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Stable Isotope Evidence for Sex- and Status-Based Variations in Diet and Life History at Medieval Trino Vercellese, Italy

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ABSTRACT The medieval period in Europe was a time of unprecedented social complexity that affected human diet. The diets of certain subgroups—for example, children, women, and the poor—are chronically underrepresented in historical sources from the medieval period. To better understand diet and the distribution of foods during the medieval period, we investigated stable carbon and nitrogen isotope ratios of 30 individuals from Trino Vercellese, Northern Italy (8th–13th c.). Specifically, we examined diet differences between subgroups (males and females, and high- and low-status individuals), and diet change throughout the life course among these groups by comparing dentine and bone collagen. Our results show a diet based on terrestrial resources with input from C_4 plants, which could include proso and/or foxtail millet. Diets of low-status males differ from those of females (both status groups) and of high-status males. These differences develop in adulthood. Childhood diets are similar among the subgroups, but sex- and status-based differences appear in adulthood. We discuss the possibility of cultural buffering and dietary selectivity of females and high-status individuals. Am J Phys Anthropol 148:589–600, 2012.

During the medieval period in Europe, human populations were coping with biological and social stresses including urbanism, climate change, growing socioeconomic differentiation, and increased interconnectedness that facilitated disease transmission, interpersonal interactions, and access to nonlocal technologies and goods (White, 1962; Shahar, 1990; Storey, 1992; Dyer, 1994; Aberth, 2005). The medieval cultural environment impacted human diet, facilitating access to nonlocal foods and food technologies and promoting food disparities along social, economic, and religious hierarchies (e.g., laity and clergy, peasants and the elite, rural and urban dwellers, and men and women; Nada Patrone, 1981; Montanari, 1988; Adamson, 2004).

Much of what is known about medieval diet comes from historical accounts pertaining to the sociopolitical and religious elite. Information about the general populace is less readily available, coming primarily from archaeology and what can be inferred from a limited number of historical accounts. These sources indicate that medieval food access followed strict delineations based on age, sex, and status (Adamson, 2004). However, additional research is needed to shed light on the complex local and transcontinental biocultural factors governing food access and consumption in medieval society. Relatively large skeletal samples from the medieval period enable stable isotope studies to address research questions about diets of both populations and of individuals, through time and between regions, including

- Did diets of high- and low-status individuals differ?
- Were there sex-based differences in diet?
- Did diet change during an individual's lifetime?
- How did diet impact health and fitness for various subpopulations?

In recent years, valuable insights into dietary variations of the general medieval populace have been provided by stable isotope analyses of human skeletal remains with known sex, age, and, in some cases, status. Stable carbon and nitrogen isotope signatures measured in bone collagen reflect a composite of the isotope signatures of foods consumed during an individual's lifetime and are a widely used tool in anthropology for reconstructing past human diet [for a recent review, see Schoeninger (2011)]. Stable isotope studies of medieval Europe have focused on diet change through time (Müldner and Richards, 2007), weaning (Richards et al., 2002; Fuller et al., 2003), sex-based differences in diet (Richards et al., 2006; Kjellström et al., 2009; Nitsch and Hedges, 2010; Reitsema et al., 2010), and status-based differences in diet (Schutkowski et al., 1999; Czermak et al., 2006; Kjellström et al., 2009; Müldner et al., 2009). These studies underscore the dynamic ways in which culture and circumstance affected food access

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during the medieval period. Regional variation in diet during the medieval period is impressive, and more research is needed to understand specific biocultural adaptations and overall dietary variation at both transcontinental and local scales.

Beyond basic diet reconstruction, an important contribution of stable isotope analysis is the reconstruction of diet change over the life course using stable isotope signatures from different components of the skeleton. Previous stable isotope research has capitalized on the fact that different parts of the skeleton either form at different ages (e.g., teeth vs. bones) or model and remodel at different rates (e.g., cortical vs. trabecular bone) and thus represent different time periods in an individual's life. With the entire human skeleton functioning as a storehouse of information throughout the life course, mobility, ancient weaning practices, and diet change during an individual's lifespan can be studied (Sealy et al., 1995; Balasse et al., 1999; Bell et al., 2001; Richards et al., 2002; Fuller et al., 2003; Herrscher, 2003; Linderholm et al., 2008a; Salamon et al., 2008; Jørkov et al., 2009; Berger et al., 2010; Nitsch et al., 2011). Thanks to the ability to study childhood diet using the skeletal remains of adults (i.e., children who *lived*, rather than children who died), stable isotope biochemistry is uniquely well-suited to circumvent the osteological paradox and explore life history of past populations. When applied to a period of intense cultural change and social pressure such as the European medieval period, bone biochemistry can provide insights on social inequality and food access throughout an individual's lifetime.

Because of its well-documented social stratification and excellent preservation, the medieval population from Trino Vercellese, Italy, is ideally suited for this kind of investigation. Few medieval samples exist that permit such clear identification of different status groups, nor which are accompanied by such rich archaeological information supporting proper interpretation of the results, nor for which such extensive paleopathological and growth data are available. To interpret stable isotope results, it is fundamental to have as much biocultural information on the population as possible. Trino Vercellese is a rare site where such data—including palynology, archeozoology, archeobotany, demography, pathology, and material culture analyses—are available.

GOALS

The first goal of this research is to reconstruct diet of a socioeconomically diverse medieval population at Trino Vercellese to shed light on the complex dynamics of food access in medieval society. Most previous stable isotope research in Italy focuses on the Roman period (Prowse et al., 2004, 2005, 2007; Craig et al., 2009; Rutgers et al., 2009; Crowe et al., 2010; Nitsch and Hedges, 2010) with a limited number of reports from the Bronze Age, Neolithic, and medieval periods (Le Bras-Goude et al., 2006; Salamon et al., 2008; Tafuri et al., 2009; Nitsch and Hedges, 2010). Beyond reconstructing diets, we also investigate sex- and status-based differences in diet and diet change between childhood and adulthood using dentine and bone collagen in tandem. Where relevant, we also consider the relationship between diet and paleopathology, drawing from previous research at Trino Vercellese (Celoria, 1999; Girotti and Garetto, 1999; Vercellotti et al., 2011).

Stable isotopes in anthropological diet reconstructions

Stable isotope analysis has become a widespread technique in anthropology for reconstructing past human diet since its initial applications in the 1970s (Vogel and van der Merwe, 1977; van der Merwe and Vogel, 1978). Stable carbon and nitrogen isotopes provide differing and complementary information about human diet (Schoeninger, 2011). In general, stable carbon isotopes reflect the local ecosystem of a consumer and consumption of aquatic versus terrestrial foods, whereas stable nitrogen isotopes provide information about an animal's trophic position (Vogel and van der Merwe, 1977; Minawaga and Wada, 1984; Schoeninger and DeNiro, 1984). Because collagen is formed from amino acids, stable isotope signatures from collagen primarily reflect protein sources in the diet (Ambrose and Norr, 1993; Tieszen and Fagre, 1993). For a more detailed discussion of stable isotopes in anthropology, a number of excellent reviews are available (Katzenberg, 2000; Ambrose and Krigbaum, 2003; Schoeninger, 2011).

Mineralized tissue remodeling

Stable isotope ratios of foods are preserved in the bone chemistry of consumers, yet bone is not a static reservoir of these chemical signatures. Rather, bone is a dynamic tissue that changes during life in response to stress. As a result of bone modeling (the formation of new bone in response to mechanical loading) and remodeling (the maintenance replacement and repair of bone), much of the bone collagen formed in younger years disappears with time, and the skeleton is composed of increasingly more "new" bone. Different skeletal elements exhibit different remodeling rates in relation to their mechanical loading and microarchitecture (Stout and Lueck, 1995), indicating that remodeling rates are higher among "active" individuals. Unlike bone, enamel and dentine do not remodel during life, and isotopic signatures in these substrates record information about childhood diet (with the exceptions of secondary and tertiary dentine). Comparing stable isotope signatures in dentine and bone from a single adult has thus the potential to reveal diet change or residential relocation during an individual's lifespan (Balasse et al., 1999; Fuller et al., 2003; Salamon et al., 2008; Berger et al., 2010; Chenery et al., 2010).

MATERIALS

The medieval population from Trino Vercellese

This study includes skeletal materials from the medieval site of Trino Vercellese (VC), Italy. This site complex is located in the Piedmont region and consists of a fortified settlement that developed around San Michele's church and its cemetery (Fig. 1). Starting around the 8th c. and until the 13th c. AD, due to obligatory interment in its grounds of all individuals belonging to the parish, the church of San Michele became the funerary epicenter of the area surrounding Trino Vercellese. Excavations carried out by the University of Torino between 1980 and 1994 led to the recovery of a total of 749 burials located inside and outside the church (Mancini, 1999). The majority of the burials (n = 688) dated to the medieval period (8th–13th c.), while a minority of the burials recovered inside the church was postmedieval

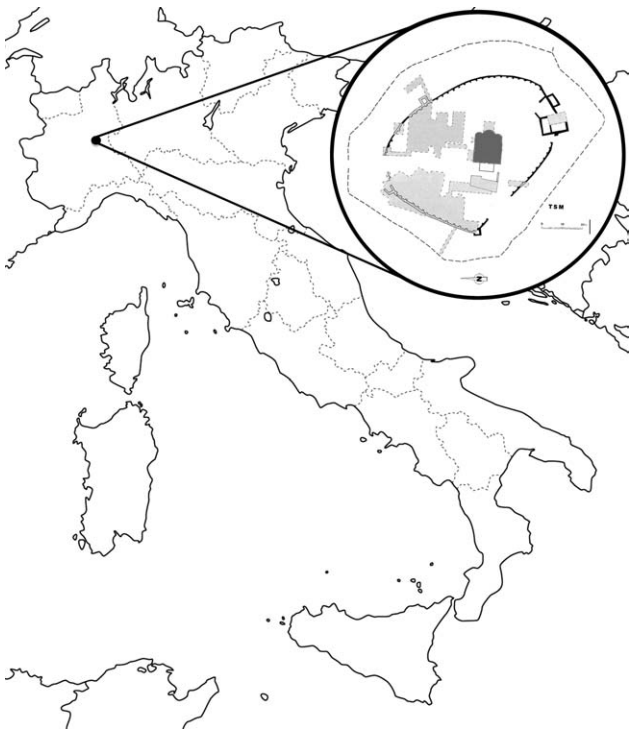

Fig. 1. Map of Italy showing the location of Trino Vercellese (black solid circle) and the planimetry of the site [modified from Mancini (1999)]. In the map of the site, the dark gray area represents the church of San Michele, the light gray area represents the cemetery outside the church, and the black line indicates the fortification walls.

(14th c.). Among the medieval burials, 585 (85%) were adults and 103 (15%) were juveniles. Based on the demographics of the adult cemetery, the skeletal collection is considered to be a representative sample of Trino Vercellese's adult inhabitants during the medieval period (Mancini, 1999; Vercellotti et al., 2011). Furthermore, it has been advanced that the skeletal sample recovered from Trino is representative of the socioeconomic variation expressed by the population during the medieval period. Several lines of evidence suggest that groups of different social status were buried in different areas of San Michele's cemetery, supported by differences in (1) burial location, (2) burial typology, and (3) grave good typology [for a detailed review of this evidence, see Vercellotti et al. (2011)].

Extensive archaeological, archaeozoological, palaeobotanical, and anthropological studies have been carried out on the site, allowing for an extremely detailed reconstruction of environmental conditions and lifestyle of the medieval population inhabiting Trino Vercellese (Accorsi et al., 1999; Aimar et al., 1999; Caramiello et al., 1999; Celoria, 1999; Ferro, 1999; Girotti and Garetto, 1999; Mancini, 1999; Porro et al., 1999). Overall, this research indicates that throughout the medieval period, the area surrounding Trino Vercellese was characterized by hardwood forests, the extension of which was progressively reduced by anthropic deforestation in favor of pastures and crops (Caramiello et al., 1999). Primary crops were represented by cereals, legumes, and aromatic plants (*Umbelliferae*; Accorsi et al., 1999). The local economy was centered on livestock breeding, destined not only for local consumption but also for regional trade. Faunal remains at the site indicated that the most abundant domestic species were swine, cattle, and sheep/goats, followed by horses and domestic fowl (Ferro, 1999). Based on butcher marks and age-at-death profiles, it was determined that swine and cattle were mostly bred for meat and hides, while sheep and goat were primarily a source of wool and milk (Aimar et al., 1999). The consumption of wild ungulates, primarily red deer (*Cervus elaphus*) and roe deer (*Capreouls capreouls*) also was commonplace, because these animals were sought for their antlers and hides. Fish remains are also documented, although aquatic resources were probably not a major component of the everyday diet.

Anthropological analyses suggested that the medieval population from Trino Vercellese experienced relatively good living conditions, without major growth disruption and with an overall varied and rich diet (Celoria, 1999; Girotti and Garetto, 1999; Porro et al., 1999). This notwithstanding, sex and status-based differences in somatic growth and oral health were observed (Porro et al., 1999; Vercellotti et al., 2011), suggesting underlying sociocultural differences in terms of access to resources and exposure to disease.

We sampled collagen from teeth and bones of 30 (20 males; 10 females) adult individuals from medieval Trino Vercellese, for a total of 60 samples for isotopic analyses. Because accurate knowledge of age, sex, and status is absolutely essential for exploring complex food dynamics in medieval society, and thus for accomplishing our goals, we adopted strict selective criteria for identifying suitable individuals to be included in this study. Specifically, selection was based on (1) skeletal completeness, defined in terms of preservation of at least 70% of the skeleton—based on this criterion, 52 skeletons from well-defined, individual burials for which accurate information on sex, age, and status were available for the analysis; (2) availability of both ribs and second molars (M2)—based on this criterion, a total of 37 skeletons were suitable for sampling; (3) minimal dental wear—so as to avoid issues related to sampling of secondary and tertiary dentine, all individuals whose M2s were extremely worn or affected by carious lesions could not be included, reducing our sample to 32. Of the 32 skeletons meeting all selective criteria, we chose 30 individuals so as to equally represent the different status groups. With these strict selection criteria, data from all 30 individuals can contribute to broader parallel investigations into not just diet, but also health and nutrition at Trino Vercellese.

To represent both sexes and status groups equally, a similar number of high and low-status burials were sampled, based on availability of suitable individuals: (1) high status (4 females, 10 males) and (2) low status (6 females, 10 males). Status groups were determined based on burial location and typology, and the presence of grave goods, as described in detail elsewhere (Vercellotti et al., 2011). Sex and age-at-death of all individuals were estimated from sexually dimorphic features of the pelvis (Phenice, 1969; Buikstra and Ubelaker, 1994), morphological alterations of the os pubis' articular surface (Brooks and Suchey, 1990), and the ilium auricular surface (Lovejoy et al., 1985). Age-at-death of all individuals for all individuals fall between 20 and 55 years. The age structures of the four subsamples show no significant difference (Kruskal–Wallis, $P = 0.51$).

TABLE 1. Comparative fauna used for a dietary baseline

Sample	δ^{15}N [‰]	δ^{13}C [‰]	Reference
Southeastern France; medieval	4.9 ± 1.0	−20.8 ± 0.6	Eleven animals (cow, pig, sheep, goat, chicken; Herrscher et al., 2001)
Northern Italy; Bronze Age			
Olmo di Nogara	6.4 ± 1.0	−16.6 ± 1.2	Three animals (cow, pig, goat; Tafuri et al., 2009)
Mereto	4.5	−20.5	One cow (Tafuri et al., 2009)

METHODS

Sample collection and preliminary treatment

To investigate diet change over the lifetime at Trino Vercellese, we examined stable carbon and nitrogen isotope values from cortical bone of a rib along with a tooth for each individual included in the study. Subsequent identification numbers for individuals are given as the burial number, tooth or bone initial, and sex initial (e.g., S-133-T-M, a tooth from the male individual #133). We chose to sample M2, which form between 3.7 and 6.7 years of age on average (Moorrees et al., 1963), to provide information on diet during childhood. Medieval records indicate a recommended weaning age of 2 years (Shahar, 1990), which has been supported by stable isotope studies (Richards et al., 2002); thus, the isotopic signature of M2 is expected to reflect postweaning childhood diets at Trino Vercellese. The majority of teeth sampled were still in situ in the alveolar bone. Mandibular M2 were sampled preferentially, and from the left side, when possible; if absent, maxillary M2 were sampled. Casts were made of all teeth before preparing them for isotopic analysis.

Each tooth was prepared by resecting the root at the cementoenamel junction using a Piezosurgery® 3 device (Piezosurgery Incorporated, Columbus, OH). This technology uses modulated ultrasonic frequencies to cut mineralized tissues with extreme precision while respecting soft tissues. This technology was selected, because it allows resecting and scraping samples with extreme precision and safety for the operator. Upon removal of the root, crowns were sectioned in four pieces, and any secondary dentine lining the pulp cavity (easily recognized due to its darker color) was entirely removed using an ultrasonically operated scraper. No special effort was made to remove the enamel, although it chipped in some cases and was then removed.

Preparation of samples for isotopic analysis

Between 0.30 and 1.00 g of whole tooth and rib pieces were demineralized in 1% HCl, rinsed, and soaked in 0.125 M NaOH to remove humic contaminants (Richards and Hedges, 1999; Garvie-Lok, 2001). In most cases, structural integrity of bone and dentine pieces was preserved, but, in two cases (S-424-B-M and S-535-B-F), the model had crumbled into debris during chemical leaching. Bone and dentine pieces were rinsed, dissolved overnight in dilute HCl (pH = 3) in a 90°C oven, centrifuged, and freeze-dried. Weights of dried bone collagen were obtained to estimate collagen concentration in bone (%coll). In one case (S-41-B-M), a small amount of sample leaked from the vial during lyophilization, so its actual %coll is somewhat greater than the 3.3% measured. In another case (S-68-B-M), the amount of collagen remaining was less than the tare of the scale used (<0.01 g) indicating a problem with the initial weight obtained, and %coll can only be estimated at less than 3.2%.

Dried collagen was homogenized using an agate mortar/pestle. Between 0.600 and 0.700 mg of powdered dentine/bone collagen for each sample was analyzed on a Costech Elemental Analyzer coupled to a Finnigan Delta IV Plus stable isotope ratio mass spectrometer under continuous flow using a CONFLO III interface in the Stable Isotope Biogeochemistry Laboratory at The Ohio State University. Approximately 10% of all samples were run in duplicate. Stable carbon (δ^{13}C = permil deviation of the ratio of ^{13}C:^{12}C relative to the Vienna Peedee Belemnite Limestone standard) and stable nitrogen (δ^{15}N = permil deviation of ^{15}N:^{14}N relative to AIR) isotope measurements were made where the average standard deviation of repeated measurements of the USGS-24, IAEA-N1, and IAEA-N2 standards were 0.05‰ for δ^{13}C and 0.13‰ for δ^{15}N. Stable isotope ratios are expressed as a permil (‰) ratio of one of an element's isotopes to another in relation to a standard of known abundance (Vienna Pee Dee Belemnite for δ^{13}C and AIR for δ^{15}N). Both carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotope ratios are reported according to the equation [$\delta = (R_{\text{sample}} - R_{\text{standard}})/R_{\text{standard}} \times 1{,}000$].

Animal bones were not made available and consequently were not directly sampled for this study. Instead, a faunal baseline is estimated using two previously published samples (Table 1). The first sample comprises 11 animals (cow, pig, sheep, goat, chicken) from an inland medieval site from Grenoble, Isère (France) located ~ 250 km due west of Trino (Herrscher et al., 2001). The second comprises four animals (cow, pig, goat) from two Bronze Age sites in Northern Italy (Tafuri et al., 2009).

Statistical analyses

To evaluate and compare stable isotope signatures among sex and status subsamples, we used the Mann–Whitney or Kruskal–Wallis tests, depending on the number of subsamples being compared. These nonparametric tests are preferable to the parametric ANOVA, because they are applicable even when the distribution of the data departs from normality (Zar, 1999). Statistical analyses were performed with MYSTAT Software. In the following sections, *P*-values are considered statistically significant if less than or equal to 0.05.

RESULTS

Sample quality

To evaluate diagenesis, five measurements are considered (1) carbon content in collagen (%C), (2) overall nitrogen content in collagen (%N), (3) atomic carbon to nitrogen (C:N) ratios calculated as C:N = [(%C/12)/(%N/14)], (4) collagen content in bone (%coll; not measured in dentinal collagen due to variable amounts of enamel affecting initial weights), and (5) preservation of a colla-

TABLE 2. Stable isotope medians and ranges for four demographic subgroups

	δ^{15}N (‰)				δ^{13}C (‰)			
	Dentine		Bone		Dentine		Bone	
Subgroup	Median	Range	Median	Range	Median	Range	Median	Range
Males (n = 19)	9.5	8.0–12.0	8.8	8.1–11.8	−19.4	−20.0 to −17.6	−18.9	−19.9 to −17.4
High-status (n = 10)	9.4	8.9–10.4	9.2	8.6–10.3	−19.5	−19.6 to −18.2	−19.3	−19.9 to −18.5
Low-status (n = 9)	9.6	8.0–12.0	8.4	8.1–11.8	−19.1	−20.0 to −17.6	−18.5	−19.3 to −17.4
Females (n = 9)	9.2	6.7–10.3	9.2	9.0–10.5	−19.4	−20.1 to −18.5	−19.5	−19.9 to −19.1
High-status (n = 4)	9.2	9.0–9.2	9.3	9.1–10.5	−19.3	−19.9 to −18.5	−19.8	−19.9 to −19.4
Low-status (n = 5)	9.5	6.7–10.3	9.1	9.0–9.4	−19.4	−20.1 to −18.6	−19.3	−19.8 to −19.1

gen model of the original bone piece(s) following the HCl and NaOH components of sample preparation. Details on the rationale for acceptable ranges for these measurements are described elsewhere in greater detail (Ambrose, 1990; Garvie-Lok, 2001). With the exception of two bone samples, all bone and tooth samples show little or no signs of diagenetic alterations. Sample S-424-B-M did not yield an intact collagen model, exhibited low %C (3.7%), low %N (0.7%), and a very high C:N value of 6.1. Sample S-535-B-F also did not yield an intact collagen model, exhibited a relatively high C:N value of 3.7, and yielded a %coll value of just 1.00%. Sample S-535-B-F yielded only the %coll value to fall below a threshold level of 2% described by Ambrose (1990). These two bone samples are excluded from further analyses, although the dentine values from these individuals are included where possible.

For the 58 remaining bone and tooth samples, C:N ratios range from 3.2 to 3.5. Collagen concentration in bone (%coll; only measured for bone) falls between 2.6 and 22.5%. For bones, %N values fall between 2.8 and 14.8%, and %C values fall between 8.4 and 41.8%. For teeth, elemental concentrations are generally higher and show more restricted ranges: tooth %N ranges from 13.1 to 15.9% and tooth %C ranges from 29.1 to 43.7%. Two samples have %N and %C values below the "well-preserved" values of 4.8 and 13.0%, respectively, for prehistoric bones reported by Ambrose (1990; S-134-B-M and S-57A-B-M). However, both exhibit acceptable C:N and %coll values and yielded intact collagen models and are not excluded from subsequent analyses. There are no correlations between any of the collagen quality indicators (except %C and %N, as expected), indicating that diagenetic alteration of stable isotope signatures in the sample is minimal. Collagen quality indicators for all individuals, including the two whose bone data were excluded on the basis of poor collagen quality (demarcated), are reported in Table S1 along with stable isotope data.

Seven duplicates (four bones and three teeth) of the same collagen powder were analyzed to estimate a margin of analytical error. Within this margin of error, differences in stable isotope signatures may not be reliably interpreted as biologically meaningful. For δ^{15}N, the maximum difference between two duplicates was 0.7‰, and the mean difference was 0.3‰. For δ^{13}C, the maximum difference between two duplicates was 0.1‰, and the mean difference was less than 0.1‰. Both the mean and the maximum differences between duplicates to represent margins of error are shown in figures in the following sections.

Stable isotope results

Overall, δ^{15}N values in dentine ($\delta^{15}N_{dentine}$) ranged from 6.7 to 12.0‰ (mean = 9.4 ± 0.9‰) and in bone ($\delta^{15}N_{bone}$) ranged from 8.1 to 11.8‰ (mean = 9.2 ± 0.8‰). δ^{13}C values in dentine ($\delta^{13}C_{dentine}$) ranged from –20.1 to –17.6‰ (mean = –19.2 ± 0.7‰) and in bone ($\delta^{13}C_{bone}$) ranged from –19.9 to –17.4‰ (mean = –19.1 ± 0.7‰). A complete data set is presented in Table S1. Summary data, including medians and dispersion (range) for each of the four subgroups in accordance with the nonparametric statistics used, are presented in Table 2.

Dentine. Dentine stable isotope values are presented in Figure 2 divided into sex and status groups. For the pair-wise comparisons among subgroups using the Mann–Whitney U test statistic, Table 3 displays P-values, with statistically significant values (P = 0.05) appearing in bold. The $\delta^{15}N_{dentine}$ ratios did not differ significantly by sex (males: 9.5 ± 0.9‰; females: 9.1 ± 1.0‰; P = 0.481). The $\delta^{13}C_{dentine}$ ratios also did not differ significantly by sex (males: –19.1 ± 0.7‰; females: –19.3 ± 0.6‰; P = 0.367).

Neither $\delta^{13}C_{dentine}$ nor $\delta^{15}N_{dentine}$ ratios differ significantly by status, when males and females are grouped together in status groups. The mean $\delta^{15}N_{dentine}$ value of high-status individuals is 9.4 ± 0.4‰ compared to 9.3 ± 1.2‰ for low-status individuals (P = 0.724). Despite no statistically significant differences, all the lowest dentine $\delta^{15}N_{dentine}$ values are exhibited by low-status individuals. Also, dentine of high-status individuals shows a much narrower δ^{15}N range (9.0–10.4‰) than dentine of low-status individuals (6.7–12.0‰). The mean $\delta^{13}C_{dentine}$ value of high-status individuals is –19.2 ± 0.5‰ compared to –19.1 ± 0.8‰ for low-status individuals (P = 0.724). The range of $\delta^{13}C_{dentine}$ values is also narrower for high-status individuals than for low-status individuals, although not to the same extent as for $\delta^{15}N_{dentine}$.

When status groups are further divided by sex, there are no significant differences between dentine stable isotope values of high- versus low-status females or between high- versus low-status men. Lack of statistical significance could be due to the small female subsample sizes, although the overall variation among females is also small and, excepting one high-δ^{15}N outlier (S-48A-F; δ^{15}N = 10.5‰), all female values are within the maximum margin of error for duplicate analyses.

Bone. Bone stable isotope values are presented in Figure 3 and divided into sex and status groups. The δ^{15}N values of bones ($\delta^{15}N_{bone}$) did not differ significantly by sex. The mean $\delta^{15}N_{bone}$ value for males was 9.1 ± 0.9‰ and for females was 9.3 ± 0.5‰ (P = 0.134). However, $\delta^{13}C_{bone}$ did differ significantly by sex, with males exhibiting on average higher values: –18.8 ± 0.7‰ compared to –19.6 ± 0.3‰ for females (P = 0.005).

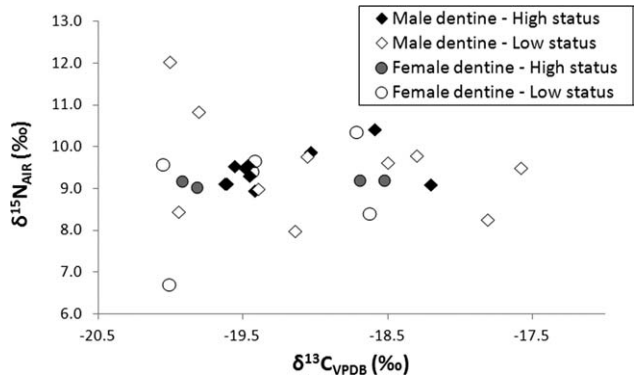

Fig. 2. Stable isotope data from dentine of M2, representing childhood diet, of the four subgroups investigated (high- and low-status men and women).

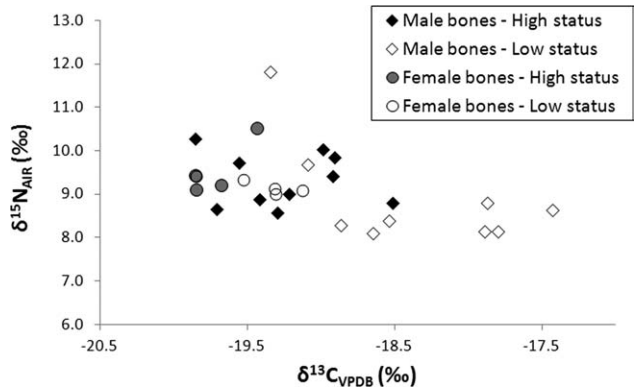

Fig. 3. Stable isotope data from bone collagen (rib), representing adult diet, of the four subgroups investigated (high- and low-status men and women).

There are differences in both δ^{15}N and δ^{13}C of bones of high- and low-status individuals (males and females grouped together). The mean $\delta^{15}N_{bone}$ value for high-status individuals is 9.4 ± 0.6‰, compared to 9.0 ± 1.0‰ for low-status individuals ($P = 0.060$). The mean $\delta^{13}C_{bone}$ value of high-status individuals is –19.4 ± 0.4‰ compared to –18.8 ± 0.8‰ for low-status individuals ($P = 0.024$).

When considering each sex separately, bones of high- and low-status females do not differ significantly in either δ^{15}N ($P = 0.133$) or δ^{13}C ($P = 0.221$), although the female subsamples are admittedly small. However, high-status males exhibit significantly higher $\delta^{15}N_{bone}$ ($P = 0.034$) and significantly lower $\delta^{13}C_{bone}$ ($P = 0.009$) values than do low-status males.

When considering each status group separately, sex-based differences in bone stable isotope ratios are most pronounced among low-status individuals. In both status groups, females exhibit lower $\delta^{13}C_{bone}$ values than do males, but the difference is most pronounced among low-status individuals (low-status males versus females, $P = 0.009$, compared to $P = 0.066$ for high-status male versus female individuals). With one exception (S-408-B-M; low δ^{13}C), there is no overlap between $\delta^{13}C_{bone}$ values of males and females among the low-status individuals, whereas there is considerable overlap between high-status males' and females' $\delta^{13}C_{bone}$ values (Fig. 3).

Comparing Figures 2 and 3, there appears to be evidence that childhood diets were more variable than adult diets, particularly for individuals of low status. The $\delta^{15}N_{dentine}$ values show greater dispersion than do $\delta^{15}N_{bone}$ values, although this is mostly the effect of a single low-$^{15}N_{dentine}$ outlier (S-528-F; $\delta^{15}N = 6.7‰$). When this individual is removed, the δ^{15}N ranges of the overall sample are nearly the same (dentine: 8.0–12.0‰; bone: 8.1–11.8‰). The δ^{13}C ranges of dentine and bone are also nearly the same (dentine: –20.1 to –17.6‰; bone: –19.9 to –17.4‰).

Dentine-bone spacing relationships. Figures 4 and 5 display the difference between teeth and bones from the same individual, as calculated by subtracting the bone stable isotope value from the dentine value. On average, the $\delta^{15}N_{dentine}$-$\delta^{15}N_{bone}$ (δ^{15}N) absolute values of low-status individuals are greater and more variable than δ^{15}N absolute values of high-status individuals. The mean δ^{15}N absolute value of low-status individuals is 0.8 ± 0.9‰, whereas the mean absolute value of high-status individuals is just 0.4 ± 0.4‰ ($P = 0.346$). The same is true for δ^{13}C: the mean $\delta^{13}C_{dentine}$-$\delta^{13}C_{bone}$ (δ^{13}C) difference of high-status individuals is 0.5 ± 0.4‰ and of low-status individuals is 0.7 ± 0.7‰ ($P = 0.535$). The δ differences between high- and low-status groups are the product of a few high-δ outliers within the low-status subgroup and are not statistically significant.

The direction of these dentine-bone stable isotope shifts throughout life is depicted in Figures 4 and 5. In each of these figures, dashed lines above and below the main axis represent the mean δ difference obtained for all duplicate analyses, and solid lines above and below the main axis represent the maximum difference obtained for all duplicate analyses.

Bones of younger individuals should retain relatively more collagen from childhood than bones of older individuals, whose bones are more highly remodeled. However, there is no correlation between age and either δ^{15}N ($R^2 = 0.0443$) or δ^{13}C ($R^2 = 0.0585$), suggesting that bone had remodeled enough even by the youngest ages of 20 to record an adult diet that differed from childhood diet, as expected (Hedges et al., 2007).

TABLE 3. Results of pair-wise comparisons using the Mann–Whitney U test statistic

Sex and status comparisons	Dentine		Bone	
	δ^{15}N	δ^{13}C	δ^{15}N	δ^{13}C
Males versus females—status groups combined	$P = 0.481$	$P = 0.367$	$P = 0.134$	***P* = 0.005**
High status—males versus females	$P = 0.322$	$P = 0.671$	$P = 0.396$	$P = 0.066$
Low status—males versus females	$P = 0.588$	$P = 0.193$	$P = 0.096$	***P* = 0.009**
High status versus low status—sexes combined	$P = 0.724$	$P = 0.724$	$P = 0.060$	***P* = 0.024**
High status versus low status—males	$P = 0.970$	$P = 0.496$	***P* = 0.034**	***P* = 0.009**
High status versus low status—females	$P = 0.394$	$P = 0.522$	$P = 0.221$	$P = 0.133$

Highlighted P values are significant at the 0.05 level

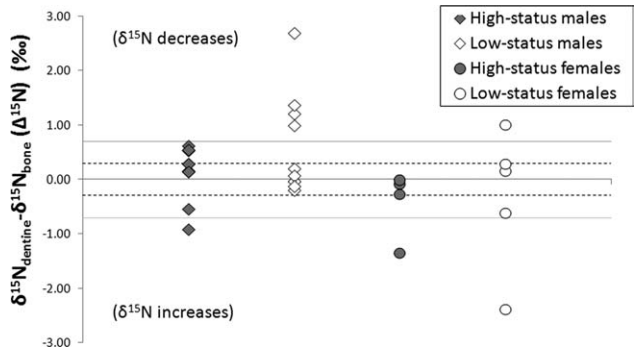

Fig. 4. Differences between $\delta^{15}N$ values obtained from teeth and bones of each individual, divided into four subgroups (high- and low-status men and women). The solid line represents the maximum difference between two $\delta^{15}N$ duplicates (0.7‰), and the dashed line represents the mean difference between two $\delta^{15}N$ duplicates (0.3‰). Negative $\delta^{15}N$ values represent an increase in $\delta^{15}N$ between childhood and adulthood, whereas positive $\delta^{15}N$ values represent a decrease in $\delta^{15}N$.

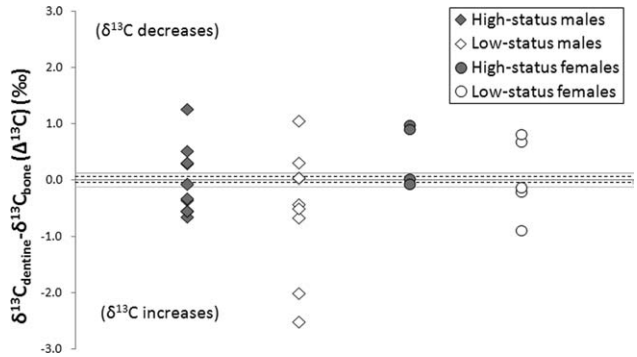

Fig. 5. Differences between $\delta^{13}C$ values obtained from teeth and bones of each individual, divided into four subgroups (high- and low-status men and women). The solid line represents the maximum difference between two $\delta^{13}C$ duplicates (0.12‰), and the dashed line represents the mean difference between two $\delta^{13}C$ duplicates (0.05‰). Negative $\delta^{13}C$ values represent an increase in $\delta^{13}C$ between childhood and adulthood, whereas positive $\delta^{13}C$ values represent a decrease in $\delta^{13}C$.

DISCUSSION

Diet

Stable isotope data support an interpretation of a terrestrial-based diet including both plant and animal protein. Compared to the faunal baseline, human $\delta^{15}N$ values are generally consistent with one trophic level of enrichment. The human data are most similar to results reported by Richards et al. (1998) for wood-coffin burials in the Roman period cemetery at Poundbury, UK (n = 26) (Fig. 6), which were interpreted as indicating a terrestrial C_3 diet. There is little evidence for fish consumption. All individuals exhibit $\delta^{15}N$ values lower than 12.5‰, a terrestrial–marine cutoff used by Salamon et al. (2008) for a medieval sample from Rome. This is perhaps not surprising, as Trino Vercellese is an inland site. Freshwater fish may have been reasonably accessed by the population in local streams, but the archaeological and stable isotope evidence for freshwater fish consumption is not strong (Ferro, 1999). Rutgers et al. (2009) evoke freshwater fish consumption for individuals in 3rd–5th c. Roman catacombs whose $\delta^{15}N$ values are higher than 11.5‰ and whose $\delta^{13}C$ ratios are lower than –19.5‰. None of the individuals in the present study exhibit values such as these. In the recent years, there has been a growing appreciation for the complexity of aquatic isotope environments and the fact that fish from both marine and freshwaters may exhibit isotope values similar to those of terrestrial animals (Katzenberg et al., 2010; Bourbou et al., 2011). Although the evidence is not strong, in the present study, the wide range in $\delta^{15}N$ values within a relatively narrow range of $\delta^{13}C$ values (–19.5 to –20.1‰) could suggest that people were eating small amounts of fish with $\delta^{15}N$ values of $\sim$ 6–9‰ and $\delta^{13}C$ values similar to those of terrestrial animals, such as have been reported previously for the Mediterranean region and some freshwaters (Grupe et al., 1999; Prowse et al., 2004; Keenleyside et al., 2006; Reitsema et al., 2010; Bourbou et al., 2011). Detecting fish such as these in human diet remains a challenge in stable isotope studies (e.g., Privat et al., 2002; Müldner and Richards, 2005).

The paucity of fish in diet in the present study is noteworthy. At this time in Europe, Christian fasting regulations provided an impetus to replace protein from terrestrial animals with fish (Woolgar, 2000). Fish are documented to increase in diet with Christianity elsewhere in Italy and Europe and may be more common in diets of the clergy than of the general populace (Polet and Katzenberg, 2003; Barrett and Richards, 2004; Salamon et al., 2008; Müldner et al., 2009; Rutgers et al., 2009). Even among bones of high-status individuals at Trino Vercellese buried in the church, there is no compelling evidence for fish consumption. Although fish were sometimes considered a luxury in medieval Europe, in other cases, they were regarded as an undesirable food or a marker of low status (Ervynck et al., 2003; Van Neer and Ervynck, 2004). In this regard, it is interesting to notice the cultural belief in medieval Northern Italy that fish from stagnant bodies of water were to be avoided, as they were considered unhealthy (Nada Patrone, 1981). In an area containing many smaller slow moving fluvial branches and ditches, yet lacking major streams and rivers such as medieval Trino Vercellese, fish would therefore have been marginally exploited as a food source. This seems to be corroborated by the paucity of fish remains from the site (Ferro, 1999). The only fish remains recovered in Trino belong to the northern pike (*Esox lucius*), a fish locally found in slow-moving riverine environment, the consumption of which was likely not advisable by Piedmont medieval cultural dietary beliefs. In light of this, Christian fasts may not have been rigidly observed. Based on the complex medieval ideology centered on meat consumption as a status symbol (Montanari, 1988), it is plausible that high-status individuals did not abstain from consuming animal meat despite Church directives. According to Montanari (1988), even members of the clergy—as high profile elites themselves—would have had social and political reasons not to observe Christian fasts. It is also possible that while meat from terrestrial animals was eschewed during fasts, it was replaced with protein from dairy products (milk, cheese, eggs), the stable isotope signatures of which do not differ appreciably from meat (Steele and Daniel, 1978; Garvie-Lok, 2001).

The wide range in $\delta^{15}N$ values could also reflect consumption of omnivore protein or protein from suckling animals, both of which may exhibit $\delta^{15}N$ values as high

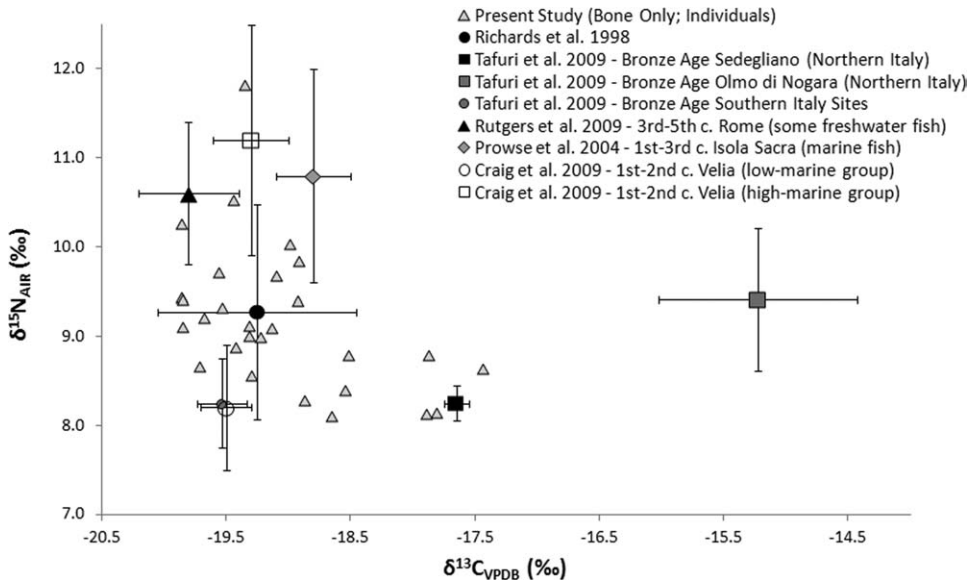

Fig. 6. Individual bone samples from Trino Vercellese are shown in comparison with other European populations, which are displayed as mean ± 1 standard deviation. Individuals from Trino Vercellese overlap with populations consuming terrestrial-based diets. Some individuals overlap with a Northern Italian population believed to consume the C_4 plant millet. One individual with a high-$\delta^{15}N$ value plots with a population-consuming marine fish; this individual likely moved to Trino Vercellese from the coast, as discussed in the text.

TABLE 4. Cereal species present in Piedmont and at Trino Vercellese during the medieval period (after Nada Patrone, 1981 and Accorsi et al., 1999)

Cereal	Scientific name	Grain type	Photosynthetic pathway	Archaeologically present at Trino Vercellese
Rye	*Secale cereale*	Large	C3	Present
Wheat	*Triticum sp.*	Large	C3	Present
Barley	*Hordeum sp.*	Large	C3	Present
Proso millet	*Panicum miliaceum*	Small	C4	Present
Foxtail millet	*Panicum italicum (Setaria italica)*	Small	C4	Absent
Sorghum	*Sorghum sp.*	Small	C4	Absent

as 9+‰ due to their elevated trophic position (Müldner and Richards, 2007). Historical accounts of dietary preferences and culturally mandated dietary behaviors in Piedmont in the medieval period support this explanation (Nada Patrone, 1981). Indeed, according to the culture of the time, it was preferable for sociocultural elites to consume the meat of young animals (such as lambs, kids, calves, and young fowl). The presence of large numbers of subadult animals bearing butcher marks at Trino Vercellese (Ferro, 1999) suggests that such dietary customs were applied here as well. Birds, too, may exhibit variable $\delta^{15}N$ values due to their diets and habitats (Grupe et al., 1999). Human consumption of either domestic or wild fowl could contribute to the observed variable $\delta^{15}N$ values accompanying restricted $\delta^{13}C$ values at Trino Vercellese.

Several individuals from Trino Vercellese exhibit $\delta^{13}C_{bone}$ values higher than –18.0‰. These individuals also exhibit relatively low $\delta^{15}N_{bone}$ values (Fig. 3). Because fish consumption is an unlikely explanation in this case, ^{13}C enrichment is probably due to a C_4 plant in the diet. The presence of C_4 cereals such as millet (including *Panicum miliaceum* and *Panicum italicum*, also known as *Setaria italica*), and sorghum in the Piedmont during the medieval period is well documented. In particular, the cultivation of millet was much more common in the provinces of Novara and Vercelli (hence at Trino Vercellese) than in other areas of the region, likely due to their geographical proximity to Lombardia, where millet was much more common (Nada Patrone, 1981). Analyses of the paleobotanical evidence from Trino Vercellese indicate that a number of different cereals were cultivated at this site (Accorsi et al., 1999; Caramiello et al., 1999; Nisbet, 1999), including millet (Table 4).

Based on this evidence, it is reasonable to assume that some individuals at Trino Vercellese may have consumed millet, a C_4 cereal that has a $\delta^{13}C$ value of $\sim$ –10 to –12‰ (modern values) (McGovern et al., 2004). Stable isotope values of the high-$^{13}C_{bone}$ group overlap with data reported by Tafuri et al. (2009) for millet-consuming individuals from Bronze Age Northern Italy (the site of Sedegliano; Fig. 6). Without a local faunal baseline, it is not yet possible to discern whether the high-^{13}C signal in human collagen is from consumption of millet or of animals foddered on millet. Tafuri et al. (2009) observed a much stronger "millet signal" in bones of Bronze Age individuals from Olmo di Nogara in Northern Italy, where the faunal baseline clearly demonstrated that millet was used as a fodder. Because collagen preferentially reflects protein sources in diet, it may be the case that the humans studied by Tafuri et al. (2009) exhibit

greater enrichment in ^{13}C, because the signal came from protein, whereas in the present study, the high-^{13}C foods are underrepresented in collagen because of direct consumption of millet and not consumption of millet-foddered animals. Also, it would seem that if animals at Trino Vercellese were fed millet, the "millet signal" would be even stronger among individuals who consumed more animal protein; that is, a positive correlation may be expected between $\delta^{13}C$ and $\delta^{15}N$, which is not observed. Comparative analysis of $\delta^{13}C$ from bone apatite, which more equally reflects all dietary macronutrients (Krueger and Sullivan, 1984; Ambrose and Norr, 1993; Tieszen and Fagre, 1993), would help clarify the question of millet in diet, as has been done elsewhere (Reitsema et al., 2010).

Status- and sex-based differences

A narrower range of high-status $\delta^{15}N_{dentine}$ values suggests that high-status children had more consistent diets within their class, whereas the diets of low-status children were unselective. Status-based differences in females' diets are not apparent; however, sample sizes may be too small to detect significant differences. High-status adult males consumed more animal protein than did low-status adult males. High-status males likely include members of the clergy and local nobles who in life were of higher socioeconomic status (Negro Ponzi Mancini, 1999; Vercellotti et al., 2011). During the medieval period throughout Europe, protein from terrestrial animals was generally more expensive than other foods and thus restricted to the sociopolitical elite (Adamson, 2004; Dembinska, 1999; Dyer, 1994). At Trino Vercellese as elsewhere (Kjellström et al., 2009; Linderholm et al., 2008b; Polet and Katzenberg, 2003; Schutkowski et al., 1999), these status-based medieval dietary differences are visible in bone chemistry.

Another status-based difference is the greater millet intake by low-status adult males. The four individuals showing the strongest evidence for millet consumption (see Fig. 3) are all males buried outside the church, whose diets are also relatively low in animal protein. This is consistent with historical reports of millet as a low-status food (Nada Patrone, 1981; Spurr, 1983; Adamson, 2004). An historical examination of cereal production and consumption in Piedmont during the medieval period reveals the presence of both large grain cereals (rye, wheat, barley) and small grain cereals (millet, sorghum). It is interesting to note that, according to land use contracts, small grain cereals were subject to lower fees than large grain cereals, which were considered more valuable. This was the expression of a food culture that reserved large grain cereals—in particular *Triticum*—to the higher class, while consumption of small grain cereals was limited to the populace (Nada Patrone, 1981). As a consequence, landowners had a diet that differed from that of their workers also in terms of choices between food types. Although the nutritional profiles of these different grains differ, the small-grained cereals cannot be considered less nutritious than the large-grained cereals, such that the status-based difference in their regard should be biologically meaningful (Watt and Merrill, 1975).

Although differences between high- and low-status males are observed, there are no discernible status-based differences in stable isotope ratios of females (Fig. 3). The subsamples of females are small, but the lack of statistically significant female status differences is consistent with previously reported evidence from this population from indicators of developmental stress (linear enamel hypoplasia and adult stature) and dental pathology (tooth loss and dental caries) showing pronounced differences in developmental stress and poor oral conditions between high- and low-status males, but almost no differences between high- and low-status females (Girotti and Garetto, 1999). Evidently, low-status females consumed diets more similar to both high-status females and high-status males, including more animal protein and less millet than diets of low-status males.

Another notable difference between the diets of high- and low-status adults is that bone δ values of low-status individuals show greater variation, whereas values of high-status adults are more restricted (Fig. 3). A similar situation is reported for Roman period UK (Richards et al., 1998), where high variability among low-status individuals was attributed to diverse diets characteristic of life in an urban center. Lower isotopic variation for high-status individuals than for low-status individuals is also reported for early medieval Bavaria (Czermak et al., 2006), where it is attributed to elites having more consistent access to animal protein. Similarly, at Trino, variability in low-status diets is probably due to individual fortunes and misfortunes, and the ever-present uncertainty of the access to resources experienced by low-status individuals in the medieval period.

Interestingly, the highest bone and dentine $\delta^{15}N$ are from a single low-status individual (S-408-M). His stable isotope values are very similar to those reported for individuals consuming marine fish at the coastal site of Velia in Southern Italy (1st–2nd c. A.D.; Craig et al., 2009). We propose that this individual may have spent most of his life at a coastal site, consuming more marine protein than the rest of the studied individuals. This individual was buried in an area (Sagrato Nord) that was recognized by the archaeologists as distinct from the rest of the cemetery. Specifically, this area had 24 individual burials organized in clusters and disposed in parallel lines. Additionally, whereas sex ratio in the rest of the cemetery is about 50:50; in this separate area, skeletons are 80% male. Although no specific interpretation of the formation of this separate area was advanced, it was observed that, like anomalous burial clusters in other medieval cemeteries, the area may have formed during the transition from family to parish cemetery (or vice versa; Mancini, 1999).

Life history

Stable isotope data support an interpretation of similar diets between status groups and the sexes during childhood, with increasing disparities into adulthood, as estimated from bones. In general, the disparity consists of reduced access to animal protein for low-status males throughout life (Fig. 4). Another change in diets of low-status males over time is an increase in millet consumption (Fig. 5). Childhood diet may have been more varied than adult diet, although the evidence for this is not strong.

Compared to what is observed among low-status males, diets of females changed little from childhood to adulthood (Figs. 4 and 5). Based on historical evidence suggesting that millet was a less-desirable food, children and females may have been treated differently to help guarantee survival. We propose that there may have

been a cultural buffer for females of reproductive age. Although medieval society was undoubtedly male-dominant, other evidence for female buffering in medieval society exists. For example, skeletal indicators of health suggest that females experienced more stable living conditions in the transition from Late Antiquity to the medieval period in Croatia (Šlaus, 2008). In medieval Sweden, females consumed more consistent diets than did males, which may also be a case of cultural buffering, although the authors advance the possibility that females were more stationary than males (Kjellström et al., 2009). It is also possible that the relative consistency of medieval females' stable isotope values in the present study has to do with their regular involvement in day-to-day food preparation tasks. Low-status male laborers, in contrast, may have had access to fewer foods—and more specific foods (e.g., millet) —simply because of their daily routines outside the home.

As with diets of women, there are minimal changes throughout life in diets of high-status individuals (both males and females). This likely reflects a certain degree of certainty or selectivity in high-status diets.

CONCLUSIONS

Diets of the studied individuals are terrestrial-based, which could be expected based on geography (Trino Vercellese is an inland site), but is in fact noteworthy considering the various impetuses for fish consumption in medieval Europe (e.g., Christianization, trade connections with the coast and feeding aggregated communities). This questions the idea that fish are dietary markers for certain medieval religious and economic influences (Müldner and Richards, 2005; Barrett et al., 2008).

Differences among the subgroups are relatively small in childhood as measured from dentine and expand into adulthood as measured from bone, which may be the effect of cultural buffering of children. The most pronounced changes during the life course are seen among low-status males. Low-status adult males differ considerably from females and high-status males in that they consumed a diet with more millet and less meat, a difference that developed after childhood.

A look at life history of the studied population yields several interesting observations. Evidently, at Trino Vercellese, the diets of high-status individuals and diets of females in general are more consistent throughout the life course. Perhaps, due to their role in reproduction and child rearing, females were afforded consistent access to foods without regard to their socioeconomic status and without risky fluctuations year-to-year or season-to-season. This consistent food access may have been in recognition of women's nutritional needs during their reproductive years, which for medieval females was most of their adult lives, or it could have been the by-product of providing consistent food access to *children*, with whom females may have spent more time day-to-day than males. This possibility underscores the significant potential that bioarchaeology has to nuance interpretations of male-dominant medieval society.

While high-status males, high-status females, and low-status females show similar dietary trajectories throughout life, it is the *low-status males* that show different stable isotope values, which suggest a more plant-based diet including millet. The diets of low-status males were less predictable and could tend to vary considerably. We do not know on what basis diets of males varied, but it stands to reason it could have had something to do with their occupation or ability to earn a living.

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Table 2. Human stable isotope and collagen quality results.

			Dentine					*Bone*				
Sample ID	**Sex**	**Status**	**%N**	**%C**	**C:N**	**$\delta^{15}N$ (‰)**	**$\delta^{13}C$ (‰)**	**%N**	**%C**	**C:N**	**$\delta^{15}N$ (‰)**	**$\delta^{13}C$ (‰)**
S-46	Female	High	15.2	41.7	3.2	9.0	-19.8	14.2	41.6	3.4	9.1	-19.8
S-48A	Female	High	14.4	40.0	3.2	9.2	-18.5	13.8	40.2	3.4	10.5	-19.4
S-73	Female	High	14.5	40.4	3.2	9.2	-19.9	14.4	41.8	3.4	9.4	-19.9
S-80	Female	High	15.0	41.4	3.2	9.2	-18.7	14.2	40.9	3.4	9.2	-19.7
S-207	Female	Low	15.3	42.2	3.2	9.6	-20.1	14.2	40.0	3.3	9.4	-19.8
S-297	Female	Low	15.3	42.0	3.2	8.4	-18.6	14.8	41.3	3.3	9.0	-19.3
S-348	Female	Low	15.1	41.4	3.2	9.4	-19.4	14.6	40.6	3.2	9.1	-19.3
S-528	Female	Low	15.5	42.9	3.2	6.7	-20.0	13.9	39.6	3.3	9.1	-19.1
S-535	Female	Low	15.1	41.4	3.2	9.7	-19.4	~~*10.2*~~	~~*32.4*~~	~~*3.7*~~	~~*8.3*~~	~~*-19.1*~~
S-542	Female	Low	15.7	43.0	3.2	10.3	-18.7	14.8	41.2	3.3	9.3	-19.5
S-41	Male	High	15.2	42.5	3.3	10.4	-18.6	12.2	35.8	3.4	10.3	-19.9
S-44	Male	High	14.5	40.5	3.3	9.9	-19.0	12.3	35.5	3.4	9.7	-19.6
S-56	Male	High	15.6	43.3	3.3	9.5	-19.6	5.0	15.3	3.5	9.0	-19.2
S-57	Male	High	15.0	41.7	3.2	9.5	-19.5	3.7	11.1	3.5	8.9	-19.4
S-68	Male	High	14.9	41.2	3.2	8.9	-19.4	11.8	34.3	3.4	8.7	-19.7
S-133	Male	High	14.9	41.3	3.2	9.1	-19.6	12.5	35.5	3.3	10.0	-19.0
S-134	Male	High	15.2	42.2	3.2	9.1	-19.6	2.8	8.4	3.5	8.6	-19.3
S-143	Male	High	15.6	43.0	3.2	9.1	-18.2	7.3	20.7	3.3	8.8	-18.5
S-166-1	Male	High	14.6	40.8	3.3	9.3	-19.5	12.9	36.8	3.3	9.8	-18.9
S-166-2B	Male	High	13.1	39.1	3.5	9.5	-19.5	7.8	22.2	3.3	9.4	-18.9
S-328	Male	Low	15.9	43.7	3.2	10.8	-19.8	6.8	19.0	3.3	8.1	-17.8
S-346	Male	Low	14.7	41.0	3.2	9.6	-18.5	5.6	16.1	3.3	8.4	-18.5
S-367	Male	Low	15.1	41.8	3.2	9.8	-18.3	7.7	21.3	3.3	8.8	-17.9
S-398	Male	Low	15.1	41.8	3.2	8.4	-19.9	12.8	35.4	3.2	8.6	-17.4
S-408	Male	Low	15.3	42.5	3.2	12.0	-20.0	11.9	33.4	3.3	11.8	-19.3
S-424	Male	Low	14.9	41.6	3.3	9.0	-19.4	~~*0.7*~~	~~*3.7*~~	~~*6.1*~~	~~*2.00*~~	~~*-20.9*~~
S-456	Male	Low	15.3	42.4	3.2	8.3	-17.8	9.7	26.9	3.2	8.3	-18.9
S-474	Male	Low	14.7	41.4	3.3	9.8	-19.1	12.7	34.5	3.2	9.7	-19.1
S-545	Male	Low	15.5	42.7	3.2	9.5	-17.6	8.4	23.6	3.3	8.1	-17.9
S-555	Male	Low	15.2	42.2	3.2	8.0	-19.1	12.5	34.0	3.2	8.1	-18.6