ABSTRACT

KORN Mayer, Reina Isabella. Investigating Socioeconomic Status in Historic Charleston through Dietary Analysis of Urban Sus scrofa. (Under the direction of Dr. Chelsey Juarez).

This study examines socioeconomic status (SES) in Charleston, South Carolina during the 18th and 19th centuries by performing carbon and nitrogen isotopic analysis on Sus scrofa (pig) remains excavated from upper and lower SES sites throughout the city. Stable carbon and nitrogen isotopic analyses can be utilized to investigate dietary differences in protein consumption and trophic level. Examining the $\delta^{13}C$ and $\delta^{15}N$ values from hogs can provide insight into the dietary protein consumed by the animals and if there are differences in dietary protein sources based on the status of the individuals eating the pork. These differences in swine husbandry practices may provide insight into how pork products were sourced to residents within the city. Carbon and nitrogen isotopes from thirty-six samples of Sus scrofa bone fragments from six archaeological sites (five high SES and one lower SES) dating from 1700 to the late 1800s in Charleston, South Carolina were made available from the Charleston Museum for study.

This study found that there were no statistically significant differences between individual sites in $\delta^{13}C$: $F(5,30)=1.030$, $p=0.418$; or $\delta^{15}N$: $F(5,29)=0.912$, $p=0.487$; or time periods (1700s vs. 1800s). The Sus scrofa samples were significantly different than Bos taurus (cattle) remains from Charleston formally analyzed by Reitsema et al. (2015) for $\delta^{13}C$: $F(1,67)=5.707$, $p=0.020$; and $\delta^{15}N$: $F(1,67)=104.671$, $p<0.0001$. These results indicate that there was a variety of dietary protein sources consumed by the hogs and that they were at a higher trophic level than the cattle. The results also show that individuals across the SES spectrum were consuming pork products that were from pigs raised in different ways and on different diets. This research adds to the previous literature on faunal remains and their relationship to socioeconomic status by providing more support for the idea that the quantity of meat and choice of meat cut
were more important for symbolizing status than the quality of the meat. Further research should focus on isotopic analyses of possible foodstuffs that *Sus scrofa* would have had access to in historic Charleston and the greater state of South Carolina.
Investigating Socioeconomic Status in Historic Charleston through Dietary Analysis of *Sus scrofa*

by
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A thesis submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Master of Arts

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DEDICATION

To my long-suffering family, for endlessly supporting my love of dead things.
BIOGRAPHY

Reina Kornmayer grew up in the small town of Columbus in the foothills of Western North Carolina. In the second grade she found a sun-bleached turtle shell in the parking lot of her father’s workplace and smuggled it home, beginning a life-long passion for natural history and a hobby of collecting the skeletal remains of animals. A love for reptiles and amphibians developed in middle school and resulted in her eagerly catching snakes, lizards, turtles, and toads, sometimes resulting in personal injury, all while harvesting the skeletal remains of donated dead animals from her bone box in the back yard. While in high school she graduated from the South Carolina Master Naturalist program, becoming the youngest person to do so, and decided to pursue an undergraduate degree in ecology and evolutionary biology from the University of North Carolina at Asheville. During her time at UNCA she focused on courses dealing with wildlife, but her yearly trips to state and local medical examiners conferences fanned a life-long interest in forensic science, specifically forensic anthropology.

She entered the anthropology program at NC State after receiving her Bachelor of Science degree and tried to disguise herself as an anthropologist. Having no previous experience or knowledge of anything anthropological, she was quickly recognized as a biologist, but she pressed on and, after two very exhausting years, successfully defended her thesis. She looks forward to a future career in wildlife forensics, allowing her to work with animals and forensics at the same time, and plans to publish a novel or two along the way.
ACKNOWLEDGEMENTS

First and foremost, I would like to thank my parents for supporting my decision to move from biology to anthropology. Second, I would like to thank my advisor, Dr. Juarez, for providing me with a thesis idea where I could still work with animals in some aspect and also learn a new skill. I also owe gratitude to my other anthropology professors, Dr. Millhauser and Dr. Case, both of whom agreed to be on my committee and had to teach a graduate student with no prior anthropology training, which must have been challenging. My thesis would not have been able to happen without Martha Zierden and The Charleston Museum: she guided me through the process of gaining access to the museum collections and provided me with the faunal assemblages that I utilized for my research. She also provided literature on foodways and animal use in Charleston to help with my investigation of pig-human interactions in the city. Virginia Ellison of the South Carolina Historical Society was incredibly helpful with assisting me in locating historical resources on husbandry practices for hogs in the Southeastern United States. Without Jena Caiazza, my undergraduate assistant, preparing the isotope samples would have taken a huge amount of time and also would have been a bit lonely; it was nice to have company during all of the washing, weighing, crushing, pipetting, and tooth drilling. I would like to thank my good friends and fellow classmates Amanda Finnen and Karey Wall, for making me laugh, helping me when I didn’t understand basic anthropology theories, playing cards, and just being supportive in general. Finally, to my brother Joshua, thank you for driving to Charleston with me when I needed to spend a few days in the South Carolina Historical Society’s library doing research.
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**I. INTRODUCTION**

Hogs are an integral part of Southern culture in current times, even if the days of driving pigs down mountains to markets have long since passed. Barbecue continues to be a staple of Southern cooking, and the pig is revered “as a symbol of regional pride” as a result of the species’ history with people in the region (Bass 1995). Almost every part of the pig could be and was consumed, from the ears down to the curly tail, and slaughtering hogs was a community event celebrated by people of all ages (Bass 1995; Burnett 1947). Hog farming ranged from farmers raising huge herds to small families with a single pig (Burnett 1947). As the twentieth century progressed, pork production became more modernized, and more and more people procured their pork products at local grocery stores as opposed to raising their own pigs. Nevertheless, pork continued to be a dietary staple for people across the socioeconomic spectrum, with barbecue joints connecting individuals from all walks of life (Bass 1995). Prior to the modernization of hog farming, all people, regardless of wealth, raised pigs for their meat; as a result, investigating the husbandry practices of individuals of high and low SES may reveal distinctions in hog farming techniques utilized by people with more resources versus those with less. While pigs of privilege and pigs of want all end up on the dinner table, how they get there may illuminate whether one’s SES affects the way hogs are raised. This thesis aims to determine whether the socioeconomic status (SES) of people consuming pigs from the 1700s-1800s in historic Charleston, South Carolina can be determined through the analysis of the carbon and nitrogen isotopic composition of the animals’ skeletal remains.

Animals were an important part of everyday life in historic Charleston, as is evident from the thousands of animal remains that have been recovered through excavations, the vast majority of them coming from cows, pigs, and chickens, though many other domestic and wild species
have also been found. Within the city, animal remains have been found at private, public, and dual function sites (places where individuals lived and worked at the same location) and at both high and low socioeconomic status locations, indicating people and animals were living and working in the same locations (Zierden and Reitz 2016). Domesticated cattle and swine were raised in the forests and marshes surrounding the city, and wild animals were procured through hunting and through trading with local tribes (Shaw 1940; Zierden and Reitz 2016). Most animal species could be purchased at markets within the city, though many city residents kept livestock on their urban properties, and the same cuts of meat were utilized at sites across the entire socioeconomic spectrum, making it difficult to determine which classes of society were eating which cuts of meat (Zierden and Reitz 2016). Remains from consumed species have been used as proxies for humans because the specific skeletal elements and amount of elements found at sites provide insight into what animals were available for consumption, what cuts of meat were being utilized, and how much meat the human inhabitants were eating, which can reveal information about trade and SES for those people at that site during a specific time period (Crabtree 1990). Previous studies have utilized differences in the carbon and nitrogen isotopes among different animal species as proxies for human, producing reliable results. Thus, stable carbon and nitrogen isotopes can reveal differences in the sources of dietary protein consumed by humans and animals, which can help determine if there were differences in the husbandry practices for swine based on their owner’s SES (Schoeninger and DeNiro 1984; Reitsema et al. 2015). If there were differences in hog farming practices based on SES, it may be possible for archaeologists in the future to perform isotopic analyses of pig remains excavated from archaeological sites to infer which husbandry practice was being used and, in turn, what that might say about the people who consumed the pig.
The following chapters delve into why animals can be used as a proxy for SES, the background on the isotopes utilized in this thesis and how they have been used in similar studies, and the history of Charleston, South Carolina, which continues to be home to a variety of people, cultures, and cuisine to this day. This thesis uses 36 samples of *Sus scrofa* (pig) remains dating to the 17th and 18th centuries that were excavated from five high SES domestic sites and one low SES market site in Charleston, South Carolina. Carbon and nitrogen isotopes were analyzed to determine if there were differences in the protein portion of the diet of the pigs between the low SES site and the high SES sites. Pigs are omnivorous animals and will consume a wide variety of foodstuffs, depending on what they have access to. Pigs raised in the pastures, cultivated fields, and forests of plantations of the wealthy would have a diet consisting of primarily C₃ vegetative sources of protein, mirroring that of wild pigs (Wood and Roark 1980). C₃ plants follow the C₃ photosynthetic pathway, which involves converting carbon dioxide from the air into a phosphoglycerate compound containing three carbon atoms (van der Merwe 1982). Pigs feeding within the city on meal scraps and human refuse would have a diet where meat sources of protein and C₄ corn play a larger role. C₄ plants undergo a photosynthetic pathway that converts carbon dioxide from the air into dicarboxylic acid, which has four carbon atoms (van der Merwe 1982). The main hypothesis for this study is that isotopic differences in the skeletal remains of pigs will reflect the socioeconomic status of the people who ate them. If this hypothesis holds true, pigs from the low SES site will exhibit higher δ¹³C and δ¹⁵N values reflecting a diet of mainly corn, table scraps, and some animal meat products, as representative of the husbandry practices for urban hogs (Reitz et al. 2006). In contrast the pigs from high SES sites will exhibit low δ¹³C and δ¹⁵N reflecting a diet consisting of mast (fruit produced from trees, such as acorns and chestnuts)
and other vegetative material, as representative of the free-range husbandry practices for rural hogs (Shaw 1940).
II. ANIMALS AS A PROXY FOR SOCIOECONOMIC STATUS

In this thesis, SES includes material wealth and social status; the sites categorized as upper SES belonged to prestigious families of the Charleston community who owned vast plantations throughout the state in addition to their luxurious city town homes. While previous archaeological research in Charleston has found that people from all walks of life were consuming the same domestic and wild species, material remains from culinary accoutrements revealed that the rituals, the spectacle of consuming food, was a primary means of separating the rich from the poor in the city (Zierden and Reitz 2016). Nevertheless, zooarchaeological analyses of faunal remains recovered from historic sites have been previously used to investigate SES in various contexts. Many of these studies have used the differences in quality and quantity of meat from different cuts that were consumed and the variety and proportion of animal species consumed to investigate dietary discrepancies in SES (Crabtree 1990). Schulz and Gust (1983) examined 19th century cattle bones recovered from four sites in Sacramento, California, to study the social status of the residents. Their hypothesis was that, because retail cuts of beef have different rankings economically, the prevalence of expensive and inexpensive cuts will vary according to the social status of the consumers and that this should be reflected in the archaeological record (Schulz and Gust 1983). Using historical records the authors were able to identify the probable social status of individuals eating beef products at four separate sites: the city jail, two saloons, and one hotel, with the understanding that prisoners were probably being fed the cheapest cuts while hotel residents were probably being fed the highest-quality, more expensive cuts. Schulz and Gust used contemporary prices for retail beef cuts to create a ranking for each cut of meat and compared those rankings with the cuts found at the four sites.
Their results revealed that over 50% of the cuts from the hotel consisted of meat from the short loin region, which is the most costly portion of the carcass, while the neck and shoulder cuts, which were used for soup and stews, dominated the assemblage from the city jail. The authors did find that high and middle-value cuts of meat were present at the saloon assemblages, but were butchered in such a way that they could be used for roasts as opposed to the steaks consumed at the hotel. Roasts were an easy meal for saloon cooks to prepare for the free lunches that drew people into the bars during the day. The authors stated that their evidence illustrated how disparities in the composition of the different meat cuts from 19th century faunal collections are primarily due to differences in the SES of the meat consumers. They conclude that future socioeconomic status studies should incorporate faunal remains, historical records, and other forms of archaeological data to expand the knowledge of social status in urban 19th century contexts (Schulz and Gust 1983).

A study of faunal remains from a historic mining community in Nevada also investigated whether the animal remains excavated from twelve separate features were a good indication of the SES of different populations in the community (Schmitt and Zeier 1983). Knowing where people were eating (within the home or at other establishments) and what they were eating (what livestock was readily available and what meat products could be kept long term) can help researchers interpret the faunal evidence. Schmitt and Zeier examined the quantity of remains recovered and the quality of the meat cuts, focusing primarily on beef, in order to determine household composition (whether a mining family or a sole miner was the consumer of the meat) and the SES of the household (whether they were consuming expensive or less expensive cuts of meat). They found that historical records could only identify the SES of occupants from three features: an upper-class home, a blacksmith’s shop, and the home of a shoemaker. As an
alternative, they calculated the ceramic-index values for each feature in order to examine SES from another angle. When they compared the ceramic and faunal data, they found no correlation between the quality of the meat cuts present at each feature and the estimated SES of the household. However, the quantity of animal bones present was correlated with SES, as the higher-class site produced a large amount of remains representing various cuts of meat. Schmitt and Zeier argue that the disparity between ceramics, cuts of meat, and quantity of meat was the result of the community readily having access to retail ceramic items that could be purchased to reflect one’s social status, while beef was only available through the local butcher and would depend on what cuts of meat were left after the restaurants and boarding houses made their purchases. The authors state that their research shows how analyzing cuts of meat is not the only way to use faunal remains to investigate SES, as in their case just looking at the quantity of remains was a better indication of status and correlated better with the ceramic data and the historical records (Schmitt and Zeier 1983).

These studies show how the analysis of faunal remains can reveal SES differences among households in the same location, but these studies can also reveal differences in lifestyles between urban and rural settings. Reitz (1986) analyzed animal remains from sixteen archaeological sites in coastal South Carolina and Georgia dating from the 18th century to the middle of the 19th century. Based on comparisons of MNI’s, urban locations used more domesticated animals and a wider variety of domestic species than rural locations. Commensal species, including rats, snakes, and other vermin, were more prevalent in urban settings than in rural ones. In contrast more wild animals and a wider variety of wild species were utilized at rural contexts, perhaps because it was easier to hunt, trap, and fish in rural areas. Reitz determined that location was more influential over the diet than SES, as faunal remains from
rural slave and planter deposits showed that fewer domesticated species were consumed than at the urban sites, though the author concedes that planters may have had a more varied diet than the overseers and slaves on the same property. Reitz argues that whenever socioeconomic status is being studied through the analysis of faunal material, the geographic location should be kept in mind, as this can have an impact on what animals are present for food and how long food would need to stay fresh (Reitz 1986).

Within Charleston, South Carolina, socioeconomic status has been examined previously by examining the isotopic composition of cattle bones from residential upper SES sites, public market sites, and low SES/dual function sites. Reitsema and colleagues (2015) attempted to determine if there was isotopic variation among the samples, if different grazing areas could be identified, and if cattle could be used as proxies for human differences in socioeconomic status studies. The results revealed significant differences in the $\delta^{13}C$ values among the sites. Specifically, the samples from cattle excavated from the upper SES residential sites and the public market sites had similar $\delta^{13}C$ levels, and these levels were significantly different from the isotope levels from the low SES/dual function sites. The authors hypothesized that the plantations owned by the elite residents of the upper SES sites were supplying the markets with cattle, while individuals of lower socioeconomic status were not acquiring their beef products from the market places. In addition, the authors hypothesize that the wide variability in isotope values from cattle remains excavated from the upper SES sites could be due to those household purchasing beef products from the markets or consuming beef from their own herds, which could have been raised in isotopically different regions of the state (Reitsema et al. 2015).

The above studies illustrate how SES can be inferred from patterns in faunal data. High SES households tend to consume more meat than low SES households, and low SES households
tend to consume less expensive cuts of meat than their high SES counterparts. In some instances the location of the household may have more influence over the kinds of animals consumed than wealth and status, as it is easier to catch wild animals for consumption in rural settings than in urban ones, and the rate of butchering domesticated cattle and pigs can be less common in rural settings when there are fewer people to consume the meat before it spoils. As this research shows, this information can help elucidate the SES of the consumers of the meat at those sites, but it does not reveal disparities that may exist in animal husbandry practices between high and low SES individuals, and pork production has not been studied as heavily as cattle farming and beef production. The use of stable carbon and nitrogen isotopes in this thesis is a different approach that allows for the dietary sources of protein for animals to be estimated and relationships between protein types and SES investigated. The following chapter presents a background in the chemistry of the isotopes that are used in this thesis as well as research that has been previously performed on animal diets and their relationship to the people who consumed them.
III. ISOTOPES

History of Isotopes

This study focuses on the light isotopes of carbon and nitrogen and this chapter will summarize the standards, nomenclature, and literature relevant to these isotopes. Stable isotopes were first discovered in 1913 by Joseph John Thomson, a physicist and Nobel Laureate. Soon after this discovery researchers in the natural sciences began to recognize their utility in studies on photosynthetic pathways and in radiocarbon-dating methodologies (Katzenberg 2008). Isotopes are variants of a single chemical element that have the same number of protons but differ in the number of neutrons and thus have different atomic masses. Studies on the stable isotope composition of vertebrates from the fossil record began in the 1970s, with the goal of learning more about specific biochemical processes or how specific elements moved through a food chain (Koch 2007). For example, the element carbon can exist naturally as the isotope $^{12}$C, which is the most common form, or as the isotope $^{13}$C. Carbon 12 is lighter than carbon 13, making it more easily integrated into photosynthetic pathways than carbon 13. Thus, within the tissues of a plant, carbon 12 will become enriched (more of it will be present and incorporated into the tissues) more quickly relative to carbon 13. The change in the isotope ratios of an element due to chemical processes, or between an organism and that of the atmosphere and food sources is called fractionation (Katzenberg 2008). Not all plants will have the same levels of fractionation, as plants in differing environments undergo different photosynthetic pathways (van der Merwe 1982). The delta notation represents the formula for how stable isotopes are measured: $\delta X = \left[ \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right] \times 1000$, where delta ($\delta$) value is expressed in parts per thousand (‰), $X$ is the heavier isotope, and $R$ is the ratio of the heavy to light isotope. So, for $^{13}$C, one would use...
the following formula: \( \delta^{13}C = \left[ \frac{(C_{13}/C_{12})_{\text{sample}}}{(C_{13}/C_{12})_{\text{standard}}} - 1 \right] \times 1000. \) The laboratory standard for carbon used in this study is (PDB) and the laboratory standard for nitrogen is (AIR).

Carbon

The levels of \( \delta^{13}C \) within terrestrial vertebrates tend to reflect differences in photosynthetic pathways of the primary producers within an ecosystem. The three different pathways are C\(_3\), C\(_4\), and CAM, with C\(_3\) being the most common and CAM being the least common (Koch 2007). In the historic context of Charleston, the C\(_3\) and C\(_4\) pathways are of the greatest importance. C\(_4\) plants in North America are mainly agricultural, including corn, millet and sorghum, while the majority of native, non-agricultural plants, as well as fruit trees, many non-native flowering plants, and rice, are C\(_3\) (van der Merwe 1982). Plants employing each pathway utilize different methods to convert atmospheric carbon dioxide into glucose for energy, and each process of carbon fixation results in distinct \( \delta^{13}C \) signatures within the plant tissues (van der Merwe 1982). Research has shown that the carbon isotope values for C\(_3\) plants globally range from -34\(^\circ\) to -22\(^\circ\) and from -20\(^\circ\) to -7\(^\circ\) for C\(_4\) plants (O’Leary 1981). Different anatomies and physiologies cause the preference for C\(_3\) or C\(_4\) plants as foodstuffs to vary from species to species, as more intense gastrointestinal processing is necessary to properly digest C\(_4\) plants (Pearson et al. 2015). Many herbivores, including pigs, which can be omnivorous or even carnivorous, prefer C\(_3\) plants because they are easier to digest (Heckathorn et al. 1999).

For terrestrial plants, the \( \delta^{13}C \) value is determined by the CO\(_2\) value in the surrounding environment; in oceans the \( \delta^{13}C \) value is determined by the levels of dissolved CO\(_2\) in the water, carbonates, and bicarbonates (van der Merwe 1982). Marine plants have higher \( \delta^{13}C \) values, ranging from -17.0 to -8.1, than the \( \delta^{13}C \) of terrestrial plants, which ranges from -27.9 to -22.5 (Craig 1954). In freshwater systems, the \( \delta^{13}C \) value is also determined by carbonates,
bicarbonates, and dissolved CO₂, though the δ¹³C value for plants differs depending on whether or not they grew in hard or soft water, with hard water plants having δ¹³C values that resemble those of C₄ plants (van der Merwe 1982). A review of the literature revealed that the specific δ¹³C values for terrestrial and marine plants occurring within Charleston, South Carolina has not yet been determined; rather, δ¹³C values are often calculated for large locations or large groups of plants as a whole (i.e., for North America or for C₃ plants globally).

There are two types of tissue that are utilized for carbon isotope analysis. Biological apatite is the inorganic component of bone or enamel, that is largely comprised of the mineral hydroxyapatite, while bone collagen, or Type-1 collagen, is the organic component of bone. Studies conducted in 1993 revealed that δ¹³C extracted from biological apatite reflects the individual’s overall diet throughout that bone’s period of turnover, while δ¹³C extracted from bone collagen reflects the carbon absorbed from protein sources specifically (Ambrose and Norr 1993; Tieszen and Fagre 1993). DeNiro and Epstein (1978) discovered that the carbon taken in by an animal is enriched in ¹³C compared to its diet, resulting in a depletion of ¹³C in the carbon excreted by the animal. DeNiro and Epstein explain that the isotopic composition of the diet of an animal can be estimated if one takes into account how the carbon fractionates in the specific species under study, as the fractionation factor can differ from species to species and even from individual to individual (DeNiro and Epstein 1978). Such information allows for the creation of food webs: if the δ¹³C of an organism’s collagen is known, along with the δ¹³C of its diet, the enrichment factor can be calculated. When δ¹³C values for another organism of a different species are discovered, the placement of that individual in the food chain can be determined by comparing its δ¹³C values with those of plants and other animals that are present in the same ecosystem. A 2006 study by Nardoto et al. found that the cartilage of swine was enriched by
~1.0‰, while all other tissues were not enriched or were depleted in $^{13}$C in relation to the $^{13}$C of the diet (Nardoto et al. 2006).

South Carolina is comprised of five ecoregions, all with their own unique ecosystems, resulting in the potential for differences in $^{13}$C across the landscape (SC DNR 2015). Charleston is located in the Southern Coastal Plain ecoregion, specifically in the Sea Islands/Coastal Marsh portion. During the 18$^{th}$ and 19$^{th}$ centuries agriculture dominated the region, producing Sea Island cotton, indigo, and rice, which are all C$_3$ plants. Before plantation agriculture took hold, the area was home to maritime forests that consisted of slash pine, cabbage palmetto, live oak, and red cedar trees as well as various grass and rush species, which are C$_4$ plants (Griffith et al. 2002).

Most of the plantations associated with the sites under study are located in the Middle Atlantic Coastal Plain ecoregion, with one located just outside of Charleston and the other located in the Sand Hills ecoregion. All of the Charleston sites are within the Southern Coastal Plain ecoregion (Griffith et al. 2002). The Middle Atlantic Coastal Plain ecoregion now consists of primarily shortleaf and loblolly pine forests, with some sweet gum, cypress, and oak patches, though the region once consisted of mainly longleaf pine. The Sand Hills ecoregion now consists primarily of pine forests for the logging industry, though it once had a more diverse forest of various pine and oak species and a ground covering of wiregrass, a C$_4$ plant (Griffith et al. 2002).

For raising hogs, trees producing large mast crops every year were of the utmost importance in Europe and, after pigs were introduced to the continent, in North America as well. In North America, the most important trees of this type were the chestnut, oak, and beech, all of which are C$_3$ plants (Shaw 1940). Once a large number of masts had been produced, hogs were driven into the forests to feed, and were either allowed to fatten until it was time to go to market
or slaughter, or removed from the forests after a feeding period and fed corn for the remainder of their life. In South Carolina, most hogs were mast-fed in forests along river and coastal swamps, though this practice sharply declined after the Civil War, as corn gained in popularity for producing higher quality pork products (Shaw 1940). A review of the literature did not reveal any studies performed on the carbon and nitrogen isotope content of the masts of oak species or on the masts of the American chestnut and beech species that inhabit the East Coast. As a result the $\delta^{13}C$ and $\delta^{15}N$ for the Eastern United States species of acorn, chestnut, and beech masts that the hogs would commonly feed on remain unknown at the time of this thesis. Stable isotope studies performed on corn have shown that the $\delta^{13}C$ value ranges from $-13.2\%o$ to $-11.1\%o$. Thus, this study expects to see $\delta^{13}C$ values that reflect a primarily C$_3$ diet for pigs that have been allowed to forage freely, most likely on plantation lands and the surrounding areas of Charleston, while pigs kept penned within the city would have $\delta^{13}C$ values reflecting a C$_4$ diet of corn and human refuse (Youatt and Martin 1884).

Nitrogen

Nitrogen ($\delta^{15}N$) isotope levels are directly related to the amount of nitrogen entering a terrestrial vertebrate’s body through their dietary protein and the amount exiting the body through nitrogenous wastes (urea, uric acid). Nitrogen enters the food chains through plants, with local herbivorous species having $\delta^{15}N$ values that reflect that of the local vegetation (Hedges and Reynard 2007). As the $\delta^{15}N$ of a whole plant reflects the source nitrogen of the plant’s local habitat, the $\delta^{15}N$ differs from location to location, resulting in nitrogen data from one environment only being applicable to trophic level studies of individuals occurring in that same environment. Plants can get their nitrogen from the atmosphere as NH$_3$ or N oxides, from the soil as NO$_3^-$, NH$_4^+$, or amino acids, and from nitrogen-fixing microbes present in the soil or on the
roots of the plants (Robinson 2001). Environmental factors can have a large influence on the amount of $^{15}$N present within plants and, subsequently, the animals that feed on them. Plants in arid environments have higher $\delta^{15}$N values, probably as result of the higher $^{15}$N values present in the soils in very dry ecosystems (Heaton 1987). Similarly, plants located in coastal environments also have increased $^{15}$N values, which are likely a result of the high $^{15}$N values of sea spray, suggesting that nitrogen from the sea is a significant source of nitrogen for coastal plants (Virginia and Delwiche 1982). Despite these environmental effects, it is possible to use $\delta^{15}$N values to distinguish between different trophic levels within a food web, as the enrichment factor of nitrogen in bone collagen is relatively constant throughout the food chain at 4‰ (Hedges and Reynard 2007). Thus, it is possible, by utilizing the enrichment factor, to calculate where an individual is located within the local food chain.

As Charleston, South Carolina is a coastal city, plants present along the coast line would have elevated $^{15}$N values due to the influence of the nitrogen present in seawater, which is enriched by 0.0025 atom‰ over atmospheric nitrogen (Virginia and Delwiche 1982; Miyake and Wada 1967). Thus, pigs raised along the coast, in the dunes and pine forests that abut the beach, would be expected to have higher nitrogen values than those raised further inland, as the vegetative materials consumed in the coastal regions would contain higher nitrogen levels. In addition, marine sources of protein, including fish and turtle species, have higher nitrogen values due to the higher $^{15}$N levels present in marine plants (Miyake and Wada 1967; Virginia and Delwiche 1982). Nitrogen data presented in this thesis for marine turtle and fish species and for freshwater turtle species indicates that the $\delta^{15}$N value for freshwater species in Charleston is around 5.8‰, while marine species have a $\delta^{15}$N range of 8.4‰-11.2‰. Swine in Charleston that were fed marine fish scraps would have higher $\delta^{15}$N values than swine fed meat scraps from
terrestrial animals and those fed little to no meat products, as the elevated nitrogen levels are reflected throughout the food chain (Schoeninger et al. 1983).

**Diagenetic Alteration of Bone**

Diagenesis, the physical and chemical changes that occur in skeletal elements after death, can alter the isotopic composition of the organic and inorganic materials of bone. A 1986 study on the diagenetic effects on the carbon, nitrogen, oxygen, and strontium isotope levels within prehistoric and modern samples found that the isotopic composition of carbon and nitrogen within bone collagen, the organic component, appeared to be relatively unchanged in prehistoric samples (Nelson et al. 1986). However, the isotopic composition of strontium within the inorganic portion was significantly altered diagenetically, probably as a result of an interaction with the strontium in the groundwater in the area of burial. The authors caution that the diagenetic effects will differ with every situation and that they should always be considered when working with older remains and isotopes (Nelson et al. 1986). As the current study works with archaeological remains, some of which are over 300 years old, there is a possibility that the resulting isotope concentrations have been diagenetically altered over time.

The major concern with archaeological samples that have experienced diagenetic alteration in some capacity is that the original isotope composition of the animal at death is lost and has been replaced with the local isotopes of the soil and groundwater. Thus being able to tell if bones from a location have experienced diagenetic alteration before studies on them are performed is very important. Hedges et al. (1995) presented four diagenetic parameters along with ways that the level of diagenetic alteration can be assessed. First, the histology of a bone sample from an archaeological site can be studied by injecting it with resin under a vacuum, polishing it, and observing it under a microscope to determine whether the osteocytes and
lamellar structure in osteons has been well preserved through time or not. In well-preserved samples the Haversian systems should be intact, clearly visible, and in overall good condition; poorly preserved samples contain many pores and the Haversian systems are not visible (Hedges et al. 1995).

Second, the protein content of a bone sample can be measured using the nitrogen content. The direct combustion of the sample in a CHN analyzer, with those results then analyzed by a mass spectrometer, can measure the amount of nitrogen that is still present in the bone (Hedges et al. 1995). An alternative method for protein content analysis would be decalcifying a bone sample, gelatinizing the insoluble residue, and measuring the purified gelatin that remains for its nitrogen content. The authors cautioned that a protein content of 1-2% and below means that the sample has significantly degraded.

Third, the crystallinity of a bone sample can be examined by crushing the sample into powder, depositing it onto a glass slide, and analyzing it with an X-ray diffractometer. The greatest reproducibility rates came from samples that had a hydroxyapatite 002 diffraction peak at $2\theta=26^\circ$ (Hedges et al. 1995). However, different results were found when the grain size of the bone sample powder was changed, causing the authors to use caution when utilizing the crystallinity test for degree of diagenetic alteration.

The final test for degree of diagenetic alteration was to examine the porosity of the bone by bringing a weighted, cortical bone sample into equilibrium with water vapor before weighing the water content within the sample. The authors found that there was an inverse relationship between a bone sample’s microporosity and its macroporosity. The more diagenesis has occurred for a sample, the more large pores form and the more small pores disappear, which has implications for how the bone will interact with the groundwater. Hedges and colleagues propose
that examining the histology and the porosity of archaeological remains will provide a better estimation for the degree of diagenesis that has occurred (Hedges et al. 1995). In this thesis, due to time constraints, the tests outlined by Hedges and colleagues in their 1995 paper were not performed on the specimens. Diagenetic alteration was recognized in specimens that either did not survive the first digestion, or survived all digestions and rinses but did not yield any isotope results. Severely degraded samples simply disintegrated during the digestions, or retained some structure but did not produce results. Samples that survived the digestions and rinses and yielded results were included in this thesis.

Previous Research on Carbon and Nitrogen Isotopes

Isotopes, particularly carbon and nitrogen, have been utilized previously to examine the diets of animals, past and present, and people from past populations. Kelly (2000) presented a review of mammalian and avian trophic ecology studies that discussed the use of carbon and nitrogen in examining trophic level distinctions and geographic/habitat isotope differences seen across the literature. Unfortunately, there has been little isotopic research performed on faunal remains from sites in the southeastern United States. Reitsema and colleagues’ (2015) work is the only large study in the region. It detailed carbon and nitrogen analysis of *Bos taurus* (cattle) bones that were excavated from six historical sites around Charleston. The purposes of the study were to document isotopic variation among beef cattle, assess possible differences in grazing locations, and determine if cattle could be used as a proxy for SES within Charleston. Bone collagen from twenty-seven different *Bos taurus* individuals from the six sites of known SES were prepared and analyzed for carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$). Reitsema and colleagues (2015) found that there were some isotopic differences between cattle remains from upper-class sites and lower-class sites. Specifically, cattle remains from upper class and market sites had
similar δ¹³C isotope levels that differed from the levels determined for lower class and dual-function sites. The authors hypothesized that the gentry were supplying the markets with cattle from their plantations, while individuals of lower socioeconomic status were consuming cattle from other sources (Reitsema et al. 2015). The variations in δ¹³C values seen across the Bos taurus specimens led Reitsema and colleagues to hypothesize that there could have been differences in places of origin or differences in cattle husbandry practices, and that cattle with lower δ¹³C may have foraged further inland, in habitats and ecoregions populated more heavily with C₃ plants (Reitsema et al. 2015). Swine are easier to raise in confined spaces than cattle, making urban swine raising a possibility for many Charleston residents. It is therefore possible for similar differences in isotopic values to occur in swine remains from sites of both higher and lower socioeconomic status sites, and that the isotope data may also reveal differences in places of origin and geographic locations for hog farming.

Previous research on Sus scrofa remains globally has focused on differentiating between remains of wild boar and domesticated pig from numerous archaeological sites around the globe. Hu et al. (2008) performed carbon and nitrogen isotopic analysis on human and animal remains from two different sites in China, dating to 8500-7500 years ago, in order to determine the dietary differences among pigs and their wild counterparts. Their results showed that for humans at the time, millet agriculture was not a large part of their diet. Instead, their diet consisted of foodstuffs collected while hunting, gathering, and to some extent feeding on livestock. The Sus scrofa remains analyzed, consisting of four separate individuals, fell into three different groups in terms of their carbon and nitrogen content. The first group contained two individuals with low δ¹³C (-18.1‰ and -20.0‰) and δ¹⁵N (4.7‰ and 6.0‰) values; the second group, containing only one individual, had the highest δ¹³C value (-10.6‰) and a δ¹⁵N value in the middle at 6.4‰; and
the final group, with only one individual, had a low $\delta^{13}$C value (-19.0‰) and a high $\delta^{15}$N value (9.1‰). The $\delta^{13}$C and $\delta^{15}$N values for the first group reveal that C$_3$ vegetation was the primary food source for those pigs; the pig in the second group was feeding primarily on C$_4$ plants, as evidenced by the high $\delta^{13}$C value. The sole pig in the final group, while having a low $\delta^{13}$C value, had the highest $\delta^{15}$N value, which placed it within the range of the human $\delta^{15}$N values. This result suggests that pig was at a similar trophic level and had a closer relationship to humans. These results indicate that swine in the first two groups were wild boars feeding primarily on C$_3$ and C$_4$ vegetative material, while swine from the third group was a domesticated pig feeding on human leftovers and waste.

To date there has not been any isotopic research performed on Sus scrofa remains from archaeological sites of varying socioeconomic status in Charleston, SC. Reitz et al. (2006) point out that dual-function sites, where business was conducted but also where people of low socioeconomic status lived, might have been considered “open ground,” resulting in individuals disposing of garbage at those spots. Until 1837 pigs could roam the city’s streets freely, and urban residents frequently kept pigs, resulting in a love-hate relationship, as the swine consumed the garbage but also caused daily disruptions (Reitz et al. 2006). Thus, an isotopic analysis performed on Sus scrofa remains could result in a distinction being identified between pigs raised on the streets and those brought from the forests and plantations, as well as evidence for which pigs were being consumed by what group of people.

The above studies illustrate that there is an interest in the diet of Charleston, SC residents from its founding in 1640 through the 1800s, in what animals were utilized and in who utilized them. On southern plantations, pigs were often allowed to forage throughout the property, whereas pigs raised within the city limits primarily fed on human garbage (Zierden and Reitz
Thus, carbon and nitrogen isotopic analysis performed on *Sus scrofa* remains from sites around Charleston, SC, should reveal their diet and help answer the question of whether all social classes were consuming pigs fed similar diets. The following chapter delves into the history of the city of Charleston and of the sites that produced the archaeological samples analyzed in this study.
IV. HISTORY OF CHARLESTON

In 1670 British colonists established Charles Town, the precursor to Charleston, in an area walled off by marsh on three sides (Zierden and Reitz 2016). Access to the mainland was through a narrow land bridge, and the colonists quickly established settlements and began farming. In 1680, the city’s center moved to the peninsula, but many people stayed in the original settlement. Domesticated animals were introduced to the region, mainly pigs and cattle, which were better-suited for the environment than sheep and goats (Zierden and Reitz 2016). Pigs were first introduced to the North American continent in 1538 by the Spanish explorer DeSoto in Florida, with more shipments from Europe bringing hogs to more northern locations. As is often the case with introduced animals, many hogs escaped and became the ancestors of the feral hogs that wreak havoc today (Shaw 1940). Food traditions of the indigenous peoples influenced the cuisine of the European and African settlers, and wild animals were incorporated into the dietary traditions of the colonizers. At the Charles Town site in South Carolina a fourth of the wild animals consumed consisted of fish and turtle species (Zierden and Reitz 2016).

The production of beef was also of major importance for the economy, and most of the time the cattle were raised free-range in the surrounding forests and marshes and rounded up in the fall for slaughter. Similarly, much of the pork came from free-range pigs or feral hogs, which could cause significant damage to gardens but polished off garbage piles throughout the city (Zierden and Reitz 2016). Raising pigs in a free-range style, where they roamed through the large, mast-producing forests that dominated the East coast at the time of colonization, was the primary method for hog farming until the end of the Civil War (Shaw 1940). By that time intensive logging practices had reduced the size of the forests, and corn production in the Midwest was resulting in more farmers feeding their swine herds corn (Shaw 1940). Due to their
omnivorous diet and ability to bulk up quickly, wealthier residents often kept pigs on-site in Charleston in order to easily feed large households.

The *Sus scrofa* bones used in this study came from sites of high and low socioeconomic status (SES). The five high SES sites are townhomes that were owned by members of Charleston’s elite, and these sites were given the high SES label because their owners also owned at least one plantation outside of the city, kept at least eight slaves at their townhome, and more on their plantation(s), and held public office at some point in their lives (Zierden et al. 1995). It was commonplace for hogs to be raised in the forests surrounding plantations, where the animals could feed on the masts and vegetation, with little or no corn to supplement their diets (Genovese 1962). Wood and Roark’s (1980) study of feral hogs in coastal South Carolina revealed that their diets consisted primarily of vegetation, with acorns being important winter fodder, new shoots being important fodder in the spring, roots being important food sources in the fall, and invertebrates and vertebrates comprising a very small portion of the diet throughout all four seasons (small mammals, snakes, and worms). Thus, if one assumes that the wealthy townhome households of Charleston are consuming pigs that foraged on their plantations, one should expect isotope results to reveal a diet heavy on C₃ plants (δ¹³C of -34‰ to -22‰) with little to no signs of C₄ (δ¹³C of -20‰ to -7‰) plants (corn) in the diet, as well as nitrogen values indicative of a diet low in animal protein.

The one low SES site represented in this study is South Adger’s Wharf (Butler et al 2012). Originally called the Lower Market, it operated as a market for the last half of the 18th century before being shut down. At the beginning of the 19th century tenement buildings replaced the market structures, with service structures for equipment and livestock built behind many of the housing complexes. While local plantations were the primary suppliers of livestock and
produce for the markets, city residents often kept livestock at their residences. Thus, if one assumes that low SES households were raising their own pigs at their residences partly on human refuse, one should expect isotope results to reveal diets higher in animal protein, due to meat scraps from meals and butchering activities. However, if one assumes that households of low SES were purchasing and consuming pork products that were sourced from hogs from the surrounding plantations, then the isotope results should be similar to those taken from *Sus scrofa* bones from the high SES sites.

The Miles Brewton House

Miles Brewton was born in 1731 and, as an adult, became the largest slave dealer in South Carolina (Zierden 2001). He began constructing what is now known as the Miles Brewton House on 27 King Street in 1765 and finished construction in 1769. When he and his family were lost at sea in 1775 the property was bequeathed to Rebecca Brewton Motte, his sister, along with his Mount Joseph plantation. During the 1700s much of the food eaten at 27 King Street was produced on the Mount Joseph plantation; during the 1800s much of the food eaten was produced on the Richfield and Camp Main plantations (Cote 1988). By this time the home was owned by William Bull Pringle and his daughter, Rebecca. Rebecca Pringle Frost occupied the house while her husband, Dr. Frank L. Frost, managed the two North Santee plantations. Correspondence between Frank and Rebecca revealed that roast pig and shoals (young hog) were consumed regularly at the home (Cote 1988).

The eight Miles Brewton *Sus scrofa* samples in this thesis came from remains that were recovered from deposition layers dating to the Brewton and Pringle-Frost ownership periods, which were from 1750-1775 and from 1840-1890, respectively (Zierden 2001). The specific units that contained the remains represented the carriage house front room, a refuse/food
preparation pit, a privy that was repurposed into a refuse pit, and a garden path/flower bed. Each area yielded a large amount of artifacts, and the ceramic and glass fragments were what the archaeologists used to date the different deposition layers (Zierden 2001).

The Heyward-Washington House

The property on which the house now sits was purchased by Colonel Daniel Heyward in 1770 (Zierden and Reitz 2007). A year later he sold the property to his eldest son, Thomas, who began constructing the current house. Thomas Heyward leveled a single home that had been on the property but spared the stable and kitchen. The Heyward Dynasty owned multiple plantations, but the main ones included the Old House Plantation and both White Hall Plantations, where rice was the primary crop grown. Nathaniel Heyward, after his half-brother Thomas passed away, chose The Bluff plantation as his base of operations and continued to grow rice (Linder 1995). The Washington part of the name comes from President George Washington’s 1791 tour, during which time he stayed at the Heyward house while in Charleston (Zierden and Reitz 2007).

The ten Heyward-Washington Sus scrofa samples in this thesis came from remains that were recovered from deposition layers dating to the Milner and Heyward ownerships periods, which were 1740-1760 and 1750-1820, respectively (Zierden and Reitz 2007). The specific units that contained the remains represented a refuse pit, a pile of ash from a 1740 fire on the property, a builders trench, a postmold found within a post hole, a well construction pit, and a pile of building rubble. The large amount of ceramic and glass fragments were utilized by the archaeologists to date the different deposition layers (Zierden and Reitz 2007).
The Nathaniel Russell House

Nathaniel Russell was born in 1738 in Rhode Island but gradually moved his business dealings to the southern states (Zierden et al. 1995). Construction of his Charleston townhouse was completed in 1808, and according to the Charleston Museum’s archaeology reports for the site much of the food consumed at the home would have come from the family farm on Romney Street, just up the road off of Meeting Street. All seven Nathaniel Russell Sus scrofa samples in this thesis came from remains that were excavated from deposition layers dating to the Russell and Allston ownership periods, which were 1808-1857 and 1857-1870, respectively. Most of the remains came from layers dating to the time period where the home was occupied by the Russell family, however, and the specific excavated units represented concentrations of building rubble, a trash pit, a garden fence/foundation, and the interior of the kitchen (Zierden et al 1995; Zierden et al 1996). Cultural materials recovered from each unit were utilized by the archaeologists to date the deposition layers.

The John Rutledge House

John Rutledge was governor of South Carolina from 1779-1782 and resided in Charleston at the stately townhome he built for his new bride, Elizabeth Grimke, in 1763 (Zierden 1989). Sans Souci Plantation was the governor’s summer residence but he also acquired Edgehill Plantation after the Revolutionary War, which had been previously owned by loyalists to the British crown (South Carolina Plantations 2014). Excavations at the John Rutledge house revealed the lowest percentage of remains from species deemed commensal: that is, they lived alongside humans by surviving on their refuse (e.g. rats) (Zierden 1989). The archaeologists also found that more wild species were consumed at the Rutledge site than at other wealthy sites throughout Charleston; the remains of deer equaled the remains of pigs that were excavated.
Signs of on-site butchering were present, which suggested, along with the lack of commensal species remains, that the owners were wealthier than most and able to keep a cleaner property with animals on site for butchering (Zierden 1989).

The two John Rutledge *Sus scrofa* samples in this thesis came from remains that were excavated from one unit located directly adjacent to the carriage house outbuilding on the property (Zierden 1989). This unit, and another located directly adjacent to it, revealed a large artifact assemblage, with the excavated ceramics being used to date the deposition layers. Based on the large collection of cultural materials excavated from both units, the area was interpreted as that of a refuse site. Pearlware found in the same zone as the remains allowed the archaeologists to provide a narrow timeline of 1780s-1790s for the deposition of the bone fragments (Zierden 1989).

The Simmons-Edwards House

The Simmons-Edwards house is named after Francis Simmons, who had the house constructed around 1801, and George Edwards, who added many features after purchasing the property in 1816 (Zierden 2001). Unfortunately, little is known about those men or the other owners of the property who preceded them, though Edwards did own Spring Island Plantation, where he grew Sea Island cotton. The sole archaeology report for the Simmons-Edwards property lists only one feature number, out of the six feature numbers that yielded the remains from which the six *Sus scrofa* samples were taken, with that feature located in a unit excavated in what was the work yard (Zierden 2001). Thus the exact location of the other five remains is not known, though there were three times as many bone fragments excavated from the rear garden, suggesting that bone debris may have been used as fertilizer. The particular artifact dispersal patterns seen throughout the work yard excavation were interpreted as refuse from lower levels
being re-deposited as a result of daily work traffic and yard renovations, resulting in the deposits being dated to the late 18th to early 19th centuries (Zierden 2001).

Figure 4.1 Map showing the locations of the city townhomes (red dot) and associated plantations (orange squares). At this distance, all of the townhomes are represented by a single dot, due to every home being within a few blocks of each other. The owner(s) of each plantation are shown.

South Adger’s Wharf

What is now known as South Adger’s Wharf began as an extension of Tradd Street on which a new market was constructed in 1750. The Lower Market, as it was called, was a bustling center where all kinds of animals were slaughtered and butchered on site. (Butler et al. 2012). Much of the animal and plant produce sold at the market was supplied by the surrounding plantations, and stalls were reserved for the plantation owners to come and sell their goods. Being on the waterfront allowed for plant and animal remains to be disposed of right into the harbor; however, by the end of the 18th century the waterfront area was becoming too crowded,
and the Lower Market was closed in 1799 by the city in an effort to consolidate all of their markets in one place (Butler et al. 2012).

Today the area is called South Adger’s Wharf and is covered in large cobblestones, some of which were removed to allow for the excavation. Excavations began in 2008 and continued through 2009, and were done with the purpose of exposing the redan, a triangular structure armed with cannons that was built in the early 18th century as part of Charleston’s wall (Butler et al. 2012). The three wharf Sus scrofa samples in this thesis came from remains excavated from Zones 3 through 9, which are associated with the Lower Market time period, after the redan was destroyed.

Previous Research

Research has been performed on the historical use of animals in Charleston, SC. Zierden and Reitz (2009) studied what and how animals were used within the city in the past. Cattle and pigs were raised in the surrounding forests and beef and pork surpluses were traded for other goods, such as sugar. Individuals took advantage of the wildlife populations, hunting deer, turkey, and turtles, among other animals. People living on small farms or large plantations had easier access to nature’s bounty and more land to grow livestock on, while city dwellers often had to rely on whatever animals were transported to the city’s markets for sale and/or whatever livestock they were able to raise where they lived within the city (Zierden and Reitz 2009; Reitz et al. 2006).

Reitz and colleagues (2006) focused on the question of whether counts of specific parts of pigs (reflecting different cuts of meat) could indicate differences in status level. They discovered that all households, whether of upper, middle, or lower socioeconomic status, were utilizing pigs the same way, regardless of time period. Thus cuts of meat alone could not be used
to differentiate between the classes, and the span from 1712-1900 did not appear to have any effect on what cuts of meat were utilized by whom. In addition, the authors found evidence of on-site hog raising and butchery, indicating that pigs easily fit into urban life and that most Charleston residents could raise them at their homes and workplaces (Reitz et al. 2006). Wealthier individuals relied on what their plantations produced and what they raised on their city property. If market goods were required servants were sent to perform the purchasing, and an array of wild and game animals were also available for purchase (Zierden and Reitz 2009).

Reitz and Zierden performed a similar study on cattle bones to see if the types of fragments present and the amount of those fragments could reveal distinctions in socioeconomic status (Reitz and Zierden 1991). Their hypotheses were that higher SES sites would contain fragmentary evidence that more domestic meat was consumed, more species of animals were eaten, more exotic taxa would be present, and that meatier portions of a cow were more often consumed at those sites than at middle and lower SES sites. What they found were patterns associated with what the sites were used for as opposed to the socioeconomic status of the people who occupied them. At sites designated as residential, whether they were upper or middle-class, fragments from the forequarter and hindquarter were more abundant than fragments from other parts of the skeleton. At sites that were primarily places of entertainment, such as taverns, head and foot fragments were present in amounts greater than at residential sites. The researchers noted that the faunal remains at residential sites most likely got there through on-site butchery or through market purchases, but the authors were not able to distinguish between marks made by a butcher and marks that were made on-site (Reitz and Zierden 1991).

The above research illustrates the interest in faunal remains and what they can reveal about the status of the people who were consuming them in Charleston, South Carolina.
However, the majority of the research has focused on examining the variety of species present and what cuts of meat might be represented by the specific bone fragments that are found and what that data might say about socioeconomic status. Isotopes are moving to the forefront and have already been used in Charleston to shed some light on where cattle consumed in the city came from before being slaughtered (Reitsema et al. 2015). The following chapter details the methods and materials used in this thesis to analyze archaeological Sus scrofa remains in order to examine the socioeconomic status of the people who ate them.
V. MATERIALS AND METHODS

The Charleston Museum selected the faunal remains used in this thesis from six archaeological sites. I specifically requested *Sus scrofa* remains, so the archaeologists at the museum provided *Sus scrofa* skeletal materials in addition to a variety of wild animal remains from each site. The remains had already been identified to species and separated into individuals by their colleague Elizabeth Reitz at the University of Georgia. The number of available *Sus scrofa* remains from all of the sites was small, and all remains came from juvenile pigs. Thus samples from each individual were prepared, with thirty-six samples surviving the following digestion protocol and yielding results for this thesis. Bone samples from thirty-six *Sus scrofa* individuals were crushed, weighed, and placed in 5 mL of 0.5 M HCl for 2-3 days to decalcify. The samples were rinsed five times with MQ water and then placed in 5 mL of 0.01 M NaOH for up to four hours to remove all organic acids. The thirty-six samples were frozen for thirty minutes and placed in a freeze dryer for 24 hours. The samples were then stored in a dessicator before being shipped to the University of Cincinnati Department of Geology, where they were analyzed using a Thermo Delta IR-MS. δ¹³C and δ¹⁵N were measured and measured according to the equation \[ \delta X = \left( \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right) \times 1000 \] and reported in permil values. δ¹³C was recorded relative to the PDB standard with a reproducibility rate of 0.15‰, and δ¹⁵N was recorded relative to the air with a reproducibility rate of 0.25‰. A 5‰ enrichment factor was assumed for δ¹³C between the diet and the bone and a 3‰ enrichment factor was assumed for δ¹⁵N between the diet and the bone. Nonparametric ANOVA statistics were performed on the all data using SAS 9.4.

In order to learn more about the carbon and nitrogen isotopes ranges for freshwater and saltwater aquatic species and terrestrial omnivorous species in the Charleston area, samples from turtle, fish, and opossum remains from the sites were prepared. Five *Malaclemys terrapin*
samples, one *Trachemys scripta* sample, three *Stenotomus chrysops* samples, and two *Didelphis virginianis* samples were crushed, weighed, and placed in 5 mL of 0.5 M HCl for 2-3 days to decalcify. The samples were rinsed five times with MQ water and then placed in 5 mL of 0.01 M NaOH for up to four hours to remove all organic acids. The eleven samples were frozen for thirty minutes and placed in a freeze dryer for 24 hours. The samples were then stored in a dessicator before being shipped to the University of Cincinnati Department of Geology, where they were analyzed using a Thermo Delta IR-MS. \( \delta^{13}C \) and \( \delta^{15}N \) were measured and measured according to the equation \( \delta X = \left[ \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right] \times 1000 \) and reported in permil values. \( \delta^{13}C \) was recorded relative to the PDB standard with a reproducibility rate of 0.15‰, and \( \delta^{15}N \) was recorded relative to the air with a reproducibility rate of 0.25‰. A 5‰ enrichment factor was assumed for \( \delta^{13}C \) between the diet and the bone and a 3‰ enrichment factor was assumed for \( \delta^{15}N \) between the diet and the bone. Nonparametric ANOVA statistics were performed on the all data using SAS 9.4.
VI. RESULTS

6.1 Actual $\delta^{13}$C and $\delta^{15}$N

Thirty-six samples of *Sus scrofa* remains from six sites (five high SES, one low SES) around Charleston, South Carolina were analyzed to investigate differences in $^{13}$C and $^{15}$N between sites, time periods, and *Bos taurus* remains from a previous study. The results are shown in Table 1. Eleven samples from wild animal remains were also analyzed for $^{13}$C and $^{15}$N, with those results presented in Table 2.

**Table 1.** Actual $\delta^{13}$C and $\delta^{15}$N values for the thirty-six *Sus scrofa* samples.

<table>
<thead>
<tr>
<th>Site</th>
<th>Sample Code</th>
<th>Time Period</th>
<th>$\delta^{13}$C</th>
<th>$\delta^{15}$N</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Rutledge House</td>
<td>JR 34SS1</td>
<td>1780s-90s</td>
<td>-16.4</td>
<td>7.4</td>
</tr>
<tr>
<td>John Rutledge House</td>
<td>JR 34SS2</td>
<td>1780s-90s</td>
<td>-11.6</td>
<td>5.5</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 186SS</td>
<td>1780s</td>
<td>-18.9</td>
<td>6.5</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 90SS</td>
<td>1710-1750</td>
<td>-18.2</td>
<td>7.4</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 153SS</td>
<td>1780s</td>
<td>-14.6</td>
<td>5.1</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 710SS</td>
<td>1800s</td>
<td>-16.2</td>
<td>8.1</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 862SS</td>
<td>1700s</td>
<td>-14.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 594SS</td>
<td>1800s</td>
<td>-16.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 558SS</td>
<td>1780s</td>
<td>-16.7</td>
<td>6.4</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 865SS</td>
<td>1700s</td>
<td>-17.8</td>
<td>8.9</td>
</tr>
</tbody>
</table>
Table 1 (continued).

<table>
<thead>
<tr>
<th>House Name</th>
<th>Number</th>
<th>Year</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 727SS</td>
<td>1700s</td>
<td>-9.8</td>
<td>8.3</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 73SS</td>
<td>1840s</td>
<td>-18.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 61SS</td>
<td>1820s</td>
<td>-15.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 22SS</td>
<td>1860s</td>
<td>-10.8</td>
<td>7.8</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 72SS</td>
<td>1820s</td>
<td>-17.9</td>
<td>7.4</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 49SS</td>
<td>1860s</td>
<td>-14.2</td>
<td>9.6</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 63SS</td>
<td>1860s</td>
<td>-11.4</td>
<td>4.9</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 60SS</td>
<td>1860s</td>
<td>-16.6</td>
<td>8.5</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 331SS</td>
<td>1770s</td>
<td>-17.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 336SS</td>
<td>1770s</td>
<td>-15.4</td>
<td>6.5</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 330SS</td>
<td>1800s</td>
<td>-18.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 128SS</td>
<td>1870s</td>
<td>-22.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 116SS</td>
<td>1770s</td>
<td>-17.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 142SS</td>
<td>1800s</td>
<td>-18.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td>MB 124SS</td>
<td>1800s</td>
<td>-15.3</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Table 1 (continued).

<table>
<thead>
<tr>
<th>Site</th>
<th>Sample Code</th>
<th>Date</th>
<th>δ¹³C</th>
<th>δ¹⁵N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles Brewton House</td>
<td>MB 337SS</td>
<td>1770s</td>
<td>-15.3</td>
<td>4.6</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 87SS</td>
<td>1750-1820</td>
<td>-21.6</td>
<td>9.1</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 55SS1</td>
<td>1740-1750</td>
<td>-19.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 183SS</td>
<td>1730-1740s</td>
<td>-18.7</td>
<td>8.7</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 151SS</td>
<td>1740-1750</td>
<td>-19.6</td>
<td>7.4</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 155SS</td>
<td>1750-1820</td>
<td>-16.8</td>
<td>5.9</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 157SS</td>
<td>1730-1740</td>
<td>-15.6</td>
<td>6.3</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 150SS</td>
<td>1750-1820</td>
<td>-14.2</td>
<td>7.9</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 164SS</td>
<td>Unknown</td>
<td>-10.7</td>
<td>9.0</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 144SS</td>
<td>1800s</td>
<td>-13.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>HW 53SS</td>
<td>1740-1750</td>
<td>-21.9</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Table 2. Actual δ¹³C and δ¹⁵N values for the eleven native wild animal samples.

<table>
<thead>
<tr>
<th>Site</th>
<th>Species</th>
<th>Sample Code</th>
<th>δ¹³C</th>
<th>δ¹⁵N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles Brewton House</td>
<td><em>Didelphis virginianis</em> (Virginia opossum)</td>
<td>MB 141DV</td>
<td>-14.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Miles Brewton House</td>
<td><em>Didelphis virginianis</em> (Virginia opossum)</td>
<td>MB 326DV</td>
<td>-17.2</td>
<td>9.0</td>
</tr>
</tbody>
</table>
Table 2 (continued).

<table>
<thead>
<tr>
<th>Simmons-Edwards House</th>
<th>Stenotomus chrysops (scup fish)</th>
<th>SE 565SC</th>
<th>-12.1</th>
<th>10.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simmons-Edwards House</td>
<td>Stenotomus chrysops (scup fish)</td>
<td>SE 594SC</td>
<td>-12.3</td>
<td>10.2</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>Stenotomus chrysops (scup fish)</td>
<td>SE 652SC</td>
<td>-13.6</td>
<td>8.7</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>Trachemys scripta (pond slider turtle)</td>
<td>HW 153TS</td>
<td>-22.6</td>
<td>5.8</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>Malaclemys terrapin (diamondback terrapin)</td>
<td>HW 34MT</td>
<td>-22.4</td>
<td>11.2</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>Malaclemys terrapin (diamondback terrapin)</td>
<td>SA 52MT</td>
<td>-11.1</td>
<td>9.2</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>Malaclemys terrapin (diamondback terrapin)</td>
<td>HW 53MT</td>
<td>-12.6</td>
<td>8.6</td>
</tr>
<tr>
<td>Heyward-Washington House</td>
<td>Malaclemys terrapin (diamondback terrapin)</td>
<td>HW 155MT</td>
<td>-9.2</td>
<td>8.4</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>Malaclemys terrapin (diamondback terrapin)</td>
<td>SE 688MT</td>
<td>-11.6</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Figure 6.1 graphically illustrates the relationship between the actual $\delta^{13}C$ and $\delta^{15}N$ values for the thirty-six *Sus scrofa* samples across all of the sites, and Figure 6.2 graphically illustrates the relationship between the actual $\delta^{13}C$ and $\delta^{15}N$ values for the *Sus scrofa* samples across the 18th and 19th centuries. Figure 6.3 graphically illustrates the relationship between the eleven samples from four native, wild species across all of the sites, and Figure 6.4 graphically illustrates the relationship between the actual $\delta^{13}C$ and $\delta^{15}N$ values for the thirty-six *Sus scrofa*
samples, eleven native wild animal samples, and the *Bos taurus* samples formally analyzed by Reitsema et al. (2015).

**Figure 6.1.** Scatterplot of the actual $\delta^{13}C$ and $\delta^{15}N$ values for *Sus scrofa* across all sites. Higher values for carbon suggest C4 dietary protein sources, and higher values for nitrogen suggest more protein is consumed.

**Figure 6.2.** Scatterplot of the actual $\delta^{13}C$ and $\delta^{15}N$ values for *Sus scrofa* across the 18th and 19th centuries.
Figure 6.3. Scatterplot of the actual $\delta^{13}$C and $\delta^{15}$N values for the four native wild animal species for all sites.

Figure 6.4. Scatterplot of the actual $\delta^{13}$C and $\delta^{15}$N values for the *Sus scrofa* and native wild species analyzed in this study and the *Bos taurus* samples formally analyzed by Reitsema et al. (2015).
6.2 Nonparametric ANOVA for $\delta^{13}$C.

The nonparametric ANOVA results did not reveal any statistically significant differences for *Sus scrofa* among the sites for $\delta^{13}$C [F(5,30)=1.189, p=0.338]. The complete ANOVA table can be found in Table 3.

**Table 3. Nonparametric ANOVA for $\delta^{13}$C.**

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>5</td>
<td>54.605</td>
<td>10.921</td>
<td>1.189</td>
<td>0.338</td>
</tr>
<tr>
<td>Within Groups</td>
<td>30</td>
<td>275.647</td>
<td>9.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>330.252</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3 Nonparametric ANOVA for $\delta^{15}$N.

The nonparametric ANOVA results did not reveal any statistically significant differences for *Sus scrofa* among the sites for $\delta^{15}$N [F(5,30)=1.490, p=0.223]. The complete ANOVA table can be found in Table 4.

**Table 4. Nonparametric ANOVA for $\delta^{15}$N.**

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>5</td>
<td>10.475</td>
<td>2.095</td>
<td>1.490</td>
<td>0.223</td>
</tr>
<tr>
<td>Within Groups</td>
<td>30</td>
<td>42.175</td>
<td>1.406</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>52.650</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.4 Nonparametric ANOVA for $\delta^{13}$C by Time Period

The nonparametric ANOVA results did not reveal any significant differences across the 18$^{th}$ and 19$^{th}$ centuries for $\delta^{13}$C [F(1,33)=0.448, p=0.508]. The complete ANOVA table can be found in Table 5.
Table 5. Nonparametric ANOVA for $\delta^{13}C$ by Time Period.

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>1</td>
<td>3.977</td>
<td>3.977</td>
<td>0.448</td>
<td>0.508</td>
</tr>
<tr>
<td>Within Groups</td>
<td>33</td>
<td>293.182</td>
<td>8.884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>297.159</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.5 Nonparametric ANOVA for $\delta^{15}N$ by Time Period

The nonparametric ANOVA results did not reveal a significant difference across the 18th and 19th centuries for $\delta^{15}N$ [F(1,33)=0.413, p=0.525]. The complete ANOVA table can be found in Table 6.

Table 6. Nonparametric ANOVA for $\delta^{15}N$ by Time Period.

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>1</td>
<td>0.608</td>
<td>0.608</td>
<td>0.413</td>
<td>0.525</td>
</tr>
<tr>
<td>Within Groups</td>
<td>33</td>
<td>48.647</td>
<td>1.474</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>49.255</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.6 Nonparametric ANOVA for $\delta^{13}C$ by Species

The nonparametric ANOVA results did reveal a significant difference for $\delta^{13}C$ [F(1,67)=5.707, p=0.020] between the *Sus scrofa* samples of this study and *Bos taurus* samples from the same region formally analyzed by Reitsema et al. 2015. The complete ANOVA table can be found in Table 7.

Table 7. Nonparametric ANOVA for $\delta^{13}C$ by Species.

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>1</td>
<td>36.099</td>
<td>36.099</td>
<td>5.707</td>
<td>0.020</td>
</tr>
<tr>
<td>Within Groups</td>
<td>67</td>
<td>423.833</td>
<td>6.326</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.7 Nonparametric ANOVA for $\delta^{15}$N by Species

The nonparametric ANOVA results did reveal a significant difference for $\delta^{15}$N [F(1,67)=104.671, p<0.0001] between *Sus scrofa* samples of this study and *Bos taurus* samples from the same region formally analyzed by Reitsema et al. 2015. The complete ANOVA table can be found in Table 8.

Table 8. Nonparametric ANOVA for $\delta^{15}$N by Species.

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>1</td>
<td>143.741</td>
<td>143.741</td>
<td>104.671</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Within Groups</td>
<td>67</td>
<td>92.009</td>
<td>1.373</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>235.750</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.8 Estimation of Diet for *Sus scrofa* Samples

A dietary enrichment factor of 5‰ for carbon and 3‰ for nitrogen was assumed for all samples to estimate the $\delta^{13}$C and $\delta^{15}$N values of the dietary protein that the pigs were consuming prior to death (DeNiro and Epstein 1978; DeNiro and Epstein 1981). Those results are shown in Table 9.

Table 9. Estimated Dietary $\delta^{13}$C and $\delta^{15}$N for the *Sus scrofa* Samples.

<table>
<thead>
<tr>
<th>Site</th>
<th>Sample Code</th>
<th>Time Period</th>
<th>Estimated Dietary $\delta^{13}$C</th>
<th>Estimated Dietary $\delta^{15}$N</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Rutledge House</td>
<td>JR 34SS1</td>
<td>1780s-1790s</td>
<td>-21.4</td>
<td>4.4</td>
</tr>
<tr>
<td>John Rutledge House</td>
<td>JR 34SS2</td>
<td>1780s-1790s</td>
<td>-16.6</td>
<td>2.5</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 186SS</td>
<td>1780s</td>
<td>-23.9</td>
<td>3.5</td>
</tr>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 90SS</td>
<td>1710-1750</td>
<td>-23.2</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Table 9 (continued).

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Code</th>
<th>Period</th>
<th>X Value</th>
<th>Y Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Adger’s Wharf</td>
<td>SA 153SS</td>
<td>1780s</td>
<td>-19.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 710SS</td>
<td>1800s</td>
<td>-21.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 862SS</td>
<td>1700s</td>
<td>-19.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 594SS</td>
<td>1780s</td>
<td>-21.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 558SS</td>
<td>1780s</td>
<td>-21.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 865SS</td>
<td>1700s</td>
<td>-22.8</td>
<td>5.9</td>
</tr>
<tr>
<td>Simmons-Edwards House</td>
<td>SE 727SS</td>
<td>1700s</td>
<td>-14.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 73SS</td>
<td>1840s</td>
<td>-23.3</td>
<td>4.7</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 61SS</td>
<td>1820s</td>
<td>-20.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 22SS</td>
<td>1860s</td>
<td>-15.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 72SS</td>
<td>1820s</td>
<td>-22.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 49SS</td>
<td>1860s</td>
<td>-19.2</td>
<td>6.6</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 63SS</td>
<td>1860s</td>
<td>-16.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Nathaniel Russell House</td>
<td>NR 60SS</td>
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<td>-21.6</td>
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Figure 6.5 graphically illustrates the relationship between the estimated dietary protein δ\(^{13}\)C and δ\(^{15}\)N values for the Sus scrofa samples across all of the sites.
6.9 Hierarchical cluster analysis utilizing Ward’s method for Sus scrofa Samples

A cluster analysis utilizing Ward’s method was performed on the Sus scrofa samples to reveal any potential clusters. The results are illustrated in Figure 6.6.

**Figure 6.5.** Scatterplot of the estimated dietary protein δ^{13}C and δ^{15}N values for the Sus scrofa samples across all of the sites.

**Figure 6.6.** Scatterplot of the hierarchical cluster analysis results for Sus scrofa samples across all sites. Cluster 1 is represented by open circles and cluster 2 is represented by filled-in circles. Sites are color coordinated across both clusters.
6.10 Hierarchical cluster analysis utilizing Ward’s method for all species.

A cluster analysis utilizing Ward’s method was performed on the *Sus scrofa*, *Didelphis virginianis*, *Stenotomus chrysops*, *Malaclemys terrapin*, and *Trachemys scripta* samples analyzed in this thesis in addition to the *Bos taurus* samples formally analyzed by Reitsema et al. (2015). The results are illustrated in Figure 6.7.

![Hierarchical Cluster Analysis of $\delta^{13}$C and $\delta^{15}$N for All Animals](image)

**Figure 6.7.** Scatterplot of the results from the hierarchical cluster analysis for the samples from all of the animal species analyzed in this thesis and the *Bos taurus* samples formally analyzed by Reitsema et al. (2015). Cluster 1 samples have filled-in symbols and Cluster 2 samples have empty symbols. The pigs are plotted according to their sites, and all species/sites have corresponding colors across both clusters.
VII. DISCUSSION

While there was a lack of a significant change in $\delta^{13}$C and $\delta^{15}$N values across different SES sites, the variation in the values suggests that 1) all of the pigs analyzed in this thesis were following different diets and consuming protein sources of varying $\delta^{13}$C and $\delta^{15}$N values, and 2) the consumers of the pigs did not appear to make their pork selections based on what the hogs had been consuming prior to slaughter. Articles published in *The Southern Agriculturalist* and *The Southern Cabinet* during the 1830s and 1840s revealed that most hog farmers were suggesting either a varied diet of whatever vegetables were readily available (clover, pumpkin, and peas were highly suggested), supplemented with corn and grains, or a diet that consisted primarily of grains or corn. In addition, all hogs were provided with an abundance of salt and charcoal, the latter of which apparently prevented pigs from developing certain ailments. The $\delta^{13}$C values for the pig diets in this study, when the 5‰ tissue fractionation factor is taken into account, range from -27.0‰ to -14.8‰. As this thesis only looked at bone collagen, this $\delta^{13}$C value reflects the carbon that was consumed from protein sources only, and not all foodstuffs consumed as part of the animals’ diet. This finding does indicate, though, that while nine pigs were fed primarily C$_3$ protein (with a global range of -34‰ to -22‰) and six were fed primarily C$_4$ protein (with a global range of -20‰ to -7‰), a majority (twenty-one) were fed a mixture of C$_3$ and C$_4$ protein sources.

This protein source could have been milk, which would have reflected the diet of the mothers if the *Sus scrofa* samples in this thesis came from pigs that were still nursing at the time of slaughter. A study performed on whole milk from newly lactating dairy cows in Germany discovered that the $\delta^{13}$C value of the milk directly reflected the diet that they were fed: a C$_3$ diet resulted in the milk having a $\delta^{13}$C value within the C$_3$ range (-27.3‰ to -26.2‰), and cows fed a
C₄ diet produced milk with a δ¹³C value within the C₄ range (-14.6‰ to -13.9‰) (Metges et al. 1990). This study suggests that pig milk might also have δ¹³C values that reflect the ¹³C value of the diet the mother was currently being fed.

The majority of the suggested diets in the agricultural magazines were vegetarian in nature, and the δ¹⁵N results showed that the pigs were not at the same trophic level as cattle, which feed on primarily vegetative material. This result could indicate that the pigs were being fed a diet high in animal or marine protein. The δ¹⁵N values for the marine species that were also analyzed in this study ranged from 8.4‰-11.2‰, suggesting that pigs feeding on marine protein sources would have δ¹⁵N values among this range; however, when the 3‰ tissue fractionation factor is taken into account, none of the Sus scrofa individuals have values within this range. If the pigs in this study were eating an omnivorous diet that included local vegetation as well as city waste, their δ¹⁵N values would probably resemble those of the two opossum specimens also analyzed in this study. Opossums are omnivorous animals and feed on plants, insects, small animals, and human garbage; the actual δ¹⁵N range for the specimens in this study was 9.0‰-9.5‰, with an estimated dietary range of 6.0‰-6.3‰. Two Sus scrofa samples had estimated dietary δ¹⁵N values that fell within this range; six samples had estimated dietary δ¹⁵N values in the 5.0‰-5.9‰ range, suggesting that the placement of the pigs at a higher trophic level than the cattle may be due to the hogs following a similar omnivorous diet to the opossums.

There was only one article, published in 1840 in Volume 1, Number 8 of The Southern Cabinet, where animal products were listed as part of a suggested diet for hogs. A man wrote in with his recipe for weaning piglet food, which would be fed while the piglets were still nursing to get them used to eating a semi-solid foodstuff out of a trough. The mixture contained mashed boiled potatoes, boiled rice, a small amount of cow’s milk from a newly lactating cow, small
portions of beef liver, and boiled “sheep’s plucks”, which are the heart, liver, and lungs from a sheep (Standish 1840). A review of the literature could not find stable isotope variation ratios for liver tissue from cattle and sheep and for heart and lung tissue from sheep, though a study performed on biological specimens from cattle found that milk was enriched in $^{15}$N, suggesting that piglets feeding on cow’s milk would have increased $\delta^{15}$N values compared to piglets that are not being fed cow’s milk as part of their weaning diet (Steele and Daniel 1978).

Consuming milk in general could be an alternative suggestion to why the pigs all had elevated $\delta^{15}$N levels, if they were still nursing at the time of slaughter. A 2006 study performed on pig specimens excavated from sites across the SES spectrum in Charleston, SC, found that 60% of the pig remains came from juvenile and subadult pigs, with the remaining 30% of the specimens being of an indeterminate age (Reitz et al. 2006). The *Sus scrofa* specimens utilized in this study came from juvenile pigs, which range from 5-20 months in age; piglets can be weaned as early as 2 months old to as late as 5 months old (Reiland 1978). Thus it is possible that some of the samples utilized in this study came from hogs that were still nursing while being weaned. It has been theorized that because a nursing animal is, in essence, consuming its mother via milk, it would be at a higher trophic level than its mother.

A 1978 study on biological samples from cattle found that feces, blood, and milk from the cattle were enriched in $^{15}$N when compared to the diet of the animals (Steele and Daniel 1978). However, a 2001 study performed on milk and blood samples from mother-offspring pairs of 11 species across the dietary spectrum (i.e., carnivorous, herbivorous, and omnivorous species), including pigs, found that the $\delta^{15}$N enrichment within offspring was not significant and not large enough to place the offspring at a higher trophic level (Jenkins et al. 2001). In contrast, a 2006 study performed on bone collagen samples from two otariid (fur seal and sea lion) species
found that nursing pups were a single trophic level higher than their mothers, with their \(^{15}\text{N}\) values enriched by about 3‰ (Newsome et al. 2006). These studies suggest that using \(^{15}\text{N}\) values to examine nursing and weaning periods in mammals varies in terms of its usefulness, as this method works in some species but does not work in others, and that it probably is not applicable in studies on *Sus scrofa*.

The elevated \(\delta^{15}\text{N}\) of the *Sus scrofa* samples analyzed in this study could also be due to the consumption of fungi. It is well known that pigs are excellent at finding fungi, as is evidenced by their use as truffle hunters in Italy and France, where pigs are trained to locate and dig up truffle mushrooms (Towne and Wentworth 1950). Using pigs to find these fungal delicacies can be problematic at times, as the animals will readily consume truffles as quickly as they dig them up if their human handlers are not paying close attention. As hogs were often let loose into forests to feed until it was time to slaughter them, and urban pigs often ran amok far and wide, fungi of numerous species would have been available as food sources (Towne and Wentworth 1950).

A 1993 study conducted on organ samples from plant and fungi species in a German forest discovered that the fungi had the highest \(\delta^{15}\text{N}\) values and were significantly more enriched in \(^{15}\text{N}\) than the tree and shrub plant species from the same forest (Gebauer and Dietrich 1993). The authors state that the fungi, whether saprophytic or ectomycorrhizal, consume large quantities of organic \(^{15}\text{N}\) from the humus (decaying plant and animal material) that they grow and feed on. The humus is enriched in \(^{15}\text{N}\), but this source of nitrogen is only directly available to fungi, and not to the other plant species occupying the same space. This means fungi act as nitrogen sinks in the ecosystems in which they live, producing higher \(\delta^{15}\text{N}\) values than their plant neighbors (Gebauer and Dietrich 1993). In the Southeastern United States, different species of
fungi are available year round. As a result, if the *Sus scrofa* individuals in this thesis were consuming large quantities of fungi, that could explain their elevated $\delta^{15}N$ values when compared to the cattle. Unfortunately, a review of the literature did not yield $\delta^{15}N$ values for fungi native to the Eastern United States; the fungi $\delta^{15}N$ values from the Gebauer and Dietrich 1993 study cannot be used as a substitute, because the $\delta^{15}N$ varies from location to location across the world. Thus the nitrogen data from fungi from one environment cannot be applied to fungi from a different environment (Robinson 2001).

When the $\delta^{13}C$ and $\delta^{15}N$ results for the *Sus scrofa* samples analyzed in this thesis are examined together, it becomes clear that the protein sources spanned the C$_3$-C$_4$ photosynthetic pathway ranges and were rich in nitrogen. The majority of the *Sus scrofa* samples were dated to before the Civil War, when using masts was still the method of choice for fattening hogs. The major mast-producing tree species were beech, oak, and the American chestnut, so if nuts from these trees were major sources of protein for the pigs in this study their estimated dietary ranges for $\delta^{13}C$ and $\delta^{15}N$ would fall within the $\delta^{13}C$ and $\delta^{15}N$ ranges for those plant species. A Master of Science thesis published in 2015 produced $\delta^{13}C$ and $\delta^{15}N$ values for foodstuffs commonly consumed by black bears in the Northeastern United States (Dykstra 2015). Masts from beech and oak trees had $\delta^{13}C$ values ranging from -33.5‰ to -26.8‰ and $\delta^{15}N$ values ranging from -5‰ to 1.8‰ (Dykstra 2015). When these values are compared to those of the estimated pig diet, it becomes apparent that the $\delta^{13}C$ and $\delta^{15}N$ for the *Sus scrofa* samples are higher than the carbon and nitrogen values for the masts, more so for nitrogen than for carbon. Many of the samples in this study produced $\delta^{13}C$ estimated diet values that were quite close to the range published in Dykstra 2015, indicating that the lack of an overlap in values may be due to environmental differences between the Northeastern and Southeastern regions of the United States. This is very
likely to be the cause of the large difference in the estimated diet $\delta^{15}\text{N}$ values of the *Sus scrofa* samples from Charleston and the $\delta^{15}\text{N}$ values from the beech and oak masts, which were harvested in Vermont (Dykstra 2015). As has been previously stated in this thesis, local nitrogen values vary greatly, and thus those from one environment cannot be used for comparison purposes against values from a different environment.

Based on the similarity of the $\delta^{13}\text{C}$ values of the *Sus scrofa* samples and that of the mast samples, acorns and beech nuts probably did provide a portion of the protein that the pigs consumed, or was a significant portion of the diet of animals that the pigs consumed. While the nitrogen values cannot really be compared, they do indicate that the high estimated diet $\delta^{15}\text{N}$ values for the *Sus scrofa* samples were most likely not the result of mast sources of protein. A 1993 study on the $\delta^{15}\text{N}$ values of trees, shrubs, understory vegetation, and fungi in a mixed forest stand in Germany found that the fungi were more enriched in nitrogen than the other plant species and had a $\delta^{15}\text{N}$ range of -3.5‰ to 2.3‰ (Gebauer and Dietrich 1993). Again, while the nitrogen values from Germany are different than those from Charleston, South Carolina and the surrounding region, the fact that only three of the *Sus scrofa* samples had estimated dietary $\delta^{15}\text{N}$ within this range for fungi suggest that consuming large amounts of fungal foodstuffs probably did not contribute to the high $\delta^{15}\text{N}$ values of the pigs in this thesis. However, a 1986 study on the $\delta^{13}\text{C}$ of fungi found that they had $^{13}\text{C}$ values that spanned across the C$_3$-C$_4$ $\delta^{13}\text{C}$ range, specifically ranging from -26‰ to -9‰, with the wide range due to the primary food source of the fungi (Will et al. 1986). The estimated dietary $\delta^{13}\text{C}$ for the *Sus scrofa* samples in this thesis fell more closely within this range than within the mast $\delta^{13}\text{C}$ range, indicating that fungi might also have contributed to the protein sources of food consumed by the pigs.
While corn was not used as the primary fattening agent for hogs until after the Civil War, it was still a component of hog diets and was occasionally utilized as the only source of food prior to the end of the war (Shaw 1940; Burnett 1946). The estimated dietary δ\textsuperscript{13}C values for the *Sus scrofa* samples showed that some pigs were being fed C\textsubscript{4} plants (e.g. corn) as a primary source of protein (or were consuming animals where corn had been the primary food source) and many pigs were consuming a combination of C\textsubscript{3} and C\textsubscript{4} protein sources. A 1968 study on fossil plants, including fossilized corn, from Tehuacan Valley, Mexico, yielded a δ\textsuperscript{15}N value of 13.1‰ for the corn (DeNiro and Epstein 1981). This value is higher than all of the estimated dietary δ\textsuperscript{15}N values for the *Sus scrofa* samples in this thesis, and while the nitrogen content for Tehuacan Valley cannot be compared to that of Charleston, and diagenetic alterations to the fossils could have altered the original nitrogen content, this finding suggests that corn or animals feeding on corn were not the primary sources of protein for the pigs. A 1983 study produced δ\textsuperscript{13}C and δ\textsuperscript{15}N averages and ranges for various animal groups, including herbivores and carnivores that fed primarily on terrestrial sources of protein and animals that fed primarily on marine sources of protein (Schoeninger et al. 1983). The δ\textsuperscript{13}C and δ\textsuperscript{15}N values for the *Sus scrofa* samples overlaps both the herbivore and carnivore ranges for mammals and birds that primarily feed on terrestrial protein sources, indicating an omnivorous diet consisting of both plants and animals for the hogs. If the two opossum samples also analyzed in this thesis are considered again, the estimated dietary δ\textsuperscript{13}C for the opossums ranged from -22.2‰ to -19.4‰ and the estimated dietary δ\textsuperscript{15}N ranged from 6.0‰ to 6.3‰. These ranges are the closest to the estimated dietary values for the *Sus scrofa* samples, providing more evidence that the pigs had an omnivorous diet that consisted of vegetation and animal protein sources that were foraged for by the hogs or were provided to them by humans to be specifically used as food.
Despite the fact these samples did not reveal significant differences in isotope values between the sites based on the SES factor, the results do reveal some interesting patterns. The scatterplot of the actual values for all of the samples from the *Sus scrofa* and wild animal species from this thesis and the actual values for the *Bos taurus* samples from the Reitsema et al. (2015) study reveal three groups of pigs that appear to have different dietary protein sources than the majority. Likewise the scatterplot of these same values after a hierarchical cluster analysis was performed showing the same groupings. The majority of the *Sus scrofa* samples produced δ¹³C and δ¹⁵N values that spanned the C₃-C₄ spectrum and were a trophic level above the *Bos taurus* samples. However, if one looks at Figure 4 and Figure 7, one can see a group of three *Sus scrofa* samples on the left of the graph that are solidly in the C₃ dietary protein δ¹³C range and have high δ¹⁵N values and are approaching the level of one diamondback terrapin sample. This suggests that those pigs were feeding solely on C₃ plants or on meat coming from animals that fed solely on C₃ plants and may also have had some sources of marine dietary protein in the diet, which would explain their high δ¹⁵N and proximity on the scatterplot to a marine turtle. A second group of *Sus scrofa* samples, consisting of four individuals, is clear towards the bottom of Figure 4 and Figure 7 amongst the *Bos taurus* samples. These pigs have δ¹³C values in the C₄ dietary protein range and δ¹⁵N within the range of the cattle samples, which suggests that those four hogs were primarily vegetarian and consumed C₄ vegetation. The final group of *Sus scrofa* samples consists of three individuals in the C₄ dietary protein δ¹³C range and has δ¹⁵N values very similar to those from a group of two diamondback terrapin samples. This suggests that those pigs were feeding solely on C₄ plants or on meat coming from animals that fed solely on C₄ plants and also had some sources of marine dietary protein in their diet, which would explain their position close to the diamondback terrapins on the scatterplot. What these results illustrate
is that there were differences in husbandry practices and feeding strategies for raising hogs, regardless of socioeconomic status, and that pigs from every site were the product of these various methods; one site did not appear to preferentially consume hogs from one husbandry practice over the others.

The result that carbon and nitrogen isotopes from pig remains were unable to discern between sites of high versus low SES adds to the research that has already been done on hogs and SES in Charleston, SC. The Reitz et al. (2006) study on pig remains from sites of varying SES found that everyone was consuming the same cuts of meat regardless of their status. The study also revealed that the remains excavated from residential, nonresidential, and dual-function sites across the SES spectrum were “remarkably similar” and thus it appeared that the function of the site and the status of the individuals who occupied and/or worked there did not influence what cuts of meat were consumed (Reitz et al. 2006). While that research did not examine SES through the lens of isotopic analysis, the Reitsema et al. (2015) study on cattle remains did. In contrast to the results of this thesis, their study revealed a difference in δ¹³C across site types. The δ¹³C values from bones excavated from upper-class residences and market sites (-17.9‰ to -13.4‰) were similar to each other and different from the δ¹³C values from bones coming from lower status/dual function sites (-16.5‰ to -10.6‰). The authors hypothesized that this could be due to residents from sites of lower SES not getting their beef products from the local markets, which were supplied by the plantations, and instead were getting their beef from other sources (Reitsema et al. 2015). The authors noted that this contrasts with the common idea proposed by historians and archaeologists that individuals from all SES levels were purchasing meat from the markets, and they stress that further isotope studies should be done on Bos taurus and other
faunal remains in order to further flush out the food ways utilized by the people of colonial Charleston.
VIII. CONCLUSION

The results of this study on *Sus scrofa* remains from sites of varying socioeconomic status reveal another layer to the foodways of Charleston, SC, during the 1700 and 1800s. Namely, these results tentatively reject the hypothesis that there were significant differences in $\delta^{13}$C and $\delta^{15}$N protein inputs in *Sus scrofa* diets between upper and lower socioeconomic status sites. The $\delta^{13}$C did not differ significantly across time periods or socioeconomic status. Historical accounts indicate that letting hogs fatten on the masts and vegetation of the surrounding forests was the preferred way to raise swine, whether in large herds or in small groups (Shaw 1940). Corn was often used to supplement the diet and provide a boost in weight gain right before slaughter time, and became the preferred foodstuff of choice after the Civil War. The majority $\delta^{13}$C values for the *Sus scrofa* samples in this study span the C$_3$-C$_4$ range, indicating that the protein sources most of the pigs were feeding on came from C$_3$ and C$_4$ plants or from meat from animals that fed on C$_3$ and C$_4$ plants. Studies on acorn, beechnuts, and fungal species, while from different areas of the globe, produced $\delta^{13}$C values similar to the ones produced in this thesis, indicating that masts and fungi might have been significant sources of protein for the hogs, as explained in the historical record.

The $\delta^{15}$N for the pigs were significantly higher than those from *Bos taurus* excavated from Charleston, placing them at a higher trophic level than the cattle. The $\delta^{15}$N for mast and fungal species does not fully explain this placement within the food web, but a comparison of the *Sus scrofa* $\delta^{15}$N values with those from the opossum samples also analyzed in this thesis revealed that the estimated dietary $\delta^{15}$N values for both species were similar. This indicates that the hogs might have consumed a similar diet to that of the opossums, which commonly eat vegetation, insects, small animals, and human waste. A comparison of the $\delta^{15}$N values of the *Sus scrofa*
samples with $\delta^{15}$N values for herbivores and carnivores that feed on terrestrial food sources revealed that the *Sus scrofa* samples overlapped both categories, suggesting an omnivorous feeding strategy when it comes to obtaining protein sources. A comparison of the $\delta^{13}$C values of the *Sus scrofa* samples with $\delta^{13}$C values for the same herbivores and carnivores added further support to the notion that the pigs in this study were omnivorous, which was expressed in historical records and accounts.

The variation in $\delta^{13}$C and $\delta^{15}$N values across the *Sus scrofa* samples indicates that there were differences in animal husbandry practices, and that some pigs were eating different dietary protein sources than others. As these variations occur in samples from all of the sites, this result suggests that how a hog was raised was not an important factor for people when it came to choosing pork products for their households. Individuals from high and low SES sites were consuming hogs that had eaten a wide variety of foodstuffs, potentially including marine sources of protein. While it appears that the use of isotopic analyses on *Sus scrofa* remains unable to discern between hogs consumed by the elite versus those consumed by the poor, the results of this thesis still add to the current literature on the relationship between faunal remains and socioeconomic status. Namely, that quantity of meat and specific cuts of meat appear to have been how individuals chose to show off their status (Schmitt and Zeier 1983; Schulz and Gust 1983. As opposed to today’s time, when many people wish to know exactly where their meat products have come from, this thesis lends support to the notion that individuals used lavish meals of large portions and choice cuts to better show off how well they have been faring to their peers. The wide range in dietary protein sources discovered in these samples points to further areas of research on the $\delta^{13}$C and $\delta^{15}$N values for masts of trees native to South Carolina, including red and white oak and beech trees, as well as common fungi present in the state. These
areas of research can help further narrow down what hogs were consuming, which can provide insight into how pork products were sourced into Charleston, South Carolina.
IX. WORKS CITED


SC DNR (2015). South Carolina’s landscape. In: Comprehensive wildlife conservation strategy (pp. 4-1 – 4-95). Columbia, SC: South Carolina Department of Natural Resources.


