PROVISIONING AN URBAN ECONOMY: ISOTOPIC PERSPECTIVES ON LANDSCAPE USE AND ANIMAL SOURCING ON THE ATLANTIC COASTAL PLAIN

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*Isotopic evidence from animal bones deposited in urban contexts offers a landscape perspective into urban life, hinting at where animals lived before reaching their final resting place in the city. Here, we use stable carbon and nitrogen isotope evidence from cattle (*Bos taurus*) bones excavated from commercial and residential sites within historic Charleston, South Carolina, to evaluate whether markets pooled or segregated access to beef cattle drawn into the urban economy from the broader landscape. Results indicate that stable isotope values of cattle are varied, suggesting a broad catchment area, and differ significantly among site contexts, offering preliminary evidence regarding the roles markets played in integrating the surrounding landscape through market exchange.*

KEYWORDS: *Zooarchaeology, stable isotope analysis, historical archaeology, urban provisioning*

This study reports and interprets preliminary faunal stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope data toward assessing the role of eighteenth- and nineteenth-century market exchange in redistributing cattle from dispersed producers to urban consumers in Charleston, South Carolina. Early colonial port-towns of North America relied on domesticated animals from surrounding landscapes to feed growing populations and fuel early export industries (Anderson 2004; Lewis 1999). In these economies, markets played a central role in integrating urban and rural environments and inhabitants. Located on the southern Atlantic coast of South Carolina, the city of Charleston, founded 1670, provided a livestock market for animal producers from nearby tidewater plantations and the extensive woodlands of the inland coastal plain. Southeastern cattle grazed in habitats that varied in terms of biota and microclimate, including in the city itself, on coastal plantations radiating away from the urban center, and in lowcountry woods extending inland from the coast (Zierden and Reitz 2009). Our goal is to use $\delta^{13}C$ and $\delta^{15}N$ data of cattle remains (*Bos taurus*) from historic Charleston as a first step toward describing variations in where cattle originated (grazed) in the isotopically varied lowcountry landscape before becoming beef in Charleston. To our knowledge, these are the first $\delta^{13}C$ and $\delta^{15}N$ data reported for southeastern cattle.

A second goal of this study is to compare isotopic variation in cattle bones from market and non-market sites in Charleston to question the extent to which markets integrated, or segregated, access to beef at Charleston. Markets generally are expected to provide access to goods that are pooled from a broad "catchment area," redistributing an array of foods to market patrons (cf. Lewis 1999). However, class dynamics likely influenced purchasing patterns, and patrons of markets may have differed based on social status. Comparative zooarchaeological data of cattle and other animals from sites within historic Charleston led Reitz (2007) to conclude that plantation owners (henceforth, and following from previous work, "upper-status" individuals) ate meat originating in their own herds on coastal plantations, while people living in commercial/residential "dual-function" sites, without their own herds or urban farmsteads (henceforth, and following previous work, "lower-status" individuals), purchased beef at markets. Continued archaeological investigations at Charleston have occasioned a revision of these previous

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findings, as greater similarities in the assemblages at markets, upper-status residences, and low-status residences become more apparent (Colaninno and Reitz 2012). Isotopic data offer a complementary line of evidence for testing Reitz's (2007) hypothesis that beef at market and at dual-function, low-status sites originated from the same sources (likely including rural cowpens). Similar stable isotope ratios of cattle remains in specimens from market and dual-function sites would support the hypothesis. Furthermore, greater isotopic variation at a site would indicate a broader catchment area (e.g., cowpens), whereas less variation would point to a narrower catchment area (e.g., a plantation). Do cattle from markets have more varied points of origin, reflecting the integration of a broader landscape converging at the market? Were upper-status residences supplying their own beef from their own plantation herds? We examine *Bos* from assemblages from two known upper-status households, two dual-function residences of lower status, and two markets, to address questions of segregated versus pooled beef access.

Stable carbon and nitrogen isotope ratios from *Bos* skeletal elements in urban deposits can be used to help identify the sources (grazing habitats) of cattle (e.g., Liu et al. 2013). We build on a body of recent research in archaeology that reconstructs husbandry and trade practices fueling early agglomerated settlements through stable isotope analysis of faunal remains (Guiry et al. 2012, 2014; Hartman et al. 2013; Reitsema et al. 2013; Stevens et al. 2013). These studies capitalize on the fact that plants exhibit microenvironmental δ^{13}C and δ^{15}N variations, which are passed on to animals, permitting some habitats to be distinguished isotopically. Following from these previous studies, we expect cattle from different ecoregions of South Carolina to vary isotopically, owing to microenvironmental variations in the isotopic baselines of plants (e.g., Szpak 2014; Tieszen 1991). In this study, we assume that markets pool resources from the broader South Carolina landscape. If cattle from many different sources were pooled at the markets, and then redistributed across the city evenly to consumers, we expect scrambled stable isotope variation across all site contexts. This scenario would identify the markets as a common source of beef for many of Charleston's inhabitants. If, on the other hand, markets did not pool access for all urbanites, we expect to see differences among sites and/or site contexts. This latter scenario would indicate that, rather than being pooled at the markets and redistributed to all, beef was drawn in from the landscape by different means (i.e., segregated) varying with any number of factors, including social status, occupation, and ethnicity, as Reitz (2007) had hypothesized. By comparing δ^{13}C and δ^{15}N data of *Bos* skeletal elements in historic Charleston zooarchaeological assemblages, this study provides a step toward understanding how urban markets integrated consumers, producers, and ecosystems in the Southeast.

Economic and Historical Contexts

Charleston was a key seaport, linking Europe with North America and the Caribbean and facilitating integration of the southeastern coast with the interior frontier. Into the early eighteenth century, cattle rearing dominated the economy of colonial South Carolina, although this initial cattle boom gradually gave way to a plantation economy based on rice production (Brooks et al. 2000). Planters and merchants in Charleston invested in cattle (Dunbar 1961), which grazed inland, at plantations along the inner coastal marshes, or even within the city itself (O'Steen 2007; Reitz 2007). Sizable herds of backcountry cattle were reared at "cowpens," often by an underclass of laborers, who transported cattle to markets on the coast (Jordan 1993). Documentary and archaeological evidence indicate that cattle ranged extensively across the landscape (Groover and Brooks 2003; Orr and Lucas 2007). According to the eighteenth-century historical account of Charleston resident Dr. Lionel Chalmers, "There is no need of houses to shelter, nor of provender to support the cattle during the coldest season; for they lie warm abroad, and brouse on somewhat or other. Any person, therefore, who inclines to raise black cattle, hogs, or horses, marks out a few hundred acres of land in some unsettled part of the country, where he finds a good range; and drives thither as many cows, bulls, hogs, stallions and mares as he pleases…As to the black cattle and horses, they are driven up once every year, in order to mark and brand the increase. After which they are again suffered to feed at large, perhaps to the distance of twenty miles, unless it be required to collect some of them for sale, when they are wanted" (Chalmers 1788:330). Decades before this account, Thomas Nairne, a trader, traveler, and agent to indigenous populations in the region, described the mild winters in the southeastern United States, "whereby the Planters are freed from the Trouble of providing for [their cattle], suffering them to feed all Winter in the Woods" (Nairne 1710:13).

Inequality characterized the economic class dynamics of Charleston, as most of the labor pool was enslaved. Agriculture, as the most common pursuit of wealthier Charleston residents, focused on export crops, yet some plantations supplied the city markets, often by slave merchants, who furnished produce to the urban population (Zierden and Reitz 2009). Despite the milieu of social inequality, butchers, consumers, and vendors of varied economic status and backgrounds-including Native Americans, slaves of African descent, and European emigrants converged at the markets (Zierden and Reitz 2009:337–342). The cosmopolitan bustle presented unique opportunities to witness commodities from near and far, but class dynamics likely defined purchasing patterns.

A central research problem regarding urban colonial provisioning strategies is the "extent to which urbanites purchased foods from market" as opposed to obtaining them from their own property (Zierden and Reitz 2009:343). Some Charleston residents were food producers, raising animals on plantations, or on "farmsteads based on urban lots" (O'Steen 2007:64). Other residents patronized markets, an activity which increased after the mid-eighteenth century (O'Steen 2007:65). In a survey of sites within Charleston, Reitz (2007) reports that *Bos* skeletal elements recovered from markets and from dual-function sites, where lower-status residents lived alongside commercial activities, complement each other, suggesting much of the meat purchased by the so-called "urban poor" originated from markets. At the same time, cattle remains from wealthy family residences (for example, the households once owned by Nathaniel Russell and Thomas Heyward) are redundant with those from markets, and display smaller cut marks suggestive of household butchery. A reasonable interpretation is that "elite householders probably supplemented their meat purchases through the slaughter of their own livestock either in Charleston or on their plantations," while urban poor obtained beef from vendors (Reitz 2007:100). We continue to use site status and function designations reported elsewhere for the sites (e.g., Zierden and Reitz 2009, and references therein). Our particular use of the term "upper-status" households is in reference to households of known Charleston elite residents. Our use of the term "lower-status" pertains to residences on lots shared with commercial structures – residences that would have been avoided by those who could afford to do so.

STABLE ISOTOPE ANALYSIS AND ANIMAL MANAGEMENT

Stable carbon and nitrogen isotope values in animal tissues reflect the isotopic signatures of their diet (Katzenberg 2008; Schoeninger 2011). Typically, $\delta^{13}C$ values are used to reconstruct the types of plants consumed by an animal during its lifetime, identifying differences in C_3, C_4, and CAM plants in the diet. $\delta^{15}N$ values are used to estimate trophic position (DeNiro and Epstein 1978, 1981; Minawaga and Wada 1984). Both $\delta^{13}C$ and $\delta^{15}N$ values are sensitive to environmental variations, including those in topography, aridity, salinity, substrate, fertility, and vegetation cover (Amundson et al. 2003; Britton et al. 2008; Buchmann et al. 1996; Farquhar et al. 1982; Heaton 1999; Schulze et al. 1996; Stevens et al. 2006; Stewart et al. 1995; Troughton and Card 1975; van de Water et al. 2002). Isotopic data have provided evidence for historic herding strategies in other contexts, including: the separation of grazing niches between cattle and aurochs in England during the Neolithic (Lynch et al. 2008); segregation of camelid management strategies in the Peruvian highlands (Finucane et al. 2006); use of salt-marshes for grazing cattle in Bronze Age United Kingdom (Britton et al. 2008); the environmental origins of domesticated sheep and goat traded and consumed in Early Roman Jerusalem (Hartman et al. 2013); and seasonal occupation of herding stations above Nordic farms in Greenland (Commisso and Nelson 2008). Our study builds on this literature, applying the biochemical approach to the zooarchaeological record of *Bos* from Charleston.

Five ecoregions characterize South Carolina (see Figure 1), suggesting the landscape may be divisible into isotopically varied habitats (SC DNR 2015). The Southern Coastal Plain surrounding Charleston is a mosaic of tidal floodplains, coastal dunes, marshes, and hammock islands influenced by high annual rainfall (117–140 cm) and salt spray (Griffith et al. 2002). This estuarine zone consists of abundant year-round C_4 forage, including cordgrass (*Spartina* spp.). Three species of *Spartina* provided range pasturage for seaside cattle on the southeastern Atlantic coast (Ranwell 1967), and windfall from cyclic weather events, such as hurricanes, regularly added Spanish moss (*Tillandisa usneoides*), a

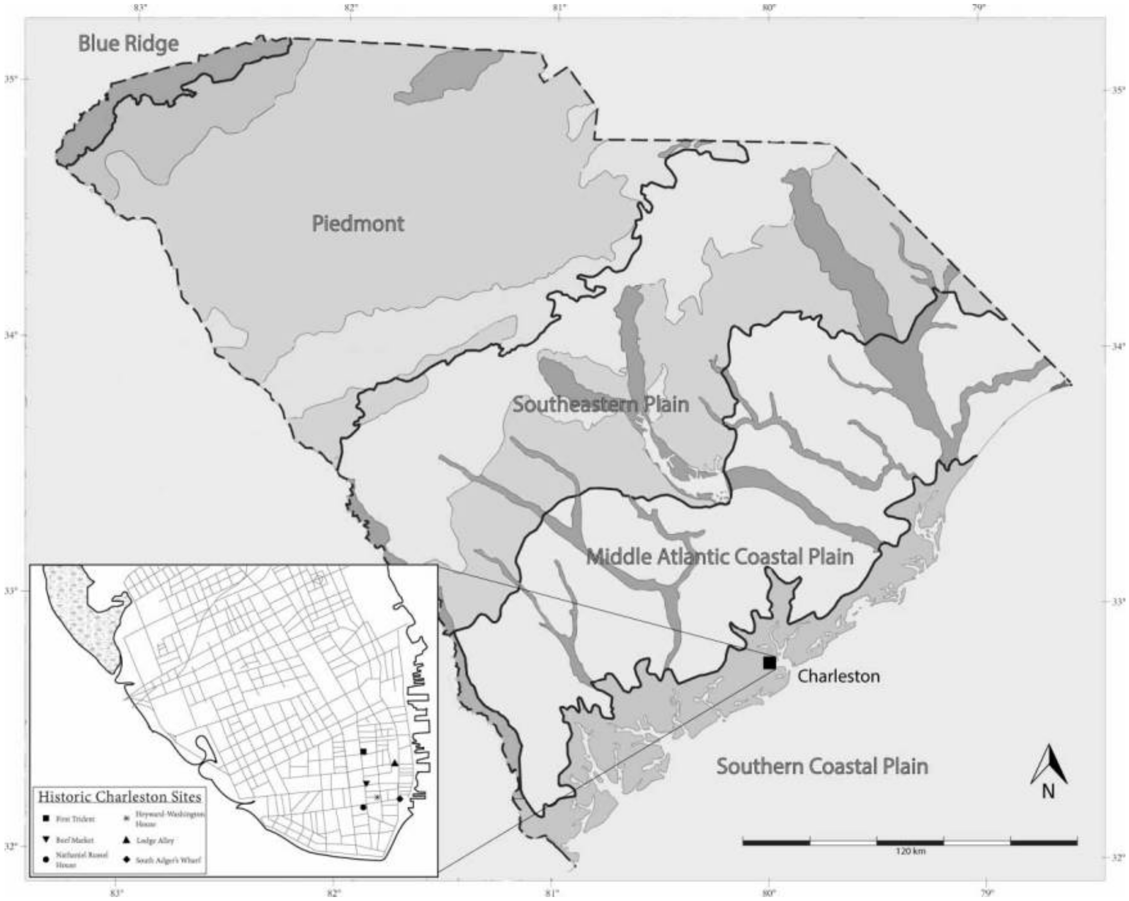

FIGURE 1. Map of South Carolina ecoregions described in text, after Griffith et al. (2002). Inset of Charleston modified from Zierden and Reitz (2009).

CAM species, to the cattle diet in this ecoregion (Otto 1986). The earliest cattle grazing in South Carolina occurred in this coastal setting. Coastal plantations thrived on sea islands. William Bartram described the economic application of these sea islands in the eighteenth century, writing that "the greatest part of these are as yet the property of a few wealthy planters…they settle a few poor families on their insular estates, who rear stocks of horned cattle, horses, swine and poultry, and protect the game for their proprietors" (Bartram 1791:66–67).

By the eighteenth century, cattle rearing had spread farther inland to the Middle Atlantic Coastal Plain. This ecoregion is characterized by the transition from flat sandy soils to rolling loamy hills, with rainfall declining from the coast (SC DNR 2015). Bottlenecks in winter forage made the evergreen foliage of river cane (*Arundinaria* spp.), a C_3 species, the preferred fodder of cattle grazing this ecoregion year-round (Platt and Brantley 1997). Historically, the understory of the pine woodlands on the coastal plain was dominated by wiregrass (*Aristida stricta*), a C_4 bunchgrass. Periodic fires favored the spread of this keystone species, as the non-deciduous foliage captured resinous pine needle litter, fueling the spread of early summer lightning fires (Outcalt et al. 1999). Wiregrass comprised upwards of 90 percent of the understory in some areas (Christensen 1977), including most of the Southeastern Plains, or sandhills.

The cowpen complex expanded across South Carolina, reaching the sandhills by the 1720s (Brooks et al. 2000; Guice 1977). The infertile sands of the Southeastern Plain receive the least precipitation of the five ecoregions, creating a distinctive xeric environment. Little bluestem (*Schizachyrium scoparium*), a native perennial C_4 bunchgrass, competed with wiregrass in the interspersed savannah grasslands across South Carolina; however, wiregrass proved to be more stress-tolerant in the xeric sandhills. Bartram provides a succinct and vivid description of a cowpen comprising some 1,500 cattle and their managing homestead, from his travels in the pine forests and savannahs of northern Georgia, writing, "[I discovered] a great number of cattle herded together, and on my nearer approach discovered it to be a cow pen; on my coming up I was kindly saluted by my host and his wife, who I found were superintending a number of slaves, women, boys and girls, that were milking the cows. Here were about forty milch [*sic*] cows and as many young calves, for in these Southern countries the calves run with the cows a whole year, the people milking them at the same time. The pen including two or three acres [0.8-1.2 ha] of ground, more or less, according to the stock, adjoining a rivulet or run of water, is inclosed [*sic*] by a fence; in this inclosure [*sic*] the calves are kept while the cows are out at range; a small part of this pen is partitioned [*sic*] off to receive the cows when they come up at evening" (Bartram 1791:309–310). Cowpens did expand into the Piedmont, yet the "most numerous and important cowpens" remained located across the coastal plains (Dunbar 1961). Furthest to the interior, the broadleaf forests of the mountainous Blue Ridge, which receive the most rainfall (127–203 cm), were not heavily involved in the cattle industry of South Carolina during the period under study.

Variations in the plant communities, salinity, rainfall, canopy cover, and fire periodicity across the extensive coastal plains are expected to create greater isotopic heterogeneity than would occur within individual coastal plantations. With this in mind, we use stable isotope evidence from cattle remains in Charleston to test the null hypothesis that *Bos* skeletal elements from residential and commercial contexts exhibit similar isotopic variation. Questioning landscape and market use with faunal stable isotope evidence, we sampled *Bos* elements from six sites within Charleston, described as follows, and grouped by time period of occupation and general socioeconomic status for analysis (Table 1).

FIRST TRIDENT

During the initial development of the First Trident site, ca. 1740–1765, the site operated as a tannery and low-status residence (Zierden, Calhoun, and Pinckney 1983). Located on the sparsely populated, low-rent periphery of town, where "noxious or dangerous" activities took place (Zierden, Calhoun, and Pinckney 1983), the tannery at First Trident was most likely occupied by someone other than the property owner. As the city grew, improvements were made to the land and property values increased. By the early nineteenth century, the First Trident site was situated in a predominantly middle class business district (Zierden, Calhoun, and Pinckney 1983:75). Cattle comprise almost 15 percent of the minimum number of individuals (MNI) excavated from First Trident overall. All the *Bos* remains in the present study date to the earliest phase of the site, when it was most likely a low-status commercial and residential site.

SOUTH ADGER'S WHARF

South Adger's Wharf is one of the oldest sections of the city, and for a time it was the economic center of Charleston. In 2008 and 2009, archaeologists exposed portions of the defensive city wall and redan, as well as a portion of a waterfront

TABLE 1 CHARLESTON SITE INFORMATION

Site	Site summary	Consumer Status	Date	References
First Trident	Modest-status residence	Non-elite	1740s	Zierden, Calhoun, and Pinckney (1983)
South Adger's Wharf (Early Lower Market)	Public market	Non-elite	1760–1786	Butler et al. (2012)
Heyward-Washington House	Stable at upper-status residence	Elite	1750–1820	Zierden and Reitz (2007)
Nathaniel Russell House	Upper-status residence	Elite	1808–1857	Zierden (1995; 1996)
Beef Market	Public market	Non-elite	1760–1796	Calhoun et al. (1984) and Zierden and Reitz (2005)
Lodge Alley	Public, dual function	Non-elite	1750s–1800s	Zierden, Calhoun, and Paysinger (1983)

market, the Lower Market. The Lower Market operated between ca. 1760 and 1799 (Butler et al. 2012) and during that time it was one of three markets serving the city (Zierden and Reitz 2005). Cattle remains comprise roughly 21 percent of the Lower Market faunal assemblage MNI (Butler et al. 2012:266).

HEYWARD-WASHINGTON HOUSE

This upper-status residence is one of the few properties located within the original walled city to be studied archaeologically. Excavations on the property revealed complex stratigraphy dating from 1730 to the late 1800s (Zierden and Reitz 2007). The interior of a stable, constructed in 1750, was excavated in 2002. Cattle comprise roughly 11 percent of the faunal MNI at the Heyward-Washington House stable (Zierden and Reitz 2007). *Bos* specimens included in the present study were deposited in the late eighteenth century. The property changed hands several times during that time. In 1772, gunsmith John Milner sold the property to Daniel Heyward, one of the wealthiest rice planters in South Carolina. Heyward's eldest son, a judge and signer of the Declaration of Independence, acquired the property in 1777 (Dillon 1978). The Heywards and the subsequent owners, the Grimkes, maintained the property as a private residence, with resident slaves, until 1824 (Zierden and Reitz 2009). This is an upper-status site.

NATHANIEL RUSSELL HOUSE

The upper-status residence of Nathaniel Russell, a wealthy merchant, was constructed in 1808 and occupied by the Russell family through 1857. Included on the property are the main house, three service buildings (including slaves' quarters), and a formal garden. The lot is enclosed by a low brick wall, which is considered the site boundary. Main excavations were conducted from 1994 to 1995. Cattle comprise roughly 24 percent of the MNI from the Nathaniel Russell House, an upper-status site (Weinand 1996).

BEEF MARKET

The Beef Market was an informal open-air market opened in 1692, later replaced in the same location by a formal brick market building in 1739. A new building, twice as large as the first, was constructed on the same site in 1760 and renamed the Upper Market or Beef Market (Zierden and Reitz 2005:104). A fire broke out in 1796 and destroyed the Beef Market, by which time the neighborhood had transformed from a commercial core to an upper-status residential center. The market was not rebuilt. Excavations in the present-day Washington Square Park and in the basement of City Hall uncovered minimally disturbed stratified deposits spanning the entirety of the market's history. Cattle comprise roughly 10 percent of the MNI from the site (Zierden and Reitz 2005:165). Materials for the present study are from the Upper Market/Beef Market context dating to 1760–1796. The market provides the reference values for inferring beef sourcing at the upper- and lower-status sites.

LODGE ALLEY

Lodge Alley (known as Simmons Alley during the colonial period) was constructed in the early 1700s. By 1739, it was extensively utilized for both residential and commercial functions. During this time period, Lodge Alley was located in what was a "core commercial area of [Charleston]" (Zierden, Calhoun, and Paysinger 1983). By the late eighteenth century, the commercial emphasis had shifted to another part of the city, and boarding houses and lower-status residences lined Lodge Alley. The alley was a thoroughfare and a repository of household waste. Lodge Alley represents the lower class of Charleston's sharply stratified socioeconomic context, and was home to mariners, seamstresses, boarding house lodgers, and, perhaps, prostitutes, among others (Zierden, Calhoun, and Paysinger 1983). Cattle remains comprise almost 16 percent (MNI) of the faunal assemblage at Lodge Alley (Reitz 1983). This is designated as a lower-status site.

MATERIALS AND METHODS

MATERIALS

Cattle skeletal elements from six archaeological sites within Charleston were made available by The Charleston Museum for study (Table 1). The sample contexts represent a mix of upper-status households of known, wealthy Charleston residents, dual-function sites (having both commercial and lower-status residential components), and markets. For simplicity, we refer to the named homes of wealthy Charleston residents as upper-status residences, while acknowledging that these lots were also the homes of servants and slaves (for more details on the complicated nature of status designations for sites at Charleston, see Reitz et al. [2006]). We refer to the remaining residential sites not owned and occupied by known, wealthy residents variously as lower-status and dual-function, in acknowledgment of the fact that commercial activities also took place at these sites, and in keeping with previous work (e.g., Zierden and Reitz 2009). The collections date to the mid-eighteenth century (First Trident, Lodge Alley), the late eighteenth century (Beef Market, South Adger's Wharf, Heyward-Washington House stable), and the nineteenth century (Nathaniel Russell House). The excavation and analyses of these materials are described in detail elsewhere (Butler et al. 2012; Reitz 1983; Zierden 1996; Zierden, Calhoun, and Paysinger 1983; Zierden, Calhoun, and Pinckney 1983; Zierden and Reitz 2005). Samples were stored in bags corresponding to archaeological proveniences (i.e., site, excavation unit, zone, and level). Every effort was made to maximize the size of the sample while minimizing the chance of the sampling from the same animal more than once. Our sampling strategy assumes that bones from different spatial/temporal contexts within a site were less likely to have come from the same animal than were commingled remains from identical proveniences, but we acknowledge that mixing within archaeological deposits is always a risk. We scrutinized the available collection for each site to identify elements that were least likely to have come from the same animal, taking into account (1) provenience and physical proximity of the remains; (2) age-at-death approximations based on epiphyseal fusion and tooth-wear; and (3) the presence of non-repeating elements and skeletal landmarks.

A total of 27 individuals from the six sites were identified and sampled for stable isotope analysis. Age approximations based on epiphyseal fusion were possible for 18 of the individuals included in the study, designated by "early," "middle," and "late" fusing elements (e.g., Reitz 1983) (Table 2).

METHODS

Samples were prepared using a whole bone method (Richards and Hedges 1999). Some of the bones used in the study were unfused epiphyses consisting mainly of poorly mineralized trabecular bone. Some began to disintegrate in the first 24 hours of .2 M HCl demineralization (NR-1, NR-3, FT-2, FT-3, FT-4, HW-3). When disintegration was observed, solutions were diluted to .1 M HCl for the remainder of the demineralization process. Purified collagen samples were analyzed using a Finnegan MAT 252 IR-MS housed at the University of Georgia Center for Applied Isotope Studies. Both stable carbon isotope ratios ($\delta^{13}C$) and stable nitrogen isotope ratios ($\delta^{15}N$) are given as "permil" values (δ) reported according to the equation [$\delta = (R_{\text{sample}} - R_{\text{standard}}) / R_{\text{standard}} \times 1000$]. Analytical standards included acetanilide and internally prepared bovine tendon. Reproducibility for $\delta^{13}C$ based on repeated measurements of an acetanilide standard was .17‰, and for $\delta^{15}N$ based on an internal bovine tendon standard was .28‰. Data are reported to the nearest .1‰. The Kruskal–Wallis rank sum test (*R*) is used to determine if differences exist among sites or time periods, and post hoc Kruskal Numenyi test was used to determine which groups were different. The Mann–Whitney *U* test (SYSTAT) is used to compare groups of sites (market/non-market; upper-status/lower-status). Differences are considered significant when $p \leq .05$.

RESULTS

Stable isotope results and collagen quality indicators are reported in Table 2. Samples are noted henceforth as the abbreviated site identifier (e.g., FT for First Trident) and the specimen number assigned for this study (e.g., FT-1) (Table 2). With one possible exception noted below, all collagen samples were deemed well-preserved on the basis of criteria for collagen preservation described by Ambrose (1990), including percent carbon (percent C) and nitrogen (percent N) in collagen, and atomic carbon to nitrogen ratios (C:N) (Table 2). It was also noted whether bones yielded collagen "models"/isomorphs, described by Garvie-Lok (2001) as an indicator of good collagen preservation. Four of 27 samples did not yield intact isomorphs.

Collagen yields were measured from all samples. In two cases, both from First Trident, collagen yields were below 1 percent, and neither of these samples yielded collagen isomorphs. Four other samples yielded between 2 and 3 percent collagen, of which two yielded only partly intact collagen isomorphs. Many of these low-collagen bones were unfused epiphyses consisting of poorly mineralized trabecular bone. Because C:N ratios and other collagen quality indicators are within acceptable ranges, these samples are not excluded from the subsequent discussion. Their isotopic values are not unusual,

TABLE 2 RESULTS

ID	Site FS #	Excavation context	Date (A.D.)	Element	Fusion timing	δ^{13}C (‰)	δ^{15}N (‰)	%C	%N	C: N	% Coll	Collagen isomorph
BM-1	158	Unit 9 Zn 6A	1760–1796	Rib	–	−16.0	4.5	37.7	14.0	3.1	2.8	Yes
BM-2	98	Unit 5 Ftr 15 Area C	1760–1796	Rib	–	−14.3	3.1	40.1	15.0	3.1	4.1	Yes
BM-3	120	Unit 6 Zn 6	1760–1796	Rib	–	−14.7	3.1	28.7	10.5	3.2	5.5	Yes
BM-4	160	Unit 8 Zn 6	1760–1796	Vertebra		−17.1	3.8	31.5	11.5	3.2	3.4	Yes
BM-5	207	Unit 11 Zn A	1760–1796	Femur epiphysis, unfused	Late	−16.7	4.4	28.0	10.3	3.2	5.9	Yes
BM-6	152	Unit 8 Zn A	1760–1796	Rib		−16.0	2.6 ± .1	28.6 ± 2.1	10.4 ± .6	3.2	8.3	Yes
						−15.8 ± 1.1	3.6 ± .8	31.9 ± 5.1	11.7 ± 2.0			
FT-1	21	TP 2 Ftr 5	1750s	R distal tibia, fused	Middle	−15.6	3.8	36.8	13.3	3.2	15.5	Yes
FT-2	23	TP 2 Zn 8	1740s	Proximal 2nd phalanx epiphysis	Early	−13.0	5.8	14.0	5.6	2.9	.5	No
FT-3	23	TP 2 Zn 8	1740s	Maxilla (adult)	.	−16.5	3.7	22.5	7.8	3.4	2.9	Partial
FT-4	25	TP 2 Zn 9 Lv 1	1740s	Distal tibia epiphysis, partly fused	Middle	−13.4	1.9	18.9	6.6	3.4	.2	No
						−14.6 ± 1.7	3.8 ± 1.6	23.1 ± 9.8	8.3 ± 3.4			
HW-1	31	Feature in 117 Zn 4	1750–1820	Fibula (juvenile)	.	−15.3	3.0	43.3	15.6	3.2	11.2	Yes
HW-2	150	Unit 7 Zn 5a Lv 2	1750–1820	R distal humerus, fused	Early	−15.8	4.8	43.4	15.5	3.3	13.6	Yes
HW-3	87	Unit 3 Zn 5a	1750–1820	L proximal tibia epiphysis	Late	−13.5	3.6	42.1	15.2	3.2	9.5	Yes
HW-4	56	Unit 1 Ft 117	1750–1820	Distal phalanx, fused	Early	−17.4	4.4	41.0	15.0	3.2	8.0	Yes
						−15.5 ± 1.6	3.9 ± .8	42.4 ± 1.1	15.3 ± .2			
LA-1	13	TP 1 Zn 8	mid-18th c.	Scapula	.	−12.2	6.0	41.8	15.4	3.2	5.4	Yes
LA-2	31	TP 3 Zn 7	mid-18th c.	L prox. radius, fused	Early	−12.9	3.5	42.4	15.2	3.3	14.1	Yes

Continued

Table 2 Continued

ID	Site FS #	Excavation context	Date (A.D.)	Element	Fusion timing	δ^{13}C (‰)	δ^{15}N (‰)	%C	%N	C: N	% Coll	Collagen isomorph
LA-3	9	TP 1 Zn 6	mid-18th c.	L prox. metatarsus fused	Early	−13.5	4.6	40.7	14.8	3.2	8.3	Yes
LA-4	9	TP 1 Zn 6	mid-18th c.	L prox. metatarsus fused	Early	−10.6	4.0	41.6	15.5	3.1	4.4	Yes
						−12.3 ± 1.3	4.5 ± 1.1	41.6 ± .6	15.2 ± .3			
NR-1	53	N111 E190 Zn3 Lv4	1830–1840s	Distal unfused metapodial condyle	Middle	−17.9	5.2	35.6	12.6	3.3	7.9	Yes
NR-2	298	N221 E174 Zn4 Lv1	1840s	R distal fused radius	Late	−13.4	3.7	39.1	14.0	3.3	5.8	Yes
NR-3	298	N221 E174 Zn4 Lv1	1840s	R distal unfused radius epiphysis	Late	−14.0	7.8	37.1	13.3	3.2	2.9	Yes
NR-4	313	N221 E174 Zn5 Lv2	1830s	R prox. fused radius	Early	−15.5	4.9	30.0	10.6	3.3	5.2	Yes
NR-5	313	N221 E174 Zn5 Lv2	1830s	R prox. fused radius	Early	−15.9	3.8	42.7	15.3	3.3	3.7	Yes
NR6	An drus	N05-10 E00-05	1820–1870	R distal fused tibia	Middle	−14.7	4.9	42.1	14.9	3.3	5.6	Yes
						−15.2 ± 1.6	5.1 ± 1.5	37.8 ± 4.7	13.4 ± 1.7			
SA-1	182	N 350 E 320 Zn 3B/C	1760–1786	Unidentified	.	−15.6	4.9	39.0	14.4	3.2	2.2	Partial
SA-2	186	N 345 E 325 Zn 3C	1760–1786	R scapula blade	.	−13.9	5.6	41.9	15.6	3.1	12.7	Yes
SA-3	250	N 345 E 325 Zn 3A	1760–1786	L 2nd phalanx, fused	Early	−17.9	4.4	41.6	15.6	3.1	16.0	Yes
						−15.8 ± 2.0	5.0 ± .6	40.9 ± 1.6	15.2 ± .7			

with the exception of those of FT-4, which yielded an unusually low δ^{15}N value of 1.9‰. Because this value could nevertheless be biogenic for a terrestrial herbivore, we include it in subsequent analysis. One sample (BM-6) was analyzed in duplicate: subsamples yielded nearly identical isotopic values (δ^{13}C: −16.06‰ and −16.07‰; δ^{15}N: 2.7‰ and 2.6‰).

There are no statistically significant differences among the individual sites (Kruskal–Wallis; δ^{13}C: $p = .058$; δ^{15}N: $p = .178$), nor are there significant differences in stable isotope values of markets and non-market contexts (Mann–Whitney U; δ^{13}C: $p = .054$; δ^{15}N: $p = .536$). Between high-status households and low-status residences/dual-function contexts, δ^{13}C values differ significantly (Mann–Whitney U; δ^{13}C: $p = .033$; δ^{15}N: $p = .374$). Contrary to the null hypothesis, δ^{13}C values also differ significantly between markets and lower-status/dual-function contexts (Mann–Whitney U; δ^{13}C: $p = .011$; δ^{15}N: $p = .810$). Contrastingly, there are no statistical differences between high-status residences and markets (Mann–Whitney U; δ^{13}C: $p = .369$; δ^{15}N: $p = .487$). There is a significant difference in δ^{13}C by time period (Kruskal–Wallis; δ^{13}C: $p = .021$; δ^{15}N: $p = .254$), with mid- and late-eighteenth-century samples differing significantly (Kruskal–Nemenyi; δ^{13}C: $p = .016$).

DISCUSSION

SITE DIFFERENCES IN *BOS* STABLE ISOTOPE VALUES

The stable isotope data are varied, indicating cattle were provisioned to Charleston from more than one ecoregion. Figure 2 shows much overlap among cattle and sites. There is one notable exception. Closer examination of Figure 2, and pursuant statistical testing, reveal that despite overlap, lower-status/dual-function sites are isotopically different from the markets and upper-status residences. Lodge Alley and First Trident, pooled together as both non-market and lower-status contexts, exhibit higher δ^{13}C values than the other sites (Mann–Whitney U, $p = .011$; see Table 2). A preliminary interpretation of these data is that lower-status/dual-function sites included in this study had a different "catchment" for beef than either markets or upper-status residences, and did not procure their beef at the markets. This stands in contrast to the hypothesis that complementary skeletal elements recovered in zooarchaeological assemblages reflect Charleston's urban poor procuring meat at markets (Reitz 2007).

Similarity in isotopic values of *Bos* from upper-status residences and markets suggest similarities in catchment areas. This may reflect upper-status residents supplying market vendors with cattle from their own herds, or upper-status residents patronizing the markets. We hypothesized that meat procured primarily from local plantations should exhibit relatively low isotopic variability compared to markets, which pooled beef from multiple ecozones. Yet this is not the case; isotope values within upper-status residences are as variable as within markets. At least some of the beef consumed in upper-status households appears to have come from multiple sources, possibly through market exchange, or through the ownership of cattle in multiple and isotopically

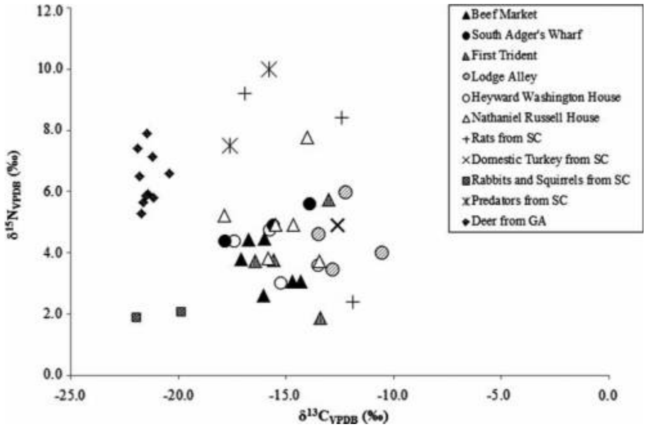

FIGURE 2. Charleston *Bos* are shown in comparison to other fauna from South Carolina (Schoeninger and DeNiro 1984) and from St. Catherines Island, Georgia (Bergh 2012). Charleston market sites include Beef Market and South Adger's Wharf (black symbols), dual function/lower-status residences include First Trident and Lodge Alley (hashed symbols), and upper-status residences include the Heyward-Washington House and the Nathaniel Russell House (white symbols).

different ecozones. The differences observed among sites caution against the assumption that meat access in Charleston was "homogenized" via markets and illustrates the importance of considering multiple provisioning strategies for agglomerated settlements.

The interpretation of site differences as socially and/or economically meaningful comes with some caveats. It is important to note that low-status contexts also are the earliest sites in the study, which conflates social, functional, and temporal causes of variability. As mentioned, cattle remains with the earliest dates exhibit higher $\delta^{13}C$ values than later samples, suggesting differences in place-of-origin, differences in the surrounding isotope ecology, or differences in cattle management strategies. Resolving this equifinality requires further contextualization of environmental changes and how they affected stable isotope variation in plants in the historic colonization of South Carolina.

Because lower $\delta^{13}C$ values are associated with greater forest cover and water availability (Tieszen 1991) and C_3 biomass, we suggest cattle with lower $\delta^{13}C$ values may have ranged in forests further inland from the coast than they had previously. This possibility is supported by ethnohistoric evidence of cattle moving inland over time: with the slow progression of settlers into the interior and concomitant land clearance for farming, herders, avoiding conflict with farmers, retreated into the pineywoods, where sandier soils favored pastoral strategies over crop agriculture (Owsley 1945). Drought is known to be associated with higher $\delta^{13}C$ values in plants, but this does not seem to underlie the isotopic variation we report: drought conditions were experienced in the Southeast during the early-mid 1800s (Seager et al. 2009), which is the time period associated with *lower Bos* $\delta^{13}C$ ratios. It will be necessary to measure stable isotope ratios in fauna from throughout Charleston's hinterlands before it is possible to attempt placing *Bos* in specific ecoregions. To assess whether the observed isotopic differences truly reflect social variables affecting beef access, rather than temporal changes, additional samples from market and upper-status contexts dating to the mid-eighteenth century will need to be analyzed.

EXPLAINING ISOTOPIC VARIATION OF CHARLESTON CATTLE

There are few stable isotope data for zooarchaeological material from the southeastern United States for comparison, to "place" cattle in the present study in ecozones across the landscape (Bergh 2012; Hutchinson and Norr 2006; Tuross et al. 1994) or for other comparisons. Compared to other *Bos* data from other regions, the $\delta^{13}C$ values of Charleston *Bos* are relatively high (for comparisons, see Jørkov et al. 2010; Müldner and Richards 2007; Reitsema et al. 2013; Schoeninger and DeNiro 1984), being most similar to mixed C_3/C_4 grazers (e.g., Atahan et al. 2011; Sealy 1996). The relatively high $\delta^{13}C$ values of *Bos* from historic Charleston can be explained by the ubiquity of C_4 plants present in the ecoregions surrounding Charleston. Many common forage species follow the C_4 synthetic pathway, including cordgrass, wiregrass, and bluestem (Table 3). Using an equation developed by White and Schwarcz (1989), the proportion of C_4 forage in the diets of cattle may be estimated using dietary endpoints for C_3 and C_4 plants in the area. Based on isotopic data from St. Catherines Island, Georgia, for modern plants (Reitsema, unpublished data; $n = 97$), for this equation, we use an endpoint value of −13.7‰ for C_4 plants and −28.1‰ for C_3 plants, and a diet-collagen offset of 5‰ for $\delta^{13}C$. Thus calculated, the proportion of C_4 plants in cattle diets ranges from approximately 36–87 percent.

Charleston *Bos* $\delta^{13}C$ values are not only high; they are remarkably varied, offering compelling preliminary isotopic evidence for a wide provisioning network. There is an 8‰ range in $\delta^{13}C$ values among cattle in the present study. For comparison, faunal stable isotope ranges of large-bodied animals in homogeneous environments are on the order of 2–3‰ (Bergh 2012; Lynch et al. 2008). As we have discussed, this likely reflects the city of Charleston pooling beef cattle from a broad catchment area. This surely included the vast cowpens, where cattle roamed and grazed on whatever was available (Chalmers 1788; Nairne 1710). All in all, cattle covered hundreds of miles of managed and unmanaged territory in South Carolina and Georgia, and the inferred isotopic diversity of their diets appears to be present in these Charleston faunal assemblages.

Bos $\delta^{15}N$ values exhibit a broad range of 6‰. This variation cannot be attributed to age and residual "weaning signals" (e.g., Fogel et al. 1989) as, with one exception (NR-3), the youngest animals do not exhibit higher $\delta^{15}N$ values (Table 2). Rather, this wide range in values can be attributed to natural variations in plant $\delta^{15}N$

Table 3 Examples of C_4, C_3, and CAM plants and their carbon stable isotope δ^{13}C values

Plant		Region reported	*n*	δ^{13}C (‰)	References
C_4					
Amaranthus spp.	Amaranth	Oaxaca, Mexico	3	−12.9 to −10.1	Warinner et al. (2013)
Andropogon gerardii	Big bluestem	Southwest Michigan	8	−12.7 ± .1 and −12.5 ± .1	Mahaney et al. (2008:300)
Andropogon virginicus	Broomsedge bluestem	St. Catherines Island, Georgia	19	−13.4 ± .5	Reitsema (unpublished data)
Aristida stricta Michx.	Wiregrass	Fort Bragg, North Carolina	4	−15.29 ± .32	Schafer et al. (2013:32)
Atriplex confertifolia	Saltbush	–	–	–	Waller and Lewis (1979)
Cynodon dactylon	Bermuda grass	–	–	−12.8	Smith and Brown (1973)
Cyperus flavescens	Yellow flatsedge	Eastern North America	–	−10.1	Li et al. (1999)
Distichlis spicata	Saltgrass	–	48	−15.0	Cloern et al. (2002)
Echinochloa crus-galli	Barnyardgrass	Arkansas	–	−13.1 ± .80	Gealy and Fischer (2010)
Eleusine indica	Goosegrass	(Experimental)	3	−12.1	Farquhar (1983)
Muhlenbergia capillaries	Muhly grass	Cape Canaveral, Florida	–	–	Keserauskis (2007:31–32)
Panicum virgatum	Switchgrass	–	–	−11.7	Smith and Brown (1973)
Portulaca oleracea (also uses CAM)	Common purslane	–	–	–	Lara et al. (2004)
Schizachyrium scoparium	Little bluegrass	Southwest Michigan	8	−13.5 ± .5 and −13.9 ± .4	Mahaney et al. (2008:300)
Sorghastrum nutans	Indian grass	Southwest Michigan	8	−14.0 ± .5 and −12.8 ± .4	Mahaney et al. (2008:300)
Spartina alterniflora	Cordgrass; salt-marsh grass	Atlantic Coast, USA	5	−12.3 to −13.6	Benner et al. (1987), Haines (1976)
Spartina foliosa	Cordgrass	–	56	−14.8	Cloern et al. (2002)
Tripsacum dactyloides	Gamagrass	–	–	−12.2	Smith and Brown (1973)
Uniola paniculata	Sea oats	–	–	−12.0 to −14.0	(Brown and Smith 1974)
C_3					
Arundinaria gigantean	River cane	Western North Carolina	1	−30.3	Griffith et al. (2009:227)
Arundinaria tecta	Switch cane	Fort Bragg, North Carolina	–	−31.8	Schafer et al. (2013:32)
Chenopodium album	Lambsquarter	–	–	−26 to −33.8	Hart et al. (2007:808)
Crotelaria spp.	Rattlepod	St. Catherines Island	3	−28.8 ± .3	Reitsema (unpublished data)

Continued

Table 3 Continued

Plant		Region reported	*n*	$\delta^{13}C$ (‰)	References
Cyperus haspan	Tapertip flatsedge	Eastern North America	–	−28.3	Li et al. (1999)
Dichanthelium ovale	Rosette/panic grass	St. Catherines Island, Georgia	14	−26 ± 1.4	Reitsema (unpublished data)
Ilex vomitoria	Yaupon Holly	Cape Canaveral, Florida	–	–	Keserauskis (2007:31–32)
Juncus roemerianus	Needlerush	–	–	−23.6 (leaf) and −23.5 (rhizome)	Benner et al. (1987)
Oryza sativa	Asian rice	Arkansas	–	−28.5 ± .11 (shoot)	Gealy and Fischer (2010)
Pinus palustris Mill.	Longleaf pine	Fort Bragg, North Carolina	2	−30.21 ± .01	Schafer et al. (2013:32)
Sabal palmetto	Sabal palm	–	–	−25.0	Baldini et al. (2007)
Salicornia	Pickleweed	California	57	−27.0	Cloern et al. (2002)
Sesuvium portulacastrum	Sea purslane	Venezuela	–	−25.8	Lonard and Judd (1997)
Typha angustifolia	Narrow-leaved cattail	California	45	−27.3	Cloern et al. (2002)
CAM					
Opuntia stricta	Prickly pear	Florida, Atlantic Coast	2 (seeds)	−16.0 ± .0	Tuross et al. (1994:294)
Portulaca oleracea (also uses C_4)	Common purslane	Southwestern USA	–	−10.6	Lara et al. (2004), Martin (1997)
Tillandisa usneoides	Spanish moss	Southeastern USA	8	−18.6 to −14.6	Smith and Epstein (1971), Hutchinson and Norr (2006), Reitsema (unpublished data)

Values of modern plants from North American locales, indicating C_3, C_4, or CAM photosynthetic pathway, including number of plants and region, when information is given (Baldini et al. 2007; Benner et al. 1987; Brown and Smith 1974; Farquhar 1983; Gealy and Fischer 2010; Griffith et al. 2009; Haines 1976; Hart et al. 2007; Hutchinson and Norr 2006; Jackson and Dewald 1994; Keserauskis 2007; Lara et al. 2004; Li et al. 1999; Lüttge et al. 1989; Mahaney et al. 2008; Martin 1997; Schafer et al. 2013; Smith and Brown 1973; Smith and Epstein 1971; Tuross et al. 1994; Waller and Lewis 1979; Warinner et al. 2013).

variations. Some plant species may exhibit higher $\delta^{15}N$ values than other plant species for genetic reasons (Ugan and Coltrain 2012) or because of microenvironmental variations in growing conditions (Szpak 2014). For example, plants in saline and waterlogged environments are associated with relatively high $\delta^{15}N$ values (e.g., Atahan et al. 2011; Britton et al. 2008). Modern within-species $\delta^{15}N$ variation at St. Catherines Island, Georgia, is as high as 6.4‰ (for *Andropogon virginicus*, $n = 19$; Reitsema, unpublished data). Taking these microregional variations into consideration, higher $\delta^{15}N$ values may indicate that some cattle grazed in salt marsh or estuarine environments near the coast.

We must also consider anthropogenic sources of $\delta^{15}N$ variations. Fires, used seasonally by ranchers to maintain pasture, and penning, for example, in the cowpens (Otto 1986) may contribute to systematic differences in the $\delta^{15}N$ values in soils, plants and subsequently, animals (Commisso and Nelson 2006, 2008; Grogan et al. 2000; Saito et al. 2007). Thus, cattle $\delta^{15}N$ variation may relate to grazing animals in areas with differing salinity, in managed versus unmanaged fields, in regions of varying proximity to coasts versus inland forests, or stall-fed versus free range. These conclusions present a series of alternatives that can be differentiated by sampling *Bos* remains directly from plantations and cowpens, allowing a comparison of isotopic diversity within Charleston against data from particular ecoregions with known stable isotope ecologies and management histories.

CONCLUSION

We explored stable carbon and nitrogen isotope variation of cattle deposited in historic Charleston as a new step toward assessing the role of markets in pooling access to beef, specifically exploring variation in *Bos* stable isotope ratios overall, and testing whether beef consumed at various sites within the historic city of Charleston exhibited systematic, or scrambled, isotopic variation. Isotopic variation at markets was high, pointing to multiple sources of beef for Charleston markets. Differences exist among sites: assemblages from two low-status/dual-function contexts differ from assemblages from markets and high-status residences. These results call into question the role markets may have played in feeding the urban population of Charleston, as they perhaps segregated, rather than integrated, sources of cattle and consumers of beef. Larger samples from multiple time periods are needed to disentangle temporal factors from social ones. Our preliminary research demonstrates how incorporating stable isotope data of faunal remains from cities into a larger landscape perspective brings the lived experience of social differentiation into archaeological interpretations of past economies and human–environment interactions. Future research should examine isotopic ratios of animals deposited in Charleston's hinterlands, to link animals in urban deposits to their points of origins.

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