Stable isotopes from the African site of Elmina, Ghana and their usefulness in tracking the provenance of enslaved individuals in 18th- and 19th-century North American populations

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Abstract

Objectives: Stable isotope values for historic period human remains from Elmina, Ghana, are compared to isotope data from 18th- and 19th-century North American sites as a test case for examining African origins and identifying first generation Africans in the Mid-Atlantic region of the United States.

Materials and Methods: Stable carbon, nitrogen, and oxygen isotope values were measured in skeletal remains. Values from the cosmopolitan port city of Elmina provide the first available reference data from Africa during this time period and region. These values serve as a proxy for West African groups in general which are statistically compared to Euro-Americans and African Americans.

Results: Elmina carbon isotope values are relatively higher than those of North Americans, and African Americans show greater statistical similarity to West Africans. Elmina nitrogen isotope values are higher than those of North Americans. Elmina oxygen isotope values are notably higher than those in all Mid-Atlantic North American sites in this study.

Discussion: Similarity in carbon isotope values between Elmina and African Americans suggests commonalities in food availability or food preferences between these groups. Elevated nitrogen isotope values in Elmina individuals support the documented reliance of the local population on marine dietary resources at this coastal port. While carbon and nitrogen isotopes provide insight into foodways, oxygen isotope data, sourced from drinking water, provide better geographical information. The higher oxygen values from Elmina not only differentiate this group from North American Mid-Atlantic sites, but also make it possible to identify outliers at these sites as potential recent arrivals from West Africa.

1. Introduction

While historians and archaeologists have known about the broad patterns of the Atlantic slave trade, including those areas in Africa from which trading countries exported enslaved individuals, specific origins for skeletal remains recovered from archaeological sites in the United States can rarely be determined. A particular African cultural group is sometimes suggested by housing, foods, religious and personal artifacts, preserved historic documents, mortuary practices, and other cultural indicators if such information is available (Blakey, 1998; DeCorse 1999; Fennell, 2011; Ogundiran and Falola, 2007; Singleton, 1995, 1999). Traditionally, features of the skull and dentition have been used to assess the ancestral origins of skeletal remains (Blakey and Rankin-Hill, 2009; Gill and Rhine, 1990; Jantz and Ousley, 2005; Spradley, 2006), but these methods do not distinguish first generation Africans from those born in North America of African parents. Even DNA is inadequate in this respect since subsequent generations of Africans born in North America may not have genetic admixture with non-African groups. Intentional dental modification has arguably been the only other means used to determine recent arrival to the Americas on the basis of skeletal remains. This practice has been noted in studies from North and Central America, and the Caribbean (Blakey, 1998; Blakey and Rankin-Hill, 2009; Handler et al., 1982; Handler, 1994; Ortner, 1966; Price et al., 2012; Schroeder et al., 2014; Stewart and Groome, 1968; Tiesler, 2002). However, the historic occurrence of distinctive dental modification patterns overlaps across African regions, varies through time, and has not been studied adequately to allow a definitive determination of regional origin. Further, the practice has not been proven to be exclusive to first-generation Africans in the Americas (Rivero de la Calle, 1973; Roksandic et al., 2016).

This study examines stable carbon, nitrogen, and oxygen isotope values from the cosmopolitan coastal site of Elmina, Ghana in West Africa and compares these data to values from historic sites in North America. To date, isotope studies of historic period remains in North America have focused on origins and demographic factors within the Americas because no comparable African data existed from this time period. Stable isotope values from Elmina allow comparisons to be made and appear unique in some respects from isotope values of individuals from the Mid-Atlantic region of the United States. In essence, Elmina values can serve as a proxy for recent West African arrivals to the Mid-Atlantic, quantitatively distinguishing them from African Americans born in this region.

Stable isotopes help determine resource use by, and thus regional origins of, historic period North American populations, including enslaved individuals (Bruwelheide et al., in press, France et al., 2014, Raynor and Kennett, 2008, Ubelaker and Owsley, 2003). Carbon isotope ratios reflect regional vegetation availability to both humans and animals, and can separate region of origin only so far as certain regions tend to rely on different grain sources. Carbon is incorporated into the hydroxyapatite carbonate ($\delta^{13}C_{carbonate}$), as well as the collagen protein within bone and tooth dentin ($\delta^{13}C_{collagen}$). Values are reported in standard delta notation where $\delta^{13}C = [(^{13}C/^{12}C_{\,sample} - {}^{13}C/^{12}C_{\,standard}) / {}^{13}C/^{12}C_{\,standard}] * 1000$; units are in permil (‰), and the standard is Vienna Pee Dee Belemite (V-PDB). Carbon isotopes fractionate differently depending on whether a plant employs the C3 or C4 photosynthetic pathway. C3 plants (wheat, barley, rice, trees, shrubs, and temperate/cool climate grasses) show more negative $\delta^{13}C$ values (approximately -33 ‰ to -24 ‰), and C4 plants (maize, millet, sorghum, sedges, sugarcane, and warm/dry climate grasses) show relatively higher values (approximately -16 ‰ to -10 ‰) (Heaton, 1999, O'Leary, 1988, Smith and Epstein, 1971). Carbon in hydroxyapatite carbonates primarily reflects the carbohydrate and lipid carbon isotope dietary input, while collagen carbon primarily reflects the protein dietary input (Ambrose and Norr, 1993; Fernandes et al., 2012; Jim et al., 2004; Krueger and Sullivan, 1984). Although carbon isotopes fractionate during incorporation into tissues, the C3/C4 pattern is still observable (Balasse et al., 1999, Hedges, 2003, Kohn and Cerling, 2002, Passey et al., 2005, van der Merwe, 1982). Therefore $\delta^{13}C_{carbonate}$ values largely indicate the types of plants and grains consumed directly by an individual, while $\delta^{13}C_{collagen}$ values are heavily influenced by the plant and grain fodder for consumed animals.

Nitrogen isotopes, incorporated exclusively into collagen in bone and dentin, reflect the amount of protein input or marine resources in the diet. Values are reported in standard delta notation ($\delta^{15}N_{collagen}$) where the ratio of interest is $^{15}N/^{14}N$, and the standard is atmospheric air. Both increased protein and/or marine resources result in higher $\delta^{15}N_{collagen}$ values (Bocherens and Drucker, 2003, DeNiro and Epstein, 1981, Fogel et al., 1997, Schoeninger and DeNiro, 1984) and tend to indicate localized availability of food within a region or population. Nitrogen values are not necessarily correlated with broad regional origins.

Oxygen isotope values have proven the most effective at determining region of origin within North America because there are significant differences between northern and southern areas. Oxygen isotopes are incorporated into bone, tooth enamel, and tooth dentin in carbonates within the mineral hydroxyapatite. Values are reported in standard delta notation ($\delta^{18}O_{carbonate}$) where the ratio of interest is $^{18}O/^{16}O$, and the standard is Vienna Standard Mean Ocean Water (V-SMOW). The primary pool of oxygen integrated into hydroxyapatite during mineralization is body water, which directly reflects oxygen isotope ratios in drinking water (Bryant and Froehlich, 1995, D'Angela and Longinelli, 1990, Daux et al., 2008, Kohn, 1996, Levinson et al., 1987, Longinelli, 1984, Luz and Kolodny, 1985, Luz et al., 1984). Prior to the 20th-century, drinking water in North America and Africa was obtained largely from local meteoric water with oxygen isotope values correlated to latitude and general region of origin (Bowen and Wilkinson, 2002; Dutton et al., 2005; Kendall and Coplen, 2001; Landwehr et al., 2014). Oxygen isotopes will fractionate during the incorporation into hydroxyapatite carbonates (i.e., $\delta^{18}O_{carbonate}$), but this fractionation is expected to be constant across the human species. As such, observed differences between oxygen isotopes in North America versus Africa will be maintained in archaeological remains. Some overlap in $\delta^{18}O$ meteoric water values exists between North America and Africa, specifically between the southern United States and northern Africa. The $\delta^{18}O$ values of North American meteoric water range from approximately -21 to -1 ‰. Values in Africa range from approximately -11 to +4 ‰ (Figure 1). While this may be a complicating factor in interpreting data from archaeologically recovered African American remains from southern locales and the Caribbean, isotope values from the Mid-Atlantic should be distinct.

2. Materials

The single site of Elmina holds four centuries of burials representing both free and enslaved Africans of diverse heritage. Effective comparison with North American remains utilizes eleven different sites in Mid-Atlantic States, and one in New Mexico (a battlefield burial for Confederate soldiers from Texas) (Table 1, Supplemental Table 1).

Elmina, Ghana

Elmina, in coastal Ghana, was already settled by Akan people before the region was reached by Portuguese traders in the 15th-century (Figure 1). It was one of the larger settlements on the coast, which was one of the reasons the Portuguese selected it as the site of *Castelo de São Jorge da Mina* (Castle of St. Jorge of the Mine), so named because of the importance of the gold trade on this part of the African coast. Founded in 1482, the fortress of Elmina was the first and largest of the European outposts established in sub-Saharan Africa (DeCorse, 2010). The castle remained the principal Portuguese trade entrepôt on the West Africa coast until its capture by the Dutch in 1637, when Elmina became the Dutch headquarters (DeCorse, 2001; Feinberg, 1989). During the 17^{th}-century, slaves replaced gold as the primary export from the Ghanaian coast, although the Elmina population itself was not the direct source for exported slaves. Enslaved Africans destined for trans-Atlantic trade were brought to the Castle from a variety of locations across Ghana, and other parts of West and Central Africa (Postma, 2003; Van den Boogaart and Emmer, 1979). Once exported, most Dutch trading ships were bound for the West Indies and Brazil (Postma, 1990).

While Elmina served as a primary export site for the Dutch slave trade, the settlement supported a diverse population of free Africans, as well as enslaved Africans living in their households. The population of Elmina grew increasingly heterogeneous during the Dutch period with immigrants arriving from adjacent areas of the coast and hinterland (Baesjou, 1979; DeCorse, 2001; Feinberg, 1989; Yarak, 1990). Population figures for West Africa in general are limited until the late 19^{th} and 20^{th} centuries (DeCorse, 2001, 2008). However, at Elmina the population expanded from a village of a few hundred people in the 15^{th}-century to a settlement of fifteen to twenty thousand inhabitants by 1870. Most of the town's inhabitants were coastal Akan, but there were also traders and immigrants from other parts of the coast including interior Akan from Asante, and Akim, Denkira, and Ewe from the eastern portion of modern Ghana. Slaves brought from the northern regions of modern Ghana may also have lived within the town.

In 1986, 1990, and 1993 multiple burials from spatially distinct loci within the Elmina settlement site were excavated. The excavations and associated anthropological interpretations are extensively documented in DeCorse (2001) and a preliminary discussion of the skeletal material recovered is presented in Renschler and DeCorse (2016); summarized information is presented here. The individuals whose remains are considered are native Africans that lived during the 17^{th}, 18^{th} and 19^{th} centuries, within the period when the Dutch controlled Elmina Castle. The majority of the burials recovered were likely free Africans of local ancestry. Most were recovered from beneath house floors; burial within the house is a traditional Akan burial practice. However, it is difficult to postulate the origins of the individuals based on archaeological data alone because there is little information on the organization of Elmina with regard to the association of portions of the settlement with specific ethnic groups. It is possible that immigrants settled within specific areas of the town. There is some historic information that immigrants were buried in separate burial areas. As the majority of the burials were recovered from beneath the floors of stone structures close to Elmina Castle, and adjacent to the market, it is probable that they represent individuals of relatively high socioeconomic status, although enslaved individuals worked and lived in houses along with their owners. While separate burial areas may have been located for both immigrants and slaves, there is insufficient information to be certain of the relationship of the persons buried at the individual loci. The burials from Locus G are the exception, as this area located at the western margins of the Elmina settlement is known to have been occupied by enslaved individuals owned by the Dutch West India Company.

Based on the settlement's history, burials at Elmina represent a somewhat heterogeneous population drawn from geographic regions similar to those of exported enslaved Africans brought to the Mid-Atlantic region of North America. The approximate area represented by these ethnic groups, roughly from coastal Ghana east to the Bight of Benin and north to northern Ghana, Togo, and Côte d'Ivoire, is between 4° and 12° north latitude and -5° west and 10° east longitude. The archaeological remains at Elmina and the isotope profiles therein provide a plausible proxy for native West Africans who were enslaved and exported to the Americas. The British slave trade, responsible for a majority of enslaved individuals imported into North America, included individuals from regions at similar latitudes to Elmina (Liberia to the Bight of Benin) and from regions further south (Bight of Biafra to western Central Africa) (Anstay, 1975; Curtin, 1969; Lovejoy, 1989; Postma, 2003; Walsh, 2001). Similarly, enslaved individuals transported on American ships hailed primarily from sites at similar latitudes to Elmina (Senegambia, Sierra Leone, Liberia, and Ghana). The isoscape in Africa (Figure 1) suggests then that enslaved persons imported on British ships would most likely have similar, or higher $\delta^{18}O_{carbonate}$ values than individuals at Elmina, while those imported on American ships should have values similar to those at Elmina. The oxygen isotope values from Elmina burials are essentially the lowest isotope values expected in exported enslaved Africans that has maximum potential overlap with isotope values in North Americans.

North American Sites

Twelve 18th- and 19th- century archaeological sites spanning various North American regions are included in this study: 11 sites from the Mid-Atlantic region and one site from the Southwest. Some sites are comprised of individuals with African ancestry from the late 1700s and early decades of the 1800s during the height of the Atlantic slave trade. Included are three Virginia sites (A.P. Hill, Pettus, and Robinson Cemetery) and one Delaware site (Parkway Gravel). Three Euro-American sites serve as comparative samples of individuals who were born, with possible exceptions, in North America. They are from North Carolina (Foscue Plantation), Connecticut (Walton Family Cemetery), and Delaware (Woodville Cemetery).

Individuals from the mid-1800s to ca. 1900 included in this study are free African Americans from the First African Baptist Church (referred to as FABC), in Philadelphia, Pennsylvania. Although no records exist detailing the geographic origin of these individuals, it is likely they were American-born. Also from the late 1800s are Euro-Americans from family vaults in Congressional Cemetery, Washington, DC, and more rural cemeteries in Maryland (Hilleary Cemetery) and Virginia (Kincheloe Plantation Cemetery). Members of these extended families, of which some individuals have known identity with documented historical and genealogical information, were born in North America, or in a few cases Europe, as this time period saw a high volume of immigration into the United States. Also included in this analysis are Civil War soldiers from Glorieta Pass, New Mexico. These Confederate soldiers from Texas provide a comparative series from the southern United States. Supplemental Table 1 lists the individuals included in the analysis by archaeological site, time period, and socio-economic status.

3. Methods

Both bone and tooth samples were included in subsequent analyses. Selection of material was based largely on sample availability. When both bone and teeth were available from an individual, a tooth was selected for this study. Approximately 24% of the remains had available teeth; the majority of teeth are from the Glorieta Pass site (Supplemental Table 1). Teeth do not remodel after mineralization and provide a better assessment of childhood origins compared to bone which remodels throughout life. The inclusion of bone from adult individuals in the comparative North American population reduces the visibility of recently arrived African individuals in the data set. However, the goal of this study is to provide a comparative data set that reflects a population of people that were most likely born in North America or spent significant time there. If a set of mixed North American bone and teeth show isotopic distinction from the Elmina individuals, it is likely that recent arrivals from the latter (and other African localities) will appear as outliers compared to the former.

Solid bone and tooth dentin samples for collagen isotope and elemental analyses were obtained by coring with a rotary tool or extraction with pliers. Powdered bone, dentin, and enamel samples for carbonate isotope and Fourier transform infrared (FTIR) spectroscopy analyses were obtained by crushing with a mortar and pestle or drilling with a rotary tool. Collagen and carbonates were extracted from bone, dentin, and enamel according to methods detailed in France et al. (2014). Briefly summarized, collagen in bone and dentin was extracted via a standard acid-base-acid method including demineralization in cold hydrochloric acid, humic and fulvic acid removal with sodium hydroxide, denaturing the collagen in weak hot hydrochloric acid, and isolation of collagen via lyophilization. Carbonates were isolated by removal of organic material with sodium hypochlorite followed by buffered acetic acid to remove secondary diagenetic carbonates.

All samples were analyzed on a Thermo Delta V Advantage mass spectrometer in continuous flow mode at the Smithsonian MCI Stable Isotope Mass Spectrometry Laboratory. Collagen samples were weighed into tin cups and combusted on a Costech 4010 Elemental Analyzer. The purified N_2 and CO_2 gases were transferred to the mass spectrometer via a Conflo IV interface and measured for $\delta^{15}N_{collagen}$ and $\delta^{13}C_{collagen}$ values. Raw values were corrected to an acetanilide house reference material and Urea-UIN3 (Schimmelman et al., 2009), both calibrated to USGS40 and USGS41 international reference materials. Weight % N and weight % C values were calibrated using the acetanilide. Carbonate samples were weighed into exetainer vials and flushed with pure helium. Samples were acidified with concentrated phosphoric acid (SG>1.92) for 24 hours at 25°C. The released CO_2 was purified and transferred to the mass spectrometer via a Thermo GasBench interface and measured for $\delta^{13}C_{carbonate}$ and $\delta^{18}O_{carbonate}$ values. Raw values were corrected to LSVEC and NBS-19 international reference materials. Errors for $\delta^{15}N_{collagen}$, $\delta^{13}C_{collagen}$, $\delta^{13}C_{carbonate}$, and $\delta^{18}O_{carbonate}$ are ±0.2‰ (1σ).

Raw bone powders were analyzed using attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) on a Thermo Nicolet 6700 FTIR with Golden Gate ATR (diamond crystal, single bounce, 45°) equipped with a DTGS detector. Spectra were collected for 128 scans from 450 to 4,000 cm^{-1} with a resolution of 4 cm^{-1}. All baseline corrections and ratio calculations were automated via TQAnalyst EZ version 8. Measured parameters include phosphate peak (v_4) heights at 565 and 605 cm^{-1} and the associated valley at ~590 cm^{-1}, phosphate peak (v_1) height at ~960 cm^{-1}, phosphate peak (v_3) height at 1035 cm^{-1}, carbonate peak (v_3) heights at 1415 and 1455 cm^{-1}, and v_1PO_4 position. Using these parameters, the following peak height ratios were calculated: infrared splitting factor [(565 + 605) / 590], carbonate/carbonate [1455 / 1415], and carbonate/phosphate [1415 / 1035].

Potential postmortem diagenetic alteration of collagen isotope values was examined using collagen yields obtained during extraction and elemental yields obtained during mass spectrometry analyses. Collagen extracted from well-preserved bones and teeth should constitute ~2–20% whole bone/dentin weight, show a weight % N of ~10–15%, and an atomic C:N ratio of 2.8–3.6 (Ambrose, 1990, DeNiro, 1985, Jorkov et al., 2007, McNulty et al., 2002). Potential diagenetic alteration of bone hydroxyapatite carbonate isotope values was examined using the calculated peak height ratios from ATR-FTIR spectra. Based on previous ATR-FTIR studies and suggested conversions from the more common transmission FTIR methods (Beasley et al., 2014, Garvie-Lok et al., 2004, Lebon et al., 2010, Lebon et al., 2011, Snoeck et al., 2014, Thompson et al., 2009, Thompson et al., 2011, Wright and Schwarcz, 1996), well-preserved hydroxyapatite should have an infrared splitting factor (IRSF) of <4.4, carbonate/carbonate ratio (C/C) of ~0.9, carbonate/phosphate ratio (C/P) of ~0.3, and a v_1PO_4 position <962.5 cm^{-1}. Collagen and hydroxyapatite samples yielding these values were considered well preserved and included in further analyses. A paucity of FTIR data in the literature precludes direct analysis of tooth enamel as the different mineralization process of enamel is expected to produce different peak height ratios than those described above. However, enamel mineralization is generally more dense than that of bone and dentin, and the former is often considered more resistant to diagenesis than the latter. Therefore, tooth enamel samples were considered well preserved if the corresponding dentin met the collagen quality criteria outlined above.

Isotope values were compared across all sites using non-parametric Mann-Whitney tests due to small sample sizes and non-Gaussian distributions for some sites. For tooth samples, dentin data were used for all $\delta^{15}N_{collagen}$ and $\delta^{13}C_{collagen}$ comparisons; enamel data were used for all $\delta^{18}O_{carbonate}$ and $\delta^{13}C_{carbonate}$ comparisons unless only dentin data were available for a particular tooth.

4. Results

Isotope data for well-preserved samples are shown in Table 2. Only samples meeting the preservation criteria outlined above are included in further analyses and interpretations; all results from diagenesis testing are included in Supplemental Table 2. The $\delta^{13}C_{carbonate}$ values from Elmina show an average of -5.9 ‰ (±1.2, 1σ) with a range of -8.9 to -3.9 ‰ (Figure 2). The study's African Americans show a slightly more negative $\delta^{13}C_{carbonate}$ average of -7.1 ‰ (±2.4, 1σ) with a greater range of -11.5 to -2.8 ‰. Euro-Americans show a considerably more negative $\delta^{13}C_{carbonate}$ average of -8.9 ‰ (±2.1, 1σ) with the widest range of -14.0 to -4.4 ‰. If the southwestern site of Glorieta Pass is removed, the remaining Mid-Atlantic Euro-Americans show a lower $\delta^{13}C_{carbonate}$ average of -9.4 ‰ (±1.7, 1σ) and a slightly smaller range of -13.3 to -6.0 ‰.

The $\delta^{13}C_{collagen}$ values show the same pattern as the $\delta^{13}C_{carbonate}$ values. Elmina has an average $\delta^{13}C_{collagen}$ value of -10.3 ‰ (±1.6, 1σ) and a range of -13.5 to -7.7 ‰ (Figure 3). African Americans have a slightly more negative $\delta^{13}C_{collagen}$ average of -12.0 ‰ (±2.6, 1σ) with a greater range of -17.0 to -8.2 ‰. A considerably more negative average of -14.2 ‰ (±2.0, 1σ) with a range of -19.7 to -9.2 ‰ is noted for Euro-Americans. Removing Glorieta Pass results in a Mid-Atlantic Euro-American $\delta^{13}C_{collagen}$ average of -14.5 ‰ (±1.7, 1σ) and a slightly smaller range of -17.8 to -10.5 ‰.

There is less variation between regions in $\delta^{15}N_{collagen}$ values (Figure 3). Elmina has an average $\delta^{15}N_{collagen}$ value of +11.9 ‰ (±1.1, 1σ) with a range of +8.3 to +14.1 ‰. Euro-Americans and African Americans show slightly lower averages of +10.7 ‰ (±0.9, 1σ) and +10.4 ‰ (±0.7, 1σ), respectively. The range of $\delta^{15}N_{collagen}$ was only slightly different among groups with Euro-Americans and African American values extending from +8.1 to +13.2 ‰ and +8.8 to +11.9 ‰, respectively. Removing Glorieta Pass results in a similar $\delta^{15}N_{collagen}$ average value for Mid-Atlantic Euro-Americans of +10.7 ‰ (±1.0, 1σ) with a range of +8.7 to +13.2 ‰.

The $\delta^{18}O_{carbonate}$ values from Elmina show an average of +27.6 ‰ (±1.0, 1σ) with a range of +23.3 to +28.9 ‰ (Figure 2); most Elmina $\delta^{18}O_{carbonate}$ values fall in the range of +26.1 to

+28.9 ‰. Both Euro-Americans and African Americans have lower $\delta^{18}O_{carbonate}$ averages of +26.0 ‰ (±2.6, 1σ) and +25.3 ‰ (±1.2, 1σ), respectively. The African Americans have a relatively smaller range of +22.0 to +27.7 ‰, while the Euro-Americans show the greatest overall range of +15.9 to +34.0 ‰. If Texans from Glorieta Pass are removed, remaining Mid-Atlantic Euro-Americans show a lower $\delta^{18}O_{carbonate}$ average of +24.5 ‰ (±2.3, 1σ) with the same range of +15.9 to +34.0 ‰.

Site-to-site comparison of isotope averages using Mann-Whitney tests are listed in Table 3. Sites are considered statistically different if $p<0.05$. The $\delta^{13}C_{collagen}$ and $\delta^{13}C_{carbonate}$ values from Elmina are consistently distinct from Euro-Americans in the study with the exception of the Kincheloe Cemetery. The Elmina $\delta^{13}C_{collagen}$ values are similar to three of the five African American sites (i.e., Robinson Cemetery, A.P. Hill, and Pettus). The Elmina $\delta^{13}C_{carbonate}$ values are also similar to three of the five African American sites (i.e., Robinson Cemetery, A.P. Hill, and Parkway Gravel). The Elmina $\delta^{15}N_{collagen}$ values are statistically distinct from all North American sites except the Foscue Plantation.

The $\delta^{18}O_{carbonate}$ values from Elmina are distinct from every North American site in the Mid-Atlantic. The $\delta^{18}O_{carbonate}$ values from Texans buried at Glorieta Pass in New Mexico are not statistically different from Elmina, showing there are similarities between certain areas of Africa and southern North America. However, the Glorieta Pass values are also notably distinct from all Mid-Atlantic sites with the exception of Foscue Plantation (although Glorieta and Foscue are statistically distinct at $p<0.08$). In the few North American sites where bone and tooth were analyzed concurrently, the teeth tend to be equal to the bone $\delta^{18}O_{carbonate}$ values, or slightly higher. However, the differences could not be robustly tested given that all sites with both elements consisted of a majority of either bone or tooth, with ≤ 3 samples of the alternate type.

5. Discussion

Current knowledge of North American slave origins is limited to a broad understanding of the Atlantic Slave Trade with exceptions where historical records and archaeological evidence exist. Once enslaved persons arrived in North America, they may have been moved to several different locations, primarily within the mid- or southern colonies or states, making it difficult to track origins. Despite the 1807 Act Prohibiting the Importation of Slaves (effective in 1808), populations of enslaved African Americans increased as children born in North America were incorporated into the existing system of enslavement. New generations of enslaved individuals are difficult to distinguish from their first generation parents. Previous studies have used oxygen, strontium, carbon, and nitrogen isotopes from individuals in Central America, Brazil, Barbados, and the Dutch Caribbean to confirm recent arrival of enslaved persons from Africa and infer dietary resources (Bastos et al., 2016, Laffoon et al., 2013, Laffoon et al., 2018, Price et al., 2012, Schroeder et al., 2009, Schroeder et al., 2014). These studies focused on origins and demographic factors within the Americas and were unable to compare enslaved individuals directly to African sites due to the lack of comparable isotope data on historic human remains from West Africa. Stable carbon, nitrogen, and oxygen isotope values from Elmina, Ghana in this study are a promising step toward identifying Africans newly arrived to the Mid-Atlantic.

Carbon and nitrogen isotopes in the Elmina population would have been influenced by local food sources. A wide variety of domesticated animals and crops were utilized at Elmina, including millet, sorghum, multiple species of yams and, by the 17^{th}-century, a variety of American cultigens (DeCorse, 2001). Maize, a C4 dietary staple in the Mid-Atlantic, was not native to Elmina or Africa, but was brought there from the Americas. By the 17^{th}-century, cornbread and kenkey, a staple dish made from fermented ground corn, were common. Fishing was a major part of the local economy and marine foods were a significant dietary component at Elmina (DeCorse, 2001).

The Elmina isotope results show higher $\delta^{13}C_{carbonate}$ and $\delta^{13}C_{collagen}$ values than Mid-Atlantic Euro-Americans. They show some overlap with the values of southern Euro-Americans and African Americans (Figures 2 and 3). This is likely due to the greater prevalence of C4 vegetation in southern North American regions and heavy reliance on maize, especially in the diets of enslaved individuals. The prevalence of C4 grains in African American diets is well documented in the historic and archaeological record (Bowes, 2011, Bowes and Trigg, 2012, France et al., 2014, Franklin, 2001, Mrozowski et al., 2008). Bruwelheide et al. (in press) observed the predominance of C4-based diets in African Americans from Mid-Atlantic sites in Virginia and eastern Maryland. Despite the observed overlap, Elmina results trend toward higher values supporting the historical evidence of significant C4 grains in the coastal Ghanaian diet by the early 17^{th}-century, particularly maize, millet, and sorghum. The observed similarity between Elmina individuals and African Americans suggests the latter group may have had diets limited to certain resources, perhaps due to food availability or economic resources. Additionally, the values may reflect retained cultural preferences for certain foods and cooking styles.

Nitrogen isotope values from Elmina are somewhat distinct from North American sites, but this isotope system does not serve as a good indicator of regional origin. The relatively high $\delta^{15}N_{collagen}$ values in Elmina support the archaeological evidence for reliance on marine dietary sources. North American sites in this study do not include coastal locations where marine dietary input would be equally high. Without this direct comparison, one cannot conclude that nitrogen isotopes are regionally distinct between Africa and all of North America. Rather, nitrogen isotopes are controlled more likely by local food sources, and to some extent, social class (France et al., 2014).

The results of this study indicate that oxygen isotope values are particularly useful for distinguishing Africans from North Americans. The Elmina population, which represents a mix of West African people, shows oxygen isotope values that are distinct from a majority of North American values in this study. Remains from Glorieta Pass (Figure 2), a military company mustered out of Texas, are the exception. As one of the southern-most points in the United States, this area shows some of the most positive North American $\delta^{18}O$ values in meteoric water. As noted, Elmina essentially represents the lowest expected oxygen isotope values in exported African slaves whereby $\delta^{18}O$ values for other exported slave populations are expected to be higher than or approximately equal to Elmina values. Individuals living for years in the southern-most regions of North America may show some oxygen isotope overlap with recently arrived Africans from Senegambia, Sierra Leone, Liberia, Ghana or the Bight of Benin (Figure 1). However, recently arrived Africans from further south (i.e., Bight of Biafra, western Central Africa, and Southeast Africa) should be isotopically distinct from North American populations. Oxygen isotopes in southeastern regions and all central and northern regions of North America potentially could be used to identify recent arrivals from Africa.

Of particular interest are North American sites with enslaved African Americans from the mid- to late-1700s: A.P. Hill, Pettus, and Robinson Cemetery. Values from the Pettus and Robinson skeletal remains show average $\delta^{18}O_{carbonate}$ statistical differences from values of several other sites, including both Euro-Americans and African Americans, while the average value for

A.P. Hill individuals is statistically similar to almost all North American sites. Most individuals from these sites show $\delta^{18}O_{carbonate}$ values ~2 ‰ less than the Elmina average. Similarly, individuals from Parkway Gravel, representing slaves or former slaves in the later 1800s, and Elmina show no overlapping $\delta^{18}O_{carbonate}$ values. Rather, Parkway Gravel remains show $\delta^{18}O_{carbonate}$ values typical of its North American location. This observation suggests that these individuals were born in North America or spent the majority of their lives there. It is notable that the two African American sites containing both tooth and bone data (Parkway Gravel and Robinson Cemetery) show similar $\delta^{18}O_{carbonate}$ values between the two tissue types. This supports the idea that these adult bone isotope values reflect a lifetime spent in North America, rather than values integrated through a forced migration. Teeth from African Americans were limited in this study, but this small sub-set of data lends credence to the idea that slaves were often born into the system by the early 1800s.

Three notable outliers with relatively higher $\delta^{18}O_{carbonate}$ values were observed among African Americans in this study: two individuals from Pettus (44JC33-PETTUS-191 and 44JC33-PETTUS-253) and one from A.P. Hill (44CEAPHILL-VAOCME-2). These three individuals show $\delta^{18}O_{carbonate}$ values that are more similar to the majority of Elmina values (Figure 2). These outliers may have been recent arrivals to the North American Mid-Atlantic from Africa, or alternatively, were born in the furthest southern states (i.e., Florida, Alabama, Georgia, or Louisiana) or the Caribbean. These two sites contain some of the earlier remains likely from the late 1700s (Pettus) or earliest 1800s (A.P. Hill) when the slave trade was still quite active. Others from these sites appear to have been in North America for most of their lives.

This preliminary case study demonstrates how an isotopic approach potentially can explore slavery as a self-sustaining system in North America, identifying a reduced influx of new individuals in the mid- to late-1800s. To comprehensively test this idea, additional isotope testing of African and North American archaeological remains is required, coupled with detailed analysis of age to facilitate interpretation of individual residency duration. While some overlap between African and far southern North American sites may become apparent in future studies, these data offer insight for identifying regional origins and numerical representation of African peoples in the North American diaspora.

While this study did not directly test isotope values from Central American and Caribbean individuals, previous research provides an isotopic comparison for this region which was active in the slave trade to North America. Local $\delta^{18}O_{carbonate}$ values from human remains in these regions ranges from approximately +25 to +29 ‰, with most values in the range of about +27 to +29 ‰ (Laffoon et al., 2013, Laffoon et al., 2018, Price et al., 2010, Price et al., 2012, Schroeder et al., 2009). This is significantly higher than the North American values in this study, but it does overlap with the Elmina values. This implies that oxygen isotope values may be able to distinguish recent arrival in the mid-Atlantic region, but distinction between a Caribbean origin and a more northern African origin may be confounded without additional data, such as strontium isotopes. However, origin from more central or southern Africa may be distinguishable, although additional data sets are necessary to test this. Both $\delta^{13}C_{carbonate}$ and $\delta^{13}C_{collagen}$ values from Central American and Caribbean locals and recent migrants show a range of values including dominantly C3 consumption to dominantly C4 consumption (Bastos et al., 2016, Laffoon et al., 2013, Laffoon et al., 2018, Price et al., 2012, Schroeder et al., 2009). The relative $\delta^{13}C$ relationship between local individuals and confirmed migrants from Africa (i.e., which group consumed more C4 plants) varies, likely depending on the dominant food base in the region of birth. With additional future analyses from African archaeological remains, the $\delta^{13}C$ and $\delta^{18}O$ values may be coupled to provide a more precise region of origin and distinguish between the African and Caribbean slave trading routes, both of which were active until the legal cessation of this practice.

6. Conclusions

The African diaspora contributed significantly to the cultural and biological make-up of the larger colonial population of the United States of America, with estimates of the number of enslaved persons brought to North America from Africa varying from approximately 208,000 to 370,000 (Curtin, 1969, Lovejoy, 1989, Voyages: The Atlantic Slave Trade Database, 2017). Exact numbers and knowledge of the precise origins of these individuals are limited to incomplete historical and bioarchaeological records. The unique stable isotope profile of West Africans presented in this study facilitates the identification of recent arrivals in a number of archaeological Mid-Atlantic sites, potentially enabling increased understanding of the slave trade and in turn, African American population dynamics.

This study presents a rare direct comparison between 18th- and 19th-century North Americans and Africans from the relatively cosmopolitan site of Elmina, Ghana to determine whether oxygen isotopes can be used to identify recently arrived Africans, and thus shed light on patterns of arrival into North America. Isotope values of individuals from Elmina serve as a proxy for isotope values of individuals exported from Africa since the values from Elmina are distinct from most North American populations, with the exception of extremely southern locations and the Caribbean. While results are considered preliminary due to available sample sizes, comparison to North American slave population samples from specific archaeological sites suggests that by the mid-1700s the North American slavery system may have been largely self-sustaining, with the majority of individuals born and raised in North America. Further broad comparison of carbon and nitrogen isotope values confirms their utility in discerning dietary resources, specifically a high influence of C4 vegetation and marine resources in Elmina.

Extrapolation of these data to the larger African continent may be possible with additional contributions and future analyses. With the current data it is not possible to discern precisely where in Africa the individuals living in Elmina originated, although it is known that this site attracted immigrants from disparate locations within a restricted geographical region based on the homogeneity of $\delta^{18}O_{carbonate}$ values with few outliers. Stable isotope data from African archaeological remains are limited for 17th–19th-century individuals, but this study demonstrates the potentially useful applications should such remains become available. With a more comprehensive data set from North America as well, it may be possible to distinguish African regional origins of North American enslaved individuals, which would provide a new window into the cultural components carried to the new world via the Atlantic slave trade.

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Data Availability Statement

This manuscript and data therein will be available upon final publication in the Smithsonian Research Online Database (https://research.si.edu).

Literature Cited

Ambrose, S. H. (1990). Preparation and characterization of bone and tooth collagen for isotopic analysis. *Journal of Archaeological Science*, 17, 431-451.

Ambrose, S. H., & Norr, L. (1993). Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate. In J. B. Lambert & G. Grupe, (Eds.), *Prehistoric Human Bone – Archaeology at the Molecular Level* (pp. 1–33). Berlin, Germany: Springer-Verlag.

Anstay, R. (1975). The volume and profitability of the British slave trade, 1761-1807. In S.L. Engerman, and E. D. Genovese (Eds.), *Race and Slavery in the Western Hemisphere: Quantitative Studies* (pp. 3-31). Princeton, NJ: Princeton University Press.

Baesjou, R. (1979). *An Asante Embassy on the Gold Coast* (Report). Cambridge: African Studies Centre, African Social Research Documents, Vol. 11.

Balasse, M., Bocherens, H., & Mariotti, A. (1999). Intra-bone variability of collagen and apatite isotopic composition used as evidence of a change of diet. *Journal of Archaeological Science*, 26, 593-598.

Barbour, M. J. (n.d.). *Having fought and died together: Examining the Battle of Glorieta Pass Confederate Mass Grave* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Bastos, M. Q. R., Santos, R. V., de Souza, S. M. F. M., Rodrigues-Carvalho, C., Tykot, R. H., Cook, D. C., & Santos, R. V. (2016). Isotopic study of geographic origins and diet of enslaved Africans buried in two Brazilian cemeteries. *Journal of Archaeological Science*, 70, 82-90.

Beasley, M. M., Bartelink, E. J., Taylor, L., & Miller, R. M. (2014). Comparison of transmission FTIR, ATR, and DRIFT spectra: implications for assessment of bone bioapatite diagenesis. *Journal of Archaeological Science*, 46, 16-22.

Bellantoni, N. F., Sledzik, P. S., & Poirier, D. A. (1997). Rescue, research, and reburial: Walton Family Cemetery, Griswold, Connecticut. In D. A. Poirier & N. F. Bellantoni (Eds.), *Remembrance: Archaeology and Death* (pp. 131-154). Westport, CT: Bergin & Garvey.

Blakey, M. L. (1998). The New York African Burial Ground Project: an examination of enslaved lives, a construction of ancestral ties. *Transforming Anthropology*, 7, 53-58.

Bocherens, H., & Drucker, D. (2003). Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: case studies from recent and ancient terrestrial ecosystems. *International Journal of Osteoarchaeology*, 13, 46–53.

Bowen, G. J., & Wilkinson, B. (2002). Spatial distribution of $\delta^{18}O$ in meteoric precipitation. *Geology*, 30, 315-318.

Bowen, G. J., West, J. B., Miller, C. C., Zhao, L., & Zhang, T. (2014). IsoMAP: Isoscapes Modeling, Analysis and Prediction (version 1.0). The IsoMAP Project. http://isomap.org.

Bowes, J. & Trigg, H. (2012). Social dimensions of eighteenth and nineteenth-century slaves' uses of plants at poplar forest. In B. J. Heath & J. Gary (Eds.), *Jefferson's Poplar Forest: Unearthing a Virginian Plantation* (pp. 155–171). Gainesville, FL: University Press of Florida.

Bowes, J. (2011). Provisioned, produced, procured: slave subsistence strategies and social relations at Thomas Jefferson's poplar forest. *Journal of Ethnobiology*, 31, 89–109.

Bruwelheide, K. S., Owsley, D. W., Barca, K. G., Jantz, R. L., France, C. A. M., Little, N. C., & Comer, E. (in press). Restoring identity to people and place: reanalysis of human skeletal remains from a cemetery at Catoctin Furnace, Maryland. *Society for Historical Archaeology*.

Bryant, J. D., & Froelich, P. N. (1995). A model of oxygen isotope fractionation in body water of large mammals. *Geochimica et Cosmochimica Acta*, 59, 4523-4537.

Child, K. M., & Kosack, K. L., (2013). *Archaeological Excavation of the Hilleary Family Cemetery, Site 18PR978, Prince George's County, Maryland*. Frederick, MD: R. Christopher Goodwin & Associates, Inc.

Crist, T. A. J., Roberts, D. G., Pitts, R. H., McCarthy, J. P., & Parrington, M. (1997). The First African Baptist Church Cemeteries: African-American mortality and trauma in Antebellum Philadelphia. In D. A. Poirier & N. F. Bellantoni (Eds.), *Remembrance: Archaeology and Death* (pp. 19-50). Westport, CT: Bergin & Garvey.

Curtin, P. D. (1969). *The Atlantic Slave Trade, a Census*. Madison, WI: The University of Wisconsin Press.

D'Angela, D., & Longinelli, A. (1990). Oxygen isotopes in living mammal's bone phosphate: further results. *Chemical Geology*, 86, 75-82.

Daux, V., Lécuyer, C., Héron, M., Amiot, R., Simon, L., Fourel, F., Martineau, F., Lynnerup, N., Reychler, H., Escarguel, G. (2008). Oxygen isotope fractionation between human phosphate and water revisited. *Journal of Human Evolution,* 55, 1138-1147.

DeCorse, C. R. (1999). Oceans Apart: Africanist Perspectives on Diaspora Archaeology. In T. Singleton (Ed), "*I, Too, Am America": Archaeological Studies of African-American Life* (pp. 132-155). Charlottesville, VA: University of Virginia Press.

DeCorse, C. R. (2001). *An Archaeology of Elmina*. Washington, DC: Smithsonian Institution Press.

DeCorse, C. R. (2008). Varied Pasts: History, Oral Tradition, and Archaeology on the Mina Coast. In J. Brooks, C. R. DeCorse, & J. Walton (Eds.), *Place, Event, and Narrative Craft: Method and Meaning in Microhistory* (pp. 77-93). Santa Fe, New Mexico: School of American Research Press.

DeCorse, C. R. (2010). Early Trade Posts and Forts of West Africa. In E. Klingelhofer (Ed.), *First Forts: Essays on the Archaeology of Proto-colonial Fortifications* (pp. 209-233). Leiden, Netherlands: Brill.

DeNiro, M. J., & Epstein, S. (1981). Influence of diet on the distribution of nitrogen isotopes in animals. *Geochimica et Cosmochimica Acta,* 45, 341–351.

DeNiro, M.J. (1985). Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. *Nature,* 317, 806–809.

Doms, K., Hoseth A., Silber, B. H., Grettler, D. J., Gentile, S. M., & Faulls, F. D. (1995). *Archaeological Investigations of the Scott's Run Project Area, the Route 72/13 Intersection Improvements Project Area, and the Woodville Grave Site (7NC-E-98A), State Route 1 Corridor, New Castle County, Delaware* (Report). University of Delaware, Department of Anthropology, Center for Archaeological Research. Delaware Department of Transportation Archaeology Series No. 147.

Dutton, A., Wilkinson, B. H., Welker, J. M., Bowen, G. J., & Lohmann, K. C. (2005). Spatial distribution and seasonal variation in $^{18}O/^{16}O$ of modern precipitation and river water across the conterminous USA. *Hydrological Processes*, 19, 4121-4146.

Feinberg, H. M. (1989). Africans and Europeans in West Africa: Elminans and Dutchmen on the Gold Coast during the eighteenth century. *Transactions of the American Philosophical Society*, 79, 1-186.

Fennell, C. C. (2011). Early African America: Archaeological Studies of Significance and Diversity. *Journal of Archaeological Research*, 19, 1-49.

Fernandes, R., Nadeau, M., & Grootes, P. M. (2012). Macronutrient-based model for dietary carbon routing in bone collagen and bioapatite. *Archaeological and Anthropological Sciences*, 4, 291–301.

Fesler, G. (2011). *Documents on Pettus Burials* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Fogel, M. L., Tuross, N., Johnson, B. J., & Miller, G. H. (1997). Biogeochemical record of ancient humans. *Organic Geochemistry*, 27, 275-287.

France, C. A. M., Owsley, D. W, & Hayek, L. C. (2014). Stable isotope indicators of provenance and demographics in 18^{th} and 19^{th} century North Americans. *Journal of Archaeological Science*, 42, 356-366.

Franklin, M. (2001). The Archaeological and Symbolic Dimensions of Soul Food: Race, Culture, and Afro-Virginian Archaeology of Identity. In C. E. Orser (Ed.), *Race and the Archaeology of Identity* (pp. 88–107). Salt Lake City, UT: University of Utah Press.

Garvie-Lok, S. J., Varney, T. L., & Katzenberg, M. A. (2004). Preparation of bone carbonate for stable isotope analysis: the effects of treatment time and acid concentration. *Journal of Archaeological Science*, 31, 763-776.

Gill, G. W., & Rhine, S. (1990). Skeletal attribution of race: Methods for forensic anthropology. Anthropological Papers of the Maxwell Museum of Anthropology 4.

Handler, J. S. (1994). Determining African birth from skeletal remains: a note on tooth mutilation. *Historical Archaeology*, 28, 113-119.

Handler, J. S., Corruccini, R. S., & Mutaw, R. J. (1982). Tooth mutilation in the Caribbean: evidence from a slave burial population in Barbados. *Journal of Human Evolution*, 11, 297-313.

Heaton, T. H. E. (1999). Spatial, species, and temporal variations in the $^{13}C/^{12}C$ ratios of C_3 plants: implications for palaeodiet studies. *Journal of Archaeological Science*, 26, 637-649.

Hedges, R. E. M. (2003). On bone collagen-apatite-carbonate isotopic relationships. *International Journal of Osteoarchaeology*, 13, 66-79.

Imlay, J. (2011). *Nails associated with Kincheloe Historic Cemetery, NMNH 91-14* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Imlay, J. (2012). *Parkway Gravel, Coffin Nail Analysis* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Jantz R. L., & Ousley S. D. (2005). Fordisc, *version 3.0.* Knoxville, TN: University of Tennessee.

Jim, S., Ambrose, S. H., & Evershed, R. P. (2004). Stable carbon isotopic evidence for differences in the dietary origin of bone cholesterol, collagen and apatite: implications for their use in palaeodietary reconstruction. *Geochimica et Cosmochimica Acta*, 68, 61–72.

Jorkov, M. L. S., Heinemeier, J., & Lynnerup, N. (2007). Evaluating bone collagen extraction methods for stable isotope analysis in dietary studies. *Journal of Archaeological Science*, 34, 1824-1829.

Kendall, C., & Coplen, T. B. (2001). Distribution of oxygen-18 and deuterium in river waters across the United States. *Hydrological Processes*, 15, 1363-1393.

Kohn, M. J. (1996). Predicting animal $\delta^{18}O$: accounting for diet and physiological adaptation. *Geochimica et Cosmochimica Acta*, 60, 4811-4829.

Kohn, M. J., & Cerling, T. E. (2002). Stable isotope compositions of biological apatite. In M.J. Kohn, J. Rakovain, & J. M. Hughes (Eds.). *Phosphates: Geochemical, Geobiological, and Materials Importance, reviews in Mineralogy and Geochemistry vol. 48* (pp. 455-480). Washington, DC: The Mineralogical Society of America.

Krueger, H. W., & Sullivan, C. H. (1984). Models for carbon isotope fractionation between diet and bone. In *Stable Isotopes in Nutrition*. *ACS Symposium Series 258* (pp. 205–220). Washington, DC: American Chemical Society.

Laffoon, J. E., Espersen, R., & Mickleburgh, H.L. (2018). The life history of an enslaved African: multiple isotope evidence for forced childhood migration from Africa to the Caribbean and associated dietary change. *Archaeometry*, 60, 350-365.

Laffoon, J. E., Valcárcel Rojas, R., & Hofman, C. L. (2013). Oxygen and carbon isotope analysis of human dental enamel from the Caribbean: implications for investigating individual origins. *Archaeometry*, 55, 742-765.

Landwehr, J. M., Coplen, T. B., & Stewart, D. W. (2014). Spatial, seasonal and source variability in the stable oxygen and hydrogen composition of tap water throughout the United States. *Hydrologic Processes,* 28, 5382-5422.

Lebon, M., Müller, K., Bahain, J. J., Fröhlich, F., Falguères, C., Bertrand, L., Sandt, C., & Reiche, I. (2011). Imaging fossil bone alterations at the microscale by SR-FTIR microspectroscopy. *Journal of Annalytical Atomic Spectrometry*, 26, 922-929.

Lebon, M., Reiche, I., Bahain, J. J., Chadefaux, C., Moigne, A. M., Fröhlich, F., Sémah, F., Schwarcz, H. P., & Falguères, C. (2010). New parameters for the characterization of diagenetic alterations and heat-induced changes of fossil bone mineral using Fourier transform infrared spectrometry. *Journal of Archaeological Science*, 37, 2265-2276.

Levinson, A. A., Luz, B., & Kolodny, Y. (1987). Variations in oxygen isotopic compositions of human teeth and urinary stones. *Applied Geochemistry*, 2, 367-371.

Longinelli, A. (1984). Oxygen isotopes in mammal bone phosphate: A new tool for paleohydrological and paleoclimatological research? *Geochimica et Cosmochimica Acta*, 48, 385-390.

Lovejoy, P. E. (1989). The impact of the Atlantic slave trade on Africa: a review of the literature. *Journal of African History,* 30, 365-394.

Luz, B., & Kolodny, Y. (1985). Oxygen isotope variations in phosphate of biogenic apatites, IV. Mammal teeth and bones. *Earth and Planetary Science Letters*, 75, 29-36.

Luz, B., Kolodny, Y., & Horowitz, M. (1984). Fractionation of oxygen isotopes between mammalian bone-phosphate and environmental drinking water. *Geochimica et Cosmochimica Acta,* 48, 1689-1693.

Mancl, T. (2007). *Investigations at Parkway Gravel in New Castle County, New Castle, Delaware* (Report). Little Creek, DE: Heite Consulting, Inc.

McDonald, B., & Meacham, S. (2001). *Archaeological Excavation of an Unmarked Cemetery at Site 44HE950 at the Confederate Forest Development, Henrico County, Virginia* (Report). Richmond, VA: Gray & Pape, Inc.

McLearen, D. C., McCartney, M., Kiser, T., & Richards, L. A. (2003). *Phase III Data Recovery at Site 44CE326, Fort A.P. Hill, Caroline County, Virginia* (Report). Fredericksburg, VA: Cultural Resources, Inc.

McNulty, T., Calkins, A., Ostrom, P., Ganghi, H., Gottfried, M., Martin, L., & Gage, D. (2002). Stable isotope values of bone organic matter: artificial diagenesis experiments and paleoecology of Natural Trap Cave, Wyoming. *Palaios,* 17, 36-49.

Mrozowski, S. A., Franklin, M., & Hunt, L. (2008). Archaeobotanical analysis and interpretations of enslaved Virginian plant use at Rich Neck Plantation (44WB52). *American Antiquity*, 73, 699–728.

O'Leary, M. H. (1988). Carbon isotopes in photosynthesis. *BioScience*, 38, 328-336.

Ogundiran, A. & Falola, T. (2007). *Archaeology of Atlantic Africa and the African Diaspora.* Bloomington, IN: Indiana University Press.

Ortner, D. J. (1966). A recent occurrence of an African type tooth mutilation in Florida. *American Journal of Physical Anthropology,* 25, 177-180.

Owsley, D., Pearlstein, K., & Bruwelheide, K. (2016). *The White Family Vault, Congressional Cemetery* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Owsley, D., Pearlstein, K., Bruwelheide, K., Hull-Walski, D., Falquero, K., & Ramsey, A. (2017). *Skeletal inventory of the Keyworth, Family Vault, Congressional Cemetery* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Passey, B. H., Robinson, T. F., Ayliffe, L. K., Cerling, T. E., Sponheimer, M., Dearing, M. D., Roeder, B. L., & Ehleringer, J. R. (2005). Carbon isotope fractionation between diet, breath CO_2, and bioapatite in different mammals. *Journal of Archaeological Science,* 32, 1459-1470.

Pearlstein, K., Owsley, D., & Bruwelheide, K. (2014). *Skeletal inventory of the Causten Family Vault, Congressional Cemetery* (Report). Washington, DC: Department of Anthropology, National Museum of Natural History, Smithsonian Institution.

Postma, J. M. (1990). *The Dutch in the Atlantic Slave Trade: 1600-1815*. Cambridge, England: Cambridge University Press.

Postma, J. M. (2003). *The Atlantic Slave Trade*. Gainesville, FL: University Press of Florida.

Price, T. D., Burton, J. H., Cucina, A., Zabala, P., Frei, R., Tykot, R. H., & Tiesler, V. (2012). Isotopic studies of human skeletal remains from a sixteenth to seventeenth century AD churchyard in Campeche, Mexico. *Current Anthropology,* 53, 396-433.

Price, T. D., Burton, J. H., Sharer, R. J., Buikstra, J. E., Wright, L. E., Traxler, L. P., & Miller, K. A. (2010). Kings and commoners at Copan: isotopic evidence for origins and movement in the Classic Maya period. *Journal of Anthropological Archaeology*, 29, 15-32.

Raynor, L. A., & Kennett, D. J. (2008). Dietary variability among a sample of United States soldiers during the War of 1812. *Historical Archaeology*, 42, 76-87.

Renschler, E. S., & DeCorse, C. R. (2016). The bioarchaeology of entanglement: Burials from Elmina, Ghana. *Nyame Akuma*, 86, 34-42.

Rivero de la Calle, M. (1973). La mutilación dentaria en la problación negroide de Cuba. *Ciencias*, 4, 3-21.

Roksandic, M., Alarie, K., Suárez, R. R., Huebner, E., & Roksandic, I. (2016). Not of African descent: dental modification among indigenous Caribbean people from Canimar Abajo, Cuba. *PLOS One*, 11, 1-15.

Schimmelmann, A., Albertino, A., Sauer, P. E., Qi, H., Molinie, R., & Mesnard, F. (2009). Nicotine, acetanilide and urea multi-level ^{2}H, ^{13}C, and ^{15}N-abundance reference materials for continuous flow isotope ratio mass spectrometry. *Rapid Communications in Mass Spectrometry*, 23, 3513-3521.

Schoeninger, M. J., & DeNiro, M. J. (1984). Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta*, 48, 625-639.

Schroeder, H., Haviser, J. B., & Price, T. D. (2014). The Zoutsteeg three: three new cases of African types of dental modification from Saint Martin, Dutch Caribbean. *International Journal of Osteoarchaeology*, 24, 688-696.

Schroeder, H., O'Connell, T. C., Evans, J. A., Shuler, K. A., & Hedges, R. E. M. (2009). Trans-Atlantic slavery: isotopic evidence for forced migration to Barbados. *American Journal of Physical Anthropology*, 139, 547-557.

Seeman, M. (2011). *An osteobiographical analysis of the Foscue Plantation burial vault, Pollocksville, Jones County, North Carolina* (Unpublished master's thesis). East Carolina University, Greenville, NC.

Singleton, T. A. (1995). The archaeology of slavery in North America. *Annual Review of Anthropology*, 24, 119-40.

Singleton, T. A. (1999). "*I, Too, Am America": Archaeological Studies of African-American Life.* Charlottesville, VA: University of Virginia Press.

Smith, B. N., & Epstein, S. (1971). Two categories of $^{13}C/^{12}C$ ratios for higher plants. *Plant Physiology*, 47, 380-384.

Snoeck, C., Lee-Thorp, J. A., & Schulting, R. J. (2014). From bone to ash: compositional and structural changes in burned modern and archaeological bone. *Palaeogeography Palaeoclimatology Palaeoecology*, 416, 55-68.

Spradley, M. K. (2006). *Biological anthropological aspects of the African diaspora: Geographic origins, secular trends, and plastic versus genetic influence utilizing craniometrics data* (Unpublished doctoral dissertation). University of Tennessee, Knoxville, TN.

Stewart, T. D., & Groome, J. R. (1968). The African custom of tooth mutilation in America. *American Journal of Physical Anthropology,* 28, 31-42.

Thompson, T. J. U., Gauthier, M., & Islam, M. (2009). The application of a new method of Fourier Transform Infrared spectroscopy to the analysis of burned bone. *Journal of Archaeological Science,* 36, 910-914.

Thompson, T. J. U., Islam, M., Piduru, K., & Marcel, A. (2011). An investigation into the internal and external variables acting on crystallinity index using Fourier Transform Infrared spectroscopy on unaltered and burned bone. *Palaeogeography Palaeoclimatology Palaeoecology*, 299, 168-174.

Tiesler, V. (2002). New cases of an African tooth decoration form colonial Campeche, Mexico. *Homo,* 52, 277-282.

Ubelaker, D. H., & Owsley, D. W. (2003). Isotopic evidence for diet in the seventeenth-century colonial Chesapeake. *American Antiquity,* 68, 129-139.

Van den Boogaart, E. & Emmer, P. (1979). The Dutch participation in the Atlantic Slave Trade, 1596-1650. In H. A. Gemery & J. S. Hogendoorn (Eds.), *The Uncommon Market: Essays in the Economic History of the Atlantic Slave Trade* (pp. 353-376). New York: Academic Press.

van der Merwe, N. J. (1982). Carbon isotopes, photosynthesis, and archaeology. *American Scientist*, 70, 596-606.

Voyages: The Trans-Atlantic Slave Trade Database. www.slavevoyages.com. Accessed September 20, 2017.

Walsh, L. S. (2001). The Chesapeake slave trade: regional patterns, African origins, and some implications. *William and Mary Quarterly*, 58, 139-170.

Wright, L. E., & Schwarcz, H. P. (1996). Infrared and isotopic evidence for diagenesis of bone apatite at Dos Pilas, Guatemala: palaeodietary implications. *Journal of Archaeological Science*, 23, 933-944.

Yarak, L. (1990). *Asante and the Dutch, 1744-1873*. Oxford: Oxford University Press.

Figure and Table Captions

Figure 1 – (Top) Oxygen isotope values of meteoric water in North America and Africa (Bowen et al., 2014). (Lower inset) Primary regions in Africa from which enslaved individuals were exported (Voyages: The Trans-Atlantic Slave Trade Database 2017). As a point of reference, the Windward Coast and Gold Coast are roughly equivalent to modern Liberia and Ghana, respectively.

Figure 2 – Carbonate oxygen and carbon isotope values compared between Elmina and Euro-Americans (top), and Elmina and African Americans (bottom). Closed symbols represent bone values; open symbols represent tooth values.

Figure 3 – Collagen nitrogen and carbon isotope values compared between Elmina and Euro-Americans (top), and Elmina and African Americans (bottom). Closed symbols represent bone values; open symbols represent tooth values.

Table 1 – Site information

Table 2 – Isotope data

Table 3 – Statistical results. All values are p-value results from Mann-Whitney tests. Comparisons are considered statistically significant if $p<0.05$. Significant differences are highlighted in bold print.

Supplemental Table 1 – Detailed site and sample information.

Supplemental Table 2 – Elemental yields and FTIR data.