

COWS IN THE GALÁPAGOS ISLANDS: A STUDY OF CATTLE PRODUCTION AT  
THE HACIENDA EL PROGRESO

by

Miranda Riou-Green  
Bachelor of Arts, Simon Fraser University, 2015

A Thesis Submitted in Partial Fulfillment  
of the Requirements for the Degree of

MASTER OF ARTS

in the Department of Anthropology

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University of Victoria

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## **Supervisory Committee**

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Dr. Peter Stahl, Supervisor  
**Department of Anthropology**

Dr. Iain McKechnie, Departmental Member  
**Department of Anthropology**

## Abstract

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This thesis explores the zooarchaeology of cattle management and production at the 19<sup>th</sup>-century Hacienda El Progreso, on San Cristóbal Island, Galápagos, Ecuador. Many cattle products were exported, including salted meat, leather, and fat. In order to examine cattle commodification, comparative literature was reviewed, and the sequential steps that were undertaken to turn cattle into a product were assessed. The results were then compared to the faunal analysis of the Carpintero assemblage from Hacienda El Progreso using the chaîne opératoire framework in order to examine the possibility of interpreting the sequential production of cattle commodification from zooarchaeological specimens. Historical cattle from Hacienda El Progreso were a likely small bodied Criollo variety. While there was evidence of cattle management and production, there was limited opportunity to identify the hacienda's operational sequence of cattle production for export as the Carpintero assemblage likely represented locally consumed animals.

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# 1. Introduction

This thesis is presented in conjunction with the *Historical Ecology of the Galápagos Islands* project. The international project was an SSHRC-funded partnership between the University of Victoria (UVic), Simon Fraser University (SFU), and Universidad San Francisco de Quito (USFQ), with research located on the 19<sup>th</sup>–century Hacienda El Progreso, San Cristóbal (Chatham) Island, Galápagos, Ecuador. The goal of this larger project is to contribute to the extensively discussed issues surrounding ecological and human management on the internationally acclaimed islands by highlighting their historical context. Following the conceptual framework of historical ecology, this project explores anthropogenic influence on Galápagos landscapes through understanding the relationship between culture and environment (Armstrong and Veteto 2015; Balée 1998, 2006; Balée and Erickson 2006; Szabó 2014).

As a part of the *Historical Ecology of the Galápagos Islands* project, this thesis explores the interconnection of culture and the environment by analyzing the historical faunal specimens from the midden at Hacienda El Progreso. Specifically, this thesis is a zooarchaeological study which examines an operational sequence (*chaîne opératoire*) of cattle-related management and production during the height of the hacienda's operations. Through analyzed faunal remains, this project will provide a detailed understanding of the historical context surrounding the operational sequence of cattle production and the impact of introduced cattle management on the local San Cristóbal landscape. With future research, this thesis could serve as a departure for more studies focused on local ecological effects of commercial cattle production in an isolated environment.

## 1.1. Research Objectives

The research objective of this thesis is to understand cattle management and production using an operational sequence to explore how cattle were turned into a commodity through analysis of preserved skeletal specimens in archaeological context. Little documentation on the commercial enterprise of Hacienda El Progreso is preserved as all the associated books and ledgers were incinerated in a fire after the 1904 revolt by hacienda workers. This thesis examines how cattle were utilized on the Hacienda El Progreso. Is it possible to infer any cattle management and production techniques based upon analysis of faunal remains?

Chapter 2 begins with a broad overview of the geography and human history of the Galápagos Islands, eventually focusing on the town of El Progreso. Additionally, the historical significance of the manipulation of cows in Ecuador and globally will be examined in order to infer and compare the cultural methods in which cattle were utilized and produced into a commodity. These insights present the background for the next section of the thesis, which explores cattle management and production techniques.

Chapter 3 examines how cows were transformed into a product and by extension, how taphonomic factors can be understood through the interpretation of preserved faunal remains based on archaeological and historical comparisons. Using an operational sequence as a guiding framework, the commodification of cattle can be described through stages of production in an idealized operational sequence of cattle-related management and production. The hypothetical sequence of these production events can be inferred or assumed via historical information, ethnographic sources, and comparable archaeological

data. While not all the modifications typical of cattle-related production will be visible, a hypothesized operational sequence of cattle-related management and production inferred from historical, ethnographic, and archaeological information will be suggested.

Next, cattle production is explored through an analysis of faunal material recovered from the historic Hacienda El Progreso's midden in Chapter 4. The analysis of faunal remains examines taphonomic signatures (e.g. skeletal profiles, bone density, and surface modifications) from the assemblage. The goal of this research is to explore how the people in the hacienda transformed cattle into a finished product for consumption. Through focusing on an analysis of the faunal assemblage as it relates to the creation of cattle products, the faunal specimens from the midden are then compared to a conceptualized operational sequence.

Chapter 5 explores the similarities between the hypothetical sequence of the commodification of cattle and the analyzed specimens found in the assemblage. The comparative literature used to explore cattle management and production can provide a parallel explanation for how cattle were utilized at Hacienda El Progreso through the similarities and differences found in the assemblage. The thesis may be further used as a tool for comparison with other zooarchaeological studies focusing on the potential interpretation of taphonomic features at sites involved in cattle management and production. Furthermore, the thesis explores the effectiveness of using a chaîne opératoire framework for studying cattle production from zooarchaeological specimens. Within the larger *Historical Ecology of the Galápagos Island Project*, the results of the thesis could contribute to other questions, especially concerning the repercussions of cattle-related production for San Cristóbal's environment. Moreover, it could become an

example for inquiries surrounding the environmental consequences of turning a cow into a product on an island.

## 2. Geography and History

Galápagos is currently considered one of the most famous national parks in the world due to the isolated and pristine appearance of the islands. These traits have bestowed a unique perception on the archipelago; numerous books have been written about the wonders of Galápagos (e.g., Bassett 2009; Jackson 1993; Kricher 2006; Latorre 2002, 2005, 2011; Nicholls 2014; Stewart 2006). Tourism has flourished as many expensive cruises and tours visit the islands and multiple establishments have appeared in what was once considered an uninhabitable environment. The Galápagos Islands encompass a treasured landscape with fascinating natural and human history.

Hacienda El Progreso was uncommon within the 19<sup>th</sup> century for its geographical and historical implications. It was constructed on what was once considered an uninhabitable chain of islands in the middle of the Pacific Ocean. The ecological considerations involved in the development of agriculture and pastoralism on an island with limited resources was a testament of human ingenuity and determination. In order to better contextualize a zooarchaeological assemblage in the Galápagos Islands and understand how cattle were utilized in a hacienda, it is first important to understand the geography and history of the archipelago.

### 2.1. Geography and Ecology of the Galápagos Islands

Over the decades, scientists and tourists have universally recognized the Galápagos Islands as an internationally acclaimed location to explore ‘natural’ wilderness. Declared part of Ecuador since 1832, this South American country is the closest continental landmass to the Galápagos, with 960 km separating the islands from the mainland

(Bassett 2009:12; Jackson 1993:5). The Galápagos archipelago consists of multiple oceanic islands, which were never connected to the continental mainland (Figure 1). Within Galápagos, there are 13 main islands greater than 10 km<sup>2</sup>, six smaller islands, as well as over 233 islets and emerged rocks of which only around 40 are named (Bassett 2009:28). In total, the complete land mass of all the Galápagos Islands is about 8000 km<sup>2</sup>. At 4588 km<sup>2</sup>, the island of Isabela comprises over half of the total land mass of the archipelago. Darwin Island, Española Island, Fernandina Island, and San Cristóbal Island are the most northern, southern, western, and eastern islands, respectively. Diagonally from the most northwestern island of Darwin to the most southeastern island of Española, Galápagos covers over 430 km (Jackson 1993:10; Kricher 2006:17).



determined by the interaction of ocean currents and trade winds. Two varying seasons prevail in Galápagos: from June to November the islands are cooler and the coastal lowlands receive little rainfall, signaling the *garúa* or dry season; and, the warm season, in which temperatures can rise to 32°C and when the islands experience occasional heavy downpours (Collins and Bush 2010:237; Restrepo et al. 2012:1855; Trueman and d'Ozouville 2010:31).

The Galápagos Islands provide a unique environment for a number of unusual plants and animals, which have been studied and admired by many. Uninhabited by humans until the historic era, the Galápagos Islands contain over 560 indigenous plants with around 180 that are endemic (Bassett 2009:31; Jackson 1993:72; Stewart 2006:32). However, most of the environment consists of semi-desert lowland, and only at higher elevations on some of the islands is there enough rain to support dense vegetation (Nicholls 2014:56; Stewart 2006:30). The archipelago contains six indigenous mammals including one species of sea lion, one species of fur seal, two species of bats, and two species of rice rats (Tirado-Sanchez et al. 2016). Additionally, there are 29 resident species of birds, 22 of which are endemic to the area; and 27 native reptiles, 17 of which are endemic to Galápagos. Local fish consist of 400 species, 50 of which are exclusively found in the vicinity (Bassett 2009:31; Stewart 2006:32).

### **2.1.1. Geography and Ecology of San Cristóbal Island**

San Cristóbal is the fifth largest and easternmost of the Galápagos Islands (Figure 2). Formed by two inactive volcanoes, San Cristóbal is one of the oldest islands and contains the archipelago's largest fresh water lake, El Junco (Bassett 2009:28-29). It is composed

of six vegetation zones (Bush et al. 2014:297; Colinvaux and Schofield 1976:992; Watson et al. 2009:80; Wiggins and Porter 1971:16-30): (1) the Littoral or Coastal zone; (2) the Arid zone, the dominant plants of which include low scrubs; (3) the Transition zone, which is composed of a mixture of the lower and upper zone vegetation; (4) the Scalesia zone, a humid area comprised mainly of the endemic tree species with the same name; (5) the very humid Miconia zone, where El Junco lake is situated, largely dominated by sedges and ferns; and, (6) the Fern-Sedge zone or Grassy zone, mostly beginning at 525 to 550m above sea level. However, these zones are in most part arbitrary divisions based on a grouping of plant species for the purpose of convenient description on Santa Cruz Island. The natural vegetation zones are complex and often depend on climatic factors, as well as alterations imposed on the islands due to anthropogenic changes (Trueman and d'Ozouville 2010:28). For example, Darwin visited the Galápagos Islands in September during the cold dry season. From the ocean, the landscape of San Cristóbal Island looked like it was 'covered by stunted, sun-burnt brushwood' with 'such wretched-looking little weeds'. He described it as 'leafless as our trees during winter' (Bassett 2009:11; Kricher 2006:1; Nicholls 2014:53).



**Figure 2. Map of San Cristóbal Island. The study site is located in the town of El Progreso. (Map from Wikimedia Commons, accessed December 1<sup>st</sup>, 2016.)**

#### 2.1.1.1. Geography and Ecology of El Progreso

The present town of El Progreso is the site of the historic hacienda approximately six km inland from the port town of Puerto Baquerizo Moreno and halfway between the port and the fresh water lake, El Junco. Coastal vegetation in the lowlands surrounding Puerto Baquerizo Moreno is considered arid whereas El Progreso is situated in the Scalesia zone. The Scalesia zone only occurs on islands with higher altitude. Today, a fraction of this once extensive zone remains (Jackson 1993:64). El Progreso is situated within one of the best regions for agriculture in Galápagos (Hamann 1979:107; Wiggins and Porter 1971:7). Dense vegetation has been extensively removed for agricultural and cattle ranching purposes. Over 1,000 hectares of land are currently used for agriculture with

crops including vegetables, grains, bananas, sugarcanes, and coffee beans. However, due to low profit margins and a lack of available labour, 2,740 hectares of once agricultural land now is semi-abandoned and overrun by invasive species, including rose apple, guava, and hill raspberry (Villa and Segarra 2009-2010:87).

## **2.2. Human History of the Galápagos Islands**

The world-renowned Galápagos landscape often invokes images of a pristine ecosystem unencumbered by the devastating ecological effects of humans. What is often unrecognized is that some of the Galápagos Islands share a history of landscape changes from human colonization. While colonization of the Galápagos Islands did not begin until after their annexation by the Government of Ecuador in the 1830s, Galápagos has been visited and exploited by humans for centuries.

### **2.2.1. Early Human History of the Galápagos Islands**

It is not known with absolute certainty who the first person was to step foot on any of the islands. Some researchers argue that pre-Inca people could and would have used the islands for their natural resources (Heyerdahl and Skjölsvold 1956); however, there is no firm evidence to support this claim (Anderson et al. 2016; Suggs 1967). The sole archaeological evidence consists of scattered pre-Hispanic indigenous pottery found on the islands. However, the pottery was found in association with colonial period artifacts within the same stratigraphic context (Anderson et al. 2016:170). As it is historically known that European sailors from the 17<sup>th</sup>-19<sup>th</sup> centuries often took and used locally sourced South American pottery as storage containers (Anderson et al. 2016:181; Suggs 1967:242-243), the hypothesis of pre-Hispanic indigenous habitation in the Galápagos

Islands cannot be confirmed. Other scholars rely on prehistoric oral history of the visit of Inca Tupac Yupanqui to the islands as evidence of prehistoric contact. The story states that the maritime expedition brought back gold, silver, a copper throne, and horse-sized animals (Suggs 1967:242; Latorre 2005:7-8). Modern scholarship considers this tale as inaccurate or mistaken as there is neither gold, silver, copper, nor endemic horse-sized animals on the islands.

The first official record of the Galápagos Islands is from accidental “discovery” in 1535 by Fray Tomás de Berlanga, the Bishop of Panama, who set sail to Peru in order to investigate atrocities carried out by conquistadors after the fall of the Inca Empire (Bassett 2009:35; Heyerdahl and Skjölsvold 1956:3). On route, his ship was caught in a dead calm and drifted to Galápagos. Making landfall during the dry season, the bishop found a harsh climate with little to no water. Berlanga describes Galápagos as dross and worthless, and rejoiced when the trade winds returned to take him away from the islands (Bassett 2009:12; Jackson 1993:1; Nicholls 2014:4-5). While some of the crew died of dehydration during the voyage, the majority eventually survived to see Peru. Berlanga’s description of a desolate place with tame animals spread around the globe and the Galápagos Islands were ultimately added to the world’s map (Kricher 2006:7).

#### 2.2.1.1. Pirates, Buccaneers, Explorers, and Scholars

Since the archipelago’s discovery, the islands have been used by seafarers, including buccaneers, privateers, whalers, and sealers. Captain Diego de Rivadeneira was credited with providing Galápagos with one of its earliest names. Calling them the *Islas Encantadas* (Bewitched Islands), Rivadeneira saw the Galápagos Islands but did not stay

long, claiming that the area was difficult to navigate due to the multitude of strong and variable currents (Kricher 2006:8; Melville et al. 1940:4). Pirates however did, and from the late 1500s to the early 1700s they attacked colonial port towns in Ecuador and Peru, primarily using the island as a refuge and a base from which to launch their raids (Jackson 1993:2; Heyerdahl and Skjölsvold 1956:5). Throughout the years some would create detailed maps and charts, occasionally noting accounts and observations of natural-history, often heavily biased toward information that would assist in satisfying a hungry and thirsty crew. For example, British buccaneer, Captain William Ambrose Cowley, created early charts and recounted how the only water source on the islands was found on the Duke of York's Island – now commonly known as San Cristóbal Island (Stewart 2006:45).

By the mid to late 1700s, the age of the pirates had come to an end. In the 1790s, the English captain James Colnett came to explore the area's possibility for whaling, becoming the first to create a reasonably accurate navigational chart of the islands. After Colnett's recommendations, the islands became a popular port for whalers and sealers in search of whales, tortoises, and fur seals (Melville et al. 1940:xxii; Jackson 1993:2). In fact, for years after, there was hardly any moment when a whaling vessel was not plying the waters somewhere near the Galápagos Islands. Whales were not the only animal hunted, as sailors practiced turpining, a 19<sup>th</sup>-century term for hunting giant tortoises, which were a welcome food source as they were capable of surviving on ships for several months (Stewart 2006:487). Additionally, sailors would club iguanas and bird for sport, and hunt the Galápagos fur seals for profit.

On September 1835, the most famous visitor to the Galápagos Islands, Charles Darwin, first stepped foot on the shores of San Cristóbal Island (Bassett 2009:47; Stewart 2006:62). Here, Darwin found a land that he believed hard and unforgiving, yet, he discovered that the wildlife was perfectly suited to this unique habitat. Only visiting four islands (San Cristóbal, Floreana, Isabela, and Santiago), he observed and collected plants and animals, inspiring him to eventually consider the theory of evolution (Jackson 1993:5). From his time in the Galápagos, Darwin was inspired to write *The Origin of Species* 24 years later, which shook the foundation of biblical origins and the fundamental way in which the development of life was viewed. While his Galápagos visit took place over only five weeks, its aftereffects have had long-lasting influence (Stewart 2006:72).

#### 2.2.1.2. The Beginning of Colonization and Settlement

Throughout the years, while many adventurers or entrepreneurs visited the islands, few attempted to inhabit it with any permanency due to the scarcity of water and the difficult ocean currents (Bassett 2009:11; Eibl-Eibesfeldt 1960:170-176). The first attempt to colonize the islands was undertaken by Ecuadorian general Jose Villamil, acquiring two islands from the Government of Ecuador (Salvin 1876:454). In 1832, he began a small plantation on Floreana, bringing 80 soldiers he had saved from execution. The colony experienced moderate success, with a growing population of between 250 and 300, composed primarily of convicts and society's undesirables. Due to harsh conditions, the inhabitants revolted and the colony failed in the early 1840s. Most settlers did not stay, dispersing to the mainland or San Cristóbal Island, but the domesticated plants and

animals remained on the islands (Kricher 2006:10; Eibl-Eibesfeldt 1960:170; Mann 1909:27).

## **2.2.2. Human History of San Cristóbal Island**

From the first steps of Darwin on the Galápagos Island to its location for the oldest and longest running hacienda, San Cristóbal Island has had its own share of human history. This included the short reign of Villamil's failed colony in Puerto Baquerizo Moreno and Manuel J. Cobos' Hacienda El Progreso. The modern town of El Progreso today occupies the site of the old hacienda.

### **2.2.2.1. History of San Cristóbal Island before Hacienda El Progreso**

Before the establishment of Hacienda El Progreso and the arrival of Cobos, San Cristóbal Island was largely uninhabited, with the exception of the occasional expedition party and Villamil's failed colonization attempt (Kricher 2006:10; Latorre 2005:41; Lundh 2004). According to the romanticized novella *The Encantadas* (Melville et al. 1940:98) based on Herman Melville's whaling trip in 1841, it was common at the time to find huts or other remains, such as graves, around the shores of the Galápagos Islands. In the 1860s, Ecuadorian entrepreneur Manuel J. Cobos, with his brother Angel and business partner José Monroy, began sporadic operations on San Cristóbal. They created a small company, *Empresa Industrial Orchillana y de Pesca*, to collect orchilla lichens from which the valued purple cudbear dye was extracted (Bilbao 1904:107; Nicholls 2014:115).

### 2.2.2.2. History of Cobos' Hacienda El Progreso (1878-1904)

After a decade of orchilla collection in Baja, Cobos moved to the island permanently due to the crashing value of orchilla brought on by artificial dyes in the latter half of the 19<sup>th</sup> century (Kok 1966:259). At that time, 80 orchilla-pickers worked on the island (Salvin 1876:456). By 1878, Cobos expanded the small farm into a large plantation, Hacienda El Progreso (Kricher 2006:10; Latorre 2011:10). With these efforts, Cobos was the first to create an industrial-scale plantation in the Galápagos. Soon his entrepreneurial efforts shifted towards a focus on large-scale mass sugar cane and coffee production. He also began to capture and domesticate the wild cattle on the island, clearing the forest to form meadows and pastures for the cattle he acquired (Bilbao 1904:108). Hacienda El Progreso exported many goods including sugar, alcohol, coffee, leather, salted meat, fish, and turtle oil (Latorre 2002).

For over 20 years, Cobos relied upon forced labourers, including convicts and desperate settlers recruited from mainland Ecuadorian jails and streets (Latorre 2005:70; Mann 1909:34). At its peak, the hacienda was producing 500 tons of sugar per year and had 100,000 coffee trees (Latorre 2002:16-17; Mann 1909:29). Over 400 people lived on the island, with 200 as employees and mill workers (Bilbao 1904:9). The hacienda eventually occupied the entire southwestern portion of San Cristóbal Island, as well as extending Cobos' interest to other islands, such as Floreana (Latorre 2002:32). On the island, he installed an aqueduct system spanning seven kilometers, built 100 kilometers of roads, and laid 10 kilometers of 'Decauville' railroad for his sugar plantation. Sugar, coffee, alcohol, tortoise oil, lime, fish, meat, and leather products were transported to the mainland from an ocean-side port built for a dedicated cargo fleet.

The Hacienda El Progreso had small huts for the workers, a sugar mill with cutting-edge machinery, a communal kitchen, and the Cobos' house (Mann 1909:29; Martinez 1919:36). A large avenue cut through the village, lined with white agaves and fruit trees. Apart from sugar canes, coffee beans, and tobacco plants that were grown for export, many fruits and vegetables were also planted for local consumption. In terms of fruit, Cobos had planted oranges, lemons, guavas, plantains, avocados, cherimoyas, soursop, plums, mangos, papayas, pineapples, rose apple, watermelons, melons, and grapes (Latorre 2005:69; Martinez 1919:77). Vegetables that fared well on San Cristóbal included cassava, sweet potatoes, lentils, chickpeas, and peas (Martinez 1919:76). Communal lunch was served at noon and consisted of stews from left-over meat, fish, and plantains. The food was described as so awful only a malnourished worker would dare to eat it (Latorre 2005:72).

Cobos' treatment of the labourers was comparable to slavery. Labourers usually worked seven days a week and had only three non-working holidays a year (Latorre 2005:73). Cobos paid the indentured labourers in his own currency that was only valid in his stores. The hacienda workers, later referring to themselves as slaves to the inhumane Cobos, remembered how he brutally punished people with flagellation. As a tyrant of the Galápagos Islands, it was common knowledge that Cobos had killed five individuals and banished at least 15 men to deserted islands, where some had died of hunger (Bilbao 1904:113). One of the most famous accounts of Cobos' cruel punishments was the story of Camilo Casanova. Exiled on the deserted island of Santa Cruz in 1900, Casanova lived off of fruits, vegetables, and chickens left by previous inhabitants. Worse than simply abandoning him on the island, Cobos had posted a sign to ensure the permanence of

Casanova's punishment. In multiple languages, the post read: "Please do not take this man off the island for he is twenty times a criminal" (Latorre 2005:102). On January 15th, 1904, Cobos was shot, hacked, stabbed, and bludgeoned to death by an angry mob of his own labourers (Latorre 2011:8; Stewart 2006:57).

After Cobos' death, many of the workers remained on the island. However, on February 17<sup>th</sup>, 1904, around eighty men and women were apprehended by police off the shores of Tumaco, on the southwestern coast of Columbia. Having fled San Cristóbal after the murder of Manuel J. Cobos, they were imprisoned to await trial. Through the trial's proceedings, the public finally heard of the atrocities committed on the indentured laborers. Their ringleader and Cobos' murderer, a laborer named Elias Puertas, fully admitted to the murder and the other workers agreed. Referring to him as 'The Liberator', all agreed that it was the only way to escape their captor (Latorre 2005:63). The Hacienda El Progreso continued to function after Cobos' death in different forms, eventually becoming a village surrounded by agricultural development (Wiggins and Porter 1971:6). The disused portion of the Hacienda landscape pasturage has since transformed into dense vegetation (Villa and Segarra 2009-2010).

### **2.2.3. Current State of San Cristóbal Island and El Progreso**

Based on the 2015 census, San Cristóbal is second to Santa Cruz in terms of human habitation of the archipelago, totaling over seven thousand residents (INEC 2016). The local inhabitants are employed today in government, tourism, and artisanal fishing. The island contains three main towns, Puerto Baquerizo Moreno, El Progreso, and Cerro Verde. Puerto Baquerizo Moreno is the political capital of the province, home to many

government offices, the Ecuadorian Navy facility, and an airport with daily flights to the mainland (Kricher 2006:193). Puerto Baquerizo is also the hub for post-secondary education. The Galápagos Academic Institute for the Arts and Sciences (GAIAS) of the Universidad San Francisco de Quito serves as a base for local and international students and scholars. The majority of the population lives in Puerto Baquerizo Moreno.

Hacienda El Progreso is the oldest surviving settlement in the Galápagos; evolving from Cobos' operation to independently owned farmland, there is little evidence left of the hacienda aside from a ruined building, a memorial tomb for Cobos, and old machinery used as decoration around the island. The town now serves as a small farming village (Kricher 2006:193). Due to unsustainable agricultural practices on the island, much of the farmlands have become semi-abandoned as people move to Puerto Baquerizo Moreno, to pursue ecotourism (Villa and Segarra 2009-2010:87).

#### **2.2.4. Cattle in the Galápagos Islands**

While there might be earlier cases of stocking on the Galápagos Islands, the accepted first official recording of domesticated animals released in Galápagos was by Captain David Porter in 1813. A captain of US navy frigate *Essex*, Porter accidentally let four goats escape on the island of Santiago (Kricher 2006:8-9; Jackson 1993:3). By the time that Darwin visited Floreana Island in 1835, he noted the presence of wild pigs and goats (Salvin 1876:455). While goats and pigs were easy to store on boats that would briefly visit the Galápagos, it was not until entrepreneurs decided to colonize the islands that cattle began to appear in the historical literature. For example, Jose Villamil's small failed settlement on Floreana in the 1840s left behind domesticated animals on the island

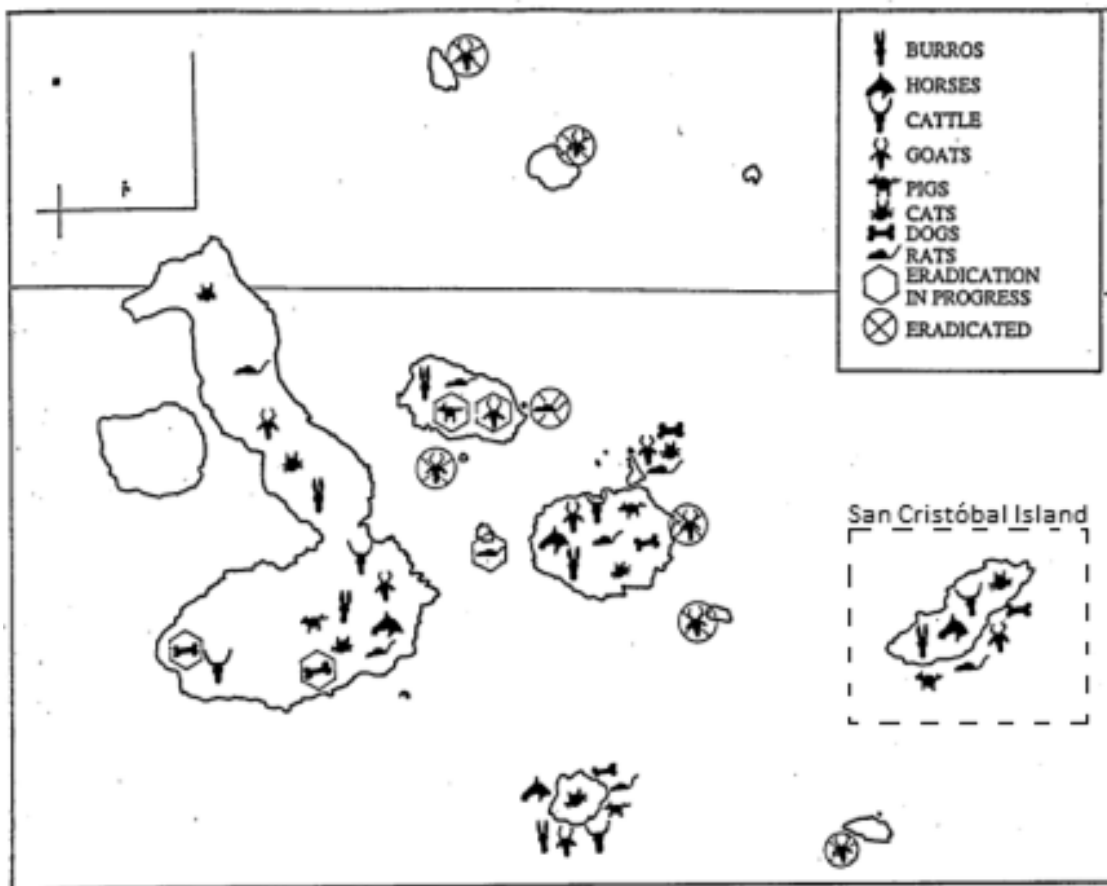
to roam free (Kricher 2006:10; Latorre 2011:15). Villamil also introduced cattle with an attempted colony on San Cristóbal (Latorre 2005:41). Cattle flourished on San Cristóbal due to abundant food and water located in the highlands (Mann 1909:27).

In the 1860s, Cobos left eight families on San Cristóbal to clear trees in order to create pasturage for cattle (Latorre 2011:21) and by 1890, it was estimated that there were 10,000 cattle on the island (Latorre 2005:68). This is potentially an exaggeration as reports from H.M.S. 'Peterel' estimated 4,000 head of cattle in 1875 (Salvin 1876:456); however, it still demonstrates the abundance of cattle on San Cristóbal Island. Alexander Mann (1909:28) described the island as once teeming with cattle, horses, donkeys, and gigantic tortoises. Cattle grazed in five large pastures surrounded with wire fences; each pasture measured 600 square cuerdas or roughly 50 km<sup>2</sup> (Bilbao 1904:10). Cobos also extended his cattle procurement to Floreana Island where 2,500 head of cattle were reported in 1875. After his death, there were still pastures with many healthy cattle on San Cristóbal and Floreana (Martínez 1919:36). Additionally, a photograph taken by Captain Rollo Beck in 1905 in the archives of the California Academy of Science depicts employees of the Hacienda El Progreso shooting cattle and jerking the beef at Black Beach, Floreana Island (Figure 3). Today, there is only a small-scale beef production concentrated on Santa Cruz Island which focuses on supplementing local consumption (Barahona and Beillard 2015).



**Figure 3. Señor Estudillo, jefe in charge of hunting and drying cattle hides for Hacienda El Progreso on Floreana Island. (Photograph from California Academy of Science, Rollo H. Beck Collection, G47, Occ. Papers #17, Plate 5.)**

Cattle and introduced animals currently populate several of the Galápagos Islands as seen in Figure 4. While the detrimental effects of wild cattle have not been fully assessed, they have been known to environmentally impact the islands (Jackson 1993:245). For example, tortoises were once abundant on the islands, now they are a rarity on certain islands due to the introductions of goats, cattle, pigs, dogs, cats, rats, and donkeys (Kricher 2006:10). Today, the habitat of the tortoises has been seriously reduced due to the fenced pastures of cattle farmers (Blake et al. 2015:148).



**Figure 4. Introduced mammal distributions on the Galápagos Islands. (Map from Jackson 1993:243.)**

Much of the environmental impact attributed to cattle has been done indirectly by humans, such as through the introduction of invasive plants (Jackson 1993:242). For instance, in the early 1900s, the highlands of San Cristóbal were cleared open grasslands, abundant with feral cattle. Due primarily to illegal hunting by settlers, wild cattle disappeared in the 1940. The open grasslands quickly grew over with guava. When domestic cattle reappeared on the island, the forests of guava remained unchanged as later herds found it unpalatable. Thus, the invasive plants were free to develop into at least a portion of the guava forests prevalent today (Eckhardt 1972:585-586).

Another example is the Smooth-billed Ani, an introduced bird that was likely brought by farmers to help solve the tick problem with cattle. As it also consumes insects in foliage of bushes or open ground, the Smooth-billed Ani's diet directly competes with native endemic birds (Jackson 1993:184; Guerrero and Tye 2011). However, the biggest direct ecological impact has been the deforestation of the native Galápagos landscape. Over half of the highland area on the four inhabited islands has been completely transformed by farming. On San Cristóbal, more than 95% of the highland habitat is seriously degraded as a result of the nearly continuous presence of humans for the past 150 years (Nicholls 2014:115).

### 3. Chaîne Opératoire

The chaîne opératoire is a methodological framework in archaeology that highlights the sequence of an operational process. The aim is to follow a primary material from its 'natural' state to an end product (Cresswell 1976:6; Lemonnier 1986:149). Understanding the techniques or technical process involved in creating the product facilitates our ability to recognize all the components involved in creating a product rather than just reciting a description of its production (Lemonnier 1986:150; Peuramaki-Brown 2013:167).

Typically, chaîne opératoire has been used in lithic or pottery studies (Lemonnier 1986; Gosselain 1992; Soressi and Geneste 2011; Jeffra 2015; Peuramaki-Brown 2013).

However, anthropologists have also used the framework for other types of studies, such as food production (Brysbaert 2013; Coupaye 2009; Dietler and Herbich 1993), social organization (Smith 2015), and evolution (Riede 2006).

#### 3.1. A Brief History of Chaîne Opératoire in Archaeology

Rooted in the study of ethnology, the chaîne opératoire framework was first proposed in France by A. Leroi-Gourhan. While he did not formalize the term, it led the way for future research in different fields of anthropology (Audouze 1999; Bar-Yosef et al. 2009:104; Soressi and Geneste 2011:336). In the late 1970s, the emergence of chaîne opératoire catalyzed the study of prehistoric technology. At the time, the typological system that was in use began to feel stale. Chaîne opératoire provided a unique point of view that promised results driven by a new way of thought. It showed promise as a methodological tool because it considered both technical processes and social acts (Bar-Yosef et al. 2009:103; Soressi and Geneste 2011:336). Chaîne opératoire examined the

life of an artefact on a step by step basis, from production, to use, and eventual disposal.

While chaîne opératoire is primarily applied to lithic and pottery studies, the methodology has also been applied to zooarchaeology, especially involving food management and production (Brysbaert 2013; Coupaye 2009; Dietler and Herbich 1993).

### **3.2. Chaîne Opératoire of Cattle Production on San Cristóbal Island**

In order to create a theoretical operational sequence of cattle-related management and production for comparison with the analytical results in chapter 4, the operational sequence will be based on historical, ethnographical, and archaeological evidence. The operational sequence involves a step-by-step sequencing of cattle production. These steps, or chain event, include raising and herding of animals, product extraction, manufacturing of goods, effects of cooking, and creation of refuse. Each chain event from the operational sequence of turning cattle into a product continuously modifies skeletal elements through periodic acts of human and natural modification. However, the assemblage of skeletal remains is constantly changing as each specimen includes different, and potentially unique, taphonomic modifications caused by different sequential events. The potential events involve butchering, leather making, bone accumulation, fat retrieval, and oil extraction. Each event potentially leaves a mark or a distinguishable feature on cattle bone, which could be identified within a cattle management and production sequence.

#### **3.2.1. Cattle Management**

During their colonization of the Americas, all Europeans ensured that sufficient amounts of livestock would join them on their journey. For example, in the early 1600s

during the beginning of sustained colonization of North America, the Massachusetts Bay Company required 20 cows and 10 horses for every 100 men (Anderson 2004:99).

Spanish colonization of the Central Andes resulted in the fusion of traditional Andean culture with European customs, in which the importance of old world livestock continued (deFrance 2003:99). Cattle were for many an important food and economic source.

Zooarchaeological analyses suggest that Spanish colonies often had a clear preference for beef and pork over sheep and goat (Reitz 1992:88-89; Newman 2010:44), although this varied immensely between different regions (deFrance 1996:43-45; Jamieson 2008:21).

Cattle raising can be divided into three stages: calf-rearing, growth, and fattening (Goodwin 1977:54). During the 17<sup>th</sup> century, farmers let cows roam free and similarly, Spanish colonial cattle were also left to fend for themselves (Anderson 2004; Reitz and Ruff 1994:708). However, problems arose during the early 1600s at Jamestown and other settlements with free range management, prompting a demand for cowkeepers to keep track of wandering cattle. Nevertheless, cowkeepers spent more time protecting cattle from predators and in later years fencing cattle proved a moderate success. Cattle were also kept on islands, free of wolves, to presumably fend for themselves (Anderson 2004:113). Few colonists penned animals on their plantations, as for the most part, penning animals provided more disadvantages than benefits. Building sheds and fences was easy, whereas sufficiently feeding cattle confined in small closures was not (Anderson 2004:113). It was far easier to let cattle fend for themselves. This management style was continuously used on plantations or farms especially on islands, including the Hacienda El Progreso.

### 3.2.1.1. Raising Cattle

Each day, modern beef cattle eat about 2% of their weight in forage and drink up to 12 gallons of water (Anderson 2004:113). Feeding cattle requires time and resources. While cattle production was important to 17<sup>th</sup>-century farmers, they also could not let their herds exceed the grazing capacity of their lands. They also needed to consider evolving family needs and market demands. For this reason, farmers would regularly intervene in the animal's reproductive lives. To increase the manageability of their herds and limit their size, farmers would castrate all but a few of the bulls, restrict mating season, and butcher unneeded calves (Anderson 2004:87). When cattle were raised to roam free, farmers relied on cattle to nourish themselves. Cattle thrived in certain arid and low elevation coastal valleys of the central Andes, which were conducive to the introduction of Old World animals (deFrance 2009:2).

However, the colonial use of land for cattle raising was not always optimal. Often there were disastrous consequences when introducing these exotic domestic animals into a New World environment. For example, in the 16<sup>th</sup> century Valle del Mezquital, Mexico, dramatic changes in land use and rapid environmental degradation were caused by overstocking and indiscriminate excessive grazing of domesticated animals (Melville 1990:24). Cattle were not just passive actors simply transported to new worlds; they too were colonists that also faced the need to adapt in new environmental conditions (Reitz 1992:84). While not greatly sensitive to high heat and humidity, cattle as a species are sensitive to other environmental changes that can affect their weight, growth, and reproduction (Reitz 1992:85).

### 3.2.1.1.1. Cattle Breeds

Before the 19<sup>th</sup> century, the specific breeds of cattle were considered less important (Berg and Butterfield 1976:8). Smaller locally isolated landscapes, regionally specific utilization of cattle, and unique environmental conditions created characteristically localized breeds (Reitz and Ruff 1994:708). After the arrival of Columbus to the Americas, a few hundred head of Spanish cattle were transported to the island of Hispaniola. While it is not confirmed, many believe that the cattle introduced were Andalusian due to phenotypic characteristics (Ajmone-Marsan et al. 2010:155; Alderson 1992:331). For the first century after their arrival, these ancestors of Criollo cattle were one of the first domesticated bovines in the western hemisphere, spreading across the American continents with the help of Spanish settlers (Rouse 1977:3; Wilkins 1984:1).

In 1524, the first Criollo cattle to step foot on continental America arrived in present-day Colombia. Colombian Criollo cattle were brought to Ecuador shortly after (Ajmone-Marsan et al. 2010:155; Cevallos-Falquez et al. 2016:314; Rouse 1970:418). Criollo varieties were dominant in Latin America until the mid-1800s when new breeds emerged on the market, causing the Criollo cattle to be replaced or cross-bred (Rouse 1970:355). For draught purposes, Criollo breeds were preferred until the 1930s; they were then succeeded by American Brahman bulls (Rouse 1977:108). In the 1860s, Zebu breeds were imported to the tropics, when the Zebu-Criollo crossbreed started to appear. One of the main reasons for the widespread use of Zebu for cross-breeding was the improvement in growth rates (Stonaker 1971:1). By 1870, Northern European breeds had reached Argentina (Rouse 1977:7). Slowly, Northern European purebreds became available in Ecuador by 1900. Yet, the pure bred Criollo was still preferred as they had become

acclimated to higher altitudes (Rouse 1977:108). By 1967, native Criollo breeds still comprised 65% of cattle production (World Bank 1967:2). Today, the preferred beef cattle breeds are Brahman and Charolais, while Holstein, Jersey, and Brown Swiss are the preferred dairy cattle breeds (Barahona and Beillard 2015).

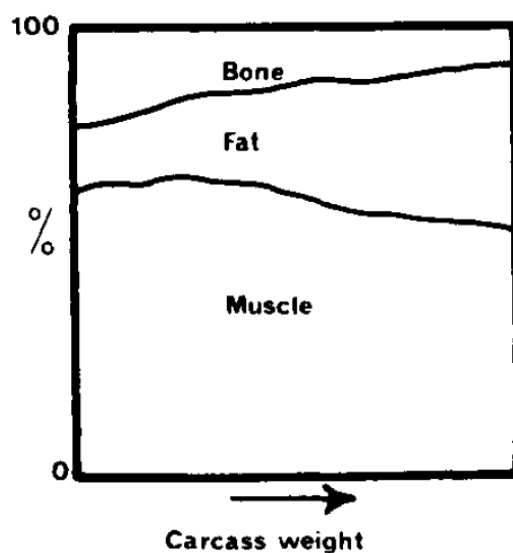
Criollo is not a breed, rather a new world landrace in which a wide variation developed from a relatively small but heterogeneous gene pool (Wilkins 1984:2). Differences in environment, nutrition, and management easily resulted in variations of Criollo cattle. For example, size fluctuated; a Colombian Criollo weighed 200 to 225 kg, rarely over 320 kg, while a Cuban Criollo could be 550 kg (Rouse 1970:405, 1977:253). Ecuadorian Criollo cattle are often estimated as being somewhat larger than the Criollo of Columbia and Venezuela (Rouse 1970:418). However, the live weight of Criollo cattle from the Ecuadorian province of Manabí is between 246 and 550 kg (Porter et al. 2016:172; Cevallos-Falquez et al. 2016). Improvements in breeding, nutrition, and disease control in the late 19<sup>th</sup> and early 20<sup>th</sup> century contributed to the development of modern breeds which are completely different from earlier varieties (Reitz and Ruff 1994:707). Assisted husbandry's obsession with the ideal cow has today produced varieties which would not survive in a semi-feral population.

### **3.2.2. Butchery**

Selection of a cow for beef production involves the animal's age, weight, and health. The slaughtering age of animals depends on a range of factors: the relative value placed on different cuts of meat, the characteristics of the herd, and other environmental or economic factors. In the 1970s, a good carcass would include 60% prime joints (e.g.

rump, rounds, and sirloin) and 40% coarse cuts (e.g. brisket, flank, and clod). The butcher would also prefer a younger carcass, which provides a high proportion of red meat compared to fat and bone (Goodwin 1977:44); however, cattle older than three years of age were historically the prime choice for beef (Goodwin 1977:152).

When considering the economics of the specific marketability of cattle products, choosing the right cattle is important. Fat is one of the most important variables when making decisions for cattle management and production. The timing of slaughter should coincide with desirable or optimum fat levels; however, it is difficult to determine when that stage has been reached. There is an ideal stage of cattle development and slaughter point; both too much and too little fat in the differing cuts of meat could potentially change the dollar percentage of saleable meat as seen in Figure 5 (Berg and Butterfield 1976:2). Household requirements and markets demands would have determined when the cattle were to be butchered.



**Figure 5. Typical carcass weight during growth in relation to the percentage of bone, fat, and muscle. (Figure from Berg and Butterfield 1976:23.)**

As previously mentioned, other environmental and economic factors contribute to the optimal age of slaughter, particularly, seasonal variation in the availability of grazing and feed. If the goal is solely meat production, most young cattle would be killed once they reach the optimum point in weight-gain, with only a few being kept for continued breeding. When environmental and economic factors are considered, the goal becomes gaining the most meat product possible while requiring the least amount of feed. Additionally, the stock raisers were responsible for assuring that more young animals were kept on than were absolutely required for cases in which there were significant losses in the herd. Often cattle that were injured, fell sick, had difficulty breeding, producing milk, or walking would be fattened or immediately killed for meat. These additions would further complicate the kill-off pattern (Anderson 2004:88; Payne 1973:281).

#### 3.2.2.1. Age Range and Historical Mortality Profiles

Different strategies for management of domestic cattle often produce different patterns for the slaughtering age of animals (Reitz and Ruff 1994:708; Vigne and Helmer 2006:16). Through mortality profiles, zooarchaeologists infer herd management based upon sex and age at death estimations in the zooarchaeological assemblage. Different assemblages would show at least some diversity in the age and pathological structure of cattle as a result of draught, dairying, or beef production (Landon 1996:14). For example, draught exploitation of cattle is usually inferred in the archaeological record through a relatively high proportion of aged cow remains, as well as specific pathological indicators on the metapodia and phalanges (Bartosiewicz et al. 1997:52; Johannsen 2011:19; Tell Dahl et al. 2011:3). With the exploitation of cows' milk, the mortality profile should

never demonstrate a slaughtering peak of newborn calves, as cows require their calf in order to lactate. The post-lactation slaughtering peak is between five and nine months (Vigne and Helmer 2006:28). As a result, cattle used for draught purposes or to supply dairy products such as milk, cheese, and butter, would be inferred in the archaeological record from mostly older cattle greater than three years at death (Bowen 1975:20). When cattle were utilized for secondary products such as milk, it was logical to keep them alive until they ceased to produce (Sportman et al. 2007:132).

Archaeological assemblages consisting of juvenile and subadult cattle specimens can suggest a prioritization of beef production (Zierden and Reitz 2009:349). For example, 52% of the cattle individuals at the Annapolis Calvert House assemblage (Maryland, USA) were juveniles or subadults, 16% were adults, and the rest were indeterminate. In the Puerto Real assemblage (Haiti), 65% of the cattle individuals were juveniles or subadults and only 14% were adults, with the rest indeterminate. These colonies had little interest in the dairy industry, so there was little incentive to support large numbers of old cows (Reitz and Ruff 1994:708). Although a cow can live up to 17 years, it was more economically viable to slaughter them at a relatively young age. Keeping cattle after they are fully grown is still to this day, a waste of time, energy, and resources (Anderson 2004:88; Goodwin 1977:152; Sportman et al. 2007:132).

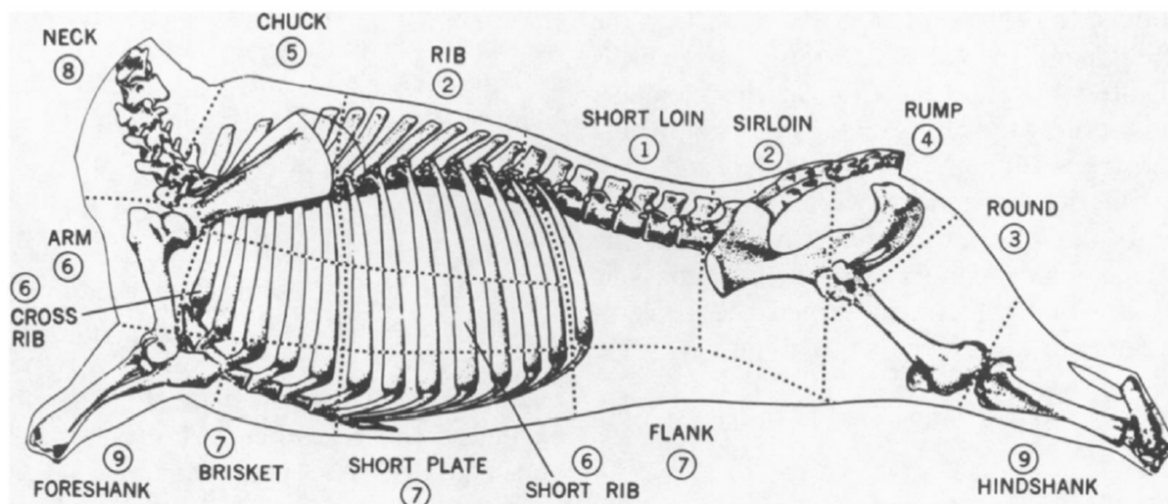
While inferring butchering variables from cattle mortality patterns has some merit, it is important to remember that variation does occur. For example, Johannsen (2011) advises caution in using mortality patterns as sole indicators for cattle exploitation strategies as they may not be correct in all contexts. It is important to consider that historical sources, ethnographic observation, and literature on modern cattle exploitation techniques

demonstrate variations in cattle utilization (Johannsen 2011:19). There is also a wide range of natural and cultural processes which can affect the nature of the preserved animal assemblage available to the zooarchaeologists for study. Another difficulty in constructing a mortality profile is that zooarchaeologists have confused mortality profiles with animal production rather than human consumption patterns (Chang and Koster 1986:107). Nevertheless, mortality profiles are a good starting point when analyzing cattle production even though the assemblage is incomplete, as it can still demonstrate utility by inferring management and production intentions. Zooarchaeologists must be aware of the potential gaps in the faunal record due to exported cattle products, other carcass deposition areas, and butchery variability.

#### 3.2.2.2. Butchery Variability

Selecting a cow for butchery was decidedly a subjective task due to the vagaries of supply and demand for cattle products, as well as individual needs. In a 1970s guide, it was suggested to constantly handle the fattening stock in order to note the changes in body size, shape, and skin (Goodwin 1977:48). Once the animal was slaughtered, it was butchered into different cuts of beef (Figure 6). Additionally, different cuts of meat amounted to different costs. This is exemplified in Schultz and Gust's (1983) study of 19<sup>th</sup>-century beef cuts. Different butchered beef price categories were ranked differently depending on cut. The beef cuts that ranked higher were short loin, rib, sirloin, and round. The medium ranked cuts were rump, chuck, arm and cross/short rib. Lastly, the lower ranked cuts were plate, brisket, neck, foreshank, hindshank, head, and foot. (Newman 2010:44; Schultz and Gust 1983:48; Scott 2001:688). Various elements found in the assemblage could suggest economic status through beef prices. For example, an

excavation of a 19<sup>th</sup>-century plantation inhabited by two different owners at two different moments in time, exhibited different social standing due to the proportions of various quality of meat cuts (Scotts 2001).



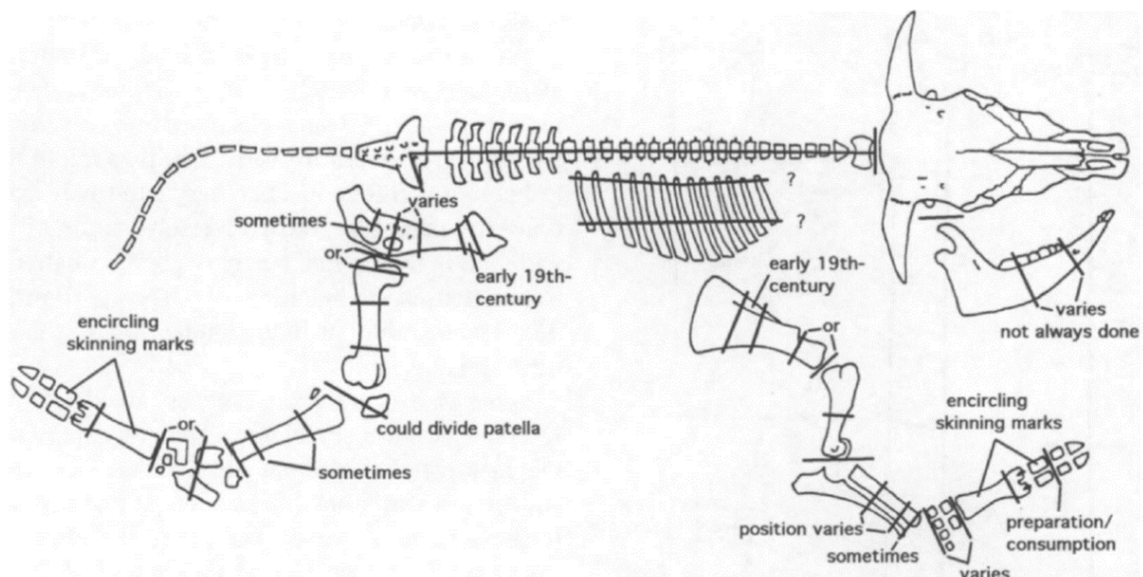
**Figure 6. Late 19<sup>th</sup>-century cuts of beef. (Figure from Schultz and Gust 1983:48.)**

The major divisions of a butchery method can be separated into three steps. The primary butchery step includes initial slaughter, skinning, and evisceration. Next, the secondary step in butchery involves the initial division of the carcass into larger portions, followed by the tertiary butchery step that takes place just before and during consumption (Landon 1996:58). At many urban historic centers, each of the three butchery steps took place in a different location. The primary, and a significant amount of the secondary, butchery steps were performed by a butcher, whereas some of the secondary butchery and all of the tertiary butchery was completed within the household. The inclusion of a distinct specialist butchery locations caused a spatial separation within the butchery process and consequently the faunal assemblage. Like other historic centers, Hacienda El

Progreso could have had multiple production sites for different stages of butchery and cattle commodification.

### 3.2.2.3. Types of Butchery for Consumption

While examining a faunal assemblage, it is important to consider the multiple ways in which an animal can be butchered, especially for food. For example, beef was an important part of the late 19<sup>th</sup>-century California market in terms of demand. At the time, the range of values assigned to beef in California varied from the high prices for steak cuts to the cheaper section of the carcass (Schulz and Gust 1983). Every major part of the cow can be utilized, and the zooarchaeological assemblage could reflect preferences through analyses of surficial cultural modifications and preserved skeletal profiles. Different patterns of dismemberment could appear on a carcass, suggesting different uses and cuts of beef. These different methods of cow butchery cited from multiple archaeological, ethnographical, and historical sources are outlined below. These sources serve as suggestions for examining butchery marks, because with the exception of power tool usage, butchery patterns from the late 19<sup>th</sup> century are comparable to those used today (Schulz and Gust 1983:48). Examples of possible butchery marks are illustrated in Figure 7.



**Figure 7. Carcass division of cattle with examples of typical butchery marks. (Figure from Landon 1996:94.)**

On the head of the cow, most of the butchery marks appear on the posterior portion of the skull, which relate to the disarticulation of the skull from the body. A cluster of marks on the dentary around the second or third molar indicate removal of the animal's hide (Welbourne 1975:13; Landon 1996:67). Recipe collections from the 17<sup>th</sup> and 18<sup>th</sup> centuries mention calves' heads, which were boiled before cutting off the meat. Boiling would soften the meat, resulting in fewer butchery marks (Landon 1996:68). To separate the vertebral column from the ribs, little evidence is found on the thoracic vertebrae as typically, the easier location for separation is through the shaft of the rib (Landon 1996:72-74). Preparation of meat cuts for cured shoulder joints from the scapula involved removal of the spine, trimming around the glenoid cavity, and leaving knife marks, usually on the medial surface of the blade (Dobney et al. 1996:26).

During joint disarticulation, the reduction of the carcass into smaller units is indicative of extensive butchery and demonstrates a commercial scale of butchery (Dobney et al. 1996:25). In general, the carcass joints are disarticulated by means of a chopping blow concentrated at the limb articulation. With humeri, marks on the head and on the greater trochanter result from disarticulation of the humerus from the scapula, while butchery marks related to disarticulation of the humerus from the radio-ulna are located on the distal end of the bone (Landon 1996:76). Hind limbs are disarticulated with chop marks below the femoral head (Welbourne 1975:13). This is due to the size of cattle; dismembering larger animals often requires chopping or sawing through a bone in order to separate the joint. The disarticulation of the distal femur from the proximal tibia is also accomplished by cutting the two bones apart or chopping through the joint and the patella (Landon 1996:86-87). Moreover, long bones, such as the humerus and the femur, are occasionally divided into smaller portions by sawing or chopping through the shaft (Landon 1996:76).

Stripping muscle off the bone occasionally involves shallow marks along the length of the bones, often focusing around the muscle articulations of tough tendons (Welbourne 1975:13). Occasionally, during butchery, the animal is hung, which could potentially produce butchery marks on the calcaneum and on the posterior surface of the distal tibiae (Landon 1996:92). Two methods were used to disarticulate the distal limbs. The first was to chop below the wrist and ankle joints, in this way those bones remain with the shank cuts (Schulz and Gust 1983:48). The second was to chop through the distal tibia, including a small portion of the distal end of the bone with the foot cut (Landon

1996:88). Almost all butchery marking on the carpals and tarsals resulted from the dismemberment of the animal.

#### 3.2.2.3.1. Curing Meat Process

Prior to refrigeration technology, there were only a few ways to keep food from spoiling. Meat could be consumed fresh; otherwise, it had to be preserved, especially when preparing consumable meat products for export. There were a few ways to preserve the meat, including drying, smoking, or curing with salt. The drying or smoking of meat is based on the principle of removing water content from meat. These processes limit the development of micro-organisms, essentially halting the decay of meat. Smoking meat also has the advantage of adding additional disinfectant from the smoke (Wijngaarden-Bakker 1984:195). The equipment necessary for drying or smoking included a source of heat (sun, wind, or fire), and racks to lay or hang the meat. Smoking meat also required an encasement to prevent the smoke from escaping. Typically, the smoking process was only practiced in regions where the climate was too wet, unstable, or windless to permit open air drying, or where there was a sufficient amount of cheap fuel available (Wijngaarden-Bakker 1984:196).

The practice of salting meats was practically the same as the others except that the addition of salt increased the inhibition of micro-organisms (Wijngaarden-Bakker 1984:197). The whole curing process took about two weeks. It began with placing the meat in a solution of salt, water, and the occasional spice, followed by storage in a cool, dry place (Reitz 1986a:52-53) There is some debate as to whether cured beef occasionally contained pieces of bone, although most conclude that it probably did not

usually contain pieces of metapodia or phalanges (Reitz 1986a:52-53). This is seen in an archaeological assemblage from an historic arctic whaling settlement. Here, it was assumed to represent imported cured beef from Norway as this northern location could not support domesticated farm animals. The assemblage contained all parts of the cow except the skull, mandible, metapodia, and phalanges. Additionally, most of the cattle were older than three and a half years at slaughter (Wijngaarden-Bakker 1984).

Therefore, if cured beef was exported from the hacienda, the faunal assemblage would possibly contain cattle specimens older than three years of age, as well as an overrepresentation of skulls, mandibles, metapodia, and phalanges.

#### 3.2.2.4. Butchery for Leather Production

As Old World domesticated animals became a part of the colonized landscape, the use of cattle products began to take hold. For example, in Peru, llamas initially supplied jerky, tallow for candles, and hides for bags, shoes, clothes, and bindings. Later, cattle ranches started to supply similar products from cows (deFrance 2003:107), of which leather was one. Due to the nature of the hide trade, few obvious ways of identifying its existence are preserved in the archaeological record, yet some physical traces can be found. Although it is possible to skin an animal while leaving no trace on the bones, the absence of evidence for skinning does not indicate an absence of the activity.

(Serjeantson 1989:131). A 1961 guide to slaughtering a cow for beef provides instructions for skinning the animal directly after initial slaughter (Andrew and Juergenson 1961:223). Preserved osteological evidence for skinning cattle in the archaeological record can be often confounded by tanning waste, which can also be associated with primary butchery (Murphy et al. 2000:37). These assemblages typically

consist of cattle skulls and feet, with most metapodia remaining intact. Skinning cut marks often appear as encircling cut marks on the metapodial and first phalanx. (Landon 1996:92). They can also be located on the anterior portion of the jaws (Landon 1996:95).

The presence of an overabundance of distal limb bones can be indicative of tanning activities (Serjeantson 1989:141). However, other evidence can be used to differentiate skinning as a butchery step versus skinning with the goal of obtaining hides. These differences can be seen from location of the encircling butchery marks. Marks clustered around the proximal end of metapodia suggest a lack of interest in protecting the hide (Landon 1996:80). If leather was an important part of production, cattle would be skinned with more precision, with encircling cuts marks appearing mainly on phalanges instead of the middle to upper shaft of the metapodia (Landon 1996:81). Historical archaeological records from the southern Atlantic coastal plains indicate that the majority of slaughtered cattle in tanning assemblages consisted of subadults, suggesting a slight preference for younger cows and a desire for younger unblemished hides. However, it was evident that the condition of the hide was not the only consideration as there were also adult specimens present in the assemblage (Reitz 1986b:320).

#### 3.2.2.5. Butchery for Fat Production

Animal fat is important for multiple reasons, such as culinary necessities, consumption, soap, and lubricant for machinery (deFrance 2003:107; Olukoju 2009:106). In order to extract marrow, long bones were commonly chopped towards their distal ends (Welbourne 1975:13). They could also be chopped longitudinally and split (Dobney et al. 1996:25). Additionally, some remaining bones, typically from the shoulder and neck,

were smashed into smaller manageable pieces and placed in large boiling cauldrons in order to produce other by-products, such as soup (Dobney et al 1996:26; Schulz and Gust 1983:49). Bone fats were skimmed once the boiling mixture had cooled.

### **3.2.3. Discarded Elements**

The multiple uses of cow by-products at Hacienda El Progreso could have resulted in the deposition of preserved bone in various locations. For example, excavations in the city of Lincoln (UK) suggested that primary carcass components would appear near butchery after initial slaughter. From there, pieces of meat, skin, and bone moved throughout the city, to the cured meat preparer, the horn worker, the tanner, the oil lamp producer, and even the cosmetic manufacturer, resulting in bone deposition in different parts of the city (Dobney et al. 1996:28). On a smaller scale, the hacienda would have performed certain types of cattle commodification in separate locations, resulting in cattle by-products being discarded in different middens.

The differential preservation of bone, particularly density mediated attrition favouring the survival and recovery of denser bones, must be taken into account (Sportman et al. 2007:130; Welbourne 1975:14). Burning will often make the bone brittle as the organic constituents are reduced to the point where the element could fragment and eventually disintegrate (Lyman 1994:389). However, burning depends on a wide variety of factors, such as the size and density of the elements, the intensity and condition of the fire, the length of time that the bone is exposed to heat, and the location of the bone in relation to the fire (Reitz and Wing 2008:132).

The location of the burned portion of the bone and the severity of burning colouration could indicate the nature of the activity, human or otherwise. For instance, burned bones are generally not the result of cooking food in pots, but direct burning exposed to flame, such as in open-fire roasting (Crader 1990:710). Blackened or calcined bones often are indicators of other activities, such as burning trash or sweeping discarded bones into a fire. Smaller burned and fragmented specimens are often good indicators of housekeeping activities (Sportman et al. 2007:130).

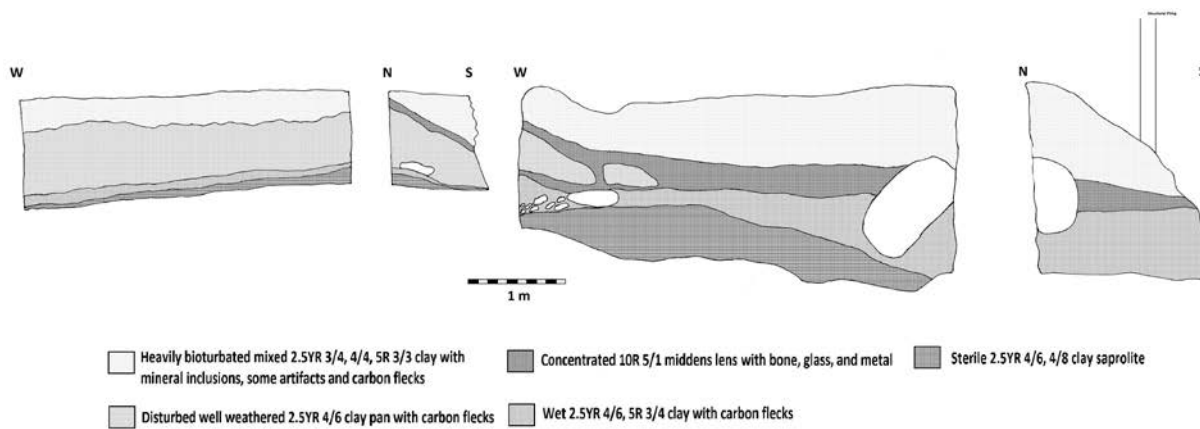
## **4. Zooarchaeology of the Hacienda El Progreso**

This chapter focuses on a descriptive analysis of bone specimens collected from excavations undertaken at El Progreso during the summers of 2014 and 2015. This chapter details excavation and laboratory methods, as well as discusses the studied sample of zooarchaeological specimens. Next, the zooarchaeological assemblage is described and quantified by weight, the number of identifiable specimens (NISP) and the minimum number of individuals (MNI). Taphonomic consideration is given to bone density, preserved skeletal profiles, butchery, breakage, and burning. Additionally, sex, withers height, and live weight of Hacienda El Progreso cattle are examined. These data are used in a reconstructed operational sequence for cattle management and production on the island. The reconstruction of the operational sequence will be explained in the following chapter of the thesis.

### **4.1. Excavation**

Excavations were undertaken in 2014 and 2015 around the present town of El Progreso under permit from the National Institute of Cultural Heritage of Ecuador in Puertoviejo. Prior to excavation, a midden belonging to the 19<sup>th</sup>-century Hacienda El Progreso, later named the Carpintero midden, was discovered by a local carpenter on his property while he was attempting to build a small restaurant for his wife. The Carpintero midden is located in proximity to the kitchen and lies downhill from the historic Cobos house. The midden was excavated in arbitrary 10 cm intervals following exposed stratigraphy, with excavated material later sorted, washed, and bagged by provenience. The Carpintero

profile revealed a concentrated midden lens with bone, glass, and metal artifacts (Figure 8).



**Figure 8. Carpintero Midden Profile**

Most of the Carpintero midden was excavated during the 2014 field season. In the 2015 field season, the profile of the midden was extended to the west and attempts were undertaken to discover its limits. Due to the slope of the land, buildings on the carpenter's property, and disturbance of the modern village site, the boundaries of the midden were not found (Figure 9). Excavations in 2015 also included multiple one-by-one meter units and a few larger units closer to the house. Most of these units were disturbed, thus the Carpintero midden was the only excavation unit with stratigraphic integrity.



**Figure 9. Excavation of the Carpintero midden in 2014. (Photograph from Peter Stahl 2014.)**

#### **4.2. Laboratory Research Methods**

Laboratory research was conducted during the 2015 field season in the Galápagos Science Center laboratory in Puerto Baquerizo Moreno. All of the zooarchaeological specimens uncovered from the excavation units were analyzed, totaling more than 25,000 specimens. Excavated materials were not allowed to leave the park according to Federal law and national park restrictions. The research center had no comprehensive comparative collection. With the assistance of Dr. Peter Stahl, vertebrate and invertebrate specimens were identified to the lowest taxonomic level possible using osteology reference books and articles (Gilbert 1980; Hickman Jr. and Finet 1999; Hickman Jr. 2008; Hickman Jr. and Zimmerman 2000; Hillson 2005; Jiménez-Uzcátegui and Snell

2016; McGrouther 2016; Wyneken and Witherington 2001). Additionally, a *Bos* skull and mandible were available for comparison.

Primary data were entered and sorted in a relational database using Paradox. While cattle were the focus of this thesis, the entire database will be accessible in 2018 on a dedicated website and a book in preparation (Peter Stahl, personnel communications 2018). Each specimen was identified along with corresponding provenience to the lowest taxonomic level possible. The non-identifiable fragments were also weighed and tallied. Where applicable, specimens were assigned arbitrary size designations, such as small, medium, or large. Element, portion, and side of the identifiable specimen were noted, when applicable. Published bison bone mineral density measurements (Kreutzer 1992) were utilized to record bone density scan sites for *Bos* and large Artiodactyla specimens. Where possible, bone fusion or the stages of tooth eruption were recorded following the methods outlined by Grant (1982). Also recorded were bone modification including descriptions and location of butchery scars, breakage categories, weathering, root staining, and colouration from heat exposure.

### **4.3. Zooarchaeological Analysis**

This section describes the sampled component, the entire assemblage, and descriptive statistics. Other analyses include bone density, skeletal profiles, butchery, breakage, burning, ageing, sexing, as well as withers height and live weight estimations. Their significance and relation to the chaîne opératoire is discussed in Chapter 5.

#### **4.3.1. Midden Sample**

For the thesis, cattle data were drawn exclusively from the Carpintero assemblage as the midden has contextual integrity and provides a restricted lens of deposition at the Hacienda El Progreso. The midden is in close proximity to Manuel J. Cobos' hacienda house, which he predominantly used from the beginning of the hacienda to his death. It is possible that the midden was used for a portion of time before 1878 or after 1904; however, the majority of the assemblage was likely deposited within a 20-30 year timeframe.

For this analysis, specimens of *Bos* have been included with large Artiodactyla specimens in the zooarchaeological assemblage of the Carpintero midden as cattle were the only large Artiodactyla on the island. Large Mammalia specimens were excluded as two other large mammals, horses and donkeys, have also been identified on the Galápagos Islands. From the 23,025 Carpintero specimens recorded, the analyzed sample size included a total of 1,383 cattle specimens.

#### **4.3.2. Description of the Zooarchaeological Assemblage**

Some 44 categories were identified in the Carpintero midden which had accumulated over an estimated quarter century of occupation (Table 1). Identifiability was potentially hindered by fragmentation and the absence of comparative material. Mammals and bony fish specimens dominate by frequency and weight.

Categories	Common Name	NISP	Weight (g)
Indeterminate	Indeterminate	37	26
Anthozoa	Coral	1	3
Eucidaris	Pencil Urchin	13	4
Chiton	Chiton	535	1263
Chiton sulcatus	Sculptured Chiton	53	77
Mollusca	Mollusc	22	20
Bulla	Bubble Snail	2	5
Cantharus sanguinolentus	Sanguine Cantharus	1	2
Cerithium	Pada	4	27
Cerithium gallapaginis	Galápagos Cerith	2	0
Conus	Cone	2	32
Plicopurpura	Purpura	1	58
Plicopurpura patula	Wide-Mouthed Purpura	2	64
Patellogastropoda	Limpet	1	0
Fissurellidae	Key Hole Limpet	6	2
Lottiidae	Limpet	8	1
Bivalvia	Bivalve	2	0
Arcidae	Ark Clam	1	0
Lucinidae	Lucine	1	0
Ctena	Galápagos Lucine	1	1
Ostreidae	Oysters	1	1
Pinctada	Panamanian Pearl Oyster	1	17
Pectinidae	Scallop	1	4
Osteichthyes	Bony Fish	1618	1070
Serranidae	Grouper	1146	2423
Reptilia	Reptile Indeterminate	9	0
Cheloniidae	Marine Turtle	766	5025
Iguanidae	Iguana	18	8
Aves	Bird Indeterminate	35	8
Gallus	Chicken	38	39
Mammalia	Mammal Indeterminate	16839	60963
Carnivora	Carnivore	36	13
Canis	Dog	66	179
Felis	Cat	15	11
Artiodactyla	Two-Toed Ungulate	221	2118
Sus	Pig	26	161
Bovidae	Bovid	1	2
Capra	Goat	221	1485
Bos	Cow	1261	34304
Equus	Horse	2	35

Rodentia	Rodent Indeterminate	3	0
Rattus	Rat	5	0
Leporidae	Rabbit	1	0
Total	Total	23025	109451

**Table 1. Weight and frequency of faunal specimens recovered in the Carpintero assemblage.**

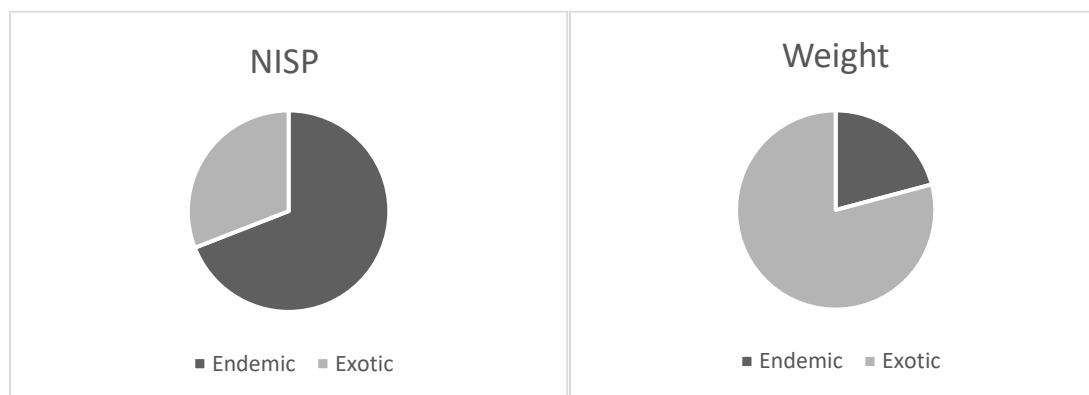
*Bos* specimens are the third most frequent category and the second heaviest (Table 1). However, it is important to note that these figures do not include large Artiodactyla specimens that may have been cattle. Adding large Artiodactyla increases the number of cattle specimens to 1383, weighing 35, 984g. Weight and NISP are largely dependent on species size, bone preservation, and the degree of fragmentation. However, NISP and weight are not a guide to the species' economic importance. Different sized animals provide different amounts of usable products. Additionally, secondary production, such as milk and traction, cannot be simply measured by reporting NISP (Davis 1987:36).

The animal resources identified in the Carpintero assemblage suggest a strong reliance on terrestrial resources based on frequency and weight, yet with low variety (Table 2). This is most likely due to indeterminate mammal specimens which comprise a large portion of the assemblage and *Bos* contributing 31% of the total assemblage weight. Marine resources contribute only 18% of the total frequency and 9% of the total weight, the majority of which were bony fish (Osteichthyes), sea bass and groupers (Serranidae), marine turtle (Cheloniidae), and chiton.

	Categories	Frequency	Weight (g)
Ocean	24	4138	10022
Land	19	18850	99403
Indeterminate	1	37	26
Total	44	23025	109451

**Table 2. Land versus ocean based resources represented in the Carpintero assemblage.**

Figure 10 categorizes specimen NISP according to endemic/exotic fauna, in which 70% of the identifiable taxonomic categories are endemic and 30% are exotic. By weight, 21% of the taxonomic categories were endemic and 79% were exotic. The specimens only identified to the level of class were excluded from these percentages. NISP and weight of endemic and exotic taxa provided different results. This discrepancy was most likely due to size differences between endemic and exotic species. From the NISP, endemic resources were more abundant. However, most of the endemic taxa were fishes while most exotic taxa were cows. More fish would have been required to equally feed the hacienda's population compared to one cow. Based on weight, exotic resources were more abundant, yet cow specimens are heavier than fish bones.



**Figure 10. NISP and weight for endemic versus exotic taxa identified in the Carpintero assemblage.**

### 4.3.3. MNI

MNI is defined as the minimum number of individuals required to account for a specified set of identified specimens found within an assemblage (Lyman 1994:100; Newman 2010:40; Reitz 1992:84). In this case, it is an estimation of the fewest number of cows necessary to account for all of their skeletal elements in the studied collection. Popularized by Theodore White, the MNI is one of the most commonly utilized quantitative units by zooarchaeologists (Lyman 1994:105). Similar to White's method of quantifying MNI, the MNI calculated in this study is based on the separation of left and right components, as well as bone portions. Moreover, the highest calculated MNI from a portion of an element becomes the standard for comparison. In this thesis, the MNI for cattle identified in the assemblage was 22, provided by the right calcaneum (Table 3).

Element	Left	Right
Dentary	21	16
Scapula	6	5
Humerus	4	10
Radius	6	13
Ulna	8	8
Femur	6	7
Patella	4	3
Tibia	12	11
Lateral Malleolus	3	4
Astragalus	17	16
Calcaneum	18	22

**Table 3. MNI of *Bos* and large Artiodactyla specimens per skeletal portion.**

### 4.3.4. Preservation

The differential preservation of skeletal specimens is important for the interpretation of recovered faunal assemblages. For example, it has been suggested that small animals

preserve significantly less well than larger animals (Lyman 1994:397). This can be attributed to lower structural density of *Bos* and caused by greater destruction of bones from carnivores and scavengers, rapid weathering and fragmentation, trampling of small bones, or an increased vulnerability to acidic dissolution during diagenesis as a factor of a higher ratio of surface-to-volume (Retallack 1988:338). Moreover, differential preservation may be due to intra-taxon variation, as in the case of juvenile specimens preserving less well than adult of the same taxon (Behrensmeyer et al. 1979:18).

#### 4.3.4.1. Bone Density

Different bones, and portions thereof, within the skeleton have differing structural properties which can influence their preservation in an archaeological context (Lyman 1994:237; Reitz and Wing 2008:143). Typically, higher-density bones tend to preserve better than lower-density elements (Kreutzer 1992:272). However, other factors can affect bone survivorship. For example, scavenging animals prefer lower density bone portions, smaller skeletal elements, or juvenile remains. Additionally, the presence of certain skeletal elements over others can provide evidence of human modification in the assemblage. Understanding assemblage preservation is important for assessing the validity of this research in terms of whether the Carpintero midden adequately portrays the remnants of human-based cattle management and production.

This section will examine density mediated survivorship of the cattle assemblage employing published scan site locations for modern bison (Kreutzer 1992). A tally of bone density from the cattle skeletal scan sites of each element is presented in Table 4.

Bone survivorship estimation is based on a modified version of Lyman's (1994:256) formula.

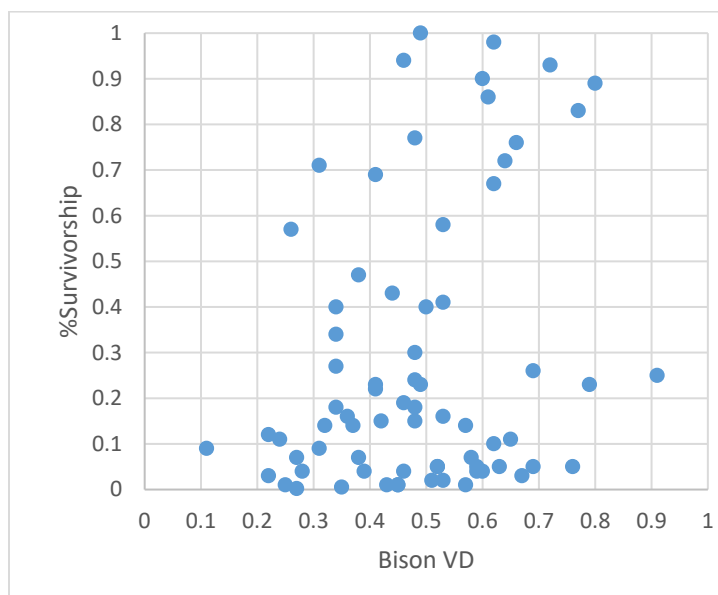
$$\frac{\text{tallied total of scan site}_i \div \text{number of times scan site}_i \text{ occurs in one skeleton}}{\text{maximum scan site in the assemblage} \div \text{amount of times that scan site occurs in one skeleton}}$$

Element	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8
Dentary	16.00	23.75	18.50	11.50	4.50	3.75	6.50	6.25
Vertebra Atlas	0.75	3.50	4.75					
Vertebra Axis	1.50							
Vertebra Cervical	9.50	7.00						
Vertebra Lumbar	7.50	7.25	3.00					
Vertebra Thoracic	27.25	13.00	1.00					
Rib	1.00	1.75	2.00					
Scapula	11.00	4.25	1.00	0.25				
Humerus	3.00	0.25	0.25	8.50	13.00			
Ulna	11.00	7.25			1.00			
Radius + Ulna	1.75	0.75						
Radius	12.50	8.50	0.50	7.25	12.75			
Metacarpus	3.00	3.00	2.75	2.00	2.00	1.00		
Hip	10.25	4.00						
Ilium	0.75							
Sacrum	1.00							
Femur	19.75	7.50	5.00	0.25	4.50	15.75	3.25	
Tibia	6.25	2.00	1.25	12.00	19.25	1.00		
Astragalus	25.75	27.25	25.00					
Calcaneum	26.00	24.75	27.75	21.00				
Naviculo-Cuboid	21.25	20.00	23.00					
Metapodium				1.00	2.50	9.00		
Metatarsus	2.50	2.00	1.50	1.00				
Phalanx	1.00							
Phalanx 1	20.50	20.75	26.25					
Phalanx 2	24.50	25.25						
Phalanx 3	15.75		0.50					

**Table 4. Tallied total of *Bos* and large *Artiodactyla* scan sites (SS) in the Carpintero midden.**

These survivorship values were compared to bison bone density scan sites published by Kreutzer (1992) and presented in a bivariate scatterplot (Figure 11), Spearman's Rho

( $r_s=+0.228$ ) indicates a weak relation between bone density and survivorship. However, the statistical assessment of significance ( $p=0.054$ ) indicates that the positive weak relation between bone density and survivorship is insignificant. The element survivorship was not dependent on bone mineral density, suggesting that other factors influenced the composition of the assemblage, such as the difficulty of identifying certain elements to lower taxonomic levels (e.g. ribs and vertebrae).



**Figure 11. Scatterplot of the %survivorship of *Bos* and large Artiodactyla skeletal scan sites from the Carpintero midden compared with Kreutzer's (1992) bone mineral volume density (VD) values for bison.**

#### 4.3.5. Skeletal Profile

Skeletal profiles provide a view of the relative presence and absence of certain skeletal elements through a comparison with complete survivorship of the minimum number of complete cow skeletons in the assemblage (Lyman 1994:236). The skeletal profile is derived by comparing the MNI of the observed assemblage to an expected frequency with 100% survivorship. The MNI of the assemblage is 22, therefore the expected

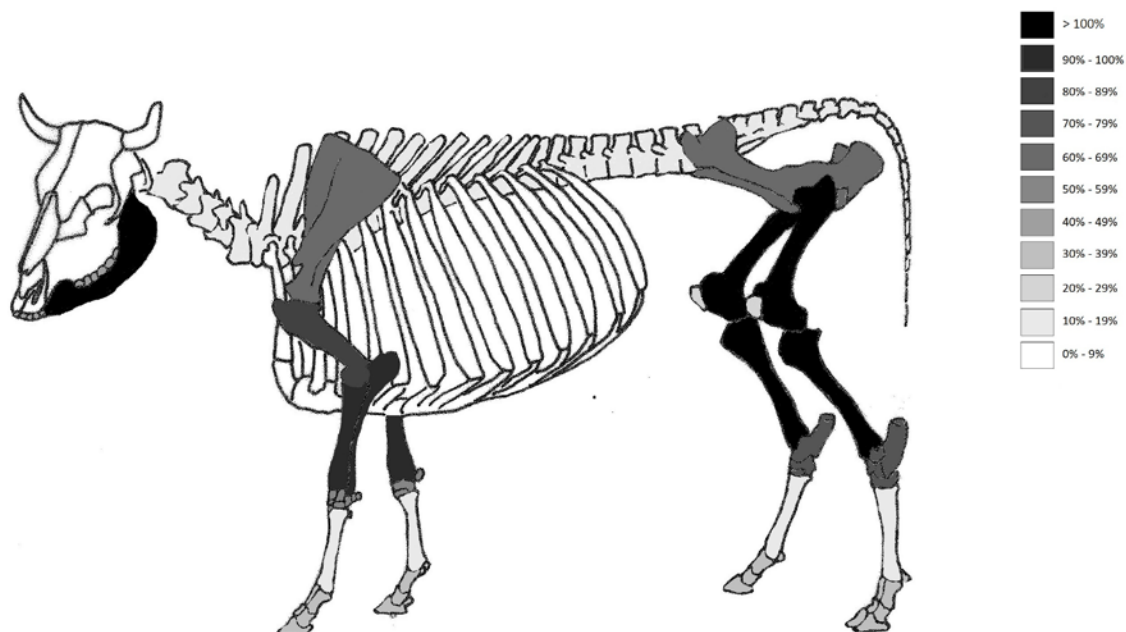
frequency of 100% survivorship would be 22 complete cattle skeletons. The profile value of each element is then based on a number of elements represented by 22 complete cattle skeletons. Table 5 demonstrates the skeletal profile of the elements found in the Carpintero midden.

Element	Hacienda El Progreso assemblage	Typical profile of 22 cattle skeletons	Percentage of observed vs. expected
Cranium	43	638	6.7%
Mandibles	72	44	163.6%
Teeth	290	704	41.2%
Vertebrae	179	990	18.1%
Ribs	2	572	0.3%
Scapulae	28	44	63.6%
Humeri	38	44	86.4%
Radii and Ulnae	84	88	95.5%
Carpals	131	264	49.6%
Pelves	30	44	68.2%
Femora	73	44	165.9%
Patella	11	44	25.0%
Tibiae	51	44	115.9%
Tarsals	163	220	74.1%
Metapodium	26	176	14.8%
Phalanx	83	264	31.8%

**Table 5. Skeletal profile of observed versus expected cattle elements.**

Figure 12 illustrates the percentage values of cattle skeletal elements identified in the faunal assemblage compared to the expected MNI of 22 cattle, as seen in Table 5; the figure indicates a higher representation of long bones and dentaries. As bone density was suggested to not have impacted the survivorship of the assemblage, selective human waste disposal based on carcass processing could potentially factor into survivorship. The illustrated differences between expected and observed values may potentially indicate production choices through the presence and absence of certain skeletal elements. While,

underrepresentation may be the result of fragmentation, it is also possible that certain skeletal elements are absent from the assemblage due to production techniques or trade.



**Figure 12.** *Bos* and large Artiodactyla skeletal profile from the Carpintero midden based on the percentage of elements observed versus expected.

#### 4.3.6. Pathology

While age, live weight, environment, and general health of the animal can influence the skeletal modifications, many lesions would mostly occur mildly and symmetrically (Bartosiewicz et al. 1997:32). As a result, extreme, asymmetrical pathology on cattle specimens provides useful information concerning the mortality profile, specifically if the herd was used for draught purposes. Many pathologies for draught exploitation occur on the metapodia and phalanges, such as exostosis, lipping, and broadening of the trochlea capitis medialis, on the distal portion of metapodia (Bartosiewicz et al. 1997:52; Telldahl

et al. 2011:3). Additionally, there is potential for sex-specific pathology as a study found that females exhibited mainly lesions of unknown etiology and males displayed lesions potentially associated with draught use (Telldahl et al. 2011:5). Within the Carpintero assemblage, there were no pathologies noted.

#### **4.3.7. Taphonomy**

Taphonomy is the study of processes affecting preservation of an organism from the moment of death to the recovery by archaeologists (Lyman 1994:3, 2010; Davis 1987:23; Reitz and Wing 2008:118; Gilbert 1980:7). Taphonomic agents include natural and cultural processes. Various taphonomic factors affecting any assemblage can be arranged in a non-linear taphonomic history. A taphonomic history of the Carpintero assemblage, involving butchery, breakage, and burning is examined below.

##### **4.3.7.1. Butchery**

Butchery can be defined as “the human reduction and modification of an animal carcass into consumable parts” (Lyman 1987:252). This definition considers “consumable” as including all variables associated with utilizing animal carcasses. It is not limited to the consumption of animals as food products, but includes other animal by-products, such as oil or leather. Furthermore, butchery is not a single event; rather, it is a sequence of acts that occur from the moment the animal is killed continuing through various different production stages and ending when the animal is wholly consumed or discarded (Binford 1978:48). The Carpintero midden assemblage was associated with two types of marks, small v- to u-shaped cut marks and larger chop marks. While there were only 47 cattle specimens with evidence for cut or chop marks, it does not detract

from a local cattle production narrative. The butchers at the Hacienda El Progreso undoubtedly had a strong working knowledge of the anatomy of cattle and a desire to preserve the sharpness of the tool's edge (Lyman 1994:297). As a result, the lack of taphonomic signatures does not mean that butchery was absent since skilled butchers would have avoided bones.

#### 4.3.7.1.1. Cut Marks

The anatomical location and orientation of butchery marks indicate the intention of the butcher and different processing operations (Gilbert 1980:3). For the Carpintero midden assemblage, cut marks appeared on 19 *Bos* and large Artiodactyla specimens (Table 6). Cut mark locations situated near joints of the dentary (ramus), scapula (neck), tibia (proximal epiphysis), and ulna (proximal shaft) were most likely due to disarticulation and muscle detachment. On the phalanges, transverse butchery scars were parallel, and found on multiple surfaces surrounding the bone. These cut marks possibly indicate skinning practices. While there was only one mark discovered, the marks on the spinous process of a thoracic vertebra also indicate skinning practices.

Element	Elements with cut marks	Total Elements in Assemblage	Percentage
Dentary	2	72	3%
Hyoid	2	12	17%
Vertebra Caudal	1	30	3%
Vertebra Thoracic	1	58	2%
Vertebra Cervical	1	31	3%
Scapula	1	28	4%
Ulna	1	39	3%
Ilium	2	29	7%
Tibia	1	51	2%
Calcaneum	3	57	5%
Phalanx	4	83	5%

**Table 6. Cut marks on *Bos* and large Artiodactyla elements in the Carpintero assemblage.**

#### 4.3.7.1.2. Chop Marks

The locations of butchery marks can be indicative of specific activities. The zooarchaeological assemblage of the Carpintero midden contains 28 different specimens with chop marks. Chop marks differ from cut marks as they were utilized for different practices, mainly to divide the carcass of an animal into more manageable pieces in the area of the joints. At least six of the specimens were chopped off and certain chop marks were obviously located near joints including a dentary chopped below the condyle, a rib chopped through the head, and a humerus with the distal condyle chopped off. Elements with recorded chop marks were relatively rare in comparison to the amount of cow bones identified in the assemblage as displayed in Table 7.

Element	Elements with chop marks	Total Elements in Assemblage	Percentage
Dentary	3	72	4%
Vertebra	1	25	4%
Vertebra Atlas	1	7	14%
Vertebra Thoracic	3	58	5%

Vertebra Lumbar	2	21	10%
Rib	1	2	50%
Humerus	3	38	8%
Radius	1	43	2%
Ulna	3	39	8%
Metacarpus	1	4	25%
Hip	2	29	7%
Femur	4	73	5%
Tibia	2	51	4%
Astragalus	1	53	2%

**Table 7. Chop marks on *Bos* and large Artiodactyla elements in the Carpintero assemblage.**

#### 4.3.7.2. Breakage

Bone fragmentation is regularly present in archaeological samples due to the many possible ways that bone can be fractured (Lyman 1994:315). Few specimens presented obvious signs of breakage with Table 8 indicating that only 28 specimens exhibited helical breakage patterns. Most helical breakage occurs when fresh bone is fractured. It can be indicative of marrow extraction; however, it could also be produced by other factors, such as different food preparation techniques, creation of animal products, or post depositional destruction (Gilbert 1980:9-11; Reitz and Wing 2008:141).

Element	Number of Specimens	Percentage from the assemblage
Scapula	1	4%
Humerus	3	8%
Radius	7	16%
Metacarpus	2	50%
Hip	1	3%
Femur	8	11%
Tibia	5	10%
Phalanx 1	1	3%

**Table 8. *Bos* and large Artiodactyla helical breakage found in the Carpintero assemblage.**

#### 4.3.7.3. Burning

The Carpintero midden was adjacent to the communal kitchen and Cobos' house, where cooking and waste management activities took place. Cooking is defined as a form of food preparation involving heat through boiling, roasting, baking, or frying. The goal of cooking is to create an edible product, which involves avoidance of burning muscle. Direct burning of bones from contact with high temperature and/or long exposure to heat is likely not evidence of cooking (Lyman 1994:284). Burned bones, especially calcined bones, were probably not caused by cooking, but are products of post culinary discard.

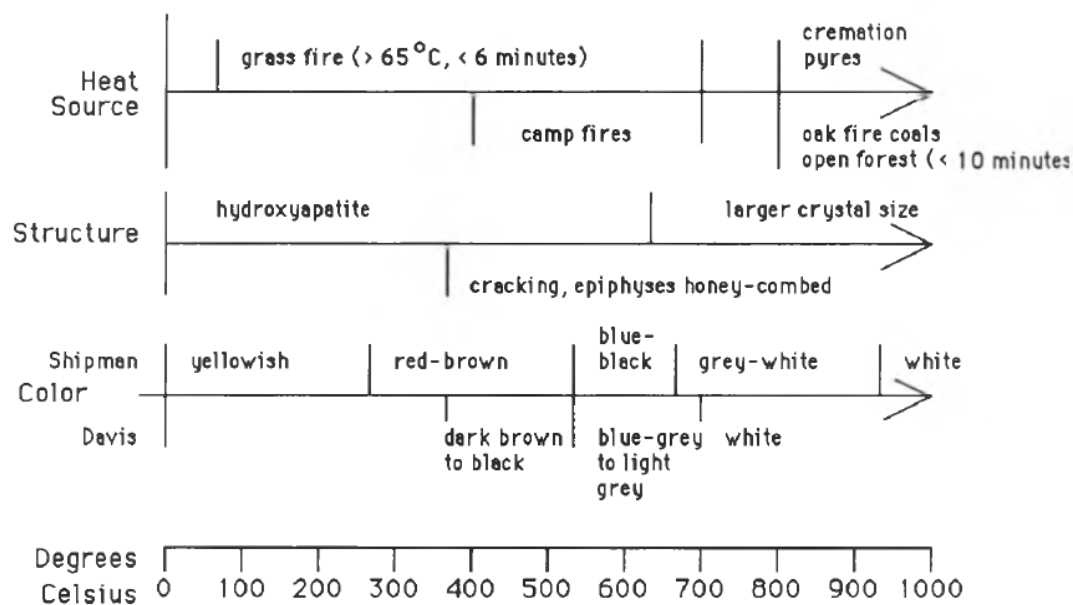
Fourteen taxonomic categories exhibited evidence of burning; 98% of burned specimens were of domesticated and introduced animals. Within all of the *Bos* and large Artiodactyla specimens, only 10% showed signs of burning. Most of the burning on cattle specimens was amongst carpals and tarsals, followed by fore- and hind legs, and metapodia and phalanges (Table 9). Most (92%) of the elements displaying evidence of burning are limb bones.

<b>Element</b>	<b>NISP of burned elements</b>
Dentary	2
Premolar Upper	1
Molar Upper	3
Premolar Lower	2
Molar Lower	2
Vertebra Cervical	1
Scapula	2
Humerus	4
Radius	7
Ulna	4
Carpal Accessory	1
Carpal Cuneiform	6
Carpal Intermediate	10

Carpal Magnum	3
Carpal Ulnar	3
Scaphoid	10
Pisiform	2
Femur	7
Patella	1
Tibia	7
Calcaneum	13
Astragalus	25
Naviculo-Cuboid	6
Tarsal 1+2	1
Tarsal 2+3	3
Metapodium	6
Phalanx 1	5
Phalanx 2	4
Phalanx 3	1

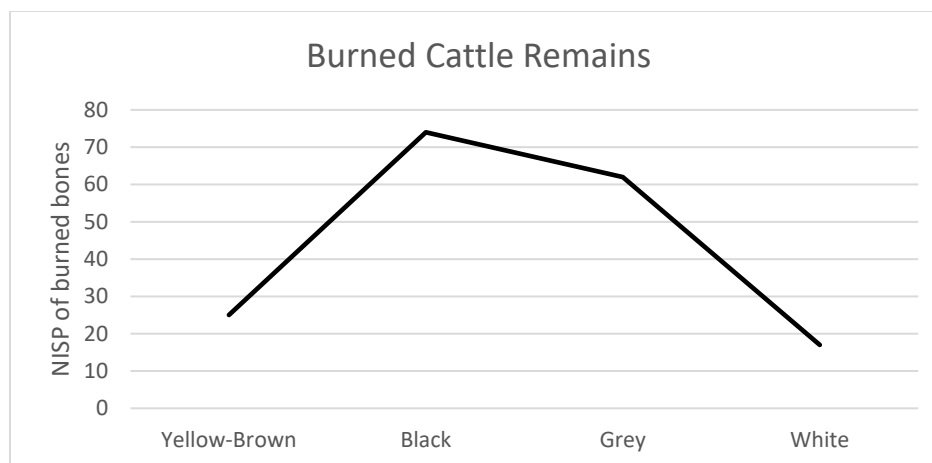
**Table 9. Burned *Bos* and large *Artiodactyla* specimens found in the Carpintero assemblage.**

Many studies have investigated burning colouration as an indicator of temperatures to which bones were heated (e.g. Buisktra and Swegle 1989; Johnson 1989); however, colour is not a precise temperature measure (Marshall 1989:18). The colour of burning can provide a general temperature range that could potentially indicate the type of burning (Shipman et al. 1984:313-314). Here, the results published by Shipman et al. (1984) from bones heated in a muffle furnace/kiln were consulted. As seen in Figure 13, bones with yellowish colouration were lightly heated at less than 400°C. At over 600°C, bones tended to appear purplish-blue to blue in colour. Once it turned greyish-white to white, the bone had been completely calcined.



**Figure 13. Changes to bone after being subjected to heat. (Figure from Lyman 1994:386.)**

Burned bones from the Carpintero midden were assigned a colour code based on the 10YR and 5YR pages of the Munsell Color Charts (1990). These colour codes were grouped into four categories, yellow-brown, black, grey, and white (Figure 14). The majority of burned bones were black or grey in color indicating high heat in either an oven or outdoor fire. There was only a limited amount of calcined (white) bones, indicating that the most of the cattle specimens were not subjected to direct intense heat. This potentially implies that fire disposal techniques were not heavily employed at the hacienda. As well, this suggests that element frequency would not have been heavily affected by the fragility of brittle burned bones (Lyman 1994:389).



**Figure 14. Colour changes caused by heat found on *Bos* and large *Artiodactyla* specimens in the Carpintero assemblage.**

#### 4.3.8. Ageing

Accurate ageing information within a faunal assemblage can provide a fundamental understanding about historical cattle management and production techniques due to multiple factors surrounding the optimal age of death based on production decisions for cattle management. Different mortality profiles are associated with different industries, such as beef or milking. The methods used to infer age within the Carpintero midden assemblage are derived from patterns found in epiphyseal fusion, tooth eruption, and tooth wear.

One of the best known published work regarding ageing in cattle is Silver's (1969) "Ageing of Domestic Animals", which has been consulted by many researchers (e.g., Chaplin 1971; Grigson 1982; Landon 1996). Interpretation of ageing data intrinsically contains assumptions about the faunal assemblage as it is assumed that the assemblage accurately represents what was originally deposited (Maltby 1982:81). The context of the Carpintero midden, as a garbage deposit directly near the hacienda kitchen and the Cobos house, might suggest that it contains specific refuse. Other cattle by-product waste,

whether on another island or located in different areas on San Cristóbal Island, would not be represented in the mortality profile. Preservation, recovery of the bones, and variation in the disposal of remains also affects sample interpretation (Maltby 1982).

#### 4.3.8.1. Bone Fusion

Ages for epiphyseal fusion used in this analysis (Table 10), are based on Silver (1969). Faunal specimens from the Carpintero assemblage display an inclination toward older cattle. There is no evidence of young cattle with early fusion states (7-18 months). Unfused elements in the assemblage correspond with ages between two to four years, as most unfused bones indicate fusion stages representing 24-48 months at age of death.

Age of Fusion	Skeletal Element	Number of Unfused Specimens	Number of Fused Specimens
7-10 months	Scapula	0	28
	Acetabulum	0	14
12-18 months	Distal humerus	0	31
	Proximal radius	0	20
18 months	Distal first phalanx	0	28
	Distal second phalanx	0	25
24-30 months	Distal metacarpus	1	1
	Distal tibia	7	23
24-36 months	Distal metapodium	9	10
27-36 months	Distal metatarsus	0	0
36-42 months	Calcaneum	17	40
42 months	Proximal femur	16	18
42-48 months	Proximal humerus	4	3
	Distal radius	10	13
	Ulna	7	32
	Distal femur	6	32
	Proximal tibia	8	12

**Table 10. Fusion chart of *Bos* and large Artiodactyla elements found in the Carpintero assemblage. (Based on Silver 1969.)**

#### 4.3.8.2. Tooth Eruption and Wear

Another technique used to identify slaughtering ages within the faunal assemblage is through tooth eruption and wear. Teeth are amongst the most durable elements of the skeleton and are often viewed as a more accurate indicator of slaughtering patterns than fusion data (Landon 1996:98). Even though tooth eruption can provide specific ages of the specimen at death, the age at which a tooth erupts can be affected by multiple factors, such as breed differences, the diet of the population, and environmental conditions (Chaplin 1971:78). One example of how these factors can influence the development of teeth is demonstrated through Silver's (1969) comparison of modern and French 19<sup>th</sup>-century cattle dental eruption schedules (Table 11). Additionally, while tooth wear has often been used as a basis to determine the age at death of many species, it also is susceptible to environmental conditions that could potentially skew results. For instances, the dental attrition rate of cattle grazing on gritty soils is greater due to the consumption of abrasive particles (Chaplin 1971:86).

Tooth	Deciduous Teeth	Permanent Teeth	
		Modern	France 19 <sup>th</sup> century
Incisor 1	Present at birth	14-25 mo.	18 mo.
Incisor 2	Present at birth	17-36 mo.	30 mo.
Incisor 3	Present at birth or in the first 2 weeks	22-40 mo.	42 mo.
Canine	Present at birth or in the first 2 weeks	32-48 mo.	54 mo.
Premolar 1	Occasional	Occasional or lost before 3 years	
Premolar 2	Birth to 3 weeks	24-30 mo.	18 mo.
Premolar 3	Birth to 3 weeks	18-30 mo.	30 mo.
Premolar 4	Birth to 3 weeks	28-36 mo.	42 mo.
Molar 1	Absent	5-6 mo.	6-9 mo.
Molar 2	Absent	15-18 mo.	30 mo.
Molar 3	Absent	24-30 mo.	48-60 mo.

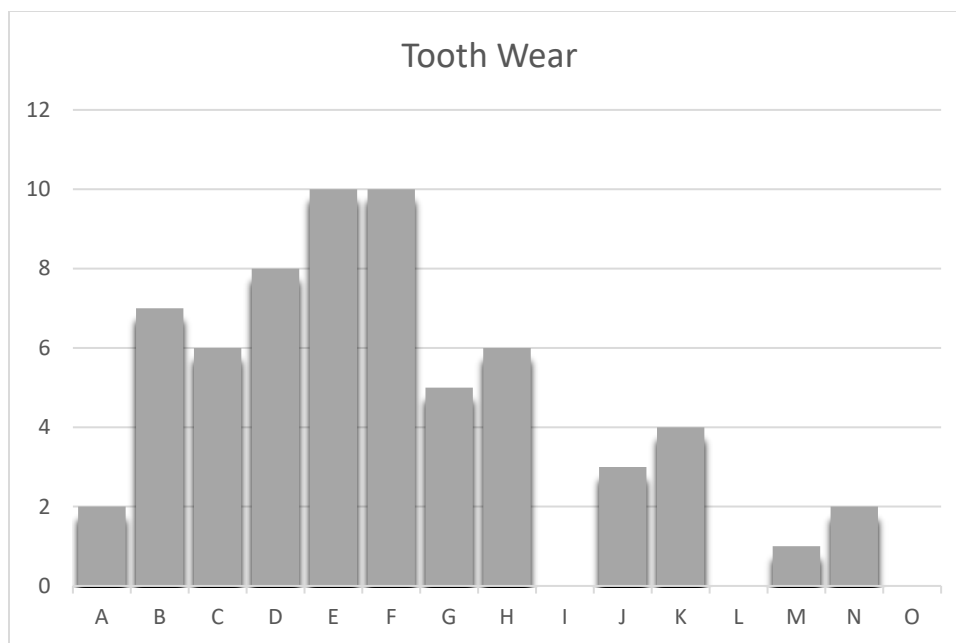
**Table 11. Tooth eruption ages for cattle. (Based on Silver 1969:296.)**

Tooth eruption and wear can provide corroborating data for age at death estimates based on fusion. Multiple sets of eruption data for cattle (Grigson 1982; Silver 1969; Hillson 2005) that slightly differ from one another were referred to; however, Silver's (1969) data were used for determining age based on tooth eruption in order to be consistent with fusion data. Age ranges established for the eight dentaries are found in Table 12. All eight erupting dentaries indicate that the butchered cattle were under three years old.

<b>Description of the erupting dentaries from the Carpintero assemblage</b>	<b>Age Range</b>
Molar 3 was erupting	24-30 months
Molar 3 was erupting	24-30 months
Premolar 2 was erupting	24-30 months
Premolar 1 was erupting	Before 36 months
Premolar 1 was erupting	Before 36 months
Premolar 2 was deciduous while permanent premolar 2 was underneath	3weeks – 24 months
Molar 1 and 2 were erupting with dm erupted	5 -18 months
Premolar 3 was erupting	18-30 months

**Table 12. Tooth eruption ages in *Bos* and large Artiodactyla specimens in the Carpintero assemblage. (Based on Silver 1969.)**

The data collected for tooth wear analysis were based on Grant's (1982) tooth wear chart, which provides a relative measurement for cattle age. For instance, teeth with wear stage A would be possibly younger than tooth wear stage O (see Grant 1982:92). From Figure 15, the tooth wear of the cattle in the Carpintero midden indicates multiple stages of wear. While the majority of the wear is relatively minimal, there are a few with heavy wear. Tooth wear is largely dependent on the environmental and health conditions of the cattle. The cattle of Galápagos grazed freely on the island and likely consumed more abrasive vegetation, causing abnormally advanced tooth wear.



**Figure 15.** Tooth wear on *Bos* and large *Artiodactyla* specimens found in the Carpintero assemblage. (Based on Grant 1982.)

#### 4.3.9. Sexing

Sex identification provides vital information on animal exploitation techniques as the relative abundance of male and female cattle can indicate specific mortality profiles and their associated production priorities, whether dairy, beef, or draught (Davis et al. 2012:1145; Svensson et al. 2007:942). While the difference between female and male cattle differs depending on the time period, geographical boundary, and cultural practices, certain elements can still be used as sexual identification indicators (Svensson et al. 2007:945). Morphological sexing has been carried out on many different elements as some show signs of sexual dimorphism, while others do not, such as tooth row and tooth size (Grigson 1982:7). Skull, atlas, axis, sacrum, limb bones, mandible, and acetabulae have slight variation yet have been rarely used (Grigson 1982:9-10; McGrory et al. 2012:3324).

The main method used to assess the sex of cattle remains is the distal breadth of metapodia (Albarella 1998; Berteaux and Guintard 1995; Telldahl et al. 2011). Metapodia are often used as they tend to have a higher survivorship in archaeological excavations (Berteaux and Guintard 1995:98; Grigson 1982:10). Additionally, they demonstrate a higher sexual dimorphism, specifically the width of metacarpals as the forelimbs carry the brunt of the animal's live weight (Davis et al. 2012:1446; Higham 1969:64; Svensson et al. 2007:943). The length of the metapodia display little variation, unless there is presence of castration as steers have been shown to typically have longer and slender metapodia compared to bulls (Davis 2008:995; Grigson 1982:10). Osteological sex identification using metacarpals has been supported by ancient DNA analysis (Svensson et al. 2007).

For this assemblage, all measurements were documented with digital calipers to the nearest 0.01 mm. Only one metacarpal was found complete, the distal breadth was 57.93 mm and greatest length was 205 mm. One specimen cannot provide adequate sexing results as osteological sexing is often based on observing trends found within a larger sample size. Comparison of the sole metacarpal to other comparative data, such as Aberdeen Angus (Higham 1969), the German "*Schwarzbuntes*" breed (Grigson 1982), and historic French island landraces (Berteaux and Guintard 1995), indicates that the specimen is potentially female. However, sex identification cannot be confirmed as the breeds and environmental circumstance used for comparison are different than that of the El Progreso cattle. The potential size difference between breeds would cause variation between the size of cows and bulls (Davis et al. 2012:1446).

#### 4.3.10. Withers Height and Live Weight

Calculated withers height (WH) and live weight have been widely used to infer breeds and to discuss fluctuations in livestock size due to environmental or cultural factors (Cossette and Horard-Herbin 2003:265; Telldahl et al. 2011:2). The WH is often calculated using the greatest length of the metacarpus (McGL). As there is only one complete metapodium determined to be female, the calculation for females was  $WH = McGL \times 6.03$ . The formula was utilized in other studies, suggesting that it can be reliable for other breeds (Berteaux and Guintard 1995:107). The WH found in the Carpintero assemblage was 123.6 cm. This indicates that the specimen was smaller bodied when considering the average height of other modern breeds, such as Aberdeen Angus (131 cm), Charolais (137 cm), and Brahman (133 cm) (Arango et al. 2002: 3146; Bene et al. 2007:366). Nevertheless, the specimen was of an average size compared to other historic landraces, such as cattle from other historic assemblages including Amsterdam Island Cattle (122 cm), historic Spanish cattle from Puerto Real (123 cm), and Annapolis area cattle (119 cm) (Berteaux and Guintard 1995:107; Cossette and Horard-Herbin 2003:265). Compared to the average withers height (128 cm) of Ecuadorian Criollo cows (Porter et al. 2016:173), the cattle at Hacienda El Progreso were shorter.

Body weight predictions from skeletal measurements always involve some degree of uncertainty. Within the same species, there is often variation found in size between different breeds of modern domestic animals (Meadow 1999:291). In addition, wild animals tend to be smaller than their domestic counterparts. Due to scaling issues, different elements must be considered separately so as to not obscure the pattern of size variation (Albarella 2002:54). Elements used to estimate live weight include: astragalus,

metapodia, phalanges, calcaneum, and the length of certain long bones (Grau-Sologesta 2014; Matolcsi 1970; Meadow 1999; Noddle 1973). Matolcsi's (1970:136) formula was the method used to estimate the live weight of the Carpintero assemblage:

$$\left( \frac{\text{Weight of Metapodial (g)}}{\text{Quantitative Value}} \times \frac{\text{Mean length of Metapodials}}{\text{Real Length of Metapodial}} \times k \right)^2 \times 1000$$

The formula was calculated using Hungarian Longhorn as a standard. The live weight of the specimen was found to be 203.3 kg. Compared to modern breeds such as Aberdeen Angus (545 kg), Hungarian Longhorn (310 kg) and Brahman (583 kg) (Bene et al. 2007:366), the hacienda specimen is significantly smaller. Additionally, it is considered smaller bodied compared to modern Colombian Criollo (200-225 kg) and Ecuadorian Criollo of Manabí province (246-550 kg) (Cevallos-Falquez et al. 2016; Porter et al. 2016:172; Rouse 1970:405, 1977:253).

However, sexual dimorphism may have been a factor as the metacarpal used to determine withers height and live weight was likely female. Most breed averages for height and weight were calculated with measurements from both sexes. Estimating the size of the herd based on one specimen could shift the results if the specimen was an anomaly. Nevertheless, these findings suggest that Hacienda El Progreso's cattle were generally smaller.

## 5. Interpretation and Discussion

This chapter focuses on the interpretation of cattle production and management using comparative literature and zooarchaeological data. This chapter also briefly contributes to the literature about the effect that cattle had on Hacienda El Progreso and the Galápagos Islands, as well as the utility of the chaîne opératoire framework in a zooarchaeological context.

### 5.1. Hacienda El Progreso's Operational Sequence

Cattle were integral to daily life at Hacienda El Progreso and likely used in multiple ways, for different purposes and in unique sequential steps. This section explores a potential operational sequence of cattle management and production at Hacienda El Progreso by comparing comparative literature with zooarchaeological data from the Carpintero midden. Comparative literature obtained from historical and archaeological sources, condensed into Table 13, will be used to construct inferences or potential steps in a plausible operational sequence of cattle production. Empirical evidence from the zooarchaeological analysis will also provide a basis for understanding how the historic commodification of cattle can be visualized through the zooarchaeological record.

Chaîne Opératoire		Expected in the assemblage
Cattle Management	Raising Cattle	-The hacienda most likely allowed the cattle to graze freely as there was open land and feeding cattle was likely a strain on resources. As a result, cattle may be smaller in stature. -Breed of cattle at the hacienda is expected to be Criollo since it was the only variety of cattle in Latin America until the late 19 <sup>th</sup> -century.
Butchery	Primary	- Primary butchery involved initial slaughter, skinning, and evisceration.

		<p>-Evidence for skinning includes clusters of marks on the dentary around the second or third molars and encircling marks on metapodia.</p> <p>-If the animal was hung, there is potential for butchery marks on the calcaneum and on the posterior surface of distal tibia.</p>
	Secondary	<p>-Secondary butchery occurs when the carcass is divided into larger portions.</p> <p>-Carcass disarticulation is evident through butchery marks on bones near joints.</p>
	Tertiary	<p>-Tertiary butchery takes place during the preparation and consumption of food.</p> <p>-This step is represented in the archaeological record through shallow butchery marks, often around muscle articulations of tough tendons.</p> <p>-If the food was boiled, there would potentially be fewer butchery marks</p>
Cattle Commodification	Dairying Production	-This type of production is present in the archaeological record through a mortality profile mostly composed of calves between five to nine months and older cattle
	Draught Production	-The mortality profile of an assemblage mostly involved in draught practices would see a majority of older cattle with pathology on metapodia and phalanges.
	Beef Production	<p>-The mortality profile of beef production tends to be mostly juvenile or subadult specimens; however, certain assemblages were comprised of cattle older than three and a half years of age.</p> <p>-In an archaeological assemblage primarily composed of cured meat, there would be an absence of skull, mandible, metapodia or phalanges.</p>
	Fat Production	<p>-For fat production, long bones are often chopped towards distal ends or chopped longitudinally and split.</p> <p>-The assemblage can occasionally be highly fragmented due to fat extraction processes.</p>
	Leather Production	<p>-Butchery indicators are similar between leather production and general skinning from primary butchery.</p> <p>-The skeletal profile of leather production is often comprised of an overrepresentation of skull and distal limb bones.</p> <p>-Encircling cut marks on phalanges or distal metapodia indicates a desire to preserve the skin.</p>
Discard	Depositing the remains	-Blackened or calcined bones indicate waste management.

		-The discarded elements that forms the archaeological assemblage can be indicative of which production activities were performed at the hacienda based on the skeletal and mortality profile
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**Table 13. Summary of the expected chaîne opératoire.**

### **5.1.1. Cattle Management**

Criollo varieties dominated Latin America from the 16<sup>th</sup> to the 20<sup>th</sup> century. In fact, they were the only cattle available in Ecuador until the early 1900s and were the preferred cattle variety in the 1960s (Rouse 1977:108; World Bank 1967:2). Cattle at Hacienda El Progreso were likely also Criollo. In total, only one metacarpal was available to estimate sex (female), wither height (123.6 cm), and live weight (203.3 kg). While this cow could have been larger or smaller within the hacienda herd's average size, the cattle belonging to Hacienda El Progreso were likely smaller bodied compared to modern Ecuadorian Criollo cattle. In order to import livestock to the Galápagos Islands, it would have been easier to bring smaller cattle aboard a ship.

Colonized locations are often influenced by a blend of cultures. Cobos was born in Cuenca in 1836 (Latorre 2005:64). Much like American farmers and Spanish colonists, cattle belonging to the Hacienda El Progreso roamed free in large pastures on San Cristóbal Island. Historical accounts mention that Cobos cleared the land for grazing and created multiple fenced pastures (Bilbao 1904:10; Latorre 2011:21). Considering that the hacienda was on an island, there would have been a limited amount of deforested area and a lack of government control; cattle roamed unfettered to graze on pastures that were likely rotated in order to properly make use of the land.

An important part of managing herd size was castration and slaughtering of extra calves (Anderson 2004:87); however, there has been some question on whether English or Spanish colonists castrated bulls as Mexican range cattle were rarely castrated (Brand 1961:138; Reitz and Ruff 1994:709). It is difficult to determine whether Hacienda El Progreso strictly managed cattle throughout the island. Early castration is typically examined through metacarpal length in relation to distal breadth (Albarella 1998:38; Davis 2008:995). There was no evidence of castration in the hacienda's assemblage as there was only one metacarpal, presumed to be female. A method of cattle management that did not often occur on the hacienda was the slaughter of unwanted calves. The evidence from epiphyseal fusion and tooth eruption indicates that few calves were slaughtered under one year of age.

As more advanced farming technologies emerged at the end of the 19<sup>th</sup> century, there was less of a need for draught animals. The sugar cane was brought to the mill by the Decauville railway system, then the sugar was brought to the coast on carts hauled by oxen (Martínez 1919:39). Within the Carpintero midden, there were no signs of the common skeletal deformity found on draught cattle, such as work-related strain and degenerative abnormalities on metapodia and phalanges (Bartosiewicz et al. 1997:52; deFrance 2009:15; Telldahl et al. 2011:3). However, diseased or injured draught cattle may have been butchered and deposited in other locations. Additionally, other animals may also have been used for draught purposes. Donkeys and horses were likely also used as transportation animals, as seen with Figure 3. Moreover, Nicolas Martínez (1919:33) describes travelling by horse in order to reach the hacienda.

### 5.1.2. Mortality Profile

Mortality profiles reconstruct past animal exploitation techniques. Depending on slaughtering age patterns found in the zooarchaeological record, mortality profiles describe different types of production (Reitz and Ruff 1994:708; Vigne and Helmer 2006:16). The slaughtering age of cattle is determined by production need, market value, and size of the hacienda herd. Historically, cattle around three years of age were preferred for beef production (Goodwin 1977:152). The historical beef production mortality profile would favor juveniles and subadult animals in order to have the most meat for the least amount of environmental and economic cost (Zierden and Reitz 2009:349). A mortality profile based on draught exploitation would contain a high number of older specimens (Johannsen 2011:19). A farm focused on dairying would include a mortality profile with a mix of younger cattle, around five to nine months, with older cattle (Vigne and Helmer 2006:28; Reitz and Ruff 1994:708).

Epiphyseal fusion, tooth eruption, and tooth wear were used in order to analyze the age of the hacienda's cattle. Epiphyseal fusion indicates that there were no slaughtered cattle under the age of two years. However, there was a significant increase of unfused elements ranging in ages between two and four years old. Only eight out of 64 dentary specimens exhibited erupting teeth, and there were only two that were clearly under two years old. Additionally, the majority of teeth in the assemblage had wear, indicating adult cattle were principally butchered.

The mortality profile of Hacienda El Progreso indicates patterns partly consistent with draught and dairying production as the majority of cattle specimens were from

individuals over five years old. However, there were no calves under a year old, a requirement in the dairying mortality profile, and no pathology patterns common with draught cattle assemblages. Using historical records, it is known that the hacienda exported salted meats and leather. Yet, the mortality profile of the Carpintero assemblage contains a mix of cattle ages not in line with typical slaughtering ages of beefing cattle, except for the historic Norwegian assemblage comprised of cured beef (Wijngaarden-Bakker 1984). As Cattle were free to graze in large pastures, it is possible that Cobos did not face the same economic constraints due to the large supply of cattle on the island. Considering the Norwegian assemblage, perhaps cattle age was also not an important consideration for the export of cured beef.

### **5.1.3. Butchery at the Hacienda**

Butchery of cattle comprises sequential steps, including the initial slaughter, skinning, and the division of meat portions. The division of meat portions often took place in multiple locations, including the farm, the butchery, the household kitchen, and the dining room table. However, in rural environments, these steps were condensed into fewer locations. The skeletal elements represented in the Carpintero assemblage can indicate the type of butchery that took place. The Carpintero assemblage was located in proximity to the communal kitchen and Cobos' house; the midden was likely used for kitchen waste management.

In regards to dismembering the carcass, different taphonomic indicators are representative of individual butchering events. From the available data, there was little indication of cut and chop marks. The majority of the cut and chop marks suggest

disarticulation. Two of the dentaries exhibited cut marks clustered around the ramus. These markings potentially signify an attempt to cut free the animal's hide or disarticulate the jaw in order to remove the tongue (Landon 1996:67; Welbourne 1975:12). A cut mark found on the dorsal side of a cervical vertebra may indicate skinning (Landon 1996:94); however, the evidence is not conclusive. A chop mark found on an atlas is indicative of practices surrounding the disarticulation of the head from the body. There was also a rib found in the Carpintero assemblage with its head chopped off; often butchers would cut through the rib head in order to separate the ribs from the vertebrae.

Only one scapula was found with cut marks. The marks were not consistent with the curing of shoulder joints; they were found on the neck of the scapula indicating muscle detachment, perhaps for shoulder disarticulation. There were only a few indicators of joint disarticulation in the assemblage. Multiple cut marks near the joints on the tibia and ulna were probably due to muscle detachment. Chop marks on the humerus, femur, ulna and tibia may have resulted from separating the carcass into different cuts of meat. The removal of meat off the bones often leaves multiple shallow cut or chop marks on the bone, often around muscle articulations with strong tendons (Welbourne 1975:13).

Another activity that could leave a surficial mark occurs when hanging the carcass. Typically, such actions would leave marks on the calcaneum and on the posterior distal tibia (Landon 1996:92). While three calcanea displayed cut marks in the Carpintero assemblage, they could be the result of separating the feet from the body. There are a few methods of disarticulating the feet, either chopping below the wrist and ankle joints or chopping through the distal tibia (Landon 1996:88; Schulz and Gust 1983:48). There

were also two distal tibias with chop marks. However, there is insufficient evidence to support either claim.

#### **5.1.4. Cattle Commodification**

After cattle were slaughtered, they were skinned and disarticulated into smaller portions of meat. Skins were then transformed into leather. The portions of meat were then distributed for household consumption or to sell off island. While some fresh meat could have been locally consumed, most of the beef was likely preserved through curing methods as refrigeration did not yet exist (Reitz 1986a:52). Salting meat was likely the preferred method of preservation as salt was easily accessible on Isabela and Santiago Islands (Martinez 1919:79). The sequential steps of turning cattle into a commodity often can be seen through butchery marks and burning. However, the absence of elements seen in the preserved skeletal profile can also be indicative of production techniques (Reitz and Wing 2008:131).

##### **5.1.4.1. Leathering**

Historical records indicate that leather was an important export product for the Hacienda El Progreso (Mann 1909:23). However, analyzing the zooarchaeological evidence is difficult as there is only a subtle difference between skinning as a necessary butchery practice and skinning to produce leather (Murphy et al. 2000:37). There are a few zooarchaeological indicators to determine leather production: 1) the skeletal profile would mainly include cattle skulls and feet (Serjeantson 1989:141), 2) the mortality profile of a leather production assemblage often favours subadults (Reitz 1986b:320), 3) there would be surficial markings on the anterior portion of the dentary, as well as

encircling marks on the metapodia and first phalanges (Landon 1996:92-95), and 4) the location of the marking on the bone would cluster around the distal end of the metapodia or the phalanges as there would be a conscious effort to preserve as much skin as possible (Landon 1996:81).

Based on the faunal specimens from the Carpintero assemblage, there is conflicting evidence of leather production. The skeletal profile had an underrepresentation of skulls and feet bones. While the underrepresentation could have been the result of fragmentation, it could also potentially suggest that leather production was performed elsewhere. Next, the mortality profile of the hacienda's assemblage included few subadults. However, perhaps the hacienda did not follow standard subadult cattle selection for leather production. In terms of location, there were no marks evident on any metapodia or on the anterior portion of dentaries. Yet, while there was an underrepresentation of phalanges in the assemblage, a few did show signs of multiple parallel cut marks, potentially indicating a desire to keep as much skin as possible. From historical sources (Latorre 2005:67) and photographic evidence (Figure 3), hacienda labourers butchered cattle and produced leather products throughout the Galápagos. Since the Carpintero midden was in proximity to the kitchens and household, leather production waste was perhaps not deposited in that assemblage.

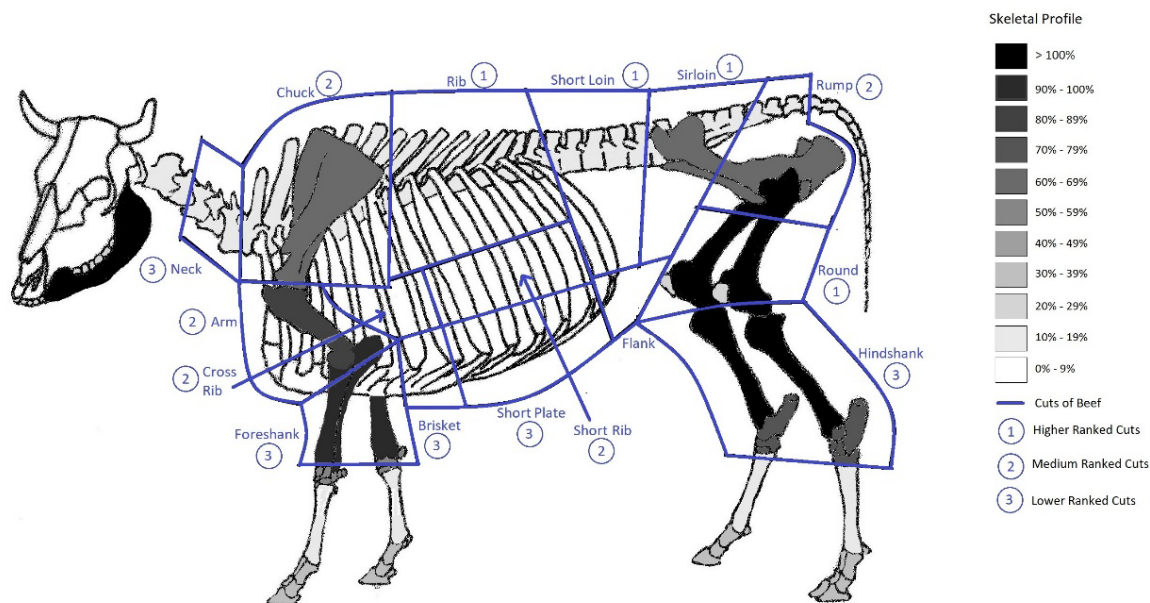
#### 5.1.4.2. Consumable products

Differences in socioeconomic status, cultural standards, and geographical locations contribute to the variability of the faunal assemblage. For example, there is often less domestic livestock remains found in rural or island assemblages compared to urban sites

due to supply shortage of domestic animals. In these instances, domestic livestock were more likely to be sold than locally consumed (Reitz 1986a:56). However, the majority of the faunal specimens in the Carpintero assemblage were of domestic livestock. The preference for domestic animals was perhaps facilitated by previous stocking efforts, resulting in a large herd size. Present day efforts to remove unwanted intrusive animals also suggest that the islands were stocked with domestic animals. While fish were also an important resource for local consumption and trade (Martinez 1919:79; Latorre 2005:72), certain endemic Galápagos fauna found in the assemblage were possibly not eaten. For example, certain smaller molluscs were likely accidentally brought back from the ocean as a consequence of fishing activities, adding to the NISP of endemic specimens (Figure 10).

Cuts of meat have the potential to be indicators of economic status as different portions often vary in cost (Newman 2010:44; Schultz and Gust 1983:48; Scott 2001:688). Based on cattle MNI, the skeletal profile of the Hacienda El Progreso demonstrated an underrepresentation of certain skeletal elements. Better represented elements corresponded to the chuck, arm, foreshank, sirloin, rump, round, and hindshank cuts (Figure 16). Represented elements that stood out included a range of higher, medium, and lower valued cuts; meanwhile the other meat cuts from the vertebrae and ribs were not represented, likely due to the fragmentation of both elements in the assemblage. As a result, the socio-economic status of the hacienda could be considered middle-class. Yet, if the midden was a result of communal kitchen waste, then various people of different socio-economic status would have been depositing their individual waste. Hypothetically,

this would include higher valued cuts of meat for the richer hacienda owner and lower valued cuts for the poorer workers.



**Figure 16. The skeletal profile of cattle specimens from the Carpintero assemblage and the ranked prices of different cuts of meat. (Based on Newman 2010, Schultz and Gust 1983, and Scott 2001.)**

Before refrigeration, butchered meat was required to be consumed or cured as soon as possible to prevent it from spoiling. It is difficult to interpret what cuts of beef described above were eaten fresh or preserved as there is no consensus on whether or not bones were removed during the curing process (Reitz 1986a:53). It is more difficult to properly preserve meat with bones; however, it was possibly of less concern to the hacienda as tainted cured meat was common during that time. If bones were present in cured meats, they would have decomposed quickly once discarded due to the effects of preservation (Reitz 1986a:53). If locally consumed food was mainly comprised of cured beef, there would potentially be an underrepresentation of those bones in the Carpintero assemblage.

Another method of consuming cattle was through fat production. In the assemblage, there were 28 helical fractures observed mainly appearing on long bones. Since spiral fractures on long bones are often associated with marrow extraction, this could indicate that some of the breakage could have been the result of retrieving marrow. However, these types of fractures could also have been caused by natural processes. In order to extract animal fat, certain skeletal elements could have been smashed or boiled. These bones would not be represented in the assemblage.

#### **5.1.5. Depositing the Remains**

The zooarchaeological assemblage of the hacienda should reflect the waste of all the cattle butchery unless different butchery steps took place in other locations or if the final product was discarded elsewhere, such as through export trade. Additionally, Cobos was active throughout San Cristóbal and neighboring islands; the extraction of cattle products would have taken place in other locations. Hacienda El Progreso was a larger plantation with access to enormous plots of land; therefore, carcass portions could have travelled through a sequence that could have taken place in different locales. Potentially, the absence of certain skeletal elements could suggest such activities. For example, the underrepresentation of phalanges and distal metapodia in the Carpintero assemblage could provide evidence that primary butchery or leather production took place in another location.

The potential of underrepresentation could be due to bone density as denser bones are more likely to preserve (Sportman et al 2007:130; Welbourne 1975:14). However, the analysis of bone density in relation to survivorship suggests that there was a weak and

insignificant correlation; skeletal underrepresentation may have been due to cultural behavior, or perhaps linked to bones being burnt past the point of identifiability (Buiskra and Swegle 1989:248; Reitz and Wing 2008:131).

It is difficult to distinguish between burned bones as a result of cooking or garbage management. 92% of the burned elements are limb bones. While limb bones were highly represented in the assemblage, dentaries were also well represented but only two displayed signs of burning. Nevertheless, only 10% of the cattle specimens had evidence of burning suggesting that, as in other assemblages (e.g. Zierden and Reitz 2009:349), burning was not a common trash disposal technique.

## **5.2. Ecological and Contextual Impact**

Galápagos has long been considered an untouched wilderness, an impression that began to rise in popularity after the visit of Charles Darwin. However, the islands have a history of human influenced environmental change. From the formation of the islands to the now-booming eco-tourism industry, the Galápagos Islands have undergone multiple changes that have left a mark on the landscape. As such, insights on the cattle management and production that occurred at the turn of the 19<sup>th</sup> century can illuminate an often-forgotten result of historical human activity with long-term ecological consequences.

### **5.2.1. Environmental Impact**

The colonization of the Galápagos Islands by Manuel Cobos has left an undeniable environmental impact, resulting in dramatic changes to the landscape. One of the main

products exported by Hacienda El Progreso was sugar. Often, sugar production has been described as “the death of the forest” because of the amount of land required to harvest the sugar, and the need to provide fuel to stoke the fires of the sugar mill (Derby 2011:606).

While perhaps not as damaging as sugar production, cattle management also requires ample land for grazing (Bishko 1952:494). Spanish custom recognized grass as a common resource and encouraged the use of any unexploited natural resource necessary for grazing animals (Melville 1990:29-30). In Spain, cattle herd sizes were limited. However, Hispanic cattle-herding procedures in the Americas later expanded as the economy encouraged the growth of herd size. The new colonized landscapes based this on the notion of unlimited land and unrestricted use (Butzer 1988:50). Cattle were allowed to roam the San Cristóbal landscape in large pastures with minimal management (Bilbao 1904:10; Latorre 2011:21). Allowing ungulates to roam and graze freely greatly reduced the density and species diversity of local vegetation and limited resources for endemic birds (Salvin 1876:456).

### **5.2.2. Local and Global Repercussions**

Throughout the years, conservationists have attempted to restore the islands, intending to return them to a western idealization of a wild nature and a people-free land (Balée 2006:9; Quiroga 2009). This often ignores the role of culture on landscapes, whether contemporary or historic, resulting in a struggle between nature, conservation efforts, and local inhabitants (Bassett 2009). The Galápagos archipelago is viewed as an unspoiled ecosystem cut off from the environmental effects caused by humans. Yet, a history of

constant environment change also plagues the islands. The ‘Galápagos Paradox’ indicates the problem that the islands face today (Quiroga 2009); while tourists are attracted to the pristine nature of the Galápagos, they diminish the islands’ original appeal by heightening its vulnerability to invasion and landscape transformation. Cattle have played a key role in the history of Latin America as herding and pastoralism changed both the environmental and political landscape of the regions due to its importance in Spanish colonial economies (Jamieson 2008:21). The many *Bos* specimens in the Carpintero midden indicate that cattle were important to the growth of the hacienda and must have had a large impact on the local environment.

### **5.3. The Use of Chaîne Opératoire in a Zooarchaeological Context**

The chaîne opératoire method was utilized in this thesis as a unifying concept for discerning cattle management and production protocols. The aim was to assist in the visualization of cattle management and production process as a step-by-step practice. The management and production of cattle was constructed using information gathered from historical sources and included: raising cattle, initial slaughter, butchery stages, production techniques, and disposal methods. However, it is difficult to discern the individual steps and their place in an operational sequence based upon preserved specimens in the assemblage. Bones often provide an incomplete view of the complex system of past foodways, including historic cattle management and production.

On occasion, the faunal assemblage may provide evidence of some food preparation techniques; however, the variety of ethnic food processes and consumption steps are difficult to separate (Landon 2005:21). While there are logical sequential steps assumed

through historical documentation, there was no conclusive evidence confirming the operational sequence of the cattle management and production event at the Hacienda El Progreso. Certain steps of cattle management and production were discernable in the assemblage, but their specific place in an operational sequence was not. In those particular examples, the use of chaîne opératoire in this thesis has been useful in helping to organize the necessary steps potentially taken in order to turn cattle into a commodity.

## 6. Summary and Conclusion

In the midst of one of the most celebrated archipelagos in the world, Hacienda El Progreso stands as a significant outlier in the history of 19<sup>th</sup> century Latin America cattle ranching. The hacienda, constructed in the middle of an uninhabited island far out into the Pacific Ocean, was unique. The *Historical Ecology of the Galápagos Islands* Project studied the complexities of the site and surrounding environment. This thesis explored the archaeological fauna of Hacienda El Progreso, focusing on cattle management and production techniques.

### 6.1. Summary

Hacienda El Progreso was built in the 19<sup>th</sup> century on the easternmost Galápagos island, San Cristóbal. While sugar was the main resource on the hacienda, cattle products were also exported, including salted meats, leathers, as well as animal fats and oils. After unsuccessful colonization attempts, Manuel Cobos was the first settler to create a moderately successful hacienda, running for a quarter of a century until his death in 1904. Afterwards, the hacienda continued in various levels of capacity until it became a small farming village.

Cattle have played an important part of colonization in Latin America. In Galápagos, Cobos deforested land and turned cattle into an exportable product. In order to fully assess cattle commodification, comparative literature was examined, primarily focusing on historical accounts and archaeological records. Since the hacienda was a unique cattle ranch due to its location, comparative literature based primarily on cattle ranches around the American continents was accessed. The comparative literature was used to assess the

breed of cattle, and mortality profile associated with different production activities, typical archaeologically visible indicators for butchering cattle, and the sequential steps historically undertaken to turn cattle into a product.

This thesis examined faunal remains recovered from the Carpintero midden. Situated in proximity to the kitchen and Cobos' home, the midden likely contained household refuse and kitchen waste reflecting localized consumption. The midden was a concentrated lens containing faunal remains, glass shards, and metal artifacts. The faunal remains were a mix of endemic and exotic species. A total of 1,383 cattle specimens were identified in the assemblage. An assessment of bone preservation suggested that the differential survivorship of skeletal specimens in the assemblage was not based solely on bone density. A minimum estimate of 22 individual cows contributed to the assemblage, and the skeletal profile indicated a larger percentage of preserved limb bones and dentaries.

Butchery modifications included cut and chop marks, as well as breakage and burning. Specimens with cut marks demonstrated typical skinning modifications on the phalanx and thoracic vertebra, as well as dismemberment and muscle removal near the joints. Chop marks displayed evidence of dismemberment near anatomical joints. Few breakage indicators were observed; however, helical fractures could have been associated with marrow extraction. Roughly only 10% of the cattle specimens were burnt, primarily with black-grey colouration. The assemblage suggests that burning was not heavily used as a disposal technique. The estimated age of death of the cattle was assessed using epiphyseal fusion, tooth eruption, and tooth wear. Most cattle were over four years of age at death; however, some subadults were slaughtered between two to four years of age. Examination of sex, withers height, and live weight was based on one complete

metacarpal, suggesting that the specimen was female, around 123.6 cm tall and weighed 203.3 kg. As there was only one available specimen, the sex and withers height estimates remain tentative, yet are relatively consistent with a Criollo breed of cattle.

The results from the analysis were considered in a chaîne opératoire framework to examine the possibility of observing the sequential production of cattle commodification from zooarchaeological remains. The Carpintero midden was likely formed through local consumption. This is corroborated by the location of the assemblage near the communal kitchen and Cobos' living quarters. While production indicators, such as the cut marks found on the phalanx demonstrate leather making techniques, the relative absence of large amounts of phalanges expected for leather production indicates that the assemblage was not primarily accumulated as leather production waste. Moreover, the mortality profile of the midden does not match that of expected beef or leather production as the cattle tended to be older. It remains possible that the hacienda selectively avoided younger cattle for production. It is also possible that the hacienda slaughtered cattle, skinned carcasses, cured meat, and exported most of the prime food elsewhere, leaving hacienda workers with the remaining portions for subsistence.

## **6.2. Conclusion**

Hacienda El Progreso was completely different from other 19<sup>th</sup>-century Latin American cattle ranches. In the Pacific Ocean, cattle thrived with little competition from endemic flora and fauna. Smaller cattle were brought to the island on boats. The geographical isolation enabled Manuel Cobos to have complete autonomy over all resources on the island. The landscape was substantially altered to sustain the hacienda, including the

clearing of land for agriculture. Historical accounts mention the importance of cattle in the hacienda's economy. Photographic evidence and the large amount of *Bos* specimens in the midden only confirm this claim.

As the Carpintero midden was composed of primarily locally consumed products, there was limited opportunity to observe the taphonomic operational sequence of cattle commodification during the length of the hacienda's operations. Further investigation will be required to locate additional production sites in order to fully grasp the scale of cattle production on San Cristóbal Island. In conjunction with the *Historical Ecology of the Galápagos Islands* project, this thesis serves as a starting point to improve our knowledge of human activities in the Galápagos Islands, and as a means to highlight the record of cattle management and production on an island in the middle of the Pacific Ocean.

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