-based $\delta^{13}C$ averages, adult males also exhibit more positive values than young adults and individuals of indeterminate sex (Fig. 10). Individuals of indeterminate sex and age fall between these ranges (Figs. 10–11).

While no sample in the dataset can be qualified as a statistical outlier, two individuals constitute extreme observations (Fig. 8). A young adult female from burial M 164 exhibits both the most negative $\delta^{13}C$ of -19.8‰ (z1 = -2.27) and the lowest $\delta^{15}N$ values of 7.5‰ (z2 = -1.65), suggesting heavy reliance on C3 plants and limited access to animal protein. At the opposite end is an adult male from burial M 116 with $\delta^{13}C$ of -18.4‰ (z1 = 0.87) and the highest $\delta^{15}N$ in the dataset of 9.6‰ (z2 = 1.51), consistent with a potential contribution of C4 input and greater consumption of terrestrial animal protein. When considered alongside burial context, these contrasts reveal no straightforward relationship between diet and funerary treatment. Burial type appears to have little effect on $\delta^{15}N$ values, but $\delta^{13}C$ values

14 See Martyn et al. (2018) for a discussion on a narrower $\delta^{15}N$ distribution at Herculaneum (simultaneous and instantaneous deposition) versus wider distribution of nitrogen values at Velia and Isola Sacra, used for ca. 150 and ca. 300 years, respectively. Other factors may include an analytical error for $\delta^{15}N$ (± 0.4‰) and individual metabolic rate, accounting for variation by up to ± 1‰ (Gaye-Siessegger et al. 2004).

15 See Martyn et al. (2018) for a discussion on a narrower $\delta^{15}N$ distribution at Herculaneum (simultaneous and instantaneous deposition) versus wider distribution of nitrogen values at Velia and Isola Sacra, used for ca. 150 and ca. 300 years, respectively. Other factors may include an analytical error for $\delta^{15}N$ (± 0.4‰) and individual metabolic rate, accounting for variation by up to ± 1‰ (Gaye-Siessegger et al. 2004).

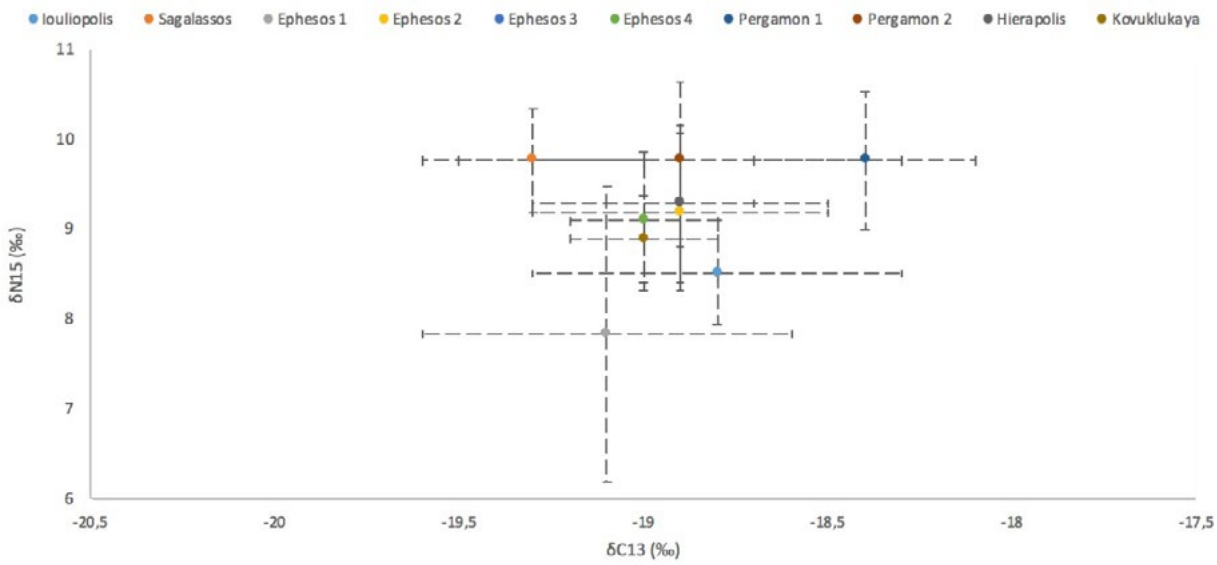

FIG. 9

Comparison of mean $\delta^{13}C$ and $\delta^{15}N$ values from Iouliopolis with contemporaneous mean values in Anatolia.

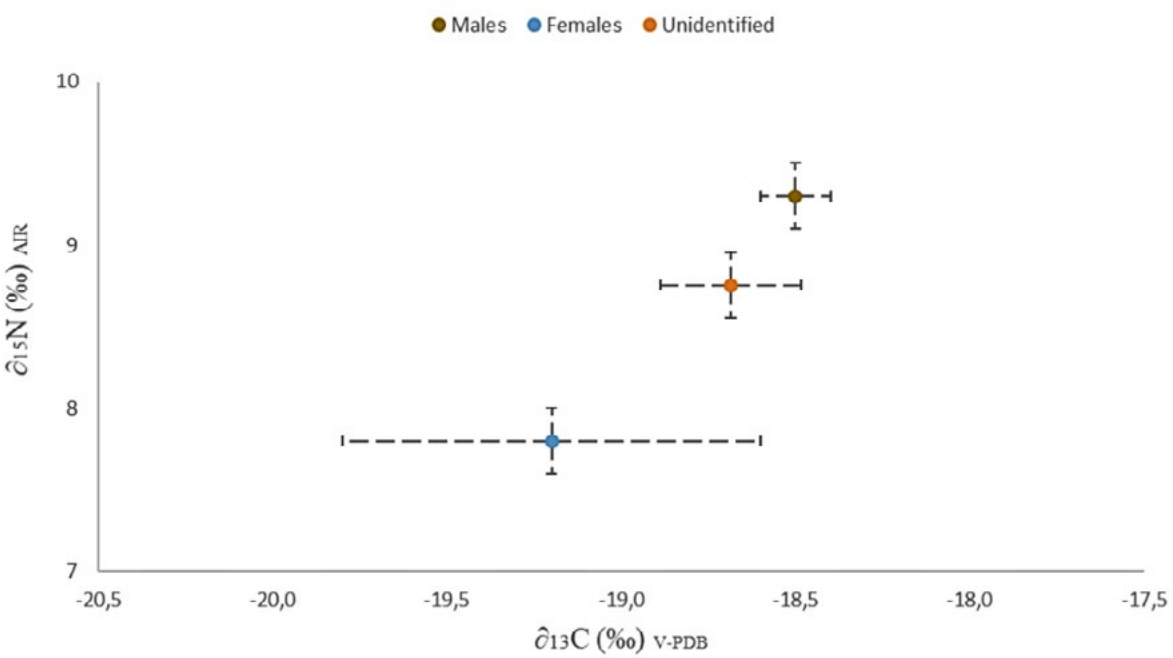

FIG. 10

Scatter plot of $\delta^{13}C$ and $\delta^{15}N$ values by sex.

are slightly higher in individuals from cist graves compared with those from chamber tombs (Fig. 12). Grave goods show no clear correlation with diet, as illustrated by the two extreme observations: the adult male from M 116, who had better access to protein, was buried with a single bronze coin, whereas the young adult female from M 164, whose animal protein consumption appears more restricted, was associated with a comparatively rich burial assemblage including a terracotta jug and bowl, a bronze coin, a silver ring, a single bronze earring, an iron ring, and nine blue glass beads (https://libdigitalcollections.ku.edu.tr/digital/collection/JLP/id/1585/rec/79) (Fig. 13).

These preliminary observations align with broader patterns observed in Roman society, where written sources suggest women and subadults often had more restricted access to animal protein. Comparable isotopic differences have been documented elsewhere in the Roman and Byzantine worlds, for example, at Isola Sacra, Velia, and Herculaneum in Italy; Queenford Farm, Catterick, and Gloucester in Britain; and Jerusalem in the Byzantine Levant (Chenery, Eckardt, and Müldner 2011; Cheung, Schroeder, and Hedges 2012; Craig et al. 2009; Fuller et al. 2006; Martyn et al. 2018; Prowse 2001). At sites such as Herculaneum and Velia, males over 30 show distinct isotopic signals, suggesting that both sex and age could shape dietary access. Explanations for such variation include environmental and socio-cultural factors such as crop failures, seasonal shortages, postmarital residence patterns, gender inequality, and a lower status of children (Garnsey 1999, 49; Katzenberg et al. 1995, 343).

While the limited sample size at Iouliopolis (n = 7) prevents statistically significant conclusions, it lays foundations for further exploring dietary inequality in provincial Anatolia. The study also illustrates the

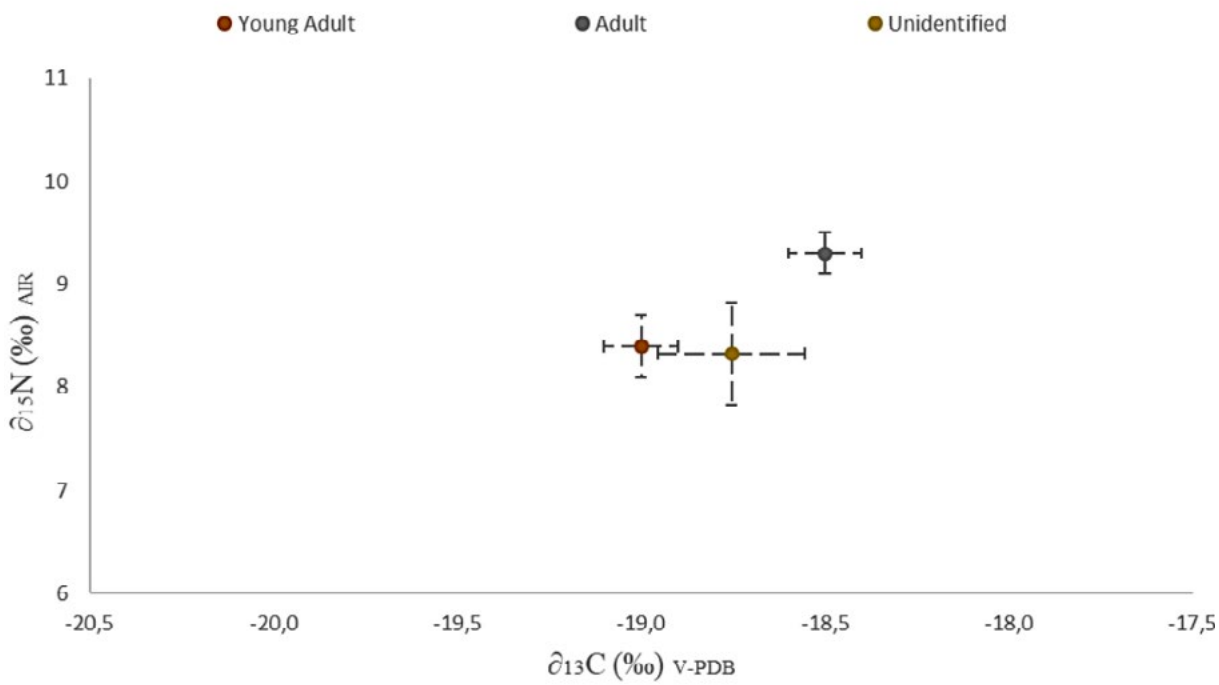

FIG. 11

Scatter plot of $\delta^{13}C$ and $\delta^{15}N$ values by age.

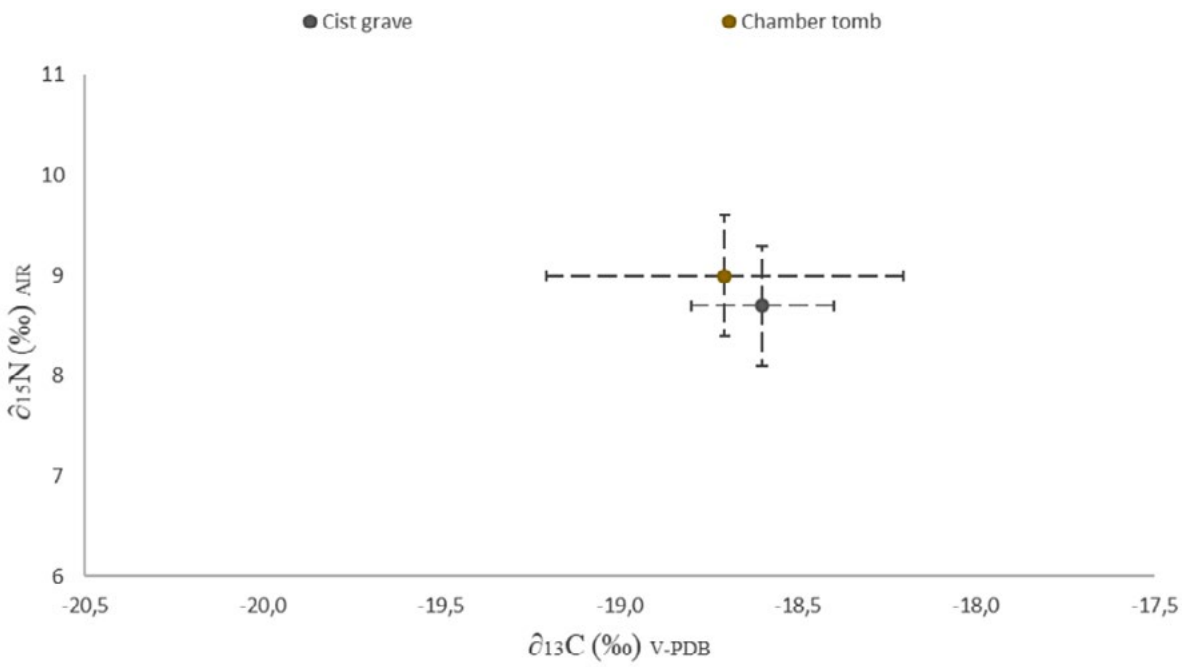

FIG. 12

Scatter plot of $\delta^{13}C$ and $\delta^{15}N$ values by burial type.

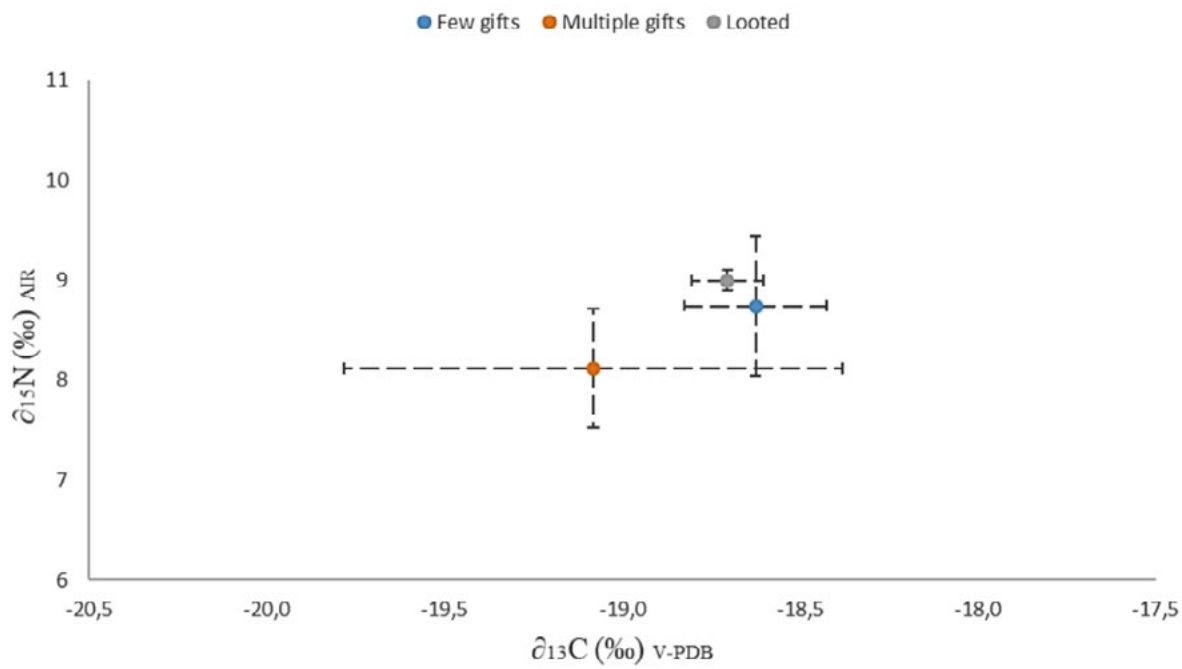

FIG. 13

Scatter plot of $\delta^{13}C$ and $\delta^{15}N$ values by number of grave goods (relative to MNI).

current state of collagen preservation, providing a reference for planning any expanded research of the human bone assemblage from the site in the future. Complementary lines of evidence—ceramic assemblages and isotopic baselines from regional fauna and flora—are needed to strengthen dietary reconstructions and avoid equifinality. Additionally, the riverine nature of the settlement leads to the question of reliance on freshwater fish and the possibility of its detection through stable isotope analysis.

CONCLUSION

This pilot study and the Juliopolis Anthropological Research project in general demonstrate the potential of expanding the scope of inquiry in rescue contexts. The adopted approach moves beyond a commonly narrow focus on funerary customs and material culture to address questions of health, diet, and physical well-being by combining bioarchaeological and archaeological data in a more holistic manner. As the town of Ioulipolis itself remains inaccessible for more comprehensive research, the remaining necropoleis, with their archaeological and anthropological assemblages, provide a crucial window into the lifeways of poorly documented peripheral communities. Given the absence of other isotopic datasets in the Roman provinces of Bithynia and Galatia Prima, the values obtained at the site are foundational to building a regional isotopic dataset for exploration of subsistence strategies and rural agricultural economies in the eastern Mediterranean in the Roman and, potentially, the Byzantine periods.

Despite a small and selective dataset limited by preservation issues, the carbon and nitrogen isotope results indicate that the diets of the individuals in question were dominated by C3 plants and terrestrial animal protein, matching broader patterns observed at other sites in Anatolia. Preliminary indications of potential sex- and age-based dietary differences parallel patterns documented elsewhere in the Roman and Byzantine worlds, thereby highlighting the potential for isotope studies to illuminate inequality in food access among provincial communities, as well as the effect of historical processes on them. The poor preservation of skeletal material constrained the scope of this study, but it also underscores the value of bioarchaeological approaches at rescue sites where traditional palaeobotanical and zooarchaeological evidence is limited. Additionally, this work tested the viability of isotopic data recovered from rescue contexts, offering a crucial framework for planning more comprehensive studies.

The long-term use of the necropoleis at Ioulipolis provides an exceptional opportunity to study diachronic changes in subsistence, health, and mobility. Comparison of tissues with different turnover rates (e.g., bone, teeth enamel, hair) could increase temporal resolution and clarify life-course dietary variation. The relationship between dietary diversity and mobility at the site can be further explored through oxygen and strontium isotope analysis, particularly by comparing dental isotopic values with those from bone. The town's position on the Pilgrim's Road makes such approaches especially promising, as they can help reconstruct regional dynamics over the course of the Roman and Byzantine periods and illuminate how this key route shaped local population structure. Another important avenue of future research is to investigate changes in subsistence strategies and physical well-being that accompanied the advance of the Roman Empire into the region, the adoption of Christianity, and the transition into the Byzantine period. By embedding these lines of evidence within the Juliopolis Anthropological Research framework and the Juliopolis Digital Archaeology Archive (https://librarydigitalcollections.ku.edu.tr/collection/juliopolis/), the Ioulipolis record can support comparative, open-access research while raising the bar for bioarchaeology at rescue sites in Türkiye.

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