MARITIME TRADE AND DEERSKIN IN IRON AGE CENTRAL TAIWAN:

A ZOOARCHAEOLOGICAL PERSPECTIVE

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ABSTRACT

This study explores the commercialized deerskin production of Iron Age central Taiwan, developed in the context of maritime trade starting from the third century. Three specific hypotheses were proposed to investigate the deerskin trade: (1) the transition-to-commerce hypothesis proposes that there was a commodity-oriented deerskin production developed for export during the Iron Age; (2) the overseas-trade hypothesis proposes that the transition to commerce was associated with expanding overseas trade; (3) the tramping-for-profit hypothesis proposes a trade mode of navigation along the coast in search of profit. These hypotheses were tested by a quantitative analysis of faunal remains and the concentration of exotic artifacts from three Iron Age sites.

The empirical data analyzed in this dissertation include materials from the early Iron Age Huilai and the late Iron Age Luliao and Nanshikeng sites. A comparison between the three assemblages suggests that there was a transition to commerce during the Iron Age and that transition was associated with expanding overseas trade. The commodity-oriented deerskin production and maritime exchange are not evident in the early Iron Age, but appear to have increased in the late period. However, the transition varied among the two late Iron Age sites, with the commercial pattern more evident at Luliao. Based on the associated materials from Luliao, rather than just tramping along the coast, sustained trading may have been established at the site.

This study proposes that indigenous structure was significant for the transition to commerce, in addition to the external influence of maritime trade. Gift exchange was essential to the societies of prehistoric Taiwan. The decline in the production of native trade goods provided an opportunity for the adoption of exotic items, and thereby the rise of a commercial export economy. Trading for foreign items with social significance was competitive. Successful trade competition relied heavily on the strategies used by the Iron Age people, resulting in this variation of commerce in central Taiwan.

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CHAPTER 1. INTRODUCTION

1.1 Introduction

Archaeologists have recognized that intersocietal interactions are often vital to understand local events; no society, even the least populous one, can be understood entirely in isolation (Hall et al. 2010). This is especially true for Iron Age Taiwan as archaeological evidence strongly suggests that the Iron Age culture of Taiwan was stimulated by an expanding maritime trade. Taiwan is an island located in East Asia, 150 km off the southeastern coast of the mainland. Around 3500 BC, a growing agricultural economy in the mainland coast triggered the Austronesian dispersal to Taiwan and the earliest Neolithic culture on this island (Bellwood 2012). A change in the makeup of artifact assemblages after AD 200, characterized by a decreasing lithic diversity and an increasing number of exotic artifacts, has been found in Taiwan. One of the most prominent exotic artifacts is metal (iron and bronze), which symbolizes a new era of Taiwan prehistory—the Iron Age; such material change became more dramatic from the late period (AD 1000–1624). Most of the exotic artifacts were considered to be imported primarily through maritime trade, although there is limited evidence for local production of iron and bronze.

Textual records suggest that a market-based overseas trade in the China Seas had gradually developed since the third century, spurred by the expansion of Indian Ocean trade (Ten 2014) and the economic transformation of southeast China (Clark 1982, 1991). Evidence from underwater archaeology also shows an advanced level of ship construction, oceanic voyaging, and materials associated with overseas commerce in the thirteenth-century China (e.g., Quanzhou Collaborative Archaeological Team [QCAT] 1975, 1987). Chronologically, the rise of the Iron Age in Taiwan is associated with expanding maritime trade, but very few textual sources document trade with Taiwan prior to the seventeenth century. Historians, therefore, proposed that Taiwan was generally bypassed by merchants, and trade with Taiwan was conducted by a small number of fishermen and peddlers (e.g., Chen 2006:36, 44–45; Jiang 1984). However, the material record from Iron Age sites demonstrates a surprising degree of foreign contact. I suggest the textual record may be incomplete because many of these activities would not have been recorded in the literature. Archaeology, in this case, provides an opportunity to explore the maritime history. As with the textual evidence, archaeological evidence is also biased and incomplete, but the bias is physical and can be minimized by controlling for taphonomic effects (Gould 2011:11).

1.2 Market Exchange in Iron Age Taiwan

Trade and exchange have been extensively studied in anthropology. In the latter half of the twentieth century, this was prompted by reciprocity, redistribution, and marketing proposed by Karl Polanyi (1957:262–263) and Marshall Sahlins (1972). Ancient trade is often viewed as essentially different from the contemporary market exchange. Trade in the past or in clan societies is believed to build upon social and cultural relations. The rational economic logic that maximized individual self-interest is often absent in the exchange. Goods circulated during such exchange are often seen as gifts, an inalienable item in the obligatory transfer between related individuals. By contrast, in modern market economies, exchange often involves self-interest and profit, with a low degree of social relation among transactors. Goods circulated in modern market economies are commodities, alienable things transferred between independent individuals without future obligations. Over the years, this simple dichotomy has been modified by anthropologists because the status of an object as a gift or commodity may change (e.g., Appadurai 1986). The social correlates of these two economies are also over-simplified because gift and commodity exchanges often coexist in a society (e.g., Morris 1986).

In anthropology, the distinction of the gift and commodity/market economies lies in the inalienability of gifts. The gift economy is viewed substantially more than a simple exchange of objects, because gifts "are to some extent parts of persons" and "there is a series of rights and duties about giving and receiving" (Mauss [1925] 1967:11). A gift has "an immaterial aura of connection to other humans and to something greater than any individual human"; thus, a gift is inalienable because it concerns "the spirituality and sociality of subjects and objects" (Osteen 2002:244). Hence, the inalienable status of gifts can be recognized by "their enduring intrinsic relation to the subject" (Goddard 2000:145). Commodity, by contrast, bears little intrinsic aspects of the givers/producers and no substantial obligation between the transactors.

The ethnographically derived concepts and models reviewed above are useful to investigate the circulation of material goods in prehistory. In this dissertation, I hypothesize there was a market-based maritime trade in Iron Age Taiwan based on the sociability between the transactors and the alienability of export products. Prior to the Iron Age, there is little evidence showing an intensive interaction with non-Austronesian societies. Although foreign artifacts had already been imported in the late Neolithic (see Chen 2011), they have been found in small numbers and had little significance in Taiwanese societies. However, the large amount of foreign artifacts from India, Southeast Asia, and China since the third century suggests an expanding scale of maritime trade around Taiwan waters. This cross-cultural exchange appears to have a low degree of sociability, operated primarily by market force.

If the maritime trade was market-based, there should be a commodity-oriented export economy in Iron Age Taiwan. Although limited, textual records show that the Iron Age people in Taiwan used local plants and animals (e.g., cereals, herbs, meat, antlers, and deerskin) in exchange for both necessary and luxury goods (e.g., salt, cotton cloth, metal, agate, and glass beads). Among the exported articles, deerskin was likely the main export since all the written sources pertaining to Iron Age Taiwan mention a deerskin trade with Chinese traders. Archaeologists also propose that a deerskin trade may have existed during the Iron Age since a large amount of deer remains has been discovered at some coastal sites (e.g., Liu et al. 2007).

I, thus, hypothesize that the Iron Age people of Taiwan participated in maritime trade by exporting primarily deerskin. Deerskin is viewed as the main export commodity of Iron Age Taiwan based on the principles of scarcity and monopoly. Deer was reportedly abundant and widely distributed in the past and thus was difficult to monopolize. The supply of deer products also can be built upon household activity since hunting was important to the indigenous subsistence. Deerskin, therefore, can be considered as an alienable material for market exchange in terms of both resource and production. In the context of maritime trade, deerskin was portable, preservable, and could be produced in large quantity, making it an ideal commodity to be transported over water.

In archaeology, however, identifying market exchange is often challenging. This may result from the problem of *equifinality*, wherein “different initial conditions and different processes lead to the same end-product in the archaeological record” (Renfrew 1977:82). Market exchange is often spatially identical with centralized redistribution, and both economies would attract a larger population, a larger quantity of high-value materials, and a higher class of persons who have access to the goods in a central place (Renfrew 1977). Investigations about market exchange, therefore, are mainly conducted for times and places with well-documented written sources. It has been argued that there is a strong association between market exchange and the presence of textual records of the society/culture under study (Oka and Kusimba 2008). Those with extensive textual records often reveal a trade in the form of modern commerce; those without records tend to be seen as centralized redistribution. This study, thus, investigates the market behavior concerning the production of deerskin rather than identifying an actual presence of a marketplace. Deerskins in maritime trade, of course, do not survive in the archaeological record. Patterns on the deer remains serve as a proxy to explore the market behavior in Iron Age Taiwan.

1.3 Research Area

The western lowland of the central area was selected to investigate the deerskin trade in Iron Age Taiwan. This area consists of coastal plains, river basins, and hills with good water resources. The subtropical environment and heavy seasonal precipitation are especially favored by deer species. According to archaeological research, the cultural transition from the Neolithic to the Iron Age was apparent in this area, characterized by the disappearance of jade, diminishing lithic technology, and the presence of exotic artifacts. The Iron Age transition of the central-western lowland, however, began around several hundred years later than those of other areas (see Ho and Liu 2006:142–143). This late development may suggest that the foreign materials in the early Iron Age were imported from other lowland regions. A chemical study of iron artifacts from a coastal site (Yuanli) in the central area also proposed that the early Iron Age people acquired iron and smelting technology from the northern Shisanhang culture (Chen 2000a:267). Although the chemical composition of an iron artifact indicates a possibility of local manufacture in the central-western lowland (Chen 2000a:267), no evidence of metalworking has been reported at archaeological sites. In the late Iron Age, iron and other exotic artifacts substantially increased at some coastal sites, accompanied by a further decline of lithic production. Hence, the central-western lowland provides a good example to explore maritime history, by comparing the early and late Iron Age assemblages.

The empirical data analyzed in this dissertation include materials from three Iron Age sites: the early Iron Age Huilai site and the late Iron Age Luliao and Nanshikeng sites. The early Iron Age Huilai site is located in an inland basin close to a navigable tributary of a large river, which provided access to maritime trade. The two late Iron Age sites are remnants of coastal settlements, with a similar geography and chronology and only 3 km apart. At all three sites, excavations recovered large amounts of cultural and biological remains. Water screening was conducted during some of the excavations and provided qualified materials for systematic analysis. Data from the three sites were compared to investigate the deerskin production and to propose a possible trade mode in Iron Age central Taiwan.

1.4 Hypotheses and Methods

The analytical strategy used in this study is hypothesis testing. Here, I propose three specific hypotheses for investigating the maritime exchange, based on current archaeological, ethnographic, and textual evidence, as well as the exchange and prey choice models reviewed in later chapters.

1.4.1 The Transition-to-Commerce Hypothesis

The first hypothesis of this study is that there was a commodity-oriented deerskin production developed during the Iron Age. The use of deer changed from a subsistence resource in the early Iron Age to a commodity in the late period. This hypothesis, however, does not preclude subsistence and social uses of deerskin in these societies; in fact, such uses are well documented in the textual record. This study does not attempt to identify how deerskin was used at each site, nor identify a physical marketplace in the central-western lowland. Rather, I compare the market behaviors of deerskin production between the three Iron Age sites. Ethnographic studies suggested that hunting in indigenous cultures is often socially embedded, with restricted territory, prey selection, seasonality, and technique (e.g., Pei 2010). The transition to commerce, therefore, must require related economic intensification of hide production that involves altering prey selection, hunting practice, and butchery activity. Hence, I propose four archaeological expectations for the transition, and later test them with quantitative analyses of faunal remains.

First, animal resource procurement is expected to change from a generalized to a more specialized strategy focusing more on deer. The relative frequencies of taxa and species diversity are used to test this expectation. There are at least three native deer species in Taiwan, but sika deer (*Cervus nippon taiouanus*) is recorded as abundant in most lowland areas. Sika deer have a medium body size, low-lying habitat, and gregarious behavior, and thus should be the most ideal prey of hunters, based on the prey choice model. I expect that sika deer were the highest ranked prey throughout the Iron Age, but hunters increasingly exploited sika as the maritime trade expanded in the late period.

Second, deer hunting is expected to change from random hunting to a mass kill and/or a selective hunting, in order to increase the quantity and/or quality of deer products. The mortality profile of deer is used to test this expectation. If there was such a change, the mortality profile of deer should change from an attritional pattern to a catastrophic and/or prime-dominated profile. An attritional pattern is similar to ecological mortality, characterized by an over-representation of young and old individuals in a U-shaped curve; a catastrophic pattern resembles the expected age structure of a living population, in which older age classes contain progressively fewer individuals in an L-shaped curve (Klein and Cruz-Uribe 1984:56). In addition to these patterns, Stiner (1990) also added several other profiles such as juvenile-dominated, prime-dominated, and old-dominated. If deer were hunted individually and randomly, the mortality profile of deer is expected to show an attritional pattern, since young and old individuals are usually more vulnerable than the middle-aged adults. If, on the other hand, hunters carried out a mass kill and/or a selective hunting for the most profitable middle-aged adults, the mortality profile of deer would show a catastrophic and/or prime-dominated pattern.

Third, the seasonality of hunting is expected to change from dry season to year-round. The death season of young deer serves as a proxy for hunting season. Most ethnographic and historical records suggest that hunting in Taiwan is primarily carried out in the dry season (late fall to early spring). Based on the prey choice model, hunting in the dry season should be more ideal because sika deer tend to have a larger foraging range (e.g., Hu et al. 1994) and form a larger herd in the dry season. As the maritime trade expanded, people would hunt deer more in the wet season (late spring to early fall) in order to provide a steady supply of deer products. In addition, sika deer often molt in May or June, and the summer coat exhibits a lighter color and white spots. This would provide an incentive to hunt more in the wet season in order to provide a higher quality of deerskin.

Finally, the butchery pattern on the deer remains is expected to change from disarticulation to skinning, as determined by the relative frequencies of cut marks on six limb-bone joints. Despite some taphonomic concerns (e.g., Abe et al. 2002; Lyman 1987, 1994), experimental studies have concluded that skinning operations often leave cut marks on metapodials (e.g., Val and Mallye 2011) because these areas have very little edible meat for defleshing and disarticulating. Marks on meat-bearing bones, on the other hand, often represent butchery behavior. If deer had changed from a subsistence resource to a primary use in fur trade, the butchery patterns on deer remains would show a change from disarticulation to a more frequent occurrence of skinning activity.

1.4.2 The Overseas-Trade Hypothesis

The second hypothesis of this study is that the transition to commerce was associated with expanding overseas trade. This hypothesis is tested by the faunal and material evidence from the three sites. Based on the evidence for development of metallurgy (Chen 2000a:267), I hypothesize that iron and other foreign items were imported to central Taiwan through an internal exchange with other lowland regions in the early Iron Age. However, the larger quantity of these artifacts in the late period was primarily acquired from exchange with foreign merchants. This change is chronologically associated with Chinese overseas trade developed since the tenth century. The early Iron Age Huilai, therefore, is expected to have a smaller number of exotic artifacts and no apparent commodity-oriented deerskin production. By contrast, I expect a higher concentration of the exotic artifacts and more commodity-oriented deerskin production at the late Iron Age sites. This shift may also denote a change in the modes of trade modeled by Renfrew (1975), from a land-based internal exchange, to a maritime commerce during the Iron Age.

1.4.3 The Tramping-for-Profit Hypothesis

My final hypothesis is that the maritime trade was carried out with tramping navigation along the coast in search of profit. This hypothesis is tested by the evidence of faunal remains and exotic artifacts from the two late Iron Age sites. Tramping is a type of slow-motion shipping from one port to another, often following coastlines (Braudel 1972:103–108). The navigation patterns of tramping are dependent on a combination of factors, including winds, currents, and harbors (Braudel 1972:103–105; Sherratt and Sherratt 1991:357–358). In 1623, a Dutch visitor recorded how the merchants traded in Taiwan: "as the inhabitants have no vessels at all, these Chinese sail from one place to the other along the coast in search of profit and trade" (Blussé and Roessingh 1984:77). Since Luliao and Nanshikeng have a similar geography and chronology, I expect that the tramping navigation would result in a similar pattern of exotic artifacts and deerskin production at the two sites.

1.5 Dissertation Structure

In Chapter 2, I will briefly review the early history of maritime trade in Taiwan, including maritime exchanges since the Neolithic; Iron Age archaeology; and the maritime history of the China Seas, as well as the role of deerskin in the maritime trade. Chapter 3 discusses animal resource procurement in prehistoric Taiwan. I first review relevant research to argue that hunting terrestrial animals was an important component of prehistoric subsistence, which provided an underlying condition for the deerskin trade in Iron Age Taiwan. Then, I examine past Taiwanese faunal records to hypothesize a simple prey rank of Iron Age people. Finally, I review deer hunting documented in the ethnographic and textual records to provide a baseline for reconstructing Iron Age hunting through faunal analysis.

Chapter 4 reviews the natural and cultural history of the central-western lowland. The central-western lowland is defined by its geography, temperature, precipitation, cultural history, and ethnohistory. The archaeological excavations of the three sites are presented in Chapter 5, with a discussion of the possible constraints and the material evidence for the three hypotheses. The archaeological context, taphonomic evaluation, recovery method, and sampling strategy for the faunal assemblages are presented in Chapter 6. Chapter 7 introduces the identification protocol, quantitative methods, and potential problems of the faunal analyses used in this study.

In Chapter 8, I present the quantitative results of the faunal analyses and assess the data with a consideration of possible biases. Chapter 9 examines the three hypotheses with the evidence of faunal remains and exotic artifacts. A discussion about the transition to commerce from an internal point of view is also presented. Finally, because this project represents the first archaeological-based research on deerskin trade in Iron Age Taiwan, I identify the limitations of this study and several directions for future research.

CHAPTER 2. EARLY HISTORY OF MARITIME TRADE IN TAIWAN

As an island located between the East and South China Seas, Taiwan has a long history of maritime interactions with its neighbors. Since 3000 BC, maritime exchange with Southeast Asia and the mainland coast have flourished. This interaction was further strengthened beginning in the third century. From this time onwards, there was a substantial change in the material record of Taiwan, showing a diminishing lithic production and increasing exotic materials. Based on chemical and topological analyses, these exotic materials were imported primarily through maritime trade, although there is also evidence of metalworking at some coastal sites. In this chapter, I briefly review the early history of maritime exchange with archaeological and textual evidence. I will also demonstrate that a market-based overseas trade developed at the turn of the first millennium, which later stimulated an island-wide cultural transition in Neolithic Taiwan.

2.1 Maritime Trade in Taiwan Archaeology

Taiwan archaeology has been a century in development. Early studies were predominantly a by-product of anthropological surveys and endeavored to understand the correlations between archaeological remains and modern aboriginal cultures. After the Second World War, many studies focused on the origin of prehistoric cultures and hypothesized a cultural transmission from the mainland (e.g., Chang 1970; Kano 1952). The archaeological sequence of Taiwan was first revealed in the 1960s, and became much clearer in the 1980s (Lien 1998). It was during this time that Taiwan archaeology also had a conceptual and methodological breakthrough, with many studies focusing on human-environment dynamics (e.g., Chang 1977), in addition to traditional cultural historical analysis. Since the 1990s, the research interests of Taiwan archaeology have expanded to examine topics such as cultural interaction (e.g., Liu 2002a), settlement pattern (e.g., Chen 1997), subsistence strategy (e.g., Li 1997), and bioarchaeology (e.g., Pietrusewsky and Tsang 2003). In recent years, Taiwan has received much more attention internationally as a result of growing interest in Austronesian culture and history (e.g., Bellwood 2012; Diamond 2000), and this further expanded the scope of Taiwan archaeology from a localized context to a larger, inter-regional point of view.

According to research, maritime exchange has existed in Taiwan waters since the Neolithic. For example, from the early to the mid-Neolithic, basaltic adzes and axes were widely transported to the communities on the southwestern lowlands of Taiwan (e.g., Hung 2004; Rolett et al. 2000), but the raw materials occur naturally in the Penghu archipelago between Taiwan and the mainland coast. Archaeologists further discovered a lithic workshop on one of the Penghu Islands－Qimei (Figure 2.1), which was likely a source of the basaltic artifacts found in Taiwan (e.g., Tsang 2016; Tsang and Hung 2001). These artifacts were also discovered at a Neolithic site on the mainland coast (Jiao 2007:256–257), suggesting an exchange network circulating basalt across the Taiwan Strait (Tsang 2016).

Another lithic artifact widely distributed in Neolithic Taiwan was jade/nephrite, of which the raw materials can only be found in the eastern area (Fengtien), present-day Wanrong Town, Hualien County (Figure 2.1). Throughout the Neolithic, jade materials and finished products were distributed almost island-wide (e.g., Liu 2016). How the jade artifacts were circulated in Neolithic Taiwan remains unclear, but a hypothesis can be proposed by following Renfrew’s ideas and models (1975). Since the jade artifacts had traveled from a distant source to destinations through numerous transactions, they may have been circulated with a down-the-line mode, in which “the commodity travels across successive territories through successive exchanges” (119). In Renfrew’s model, however, a down-the-line trade can be carried out through a prestige chain, a variation that often results in a different pattern of artifact distribution. Unlike other items, prestige goods are often circulated by a limited number of owners and within a restricted conveyance range (Renfrew 1977). Goods carrying high prestige or value and exchanged reciprocally can travel through a larger geographic range and produce a more gradual falloff pattern (Renfrew 1975). Therefore, the wide distribution of jade and a gradual decrease from the source suggest a prestige network circulating these items in Neolithic Taiwan. Archaeological research also confirmed the social significance of jade artifacts. In some societies such as Beinan (Figure 2.1) in the southeastern coast, jade artifacts are mostly found in slate coffins (Lien 2003:116) and often display repair marks (Yeh 2005:137), suggesting their high value in the Neolithic society.

Jade artifacts and raw materials were also transported from Taiwan to the Philippines. The overseas exchange of jade began shortly after the Neolithic people settled Luzon from Taiwan around 4,000 years ago, and later expanded to Mainland Southeast Asia until the Metal Age (Hung et al. 2007). This maritime exchange was carried out between these Austronesian communities in the South China Sea, transporting jade artifacts along the coast and between islands. When the jade culture began to decline in late Neolithic Taiwan, some of the jade craftsmen even traveled to Southeast Asia with the raw materials and produced ornaments there

(Hung et al. 2007). This maritime system and the land-based exchange appear to have a common source－eastern Taiwan, which connected the two exchange networks inside and outside of Taiwan.

Since AD 200, the widely dispersed jade artifacts disappeared in most western lowlands, accompanied by the appearance of larger quantities of exotic materials (e.g., Lien 1998; Liu 2002a:45). Among these materials, iron tools appear to symbolize a new stage of Taiwan prehistory following the Neolithic period. Archaeologists have proposed a Metal Age for the prehistory of Taiwan as early as 1944 (Kano 1952), but the Iron Age was not fully recognized until the 1980s (Lien 1998). In general, archaeologists divided the Iron Age in Taiwan into two periods: an early period (AD 200–1000) and a late period (AD 1000–1624). At a majority of sites dating from the early period, a small number of exotic artifacts (e.g., agate, glass, metal tools, Chinese coins and ceramics) have been found. The presence of stone tools markedly decreased in diversity in comparison to Neolithic sites. At the later sites, more metal artifacts and exotic trade items appeared in the lowland areas. Stone tools were rare and largely restricted to the mountain areas (Liu 2002a:45). This change in the makeup of artifact assemblages suggested an increasing importance of foreign goods in Iron Age Taiwan.

Several cultural changes were also noted during the transition from the Neolithic to the Iron Age. The Iron Age people tended to have a more advanced technique of pottery firing than their predecessors (Lien 1998; Liu 2002a:46). The lithic tools that remained in use were predominantly stone hammers that did not require advanced skill in production. Osteological evidence also suggested fewer cases of ritual tooth ablation that was commonly seen on Neolithic Taiwanese skeletons (Lien 1998). Iron Age cultures also exhibited more regional variations than their Neolithic counterparts in terms of burial practice (Lien 1998). Despite these differences, most archaeologists believe that Iron Age cultures developed directly from their Neolithic predecessors. These Iron Age cultures continued to develop into the historical period, and became the ancestral cultures of modern indigenous groups (Lien 1998; Tsang 1995:62).

Since most of the exotic artifacts had never existed prior to the Iron Age, archaeologists are interested in exploring where these items may have been produced. Two competing hypotheses have been proposed for the origin of these artifacts－native innovation/production and external trade. A chemical study of iron remains proposed a native innovation of iron technology at the Shisanhang site (Figure 2.1) in northern Taiwan (Chen 2000a). The evidence of metal slag, casting molds, and semi-finished glass beads also hints at local production of metals and glass beads at the Jiuxianglan site (Figure 2.1) in the southeast (Hung and Chao 2016; Lee 2005a, 2005b, 2007, 2015). However, the apparent existence of native innovation or production does not preclude an additional influx from external cultures. For example, some artifacts from Shisanhang also show a strong foreign style (e.g., Chinese coins) (Chen 2011; Tsang and Liu 2001). The chemical and topological analyses also proposed a multiple origin for glass beads, with the beads apparently from India and Southeast Asia in the early Iron Age, and predominately from China in the late period (Cui et al. 2008; Hung 2005; Hung and Chao 2016; Wang 2016:239).

Research focusing on recent excavations in the southeastern coast such as the Jiuxianglan site suggests that the Iron Age in Taiwan probably began somewhat earlier than previously believed. The lowest cultural deposit with iron artifacts and glass beads at Jiuxianglan is dated to 400–300 BC (Kuo 2010a), along with the evidence of bronze production (casting molds) and iron smelting (slag, ash) dated to as early as 100 BC (Lee 2015). Hung and Chao (2016) further link these early exotic artifacts to the jade exchange, since not only do these artifacts appear to have been from India and Southeast Asia (e.g., the Indo-Pacific glass beads) but some jade ornaments found at the sites also exhibit a Southeast Asian style. Based on this discovery, Hung and Chao revised the sequence of Iron/Metal Age Taiwan by adding an earlier phase from 400 BC to AD 200. I, however, consider this period as a “Transition Era” since such a transition was restricted to the southeastern coast and not prominent in other areas until the third century.

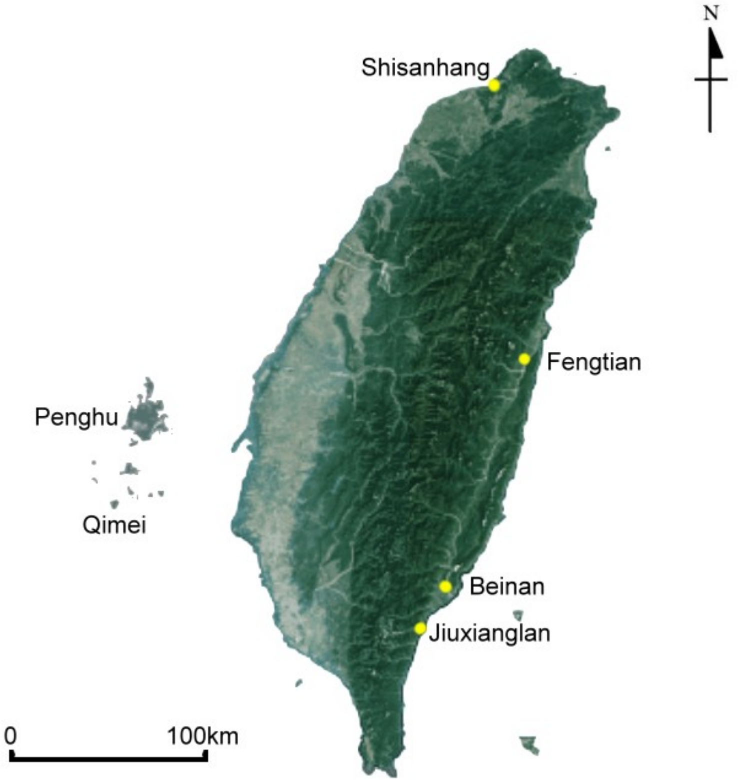

Figure 2.1. Sites and places mentioned in the text. (Background map from CNES/CSRSR 2014)

In sum, archaeological evidence shows that there is a clear transition in maritime trade around Taiwan waters from the Neolithic to the Iron Age. The Neolithic maritime exchanges circulated high-value items made of Taiwanese materials within Austronesian-related communities. The jade network later expanded to Mainland Southeast Asia and introduced foreign items into Taiwan after 400 BC. Interestingly, this introduction is chronologically associated with the expanding Indian Ocean trade in Southeast Asia. The commercial interactions between India and Rome had increased the demand for exotic goods (e.g., spices) in the urban civilizations of the Mediterranean Basin. This commerce later expanded to include the South and Southeast Asian exchange networks in the fourth century BC (Bellina and Glover 2004). Since then, Southeast Asia became a convergence of the Austronesian and the Indian maritime trade routes, and, through the Austronesian jade exchange, Indo-Pacific artifacts first appeared in eastern Taiwan in 400–300 BC.

Although the earliest exotic artifacts in the southeastern coast were apparently from Southeast Asia, the origin of these artifacts in the western lowlands (e.g., northern, southwestern) seems to be more complex. The typological and chemical analyses of glass beads suggest that the materials from southeastern Taiwan are different from those seen from the northern sites (Wang 2016:240). There is also a difference in the pattern of the Iron Age transition between the southeastern and western regions (Liu 2005). For example, in the southeast, the change in grave goods was gradual, from jade to a combination of jade and foreign artifacts in the early Iron Age, and then to predominately exotic jewelry in the late period (Yeh 2005:156–157). However, the transition was rapid and abrupt in other areas; almost no jade artifacts were found from the early Iron Age. On the other hand, the additional Chinese materials (e.g., coins) from the early Iron Age deposits of Shisanhang indicate a new form of maritime exchange, that is, a cross-cultural trading network connecting the East and South China Seas. The Taiwan Strait appears to have been a major pathway of this new trade route, and this trade was further strengthened after AD 1000 as a larger amount of such artifacts was discovered in the western lowland of Taiwan.

2.2 Maritime History of the China Seas

Since maritime trades may have been a catalyst for the Iron Age transition, this section reviews the history of overseas trade in the China Seas based on the textual record. Written sources have been widely used in Iron Age research (e.g., Chen 2005; Hsieh 2012; Liu 2006; Wang and Liu 2007) and provide a dialogue between archaeology and history. However, most of the textual records pertaining to Taiwan appeared only after the seventeenth century. The scope of inquiry of historical archaeology, therefore, is often limited to the ending phase of the Iron Age. Since foreign influence appears to have started much earlier, I review the regional maritime history of the past 2,000 years. Although the maritime exchanges around Taiwan waters involved a large geographic region and diverse cultural entities, my review mainly focuses on the overseas trade of Chinese and European merchants because their economic activities are well documented in literature.

Textual records suggest that China began its relations with the South Sea area as early as 200 BC, but many of the contacts were made for military, diplomatic, or political purposes instead of purely commercial ones (Schottenhammer 2012). However, commodities originating from South Asia had reached the coastal regions of Han China in the second century BC. These foreign goods were likely transported through Southeast Asia's export networks (Ten 2014). By

AD 250, commercial activities had increased in the Indian Ocean and gradually linked the networks of the East China Sea. This trade had started to overshadow Chinese military expeditions by the seventh century. At the beginning of the tenth century, maritime trade routes replaced the traditional land-based ones in China (Schottenhammer 2012). During this period, also known as the Tang-Song interregnum (AD 907–979), dozens of small polities were established from the collapse of the centralized Tang Empire. Southeast China began to import supplemental foodstuffs (Tang 1995:378) and various exotic luxury goods through maritime trade in order to provide for its growing population, polity finance, and urban economy (Clark 1982, 1991). In the case of the Min kingdom in Fujian, maritime trade also increased the wealth of the prefectural elite and the educational investment in local youths (Clark 1982). The independence of the Min kingdom, therefore, not only transformed the once-marginal Fujian to a maritime trade center, but also increased the social status of the southern people who were less wealthy and less erudite.

In the Song dynasty (AD 960–1279), the Chinese court actively and directly participated in maritime trade. A liberalization of shipping and privatization of exchange can be seen at this time. Maritime trade continued to flourish in the Yuan (AD 1271–1368), but was suddenly interrupted by the Chinese government in the early Ming (AD 1368–1644). In 1371, the Ming court enacted a ban, restraining any private seafaring conducted in the China Seas. Imports by foreign traders were mostly tribute (Chiou 1993), and the remaining goods could only be sold under government supervision (Schottenhammer 2012). Although occasionally merely a formality (Chiou 1993), this policy deleteriously impacted foreign trade, as well as the livelihood of coastal populations who heavily depended on maritime trade. In the early fifteenth century, the Ming emperor started several overseas expeditions, but the purpose of these expeditions was diplomatic rather than commercial (Chiou 1993), perhaps mainly to demonstrate the empire's power (Schottenhammer 2012). At the same time, maritime trade was still prohibited and mostly carried out in the form of smuggling and piracy. Such piracy active on the offshore islands strongly compromised the international relations and trade policies of the Ming Empire. Although frequently attempted, the Ming court could never completely eradicate piracy.

Iron Age Taiwan was also influenced by this ban on overseas trade, when it became a mediation point of pirating exchange between China and Japan (Andrade 2000:29; Borao 2007). It was also at this time that western merchants first appeared in Asia. Western merchants eventually gained control over Asian seas because the two most powerful Asian states (China and Japan) were less interested in overseas commerce (Andrade 2006). The Portuguese were the first Europeans to settle in Macao and later monopolized the informal trade between China and Japan (Borao 2007). Since the Portuguese were the first Europeans to systematically explore East Asian waters, they were likely the first westerners to sail near Taiwan. The Portuguese, however, were not interested in Taiwan due to a lack of desirable luxury items (Schottenhammer 2011). By the early seventeenth century, the Dutch and Spanish became dominant in Asian seas, and also occupied Taiwan's southwestern and northern coasts.

European colonization had a tremendous impact on late Iron Age Taiwan, especially the Dutch colonization in the southwest (AD 1624–1662). The Dutch East India Company established a trading base near present-day Tainan City. This colony was initially built as a base to trade with China, but the Dutch later recognized the economic potential of this island, that is, the profit of deerskin in the international market. With financial and military support from the state (Andrade 2005), the Dutch built a colony and introduced a licensed hunting and franchise system－*Pushe* (贌社)－to gain a monopoly on deerskin and other export articles. Unlike the aboriginal hunting with arrows and traps, the licensed hunting was conducted by Chinese, with a more effective technique－pitfall－to capture more deer. It is reported that there were 20,000–150,000 deerskins exported from Taiwan each year under the Dutch rule (Nakamura 1997). By the 1640s, the Dutch had noticed a significant decrease in the deer population and had to enact a series of policies to restore the population (Tsao 2011:218). To sustain the colony, the Dutch also hired Chinese farmers and converted the aboriginal plains into Chinese rice fields. Therefore, although they occupied Taiwan for no more than half a century, the Dutch substantially transformed the ecology and economy of southwestern coast (Andrade 2006).

This trading community persisted until Chenggong Zheng and his troops arrived in Taiwan in 1661. Unlike Ming China's lack of interest in overseas commerce, Zheng's troops were sponsored by maritime merchants and thus became a competitor of the Dutch East India Company (Andrade 2006). Zheng later defeated the Dutch and founded the Kingdom of Tungning on the island, as a loyalist movement to restore Ming China after it was overthrown by the Qing (AD 1644–1911). This kingdom was later destroyed by Qing troops. Taiwan, therefore, was officially incorporated into Qing China in 1684. Since then, although European merchants continued to trade in China (Chuan 1993), there were few official episodes of seafaring because the Qing court concentrated predominantly on its continental border (Schottenhammer 2012). In Taiwan, the *Pushe* system of deerskin economy continued to work in the early Qing, though mainly as a source of state revenue (Tsao 2011:206). At the same time, the increase in Han population and the expansion of rice fields led to deforestation on a larger scale (Liu 1998). Such habitat loss further depleted the deer population, and the deerskin economy eventually perished in the mid-eighteenth century (Tsao 2011:228).

2.3 Archaeology and History of Maritime Trade in Taiwan

The archaeological records and maritime history reviewed above are summarized in Table 2.1. It appears that there is a chronological association between the two lines of evidence. In the Neolithic period, basalt and jade artifacts were circulated within Austronesian maritime communities. The jade exchange later introduced the foreign items to southeastern Taiwan after 400 BC. There was a clear, island-wide transition in the third century as iron and other exotic artifacts appeared in the western lowlands. Due to the additional Chinese materials at some sites, I suggest this island-wide transition may have been associated with the increasing commercial trade in the East China Sea, although it does not preclude the influence of native tradition and innovation. Historical research also shows that there was a more intense commercial interaction between South China and South Asia through the Southeast Asian networks during that period (see Ten 2014). Southeast Asia, however, was not merely a transit zone for India-China trade; rather, the polities independently and actively participated in the trading networks and control of the flow of goods. As Ten noted, “Southeast Asia had its own networks of exchange and its engagement with Chinese dynasties was often independent of their interactions with the polities in South Asia” (2014:32). Southeast Asian polities also “introduced their local produce and products into these cross-regional trading networks” (35). I suggest such modes of trade and interaction would have contributed to the diverse composition of exotic artifacts (India, Southeast Asia, and China) in Iron Age Taiwan.

Table 2.1. Summary of the early maritime trades around Taiwan waters.

Date	Taiwan	Southeast Asia	China	Summary of Maritime History
3500–2500 BC	Early Neolithic	Neolithic	Late Neolithic	Austronesian populations moved to Taiwan from the mainland coast and later expanded to Island Southeast Asia.
2500–1500 BC	Middle Neolithic	Neolithic	Bronze Age (Xia–Shang Dynasty)	Maritime exchanges circulated basalt and jade within the Austronesian communities in Taiwan and Island Southeast Asia.
1500–400 BC	Late Neolithic	Bronze Age Iron Age	Bronze Age–Iron Age (Shang–Zhou Dynasty)	
400 BC–AD 200	Transition Era	Iron Age Spread of Hinduism	Iron Age–Imperial Period (Warring States Period–Han Dynasty)	1. Indian Ocean trade expanded to Southeast Asia. 2. Jade exchange expanded to Mainland Southeast Asia and introduced exotic goods to eastern Taiwan. 3. China began its relations with overseas areas.
AD 200–1000	Early Iron Age	Indianized and Buddhist Kingdoms	Han–Song Dynasty	1. Commercial activities had largely increased in the China Seas. 2. A substantial material change emerged in Taiwan. 3. At the beginning of the tenth century, maritime routes became the major trade routes of China.
AD 1000–1624	Late Iron Age	Spread of Islam European Contact	Song–Ming Dynasty	1. Liberalization of shipping and privatization of exchange appeared. 2. More exotic goods appeared in lowland Taiwan. 3. Privatized exchanges were suddenly interrupted by Ming China in 1371. 4. Most trade was carried out in the form of smuggling and piracy. 5. Europeans explored and occupied offshore islands beginning in the 16th century.
AD 1624–1662	Dutch/Spanish Period	European Colonization	Ming–Qing Dynasty	Commercial trade was intensively carried out by Europeans.
AD 1662–1683	Kingdom of Tungning	European Colonization	Qing Dynasty	1. Ming was overthrown by the Manchu Qing. 2. Loyalist movements were active on the offshore islands.
AD 1684–1895	Qing Period	European Colonization	Qing Dynasty	1. Qing conquered the offshore islands and mostly concentrated on continental borders after that. 2. There were few official seafaring expeditions from China, but Han Chinese settlements increased in Taiwan.

In the middle of the first millennium AD, this flourishing cross-cultural trading would have enriched the early Iron Age cultures, since some societies reached their peaks during this period (e.g., Shisanhang). At the beginning of the second millennium, maritime transit patterns became the major trade route for China. Liberalization of shipping and privatization of exchange also increased. In Taiwan, exotic artifacts were also found in fairly large numbers at some coastal sites. The seafaring and overseas trade, however, were suddenly interrupted by the Chinese ban in 1371. This policy not only deprived Chinese and foreign merchants of trading freedom, but also influenced the Iron Age people of Taiwan who had heavily depended on trade items. For example, at some sites in northern Taiwan, the number of Chinese ceramics was larger than that of native pottery in the early stage of the late Iron Age (Sheng 1962), but the situation was reversed in the later period since the people had to restore pottery production due to the ban on overseas trade (Liu 2002b:129). In the seventeenth century, Ming/Qing China's continued lack of interest in overseas commerce led to the Asian seas falling under European control. Porcelain at this time in Taiwan showed a variety of foreign styles, including Chinese, European, Japanese, and Southeast Asian (Wang and Liu 2007). The new import of tobacco pipes additionally signified a larger, global trading network that connected Taiwan and the Americas through the European voyages (Wang and Liu 2007).

Although there is a chronological association between the two lines of evidence, very few Chinese sources documented trade with Taiwan prior to the seventeenth century. Chinese overseas trading partners were mainly in Northeast Asia (e.g., Japan, Korea), Mainland and Island Southeast Asia (e.g., Malaysia, Indonesia), South Asia (e.g., India), the Middle East (e.g., Iran), and North Africa (e.g., Egypt) (Huang 2003:31–33). The earliest text about Taiwan is also ambiguous. The island of *Liuqiu* (流求) has been mentioned in Chinese literature ever since the Sui dynasty, but it is controversial whether this island name refers to Ryūkyū or Taiwan (Schottenhammer 2011). Although a majority of historians considers *Liuqiu* to refer to Taiwan (e.g., Tsao 2000:40), some have argued that Taiwan was not recognized by the Chinese until the Ming (e.g., Chou 2007). I suggest the book *Dao Yi Zhi Lue* (島夷志略), written by the Chinese traveler Dayuan Wang in 1349, should be considered the earliest reliable text about premodern Taiwan. Wang started his journey from Penghu, Liuqiu, and then traveled to over a hundred places in South and Southeast Asia. In the section *Liuqui*, he mentioned a few places such as *Cuilu* (翠麓), *Chongman* (重曼), *Futou* (斧頭), and *Dashi* (大峙). These names are pronounced similarly to aboriginal villages and hills in the western lowland of central Taiwan (*Shalu* 沙鹿, *Niuma* 牛罵, *Hutou* 虎頭, *Dadu* 大肚).

Because Taiwan was only vaguely described in the literature, many historians have argued that Taiwan prior to the seventeenth century was generally bypassed by merchants and only visited by fishermen, shipwreck refugees, and international outlaws (e.g., Tsao 2002:43–44). Maritime trade with Taiwan was most likely carried out as a form of private exchange, performed by a small number of peddlers (Chen 2006:36, 44–45) and/or fishermen (Jiang 1984). The lack of reference to Taiwan trade has led to an assumption that the trading was sporadic and of low value, but this assumption appears to be challenged by the archaeological record. For example, the substantial change in artifact assemblages implies a frequent rather than sporadic interaction so that the foreign trade goods could be incorporated into aboriginal life. In addition, many of the exotic artifacts, such as glass beads, were made of unusual materials and were supposedly of high value, indicating this trade was likely sponsored by prefecture elites, although not organized by state. The merchants were probably also fishermen, but they were active sailors who navigated the waters in search of profit and trade.

2.4. Watercraft and Transportation of Maritime Exchange

As Renfrew noted, “rivers or seas, or indeed deserts, may be regarded either as barriers or as easy channels of communication according to the transport available” (1975:45). Hence, a systematic maritime exchange would require a certain level of shipbuilding technology. The watercraft used in the Neolithic Austronesian dispersal has been extensively studied in anthropological research. Their Pacific seafaring was carried out as a result of two technological breakthroughs: outrigger canoes and double-hulled canoes. The outrigger canoe is believed to have been invented in Island Southeast Asia, most likely in the Philippines (Blust 1999), and this watercraft contributed to successful journeys to Micronesia. The double-hulled canoe facilitated long-distance voyaging, allowing peoples to sail from Melanesia and settle in the eastern Pacific. However, no evidence indicates that outrigger canoes were adopted in Taiwan or mainland Asia. Thus, some studies proposed that the early seagoing vessels in Taiwan were probably developed from bamboo rafts (e.g., Rolett 2007), which were used for that purpose until the 1950s (Ling 1970).

Maritime transportation during the Iron Age would have involved advanced ship construction so that cross-regional trade could become possible. Seagoing trading ships are rarely documented in Chinese records prior to the Song, although China had built large warring vessels since the Han. However, Chinese sources in the middle of the first millennium (e.g., *Beiqishu*) document Southeast Asian trading ships, known as *Kunlun Bo* (崑崙舶), arriving with exotic goods. In the Tang record, the *Kunlun Bo* "with hulls constructed with wooden planks sewn together with cords made with the bark of coconut trees, were reported to have the capacity to transport 1000 men in addition to their normal cargo" (Ten 2014:41).

Underwater archaeology has revealed the earliest known shipwreck in the China Sea, which demonstrates a direct trade with China, at a site 2 nautical miles off the coast of Belitung Island, Indonesia. This ship, dated to the second quarter of the ninth century, estimated to be 18 meters long, exhibits Arabian/Indian construction, and was likely built in West Asia (Oman, Yemen, or Iran) (Flecker 2010; Wilson and Flecker 2010). Remarkably the ship's cargo included 70,000 Chinese Tang ceramics, bronze mirrors, gold and silver wares, and large quantities of star anise native to southern China and Vietnam (Flecker 2010). The Belitung ship appears to have been involved in commercial trade, en route from West Asia to China, which provides tangible evidence of the expanding maritime network.

There is extensive historical reference documenting advanced shipbuilding in Song China. Archaeologists have discovered the best-preserved shipwreck after the Common Era, on a sandy beach in Quanzhou, Fujian. This ship (Figure 2.2) is estimated to originally have been 34 m long and 11 m wide, with a wide shape, multiple planks, 13 compartments, a displacement of around 380 tons, and a V-shaped hull, which appears to show a capacity for oceanic voyaging (QCAT 1975). The Quanzhou ship would have been built locally in the Song dynasty since the structure of this ship is consistent with those documented in Song literature; the coins found at the site also suggest this ship sank in the late thirteenth century (Southern Song Dynasty). Additionally, both the fastening (with iron and luting seal) and ways of ensuring safety (with coins and bronze mirrors) are typical Quanzhou traditions (Zhuang and Zhuang 1987). The associated materials found with the wreck especially provide evidence of overseas trade as its main cargo (fragrant tropical wood) and other materials (e.g., cowries, cinnabar) appear to have been from Southeast Asia, the Arabian Peninsula, and even eastern Africa (QCAT 1987). Shell remains found attached to the wreck also suggest this ship had traveled to the Indo-Pacific region (Li 1987).

Figure 2.2. Reconstruction of the Quanzhou ship. (National Museum of Natural Science, Taiwan)

In Taiwan, no evidence suggests the natives had sailed out for commercial trade during the Iron Age. In the textual record, many accounts documented the Chinese junk sailed and traded in historic Taiwan, and these junks were often described as small, shallow-water crafts. However, it is important to note that most of these accounts appeared after the Ming ban on seafaring, mainly from the eighteenth to nineteenth centuries. As Green (1983) noted, the ban must have had a substantial impact on the construction of seagoing vessels, and watercraft after the fourteenth century were mostly designed for use on rivers and to sail close to shore. Therefore, although it is unclear what kind of ships were actually used in overseas trade, most of the commercial ships in the first millennium AD were likely from West, South, and/or Southeast Asia. The records of *Kunlun Bo* and the Belitung ship demonstrate the existence of such trade and, as Kung (2015:33) noted, "since *Bo* refers to foreign vessels that are suitable for sailing long distances, it implies that China's shipbuilding skills were less developed than those of the Kunlun at the time." Since the tenth century, it appears that Southeast China had greatly advanced in shipbuilding. Watercraft that transported commodities over Taiwan waters would have been primarily from China, with a structure like the Quanzhou ship.

Although there is evidence showing advanced technology for cross-regional trade, how the commodities were transported is ambiguous. Examples from other island environments may aid in contextualizing this. Two possible kinds of shipping have been proposed in the context of the Mediterranean: *destination-conscious shipping* and *tramping* (Braudel 1972:106–108; Sherratt and Sherratt 1991:357). Simply, destination-conscious shipping is the transportation of cargo directly from one point to another, while tramping is a type of slow-motion shipping from one port to another, often following coastlines (Braudel 1972:103–108). The majority of sea trade in the Mediterranean was in the form of tramping, with only large, specialized salt and grain ships traveling via destination-conscious shipping (Braudel 1972:107).

Shipping is heavily influenced by the marine and coastal environments, and Taiwan waters are notorious for their submerged reefs, fast currents, as well as strong seasonal monsoons and typhoons. As a result, it was impossible to sail far without touching land, especially when hundreds of islets are scattered around the island. Navigating along islets and coasts may also be the best strategy for sailors, since sailing close to shore can provide protection against winds, help avoid getting lost, and provide an opportunity for renewing supplies and water (Braudel 1972:107). Studies have shown that the Neolithic navigation style was tramping, with goods transported from one port to another along the coast and islands (e.g., Hung et al. 2007). Iron Age voyages may have been more varied, since the state-organized overseas trade documented in the literature may have been destination-conscious shipping. However, as reviewed earlier, Iron Age Taiwan was not a part of the official trade of China, suggesting that seafaring through Taiwan waters also likely included tramping. As reviewed in Chapter 1, a Dutch visitor in 1623 recorded that the Chinese sail from one place to the other along the coast in search of profit and trade (Blussé and Roessingh 1984:77). Moreover, although the commercial ships during that period, such as the Quanzhou ship, appear to have the capacity for oceanic voyaging, the variety of their cargo "could just as easily have resulted from tramping or even sustained cross-cultural trading partnerships" (Gould 2011:200).

2.5 Exports of Iron Age Taiwan

Tramping navigation often involves multiple transactions along the route. As Braudel (1972:107) noted, "the round trip, which could last several weeks or months, was a long succession of selling, buying, and exchanging, organized within a complicated itinerary." This raises a question: what commodities had been exported from Iron Age Taiwan? There is no literature documenting an exchange with Taiwan and possible export prior to the fourteenth century. As mentioned earlier, *Dao Yi Zhi Lue*, written in 1349, may be the earliest reliable text about premodern Taiwan. In the *Liuqiu* section, Wang recorded trade between the Chinese and native people wherein local plants, minerals, and animal furs were given in exchange for agate, jewelry, and ceramics.

Later literature describing trade was written by western shipwrecked refugees. In 1582, a Portuguese cargo ship was destroyed by a typhoon on its way from Macau to Japan. The surviving crew came to shore and spent two and a half months on an island. After returning to Macau, three missionaries on board wrote letters to colleagues about the incident, and, from their descriptions, the accident likely occurred on the central-western coast of Taiwan (Chou 2012:100–101). In one of the letters, written by Francisco Pírez, one paragraph specifically described how the indigenous peoples exchanged with the refugees:

> Once, there came some vessels sewn through with vines that they looked like matting. They brought us rice, squash, figs, and salted meat, among which was a paw of a bear. It was out of miscommunication or mistrust that they cut off the head of a gentile and left, never to be heard from again. In the strip further south, at the tail-end of the island, we heard about a port where two or three Chinese vessels would go to fish and buy skins. (Borao 2001:15)

Another source about Iron Age Taiwan was written by Chinese scholar Di Chen, who arrived in Taiwan in 1603 with Ming troops in order to expel pirates. His article *Dong Fan Ji* (東番記) described what he observed about aboriginal life during his twenty-day visit to the southwestern coast. In his record, deer products were used to trade with the Chinese for ceramics, cloth, salt, copper, and jewelry.

These three texts are the only ones known to exist that describe the Iron Age people prior to Dutch arrival. Although limited, all the documents mentioned trade between the Taiwanese and Chinese, using local wild resources in exchange for necessary and luxury goods (Table 2.2). Among the articles, deerskin (Figure 2.3) was most frequently documented and thus was likely the main export. Compared to jade, deer products were apparently "alienable" (see Chapter 1). Unlike jade material that is naturally available only in the eastern part of this island, deer were reportedly abundant and widely distributed. For example, in the *Dong Fan Ji*, Chen documented that "they [deer] are running and walking around, with a herd consisting of hundreds and thousands of individuals."

Table 2.2. Iron Age Taiwan maritime trade in early texts.

Year	Author	Location	Exports	Imports	Reference
1349	Da-Yuan Wang	Probably central-western coast	Gold dust, sulfur, soybean, cereal, wax, deerskin	Agate, beads, gold, bowls, ceramics	*Dao Yi Zhi Lue*
1582	Francisco Pírez	Probably central-western coast	Animal skin		Borao 2001
1603	Di Chen	Tayouan (southwest coast)	Deer meat, skin, antler	Agate, ceramics, cloth, salt, copper, jewelry	*Dong Fan Ji*
1623	Anonymous Dutch visitors	Tayouan (southwest coast)	Deer meat, skin	Salt, rice, Chinese tobacco	Blussé and Ressingh 1984
1628	George Candidius	Sinckan (southwest coast)	Rice, deer meat, deerskin	Cloth, salt	Blussé et al. 1999

In addition to their abundance, deerskins are easily preserved and transported over water, making them suitable for overseas trade in the eyes of foreign merchants. By the time of Dutch arrival, deer products in the southwestern coast were primarily used as an export to trade with the Chinese, instead of for local consumption (see Blussé et al. 1999: Ⅰ:117). The Dutch also estimated that there were more than 1,000 Chinese traders settled in aboriginal villages and 200,000 deerskins exported from Taiwan annually (see Blussé et al. 1999: Ⅰ:21, 37). These records indicate deerskin may have been a main export commodity, though it was not used as a currency in the exchange (Shepherd 1993:36).

Figure 2.3. Deerskin as coat lining. (National Museum of Prehistory, Taiwan)

Despite the evidence showing a deerskin trade between the Taiwanese and Chinese, where the Taiwanese deerskins were actually consumed remains unclear. In the Song records, China seems to have largely relied on the domestic supply of furs, and such trades were mainly carried out with its northwestern frontiers. Japan, on the other hand, imported a large amount of deerskin for making samurai armor, due to civil wars starting in the fifteenth century (Shepherd 1993:38). In addition to Southeast Asia, Taiwan also exported deerskin to Japan, with Chinese and Japanese merchants serving as middlemen in the international trade (see Andrade 2005; Tsao 2011). The economic profit of deerskin in the international market appears to have interested the Dutch colonists, who immediately showed a strong intention to take it over from the Chinese merchants (see Blussé et al. 1999: Ⅰ:32).

2.6 Summary

This chapter reviews the archaeological and historical evidence that were used to formulate the three hypotheses presented in the first chapter, demonstrating that commercial maritime trade developed around Taiwan waters. In the Neolithic, both basalt and jade were circulated within Austronesian maritime communities. Jade exchange with the Philippines later expanded to Mainland Southeast Asia, and introduced exotic items into southeastern Taiwan around 400 BC. Since AD 200, a substantial change in trade items is apparent on an island-wide scale and became more dramatic in the second millennium AD. This transition is chronologically associated with the expanding overseas trade that linked South Asia, Southeast Asia, and China, as well as the economic transformation of Southeast China during the Tang-Song interregnum. The additional Chinese materials after the early Iron Age indicate a cross-cultural, market-based maritime exchange, which is essentially different from the Austronesian jade network. The substantial change in the material record also suggests maritime trade with Iron Age Taiwan was frequent and intense, although it is seldom documented in literature.

Underwater archaeology of shipwrecks also provides tangible evidence of the cross-cultural trade and implies a change from Indian/Southeast Asian to Chinese dominance after the second millennium AD. The mode of transport was likely tramping along the islands and coast due to the complex environment of Taiwan waters. Based on the textual record and the principle of alienability, deerskin would have been the main export commodity of Iron Age Taiwan. Later, the Dutch colonists noticed the profit of deerskin in the international market and immediately showed a strong intention to take over the trade. Unlike the Chinese traders tramping in search of opportunity, the Dutch explorers successfully established a colony to monopolize the export economy of southwestern Taiwan. Deerskin trade in the southwest had entered a new dimension with the Dutch franchise system.

CHAPTER 3. ANIMAL RESOURCE PROCUREMENT IN PREHISTORIC TAIWAN

In Chapter 2, I propose that deerskin was an ideal commodity due to its alienability since deer were a mobile, abundant resource and difficult to control. In addition to a resource, deerskin was also alienable in terms of production. In this chapter, I first review archaeological studies to discuss resource procurement and argue that hunting was an important part of prehistoric subsistence. Unlike the Dutch commercial trade with financial and military support from the state, the deerskin trade in Iron Age Taiwan would heavily rely on indigenous hunting and hide production. The tradition of hunting, therefore, provided an underlying condition for a commercialized deerskin production. Then, the faunal records of Taiwan are reviewed to hypothesize a simple prey rank for Iron Age Taiwan. Based on the prey choice model, deer should be the highest ranked resource in the hunting economy, and become more important as maritime trade expanded. Finally, this chapter also reviews the textual and ethnographic records of deer hunting to provide a baseline for reconstructing Iron Age hunting, which can be examined later by analyzing the mortality profile of prey.

3.1 Subsistence in Prehistoric Taiwan

In the past, prehistoric subsistence in Taiwan was often described as a mixed economy, with agriculture as the main strategy and hunting-gathering as secondary. This description was probably derived from material records since a large amount of potsherds and agricultural tools were often found at archaeological sites. Biological remains, on the other hand, have received less attention in Taiwan archaeology. This lack of interest may result from the problem of preserving and collecting biological remains since Taiwan's high temperature and humidity are unfavorable for sample preservation. Since the 1990s, there has been increasing attention paid to collect floral and faunal remains during excavations in order to reconstruct prehistoric diets. At several Neolithic and Iron Age sites, a large quantity of domestic rice and millet grains have been discovered, suggesting cereal cultivation was a major component in prehistoric subsistence. (e.g., Ho and Chu 2005; Tsang et al. 2006). Archaeologists also proposed possible dry-land agriculture and occasional small-scale swamp cultivation for farming in prehistoric Taiwan (e.g., Bellwood 2012).

In addition to farming, archaeologists are also interested in exploring animal husbandry since it is often seen as an indicator of agricultural improvement. Humans have a long history of animal husbandry, but very few species have been domesticated. Scholars, therefore, endeavor to explore which attributes of animal species are necessary for successful domestication. Diamond (2002) proposed six criteria that make animal species suitable for domestication: easily supplied by humans, docile by nature, have a fast growth rate and short birth spacing, can be bred in captivity, be comfortable with leader-dominance hierarchies, and have no strong tendency to panic in enclosures or when threatened.

Among the mammals of Taiwan, pigs and dogs are often considered as good candidates for domestication. Several zooarchaeological studies have proposed that pig husbandry in Taiwan may have gradually developed from the Neolithic to the Iron Age. For example, pig remains from a mid-Neolithic site (Chihshanyen, 1500 BC) were mostly wild (Chiu 2002a), while pigs from the Iron Age Shisanhang site (AD 200) suggested a high possibility of pig husbandry (Chiu 2002b; Lin 1997). A recent study (Li et al. 2015) on pig remains from several archaeological sites in southern Taiwan also supports that argument, as domestic pigs did not appear in southern Taiwan until AD 500 (early Iron Age). In addition to pigs, it is also reported that the dogs found at the early Neolithic Nankuanli and Nankuanli East sites were probably domesticated species, and their remains are the most abundant mammal remnants at the sites (Li 2013). On the other hand, the last criterion proposed by Diamond rules out most deer species as they often become anxious in enclosures and hard to control. Therefore, although some deer species have been domesticated in other parts of the world (e.g., reindeer), no evidence suggests that the indigenous people of Taiwan attempted to domesticate deer, even at the height of the deerskin trade during the Dutch period.

It appears that the prehistoric Taiwanese were agriculturalists, with pig husbandry developing during the Iron Age. However, I suggest it is premature to conclude farming and animal husbandry were the main subsistence strategies of prehistoric Taiwan based on the cultural and biological remains. For instance, the lithic assemblages showing a high proportion of agricultural tools are potentially biased since other subsistence articles may not have entered the archaeological record. The biological evidence may also be biased. Cereals, for example, tend to produce enormous amounts of grain while other plant species may not. Grains have hard parts that can be preserved well when carbonized, but plant species without hard parts would produce little garbage in residential areas. Therefore, the significance of farming cannot be determined solely based on the raw count of floral remains. In addition, although pig husbandry may have been present in the Iron Age, the relative importance of domestic pigs in those prehistoric societies is unclear. The importance of domestic dogs at Nankuanli and Nankuanli

East is also ambiguous. These dogs were found complete in burials and may have been used as non-food resources (Tsang et al. 2006:135), which would increase the completeness of dog remains and substantially skew the relative frequencies of taxa.

Osteological evidence provides an alternative point of view regarding prehistoric subsistence in Taiwan. Studies of human skeletons from several early Neolithic sites suggest the people engaged in long-distance walking associated with a hunting-gathering lifestyle (Chen and Chiu 2009; Chu and Yen 2016; Pietrusewsky et al. 2013). Dental analyses of these skeletons also indicate a low starch/sugar diet, although rice remains were discovered at both sites (Chu 2016; Tsang et al. 2006). Pietrusewsky and Tsang (2003) examined the skeletons from the Iron Age Shisanhung site, and their overall good dental health also suggests subsistence with low-level agricultural dependence. Compared with the Neolithic skeletons from Nankuanli East, the overwhelming similarity in dental health between the two populations likely resulted from a similar subsistence economy based on a mixed strategy (Pietrusewsky et al. 2013).

The bioarchaeological studies suggest foraging played an important role in prehistoric subsistence. Compared to farming and animal husbandry, however, foraging receives little attention in the subsistence studies of Taiwanese archaeology. The research focus of foraging is predominately on marine resources. For example, Li (2002) shows that there was an intensification of fishing in the Neolithic southern tip of Taiwan, and later proposed that shellfish collecting at these sites was seasonal (Li 2005). Evidence from many coastal sites also has revealed a high abundance of fish bones and shellfish remains, suggesting marine foods were more essential to the diet than other resources. However, as with farming and pig husbandry, the importance of marine resources in the prehistoric diet is also ambiguous. Not only is the importance of shellfish in relation to terrestrial animals difficult to quantify, but the large amount of fish and shellfish remains may have resulted from few events of collection and consumption. As shown by an isotopic study of human remains from the coastal Fanziyuan site, the Iron Age people had a diet mainly composed of terrestrial animals, with only a minor component of marine shellfish (Lee et al. 2017).

In light of osteological and isotopic evidence, I suggest prehistoric Taiwan subsistence should be reevaluated as hunting terrestrial animals may have been an important component in the subsistence economy. Therefore, unlike jade artifacts that required advanced skill in manufacture, the supply of deerskin could be built upon household activity, requiring no esoteric knowledge for hunting and hide production. This tradition would have provided an incentive to skilled hunters to engage in the trade. However, Iron Age people must have enacted a series of changes for the fur trade, including harvesting more fur-bearing animals, especially deer. In the next section, I review the faunal records of Taiwan, as well as the characteristics and significance of archaeofauna, in order to hypothesize a prey rank for Iron Age Taiwan.

3.2 Animal Resources in Prehistoric Taiwan

Faunal remains are not uncommon at most archaeological sites in Taiwan. Although in the past they were seldom systematically collected, identified, and analyzed, the published records provide a generic picture of the faunal composition of prehistoric Taiwan. Chen (2000b) reviewed the faunal records published in the past eighty years and summarized three kinds of faunal records in Taiwan: remains deposited by natural forces (Pleistocene fauna), remains produced by human exploitation (archaeological fauna), and animals documented in historical accounts (documented fauna). In this section, I briefly review the three fauna and the characteristics of archaeological fauna to hypothesize a prey rank in the Iron Age.

3.2.1 Pleistocene Fauna

The Pleistocene fauna in Taiwan are generally divided into the Zuozhen Fauna and Taiwan Landbridge Fauna (Table 3.1), according to the date and species composition. The Zuozhen Fauna refers to the early–mid-Pleistocene animal fossils discovered on the riverbeds of Cailiao Stream in the Zuozhen area of Tainan City (Chen 2000b), while the Taiwan Landbridge Fauna refers to the late-Pleistocene fauna mainly collected from sea trawling in the Taiwan Strait (Chen 2000b; Ho 2004a). The two fauna share several species, such as deer and wild boar, but the composition of Taiwan Landbridge Fauna is more diverse, additionally including mammoths, water buffalo, and horses. Surprisingly, most of the species in the Landbridge Fauna are considered to inhabit northern China, rather than a subtropical environment like modern Taiwan. Chen (2000b) proposed such composition may result from a dramatic climate change since the mid-Pleistocene, causing some northern animals to migrate southward during the last Ice Age. Later, at the end of the Pleistocene, a warmer climate triggered another large-scale northward migration. Some species went extinct, while others remained in Taiwan and became the ancestors of modern animals. However, these fossil records cannot provide a complete picture of the faunal composition in Pleistocene Taiwan. As shown in Table 3.1, most of the identified species had a large body size, which appears to have resulted from recovery bias.

Table 3.1. Number of species identified in the Zuozhen and Taiwan Landbridge Faunas (summarized from Chen 2000b).

Taxon	Zuozhen Fauna	Taiwan Landbridge Fauna
Proboscidea		
Stegodontidae	5	–
Elephantidae	3	4
Artiodactyla		
Cervidae	9–12	10
Bovidae	3	6
Suidae	5	2
Hippopotamidae?	1	–
Perissodactyla		
Rhinocerotidae	1	2
Tapiridae	1	–
Equidae	–	2
Carnivora		
Felidae	2	1
Ursidae	–	2
Hyaenidae	–	1
Canidae	–	2
Primates		
Cercopithecidae	1	–
Cetacea		
Delphinidae	2	2
Cetartiodactyla		
Balaenoptiidae	–	1

3.2.2 Archaeological Fauna

The faunal composition of Taiwan displays a new dimension after the ancient Austronesians moved into the island around 6,000 years ago. This dispersal produced an unprecedented human culture and reshaped the landscape of Holocene Taiwan. The composition of Holocene fauna was mainly understood by archaeological excavations and hence is also called archaeological fauna (Chen 2000b). The mammalian species of archaeological fauna are limited to just a few, and there was no substantial change in faunal composition until the seventeenth century (Chen 2000b). Table 3.2 shows the terrestrial mammals that have been identified in previous studies (e.g., Chen 2000b; Chu et al. 2011; Chu et al. 2015; Ho et al. 1998;

Ho and Chu 2005; Ho and Liu 2005a; Li 2013; Liu 2013a, 2013b). Apparently, the archaeological fauna is limited to only 16 species. Such low diversity may be attributed to prey selection, bad preservation, sample collection, and/or incomplete identification (Chen 2000b).

Table 3.2. Terrestrial mammals in the archeological fauna of Taiwan.

Order	Family	Scientific Name	Common Name
Artiodactyla	Cervidae	*Cervus nippon taiouanus*	Sika deer
		Cervus unicolor swinhoei	Sambar deer
		Muntiacus reevesi micrurus	Reeve's muntjac
	Suidae	*Sus scrofa taivanus*	Wild boar
Carnivora	Viverridae	*Viverricula indica taivana*	Small Chinese civet
		Paguma larvata taivana	Gem-faced civet
	Herpestidae	*Herpestes urva formosanus*	Crab-eating mongoose
	Canidae	*Canis lupus familiaris*	Dog
	Felidae	*Prionailurus bengalensis*	Leopard cat
	Mustelidae	*Meles meles*	Badger
		Lutra lutra chinensis	Otter
Lagomorpha	Leporidae	*Lepus sinensis formosanus*	Hare
Primates	Cercopithecidae	*Macaca cyclopis*	Macaque
Pholidota	Manidae	*Manis pentadactyla pentadactyla*	Chinese pangolin
Rodentia	Muridae	*Rattus losea*	Brown country rat
		Bandicota indica	Bandicoot rat

3.2.3 Documented Fauna

As reviewed in Chapter 2, European colonization and subsequent Chinese immigration introduced a commercial deerskin trade and an intensified agricultural economy to Taiwan after the seventeenth century. Faunal records during this period are very scant in archaeological source materials, but can be understood from official and private accounts (Chen 2000b). Most archaeological species still existed in the early historical period, but the new settlers also introduced some exotic species such as cattle. In the latter half of the nineteenth century, an

English diplomat, Robert Swinhoe, was the first to systematically record and collect mammalian and bird species during his visits to the northwestern and southwestern areas. Table 3.3 shows the terrestrial mammals he published in 1862 and 1870 (Swinhoe 1862, 1870). Most of the recorded species still exist in modern Taiwan, with the exception of the clouded leopard that has not been seen in decades and was officially announced as extinct in 2013.

Table 3.3. Terrestrial mammals of Taiwan recorded by Swinhoe.

Order	Family	Scientific Name*	Common Name
Artiodactyla	Cervidae	*Cervus nippon*	Sika deer
		Cervus unicolor	Sambar deer
		Muntiacus reevesi	Reeve's muntjac
	Suidae	*Sus scrofa*	Wild boar
	Bovidae	*Capricornis swinhoei*	Serow
		Bos taurus	Cattle
Carnivora	Viverridae	*Viverricula indica*	Small Chinese civet
		Paguma larvata	Gem-faced civet
	Felidae	*Prionailurus bengalensis*	Leopard cat
		Neofelis nebulosa	Clouded leopard
		Prionailurus viverrinus	Fishing cat
	Mustelidae	*Melogale moschata*	Ferret badger
		Martes flavigula	Yellow-throated marten
		Mustela sibirica	Siberian weasel
	Ursidae	*Ursus thibetanus*	Black bear
Lagomorpha	Leporidae	*Lepus sinensis*	Hare
Primates	Cercopithecidae	*Macaca cyclopis*	Macaque
Soricomorpha	Talpidae	*Mogera insularis*	Mole
Chiroptera	Hipposideridae	*Hipposideros bicolor*	Bicolored roundleaf bat
	Vespertilionidae	*Myotis rufoniger*	Mouse-eared bat
		Pipistrellus pipistrellus	Common pipistrelle bat
Soricomorpha	Soricidae	*Suncus murinus*	Asian house shrew
		Sorex sp.	Small shrew
Pholidota	Manidae	*Manis pentadactyla*	Chinese pangolin
Rodentia	Sciuridae	*Callosciurus erythraeus*	Red-bellied tree squirrel
		Tamiops swinhoei	Striped squirrel
		Tamiops mcclellandii	Himalayan striped squirrel
		Petaurista philippensis	Giant flying squirrel
		Petaurista alborufus	Red-and-white flying squirrel
		Sciuropterus kaleensis	Small flying squirrel
		Belomys pearsonii	Hairy-footed flying squirrel
	Muridae	*Bandicota indica*	Bandicoot rat
		Rattus norvegicus	Brown rat
		Rattus rattus	House rat
		Niviventer coninga	Coxing's white-bellied rat
		Rattus tanezumi	Asian house rat
		Rattus losea	Brown country rat
		Mus musculus	House mouse

*Scientific names are based on modern classifications.

3.2.4 Characteristics and Significance of the Archaeological Fauna

Although limited, the species of archaeological fauna (Table 3.2) provide a list of the potential species that Iron Age people exploited. In this section, I review the characteristics and significance of these species, including their habitat, behavior, past use, and current status to hypothesize a prey rank of Iron Age people. Past uses of these animals are summarized from relevant Chinese and Dutch literature.

1. Cervidae

There are three deer species present in the current archaeological record: sika deer, sambar deer, and Reeve's muntjac. These species are also the only cervids in modern Taiwan, but it has been debated if there were more deer species in the past since there are at least a dozen different names referring to Taiwanese deer in Chinese literature (e.g., *lu, zhang, ji, mi, shanma*). However, it is believed that most of these names refer to the three deer species—sika, sambar, and muntjac (Chen 2000b)—and most *lu* (鹿), the generic term for the deer family in Mandarin, in the texts refer to sika according to the description of its spotted markings.

The Formosan Sika Deer (*Cervus Nippon taiouanus*) is a subspecies of the sika deer endemic to Taiwan (Figure 3.1). They are well known for their beautiful, white-spotted coat and thus are called "Plum-blossom Deer" in modern Chinese. This species was widely distributed throughout the entire island in the past, and their remains are also found at many archaeological sites (Chen 2000b). However, wild populations rapidly decreased in the past several centuries due to the commercial deerskin trade and habitat loss. As no wild sika deer have been recorded since 1969 (McCullough 1974), the habitat they preferred can only be known from existing records. Sika deer in other regions are highly adaptable and can live in many types of ecosystems (Wang 1985), but based on textual evidence, sika deer in Taiwan likely lived in open woodlands and grasslands at altitudes under 300 meters (Su 1985), with the prime habitat being the low-lying alluvial plain along the western coast. These areas are covered predominantly by semi-deciduous forests (Su 1985). Grass is also vital to sika deer survival since they are a mixed feeder, with both grazing and browsing habits. It appears that the mountain area was not suitable for the sika deer's gregarious social nature, as well as its mixed-feeding habits, due to a lack of grassland and deciduous forest (Su 1985). This geographic preference also explains why sika deer were unable to migrate high in the mountains during their decline. In 1984, a reintroduction program was created that released nearly 50 sika deer in Kenting National Park. These individuals were mainly selected from the captive group in the Taipei Zoo (Wang 1999), which are considered the descendants of past wild populations. Today, the deer population in that national park is estimated to be over 800 (Wang 2010).

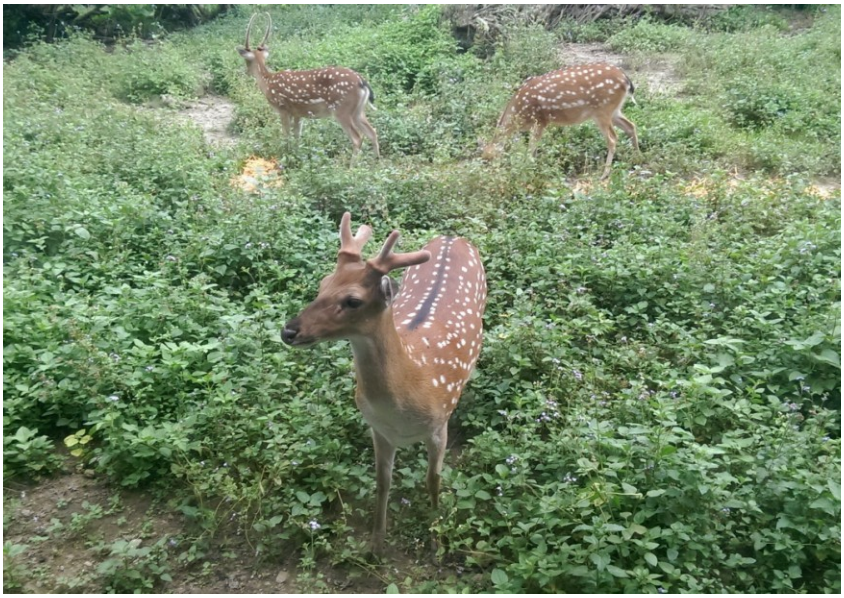

Figure 3.1. Sika deer in Taipei Zoo.

The Formosan Reeve's Muntjac (*Muntiacus reevesi micrurus*) is a subspecies of the Reeve's muntjac, which is also endemic to Taiwan (Figure 3.2). Reeve's muntjac, named after the English naturalist John Reeves, is a muntjac species widely distributed in southeastern China and Taiwan. The muntjac is a small-sized cervid and is also known as the "barking" deer for its distinctive dog-like barking. The Formosan muntjac can be found throughout Taiwan, ranging from sea level to an elevation of 3000 meters (Cheng 2004:70). They prefer broadleaf and mixed forests with some gaps in the dense canopy cover, and feed on tender grasses, leaves, and shoots (Cheng 2004:70). In general, the preferred habitat and diet of muntjac deer are similar to those of the sika deer, though there are some behavioral differences between the two taxa. Unlike sika deer, muntjac are solitary animals without seasonal rutting. Births of muntjac can occur every month of the year, but Pei and his colleagues (1995) found that the Formosan muntjac, as sika, has a pronounced peak of birth in the summer months, from June to August. Formosan muntjac can now only be seen in mountain areas (800–2500 meters above sea level). Although not endangered, they are protected by law, with illegal hunting reported from time to time.

Figure 3.2. Reeve's muntjac in Taipei Zoo.

The Formosan Sambar Deer (*Cervus unicolor swinhoei* or *Rusa unicolor swinhoei*) is the largest deer species (Figure 3.3), as well as the largest wild herbivore, in modern Taiwan. This species now can only be seen in the mountains at least 1500 meters above sea level (Cheng 2004:72), but it is believed that it may once have lived in the lowland areas as their remains are occasionally found at coastal sites (Chen 2000b). Sambar are often concentrated in the woodlands near water and feed on a wide variety of vegetation. Although there has been an increase in wild populations, sambar are still considered a vulnerable species in Taiwan.

Figure 3.3. Sambar deer (left), sika deer (center), and muntjac (right) in Taipei Zoo.

These three deer species were probably the most important animal resources for prehistoric peoples of Taiwan. As reviewed in Chapter 2, historical records have shown that deer was abundant in lowland areas, and in these records, deer products were used as sources of meat, marriage payment, and compensation (Tsao 2011:126–132). Additionally, tools manufactured from deer bones and antlers have been found at archaeological sites. Deerskin was also used for a wide range of occasions in aboriginal societies. For example, a paragraph in an early seventeenth-century account vividly describes how deerskin was used in a native house. This unsigned text was written in 1623 by a western visitor who had visited a village in southern Taiwan:

> The treasures of their houses are (apart from the above mentioned canisters with assorted cloth) deerskins, which they place before each other in their gatherings, to sit on or to sleep on; they also display their assegais and their broadswords or choppers, with a grip covered with deerskin. (Blussé and Roessingh 1984:73)

As reviewed in Chapter 2, historical accounts document that deer products were the main exports during the Iron Age, especially deerskin. Although it is unclear which deer species the texts are referring to, they are commonly considered to be sika. However, muntjac and sambar skins are also occasionally documented as an exported article in the commercial skin trade (see Chen 2000b).

2. Suidae

The Formosan Wild Boar (*Sus scrofa taivanus*) is a subspecies unique to Taiwan (Figure 3.4). As omnivores, they are highly adaptable and widely distributed on the island. Their habitats can be grassland, farmland, and woodland, spanning from lowlands to an elevation up to 3000 meters. With a long snout and a good sense of smell, they dig into the ground in search of food and often cause damage to crops, which makes them an agricultural pest. As an unprotected animal, they are also a common prey for hunters and have experienced a rapid decrease in wild populations in recent years (Wu 2009).

Pigs were also an important resource in prehistoric times and are often considered as the best candidate for domestication. As reviewed earlier, pig husbandry in Taiwan was probably developed in the Iron Age. Such practice is also frequently documented in literature. For example, Swinhoe (1870) recorded domesticated pigs in aboriginal villages, which he believed derived from wild stock in Taiwan. He also noted that there were other breeds introduced by the Chinese and Dutch colonists. However, in these records, pigs were not predominantly used as a food source, but instead were used in a wide range of social occasions as gifts, compensation, ritual offerings, festival food, and marriage payments (e.g., Blussé et al. 1999). Today, pigs still have some ceremonial significance in the aboriginal societies of Taiwan.

Figure 3.4. Wild boar in Taipei Zoo.

3. Carnivores

Carnivores have the highest diversity in the archaeological fauna. Among them, Dog (*Canis lupus familiaris*) especially interests archaeologists, since, as pigs, they were an animal species that may have been domesticated. There are no wild canine species in modern Taiwan

(Cheng 2010), and thus the earliest dogs were probably introduced by the Neolithic populations around 6000 years ago. Dog remains have been occasionally discovered at archaeological sites (e.g., Chu 2016), but most of them are fragments found with other waste. However, as mentioned earlier, excavations at the early Neolithic Nankuanli and Nankuanli East sites in southern Taiwan recovered at least six complete dog skeletons (Tsang et al. 2006:135). These dogs, therefore, were probably a domesticated species (Li 2013) used as a non-food resource (Tsang et al. 2006:135). Historical accounts also documented dogs as a hunting companion, which may explain the dog burials at Nankuanli.

Except for dogs, most other carnivores are considered to be species of the forest edge, which refers to the species living in the mixed habitat of forests and open lands. These carnivores have a relatively small body size and are mostly solitary and/or nocturnal. Among the small carnivores, the Badger (*Meles meles*) is especially important since it has never been seen on the island, nor has been recorded in any documents. The badger is widely distributed in Eurasia and can be present in many ecosystems, including forests, shrubs, open fields, graveyards, and near rivers. It is a nocturnal, burrowing animal that sleeps during the day in its sett. Although classified as a carnivore, the badger is in fact an omnivore, feeding on a variety of plants and animals. This highly adaptable animal is now extinct in Taiwan and endangered in China. The decline of the badger appears to be highly associated with human expansion as their diet diversity is found to be positively correlated with human interference (Li et al. 2013). In developed regions, badgers would expand their foraging range to cultivated lands and could be very troublesome for farmers. Therefore, the extinction of the badger in Taiwan may have resulted from the Han Chinese expansion in the past several hundred years. By the time Swinhoe arrived in the 1860s, no badgers were seen on the island.

As the badger, the Otter (*Lutra lutra chinensis*) is also a mustelid species. It is a semiaquatic, mostly solitary and nocturnal animal. They hunt prey in the river or the sea and have a diet based on fish and invertebrates. In Taiwan, they used to be widely distributed on the riverside at altitudes under 1500 meters (Cheng 2004:56), but now are also rare and endangered.

The other three carnivores are crab-eating mongoose, small Chinese civet, and gem-faced civet. Crab-eating Mongooses (*Herpestes urva formosanus*) are often found in forests near streams, as well as in holes they burrow. This animal is considered to be a good swimmer and skilled at hunting small animals in the water. Despite their name, their diet consists of any small animals they can catch, rather than solely of crab. It is now a rare and vulnerable species in Taiwan, and as a near-water animal, their decline is believed to result from water pollution (Cheng 2004:64). The Small Chinese Civet (*Viverricula indica taivana*) and Gem-faced Civet (*Paguma larvata taivana*) are nocturnal, solitary animals that are active in broadleaf forests (Cheng 2004:60; Ju and Pei 2014). Their diets primarily consist of insects, small reptiles, rats, and sometimes plants (Cheng 2004). Although they have been listed as protected species, research and conservation of these species is limited. Few studies have been conducted on these animals due to their solitary lifestyle, and, thus, population sizes in the wild are largely unknown (Cheng 2004:60).

As a species of the forest edge, these carnivores can become vulnerable when the forest in which they live is on the edge of developed land. The Leopard Cat (*Prionailurus bengalensis*) is one such example, and has become a high-profile species in recent years due to its vulnerability to suburban expansion. Leopard cats are nocturnal, solitary animals and good at hunting, swimming, and tree climbing. They are almost entirely carnivorous, feeding on small mammals, birds, and amphibians (Cheng 2004:68). Compared to other forest-edge species, leopard cats require a larger foraging range and thus are more sensitive to habitat fragmentation caused by land development (M. T. Chen 2015). This animal is now listed as an endangered species and requires immediate protection and conservation.

Except for gem-faced civet, it is documented that furs of these small carnivores were often used for making writing brushes or coat linings. As a result, their furs were sometimes exported and even used as currency in the historical period (Chen 2000b). Badger products were additionally used in Chinese medicine (Chen 2000b), which may also have contributed to their extinction in historical Taiwan.

4. Lagomorpha

The only species identified in this order is the Formosan Hare (*Lepus sinensis formosanus*), a subspecies endemic to Taiwan. In general, its habitat ranges from the lowlands to the high mountains, but it is mainly distributed in areas less than 500 meters above sea level. Limited studies show that the hare is mostly a nocturnal, solitary, and highly adaptable animal. They can survive in many habitats, such as swamps, grasslands, and abandoned farmland, and feed predominantly on newly sprouted grass and young leaves (Chen and Lue 1993; Ma 1996). Today, their population size is fairly large in the wild and they remain a popular prey for indigenous hunters (Ma 1996). Hare were also recorded as a source of meat for ancient Taiwanese, as well as an export article in the fur trade (Chen 2000b).

5. Rodentia

There are only two species identified in Rodentia: the Brown Country Rat (*Rattus losea*) and the Bandicoot Rat (*Bandicota indica*). Both are commonly seen in Taiwan, China, and Mainland Southeast Asia. The brown country rat, also known as the lesser rice-field rat, is the most widely distributed rat species in farmlands and rice fields. The bandicoot rat is the largest rat on the island, weighting up to 1000 grams. They both are nocturnal omnivores, and mostly feed on crops, seeds, and insects. Both of these rat species are often found in cultivated lands and can cause a great loss of agricultural crops. Rats were sometimes used as a food source in prehistoric and historic Taiwan (Chen 2000b; Ho et al. 1998).

In archaeology, the distribution of rats can also be valuable to study the history of human migration because many rats are commensal in human settlements. For example, the distribution of the Polynesian Rat (*Rattus exulans*) has contributed to the reconstruction of the dispersal pattern and settlement process of Pacific peoples (e.g., Matisoo-Smith and Robins 2004). Although rat remains are commonly discovered at archaeological sites in Taiwan, only the brown country rat and bandicoot rat have been identified in past studies (e.g., Chen 2000b; Ho et al. 1998, 2004). There is no sign of the Polynesian rat in prehistoric Taiwan, and this rat species has only recently been found and identified in the eastern area in 2001. Genetic analysis suggests these exotic rats were introduced from Mainland Southeast Asia and the Malay Archipelago (Chu et al. 2007). Their invasion was likely unintentional, brought by modern cargo ships from Southeast Asia (Chu et al. 2007). The bandicoot rat was also once assumed to be introduced by the Dutch in the 1630s (Swinhoe 1870). However, their remains were recently discovered at the early Neolithic Anhelu site (Chu 2016); fossil records also show they have existed in Taiwan since the mid-Pleistocene (Mao 2003). Both archaeological and genetic evidence (Chen 2009) suggest that the presence of the bandicoot rat is not a result of recent introduction; rather it may have been a native species of Taiwan.

6. Other Species

The Formosan Macaque (*Macaca cyclopis*) is a species endemic to this island and is also the only wild non-human primate living in modern Taiwan. The macaque is a gregarious, mostly arboreal, and omnivorous animal. They often live in the forest ranging from an elevation of 100 to 3200 meters, with a diet consisting of fruits, tender leaves, buds, and insects (Cheng 2004:50). In the past, they were hunted for food and for medicinal use (Chen 2000b). Recently they have increased in population size due to protection, but they also sometimes cause damage to agricultural crops.

The Chinese Pangolin (*Manis pentadactyla pentadactyla*) is the only known mammal in Taiwan with large, protective scales. They are nocturnal, mostly solitary, and burrowing animals, feeding mainly on ants and termites (Cheng 2004:52). In Taiwan, pangolins often live in the forest from 300 to 1000 meters above sea level. Their population size has decreased as a result of habitat loss (Cheng 2004:52) and being hunted for their scales (Chen 2000b).

3.3 Prey Rank of Iron Age People

The characteristics and significance of the archaeological fauna reviewed above provide necessary information to hypothesize the prey rank of Iron Age people. I hypothesize prey rank based on the prey choice model. The prey choice model is one of the optimality models that assess the costs and benefits of different strategies available to foragers. The basic assumptions are: 1) foragers search for prey randomly and rank resources on energy return rate; 2) foragers attempt to maximize their energy return rate by adding resources into their diet in rank order from highest to lowest; 3) foragers should always exploit high rank resources; the lower rank resource is included depending on the chance of encountering higher rank resources rather than its own abundances (see Lupo 2007). Energy return rate is often calculated with calories obtained per unit of handling time that includes "the time spent pursuing, processing, and consuming the prey after it has been encountered" (Lupo 2007:147). Therefore, to hypothesize prey rank in the Iron Age, a body size category for Taiwan archaeofuana should be first established to evaluate the energy return rate.

Beisaw (2013) categorized mammal species into five size classes by body weight:

Size 1 or small mammal (<50 lb or 22.68 kg), such as a rabbit

Size 2 or medium mammal (50–250 lb or 22.68–113.4 kg), such as a pig

Size 3 or medium-large mammal (250–750 lb or 113.4–340.19 kg), such as a deer

Size 4 or large mammal (750–2000 lb or 340.19–907.18 kg), such as a cow

Size 5 or very large mammal (>2000 lb or 907.18 kg), such as an elephant

The largest animal identified in previous archaeological studies (Table 3.2) is the sambar deer, weighing up to 770 lb, and thus regarded as a "medium-large mammal" in Beisaw's classification. Sika deer and wild boar, weighing under 250 lb, can each be regarded as a "medium mammal." All remaining species in Table 3.2 weigh less than 50 lb and so can each be classified as a "small mammal." However, the Taiwan native dog, muntjac, and macaque appear to be much larger than other species as they often weigh 20–40 lb, while all other small mammals weigh less than 15 lb. Thus, a new category "medium-small mammal" was created for the purposes of this study. The modified body size classification used in this study was as follows:

Size 1 or small mammal (<15 lb): hare, rat, mongoose, civet, leopard cat, badger, otter, pangolin

Size 2 or medium-small mammal (15–50 lb): muntjac, dog, macaque

Size 3 or medium mammal (50–250 lb): sika deer, wild boar

Size 4 or medium-large mammal (250–750 lb): sambar deer

Table 3.4 summarizes the body sizes and characteristics of the archaeological fauna. For prey rank, the low-lying animals would be the most ideal prey for the prehistoric hunters in lowland central Taiwan, in considering search time. All the species in Table 3.4 were potentially exploited, including sambar deer since, as mentioned earlier, sambar may once have lived in the lowland areas (Chen 2000b). Gregarious animals with a habitat preference for grassland would have a higher encounter rate than the solitary and/or nocturnal species living in the forest. Thus, muntjac, pangolin, macaque, and all the carnivores except dog should be considered as lower-ranking resources. Among the remaining species, it appears that the larger-sized animals such as sika, sambar, and wild boar can provide more energy return. However, energy return rate is also a function of handling cost that involves pursuing, transporting, and processing time.

From this point of view, sambar should rank lower due to its larger body size that may increase transport and processing costs. Wild boar would also rank lower for its aggressive behavior, which possibly requires more time to capture. Sika deer, therefore, should be the highest-ranked prey for their grassland habitat, gregarious behavior, medium body size, and docile nature.

Table 3.4. Summary of the terrestrial mammals in archaeological fauna of Taiwan.

Taxon	Body Size	Preferred Habitat	Altitude (m)	Behavior	Current Status[b]
Sika deer[a]	Medium	Open woodland, grassland	<500	Gregarious	Extinct in the wild, reintroduced
Sambar deer[a]	Medium-large	Woodland	>1500	Gregarious	Protected II
Muntjac[a]	Medium-small	Woodland	<3000	Mostly solitary	Protected II
Wild boar	Medium	Grassland, farmland, woodland	<3000	Gregarious	Not protected
Dog	Medium-small	Residential areas	<3000	Gregarious	Not protected
Badger[a]	Small	Forest, open field, graveyard, riverside	<2000	Gregarious, nocturnal, burrowing	Extinct in Taiwan
Otter[a]	Small	Forest, riverside	<1500	Semiaquatic, mostly solitary and nocturnal	Protected I
Crab-eating mongoose[a]	Small	Forest, riverside	<2600	Solitary but social	Protected II
Small Chinese civet[a]	Small	Woodland, grassland	<1000	Solitary, nocturnal	Protected II
Gem-faced civet	Small	Woodland	<1000	Solitary, nocturnal	Protected II
Leopard cat[a]	Small	Woodland	<1500	Solitary, nocturnal	Protected I
Hare[a]	Small	Swamp, shrub, grassland, abandoned farmland	<500	Mostly solitary, nocturnal	Not protected
Brown country rat	Small	Farmland, rice field	Lowland	Gregarious, commensal with humans	Not protected
Bandicoot rat	Small	Farmland, rice field	Lowland	Gregarious, commensal with humans	Not protected
Macaque	Medium-small	Forest	100–3200	Gregarious	Protected II
Chinese pangolin	Small	Forest	300–1000	Mostly solitary, nocturnal, burrowing	Protected II

a. Species that were exported for fur trade in the textual record.

b. Current conservation status is based on the Wildlife Conservation Act of Taiwan, which classifies endangered and vulnerable species into three categories: (I) endangered species, (II) rare and valuable species, (III) other conservation-deserving species.

In addition to energy return, prey rank should also consider non-consumptive value since, in many societies, animals not only provide life-sustaining energy and nutrients but are also used as a societal resource. The process of producing, distributing, and consuming animals often reflects fundamental social inequalities (e.g., Arbuckle 2012; Schmitt and Lupo 2008), and sharing animal products can also be used to cement social relationships (e.g., Rosenswig 2007). In addition to social value, other variables such as the symbolic role of the animal (e.g., Holt 1996), prestige hunting (e.g., Codding et al. 2009), food preferences and restriction, market value, and medicinal use (e.g., Pezzuti et al. 2010) would also affect prey choice.

The main research goal of this study is to explore the transition of animal use from subsistence to commerce and thus their market value is important to evaluate the prey rank of Iron Age people. However, in practice, it is difficult to eliminate all other possible variables since all these animals may have been used in a wide range of occasions, and some of the variables cannot be examined archaeologically. I, thus, use the prey choice model as a predictive tool, expecting a change in prey selection by using certain assumptions. I assume sika deer was the most ideal prey in prehistoric Taiwan for its highest energy return rate. As the market value of deerskin increased during the Iron Age, hunters would develop a more specialized strategy focusing on sika, leaving a higher abundance of this species and a lower degree of species diversity in the archeological record.

3.4 Deer Hunting in the Iron Age

In Chapter 1, I hypothesize that deer hunting had changed in the Iron Age in order to increase the quantity and/or quality of the products. This section reviews the seasonality of hunting and hunting strategies documented in historical and ethnographic records. This study, however, does not measure the relative importance of these strategies. Rather, the information reviewed here provides a baseline for reconstructing prehistoric hunting through quantitative analysis of deer remains.

Textual evidence suggests that past hunting was mainly carried out in the winter, as does an ethnographic study showing that an indigenous group (Lukai) hunt mostly from October to March (Pei 2010). It has been argued that the seasonality may be associated with agricultural activities, since people would have more time for hunting after harvesting (e.g., Li 1997:244). Based on the prey choice model, I propose that the dry season (late fall to early spring) was an ideal time for hunting because sika deer have seasonal variations in foraging behavior. In Taiwan, sika deer tend to have a larger foraging range in the dry season due to a decrease in the availability of food (Hu et al. 1994). In addition, their rutting season can be from November to February (Wang 1985), in which they may form a larger herd. Dry season, therefore, is more suitable for deer hunting in terms of diminished search time. However, as maritime trade expanded, hunting may have been modified from a dry-season activity to one practiced year-round in order to provide a stable supply of deerskin. In addition, in the example of deerskin trade in seventeenth-century North America, Native Americans tended to exploit mature male deer in the season when their furs were most valuable (Lapham 2005). Since sika deer have a seasonal molting and their spotted furs often appear in the summer, hunting mature deer in the wet season (summer) would be expected to increase in order to provide a better quality of deerskin.

Historical accounts and ethnographic records also documented various hunting strategies, especially for deer. Here, I summarize the records on four major practices:

1. Chase Hunting

Chase hunting involved chasing, stalking, and pursuing prey, often with bows and arrows; in some cases, dogs may also assist in the activity. Hunters may work alone or in a small group consisting of two or three individuals. This method was documented in the Dutch and Qing literature and was probably the most common way to hunt larger animals. The Dutch missionary Georgius Candidius recorded such hunting in 1628:

> A man alone, or two, three, does not matter, go into the field and wherever they see a herd of deer they go after it . . . , shoot one arrow in front and another one behind it, until they end up hitting the deer. (Blussé et al. 1999: Ⅰ:117)

Chase hunting was sometimes carried out by a larger group. In Candidius' record, he also documented a communal hunt in southwest Taiwan:

> The entire village (or two or three villages) go out together, each man carrying two or three assegais. They take along dogs to hunt the game. Having arrived in the field, they split up and stand in a circle, sometimes covering a whole or a half mile of the field, then close in on each other. All the animals enclosed by this circle cannot escape or only with the utmost effort. (Blussé et al. 1999: Ⅰ:116)

In addition to weapons and dogs, fire was also often used to assist in hunting. For example, an anonymous letter written by a Dutch visitor in 1623 describes hunting with fire:

> They [the Formosans] . . . gather and go together to one side of some grove in which they know a herd of deer to be. The grove is set afire at the other side in order to start the deer and the game with the fire into their own direction. They watch them and shoot and fell them with arrows and assegais. The hunters, as they are fast runners, follow them until the game is tired or falls dead to the ground. (Blussé and Roessingh 1984:76)

2. Camouflage Hunting

Camouflage hunting was not as common as other strategies in the textual record, but a paragraph in a Qing text－*Tai Hai Shih Cha Lu* (臺海使槎錄) described such a method:

> When hunting deer, they put on deerskin, wear fur caps and leather shoes, and chase deer in the thorns. (Huang 1999[1736]:120)

3. Ambush Hunting

As with camouflage hunting, ambush hunting was also not common, but it was recorded in an official Qing record－*Juluo Xian Zhi* (諸羅縣志):

> They dig holes in the wild and hide in the holes at night, with grass covering their heads and barking like deer. As deer are fooled and allured to approach, they come out to shoot them. (Zhou 2005[1717]:252)

4. Trap hunting

In addition to chasing, trapping was also a common technique documented in historical and ethnographic records. Compared to the other three methods, hunting with traps or snares is less labor intensive and effectively captured all the animals on the route. In Candidius' discourse, he mentioned two kinds of trap hunting:

> With snares again two methods are possible: they either set some up in the bush and in the thickets, wherever they know that deer and wild boar are coming down in herds. Then they surround them and chase them into the snares like that. . . . Or they put up other snares on the paths or in the open field. . . . When the deer . . . touch this, it snaps up and the deer and swine are brought to a standstill, their feet caught fast. They then close in and spear them with assegais. (Blussé et al. 1999: Ⅰ :116)

Trap hunting added a new dimension under Dutch rule as they established a franchise system for the deerskin trade (see Chapter 2). The licensed Chinese hunters authorized by the Dutch introduced the use of a pitfall, a more deadly but effective technique to capture more deer. Unlike the traditional traps, a pitfall can capture 400–600 prey per month (Jiang 1984). This mass collection effectively captured individuals of all ages, including young and pregnant deer. In addition, unlike the indigenous hunting, the Chinese pitfall hunting during this period had no seasonal restriction. By 1639, the Dutch had to institute a hunting season and prohibit the use of pitfalls to restore the deer population (Andrade 2005). The new technique, as well as the franchise system, had fundamentally changed the ecology and economy of deer hunting in southwestern Taiwan.

In the archaeological record, these hunting methods would leave different patterns of prey mortality. For example, as summarized in Chapter 1, a non-selective hunting method such as massive kill, communal drive, and pitfall would capture deer in all age groups and result in a catastrophic profile (L-shaped curve). In lone or small-group hunting, animals are often hunted individually and would have an attritional profile (U-shaped curve) since fawns and old individuals are more vulnerable than middle-aged adults. The profile of single age-group dominance, on the other hand, suggests prey selection of a particular age. Therefore, the mortality pattern of deer can be used to detect if there was a change in hunting practice during the Iron Age.

3.5 Summary

This chapter provides information about the hunting and animal resources in prehistoric Taiwan, as a basis for formulating the three hypotheses. Subsistence in prehistoric Taiwan has been extensively studied in archaeology and is often described as a mixed economy. However, in addition to farming and animal husbandry, hunting was also important in the past. Deerskin, therefore, could be an ideal commodity since it was difficult to monopolize in terms of both resource and production. Based on the prey choice model, sika deer is hypothesized as the most ideal prey and the highest-ranking animal throughout the Iron Age, but it became more important in the late period as maritime trade expanded. Finally, this chapter reviews deer hunting as described in historical and ethnographic records to provide a baseline for reconstructing Iron Age hunting, which can be examined by analyzing the mortality profile of deer in the archaeological record.

CHAPTER 4. NATURAL AND CULTURAL HISTORY OF THE WESTERN LOWLAND OF CENTRAL TAIWAN

The western lowland of central Taiwan was selected as a case study to explore the maritime trade and deerskin production in Iron Age Taiwan. This chapter first defines the study area based on its geographic features, and the distribution of prehistoric cultures. Then, the natural environment of the study area is reviewed to show its geographic potential for deer resources. This chapter also reviews the cultural history to demonstrate the Iron Age transition in the study area. Finally, the ethnohistory is provided to show the demographic and economic transformations since the eighteenth century.

4.1 Definition

Central Taiwan is officially recognized as an area of five districts located in the middle part of the island: Miaoli County, Taichung City, Changhua County, Nantou County, and Yunlin County. The geography of this area is complex, consisting of plains, basins, plateaus, hills, and part of the central mountains (Lin 1957). Liu (2002c) suggested that archaeological areas should be zoned by their geographic features and distribution of prehistoric cultures. He defined central Taiwan archaeologically as the area between the Daan and Zhuoshui River basins, to the west of the central mountain ridge (Liu 2002a:81). He further proposed that this area comprises three environmental zones for human activities: lowland (plains, plateaus, and basins), hill (below

1000 meters), and highland (1000 meters above sea level and higher) (Liu 1999:4, 2002a:81). This study generally followed Liu's definition, that is, the western lowland of central Taiwan referred to as the low-lying area between the Daan and Zhuoshui River basins that is around 2400 km^2 (Figure 4.1).

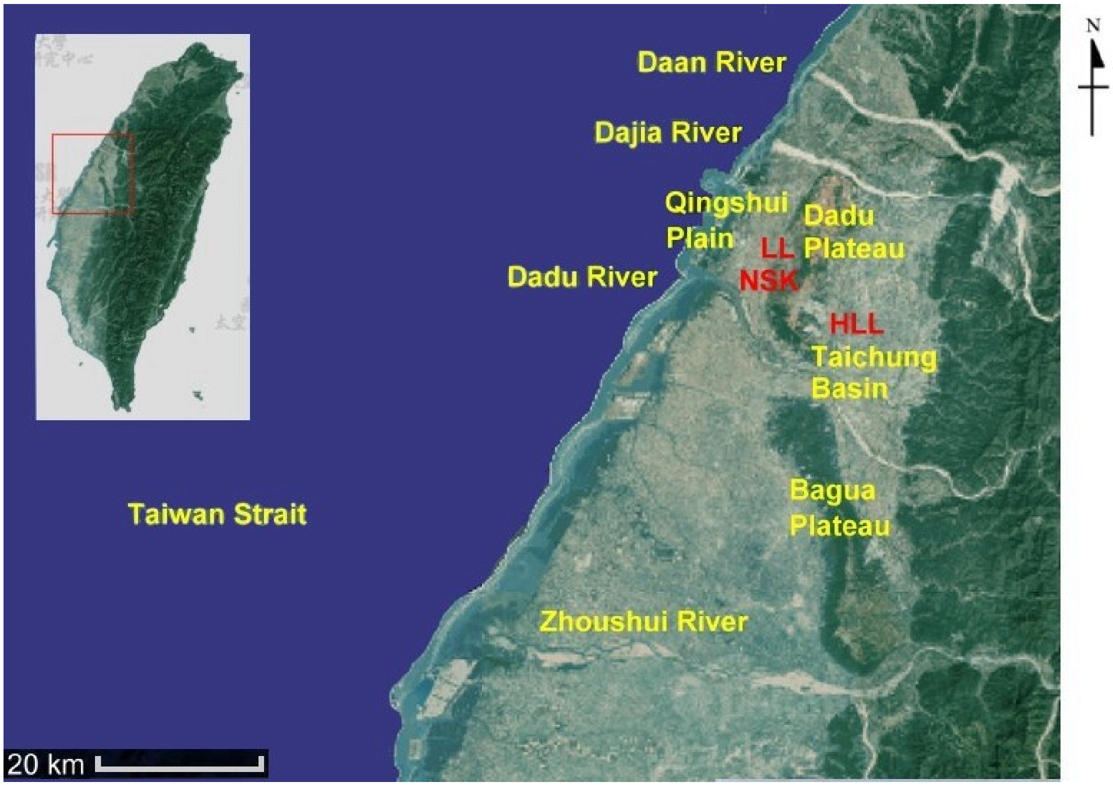

Figure 4.1. Map of the western lowland of central Taiwan and the Huilai (HLL), Luliao (LL), and Nanshikeng (NSK) sites. (Background map from CNES/CSRSR 2014)

4.2 Geography and Geology

The geography of the central-western lowland consists of coastal regions, alluvial plains, plateaus, and river basins. Several important aspects of the physical landscape facilitate and constrain human movement and settlement patterns. The lowland area here is among the broadest in Taiwan, where the distance from the coast to the foothills of the mountains is about

20–40 km. The mountains rise very steeply to elevations of 3000 m. This area is an alluvial plain formed by the Daan, Dajia, Dadu, and Zhoushui Rivers, which are among the largest ones in Taiwan (Figure 4.1). Archaeological and textual evidence suggest that this area was covered by forest in the past, and the open woodland and grassland appear to have been ideal habitat for sika deer (see Chapter 3). Although the rivers make it difficult to travel by land from north to south, they are navigable and make it easy to travel by boat from the coast to inland. Compared to the north and south coasts, the coast of modern central Taiwan is not suitable for larger ships to anchor due to its straight coastline, sandy beach, and shallow water. However, there were several good harbors in the past (Hung 1992), but they were later silted up due to the fast deposition rate.

This study used the faunal samples from the three Iron Age sites of Huilai, Luliao, and Nanshikeng, located in the Taichung Basin and on the lower western terrace of the Dadu Plateau (facing the Qingshui Coastal Plain) (Figure 4.1). Thus, this section reviews the geology, soil, vegetation, and land use of the Dadu Plateau, Taichung Basin, and Qingshui Coastal Plain. These areas are now highly developed, and their original vegetation has been heavily disturbed by rapid growth in the economy and population over the past several centuries. Therefore, past environment of the study area is reconstructed with the use of archaeological and historical evidence.

The formation of the central-western lowland was a result of a long-term geological movement. The island of Taiwan was formed approximately 4 to 5 million years ago by the tectonic movements of the Eurasian Plate and the Philippine Sea Plate. These movements first formed the current central mountains, and later the Penghu Islands surfaced after several volcanic eruptions. In the central region of Taiwan, sediments brought by the waters running from the central mountains slowly accumulated in the western area. Around a million years ago, tectonic movements further formed a large plateau in the west. Part of the large plateau was cut off by the Dajia and Dadu Rivers, dividing the large plateau into the Dadu and Bagua Plateaus (Figure 4.1). These movements also caused a structural depression between the plateaus and central mountains, which was gradually filled with the sediments of several local streams to form the Taichung Basin (Lin 1957). Sediments of the Dajia and Dadu Rivers continued to accumulate along the coastline during the Holocene to form the modern Qingshui Plain.

4.2.1 Dadu Plateau

The Dadu Plateau (Figure 4.2) lies between the Qingshui Coastal Plain and the Taichung Basin, with the Dajia River on the north and the Dadu River on the south (Figure 4.1). The plateau stretches across the lowland of modern Taichung City. It is long and narrow in shape and has a length of about 20 km and a width of 5 to 7 km. Its average height is approximately 151 meters, with the highest peak being 310 meters. The topsoil of the Dadu Plateau is laterite, developed by the weathering of underlying gravel (National Chung Hsing University [NCHU] 1976). The subtropical climate with alternating wet and dry seasons in the central-western lowland is essential to the formation of laterite. In the rainy season, organics decompose rapidly and many substances in the soil are washed away by the strong leaching process, leaving iron and aluminum oxide. In the dry season, this compound is brought to the surface by capillary action and produces the red coloration of the laterite (Figure 4.3), with high iron oxide content (NCHU 1976). This red soil is acidic, sticky, and poor for agricultural productivity, but several natural springs can be found on the lower west terrace as a result of the fault structure (Lin

1957). These springs provided good water resources for past human settlements (Hung 2009:106) and some of them are still used by modern residents.

Figure 4.2. Dadu Plateau.

Figure 4.3. Red topsoil of the Dadu Plateau exposed at a construction site.

The original vegetation of the Dadu Plateau was destroyed due to recent economic development, but archaeological evidence and historical texts provide a picture of the past landscape. The excavation of the Nanshikeng site recovered botanical remains of the chinaberry tree (*Melia azedarach*), plums (*Prunus mume*), bamboo, grass, and domesticated rice (*Oryza sativa japonica*) (Ho and Liu 2005a; Liu 2013a, 2013b), indicating that the prehistoric people exploited deciduous trees and cultivated rice around their settlement. Historical literature also provides some information about the Dadu Plateau. A Chinese explorer, Yonghe Yu, arrived in Taiwan in 1697 to collect sulfur in the northern area. He landed in the southwest region (in modern-day Tainan) and then traveled northward along the coastline. A memoir of this ten-month journey－*Pi Hai Ji You* (裨海紀遊)－describes his trip and the aboriginal life he observed. One paragraph in the book portrayed the Dadu Plateau in the late seventeenth century:

> On the 17th, . . . when I start getting on the hill, I find the bushes are tangled together, leaving no gaps for standing. The trees are like hedgehog hairs, and their branches are so dense, shadowing the woods in the day and night. I look up, as peeping from the bottom, and sometimes can only see a small circle of the sky. Although the hill is right in front of me, it is covered by dense trees and cannot be seen at all. (Yu 1996[1700]:19)

Both archaeological and historical evidence suggest that, until the late seventeenth century, the plateau was covered by forests. However, by the early twentieth century, most of this vegetation had been disturbed by human activity. Some parts of the plateau were planted with acacia and grass, while other parts were developed for dry-land cultivation due to the lack of soil fertility and water resources, producing sugarcane, sweet potatoes, fruit, and vegetables. Only a small amount of wet-rice fields were distributed on the western plain (Shalu Town

Government 1994). Since the mid-twentieth century, cultivated lands have rapidly decreased as a result of growth in the urban economy. These lands were replaced by residential buildings and public construction, such as highway, airport, and industrial park.

4.2.2 Taichung Basin

The Taichung Basin is surrounded by several plateaus and the central mountains. This basin is long and narrow in shape, covering 380 km^2. Its maximum height is 260 meters, and the lowest point is 25 meters above sea level. As an alluvial fan, it has a braided water system formed by the tributaries of the Dadu River. The soil of the Taichung Basin is mostly loam (NCHU 1976). A soil analysis from several archaeological sites shows a brownish-yellow color, a texture of high clay content, and a weak sub-angular soil block structure in the mid-Neolithic layer, and a dark sediment with abundant organisms and clay content in the early Iron Age layer (Chu et al. 2010). This suggests the basin was a stable landform in both periods, but the early Iron Age people appear to have selected an environment closer to a wetland found between streams (Chu et al. 2010).

Most of the Taichung Basin is now in downtown Taichung City, the second largest urban area of Taiwan. With its dense population, the original vegetation has disappeared, but archaeological excavations at the Huilai site recovered some macrobotanical remains, including globes glans oak (*Cyclohalanopsis qlobosa*), chinaberry tree (*Melia azedarach*), konishii tanoak (*Pasonai konishii*), plum (*Prunus mume*), rice (*Oryza sativa japonica*), and some flowering plants (e.g., Zingiberaceae and Pandanaceae) (Chu et al. 2010; Ho and Chu 2005). These plant species indicated there were evergreen or deciduous forests, subtropical herbal plants, and rice fields around the prehistoric settlements.

Although the soil is considered fertile for agriculture (Hsiao 2008:93), a large-scale settlement did not appear until the Han settlers arrived in the early eighteenth century (Hung 1992). Wet-rice cultivation widely expanded in the basin as the Han settlements and the construction of irrigation increased during the Qing period. This area was later developed as a modern city under Japanese rule (1895–1945) and, in the 1970s, the construction of railways and the Taichung Port further stimulated a rapid growth in the economy (Hsiao 2008:198, 219), making the Taichung Basin one of the largest urban areas in modern Taiwan.

4.2.3 Qingshui Plain

The Qingshui Plain is an elevated coastal plain between the Dadu Plateau and the Taiwan Strait (Figure 4.1). It is rectangular in shape with an average width of 4.5 km and a maximum length of 16 km. This alluvial plain was newly developed in the Holocene period (Lin 1957), formed by the sediments of the Daan, Dajia, and Dadu Rivers. As in the Taichung Basin, the plain soil is mostly loam (NCHU 1976). According to archaeological records, prehistoric people had lived here since the mid-Neolithic and more settlements were built in the Iron Age. Since the plain is fertile for agriculture, wet rice was cultivated intensively and was an important export product during the Qing period (Qingshui District Government [QDG] 2013:404). This plain also played an important role in merchandise transportation after a railway was built in the Japanese period (QDG 2013:465–466).

In the 1970s, more rapid development occurred with the constructions of the Taichung Port and an industrial park. While it appears that the original vegetation has been heavily disturbed by human activities, botanical remains discovered at the Qingshui site included coastal shrubs (Mangrove), grasses (Poaceae), flowering plants (Hamamelidaceae), small trees (Oxalidaceae), walnut trees (Juglandaceae), and evergreen trees (Fagaceae) (Chen 2004:48), suggesting a coastal environment with rich plant resources.

4.3 Climate

In general, the climate of Taiwan is strongly affected by the East Asian monsoons and directly influenced by the cold continental air in winter and the Pacific subtropical air in summer. The southward movement of continental air by the winter monsoon often brings cold temperatures to Taiwan, while the tropical warm air brought by the summer monsoon often causes heavy rainfall. In some years, Taiwan's climate is also affected by larger climatic systems such as the Arctic oscillation and El Niño, causing longer and larger-scale climate change on the island. This section provides a brief overview of the temperature and precipitation of the central-western lowland. Information reviewed here is predominantly based on the data of downtown Taichung, which was collected by the Central Weather Bureau of Taiwan.

4.3.1 Temperature

As an island located in a subtropical region, Taiwan has moderate temperatures throughout the year. In the lowland areas, the temperature in the coldest months (January and

February) is around 15–20°C, while it is hottest in July and August, with a temperature of 28–29°C. There is a difference in average temperature and temperature variation between the northern and southern areas. The average temperature decreases 0.73°C per one degree of latitude (Tan and Tseng 2012), and temperature fluctuation is also more pronounced in the north. In terms of altitude, temperature also gradually decreases from the lowlands to the mountain areas, with a rate of –5.21°C per 1000 m elevation (Tan and Tseng 2012).

According to Central Weather Bureau of Taiwan, the average temperature of downtown Taichung is 22.6°C (1897–2000), ranging between 15.9 and 28.1°C (Chen 2008:94–95). There are eight months with an average temperature above 21°C but no months below 10°C, indicating a long period of summer in the study area (Figure 4.4). In terms of daily temperature, there are 154.4 days a year with a temperature above 25°C, concentrated from July to September. On the other hand, only 20.2 days per year experience a temperature below 10°C, mainly from December to February. This data show there is continuous heat over a period of six months; cold days are very few and are scattered in the winter season.

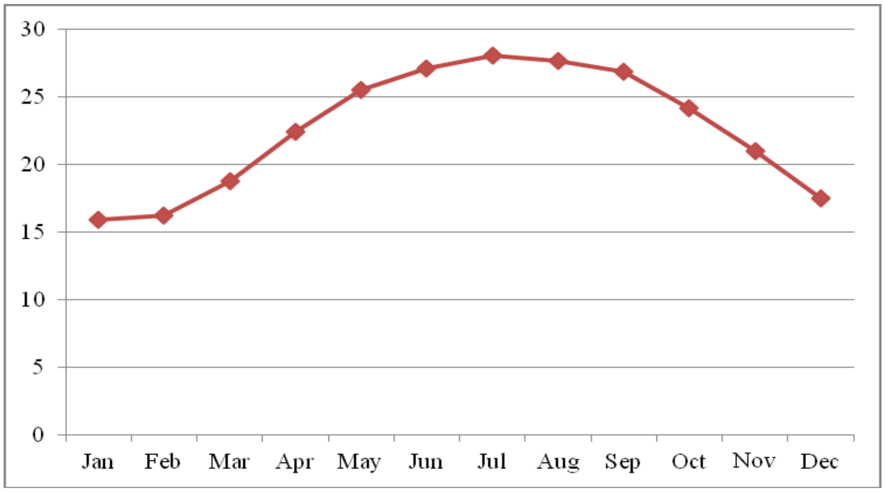

Figure 4.4. Monthly average temperature (°C) of downtown Taichung (1897–2000). (Data from Central Weather Bureau of Taiwan)

4.3.2 Precipitation

Precipitation in Taiwan is primarily influenced by two monsoon components: the southwest monsoon in the summer (May–August) and the northeast monsoon in the winter (September–April). In addition, tropical storms in the summer also frequently result in massive rainfall over the island. The summer monsoon causes the two main rainy seasons: the Meiyu season (mid-May to mid-June) and the late-summer rainfall season (mid-July to August), while the winter monsoon mainly affects the northern and northeastern coastal areas, bringing a stable rainfall during the cold season in those areas (Chen and Chen 2003). As a result, there is a different pattern of monsoon alternation in northern and southern Taiwan, with dry and rainy seasons occurring at different times in these regions (Figure 4.5). Rainfall in Taiwan, however, is not simply affected by the monsoon alternations, but can be further complicated due to its geographic structure (Yen and Chen 2000). The orographic effects of the north-south-oriented central mountain range significantly affect the spatial distribution of precipitation. Such effects cause spatial rainfall variation in an orderly fashion, where the maximum rainfall occurs counter-clockwise over the island (Yen and Chen 2000).

The rainfall of the central-western lowland is mainly affected by the summer southwest monsoon and typhoons. In downtown Taichung, the annual average precipitation from 1897 to 2000 was 1712.1 mm, slightly less than that of most other lowland areas (Chen 2008:98). The rainy season is from May to August, accounting for 69.3% of rainfall per year (Chen 2008:99). The period other than these four months, then, is considered as the dry season. In terms of four seasons in a year, late spring to summer is the wet season, while fall, winter, and two-thirds of spring are the dry seasons, with the driest period in October and November (Figure 4.6). In sum, the rainfall of the central-western lowland has a strong seasonal variation, with a summer concentration and a long period of dryness over eight months.

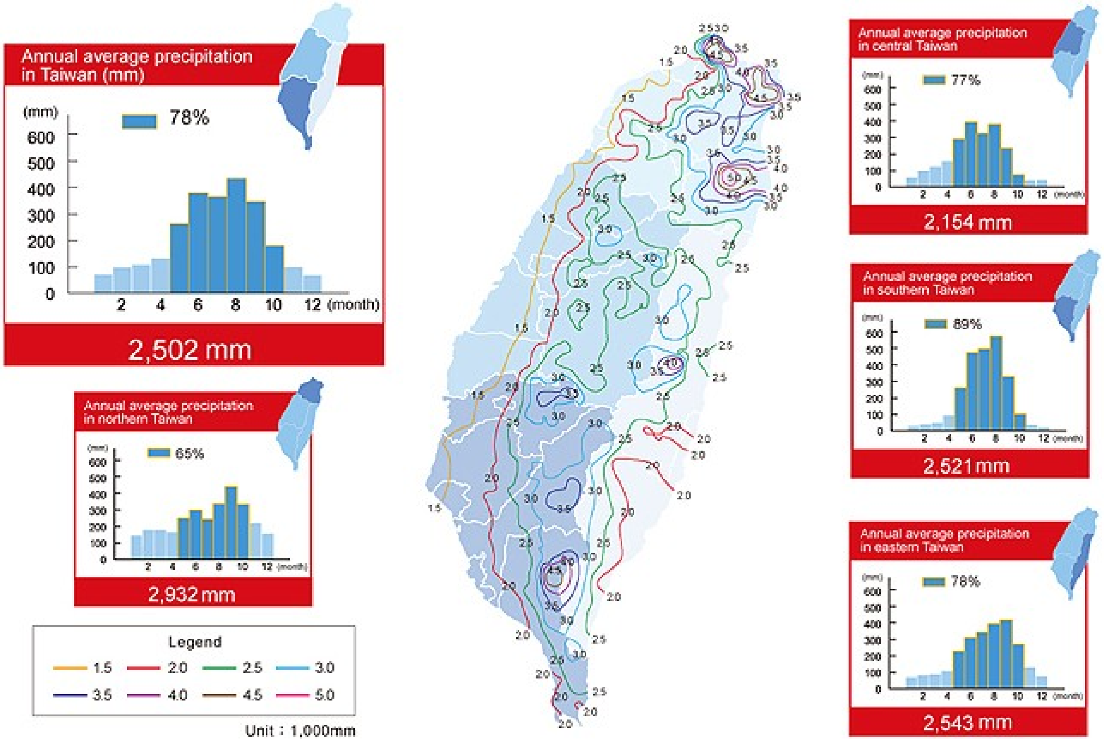

Figure 4.5. Average annual precipitation in Taiwan from 1949 to 2009. (Picture courtesy of the Water Resources Agency, Ministry of Economic Affairs, Taiwan)

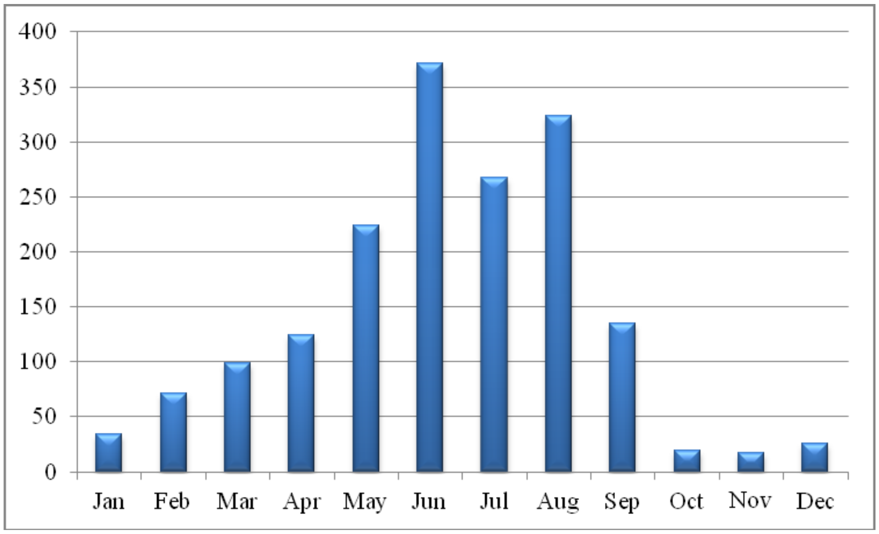

Figure 4.6. Monthly average rainfall (mm) in downtown Taichung (1897–2000). (Data from Central Weather Bureau of Taiwan)

4.4 Cultural History

Human occupation in the western lowland of central Taiwan has a long history, beginning in the early Neolithic period. The earliest Neolithic culture in Taiwan has been dated to around 6000 years ago and was first found at the Tapenkeng site in the north. Although the Tapenkeng culture has now been found in many coastal regions in Taiwan, our understanding of this earliest Neolithic culture is scarce and incomplete. In general, the Tapenkeng culture is characterized by brown, coarse, cord-marked pottery, and stone tools that include chipped agricultural tools, polished stone adzes, perforated points, and bark beaters (Chang 1971). Recent discoveries at the Tainan Science Park of southern Taiwan have provided more information about this culture. In addition to the Tapenkeng-style artifacts, evidence from the early Neolithic Nankuanli and Nankuanli East sites in the park show a large settlement that subsisted on rice and millet cultivation, dog domestication, terrestrial hunting, fishing, and shellfish gathering (Li 2013; Tsang et al. 2006). Some of the basalt artifacts at these sites appear to originate from the Penghu Islands (Tsang et al. 2006:88, 115), indicating a maritime interaction between the two regions.

The Tapenkeng population is now believed to have spread from the mainland coast, which aids in understanding the early stage of Austronesian dispersal. Two origins of Tapenkeng culture have been proposed. One model proposes that the dispersal was a result of early rice cultivation along the Yangzi Delta (Bellwood 2012), where the population increased after the agricultural improvement and later spread along the southeast coast to Taiwan. An alternative origin is the Pearl Delta, hypothesized from the similarities in artifact assemblage and the strong marine subsistence strategy found at the Nankuanli site (Tsang 2012).

In the past, there was no strong evidence for the Tapenkeng culture in central Taiwan, although a few Neolithic potsherds had reflected Tapenkeng style (Chang 1977:430; Liu 1999:70). A recent discovery at the Anhelu site, however, reveals a stronger association with the early Neolithic culture. In this section, I briefly review the cultural history of the central-western lowland, based on archaeological work carried out over the past decades.

4.4.1 Neolithic Period

Anhelu, located in downtown Taichung City, is known as the earliest archaeological site in the central-western lowland. The C14-AMS dating of charcoal samples from the site yielded a time span of 3000–2000 BC, as early as the Nankuanli site in southern Taiwan (Chu et al. 2015). There are also some similarities in artifact assemblage between the Anhelu and Nankuanli sites. For example, some potsherds from the Anhelu site are thick and coarse cord-marked as the ones from Nankuanli, which shows a much more Tapenkeng style in terms of artifact assemblage. Despite a lack of detailed sourcing analysis, several stone tools discovered from the Anhelu site appear to be made of basalt and jade (Chu 2016) that can only be found on the Penghu Islands and in the eastern region. These artifacts were found in a grave area and apparently had a ceremonial significance, indicating the central-western lowland as part of the basalt and jade exchange during the Neolithic.

At Anhelu, there were 48 human burials discovered. The bioarchaeological analysis of these human skeletons showed that the Neolithic people frequently engaged in long-distance walking that is consistent with a hunting-gathering lifestyle (Chu and Yen 2016). The people were also similar to the Nankuanli East population in many ways, such as their burial practice, long-distance-walking lifestyle, and high frequency of ritual tooth ablation (Chen and Chiu 2009; Chu and Yen 2016; Pietrusewsky et al. 2013; Tsang and Li 2013:126). As reviewed in Chapter 3, despite rice remains found at both sites (Chu 2016; Tsang et al. 2006), evidence of overall good dental health suggested a low starch/sugar diet for the two populations (Chu and Yen 2016; Pietrusewsky et al. 2013). However, their frequencies of betel-nut stain and patterns of tooth ablation were different (Chu and Yen 2016; Pietrusewsky et al. 2013), indicating regional variation in some social practices.

From the early to mid-Neolithic period, there was considerable demographic growth throughout the island, as well as in the scale of human settlements (Liu 2002a:34). As a result, many regional cultures developed from the Tapenkeng culture, with larger settlements and more advanced agricultural technology (Liu 2002a:34). In the late Neolithic, populations had expanded to higher areas and had adapted to different natural environments (Liu 1999:78). A few bronze artifacts have also been discovered in the northern coastal areas, suggesting contact with other foreign regions (Chen 2011). In the central-western lowland, the mid-Neolithic culture is called “Niumatou” and is characterized by its reddish-brown, fine-cord-marked pottery (Liu 1999:74; Tsang 1995:51). Stone tools were found in large numbers and are diverse in type, consisting of various agricultural and hunting tools. The jade exchange continued during this period, indicated by the frequency of jade artifacts found at most archaeological sites (e.g., Chu 2012, 2016; Ho 2004b:89).

In the late Neolithic, a remarkable change in terms of pottery style—from reddish-brown to grayish-black in color—can be detected in the Yinpu culture of the central-western lowland. Past archaeologists assumed this change in pottery technology resulted from a new wave of immigration (e.g., Chang 1970), but recent studies proposed local development from the earlier Niumatou tradition (e.g., Kuo 2010b). Stone artifacts were also found in large numbers and diverse in type, with many fine polished tools for subsistence and ceremony (Ho and Liu 2006:144–145; Liu 1999:83–84; Tsang 1995:56). Jade artifacts were also discovered (e.g., Ho and Liu 2006), suggesting the jade exchange continued until the late Neolithic period.

4.4.2 Iron Age

As reviewed in Chapter 2, metal tools and exotic jewelry had been imported into Taiwan since AD 200, which signifies the beginning of Taiwan's Iron Age. Exotic jewelry replaced the jade materials and artifacts that had been circulated island-wide during the Neolithic period; its multiple origins also suggest a larger inter-regional trade developed during this period (Liu 2002a:51). In addition to artifact assemblage, other changes can also be detected such as a diminishing lithic production and an increasing diversity in settlement size and burial practice (Lien 1998; Liu 1999:91; Liu 2002a:50). In the central-western lowland, the regional Iron Age culture is Fanziyuan and is often divided into an early and late period.

Fanziyuan culture was found predominantly in coastal regions and thus shell middens were common at most of the Iron Age sites (Liu 1999:93; Tsang 2000). Another distinction of the culture is that all human remains were buried in a prone position (Lien 1998). As mentioned in Chapters 1 and 2, the foreign materials found in central Taiwan had spread from other western lowland regions such as Shisanhung (Chen 2000a:267) in the early Iron Age, suggesting the exotic artifacts may have been imported through an internal, land-based exchange network. The early Fanziyuan culture is characterized by grayish-black pottery developed from the late

Neolithic tradition, but stone tools from this period decreased in diversity. For example, at a location in the Huilai site that contained both late Neolithic and early Iron Age layers, lithic diversity is shown to have decreased significantly from the late Neolithic to the early Iron Age (Figure 4.7). Data also show that stone tools from the early Iron Age were predominantly axes, flakes, and hammers (as natural gravel in the figure) that did not require advanced skill to produce, and polished artifacts (ornaments, adzes, knives, *Patu*, spearheads, and grindstones) decreased from 25.9% to 4%. In addition, almost no jade artifacts have been reported at early Iron Age sites, but iron tools and other imported items have occasionally been discovered (e.g., Ho and Chu 2009).

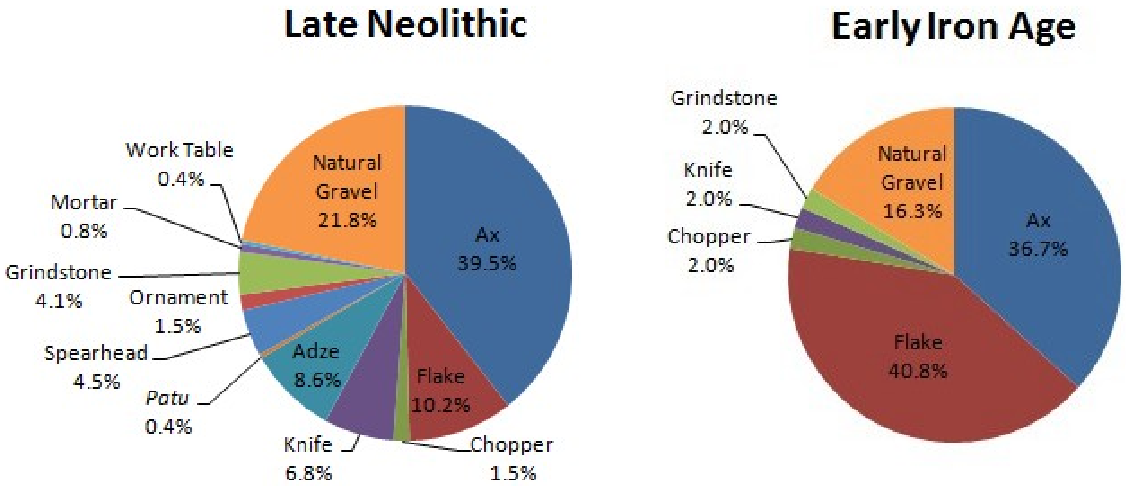

Figure 4.7. Relative frequencies of lithic artifacts from the late Neolithic and early Iron Age periods at Huilai. (Data from Chu et al. 2010)

In the late period, the artifact composition appears to be different in frequency and style, with more light-brown pottery, few lithic tools, and a larger amount of exotic items. However, the exotic items were unevenly distributed across sites. For example, over 400 iron artifacts were discovered at the late Iron Age Luliao site (Ho and Liu 2005b), although iron tools are usually found in small numbers at most other Iron Age sites (Liu 1999:95). This uneven distribution may result from taphonomic processes such as post-depositional destruction, but it may also indicate a difference in foreign contact between the villages.

The cultural history of the central-western lowland is summarized in Table 4.1. It appears that the prehistoric cultures had continually developed from the early Neolithic tradition, but the interaction with other regions had brought a number of new influxes. This interaction entered a new phase during the Iron Age, as a result of increasing foreign contact in the past two thousand years.

Table 4.1. Prehistoric cultures in the western lowland of central Taiwan.

Period	Date	Culture	Pottery	Lithic Tool	Nonlocal Item	Burial
Early Neolithic	3000–2500 BC	Tapenkeng	Thick, reddish-brown, coarse cord-marked and painted decorations	Chipped and polished tools	Basalt materials/ artifact	Extended, supine, tooth ablation?
Middle Neolithic	2500–1500 BC	Niumatou	Reddish-brown, fine cord-marked	Large amount and diverse	Jade materials/ artifacts	Extended, supine, tooth ablation
Late Neolithic	1500 BC–AD 400	Yinpu	Grayish-black, coarse sand-tempered, various decorations	Large amount and diverse	Jade materials/ artifacts	Supine, no tooth ablation?
Early Iron Age	AD 400–1000	Fanziyuan	Grayish-black, clay, fine sand-tempered, impressed dot and circle decorations	Decrease in diversity	Small amount of iron tools, agate, and glass beads	Extended, prone, no tooth ablation
Late Iron Age	AD 1000–1624	Fanziyuan	Light brown, clay, flapped square decorations	Very few	Larger amount of iron tools, porcelain, agate, and glass beads	Extended, prone, few tooth ablation

4.5 Ethnohistory

Most Iron Age societies survived into the historical period but, with no writing system, their recent history is mainly understood from texts written by westerners, Chinese, and Japanese. In general, Taiwan prehistory ended in the early seventeenth century when the Dutch East India Company built a trading community in the southwest region (AD 1624–1662) (see Chapter 2). Since then, many historical and linguistic studies have classified the native groups under different systems. These native populations are often divided into two large groups based on their geographic distribution: the Plains Aborigines and the Highland Aborigines. The Plains Aborigines refer to the groups originally residing in the lowland regions, especially in the western plains. They were also called *Shou Fan* (domesticated savages) in Qing literature for the reason that they were more assimilated and more civilized than the Highland Aborigines (Hung 2009). Linguistic and ethnographic research often divided the Plains Aborigines into eight to ten groups (Li 2000:38). Of those groups, the entire Papora and Babuza groups and part of the Taokas, Pazeh, and Hoanya people resided in the central-western lowland (Figure 4.8).

As reviewed in Chapter 2, the two earliest and most reliable records about Taiwan likely describe the central-western coast. Both the two early texts described trading with foreigners and show how the natives were comfortable with foreign contact. In the Dutch records, many of these accounts describe a multi-tribal polity in this area, where a chief called *Quataong* represented the people in the Dutch assembly (Ang 1992). Kang (2003) proposed that the rise of *Quataong*'s leadership was associated with maritime trade, by control over the flow of trade goods between the sea and inland. However, this polity had declined after the area was occupied by Chenggong Zheng's troops (Ang 1992).

Han settlement was first developed in the central-western lowland in the eighteenth century, which was later than those established in the north and south (Hung 1992, 2003). Hung (1992) proposed several causes for this late development. First, the sandy beaches and fast deposition rates at the coast were not suitable for larger ships, and thus the western colonists and Han settlers first went ashore in the northern (Danshui) or southern (Tainan) areas. Second, the strong seasonal precipitation was unfavorable for wet-rice cultivation without the construction of an irrigation system. Third, the braided water system formed by numerous local streams impeded north-south transportation. Without bridge construction, traveling through this area was not an easy task for the early settlers.

However, with irrigation systems and bridges built in the eighteenth century, the Han settlements expanded rapidly and changed the population composition of this area. On the other hand, the hunting-gathering way of life and small-scale cultivation of the indigenous people resulted in a smaller population and a lack of concept of land ownership, making them vulnerable when encountering Han expansion (Hung 1992). The matrilineal structure of some groups further increased their vulnerability, where Han Chinese gained property rights by marrying indigenous women (Hung 1992). In a Dutch census reported in 1650, the indigenous population in the central-western lowland was estimated to be around 4,000 people (Nakamura 1994), but, by the mid-eighteenth century, they were substantially outnumbered by Han settlers (Hung 2009).

In 1723, tensions between the native and Han populations eventually resulted in a large aboriginal rebellion, causing a substantial decrease in the indigenous population and a more intense assimilation policy by the Qing government (Hung 2009). In the nineteenth century, many people had moved to other regions due to a difficult life experienced under Han occupation (Hung 1992, 2003). The indigenous population further declined after that, leaving very few descendants in the modern central-western lowland.

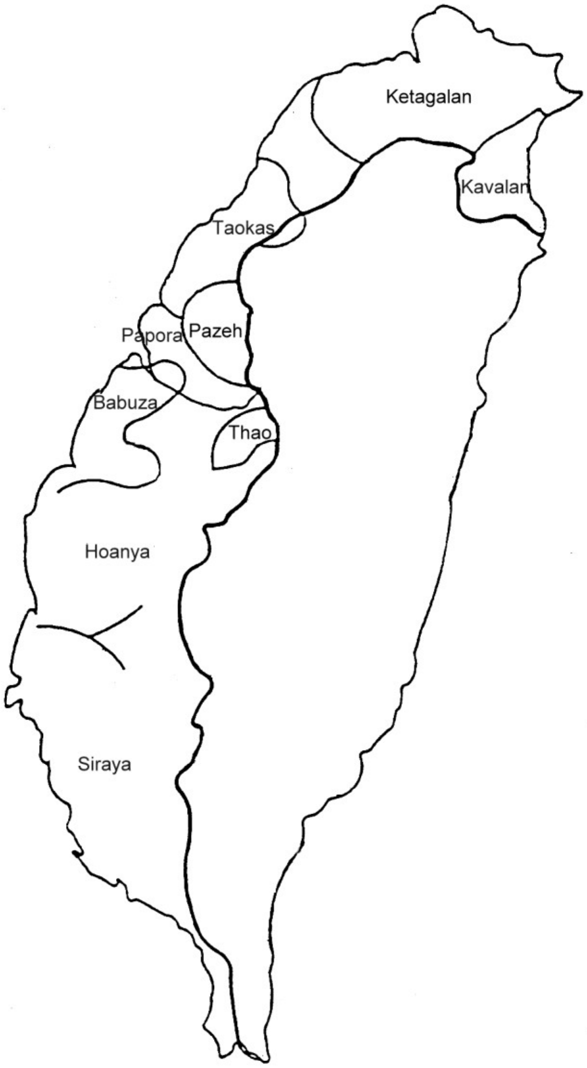

Figure 4.8. Major indigenous groups in lowland areas of Taiwan. (Redrawn and modified from Tsuchida 1982)

4.6 Summary

The western lowland of central Taiwan was selected as a case study to investigate the deerskin production and maritime trade. This chapter reviews the natural and cultural history of the study area. The archaeological region of the central-western lowland refers to the low-lying area between the Daan and Zhuoshui River basins, where the climate is characterized by high temperature and seasonal precipitation. The original landscape of the study area has been heavily disturbed by recent agricultural and urban development, but archaeological and historical records suggest that the area was mostly covered by forests and woodlands. With a subtropical environment and a low degree of deforestation, the central-western lowland provided a good habitat for wild animals; the strong seasonal precipitation is especially favored by sika deer as a mix-feeder of grass and leaves. This area has been occupied by human populations for over 4000 years. A considerable change in the material record has been detected since AD 400, which shows a typical Iron Age transition in terms of artifact composition. Both the two earliest texts about the prehistoric central-western coast describe trading with Chinese. The western lowland of central Taiwan, therefore, provides a good example to investigate the deerskin trade during the Iron Age. Most of the Iron Age societies survived into the historical period, but their populations rapidly declined as a result of Han Chinese expansion since the eighteenth century.

CHAPTER 5. ARCHAEOLOGICAL EXCAVATIONS OF THE HUILAI, LULIAO, AND NANSHIKENG SITES

The empirical data analyzed in this study included materials from three Iron Age sites in the central-western lowland, collected by the National Museum of Natural Science of Taiwan (NMNS). Located in downtown Taichung City, this museum’s anthropology department investigates the human history of central Taiwan, and their extensive work over the past two decades has enriched our understanding of the local history. To contextualize the materials, a summary about the sites is presented in this chapter.

Among the locations that have been investigated by NMNS, three were selected to test the hypotheses－the early Iron Age Huilai site, and the late Iron Age Luliao and Nanshikeng sites. All three sites are part of prehistoric settlements that had access to the sea or large rivers for maritime trade. Archaeological excavations revealed a large amount of faunal and cultural remains, which provided an opportunity for quantitative analyses. This chapter reviews the local settings, excavations, major findings, and chronologies of the three sites, as well as a discussion of some possible constraints. The exotic artifacts from the excavations also provided evidence to evaluate the overseas-trade and tramping-for-profit hypotheses.

5.1 Local Setting

All three sites selected for study are located in modern Taichung City. Administratively, the Huilai site is in downtown Taichung, while both Luliao and Nanshikeng are in the Shalu

District, with the Dadu Plateau lying between the downtown region and Shalu. The Huilai site is in the Taichung Basin, 15 km from the coastline (Figure 5.1). Compared to the late Iron Age Luliao and Nanshikeng sites, this site is more inland, but it is close to a large tributary of the Dadu River—Fazi Stream (literally raft stream), which provides access to maritime trade. The Fazi Stream now is primarily used for irrigation but, as its name implies, it was navigable by raft or boat in the past. On the other hand, both the Luliao and Nanshikeng sites are located on the western terrace of the Dadu Plateau, 6–7 km to the coastline (Figure 5.1) and only 3 km apart. As reviewed in Chapter 4, although the Dadu Plateau is poor for agricultural productivity, the natural springs provide a good source of fresh water.

All three sites appear to have good access to resources and to trade. The fertile Taichung Basin and Qingshui Coastal Plain, accompanied by the woodlands of the Dadu Plateau, had rich plant and animal resources. In terms of maritime trade, the coast of Taiwan is known for its fast deposition rate, with 0.5–5 meters shoreline progradation each year (Chen et al. 2005). With this deposition rate, these three sites would have been much closer to the coastline in the Iron Age. By the seventeenth century, the most powerful polities in the central-western lowland had located along the coast and major rivers in order to have access to maritime trade (Kang 2003), and, in the Qing period, Chinese ships also navigated along the rivers to trade with inland villages (see Hung 2003:28). Therefore, during the Iron Age, traders from outside Taiwan probably sailed up and down the coast and traveled inland along major rivers.

As reviewed in Chapter 4, the central-western lowland began to be cultivated in the eighteenth century, but farmlands have significantly decreased since the 1970s due to house and public construction. The Huilai site is now in the business center of Taichung City, surrounded by luxury buildings and department stores. The landscape of the Shalu District has also changed dramatically. Rather than woodland and forest documented in the archaeological and historical record, vegetation cover in the Shalu District is now predominately grasses and cash crops. Trees are few and can only be seen in abandoned lands and on riverbanks (Shalu Town Government 1994).

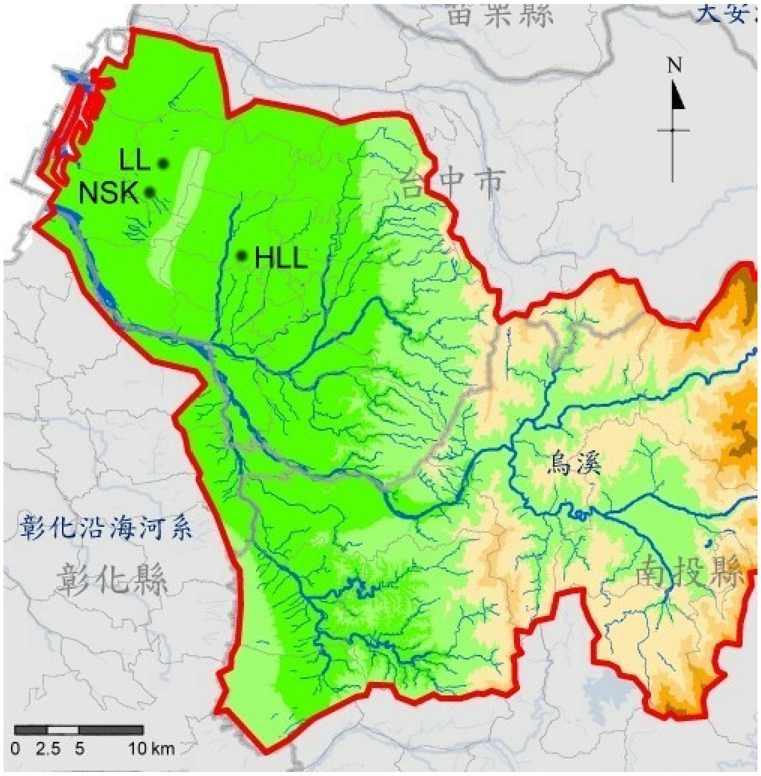

Figure 5.1. Dadu River Basin and the braided water system of the Taichung Basin. (Background map courtesy of the Water Resources Agency of Ministry of Economic Affairs and the Yu Chi-Chung Cultural & Educational Foundation)

5.2 The Excavations

5.2.1 Huilai

The Huilai site, formerly called Huilaili (HLL), was a very recent discovery, found by a college student, Mr. Sheng-Ming Cheng, during the survey of a construction site in 2002 (Ho and Chu 2002). Prior to this discovery, the archaeological sites of the central-western lowland were found predominantly on the coastal plains and higher ground around the Taichung Basin (Liu 1999:72, 93). The Huilai site, however, was located in the heart of the Taichung Basin, with a long history of human occupation since the mid-Neolithic period. The NMNS and other research teams excavated the site during the past decade. Since this study uses the materials collected by NMNS, this review focuses on the excavations conducted by the museum. Based on the distribution of prehistoric artifacts, this site is estimated to extend over 150,000 m^2 (Ho and Chu 2002). The NMNS conducted trial excavations at a dozen locations within this estimated area. Figure 5.2 shows a number of excavated locations and their possible cultural periods based on radiocarbon dates. These excavations suggested that at least three cultural periods are represented at the Huilai site—Numatou (mid-Neolithic), Yinpu (late Neolithic), and Fanziyuan (early Iron Age)—with some locations appearing to have spanned more than one period (Chu and Ho 2007; Chu et al. 2010; Ho and Chu 2004).

This study focused on Sector 144 (Figures 5.2 and 5.3) with its extensive excavation and large amount of faunal remains. Since Sector 144 is fairly large (around 9052 m^2), the NMNS research team first dug a test trench to locate the prehistoric materials, and then 462 units (2 × 2 meters each) were excavated. As of the writing of this dissertation, only a brief report about part of Sector 144 (Area I in Figure 5.4) had been published. Thus, this section reviews the excavation of Area I only according to that publication (Ho and Chu 2009). In Area I, 35 units were fully excavated. Each unit was excavated with arbitrary 10 cm levels, but in the lower layers, excavations focused on features only. There are three stratigraphic layers in the area, consisting of the topsoil, the prehistoric deposit, and the underlying natural sediment. The topsoil (20 cm thick) is loam with a few prehistoric potsherds and historical artifacts such as porcelain. The prehistoric deposit is generally divided into two sublayers, mostly black-gray loam with a thickness varying from 20 to 100 cm. Almost all remains were recovered from the prehistoric layer. The third layer is the underlying natural sediment, containing dark-gray sandy soil and gravel that are commonly seen in river deposits. No remains were recovered beneath the second layer.

Figure 5.2. Cultural periods of archaeological deposits at excavated locations of the Huilai site, based on radiocarbon dates: ● Middle Neolithic; ■ Late Neolithic; 🔴 Early Iron Age; ☐ Sector 144. (Ho and Chu 2009) (Background map courtesy of Taiwan Geospatial One Stop)

Figure 5.3. Sector 144 of the Huilai site now is a park with archaeological reconstructions for public education.

Three large and several small pit features were discovered in Area I, with the largest one being 300 cm wide and less than 100 cm deep. A large amount of prehistoric remains was recovered from the pits, including grayish-black potsherds, stone artifacts, biological remains, charcoal, and burnt soil (Table 5.1). In addition to refuse pits, some small pits are likely postholes, with charcoal and wood residue inside. There were also two complete and three partial human skeletons discovered in that area. All were found buried in the prone position. According to the excavators, water-screening was not consistently carried out until later excavations; only part of Sector 144 was routinely water-screened (gray areas in Figure 5.4).

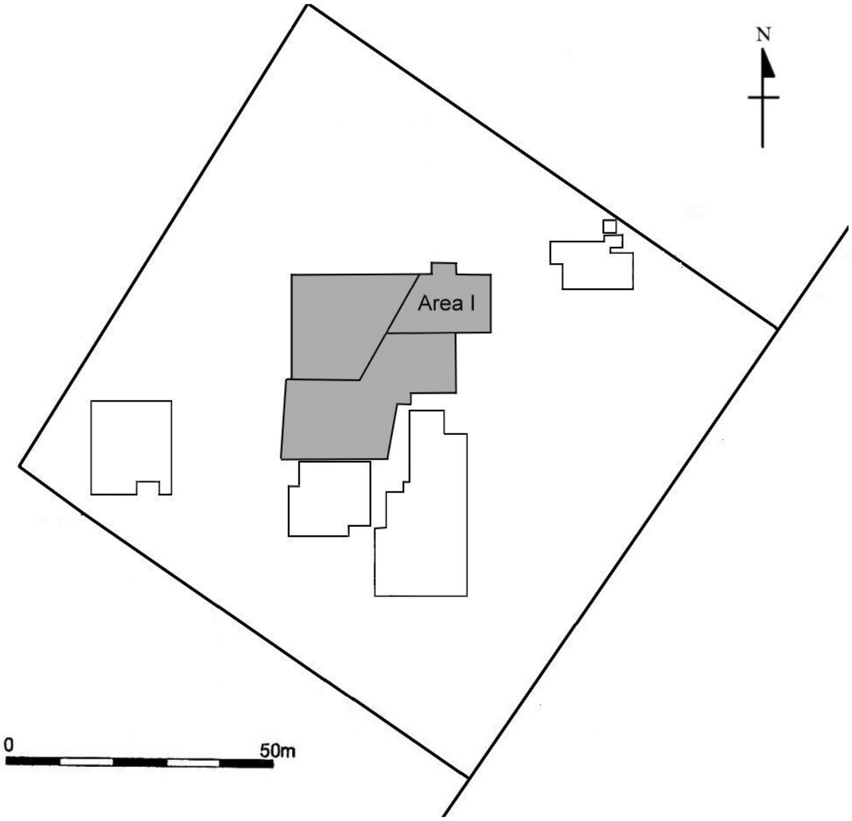

Figure 5.4. Sector 144 (thick lines), excavation areas (fine lines), Area I (as marked), and the areas routinely screened and sampled for faunal analysis (in gray). (Redrawn and modified from Ho and Chu 2004: Figure 12)

Table 5.1. Archaeological remains from Huilai Area I (summarized from Ho and Chu 2009).

Remains	Quantity	Major Style/Type/Species
Potsherd	2560	Grayish-black, fine sand-tempered, impressed dot, line, and wavy decorations
Stone tool	127	Flake, hammer, grindstone
Bone artifact	Small amount	
Iron artifact	2	Spearhead, arrowhead
Agate/glass bead	24	Red, blue, yellow, rounded and tubular shapes
Chinese coin	0	
Animal bone	Large amount	
Shell	Small amount	
Human burial	5	Extended, prone, no tooth ablation

5.2.2 Luliao

The Luliao site (LL) was first discovered in 1972 by Dr. Chuan-Kun Ho during an archaeological survey along the Dadu and Zhoushui Rivers (Ho 1977). In recent years, construction in the area has frequently exposed dark-brown cultural sediment and with it many prehistoric remains. A research team from NMNS excavated the site in 2000 and 2001, which was the first excavation since this site had been discovered. At the time of writing this dissertation, the final report of that excavation has not yet been published, and thus information can only be collected from relevant publications (Ho and Liu 2005b, 2005c; Ho et al. 2006) and interviews with the excavator. According to the excavator (Kehung Liu, pers. comm. 2015), test units were placed in an area of 180 m^2 (Figures 5.5 and 5.6); each unit was 1 m^2 and was excavated with arbitrary 10 cm levels.

There are three stratigraphic layers in the excavated area. The first layer (20–30 cm thick) is fine sandy loam from past sugarcane cultivation, and contained a few prehistoric potsherds and historical artifacts such as porcelain and glass. The second layer is the prehistoric deposit, consisting of a dark-brown loam varying in thickness from 10 to 60 cm. Almost all prehistoric remains were recovered from the second layer. The basal layer is comprised of laterite and gravel that are commonly seen on the Dadu Plateau. No remains were recovered beneath the second layer. In general, the whole excavation area was covered with large amounts of shells, bone fragments, and cultural remains; there were also two human burials found in the north corner (Figure 5.5). Thus, most of the excavation area can be seen as a large trash disposal area.

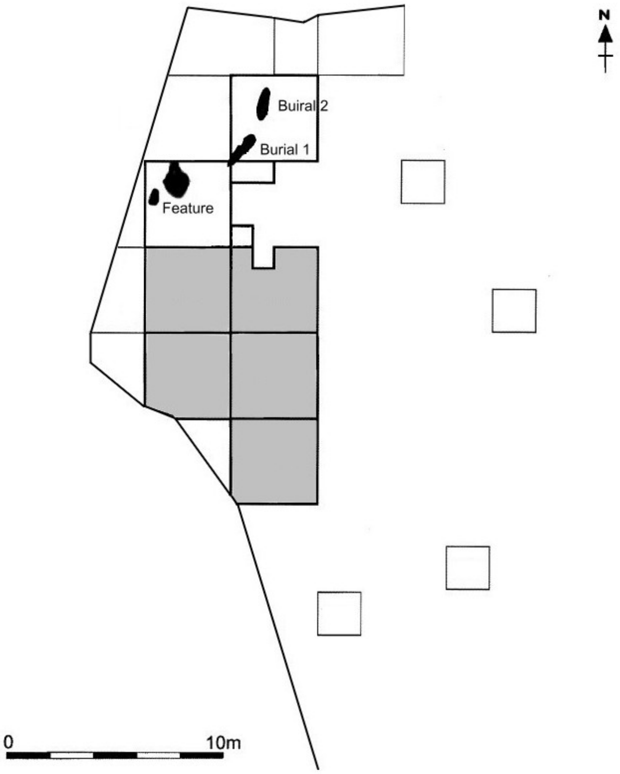

Figure 5.5. Luliao excavation area shown with large units (each was later divided into 25 smaller ones), and area sampled for faunal analysis (in gray). (Redrawn and modified from Ho et al. 2006: Figure 2)

Figure 5.6. Luliao site now is a residential area.

After features and materials were documented and recovered, the excavated sediment was immediately water-screened in search of small remains. Despite focusing on a relatively small area, this excavation revealed a very large quantity of cultural and biological remains (Table 5.2), including light brown potsherds, bone and iron tools, shells, animal bones, glass beads, and two human burials (Ho and Liu 2005b, 2005c; Ho et al. 2006). Of the two human burials, only one skeleton is well preserved and also found in the typical prone position. The bioarchaeological study of that skeleton suggested a young adult male with poor dental health (Ho et al. 2006). More interestingly, this individual appears to have experienced ritual tooth ablation that has not been observed on any other Iron Age skeletons in the central-western lowland (Ho et al. 2006). Mitochondrial DNA analysis of this individual also confirmed an affinity with modern aboriginal groups (Yen 2006).

Table 5.2. Archaeological remains from Luliao (summarized from Ho and Liu 2005b; Ho et al. 2006).

Remains	Quantity	Major Style/Type/Species
Potsherd	Large amount	Light brown, clay, flapped decorations
Stone tool	Not recorded	
Bone artifact	850	Needle, hairpin, spearhead, pendant, ornament
Iron artifact	437	Nail, needle, chisel, knife, arrowhead, spearhead, ring, and so on
Agate/glass bead	2406	Red, blue, white, rounded and tubular shapes
Chinese coin	0	
Animal bone	Large amount	
Shell	Large amount	
Human burial	2	Extended, prone, tooth ablation

The exotic artifacts found at Luliao are especially significant for the high concentration ($45.13/m^3$). Chemical analysis of a number of glass beads suggested multiple origin points for these imported items, including India and China (Cui et al. 2008). Almost all of the iron tools and agate/glass beads were found and evenly distributed in the trash area (Ho and Liu 2005b), expect for one iron shovel in one of the human burials (Ho et al. 2006).

5.2.3 Nanshikeng

The Nanshikeng site (NSK) was first surveyed by amateur archaeologist Hongbo Wong in 1948, who found many prehistoric cultural and biological remains during surface collection (Ho et al. 2004). In 2003, a researcher at the NMNS—Dr. Whei-Lee Chu—visited the site and found several exposed prehistoric pits during the construction of a house. Since then, several excavation projects have been carried out by NMNS and other research teams. The museum conducted four of them (Figures 5.7 and 5.8), and all of the excavation reports have been published (Ho and Liu 2005a; Ho et al. 2004; Liu 2013a, 2013b). This section reviews the fieldwork and major findings from these four excavations.

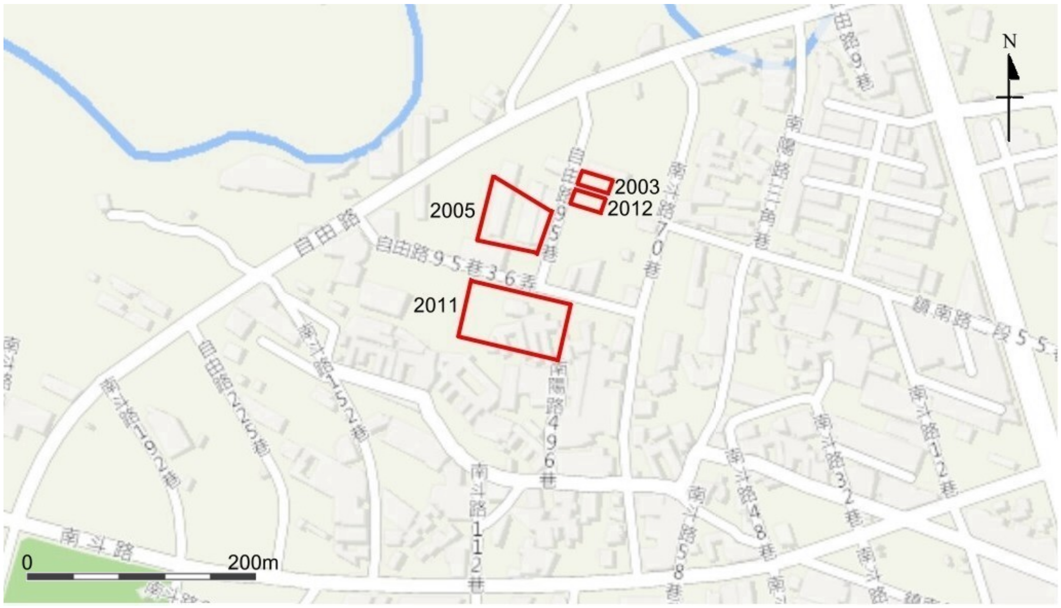

Figure 5.7. Four excavations conducted by NMNS at Nanshikeng. (Background map courtesy of Taiwan Geospatial One Stop)

Figure 5.8. Excavated area of the Nanshikeng site now is a residential area.

The 2003 Excavation

In 2003, the NMNS research team conducted a trial excavation at a construction site and documented the profiles of nine exposed pits (H1–H9). According to the excavation report (Ho et al. 2004), the profile of H1 shows a cylindrical shape; in the bottom there was a 15-cm-thick layer of burnt soil, which may indicate this pit was used as a kiln for pottery firing and then abandoned to depose trash. Four test units were placed near H1 and H7 to explore the pit features, and three 4 m^2 and one 1 m^2 units were excavated (13 m^2 in total) with arbitrary 10 cm levels. There are three depositional phases in H1 and each phase has a slight difference in artifact composition. The artifacts from the earliest phase consist mainly of grayish pottery, while light-brown pottery increases in the second and third phases. Most animal remains and exotic items were discovered in the third phase, hinting at an association between animal use and maritime trade. There is a layer of charcoal and soil between the second and third phases of

H1, suggesting the pit was burned, filled with dirt, and then reused again. After excavation, the profile of H1 was removed en bloc and preserved for exhibition. All materials were carefully collected during excavation, but the sedimentary matrix was not screened. Excavation of these units produced gray and light-brown potsherds, biological remains, and a few exotic artifacts, including one agate bead, iron tools, and a Chinese coin (Ho et al. 2004) (Table 5.3).

Table 5.3. Archaeological remains from the 2003 excavation of Nanshikeng (summarized from Ho et al. 2004).

Remains	Quantity	Major Style/Type/Species
Pottery shard	2667	Gray, light brown, clay, flapped decorations
Stone tool	1	Grindstone
Bone artifact	0	
Iron artifact	3	Arrowhead
Agate/glass bead	1	Red, diamond shape
Chinese coin	1	Minted in AD 1107–1100
Animal bone (NISP)*	2757	Deer, munjac, wild boar, rat, and so on
Shell	Large amount	Venus clams (*Gomphina aequilatera*), girdled horn shells (*Cerithidea cingulata*), orient clams (*Meretrix lusoria*), golden clams (*Corbicula fluminea*)

*Number of identified specimens.

The 2005 Excavation

The excavation in 2005 started with a systematic augering in an area of 2700 m^2. Of the 120 augerings, only 18 of them recovered dark-gray sediments and prehistoric remains. Then, 20 test units (2 × 2 meters each) around these 18 particular spots were excavated (Figure 5.9), and each unit was excavated with arbitrary 10 cm levels (Ho and Liu 2005a). This excavation discovered 23 complete and partial pits; 3 smaller holes are likely postholes. All of the pits have a cylindrical shape but vary in size, ranging from 50 to 280 cm wide and from 15 to 180 cm deep (Ho and Liu 2005a). Several larger pits partially overlap each other, and most of the pits show evidence of burning, with burnt soil and charcoal between deposits. One of the large pits displays over 10 depositional layers, indicating this particular pit had been used intensively or for a longer period of time.

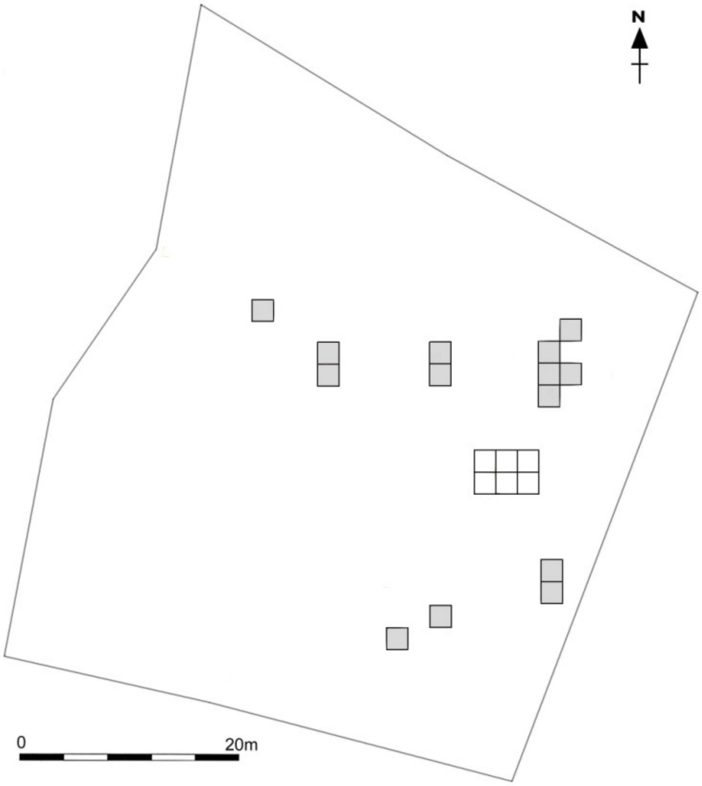

Figure 5.9. Test units of the 2005 excavation at Nanshikeng and areas sampled for faunal analysis (in gray). (Redrawn and modified from Ho and Liu 2005a: Figure 2)

All sediments from the pits were water-screened, but six of the twenty test units were not entirely excavated because part of the sediment was removed en bloc and preserved for exhibition. Thus, data from these six units were not sampled for faunal analysis (Figure 5.9). The 2005 excavation produced a large quantity of potsherds and small amounts of stone tools, iron artifacts, and exotic items (Table 5.4). Pottery is light brown and grayish in color and usually has flapped decorations. Stone tools are very few, predominately natural pebbles used as hammers. Bone fragments are mostly mammal, but, unlike the bones from the 2003 excavation, most of the fragments appear to have experienced a higher degree of burning. Through screening, small items such as glass beads and botanical remains were also recovered.

Table 5.4. Archaeological remains from the 2005 excavation of Nanshikeng (summarized from Ho and Liu 2005a).

Remains	Quantity	Major Style/Type/Species
Pottery shard	468.608 kg	Grayish, light brown, clay, flapped decorations
Stone tool	10	Hammer, grindstone, ax, flake
Bone artifact	0	
Iron artifact	10	Knife, sickle, arrowhead
Agate/glass bead	35	Blue, red, rounded and tubular shapes
Chinese coin	1	Minted in AD 1206
Animal bone (g)	19673.4	Deer, munjac, wild boar, hare, and so on
Botanical remain	Not recorded	Chinaberry tree (*Melia azedarach*), plum (*Prunus mume*), bamboo, grass, rice (*Oryza sativa japonica*)
Shell	Large amount	Venus clams (*Gomphina aequilatera*), girdled horn shells (*Cerithidea cingulata*), orient clams (*Meretrix lusoria*), Pacific oysters (*Crassostrea gigas*)

The 2011 Excavation

The 2011 excavation focused on a relatively larger area (5720 m^2). Thus, the research team first dug several test trenches and discovered most remains were concentrated in the northwest corner. Then, 127 test units were excavated in the northwest and northeast corners (4 m^2 each, 508 m^2 in total). Due to limited fieldwork time, this excavation focused on pit features only, since prehistoric remains were concentrated there (Liu 2013a). In the excavated area, 15 pit features were discovered, and most were 200 cm wide and 100–200 cm deep. As with the pits discovered in 2005, several large pits partially overlapped, with burnt soil in the basal layer (Liu 2013a). Each pit feature was excavated with arbitrary 10 cm levels. All materials were carefully collected during excavation, but the sedimentary matrix was not screened. As in previous discoveries, this excavation recovered a large quantity of cultural and biological remains (Table 5.5). Artifact composition is similar to the previous discoveries. No human burials were found but a few bones and one tooth were disposed among the faunal remains. One of the human bones appears to be part of a tibia and displays cut marks. Sediments from the pit features were not screened but collected for further study. Researchers have also extracted rice and grass phytoliths from the pit sediments (Liu 2013a).

Table 5.5. Archaeological remains from the 2011 excavation of Nanshikeng (summarized from Liu 2013a).

Remains	Quantity	Major Style/Type/Species
Pottery shard	Over 100,000	Grayish, light brown, clay, flapped decorations
Stone tool	0	
Bone artifact	0	
Iron artifact	2	Spearhead or knife
Agate/glass bead	18	Blue, red, rounded and tubular shapes
Chinese coin	0	
Animal bone (NISP)	6607	Deer, munjac, wild boar, hare, rat, small carnivores, bird, fish
Botanical remain	Not recorded	Grass and rice phytolihs (mostly grass)
Shell	Large amount	Venus clams (*Gomphina aequilatera*), girdled horn shells (*Cerithidea cingulata*), orient clams (*Meretrix lusoria*), Pacific oysters (*Crassostrea gigas*)
Human bone	4	Tibia and fibula fragments, a complete molar

The 2012 Excavation

As in the previous excavation, the 2012 research team dug several test trenches prior to the excavation and found that there were no evident prehistoric layers; only pit features have been preserved in the survey area (Liu 2013b). Therefore, the excavation also focused on pit features only and each pit was excavated with arbitrary 10 cm levels. Fourteen test units were excavated in the area; eleven of them were 4 m^2 and three were 2 m^2 (50 m^2 in total). In the excavated area, six partial pit features were discovered; their original size is estimated around 200–300 cm wide and 100–200 cm deep. As with the pits discovered previously, some pits also contained a large amount of burnt soil and charcoal in the basal level, suggesting they were originally used for firing pottery and then filled with waste over time (Liu 2013b). In addition to the pits, a rectangular hole was also discovered, with a complete pot and over 50 glass beads. These artifacts were well organized in the hole, which may indicate a human burial despite no skeletal remains preserved (Liu 2013b). All materials were carefully collected during excavation, but the sedimentary matrix was not screened. Artifacts from this work are similar to the previous discoveries, predominately potsherds and a few stone and iron artifacts (Liu 2013b) (Table 5.6). There were also macrobotanical remains recovered from the pits, including rice grains, Chinaberry tree seeds, and bamboo residue (Liu 2013b).

Table 5.6. Archaeological remains from the 2012 excavation of Nanshikeng (summarized from Liu 2013b).

Remains	Quantity	Major Style/Type/Species
Pottery shard	Large amount	Grayish, light brown, clay, flapped decorations
Stone tool	5	Hammer
Bone artifact	0	
Iron artifact	12	Ax, arrowhead, nail
Agate/glass bead	59	Blue, rounded and tubular shapes
Chinese coin	0	
Animal bone (g)	6495	Deer, munjac, wild boar, hare, rat, small carnivores, bird, fish
Botanical remain	Not recorded	Chinaberry tree (*Melia azedarach*), bamboo, rice (*Oryza sativa japonica*)
Shell	Large amount	Venus clams (*Gomphina aequilatera*), girdled horn shells (*Cerithidea cingulata*), orient clams (*Meretrix lusoria*), Pacific oysters (*Crassostrea gigas*)

5.3 Chronology

All three sites described in this chapter date to the Iron Age, with Sector 144 of Huilai from the early Iron Age and the Luliao and Nanshikeng sites from the late period. According to Ho and Chu (2004), all of the radiocarbon data for Sector 144 evidence occupation from around AD 700–800 (Table 5.7). The majority of potsherds are grayish-black clay tempered by fine sand that represents a cultural period from the early Iron Age. In Area I, however, a few artifacts appear to show a mid-Neolithic style (e.g., reddish potsherds, jade artifacts). According to the data from Ho and Chu (2009), however, the amount of mid-Neolithic pottery is very small, accounting for less than 2% of total potsherds, and no clear Neolithic layer can be detected in the stratigraphy. In addition, there were 23 human skeletons discovered from Sector 144, and all of them were buried in the typical prone position that represents the Iron Age culture of the central-western lowland (Ho and Yen 2007). In sum, despite a small amount of Neolithic artifacts, it can be concluded that only one cultural period－the early Iron Age－accounted for the excavated areas of Sector 144, based on the available information on radiocarbon dating, stratigraphy, and human burials.

The cultural sequence of the Luliao and Nanshikeng sites is relatively clear. Only one cultural period－the late Iron Age－can be detected at Luliao, based on radiocarbon dating (Table 5.7) and the cultural remains (Ho and Liu 2005b, 2005c). At Nanshikeng, the four excavation areas were very close to each other (Figure 5.7), and all of the excavations produced artifacts similar in composition, style, and type (Tables 5.3–5.6). These artifacts suggest a possible date of the late Iron Age, characterized by light-brown pottery, few stone tools, and a larger quantity of exotic items. Charcoal remains from the 2003 and 2005 excavations were also dated between AD 1300–1500 (Table 5.7), and the two recovered Chinese coins minted in AD 1107–1206 indicate the settlement existed after this period. The artifact evidence and radiocarbon dating suggest these four excavation areas at Nanshikeng were likely part of a large settlement in the late Iron Age.

Table 5.7. Radiocarbon and calibrated dates for Huilai, Luliao, and Nanshikeng.

Site	Sample	Context	Radiocarbon Date (BP)	Calibrated Date (BP)*	Reference
Huilai (Sector 144)	Charcoal	Burial	1210±40	1178–1067 1263–1055	Ho and Chu 2004 Liu et al. 2007
Huilai (Sector 144)	Charcoal	Burial	1250±40	1266–1169 1276–1076	Ho and Chu 2004 Liu et al. 2007
Huilai (Sector 144)	Charcoal	Burial	1360±40	1313–1262 1344–1233	Ho and Chu 2004 Liu et al. 2007
Huilai (Sector 144)	Charcoal		1320±50	1295–1235 1332–1168	Ho and Chu 2004 Liu et al. 2007
Luliao	Shell	Surface collection	1010±60		Ho and Liu 2005c
Luliao	Animal Bone	Surface collection	640±110		Ho and Liu 2005c
Luliao	Charcoal	Refuse deposit (P1L7)	420±40	530–430 360–330	Ho and Liu 2005c
Luliao	Charcoal	Refuse deposit (P1L9)	450±50	540–440 350–330	Ho and Liu 2005c
Luliao	Charcoal	Refuse deposit (T5P2L7)	480±40	540–490	Ho and Liu 2005c
Luliao	Shell		910±40	693–640 732–622	Liu et al. 2007
Nanshikeng 2003	Charcoal	Pit (H1, P1L6, second phrase)	690±40	678–647 692–626	Ho et al. 2004 Liu et al. 2007
Nanshikeng 2003	Charcoal	Pit (H1, P2L8, second phrase)	650±40	594–562 613–552	Ho et al. 2004 Liu et al. 2007
Nanshikeng 2005		Pit	480±70		Liu 2013a
Nanshikeng 2005		Pit	520±70		Liu 2013a

* Calibrated dates may be 1 segma (68% probability) and 2 segma (95% probability) results (Liu et al. 2007).

5.4 Discussion

The reviews presented here suggest that all three sites are located on or face large, open lowland (Taichung Basin, Qingshui Coastal Plain) that is an ideal habitat for deer. The significant diversity of artifact composition suggests they are all part of a residential area, with geographic access to maritime or riverine trade. The excavations also reveal a large quantity of faunal remains, which suggests that hunting was important to the Iron Age societies. However, although all three locations were excavated by NMNS, the focus and scale of the fieldwork are apparently different from one another. For example, the excavation at Luliao could only concentrate on a small area (180 m^2) that contains mainly refuse deposits. The survey area of Nanshikeng is relatively larger, but most of the excavation focused on pit features due to an incomplete stratigraphic record. Floor and other deposits at the two sites may have been destroyed by past house construction. As a result, a contextual analysis is not possible for the two late Iron Age assemblages. I thus compare the assemblages as a whole to explore a general pattern of deerskin production at the three sites, without a consideration of intrasite variation.

Although limited, the exotic artifacts (Figures 5.10 and 5.11) discovered from these excavations may reveal something important about maritime trade. In Chapter 1, the overseas-trade hypothesis proposed that maritime trade expanded during the Iron Age and predicted a higher concentration of exotic artifacts at the late Iron Age sites. Table 5.8 shows the estimated concentration of exotic artifacts at the three sites. Since screening is necessary to recover small artifacts such as glass beads, this table includes the published data from screened areas only (Huilai Area I, Luliao, and Nanshikeng 2005). As shown in the table, there is a substantial difference in artifact concentration between the three sites. There appears to be a higher concentration of exotic artifacts at the late Iron Age Luliao and Nanshikeng sites, which suggests maritime trade increased during the Iron Age.

Nevertheless, the recovery context of the exotic artifacts should be further discussed to confirm that observation. At Huilai Area I and Luliao, all the exotic jewelry was recovered from refuse deposits or sediments (Ho and Chu 2009; Ho and Liu 2005b), but at Nanshikeng, there were 59 glass beads discovered from a likely human burial during the 2012 excavation, although the data are not included in Table 5.8. This may suggest the exotic jewelry had a higher social significance at Nanshikeng, and the concentration of this artifact may increase if more burials were discovered at the site. In addition, the importance of exotic jewelry is potentially biased by the raw count of agate and glass beads, since a large quantity of these artifacts in the deposit may represent only a few events of consumption.

Table 5.8. Estimated concentrations of exotic artifacts at Huilai, Luliao, and Nanshikeng.

Site*	Period	Excavated Volume (m^3)	Iron Artifact (total/unidentifiable)	Exotic Jewelry	Coin	Total Concentration
Huilai	Early	126	2/0	24	0	0.21
Luliao	Late	63	437/142	2406	0	45.13
Nanshikeng	Late	30	10/3	35	1	1.53

*Include the data only from the systematic excavated and screened units at Huilai Area I (Ho and Chu 2009), Luliao (Ho and Liu 2005b), and Nanshikeng 2005 (Ho and Liu 2005a).

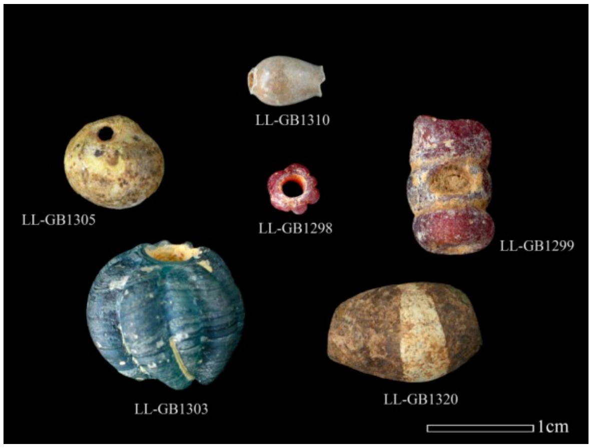

Figure 5.10. Glass beads from Luliao. (Authorized by National Museum of Natural Science, Taiwan)

Figure 5.11. Iron artifact from Luliao. (Authorized by National Museum of Natural Science, Taiwan)

The concentrations of iron artifacts are also substantially different between the three sites. Although the number of iron artifacts tends not to be biased by screening and raw count, the late Iron Age assemblages may have experienced a significant post-depositional destruction due to the acidic soil of the Dadu Plateau (see Chapter 4). Thus, I exclude the fragmented, unidentifiable iron artifacts (Table 5.8) from the analysis, and the concentrations of Luliao (4.68/m^3) and Nanshikeng (0.23/m^3) are still much higher than that of early Iron Age Huilai (0.02/m^3). In addition, none of the iron artifacts were recovered from burials except one shovel at Luliao. The concentration of iron artifacts, therefore, should provide more convincing evidence to support the overseas-trade hypothesis.

In Chapter 1, I also proposed a tramping-for-profit hypothesis that maritime trade was conducted with a tramping navigation and expected a similar concentration of exotic artifacts at the late Iron Age sites. Contrary to the expectation, the concentrations of exotic artifacts are substantially different at Luliao and Nanshikeng. It appears the artifact evidence does not support a trade mode of tramping. What kind of mechanism, if not tramping, had caused such distribution of imported artifacts? Was there a commodity-oriented deerskin production at the late Iron Age sites? The next several chapters will investigate the deerskin production through quantitative faunal analysis.

5.5 Summary

This chapter reviews the environments, excavations, and discoveries of the Huilai, Luliao, and Nanshikeng sites, which were selected to investigate the deerskin trade in Iron Age central Taiwan. Although these three sites are temporally and spatially different, all of them have access to the sea or large rivers for maritime trade. These excavations yielded a large amount of cultural and biological remains, suggesting all three sites were part of residential areas. Much of the fieldwork carried out a water-screening, which provided good materials for systematic analysis. Artifact composition and radiocarbon dating show all three locations represent a single cultural period of the Iron Age: Sector 144 of Huilai, the early Iron Age; Luliao and Nanshikeng, the late period. Although there are some limitations and constraints, the excavations revealed a substantial difference in the concentration of exotic artifacts between the three sites, which supports the overseas-trade hypothesis, but not the tramping-for-profit hypothesis. A study of deerskin production, therefore, is necessary to explore maritime trade, and will be presented in the next chapters.

CHAPTER 6. THE FAUNAL ASSEMBLAGES

To investigate a commercialized deerskin production, this study compared the faunal assemblages from three Iron Age sites. As reviewed in Chapters 4 and 5, these three sites are temporally and spatially different, and although all were excavated by NMNS, these sites were surveyed by different research teams and the faunal samples may have been processed in somewhat different ways. As archaeologist Michael Schiffer proposed, an archaeological pattern may be “due entirely to formation processes and not to the past behavior of interest” (1983:696). Therefore, to compare the patterns of the three assemblages, this chapter discusses the formation processes of the faunal materials, including the assemblage context, taphonomic effect, recovery method, curation, and the sampling strategy used in this study.

6.1 Assemblage Context

In considering the context of sample assemblages, it is important to note that almost all the faunal samples used in this study were recovered from refuse deposits. Refuse pits are common at the archaeological sites of Taiwan. These pits often contain a high concentration of biological remains and a great diversity of fragmentary artifacts, sometimes with ashes and burnt soil that indicate trash burning. Based on the published information, there is no strong evidence suggesting a ceremonial or non-consumptive use of these pits, or a deliberate disposal of faunal remains at the three sites. Materials recovered from these pits, therefore, can be used to investigate deerskin production as an export economy.

Although deposited in a similar context, the faunal assemblages may have experienced different taphonomic processes. For example, the refuse features at Sector144 of Huilai are shallow dish-like holes, ranging from 50 to 300 cm wide and 30 to 100 cm deep. The total number of pit features is not clear yet, but at Area I, at least three large refuse pits were discovered (Ho and Chu 2009). At Luliao, the excavation area can be seen as a large trash disposal area since all the cultural and faunal remains were densely distributed over the entire area. This area is also shallow and dish-like, with a depth of 20–60 cm. Pits at Nanshikeng are very different from those at Huilai and Luliao. Within the survey area, over 50 pit features were discovered; many of them cluster together and some of them even overlap each other. Most of the pits have a deep and cylindrical shape but vary in size, with the largest being 350 cm wide and 230 cm deep (Ho et al. 2004; Ho and Liu 2005a; Liu 2013a, 2013b). As reviewed in Chapter 5, some pits at the site were probably used for firing pottery at first and then abandoned to dispose trash (Ho et al. 2004). Therefore, the post-depositional effects may be varied among the pits at the three sites, and a taphonomic evaluation is necessary to compare the patterns of the three assemblages.

6.2 Taphonomic Evaluation

As Lyman (1994:38) noted, a fossil record is formed by four taphonomic effects: disarticulation, dispersal, fossilization, and mechanical alteration, resulting from both human actions and natural processes. At archaeological sites, most of these factors can be attributed to human activity, but the effects of natural processes should also be anticipated. Since no apparent geological processes, such as fluvial actions, have been reported at any of the three sites and marks of animal gnawing are also seldom observed on the bone fragments, natural processes would have little influence on the disarticulation and dispersal of these faunal remains. Natural processes, however, may have been significant in the fossilization and mechanical alteration. These effects would alter the chemistry, structure, and morphology of skeletal remains and increase the fragmentation and abrasion of bones (Lyman 1994:37).

Fragmentation in particular receives a lot of attention in zooarchaeological literature because it may substantially affect the quantitative properties of the fossil record. For example, fragmentation may increase/decrease the number of identified specimens (NISP) of certain taxa; as fragmentation continues, some fragments are too small to be identified and so become analytically absent (Lyman 1994:227). This section evaluates the difference in fragmentation between these assemblages and discusses possible taphonomic processes responsible for that difference. With limited time for research, the fragmentation evaluation was performed by comparing a small percentage of the three assemblages. First, one unit from each site was randomly selected, with samples from that unit consisting of materials recovered by screening and with assemblage size reaching at most a few hundred. All materials were collected by using a 2-mm (1/13 inch) mesh screen with water during fieldwork (see Section 6.3). There may be an intra-site variation in fragmentation, but this simple random sampling gave each qualified unit an equal chance of selection (Drennan 2010:85). In addition, the species composition of each assemblage may also affect the degree of fragmentation. According to the preliminary analyses conducted by the museum, medium mammals (sika deer and wild boar) account for the majority of all three assemblages, and thus differences in bone fragment size likely reflect the degree of fragmentation rather than species size. The selected samples were then counted and weighed to generate an index of average weight per fragment. This index was calculated by dividing the number of fragments by the total weight of the bones. Another way to evaluate fragmentation is to examine their intensities. This is shown by the lengths of the long bone diaphysis fragments, but fragments less than 5 mm were excluded from both analyses since they are too small to count precisely.

Table 6.1 shows the weight index of selected samples from each assemblage, demonstrating a different degree of fragmentation between the three assemblages. The Huilai assemblage is the most fragmented (0.52 g/fragment), followed by Luliao (0.75 g/fragment), and Nanshikeng (1.09 g/fragment). Figure 6.1 shows the fragmentation intensities of the three assemblages. Their frequency distributions per 1 cm size class appear to be different. Most bone fragments from Huilai and Nanshikeng are in the 0.5–1 cm and 1.1–2 cm size classes, while most fragments from Luliao are 1.1–2 cm and 2.1–3 cm long. The greatest differences between the three assemblages occurred in the 0.5–1 cm size class; proportionately more fragments from Huilai occurred in this size class than in the Luliao and Nanshikeng samples. These two data sets suggest that the early Iron Age Huilai assemblage is more fragmented than Luliao and Nanshikeng.

Table 6.1. Bone count, weight, index, and number of burned bones from a selected unit of each site.

Site	Count	Weight (g)	Index	Burned Bones	% Burned
Huilai	830	433.3	0.52	98	11.81
Luliao	285	215.0	0.75	54	18.95
Nanshikeng	451	490.5	1.09	338	74.94

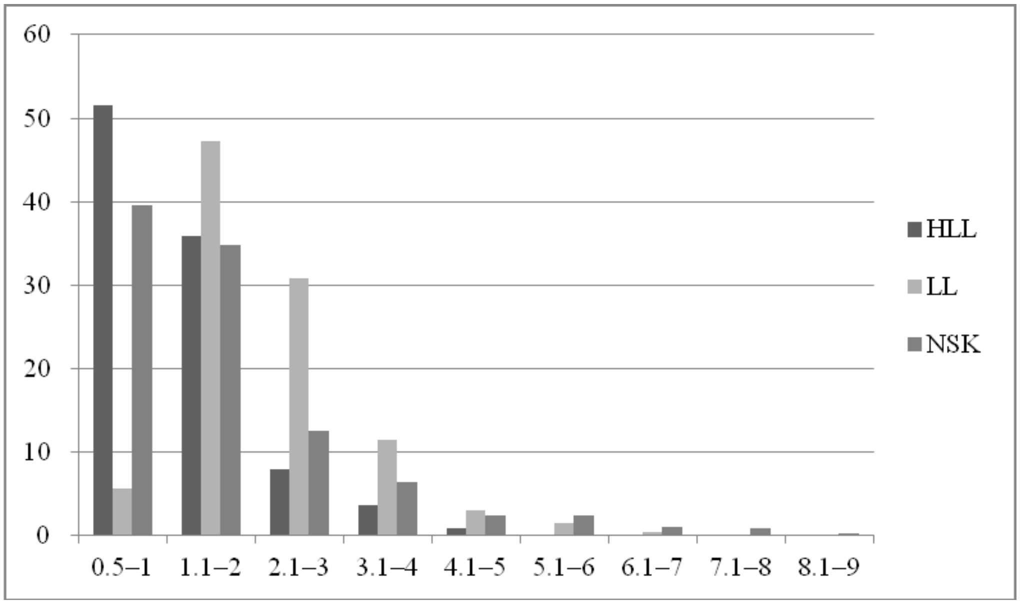

Figure 6.1. Proportion of bone fragments in each 1 cm size class.

The difference in fragmentation may have resulted from a complex process. In addition to human percussion, burning is the most common pre-depositional and/or post-depositional process that may weaken bone structure and increase fragmentation. Since all three assemblages appear to have experienced burning, an evaluation of such effects on bone fragmentation is necessary. This evaluation was conducted by counting the number of burned bones and calculating the proportion (Table 6.1). Among the three assemblages, Nanshikeng has the highest degree of completeness (weight index = 1.09), but a much larger proportion (74.94%) of the bone fragments are burned, indicating burning is not responsible for the difference in fragmentation.

Fragmentation may also result from post-depositional destruction like chemical alteration and sediment crushing. Several indicators can detect the degree of post-depositional destruction. Marean (1991) proposed a method to evaluate such an effect by comparing the completeness of carpals and tarsals between assemblages. These small compact bones are more resistant to taphonomic processes and are seldom destroyed by humans or animals. Marean excluded calcanea because they often display gnawing or percussion marks. In this study, I suggest a further exclusion of astragali from the analysis because a large number of this skeletal element in the Luliao samples displays deep, V-shaped, chopping marks. Although some of the other small bones may also have percussion marks, almost all of these marks are thin, slight cuts on the bone's surface so their influence on bone fragmentation appears to be minimal. Therefore, the completeness of the three assemblages are compared with six deer carpal and tarsal bones (scaphoid, lunar, cuneiform, trapezoid magnum, unciform, and central-fourth tarsal), but excludes samples that appear to have been broken by tools.

Materials used in this comparison were recovered from the screened units selected with systematic random sampling (see Section 6.5). Each of these bones was observed and assigned to a completeness category as <25%, 26–50%, 51–75%, or 76–100%. To simplify the calculation, bones in each category were treated as 25%, 50%, 75%, and 100%, respectively. Table 6.2 shows the completeness across six carpal and tarsal bones from the three assemblages. The completeness of the early Iron Age Huilai assemblage is not significantly different from that of the Luliao (U = 311.5, $p = 0.4902$) and Nanshikeng samples (U = 447, $p = 0.3421$). However, the difference between the two late Iron Age samples is significant (U = 384.5, $p = 0.0477$); the Luliao samples experienced a significantly larger degree of post-depositional destruction than Nanshikeng.

Table 6.2. Completeness of six deer carpal and tarsal bones from Huilai, Luliao, and Nanshikeng.

Completeness (%)	Huilai	Luliao	Nanshikeng	Total
0–25	7	4	2	13
26–50	1	6	7	14
51–75	1	5	1	7
76–100	17	12	30	59
Total	26	27	40	93
Average completeness	76.92	73.15	86.88	80.11

Combining the three evaluations above (weight index, intensity, and completeness), the early Iron Age Huilai samples are more fragmented than the others, and burning and post-depositional destruction are not the main cause for that difference. Therefore, the difference between early and late Iron Age assemblages can be largely attributed to human activity. Post-depositional destruction, however, is responsible for the difference between the late Iron Age Luliao and Nanshikeng samples, in addition to human percussion. I suggest, as reviewed in Section 6.1, the high completeness of Nanshikeng may have also resulted from the structure of the pit features, since their deep and cylindrical shape would assist in avoiding some taphonomic effects such as weathering and the acid topsoil of the Dadu Plateau. Therefore, the comparison between the two late Iron Age assemblages should consider a possible effect of post-depositional destruction.

6.3 Recovery Method

To explore resource procurement, each animal species should have an equal chance to recover. Since screening is necessary to recover the skeletal remains of small animals, this study carefully selected samples that have been screened. At Sector 144 of Huilai, although water-screening was often carried out, it did not become a routine process until later excavations; only part of the area was water-screened (Figure 5.4). In that area, 214 units were systematically excavated and thus only the faunal remains recovered from these 214 units will be used for studying resource procurement. At Luliao, water-screening was constantly carried out during the excavation, but, among the four excavations at Nanshikeng, water-screening was carried out intensively only during the 2005 excavation. Thus, only the materials from that excavation were used to investigate the resource procurement at Nanshikeng.

Another important issue about recovery is the influence of screen-mesh size. It is common sense that small fragments would easily fall through a coarse-mesh sieve, and fine-mesh sieves can catch more bone fragments of small animals. The relationship between screen-mesh size and the recovery of small animals has been discussed in the literature and examined empirically (e.g., Lyman 2008:154–156; Reitz and Wing 2008:147–150). However, research has shown that even when a fine-mesh sieve is used, small animals can still be underrepresented relative to large taxa. As Thomas (1969) showed, compared to 1/8-inch mesh screens, the number of animals weighing under 100 g (e.g., mice) increases when 1/16-inch mesh screens are used.

No official records about screen-mesh size are available for the three assemblages, but excavators reported using a 2-mm (1/13 inch) mesh screen with water during fieldwork. Although not as small as 1/16-inch, I suggest using a fine-mesh sieve may not increase the NISP values of small animals since most of the bone samples recovered would be too fragmented to identify (Cooper et al. 2006). To test this argument, I randomly selected samples from one screened unit of each site and counted the bone fragments that had a length of less than 5 mm (1/5 inch). Because many of the fragments were too small to pick up by hand, the total number of bone fragments could only be roughly estimated. Of the over 674 fragments (Table 6.3), only 18 could be identified and all of them were either antler or teeth fragments. It appears that the majority of small bone fragments in the three assemblages should be taxonomically unidentifiable. The screen-mesh size used in the fieldwork, therefore, is small enough to catch most small identifiable bones.

Table 6.3. Bone fragments less than 5 mm in selected samples.

Site	Bone Count	Identifiable Bone	Species	Skeletal Element
Huilai	>313	12	deer	antler
Luliao	>45	0		
Nanshikeng	>316	6	deer	antler, teeth

6.4 Curation

After recovery, all artifacts, skeletal remains, and excavation records of the sites were filed and stored in the National Museum of Natural Science of Taiwan. All the biological and cultural remains were roughly cleaned, sorted, and bagged with excavation information. The faunal samples have been processed and partially identified by zoologist Yen-Jean Chen. Each identified bone was given a data card with its specimen number, species, skeletal portion, and excavation information. All identified bones are stored in the zoology department at the museum and sorted by site, species, and skeletal element. Bone fragments that have not been identified are also stored in the department. This study carefully examined all the bones from selected units (see Section 6.5) to confirm the existing identification and to identify more specimens.

6.5 Sampling

The issue of sample size has been emphasized repeatedly in zooarchaeological literature as it is often overlooked by analysts. Sample size may heavily skew quantitative results (e.g., Grayson 1981) since small assemblages would limit the observation range, but studying a large sample size is not necessary due to redundancy (Lyman 2008:142–152; Simpson et al. 1960:80). The research team at NMNS has conducted a preliminary analysis on the three assemblages. Although some of the work has not been completed and published, the data could provide a rough sample size for each assemblage. The number of bone fragments discovered from the screened 214 units at Sector 144 of Huilai (Figure 5.4) is estimated at over 30,000 and NISP is approximately 3,000, with the total bone weight being at least 60,000 g. Bones from Luliao are estimated to be around 100,000. NISP is more than 20,000, and the total bone weight is at least 100,000 g. At Nanshikeng 2005 (Ho and Liu 2005a), nearly 20 kg of bones were recovered. The number of bone fragments is estimated to be around 7,000 and NISP is more than 1,000. It appears that the Huilai and Luliao assemblages are considerably larger than Nanshikeng 2005. Since assemblages should be studied with comparable sample sizes (Reitz and Wing 2008:151), a sampling strategy is needed for selecting a proper sample size for the Huilai and Luliao collections.

Several sampling methods have been discussed in the literature (e.g., Drennan 2010), and, among them, *simple random sampling* is most commonly used. As Drennan noted, the "method of simple random sampling is a very effective way to maximize the chance that the selected samples accurately represent the population" (2010:82); it will "give each individual element in the population an equal chance of selection," although "it does not provide a guarantee of representativeness" (85). The most common way to use simple random sampling is to number each sample and then select the samples with a random number table (Drennan 2010:83). For bone samples, it is almost impossible to number all of the bone fragments since there are usually too many to number individually. Thus, I randomly selected excavated grid units and then studied the remains discovered from those units. However, one flaw of this method is that, when sampling a large area, some selected units could be very close to each other, leaving one or more large sections of the area unsampled (Drennan 2010:242).

Systematic random sampling is an alternative that can avoid this situation. For the example of the Huilai site, I subdivided the screened 214 units into 13 subsets consisting of 16 contiguous units each and then selected one unit randomly from each subset by repeatedly selecting random numbers between 1 and 16. This avoids leaving large unsampled areas that often occurs in simple random sampling. Therefore, this study sampled the Huilai and Luliao assemblages with systematic random sampling, but excluded unqualified units such as (1) units that contain unscreened and/or destroyed samples, (2) units that are not systematically excavated, and (3) units that are associated with non-consumptive contexts (e.g., burial). Materials selected with the systematic random sampling are shown in the next chapter.

6.6 Summary

This chapter discusses the formation processes of the three faunal assemblages, which may affect the quantitative results of faunal analysis. All the faunal materials selected for study were recovered from refuse deposits, but the refuse features vary in size and shape. A comparison of the faunal materials, therefore, should consider some possible taphonomic effects. Taphonomic evaluation suggests that natural processes had little influence on disarticulation and dispersal, but post-depositional destruction may be responsible for the degrees of fragmentation among the two late Iron Age assemblages. The effect of recovery method should also be considered since screening was not consistently carried out during the fieldwork. This study carefully selected screened samples for studying animal resource procurement. All skeletal remains were properly stored in the National Museum of Natural Science of Taiwan, but the sample sizes of the three assemblages are substantially different from each other. A systematic random sampling is used to generate proper sample sizes for comparison.

CHAPTER 7. QUANTITATIVE METHODS OF FAUNAL ANALYSIS

In this study, I investigate the commercialized deerskin production of Iron Age central Taiwan with a quantitative faunal analysis. This chapter first presents the identification protocol of this study since identification is the most fundamental step of faunal analysis. Then, I introduce the quantitative methods for testing the four expectations proposed in Chapter 1, concerning animal resource procurement, hunting strategy, seasonality of hunting, and butchery pattern, as well as the materials selected for each analysis. This chapter also discusses some potential problems with these methods and the analytical solutions of this study.

7.1 Identification Protocol

In zooarchaeology, all studies begin with collecting primary data, and that is often conducted during the identification stage (Reitz and Wing 2008:153). Identification is essential to all faunal analyses, but its importance is often neglected in textbooks (Lyman 2002). The exact identification procedures for research are often varied, depending on the analyst's skill, work habits, and the lab protocol (Reitz and Wing 2008:161). Since no systematic protocol has been published in Taiwan zooarchaeology, I established an identification procedure for this study.

The first step of identification is making a list of potential species to narrow down the species that may be identified. This list can be established by understanding the animal species that inhabit the area and by collecting already-known data from existing research (Beisaw 2013; Lyman 2002; Reitz and Wing 2008:157–158). Since the three faunal assemblages (Huilai, Luliao, and Nanshikeng) were recovered from sites located on the Taichung Basin, Dadu Plateau, and Qingshui Coastal Plain, the potential species at the three sites may include grassland, forest, and inshore animals. However, these areas are now highly developed and thus modern faunal compositions would be substantially different from prehistoric assemblages. Another way to make the list is to focus on the species that are already known in the existing research, such as the ethnographic and archaeological record. There is almost no ethnographic research on the central-western lowland due to a rapid decrease in aboriginal populations over the past two hundred years, but the archaeological fauna in Table 3.2 can be listed as the potential species to identify.

However, identification is not restricted to the species listed in Table 3.2. For example, the Formosan serow (Figure 7.1) is a common species in modern forests, but it has never been identified in previous studies. The Formosan Serow (*Capricornis swinhoei*) is a goat species that inhabits hills and mountains, but, over the past 60 years, goat has been identified only once in the archaeological record (see Song and Chang 1954). This appears to contradict the textual record that the indigenous people of Taiwan often hunted goats for subsistence and trade. From a behavioral point of view, this animal is highly vigilant and often inhabits steep slopes of bare rocks and gravel cliffs, which may not have made them an ideal prey for prehistoric hunters. I suggest that serow cannot be ruled out for identification. The absence of serow in the archaeological record may result from a misidentification with sika deer, since, from my observation, these two species are very similar in bone morphology. However, there is still some subtle difference between the two species in terms of bone size and shape. For example, sika deer appear to be larger than the Formosan serow (55–77 lb), and thus deer bones tend to be more robust than serow bones. Their teeth are also quite similar in morphology (both are hypsodont), but, compared to deer teeth, serow teeth tend to have a flatter lingual surface. Deer antler and goat horn can also be easily distinguished as antlers have dense interior spongy bones and a wood-grain-like exterior cortex, while horns are more porous and have a cheese-like structure (Beisaw 2013:57). In this study, therefore, Formosan serow is also listed as a potential species for identification.

Figure 7.1. Formosan serow. (National Museum of Natural Science, Taiwan)

The second step of identification is attributing the specimen to a possible skeletal element and taxonomic category. Although cladistics is now widely used for establishing taxonomic relationships (Beisaw 2013), the identification work of faunal analysis heavily depends upon anatomical characteristics of bone samples. Lyman (2002) noted that there are two types of anatomical characteristics useful for identification－qualitative/morphological traits and quantitative traits. Qualitative/morphological traits are recorded by presence or absence while “quantitative traits can be metric and involve counts of anatomical structures” (Lyman 2002:15). In mammals, most species have a relatively recent common ancestor and share many qualitative/quantitative traits. Since the potentially identified mammals are limited to only 17 species, bone samples can be easily identified at an order level by traits. In going down to the family or species level, however, identification is often facilitated by other characteristics such as bone shape. For example, pigs can be easily distinguished from deer by bone shape as they tend to be excessively twisted due to a short, robust body shape (Beisaw 2013). However, when bones are too fragmented, these two species are often indistinguishable. Such data were recorded by going up one or two levels if identification is not certain.

The third step is comparing the specimen with a reference collection to confirm identification. As Reitz and Wing (2008:158) noted, a good reference collection is essential to identification. This study used the reference skeletons in the zoology department of the National Museum of Natural Science, collected by zoologist Miss Yen-Jean Chen (Table 7.1). The collection contains the most common wild mammalian species in Taiwan and should be sufficient for identifying most mammal bones. Lyman (2002) further suggested that reference skeletons should avoid using the skeletons of captive animals, if possible, as their behavior and diet may result in different skeletal anatomy from wild animals. The majority of reference skeletons at the museum were collected by wildlife agencies, except sika and sambar deer. No wild sika deer have been recorded since 1969 (McCullough 1974), although they were reintroduced in a national park in the 1980s. Sambar deer still exist in the wild, but they can only be seen in the high mountains. Therefore, the reference skeletons of sika and sambar were collected from private farms

Table 7.1. Reference skeletons of terrestrial mammals used in this study.

Scientific Name	Common Name	Number of Skeletons
Artiodactyla		
Cervidae		
Cervus nippon taiouanus	Sika deer	2
Cervus unicolor swinhoei	Sambar deer	2
Muntiacus reevesi micrurus	Reeve's muntjac	2
Suidae		
Sus scrofa taivanus	Wild boar	1
Sus scrofa domestica	Domestic pig	1
Bovidae		
Naemorhedus swinhoei	Formosan serow	1
Primates		
Cercopithecidae		
Macaca cyclopis	Taiwanese macaque	2
Soricomorpha		
Soricidae		
Suncus murinus	Money shrew	1
Lagomorpha		
Leporidae		
Lepus sinensis formosanus	Hare	2
Oryctolagus cuniculus	Rabbit	1
Rodentia		
Muridae		
Bandicota indica	Bandicoot rat	2
Rattus losea	Brown country rat	1
Ruttus tanezumi	Asian house rat	1
Sciuridae		
Callosciurus erythraeus taiwanesis	Formosan squirrel	1
Dremomys pernyi owstoni	Formosan long-nosed squirrel	1
Petaurista alborufus lena	White-faced flying squirrel	1
Petaurista philippensis grandis	Giant flying squirrel	1
Carnivora		
Viverridae		
Viverricula indica pallida	Small Chinese civet	1
Paguma larvata	Gem-faced civet	1
Herpestidae		
Herpestes urva	Crab-eating mongoose	3
Canidae		
Canis lupus familiaris	Dog	1
Felidae		
Felis silvestris catus	Cat	1
Prionailurus bengalensis	Leopard cat	2
Mustelidae		
Lutra lutra chinensis	Otter	1
Martes flavigula	Yellow-throated marten	1
Meles meles	Badger	1
Melogael moschata	Chinese ferret-badger	1
Mustela sibirica	Siberian weasel	2

In sum, the identification work for this study was carried out first by making a list of potential species based on the archaeological fauna in Table 3.2. Then, the skeletal element represented by the specimen was attributed to a possible taxonomic category. Finally, a visual comparison was made with the reference skeleton to confirm identification, with a consideration of other variables such as sex and age. Although some specimens may have been identified by other analysts at the museum, visual comparison with reference skeletons was always carried out to test the existing identifications. An uncertain identification was recorded by going up one or two levels, and an unusual identification (exotic, rare species) was recorded only when it could be 100% certain. Shellfish were not included in the analysis since most of the remains were too fragmented to systematically collect and identify. Each specimen was recorded in a database with its specimen number, excavation information (unit and level), species, skeletal element and portion, side (left/right), count, weight, and completeness (Appendix A).

7.2 Quantitative Methods and Potential Problems

In the first chapter, I proposed four archaeological expectations for investigating a commercialized deerskin production. This section presents the quantitative methods, their potential problems, analytical solutions, and materials selected for each analysis.

7.2.1 Quantifying the Change in Animal Resource Procurement

The change in animal resource procurement during the Iron Age is examined with the relative frequencies of taxa and species diversity. In zooarchaeology, relative frequencies of taxa are often calculated with two quantitative units: NISP (the number of identified specimens) and MNI (the minimal number of individuals). Analysts often tally both since each has its own strengths and problems, but Grayson (1984) and Lyman (2008) prefer NISP over MNI. Here, I summarize their arguments.

The most significant problem with NISP is specimen independence. NISP may overestimate or underestimate the true abundance of some taxa due to differential preservation and fragmentation across taxa. It is of course unlikely that “all specimens are independent of one another” and in most archaeological cases, it is also unlikely “interdependence is randomly distributed across taxa” (Grayson 1979:223). MNI seems to solve that problem because it is calculated by the individuality of the organism. However, the calculation of the MNI value is based on “the empirical verifiability of individuals” (Lyman 2008:80), causing its own significant problem of aggregation. An aggregation is often a result of the taphonomic history of an assemblage and the analysts’ decisions (Grayson 1984:49). This would also cause a problem of specimen independence when calculating MNI; that is, how to define the aggregates of a faunal assemblage. Pairing is another analyst-related problem as analysts may pair skeletal elements differently. As a result, bone specimens in an analytically bounded aggregate may or may not be independent of all others (Lyman 2008:70).

NISP has some other problems in addition to specimen independence, but many of the problems can be dealt with analytically (Lyman 2008:30–36). On the other hand, the two major problems of MNI—aggregation and pairing—cannot be solved with any quantitative methods. Additionally, NISP and MNI are statistically correlated and MNI is a function of NISP (Grayson 1984:62–63; Lyman 2008:78, 80). Therefore, there is no need to calculate MNI because the two provide redundant information, and NISP is more fundamental, less derived than MNI (Grayson 1979, 1984:62–63; Lyman 2008:79).

The faunal assemblages used in this study may also have some analyst-related problems in aggregation. First, all the three sites were excavated on a relatively small scale, which represents only a part of the prehistoric settlements. Second, due to limited time for analyses, materials used to study relative frequencies of taxa are selected with a sampling technique (see Chapter 6). The bone samples selected for analysis appear to be bounded spatially and analytically, and thus NISP is preferred over MNI as the quantitative unit.

Another approach to quantify the change in resource procurement is calculating species diversity. The concept of diversity as developed in biology and ecology is often adopted by archaeologists to explore the variability of archaeological assemblages, since it can reflect the differences in past human behavior. Diversity can be defined as “the number of categories represented in a sample or as the manner in which a quantity is distributed among those categories” (Jones and Leonard 1989:2). This definition involves two concepts: richness and equitability. In zooarchaeology, richness is “the number of species used at the site” and equitability is “the evenness with which these resources are used” (Reitz and Wing 2008:245). Although these concepts have been widely used in archaeology, it is frequently discussed that diversity may vary as a function of sample size (e.g., Grayson 1981; Kintigh 1984). In general, the larger the assemblage, the more species it should have. Several studies have developed new statistical methods for measuring archaeological diversity (e.g., Kaufman 1998; Kintigh 1989), but a detailed discussion of these methods is beyond the scope of this study. I use the Shannon-Weaver Index to calculate diversity for the advantage that diversity can be easily represented with one single value. The formula of Shannon-Weaver diversity (Reitz and Wing 2008:111–113) is that:

$$H' = -\Sigma\,(pi)\,(\log pi)$$

where H' is the information content of the sample, pi is the relative frequency of the ith taxon within the sample, and log pi equals the logarithm of pi (can be to base 2, e, or 10, but usually the natural log, e).

Equitability (V') is measured as:

$$V' = H'/\mathrm{Log}_e\, S$$

where H' is the Shannon–Weaver Index and S is the number of species in the assemblage.

A value of 4.99 for the diversity index (H') is considered as high diversity, while the equitability values (V') range from 0 to 1. When the value of equitability is approaching 1, taxa are more evenly distributed in an assemblage. Lower values, on the other hand, suggest a dominance of one or a few species.

Materials selected for calculating relative frequencies of taxa and species diversity are summarized in Table 7.2. As reviewed in Chapters 5 and 6, water-screening was not consistently carried out during the excavations. This study carefully selected the samples recovered from screened units for analysis. The Huilai and Luliao samples used in the analyses were selected with systematic random sampling (see Chapter 6) due to their large sample sizes. With the sampling, 13 units were randomly selected from the screened area of Sector 144 at Huilai (Figure 5.4). For Luliao, although the entire area was extensively excavated and water-screened, this study used the bone samples from the southern units only (Figure 5.5) in order to avoid the burial contexts in the northern area. The sampled area of Luliao was also subdivided into 5 subsets consisting of 16 contiguous units each. Due to the small size of the units (1 × 1 m), the number of bone fragments from the first selected 5 units was too small to compare with the other two assemblages. Therefore, the sampling was performed twice in order to generate a larger sample size for Luliao. For Nanshikeng, although all sediments from the 2005 excavation were water-screened, 6 of the 20 test units were not entirely excavated because part of the sediment was removed en bloc and preserved for exhibition. Therefore, only samples from the fully excavated 14 units were used in the analysis (Figure 5.9).

Table 7.2. Bone samples selected for calculating relative frequencies of taxa and species diversity.

	Huilai	Luliao	Nanshikeng
Total excavation area (m^2)	1848	180	256
Number of excavated units	462	180	64
Study area[a] (m^2)	856	80	80
Number of units in study area	214	80	20
Number of selected units[b]	13	10	14
Total area of selected units (m^2)	52	10	56
Total bone weight from the selected units (g)	16026.9	10567.1	14028.8

a. Areas that were systematically excavated and screened.
b. Units that were selected with systematic random sampling.

7.2.2 Quantifying the Change in Hunting Strategy

As reviewed in Chapter 1 and Chapter 3, the mortality profile of deer can be interpreted to reveal a particular hunting strategy. The age at death of deer is often estimated with tooth samples, by counting the annual layers of cementum and observing tooth eruption and wear. However, both methods cannot precisely estimate age since there is always a variation between individuals (Lubinski and O’Brien 2001). The cement-annuli method further requires photographing a thin section of cement under X-ray radiation, and the image of annuli may be unclear due to poor preservation (see Koike and Ohtaishi 1985). This study, therefore, estimated deer age by observing tooth eruption and wear. Since no such data is available for Formosan sika deer, this study used the data on Japanese sika deer provided by Koike and Ohtaishi (1985).

Koike and Ohtaishi (1985) used the mandibles of killed modern sika deer to establish a standard of molar wear for age estimation and determined the exact ages of the deer with annulations of the cementum of the first molar. Table 7.3 shows their estimated ages by cement and the most common combinations of the wear patterns, with eight wear stages developed by Ohtaishi (1980). Age estimation of deer in this study is generally based on this system, but one problem is that such a system requires complete or partial tooth rows that are not always available. For example, there were only six partial deer tooth rows in the Luliao assemblage, although the Luliao samples appear to be preserved better than Huilai and Nanshikeng. I, thus, include loose lower molars for a proper sample size for analysis.

Table 7.3. The most common combinations of wear stages of M_1, M_2, and M_3 of modern wild hunted deer in Japan (summarized from Koike and Ohtaishi 1985).

Estimated Age by Cement (years)	Most Common Combinations of Wear Stages		
	M_1	M_2	M_3
0.5	6	7	8
1.5	5	6	8
2.5	4	5	7
3.5	3	5	6
4.5	2	4	6
5.5	2	4	5
6.5	2	3	5
7.5	2	3	4
8.5	2	2	4

A problem in using loose molars is that these teeth must be accurately identified as M_1, M_2, or M_3. However, identifying a loose deer M_1 or M_2 is very challenging because they are almost morphologically identical, and it is especially difficult when attempting to identify a heavily worn molar. The lower third molar, on the other hand, is morphologically distinct, as M_3 has five cusps while M_1 and M_2 have four. In addition, the third molar of deer does not erupt until twenty months after birth, and thus its wear stage can reveal the age of an adult individual. For juvenile deer, there are three deciduous teeth (dP_2, dP_3, and dP_4) on a mandible; among them, the dP_4 is the largest, most distinctive and so can be better preserved archaeologically. Therefore, the loose M_3 and dP_4 were also included in the analysis to increase sample size.

However, some loose third molars cannot be assigned to a specific age class. For example, if the wear pattern of an M_3 is recognized as Stage 6, this individual may be either 3.5 or 4.5 years old based on Table 7.3. Hence, these two age classes will have to be merged into one, producing a mortality profile without a similar duration in age class. Such a profile would underestimate the relative importance of the narrower age classes. Koike and Ohtaishi (1985) dealt with such cases by calculating the probabilities of the estimated age of a loose molar, but the probabilities over 5.5 years old are not provided in their study. In addition, it has been argued that there is a large variation in tooth wear between mature animals (Lubinski and O'Brien 2001).

To avoid this problem, I present age profiles with a coarser system, dividing a population into three major age classes: juvenile, prime adult, and old adult. Individuals with deciduous teeth and unworn M_3 (wear index of 8) appear to be juveniles (younger than 2.5 years old). For adult individuals, although captive sika deer often have a life span over 20 years, I consider individuals living beyond 5.5 years as old adults (M_3 wear index of 5 or less), since few wild hunted deer can live beyond 5 years of age (Koike and Ohtaishi 1985). Individuals aged between 2.5 and 5.5 years old (M_3 wear index of 7 or 6) are considered as prime adults.

All qualified tooth rows and molars were included in the analysis, not considering side and pair. However, partial mandibles were matched to check whether they were from the same mandible. To increase sample size, both screened materials and unscreened samples from the entire collections were included in the analysis, since deer teeth are large enough to avoid recovery bias. Incomplete teeth were also included as long as their wear patterns were clear enough to determine age. Each specimen was recorded in a database with its specimen number, excavation information (unit and level), element, and wear stage (Appendix B).

7.2.3 Quantifying the Change in Seasonality of Hunting

The primary hunting season was indicated by the death season of young deer, since almost all fawns are born in the summer. Monks (1981) provided a detailed review of how to determine the death season of animals, which is often based on “presence-absence” data collected from the seasonal availability of species or “physiological” data showing the aging events on animals’ skeletons (Monks 1981). Since deer are available all year-round, the death season of deer must be determined by physiological data. Five indicators are often used as physiological data for determining death season: epiphyseal fusion, tooth eruption and wear, antler growth, osteoporosis, and medullary bone (Monks 1981).

This study focused on tooth materials for their better resistance to taphonomic destruction and recovery bias. Death season of deer can also be revealed by tooth cementum and eruption. Cement is highly calcified in the winter and thus its annual layers can be seen translucently on a microradiograph. In contrast, radiographically opaque layers indicate a death season of summer (Koike and Ohtaishi 1985). Although this method can accurately estimate the death season of deer, the images of annuli, as mentioned earlier, may be unclear due to poor preservation. In addition, cementum may also be deposited at an unstable rate since it is a complex process influenced by growth and the metabolic system (Monks 1981).

Tooth eruption provides an alternative approach to determine the death seasons of juvenile deer. For sika deer, fawns are generally born in the summer, between June and August. The M_1 often erupts about four months after birth, in the winter of the first year, and is fully erupted and begins to wear by the spring of the second year. The M_2 begins to erupt at about 12 months of age, in the summer of the second year, and would be slightly worn in the autumn and markedly worn in the winter. The M_3 appears about 20 months after birth, in the spring of the third year. It is fully erupted and begins to wear in the summer of the third year. Therefore, the death season of juvenile deer can be roughly determined by tooth eruption and wear.

Determining the death season with tooth samples requires complete or partial juvenile mandibles with both deciduous and permanent teeth. However, there are only 9, 1, and 20 partial juvenile mandibles in the entire Huilai, Luliao, and Nanshikeng collections, respectively, and thereby the sample sizes are too small to be meaningful. I suggest including the loose dP_4 and unworn M_3 to reduce the bias from mandible fragmentation since these samples also represent juvenile deer killed at the sites. To use the loose teeth, a timeline for the wear patterns of dP_4 should first be established. Table 7.4 summarizes the timeline of tooth eruption and wear pattern of dP_4 in the first two years for juvenile deer. The timeline of tooth eruption is based on the data provided by Koike and Ohtaishi (1985). Wear patterns of dP_4 that correspond to eruption was established with the 17 juvenile mandibles from Nanshikeng. Since there may be a variation in tooth wear between individuals (Monks 1981), I also present the results using a coarser system, dividing a year into wet (summer and fall) and dry (winter and spring) seasons. Although fall is often considered a dry season in modern Taichung in terms of precipitation (see Chapter 4), I suggest categorizing it as a wet season according to vegetation since, in general, the vegetation is still dominated by woodland in the fall. A change in vegetation cover to grassland is more evident in the winter after a long period of drought (Su 1985). Materials for the analysis included all qualified tooth and mandible samples from the entire collections, not considering side and pair. Data was recorded as Appendix B.

Table 7.4. Tooth eruption and wear pattern of juvenile deer.

Stage	Season	dP_4	M_1	M_2	M_3
1	First wet	No wear or slightly worn			
2	First dry	All cusps worn	Erupted in winter and slightly worn in spring		
3	Second wet	Markedly worn; 1/2 crown height		Erupted in summer and slightly worn in fall	
4	Second dry	Crown height less than half; all cusps continue by dentine			Erupted in spring; no wear

7.2.4 Quantifying the Change in Butchery Pattern

The butchery pattern on deer remains is used to explore a change in hide production, indicated by the relative frequencies of cut marks on skeletal elements. Zooarchaeologists have recognized several attributes that distinguish tool-made cut marks from the marks produced by animal gnawing and trampling. Specific attributes such as a V-shape, elongated, and parallel striae (Lyman 1994:297–299) were used to identify the marks produced by human actions. Although tallying the frequencies of cut marks seems straightforward to investigate butchery pattern, it may be problematic due to taphonomic effects. In this section, I discuss some of the problems and introduce the analytical solutions.

Several taphonomic effects on cut-mark analysis have been identified in research. The biggest problem of cut-mark analysis, and probably of all archaeological analyses, is *equifinality*; that is, "one first attempts to establish the existence of a pattern of modification, and then argues that the form of patterning isolated is referable only to the actions of people" (Binford 1981:7). In other words, butchery pattern may not solely result from human action but may have been influenced by other variables such as fragmentation, carnivore ravaging, the condition of the carcass, and tool type (Dominguez-Rodrigo and Yravedra 2009; Lyman 2005). Analysts must identify possible variables and evaluate their effects on the assemblage under study, although not all variables can be measured archaeologically.

In this study, several possible problems that may affect cut-mark frequency should be considered and discussed. The first problem is that not all marks are archaeologically visible. Lyman (1994:302) pointed out that some butchery marks may be archaeologically invisible under some circumstances. First, bones were butchered but no marks are left on the bones. Second, bones were butchered but marks have been destroyed. Since no ethnoarchaeological research has been published on the first circumstance, analysts must assume that the frequencies of butchery-marked bones and the frequencies of butchered bones are positively correlated (Lyman 1994:302). The second circumstance is that bones were butchered but marks are destroyed by taphonomic processes such as weathering, animal gnawing, root etching, and so on. The analytical solution for this scenario is that bone samples with a destroyed surface must be excluded from analysis. The exclusion, however, may substantially decrease sample size. In this study, specimen condition varied across the three assemblages. Visually, most Huilai samples experienced a certain degree of surface destruction that may obliterate some marks. This study excluded the heavily destroyed samples from analysis, but many of the remaining samples still exhibit a small degree of destruction. To have a proper sample size, I included these slightly destroyed samples. I suggest the effect of this inclusion on relative frequency of cut-marked bones would be minimal, since, from my observation, surface destruction distributes randomly across all anatomic units in this assemblage.

The second problem is that cut-mark proportion often varies with different degrees of fragmentation across skeletal elements, taxa, and assemblages (Abe et al. 2002). For example, if calculating the proportion of cut marks with the NISP of skeletal elements, a more fragmented element would have a lower proportion of cut marks. This effect should be considered when cut marks appear in limited areas of skeletal elements (Lupo and O'Connell 2002). To reduce this bias, this study focused on the major joints of deer limb bones that are more resistant to taphonomic destruction and tallied the frequency of cut marks "in the anatomical area sense" (such as distal humerus) rather than "in the archaeologically discrete object sense" (such as humerus) (Lyman 1994:304). This analytical solution not only reduces the effect of fragmentation but also shows the anatomical distribution of marks.

In this study, the third problem that may skew the result is tool type. As reviewed in Chapter 5, the concentrations of iron artifacts at the three sites are substantially different from each other. In addition to preservation, this may hint at a differential access to iron tools between the three populations. Since butchering with iron tools would leave cut marks more easily, the difference in access to iron tools should be considered when comparing the three assemblages. An analytical solution to this problem is that comparisons can only be carried out after the pattern of each assemblage has been recognized. However, this solution is based on an assumption that butchers in the same population used similar tools when butchering and skinning deer, as well as when butchering different parts of the same animal.

Finally, even when a pattern can be largely attributed to human actions, equifinality is still a problem for identifying the purpose of butchery activity. In zooarchaeology, cut marks on metapodials often represent skinning operations because these areas have very little edible meat for defleshing and disarticulating. Marks on meat-bearing bones, on the other hand, may represent butchery behavior. This “purposiveness” criterion, however, was criticized by Lyman, who argued that it “is ambiguous because marks on bones attributed to particular butchery activities may be an incidental result of other particular activities, thereby rendering the criterion a difficult concept to operationalize analytically” (1987: 262). However, experimental research suggests a strong association between mark distribution and butchering activity, although these studies have been criticized for not considering a wide range of taphonomic processes (e.g., Dominguez-Rodrigo and Yravedra 2009). For example, Val and Mallye (2011) showed that skinning marks are often located on areas that are not covered by flesh, such as metapodials, phalanges, and parts of long bones. On the other hand, few marks are made on humeri and femurs during skinning activity.

To sum up, this study used a more qualitative approach by quantifying cut marks on specific anatomical units “which are sufficiently represented at archaeological sites and whose variability in frequency of cut-marked specimens is affected by a smaller number of taphonomic processes” (Dominguez-Rodrigo and Yravedra 2009:892). The detailed protocol for cut-mark analysis generally follows Lyman (2005) and is outlined here:

1. Tally the cut-mark frequencies on six major joints of deer limb bones－shoulder, elbow, wrist, hip, knee, and ankle joints.

2. Use both screened and unscreened samples from the entire collection to increase sample size since deer bones are large enough to resist recovery bias.

3. Study the specimens with at least half of the (proximal or distal) epiphysis present. Similarly, at least half of the scapula glenoid has to be preserved, as do half of the proximal metacarpal and proximal metatarsal. For incomplete carpals and tarsals, only the samples represented by more than half of them are included in the analysis. Due to very few acetabulums found complete at the sites, this skeletal element is observed and recorded with the three subunits: ilium, pubis, and ischium.

4. Exclude unqualified samples from analysis, such as those heavily weathered and burned.

5. Do not distinguish subassemblages of bones based on recovery contexts or associations within the sites.

6. Tally the number of anatomical areas (such as proximal humerus) represented in a collection, and how many of those areas display cut marks.

7. Tally the cut-mark frequency on each of the six limb-bone joints.

8. Record data with the format given in Appendix C.

7.3 Summary

This chapter presents the identification protocol and the quantitative methods for investigating deerskin production. First, the relative frequencies of taxa and species diversity were used to study animal resource procurement. Second, hunting strategy was indicated by the mortality profile of deer based on tooth eruption and wear. Third, since almost all fawns are born in the summer, death season of juvenile deer served as a proxy to explore the seasonality of hunting, based on tooth eruption and wear. Fourth, the relative frequencies of cut marks on six limb joints were used to determine the butchery patterns on the deer remains. Although butchery pattern is often seen as direct evidence of skinning activity, it could also be affected by other taphonomic variables. This chapter also discusses some of these problems and introduces the analytical solutions.

CHAPTER 8. QUANTITATIVE RESULTS OF FAUNAL ANALYSIS

This chapter presents the quantitative results of faunal analysis on deerskin production at the three Iron Age sites. I first present the identification results and discuss challenges and solutions. I also compare the species identified in this study with those in existing research to highlight the new discoveries. Then, the quantitative results for testing the four expectations of deerskin production are presented individually, with a consideration of some possible biases.

8.1 Bone Identification

The NISP values of the bone samples from selected units of the three sites are shown in the Table 8.1. Specimens that cannot be identified with this degree of precision are not listed in the table; most of the unidentified bones are small fragments. Since deer, wild boar, and muntjac account for the majority of identified bones, most of the unidentified bone fragments should be from these three species. In the table, some bone fragments can only be recorded at the order or family level due to a high degree of fragmentation. For example, a bone fragment may be easily identified as a skeletal part (e.g., femoral head) of an Artiodactyla, but be too fragmented to determine whether it is a deer or wild boar. This fragment, therefore, was recorded as Artiodactyla. In addition, in contrast to medium-sized mammals, bones from small animals are not easily identified at a species level. Identification of small animals was carried out by comparing the bones with the reference collection and by consulting the zoologist Miss Yen-Jean Chen, but some specimen cannot be precisely attributed to a taxon category due to a lack of diagnostic traits. Non-mammal species such as fish and birds can only be identified at a generic level due to a lack of sufficient reference collections.

Within the three deer species (sambar, sika, and muntjac), an accurate identification is sometimes difficult to achieve solely based on trait and bone shape. Thus, identifying these three species was partially facilitated by metric characters such as bone measurement. For example, most muntjac bones can be easily distinguished by size because the species is much smaller than the other two taxa (Figure 3.3). However, a small number of bone sizes fall between sika and muntjac and thus can only be recorded as Cervidae. By contrast, distinguishing sambar and sika deer can be very challenging. Although the two species are assigned to different body size categories (and now sambar is sometimes classified as a different genus, *Rusa*), there may be an overlap in the body sizes of a female sambar (around 100 kg) and a male sika (up to 80 kg). Another approach to assist the identification is to use metric characteristics, but there is no statistical data on bone measurements of the two taxa. This study, therefore, did not attempt to identify these two at a species level, and both of the species were recorded as deer. However, based on overall bone size, it can be argued that the vast majority of deer bones are sika. I use the generic term “deer” to refer to the larger-sized deer (presumably all sika) in this and the next chapter, in contrast to the smaller-sized muntjac.

Table 8.1. NISP values of the bone samples from selected units at Huilai, Luliao, and Nanshikeng.

Taxon	Huilai	Luliao	Nanshikeng
Mammals			
(Sika) Deer (*Cervus nippon*)	1065	1358	1515
Reeve's Muntjac (*Muntiacus reevesi*)	45	212	297
Water Deer (*Hydropotes inermis*)	–	4	–
Wild Boar (*Sus scrofa*)	50	210	79
Dog (*Canis lupus*)	–	2	–
Small Chinese Civet (*Viverricula indica*)	–	3	5
Crab-eating Mongoose (*Herpestes urva*)	3	4	27
Leopard Cat (*Prionailurus bengalensis*)	–	2	–
Badger (*Meles meles*)	1	9	3
Hare (*Lepus sinensis*)	4	15	6
Brown Country Rat (*Rattus losea*)	–	2	3
Bandicoot Rat (*Bandicota indica*)	5	–	–
Mole (*Mogera insularis*)	–	1	–
Bat (Chiroptera)	–	–	1
Other			
Unidentifiable Artiodactyla	–	1	1
Unidentifiable Cervidae	–	1	6
Unidentifiable Carnivora	1	1	2
Unidentifiable Muridae	1	4	1
Unidentifiable Rattus	–	2	–
Unidentifiable Primates	–	4	–
Reptiles			
Snakes (Serpentes)	–	3	–
Turtles (Testudines)	5	3	–
Amphibians			
Frogs (Anura)	–	–	3
Fish	25	103	97
Birds	6	11	4
Total NISP	1211	1955	2050

Table 8.2 compares the taxa identified in this study with the ones in the previous studies. Most of the taxa identified in this study have been published in the past; only water deer, mole, and bat are new to the list, identified by Miss Yen-Jean Chen. The identified specimens of mole and bat are very tiny and fragile, indicating a screening process is necessary to recover the skeletal remains of small animals. A good knowledge of skeletal anatomy and sufficient reference collections are also required for identifying these uncommon species. As in previous studies, no Formosan serow is identified, which suggests that the cliff species was not a common prey of the prehistoric hunters of Taiwan.

Table 8.2. Terrestrial mammals identified in this study in comparison with previous archaeological studies and nineteenth-century records.

Taxon	This Study[a]	Previous Studies[b]	Swinhoe[c]
(Sika) Deer	✓	✓	✓
Muntjac	✓	✓	✓
Water Deer	✓		
Wild Boar	✓	✓	✓
Dog	✓	✓	
Small Chinese Civet	✓	✓	✓
Crab-eating Mongoose	✓	✓	
Leopard Cat	✓	✓	✓
Badger	✓	✓	
Hare	✓	✓	✓
Brown Country Rat	✓	✓	✓
Bandicoot Rat	✓	✓	✓
Mole	✓		✓
Bat	✓		✓

a. Mammalian species listed in Table 8.1.
b. Species listed in Table 3.2.
c. Some species listed in Table 3.3.

The Chinese Water Deer (*Hydropotes inermis*), *zhang* (獐) in Mandarin, is a new deer species that was first identified in the archaeological fauna of Taiwan (Chen et al. 2016), suggesting there were at least four deer species in prehistoric Taiwan. This species no longer exists in modern Taiwan, nor was it recorded by Swinhoe in the mid-nineteen century. As a wetland species, their extinction in Taiwan likely resulted from human expansion in the past several centuries. The water deer is a small-sized species (25–40 lb) indigenous to eastern China and the Korean Peninsula. With a similar body size and shape, water deer can be easily misidentified with muntjac, but they are quiet different in terms of some traits, habitat, and behavior. Unlike muntjac, water deer have elongated canines but no antlers. As implied by their name, they prefer an open enviroment near water, such as swamp, floodplain, and coastal wetland, while muntjac mostly live in dense forest. They are also good swimmers and sometimes swim several miles in search of food and shelter.

8.2 Animal Resource Procurement

8.2.1 Relative Frequencies of Taxa

The NISP values in Table 8.1 show deer is the highest ranked species and considerably outnumber other taxa in all three assemblages, suggesting deer was the main animal resource exploited by the Iron Age people. However, it is important to note that the relative importance of taxa may be biased by NISP values. For example, some morphological traits, such as antlers, are not present in all taxa. Since antler fragments are commonly discovered and easily identified, the relative frequencies of animals with antlers or horns may be overestimated. I, thus, exclude antler fragments from analysis to evaluate such bias. Comparing the data in Table 8.4 to Table 8.3, the relative frequency of deer is significantly lower in Huilai ($z = –2.5255$, $p = 0.0114$) and Nanshikeng ($z = –2.3282$, $p = 0.0198$). It is also lower in the Luliao assemblage, although the difference is not statistically significant ($z = –1.8995$, $p = 0.0574$). This suggests that the importance of deer is indeed overestimated by including antler fragments.

An additional problem with using the NISP value is that the number of skeletal elements varies across taxa. This effect can be evaluated by tallying the elements that occur in identical frequencies in individuals of compared taxa (Lyman 2008:30). Nevertheless, such comparisons must be limited to similar species (e.g., mammals) since certain taxa have very distinctive skeletal anatomy (e.g., fish, snake). Table 8.6 shows the data when tallying these skeletal elements for the mammals listed in Table 8.1 (cervical vertebrae, scapulae, humeri, ulnae, radii, hip bones, femora, tibiae, calcanea, and astraguli). Compared to Table 8.5, the relative frequency of deer in the Huilai assemblage is significantly lower ($z = –2.4799$, $p = 0.0131$) when tallying these elements only. The relative frequency of deer is not different in Nanshikeng ($z = –0.368$, $p = 0.7114$); it is higher in Luliao although not considered statistically significant ($z = 1.3328$, $p = 0.1835$). The higher frequency of deer in Luliao may result from a substantial decrease in the NISP of other mammals when tallying these elements only, since many of these species were identified with tooth samples, especially the small-sized animals.

Table 8.3. NISP and relative frequencies of deer and other taxa.

Taxon	Huilai		Luliao		Nanshikeng	
	NISP	%	NISP	%	NISP	%
(Sika) Deer	1065	87.9	1358	69.5	1515	74.2
Non-deer*	146	12.1	595	30.5	528	25.8
Total	1211	100	1953	100	2043	100

* Excludes unidentifiable Artiodactyla and Cervidae that may contain deer.

Table 8.4. NISP and relative frequencies of deer and other taxa excluding antler fragments.

Taxon	Huilai		Luliao		Nanshikeng	
	NISP	%	NISP	%	NISP	%
(Sika) Deer	775	84.1	1178	66.6	1250	70.8
Non-deer*	146	15.9	590	33.4	516	29.2
Total	921	100	1768	100	1766	100

*Excludes unidentifiable Artiodactyla and Cervidae that may contain deer.

Table 8.5. NISP and relative frequencies of deer and other mammalian species.

Taxon	Huilai		Luliao		Nanshikeng	
	NISP	%	NISP	%	NISP	%
(Sika) Deer	1065	90.6	1358	74.1	1515	78.1
Non-deer Mammals*	110	9.4	475	25.9	424	21.9
Total	1175	100	1833	100	1939	100

*Excludes unidentifiable Artiodactyla and Cervidae that may contain deer.

Table 8.6. NISP and relative frequencies of deer and other mammalian species using skeletal elements that occur in identical frequencies in individuals.

Taxon	Huilai		Luliao		Nanshikeng	
	NISP	%	NISP	%	NISP	%
(Sika) Deer	316	86.1	195	78.0	543	77.5
Non- deer Mammals*	51	13.9	55	22.0	158	22.5
Total	367	100	250	100	701	100

*Excludes unidentifiable Artiodactyla and Cervidae that may contain deer.

Fragmentation is another problem when using the NISP value as a quantitative unit, since NISP is potentially affected by butchery patterns and preservation across taxa and assemblages (Lyman 2008:29–30). For example, bones from larger animals may be more fragmented than smaller animals due to butchering and bone marrow extraction. On the other hand, bones from smaller animals can be more vulnerable to taphonomic processes, causing a higher degree of fragmentation and thus a higher NISP value in an assemblage. As mentioned in Chapter 6, fragmentation also reduces identifiability, and bone fragments without diagnostic traits would be absent in analysis (Lyman 1994:281). As a result, fragmentation potentially skews the representation of certain taxa. This problem can be evaluated by measuring the magnitude of fragmentation in two ways－extent of fragmentation (how often) and intensity of fragmentation (how fragmented) (Lyman 1994:333–338). The extent of fragmentation can be measured by the proportion of the NISP for complete bones; the intensity of fragmentation is calculated by the ratio of NISP to MNE (minimum number of skeletal elements) of the identified bones, excluding complete specimens. This method can be used to evaluate if deer bones are more fragmented than other taxa, which may overestimate the relative importance of deer.

However, as shown in Table 8.1, certain taxa have a very small value of NISP; their MNE values should also be too small to be meaningful. I suggest comparing the NISP values of deer to evaluate the magnitude of fragmentation between the three assemblages, since deer remains account for the majority of all three assemblages (>70%). To simplify the test, I used five major long bones: humerus, ulna, radius, femur, and tibia. In all three assemblages, none of these skeletal elements is complete, so the extent of fragmentation is equal. Their average NISP:MNE ratios across the five long bones are listed in Table 8.7. Although the Huilai samples tend to be more fragmented in terms of weight index and intensity (see Chapter 6), its average NISP:MNE ratio of deer long bones (avg. = 2.28) is not significantly different from those of the Luliao samples (avg. = 2.09, $t = 0.3992$, $p = 0.7002$) and of the Nanshikeng samples (avg. = 2.59, $t = –0.5018$, $p = 0.6293$); so they are between the two late Iron Age assemblages ($t = –0.9178$, $p = 0.3855$). This, however, does not mean there was no difference in fragmentation between the three collections. The inconsistency may suggest a higher degree of analytical absence of the Huilai assemblage; that is, many of the fragments are likely from deer limb bones, but they are too fragmented to identify.

Table 8.7. NISP and NISP:MNE ratios of five deer long bones.

Skeletal Part	Huilai			Luliao			Nanshikeng		
	NISP	MNE	NISP:MNE	NISP	MNE	NISP:MNE	NISP	MNE	NISP:MNE
Humerus	41	24	1.71	8	5	1.60	56	30	1.87
Ulna	24	18	1.33	14	11	1.27	28	21	1.33
Radius	31	14	2.21	12	5	2.40	57	23	2.48
Femur	22	6	3.67	32	11	2.91	73	19	3.84
Tibia	35	14	2.50	18	8	2.25	76	22	3.45
Total	153	76		84	40		290	115	
MNI		12			7			17	

These tests indicate that the relative frequency of deer remains is indeed skewed by NISP values, at least in terms of morphological traits and skeletal elements. In considering which data set is appropriate to show the relative frequencies of taxa, I suggest a flexibility of application depending on which research question is asked and the nature of the faunal collection under study. In this study, since most of the identified species are mammals, tallying only the elements occurring in identical frequencies may be ideal to compare species' abundance.

However, the NISP values of most small animals are so small that this method would substantially decrease the representation of these species. I, thus, discuss the result with the NISP values of mammalian taxa that are identified at a species level but exclude antler fragments (Tables 8.8 and 8.9).

Table 8.8 shows deer remained in the highest rank throughout the Iron Age, but their relative frequency decreased over time. Compared to the early Iron Age Huilai, the relative frequency of deer is significantly lower in Luliao ($z = -9.0665$, $p = 0$) and Nanshikeng ($z = -7.385$, $p = 0$), indicating the late Iron Age people increasingly exploited other taxa in addition to deer. The relative frequency of muntjac significantly increased at both late Iron Age Luliao ($z = 6.0265$, $p = 0$) and Nanshikeng ($z = 8.635$, $p = 0$). The frequency of wild boar is also significantly higher at Luliao than the early period Huilai ($z = 5.642$, $p = 0$). In terms of body size, the medium-sized animals (deer and wild boar) substantially outnumber smaller animals (medium-small and small-sized animals) throughout the entire Iron Age, but the relative frequency of smaller animals increased over time (Table 8.9). The difference in respect to smaller-sized animals between Huilai and Luliao assemblages is significant ($z = 6.3281$, $p = 0$), as it is between Huilai and Nanshikeng ($z = 8.8679$, $p = 0$). It appears that the late Iron Age people increasingly exploited the smaller animals, although their representation is consistently low in all three assemblages.

Table 8.8. NISP, percentage, and rank order of mammalian species (excluding antler fragments).

		Huilai	Luliao	Nanshikeng
(Sika) Deer	Count	775	1178	1250
	Percentage	87.77	71.96	75.39
	Rank	1	1	1
Muntjac	Count	45	207	285
	Percentage	5.10	12.65	17.19
	Rank	3	3	2
Water Deer	Count	–	4	–
	Percentage	–	0.24	–
	Rank	–	6	–
Wild Boar	Count	50	210	79
	Percentage	5.66	12.83	4.76
	Rank	2	2	3
Dog	Count	–	2	–
	Percentage	–	0.12	–
	Rank	–	8	–
Small Chinese Civet	Count	–	3	5
	Percentage	–	0.18	0.30
	Rank	–	7	6
Crab-eating Mongoose	Count	3	4	27
	Percentage	0.34	0.24	1.63
	Rank	6	6	4
Leopard Cat	Count	–	2	–
	Percentage	–	0.12	–
	Rank	–	8	–
Badger	Count	1	9	3
	Percentage	0.11	0.55	0.18
	Rank	7	5	7
Hare	Count	4	15	6
	Percentage	0.45	0.92	0.36
	Rank	5	4	5
Brown Country Rat	Count	–	2	3
	Percentage	–	0.12	0.18
	Rank	–	8	7
Bandicoot Rat	Count	5	–	–
	Percentage	0.57	–	–
	Rank	4	–	–
Mole	Count	–	1	–
	Percentage	–	0.06	–
	Rank	–	9	–
Total		883	1637	1658

Table 8.9. NISP, percentage, and rank order of the mammalian species in terms of body size (excluding antler fragments).

Body Size		Huilai	Luliao	Nanshikeng
Medium	Count	825	1388	1329
	Percentage	93.43	84.79	80.16
	Rank	1	1	1
Medium-Small	Count	45	213	285
	Percentage	5.10	13.01	17.19
	Rank	2	2	2
Small	Count	13	36	44
	Percentage	1.47	2.20	2.65
	Rank	3	3	3
Total		883	1637	1658

8.2.2 Species diversity

Species diversity is a function of richness and equitability. Since species richness is essential to calculate diversity, only specimens identified at a species level are used in the analysis. As mentioned earlier, although deer bones could not be distinguished as sika or sambar, it is certain that the vast majority were sika, based on overall bone size. The bat bone from Nanshikeng cannot be identified at a species level, but as there is only one specimen (representing one species), it can be included in the analysis.

Table 8.10 shows the richness, equitability, and diversity of the three assemblages. All the three assemblages have a very low equitability (ranging from 0 to 1) and a low diversity (<4.99) due to the presence of a single dominant species (sika deer). Luliao is the richest assemblage with the most taxa identified (12), followed by Nanshikeng (9) and Huilai (7). This rank order is the same for equitability, with Luliao (0.341) and Nanshikeng (0.331) more evenly distributed than Huilai (0.211). As a result, their Shannon-Weaver diversity indexes also show a similar pattern: the late Iron Age Luliao (0.848) and Nanshikeng (0.727) collections appear to be more diverse than the early Iron Age Huilai (0.411). In sum, as a function of NISP values, species diversity also shows a broader spectrum of animal resource procurement in the late Iron Age.

Table 8.10. NISP, richness, equitability, and diversity of Huilai, Luliao, and Nanshikeng.

	Huilai	Luliao	Nanshikeng
(Sika) Deer (*Cervus nippon*)	1065	1358	1515
Reeve's Muntjac (*Muntiacus reevesi*)	45	212	297
Water Deer (*Hydropotes inermis*)	–	4	–
Wild Boar (*Sus scrofa*)	50	210	79
Dog (*Canis lupus*)	–	2	–
Small Chinese Civet (*Viverricula indica*)	–	3	5
Crab-eating Mongoose (*Herpestes urva*)	3	4	27
Leopard Cat (*Prionailurus bengalensis*)	–	2	–
Badger (*Meles meles*)	1	9	3
Hare (*Lepus sinensis*)	4	15	6
Brown Country Rat (*Rattus losea*)	–	2	3
Bandicoot Rat (*Bandicota indica*)	5	–	–
Mole (*Mogera insularis*)	–	1	–
Bat (Chiroptera)	–	–	1
Total	1173	1822	1936
Richness	7	12	9
Equitability	0.211	0.341	0.331
Shannon-Wiener Diversity Index	0.411	0.848	0.727

8.3 Hunting Strategy

Hunting strategy is determined by analyzing the mortality profiles of deer. The relative frequencies of the three age classes are shown in Figure 8.1. The age composition of deer from the early Iron Age Huilai appears to be different from those at the two late Iron Age sites. There is no apparent prey selection in terms of age at Huilai, nor an attritional pattern as expected. The age profile of the Luliao deer, however, is prime-adult dominated. At Nanshikeng, the frequency of prime adults is highest, but juvenile deer also have an equally high representation. In sum, the mortality profiles of deer suggest that the late Iron Age Luliao people had a stronger selection of middle-aged adults.

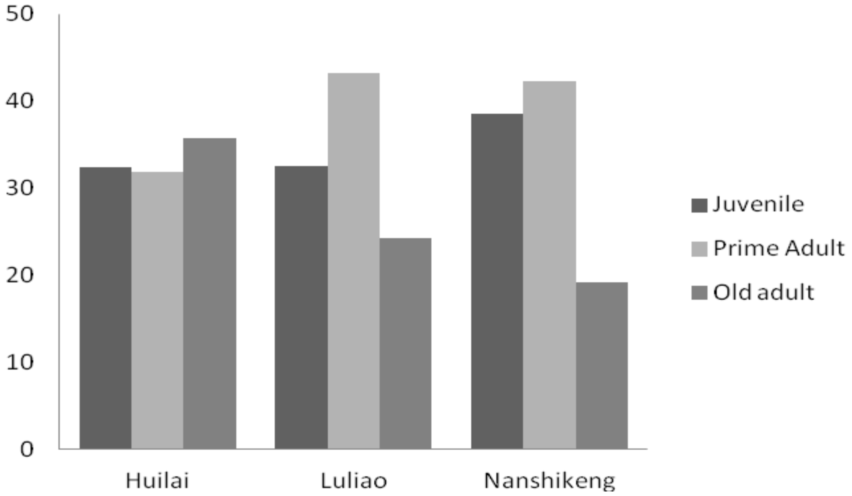

Figure 8.1. Proportions of deer in three age groups at Huilai, Luliao, and Nanshikeng.

8.4 Seasonality of Hunting

The death season of young deer served as a proxy to explore the seasonality of hunting. Figure 8.2 shows the proportions of deer killed in the dry and wet seasons. The early Iron Age Huilai is not significantly different from Nanshikeng ($z = 0.6358$, $p = 0.5222$), and both have more young deer killed in the dry season. However, the deaths of young deer at Luliao are evenly distributed in the two seasons, although the difference between Luliao and Huilai is not statistically significant (*z* = 1.6582, *p* = 0.0969). The death season of young deer suggests that Huilai and Nanshikeng people hunted deer mostly in the dry season, while the Luliao people tended to hunt deer year-round.

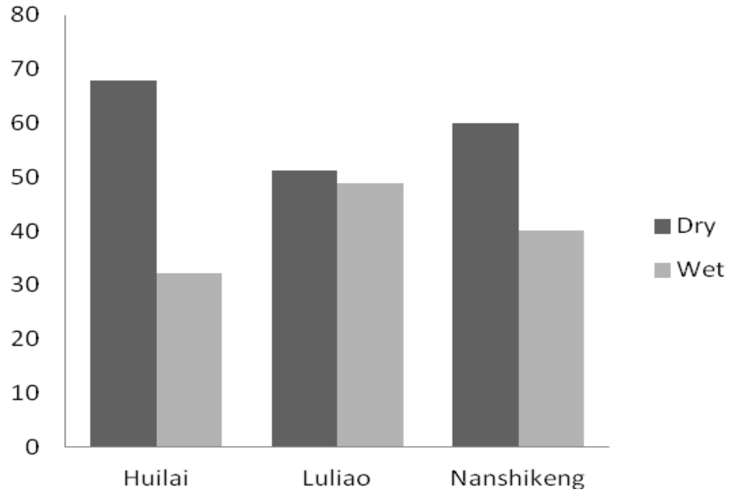

Figure 8.2. Proportions of deer hunted in wet and dry seasons.

8.5 Butchery Pattern on Deer Remains

The butchery pattern on deer remains is demonstrated by the relative frequencies of cut marks on six major joints of the limb bones. Tables 8.11–8.13 show the NISP values of skeletal portions and cut-marked specimens in the three assemblages. However, it is often argued that differences between assemblages may reflect sample size rather than the actual pattern it implies. One way to assess sample size effect is to calculate Spearman's rank-order correlation coefficient (rho). As shown in Tables 8.11–8.13, there is little correlation between the total NISP values and cut-mark proportions of the six joints in the Luliao samples (*r* = 0.0286, *p* = 0.9572). Although there is a high negative correlation between the two variables in Huilai (*r* = –0.7143, *p* = 0.1108) and Nanshikeng (*r* = –0.6, *p* = 0.208), they are not considered to be statistically significant. This provides confidence that the observed differences in cut-mark frequency reflect the actual patterns of the three assemblages.

As shown in Figures 8.3 and 8.4, the anatomical distribution of cut marks across the six major limb-bone joints is different between the three collections. The early Iron Age Huilai samples appear to signify a more frequent occurrence of disarticulation, as the proportional frequencies of cut marks on the shoulder, elbow, and hip are higher than those on the knee, ankle, and wrist. At Luliao, the proportional frequency of cut marks is highest on the ankle bones and markedly lower on other skeletal portions except shoulder, suggesting the significance of skinning during butchery. There is no apparent pattern for the Nanshikeng samples, since most of the six joints have a similar cut-mark proportion. However, 74.19% of central-fourth tarsal bones display marks, which may hint at the importance of skinning activity at the site.

8.6 Summary

This chapter presents the quantitative results of faunal analysis. First, both the relative frequencies of taxa and species diversity suggest a broader spectrum of animal resource exploitation in the late Iron Age. Deer is by far the most important taxon, but the representation of other mammals especially muntjac and wild boar increased over time. Second, the mortality profiles of deer at Huilai and Nanshikeng show no patterns as expected, but that of the late Iron Age Luliao is prime-adult dominated. Third, the death seasons of young deer served as a proxy of hunting season. The Huilai and Nanshikeng people hunted deer mostly in the dry season, while the Luliao people tended to hunt deer year-round. Finally, the butchery pattern on deer remains is indicated by the cut-mark frequencies on six limb-bone joints. The Huilai assemblage suggests a more frequent occurrence of disarticulation, while the Luliao assemblage shows a pattern of skinning activity. Although there is no apparent pattern at Nanshikeng, the unusual high cut-mark frequency of central-fourth tarsal bones may also hint at the significance of skinning at the site. A detailed discussion of these results is presented in the next chapter.

Table 8.11. NISP of deer skeletal portions and NISP with cut marks at the early Iron Age Huilai.

Skeletal Portion	NISP	NISP with Cut Marks	Proportion with Cut Marks (%)	Rank Order
Shoulder	**33**	**10**	**30.30**	**1**
Scapula glenoid	31	9	29.03	
Proximal humerus	2	1	50.00	
Elbow	**129**	**35**	**27.13**	**2**
Distal humerus	46	14	30.43	
Proximal ulna	35	8	22.86	
Proximal radius	48	13	27.08	
Wrist	**139**	**12**	**8.63**	**6**
Distal ulna	0	0	0	
Distal radius	19	2	10.53	
Scaphoid	24	2	8.33	
Lunar	16	1	6.25	
Cuneiform	10	1	10.00	
Trapezoid magnum	26	1	3.85	
Unciform	25	2	8.00	
Pisiform	5	1	20.00	
Proximal metacarpal	14	2	14.29	
Hip	**118**	**28**	**23.73**	**3**
Ilium	24	6	25.00	
Pubis	25	7	28.00	
Ischium	43	5	11.63	
Proximal femur	26	10	38.46	
Knee	**42**	**7**	**16.67**	**4**
Distal femur	13	3	23.08	
Patella	14	0	0	
Proximal tibia	15	4	26.67	
Ankle	**282**	**38**	**13.48**	**5**
Distal tibia	49	8	16.33	
Distal fibula	16	3	18.75	
Astragalus	119	10	8.40	
Calcaneus	30	8	26.67	
Central-fourth tarsal	42	8	19.05	
Second-third tarsal	15	0	0	
Proximal metatarsal	11	1	9.09	
Total	**743**	**130**	**17.50**	
Spearman's rho (NISP, %)				**–0.7143**

Table 8.12. NISP of deer skeletal portions and NISP with cut marks at the late Iron Age Luliao.

Skeletal Portion	NISP	NISP with Cut Marks	Proportion with Cut Marks (%)	Rank Order
Shoulder	**17**	**9**	**52.94**	**2**
Scapula glenoid	15	9	60.00	
Proximal humerus	2	0	0	
Elbow	**73**	**14**	**19.18**	**5**
Distal humerus	22	5	22.73	
Proximal ulna	26	3	11.54	
Proximal radius	25	6	24.00	
Wrist	**131**	**25**	**19.08**	**6**
Distal ulna	1	0	0	
Distal radius	15	4	26.67	
Scaphoid	18	2	11.11	
Lunar	20	1	5.00	
Cuneiform	13	2	15.38	
Trapezoid magnum	21	7	33.33	
Unciform	16	3	18.75	
Pisiform	5	1	20.00	
Proximal metacarpal	22	5	22.73	
Hip	**56**	**13**	**23.21**	**3**
Ilium	29	8	27.59	
Pubis	7	2	28.57	
Ischium	17	3	17.65	
Proximal femur	3	0	0	
Knee	**9**	**2**	**22.22**	**4**
Distal femur	5	2	40.00	
Patella	2	0	0	
Proximal tibia	2	0	0	
Ankle	**335**	**190**	**56.72**	**1**
Distal tibia	18	1	5.56	
Distal fibula	9	1	11.11	
Astragalus	134	97	72.39	
Calcaneus	88	58	65.91	
Central-fourth tarsal	45	22	48.89	
Second-third tarsal	23	4	17.39	
Proximal metatarsal	18	7	38.89	
Total	**621**	**253**	**40.74**	
Spearman's rho (NISP, %)				**0.0286**

Table 8.13. NISP of deer skeletal portions and NISP with cut marks at the late Iron Age Nanshikeng.

Skeletal Portion	NISP	NISP with Cut Marks	Proportion with Cut Marks (%)	Rank Order
Shoulder	**67**	**21**	**31.34**	**1**
Scapula glenoid	57	17	29.82	
Proximal humerus	10	4	40.00	
Elbow	**148**	**35**	**23.65**	**6**
Distal humerus	67	24	35.82	
Proximal ulna	36	6	16.67	
Proximal radius	45	5	11.11	
Wrist	**143**	**34**	**23.78**	**5**
Distal ulna	1	0	0	
Distal radius	47	5	10.64	
Scaphoid	10	5	50.00	
Lunar	6	1	16.67	
Cuneiform	4	1	25.00	
Trapezoid magnum	8	1	12.50	
Unciform	9	2	22.22	
Pisiform	0	0	0	
Proximal metacarpal	58	19	32.76	
Hip	**111**	**33**	**29.73**	**4**
Ilium	31	10	32.26	
Pubis	22	6	27.27	
Ischium	37	10	27.03	
Proximal femur	21	7	33.33	
Knee	**55**	**17**	**30.91**	**2**
Distal femur	24	10	41.67	
Patella	6	0	0	
Proximal tibia	25	7	28.00	
Ankle	**290**	**87**	**30.00**	**3**
Distal tibia	56	12	21.43	
Distal fibula	5	0	0	
Astragalus	65	27	41.54	
Calcaneus	68	10	14.71	
Central-fourth tarsal	31	23	74.19	
Second-third tarsal	5	2	40.00	
Proximal metatarsal	60	13	21.67	
Total	**814**	**227**	**27.89**	
Spearman's rho (NISP, %)				**–0.6**

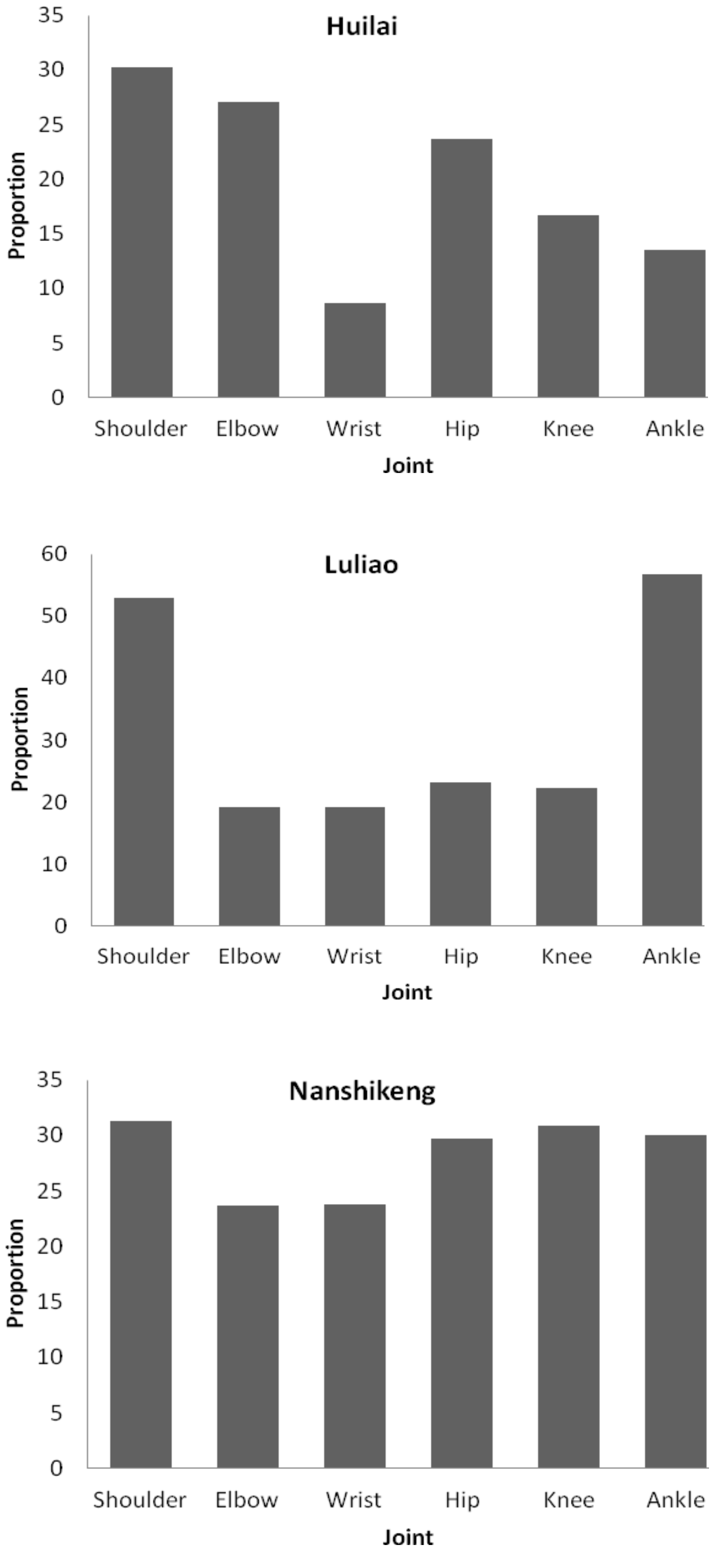

Figure 8.3. Proportions with cut marks on six deer limb-bone joints at Huilai, Luliao, and Nanshikeng.

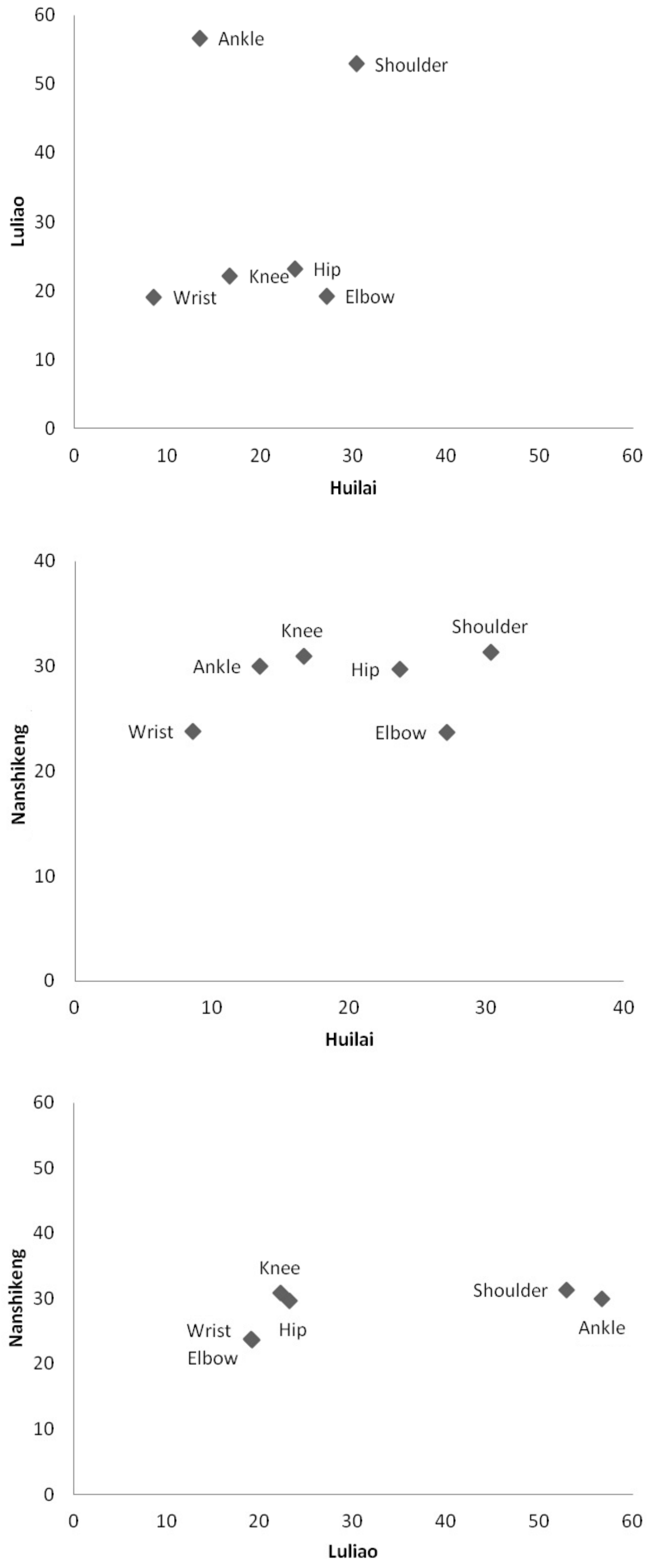

Figure 8.4. Scatter plots of proportions with cut marks on six deer limb-bone joints.

CHAPTER 9. DISCUSSION AND CONCLUDING REMARKS

In the first chapter, I propose three hypotheses for investigating the deerskin trade in Iron Age central Taiwan. I hypothesize that there was a transition to commercial deerskin production from the early to late periods. This transition was associated with overseas trade, conducted by tramping navigation in search of profit. As shown in Chapter 8, there is some consistency and some discrepancy between the expectations and results. This chapter examines the three hypotheses in light of the results of faunal analysis and the concentration of exotic artifacts, and discusses possible causes for the discrepancy. I also discuss the transition from an internal point of view, in addition to the external maritime trade reviewed in Chapter 2. Finally, I conclude by summarizing the major findings of this study and propose several directions for future research.

9.1 The Transition-to-Commerce Hypothesis

My first hypothesis is that there was a commodity-oriented deerskin production developed during the Iron Age. The use of deer had changed from a subsistence resource to a commodity. I proposed four expectations to test this hypothesis.

First, animal resource procurement was expected to change from a generalized to a more specialized strategy focusing on deer during the Iron Age. Contrary to this expectation, both relative frequencies of taxa and species diversity show a broader spectrum of resource procurement in the late Iron Age. Although deer remained the highest ranked resource and consistently outnumbered other taxa, their relative frequency decreased over time. This suggests the Iron Age people increasingly exploited other animals in addition to deer in the late period.

Second, deer hunting was expected to change from random hunting to a mass kill and/or a selective hunting, in order to increase the quantity and/or quality of deer products. The mortality profile of deer was expected to change from an attritional pattern in the early Iron Age to a catastrophic and/or prime-dominated profile in the late period. Not entirely as expected, the mortality profile of Huilai deer shows no attritional pattern. There is no catastrophic profile in the two late Iron Age assemblages either, but the deer at Luliao appear to be prime-adult dominated. Therefore, although there was no such change as expected, the Luliao hunters had a stronger selection of the most profitable middle-aged deer.

Third, seasonality of hunting was expected to change from dry season to year-round in order to provide a steady supply of deer products. As expected, data from the death seasons of young deer suggest that the Huilai people mainly hunted deer in the dry season. While the late Iron Age Nanshikeng also hunted deer mostly in the dry season, the Luliao tended to hunt deer year-round. The evidence from Huilai and Luliao suggests a change in seasonality of hunting from the early to late Iron Age, although the result is not considered statistically significant.

Fourth, the butchery pattern on deer remains was expected to change from disarticulation to skinning during the Iron Age. As expected, the cut-mark distribution of the early Iron Age Huilai indicates a butchery pattern of disarticulation. The late Iron Age Luliao, on the other hand, reveals the importance of skinning during butchery. At Nanshikeng, although there is no apparent pattern of butchery in terms of the six limb joints, the high cut-mark frequency on central-fourth tarsal bones may also hint at frequent skinning activity at the site.

Overall, the evidence suggests that there was a transition to commerce during the Iron Age. Although none of the three assemblages meets all four expectations, the commercial pattern is evident at the late Iron Age Luliao site. The hunting strategy, seasonality, and butchery pattern of Luliao suggest commodity-oriented deerskin production at the site. The Luliao people tended to provide a more steady supply (hunting year-round), a higher quality (hunting prime adults), and a larger quantity (more frequent skinning) of deerskin.

Now, I would like to discuss the result of animal resource procurement; that is, why Iron Age people increasingly exploited other animals rather than deer. There is an assumption that foragers may increasingly exploit lower-ranking prey when high-ranking resources decrease in abundance (see Chapter 3). Therefore, it can be argued that the broader spectrum of resource procurement signifies a decline in deer abundance in the late Iron Age. However, in addition to resource decline, other variables such as hunting technique and organization may also affect species abundance. For example, hunting with a non-selective method such as traps would increase the abundance of smaller animals since these animals may be more vulnerable when captured by traps. On the other hand, a change from small-group hunting to communal hunting may increase the abundance of larger prey (e.g., Hockett 2005). Prey selection is also a function of the sex and age composition of the task group. For instance, women and children foraging would focus more on low-ranking but easily captured, handled, and transported resources (e.g., Bird and Bird 2000).

Based on the mortality profiles of the most abundant prey (deer), I suggest such change in hunting technique and organization was likely minimal. None of the mortality profiles of deer show a catastrophic pattern that would signify non-selective hunting (e.g., mass kill, communal drive). The change in hunting organization cannot be evaluated at this time, but both communal and small-group hunting are well documented in literature (see Chapter 3). In terms of task groups, although women and children may have assisted in hunting smaller animals (e.g., muntjac), there is no empirical evidence for that practice. Hunting terrestrial animals, either larger or smaller prey, is almost entirely carried out by men in the ethnographic and historical records.

In addition to the economic value, the social value of these animals would also affect prey selection. Among the second- and third-ranked taxa, there is no clear evidence for the social value of muntjac, but pigs, either domesticated or wild, are often significant for indigenous ceremony (see Chapter 3). Wild boar can also be a target prey in prestige hunting due to its larger body size and aggressive behavior, since prestige hunting often involves the procurement of large animals with high value and high risk (Lupo 2007), although it may be an "unknown constant" in the archaeological record (Broughton and Bayham 2003). In all three assemblages, the relative frequency of pig/wild boar is consistently low throughout the Iron Age, but it is significantly higher at Luliao (see Chapter 8). While there is a possibility of pig domestication and prestige hunting, the higher abundance of this animal at Luliao may also be associated with the unusually high concentration of iron artifacts (see Chapter 5), as the iron tools may have assisted in hunting this powerful, aggressive animal.

In sum, there is no apparent change in hunting technique, organization, and social value of these animals. Therefore, a decline in deer abundance is the most probable cause for the broader spectrum of resource procurement in the late period. I further propose that the decline in the deer resource may have resulted from strong hunting pressure on the deer population. The increasing demand for deerskin would incite a competition for this profitable animal and lead to a decrease in deer population. Since some other fur-bearing animals (e.g., muntjac) were also exported in maritime trade (see Chapter 3), these species may have been used as substitutes in the fur trade when deer populations declined.

However, to argue overhunting, we should consider other variables that may also decrease deer population. For example, climate change and deforestation that result in habitat loss would decrease deer numbers. According to research, there has been a fluctuation in temperature and precipitation over the past 2000 years (see Liew et al. 2014; Liew and Hsieh 2000; Liew and Huang 1994; Lin et al. 2004; Wang et al. 2014), but there is no evidence for long-term climate change on a scale that would have significantly impacted deer population. The average temperatures fluctuated within only 2 degrees Celsius annually (Liew and Hsieh 2000), and a substantial fluctuation in precipitation was mainly incited by typhoon-triggered heavy rainfall (Wang et al. 2014). The evidence for deforestation is also limited. The botanical evidence found at the three sites suggests most of the areas in the central-western lowland were covered by forests (see Chapter 4). Phytoliths of cogon grass and silver grass were recovered from Nanshikeng (see Chapter 5), which may signify a certain degree of land clearance in the late Iron Age. However, this anthropogenic impact on the local environment cannot be evaluated at this time since the exact amount of grass phytoliths and how the sediment was sampled are not clear. In sum, there is no evidence for substantial habitat loss during the Iron Age, either by climate change or anthropogenic impact. Therefore, a decline in the deer resource as a result of overhunting is likely the main cause for the broader spectrum of resource procurement in the late Iron Age.

9.2 The Overseas-Trade Hypothesis

My second hypothesis is that the transition to commerce was associated with expanding overseas trade. This hypothesis was tested by the evidence of faunal remains and exotic artifacts. I expected that, as maritime trade expanded, there would be a higher concentration of exotic artifacts and a more commercialized deerskin production in the late Iron Age. In Chapter 5, I have shown there to be a higher concentration of exotic artifacts at the two late Iron Age sites. Here I combine the artifact evidence with the results of faunal analysis. Table 9.1 shows the faunal and artifact data from the screened areas of the three sites. As expected, there is an apparent association between the two data sets; higher concentrations of exotic artifacts accompany the evidence for more commodity-oriented deerskin production. Therefore, both the faunal and artifact evidence support the overseas-trade hypothesis, that commercialized deerskin production was developed for maritime trade.

Table 9.1. Faunal results and artifact concentrations at Huilai, Luliao, and Nanshikeng.

	Huilai	Luliao	Nanshikeng
Period	Early	Late	Late
Stone tools (/m^3)[a]	0.80	0?	0.33
Iron artifacts (/m^3)[a]	0.02	6.94	0.33
Exotic jewelry (/m^3)[a]	0.19	38.19	1.17
Relative frequency of deer (%)[b]	87.77	71.96	75.39
Species diversity	0.411	0.848	0.727
Deer age profile	Equally represented	Prime-adult dominated	Young and prime-adult dominated
Seasonality of hunting	Dry season	Year-round	Dry season
Butchery pattern on deer remains	Disarticulation	Skinning	Possible skinning

a. Estimated with the published data from systematic excavated and screened units at Huilai Area I (Ho and Chu 2009), Luliao (Ho and Liu 2005b), and Nanshikeng 2005 (Ho and Liu 2005a).
b. Includes all mammals identified at a species level but excludes antler fragments.

9.3 The Tramping-for-Profit Hypothesis

My final hypothesis is that the maritime trade was carried out with tramping navigation along the coast in search of profit, indicated by the faunal and artifact evidence from the late Iron Age Luliao and Nanshikeng. With tramping navigation, maritime trade should result in a similar pattern of exotic artifacts and deerskin production at the two coastal sites. However, contrary to the expectation, the patterns of Luliao and Nanshikeng are substantially different from each other (Table 9.1). The Luliao people appear to have had a more commercialized deerskin production and a more intensive maritime interaction.

The bone artifacts discovered at Luliao may provide an explanation for that difference. Bone artifacts are rare at both Huilai and Nanshikeng, but again their concentration was much higher at Luliao (13.49/m^3) (see Chapter 5). Among the artifacts, bone hairpins especially interest archaeologists (e.g., Y. B. Chen 2015; Ho and Liu 2005b), since this artifact may symbolize a foreign hairstyle (probably Chinese) absorbed by the indigenous people. The Qing text *Tai Hai Shih Cha Lu* also documented bone hairpins in central Taiwan, along with beads, agate, and shell ornaments. If the distribution of stylistic materials indicates information exchange as Renfrew (1975) noted, the maritime trade at Luliao may have involved not only a flow of traded materials but an exchange of information between the natives and merchants. Renfrew (1975:130) proposed such a case as a possible “colonial enclave”. I suggest, at least, there was sustained trading at Luliao so that the foreign style and aesthetics could be absorbed by the indigenous people.

With the faunal and artifact evidence, I revise this hypothesis: rather than just tramping, there were multiple modes of trade in late Iron Age central Taiwan. The commercialized deerskin production and associated materials at Luliao suggest that there may have been a point-to-point transportation at the site, while the less commercial pattern of Nanshikeng may have resulted from an irregular, tramping navigation. Another possibility is a land-based system, in which Luliao served as an important node of the trading network.

The variation between the two late Iron Age sites can be explained in terms of the nature of export articles and exchange strategies used by the people. In many parts of the world, export products were often controlled by a centralized system and were crucial for the emergence of a complex polity. For example, in early Bronze Age Thy, Denmark, the export production (cattle) was controlled by a chiefly system; such centralization later collapsed as exports shifted toward amber that was difficult to control (Earle 2002). In the pre-Hispanic Philippines, since many of the exports for Chinese overseas trade were interior forest products (e.g., species) that could not be directly controlled by the coastal chiefs, the political leaders had to gain control of the export articles by participating in the riverine trade networks (Junker 1999:382). In Iron Age Taiwan, however, the main export (deerskin) was from an abundant, mobile, wild resource, which was more difficult to control centrally compared to those unusual, static, and/or domesticated resources. Deerskin was also difficult to monopolize in terms of production, since the supply could be built upon household activity (see Chapter 3)

Successful trade competition in Iron Age Taiwan, therefore, would not have relied on control over resource or production but over the exchange. If the associated materials indicate sustained trading at Luliao, the people had to develop a series of strategies to attract merchants. For example, as reviewed in Chapter 3, hunting in indigenous societies was socially regulated and organized. As a result, hunting and trading year-round would substantially suppress other activities (e.g., farming) and probably go against traditional rules (e.g., seasonal restriction). Hunting prime-adult deer would also require a higher-level technique and more sophisticated skill. The Luliao people appear to have successfully overcome these challenges and thus could provide a steady and better supply of deer products.

In addition to hunting, other strategies may have been used in the competition for trade. Junker proposed the Philippine chiefs developed a number of strategies to attract foreign traders, such as "investment in housing and other port facilities for foreigners, the adoption of elite iconography or religious concepts familiar to their targeted trade partners, ritualized exchange relationships with foreigners that personalized trade alliances, and military protection of foreign vessels passing through the archipelago" (Junker 1999:377). At Luliao, the bone hairpins that symbolize absorption of a foreign hairstyle would also indicate a strategy to build trade alliances. In addition, the unusually high concentration of bone ornaments, exotic jewelry, and sewing needles at the site (see Chapter 5) also suggest the Luliao people were keen on elaborate clothing and decoration for both personalizing trade and displaying status.

More interestingly, such display is also documented in a textual record. In Chapter 2, I have demonstrated that the two earliest reliable texts about premodern Taiwan probably refer to the central-western coast. In *Dao Yi Zhi Lue*, written in 1349, the section *Liuqui* describes the people in this way: "men and women bind their hair, wear color cloth, boil sea water for salt, and make wine from sugarcane." Later, the western shipwreck refugee—Francisco Pírez—also documented the people in 1582. "They were naked and covered only by a loincloth like the ones of the Canary Islands. Their hair was loose and reached down to the ears. Some of them wore strips of white paper like a crown. All of them bore arches and a fistful of arrows with very sharp and long tips" (Borao 2001:5). It is interesting to note the contrast between how the two texts describe the natives in central Taiwan. Some historians argue that the *Liuqui* in *Dao Yi Zhi Lue* is unlikely referring to prehistoric Taiwan (e.g., Chou 2007:103) because the people acted very differently from most indigenous people described in the textual record. Based on the discovery from Luliao, I suggest the description in *Dao Yi Zhi Lue* may not be far from the truth, since it is the only reliable text dating to before the Ming ban on overseas trade (AD 1371).

9.4 Maritime Trade and Internal Exchange

In this dissertation, I have demonstrated that there was commodity-oriented deerskin production at the late Iron Age Luliao site. Chronologically, this economy was stimulated by expanding overseas trade since the tenth century, but the transition to commerce cannot be fully understood without exploring the indigenous point of view. In the case of the pre-Hispanic Philippines, Junker (1999:373) proposed that political relations of alliance and clientage in chiefdoms are key elements in examining why foreign trade goods had an evolutionary impact on societies. Therefore, in the final part of this dissertation, I discuss the driving force of the transition from an internal point of view; that is, why the Iron Age people wanted the exotic items, so that some of them carried out a commercialized deerskin production. To answer this question, it is necessary to discuss how the exotic things were used in indigenous societies. Due to the incomplete stratigraphic records at the three sites (see Chapter 5), it is impossible to determine the use of imported items in the Iron Age societies based solely on the excavations. Hence, I include textual records, ethnographic studies, and archaeological evidence from other sites to discuss the internal demand for foreign trade goods on an island-wide scale.

I use glass beads as an example because there is an extensive ethnographic record illustrating how glass beads are used in indigenous societies (see Hu 2012). This jewelry has a wide range of uses, not only for body decoration but for social transactions (e.g., compensation, bridewealth). Glass beads are also used for displaying wealth/status and transmitting ritual power. For example, in some groups in northern Taiwan, certain types of beads were used for fortune-telling and often associated with female shamans (see Hu 2012). Glass beads are also considered as heirlooms and symbolize status in groups that emphasize social rank (e.g., Paiwan). In these groups, the top-ranked beads can only be owned by elite families and exchanged exclusively within their marriage networks (Xu 2000).

Glass beads may have also played an important role in the indigenous political economy. As many societies in Southeast Asia, the political structures of native Taiwanese were weakly integrated alliance networks rather than more permanent political units. For example, as reviewed in Chapter 4, the Dutch recorded the leadership of *Quataongh* in the central-western lowland in the seventeenth century. This multi-tribal polity had a shifting network, with members varying from 15 to 27 villages (Ang 1992); powers of the chief were also limited, restricting to arbitration, protection, and ritual practices (Kang 2003). There is no record to show how the tribes were integrated, but glass beads, especially the top-ranked beads, were often used for building alliances and resolving disputes in the Dutch record (e.g., Blussé et al. 1999: Ⅱ :287, 449). The exchange of exotic jewelry, therefore, must have been significant in consolidating political ties and maintaining the power base of leaders during the Iron Age.

The ethnographic and historical records reviewed above suggest that glass beads had a social, ceremonial value, with an inalienable status as “gifts” (Hu 2012). In archaeology, however, identifying the use of these items is often challenging since most of the activities cannot be preserved in the archaeological record. Morris proposed that the circulation of gifts can be identified by one of the characteristic features of the economy—"the existence of restricted spheres of exchange" (1986:2), which leaves a pattern of limited distribution and deliberated disposal in the material record. According to research, the exotic items are unevenly distributed on the Iron Age sites, and a high concentration is often limited to a few coastal areas (e.g., Luliao, Shisanhang, and Kiwulan). Glass beads also have a regional variation in typology and composition, indicating the inter-regional exchange of these beads was limited (see Wang 2016). Within each site, although foreign materials can be found in a number of different contexts, exotic jewelry, as well as some metal artifacts (e.g., bronze knife handle, coin), is often an important component in Iron Age burials (e.g., Tsang and Liu 2001). At the Kiwulan site in the northeastern area, glass beads are unevenly distributed among the burials, and coins especially concentrate in a grave, suggesting the prestige value of these items in the Kiwulan society (Chen 2017; Cheng 2007).

This form of exchange is not restricted to the Iron Age and historical periods. Prior to the Iron Age, there were several exchange networks circulating high-value items in the Neolithic. As reviewed in Chapter 2, jade had a high social value and were circulated probably through a prestige chain. As foreign trade goods, jade artifacts can also be found in a number of different contexts, but the artifacts associated with ceremony are often prominent in terms of quantity and quality. For example, at the mid-Neolithic Xidadun site in the central lowland, rare comb-like jade artifacts are found in a significant number, together with a large stone knife and ceremonial pottery (see Chu 2012; Chu et al. 2009). At the early Neolithic Anhelu site (see Chapter 4), most jade artifacts appear to be grave goods, but the largest ones and greatest quantity were assigned to one particular individual, along with unusual ceramic artifacts and over 400 shark teeth (see Chu 2016). In addition to these elaborate offerings, this individual is also prominent by the amount of gravel disposed on both sides of the skeleton.

Based on the evidence above, I suggest both jade and exotic goods were sumptuary, inalienable items and circulated primarily through gift exchange, although some of the foreign trade goods may have served as currency in the local economy (see Chen 2017). The general pattern perhaps is that these goods can be owned by most society members, but are used and exchanged according to a rank order. Jade artifacts were probably ranked based on size and type; the exotic items were likely ranked according to symbolic values determined by the societies in which they were used.

From the Neolithic to Iron Age, there was a transition from the use of jade to exotic items for ceremony (see Chapter 2). The commercial maritime trade since the beginning of the first millennium is often considered a catalyst for this cultural evolution, but, by then, exotic goods had been introduced into the southeastern coast through the jade exchange with Southeast Asia, as a result of the expansion of Indian Ocean trade (see Chapter 2). The introduction of exotic goods eventually decreased the social value of jade in southeastern Taiwan. Since the southeastern coast was the primary consumption place of jade (Liu 2016), the introduction and incorporation of exotic items would have impacted jade production and later diminished its island-wide exchange. On the other hand, the increasing population size and social complexity in the late Neolithic (Liu 2002a) would have stimulated a growth in political economic systems. Such internal changes increased the demand for trade goods and provided an opportunity for the adoption of exotic items.

The decline of jade production and exchange may have also contributed to the decrease in lithic diversity in the early Iron Age. In Chapter 4, I have shown that lithic artifacts, especially the polished ones, substantially decreased in diversity from the late Neolithic to the early Iron Age in the central-western lowland. This change is often considered as a result of metal introduction, but metal tools are rare at most archaeological sites. Although awaiting further analysis, I suggest such a decrease in lithic diversity was associated with the decline of island-wide exchange, as, in addition to jade, some lithic artifacts may have been produced and exchanged within the same network. For example, both jade/nephrite and stone were materials for polished adzes. A sourcing analysis shows that the raw materials of polished stone adzes in central Taiwan (tuffaceous sandstone and siltsone) were probably quarried from the western foothills of Central Mountain (Hung 2004). Interestingly, there were also a large quantity of jade materials and debris found at the Damalin site in this area, which was a sub-center of jade production (Liu 2016). The overlapping sources of jade and stone adzes suggest that both artifacts were likely produced in the western foothills and later transported to the lowland area.

From this point of view, it is not surprising why exotic jewelry and metals were the main imports and why they caused a rapid, dramatic, and almost island-wide transition in the early Iron Age. The lithic production and exchange, especially jade and polished ones, were highly associated with the social economy of Neolithic Taiwan. As a result, exotic jewelry and metals were more easily incorporated when native trade goods declined. It also provides an explanation for why the popular Chinese export－porcelain or ceramic－was not reported at Luliao and Nanshikeng. I suggest, compared to the exotic jewelry and metals, the demand for porcelain or ceramic was later or never developed in Iron Age central Taiwan. Another imported item－

colored cloth—would also have a similar pattern of incorporation, although it cannot be examined archaeologically. In the Dutch record, colored cloth was often used by indigenous people to enhance social status, symbolize authority, and express cultural alliance, but a high demand for this exotic textile did not increase until the people developed a new fashion and trade alliance with foreign merchants (Shepherd 1999:36–37).

9.5 Concluding Remarks and Future Directions

The evidence provided in this study shows a transition toward a greater emphasis on commerce in Iron Age central Taiwan, although there is a variation between the two late Iron Age sites. In the maritime context, a growing population and urban economy in southeast China since the tenth century increased the demand for utilitarian and luxury goods. Although Iron Age Taiwan lacked the commodities desired by the Chinese urban elites, the western lowland appears to have attracted Chinese and other foreign merchants seeking profit from the international deerskin trade. This study has demonstrated a commodity-oriented deerskin production at the late Iron Age Luliao site. Rather than sporadic and low volume, the associated materials (e.g., bone hairpins) found at the site suggest sustained trading was established, although where the Taiwanese deerskins were actually consumed remains unclear.

In the local context, the transition is better seen as a result of internal change. Jade, as an unusual material, served as an important media in the Neolithic exchange, and the decline of jade production and exchange increased the demand for foreign trade goods. These goods, however, were highly controlled by a small number of groups due to their high value as exotic materials, the diminishing island-wide network, and the decentralized export economy. Patterns of the transition varied among the Iron Age settlements, depending on the geography for maritime trade and exchange strategies used by the people. Therefore, in addition to the growth of overseas trade, the ultimate cause of the transition must be seen as the indigenous structure, in which gift exchange is essential to the society. This study provides a case that not only can gift and commodity exchanges coexist in a society, which has been well presented in anthropological research, but gift exchange prompted the rise of a commercialized export economy.

In sum, this dissertation demonstrates how the Iron Age people participated in maritime trade. I also propose that the transition to commerce was stimulated by not only external maritime trade but also by internal demand. As the first archaeological-based research on the deerskin trade, this study contributes some new perspectives to regional maritime history, as our understanding about the history has heretofore largely relied on the textual record. Globally, this study illustrates the evolution of a regional culture within the expansion of international commerce and the growth of a world system.

However, several limitations of this study should be identified and expected to be alleviated in future studies. First, I discuss the use of exotic items largely based on the ethnographic and historical records. Archaeological investigation about the topic is very limited, although most Taiwanese archaeologists agree on the social significance of exotic artifacts. Future studies, therefore, are expected to work more on the social and political contexts of the foreign materials. In addition, I focus on the exotic artifacts to discuss the transition to the Iron Age, but they may not have been the only items exchanged in the indigenous networks. In the example of the pre-Hispanic Philippines, local products such as pottery and agricultural surplus also played an important role in the political economy (Junker 1999). Future studies, therefore, should identify possible local status goods and explore their exchange in central Taiwan. Furthermore, this study focuses mostly on deer to explore the market exchange, but, as reviewed in Chapter 3, other mammals sometimes were also exported in the fur trade. I did not investigate the patterns of other animals due to the extremely high abundance of deer in all three assemblages, but such analysis will be necessary if other taxa are more evenly represented in an assemblage.

As shown in Chapter 5, I argue all three sites have good access to maritime trade based on modern geography, and discuss the sites' variation from a social perspective. However, a reconstruction of the past environment is also necessary so that the transition and variation can be understood from a geographic point of view. Furthermore, all three sites have been partially disturbed, especially Luliao and Nanshikeng, leading to an incomplete stratigraphic record and the small-scale nature of excavation. Materials analyzed in this study thus were mostly recovered from refuse deposits. Since these deposits may not contain all the animal species exploited and certainly do not represent all activity at the sites, the sampled materials may limit the observation range and skew the results and interpretations. Although this situation is not uncommon in highly developed lowland Taiwan, more fieldwork and excavations are expected to study the transition on a larger inclusive scale. Finally, this study investigated the deerskin trade based on inter-site differences, without a consideration of intra-site variation. With more information available in the future, research can concentrate on the horizontal and vertical distributions of the materials to refine the interpretations of this study.

APPENDIX A. DATA RECORDING FOR IDENTIFICATION

Number	Unit	Level	Name	Genus	Species	Element	Portion	Side	Count	Weight (g)	Completeness

APPENDIX B. DATA RECORDING FOR TOOTH WEAR

Number	Unit	Level	Element	Wear Stage			
				dP_4	M_1	M_2	M_3

APPENDIX C. DATA RECORDING FOR CUT-MARK FREQUENCY

Skeletal Portion	NISP	NISP with Cut Marks	Proportion with Cut Marks
Shoulder			
Scapula glenoid			
Proximal humerus			
Elbow			
Distal humerus			
Proximal ulna			
Proximal radius			
Wrist			
Distal ulna			
Distal radius			
Scaphoid			
Lunar			
Cuneiform			
Trapezoid magnum			
Unciform			
Pisiform			
Proximal metacarpal			
Hip			
Ilium			
Pubis			
Ischium			
Proximal femur			
Knee			
Distal femur			
Patella			
Proximal tibia			
Ankle			
Distal tibia			
Distal fibula			
Astragalus			
Calcaneus			
Central-fourth tarsal			
Second-third tarsal			
Proximal metatarsal			

REFERENCES

Abe, Yoshiko, Curtis W. Marean, Peter J. Nilssen, Zelalem Assefa, and Elizabeth C. Stone

2002 The Analysis of Cutmarks on Archaeofauna: A Review and Critique of Quantification Procedures, and a New Image-Analysis GIS Approach. *American Antiquity* 67: 643–663.

Andrade, Tonio

2000 Commerce, Culture, and Conflict: Taiwan under European Rule, 1624–1662. Ph.D. dissertation, Department of of History, Yale University, New Haven.

2005 Pirates, Pelts, and Promises: The Sino-Dutch Colony of Seventeenth-Century Taiwan and the Aboriginal Village of Favorolang. *The Journal of Asian Studie*s 64: 295–321.

2006 The Rise and Fall of Dutch Taiwan, 1624–1662: Cooperative Colonization and the Statist Model of European Expansion. *Journal of World History* 17: 429–450.

Ang, Kaim

1992 Bei yiwang de Taiwan yuanzhumin shi: Quata (Dadu Fan Wang) chu kao [The Forgotten History of Taiwan Aboriginals: A Preliminary Study of Quata]. *The Taiwan Folkways* 42(4):145–188.

Appadurai, Arjun

1986 Introduction: Commodities and the Politics of Value. In *The Social Life of Things*, edited by Arjun Appadurai, pp. 3–63. Cambridge University Press, New York.

Arbuckle, Benjamin S.

2012 Animals and Inequality in Chalcolithic Central Anatolia. *Journal of Anthropological Archaeology* 31:302–313.

Beisaw, April M.

2013 *Identifying and Interpreting Animal Bones.* Texas AS&M Press, Texas.

Bellina, Bérénice, and Ian Glover

2004 The Archaeology of Early Contact with India and the Mediterranean World, from the Fourth Century BC to the Fourth Century AD. In *Southeast Asia: From Prehistory to*

History, edited by Ian Glover and Peter Bellwood, pp. 68–88. RoutledgeCurzon, London.

Bellwood, Peter

2012 The Checkered Prehistory of Rice Movement Southwards as a Domesticated Cereal–from the Yangzi to the Equator. *Rice* Online.

Binford, Lewis R.

1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

Bird, Douglas W., and Rebecca Bliege Bird

2000 The Ethnoarchaeology of Juvenile Foragers: Shellfishing Strategies among Meriam Children. *Journal of Anthropological Archaeology* 19:461–476.

Blussé, Léonard, Natalie Everts, and Evelien Frech (editor)

1999 *The Formosan Encounter: Notes on Formosa's Aboriginal Society. A Selection of Documents from Dutch Archival Sources*. 3 vols. Shung Ye Museum of Formosan Aborigines, Taipei.

Blussé, Léonard, and Marius P.H. Roessingh

1984 A Visit to the Past: Soulang, a Formosan Village anno 1623. *Archipel* 27: 63–80.

Blust, Robert

1999 Subgrouping, Circularity and Extinction: Some Issues in Austronesian Comparative Linguistics. In *Selected Papers from the Eighth International Conference on Austronesian Linguistics*, edited by Elizabeth Zeitoun and Paul Jen-Kuei Li, pp. 31–94. Academia Sinica, Taipei.

Borao, José Eugenio

2001 *Spaniards in Taiwan*, Vol. 1 (1582–1641). SMC Book, Taipei.

2007 An Overview of the Spaniards in Taiwan (1626- 1642). In *Proceedings of the Conference on China and Spain during the Ming and Qing Dynasties*, pp.1–17. Centre of Sino-Western Cultural Studies, I.P.M., Macao.

Braudel, Fernand

1972 *The Mediterranean and Mediterranean World in the Age of Philip II,* Vol. Ⅰ. Harper

& Row, New York.

Broughton, Jack M., and Bayham, Frank E.

2003 Showing off, Foraging Models, and the Ascendance of Large Game Hunting in California Middle Archaic. *American Antiquity* 68:783–789.

Carrier, James

1991 Gifts, Commodities, and Social Relations: A Maussian View of Exchange. *Sociological Forum* 6(1):119–136.

Chang, Kwang-Chih

1970 Zhongguo nanbu de shiqian wenhua [The Prehistoric Cultures of South China]. *Bulletin of the Institute of History and Philology Academia Sinica* 42:143–177.

1971 Prehistoric Archaeology of Taiwan. *Asian Perspectives* XIII:59–77.

Chang, Kwang-Chih (editor)

1977 *Taiwan sheng zhuoshui xi yu dadu xi liuyu kaogu diaocha baogao [Archaeological Survey of the Zhuoshui and Dadu River Basins, Taiwan]*. Papers of Institute of History and Philology, Academic Sinica, Vol. 70. Institute of History and Philology, Academic Sinica, Taipei.

Chen, Ching-Sen, and Yi-Leng Chen

2003 The Rainfall Characteristics of Taiwan. *Monthly Weather Review* 131:1323–1341.

Chen, I-lung, and Kuang Yang Lue

1993 Taiwan yetu chubu shengtai diaocha [The Preliminary Study on the Ecology of Formosan Hare (*Lepus sinensis formosanus*)]. *BioFormosa* 28: 87–101.

Chen, Kuo-Chuan

2008 *Taizhong shi dili zhi [The History of Taichung City: Geography]*. Taichung City Government, Taichung.

Chen, Kuo-Tung

2006 Cong dong ya haiyang shi dao shijie shi [From Maritime History of East Asia to World History]. In *Taiwan de shan hai jingyan [Taiwan's Experience in the Mountains* *and Seas]*, edited by Kuo-Tung Chen, pp. 35–41. Yuan Zu, Taipei.

Chen, Kwang-Tzuu

2000a Ancient Iron Technology of Taiwan. Ph.D. Dissertation, Department of Anthropology, Harvard University, Cambridge.

2000b Shi lun Taiwan ge shidai de burudongwu qun ji qi xiangguan wenti: Taiwan diqu dongwu kaoguxue yanjiu de jichu ziliao zhi yi [On Taiwan Mammalian Faunas in Different Periods of Time and Related Problems: The Background Materials for Taiwan Zooarchaeological Studies Ⅰ,Ⅱ]. *Bulletin of the Institute of History and Philology Academia Sinica* 71:129–198, 367–457, 497–503.

2011 Taiwan diqu chutu tongqi ji xiangguan yiliu chulun [A Preliminary Research on Copper-Based Artifacts and Related Remains Discovered in Taiwan]. *Bulletin of the Institute of History and Philology, Academia Sinica* 82:169–259.

Chen, Maa-Ling

1997 Settlement Patterns, Subsistence Systems and Their Changes in Kenting National Park during O-Luan-Pi Phases III and IV. Ph.D. Dissertation, Department of Anthropology, Arizona State University, Tempe.

Chen, Mei-Ting

2015 Taiwan qianshan diqu shihu *(Prionailurus bengalensis)* de kongjian shengtaixue [Spatial Ecology of Leopard Cats (*Prionailurus bengalensis*) in a Fragmented Rural Landscape in Northwestern Taiwan]. Ph.D. Dissertation, Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung.

Chen, Shu-Juo, and Hung-Lin Chiu

2009 *Tainan gongye kexue yuanqu nanguanli dong wenhua yizhi chutu rengu yanjiuan baogaoshu [The Analysis of Human Remains from Nankuanli East Site in Tainan Science Park]*. National Museum of Prehistory, Taitung, Taiwan.

Chen, Wei-Chun

2004 *Qingshui shekou yizhi jinji qiangjiu fajue baogao [Salvage Excavation at the Shekou Site, Qingshui]*. Taichung County Government, Taichung.

Chen, Wen-Shan, Shih-Hua Sung, Leh-Chyun Wu, Hao-De Hsu, and Hsiao-Chin Yang

2005 Moci bingqi yilai Taiwan haian pingyuan qu de haianxian bianqian [Shoreline Changes in the Coastal Plain of Taiwan since Last Glacial Epoch]. *Journal of Archaeology and Anthropology* 62:40–55.

Chen, Yi-Wen

2009 Cong fenzi ziliao jianshi Taiwan diqu guishu zhi yichuan bianyi [Genetic Variation of the Greater Bandicoot Rat (*Bandicota indica*) in Taiwan Based on Molecular Data]. M.A. Thesis, Department of Life Science, Tunghai University, Taichung.

Chen, Yen-Jean, Ke-Hung Liu, and Whei-Lee Chu

2016 New Record of Water Deer (*Hydropotes inermis*) from Iron Age Archeological Sites in Central Taiwan. *Collection and Research* 29:31–39.

Chen, Yu-Pei

2005 Cong qiwulan yu jiushe liang yizhi kan zuqun yanjiu [From the Chiwulan and Longmen Jiushe Archeological Sites to an Ethnic Study of the Region]. *Journal of the National Taiwan Museum* 58(2):25–35.

2015 Shiqian Taiwan de renshen zhuangshipin yanjiu [A Study on the Prehistoric Ornaments in Taiwan]. *Journal of the National Taiwan Museum* 68(1):19–42.

2017 Qiwulan yizhi chutu de wailaiwu yiyi yanjiu [Examining the Significance of the Foreign Artifacts Excavated at Kiwulan]. In *Kaogu lishi yu yuanzhumin: Taiwan zuqun guanxi yanjiu xin shiye [Archaeology, History and Indigenous Peoples: New Perspectives on the Ethnic Relations of Taiwan]*, edited by Li-Wan Hung, pp. 165–194. Shung Ye Museum of Formosa Aborigines, Taipei.

Cheng, Chieh-Fu

2007 Qiwulan yizhi yu shenei yizhi chutu bolizhu de xiangguan yanjiu [Studies of Glass Beads Excavated from Kivulan and Shenei Site, Taiwan]. M.A. Thesis. National Tsing Hua University, Hsinchu.

Cheng, Hsi-Chi

2004 Burulei [Mammals]. In *Taiwan baoyulei yesheng dongwu tujian [Atlas of Protected Wild Animals in Taiwan]*, pp. 9–74. R.O.C. Endemic Species Research Institute, Council of Agriculture, Executive Yuan, Taipei.

2010 Taiwan yesheng dongwu de duoyangxing [Diversity of Wild Animals in Taiwan]. *Science Development* 456:14–21.

Chiou, Shiuann-Yuh

1993 Ming chu yu nanhai zhu fanguo zhi chaoye maoyi 1368–1449 [The Tributes and Trades between the Ming Empire and Southeast Asia in 1368–1449]. In *Zhongguo haiyang fazhan shi lunwenji [Essays on the Maritime History of China]*, Vol. 5, edited by Pin-tsun Chang and Shih-Chi Liu, pp.111–151. Sun-Yat-Sen Institute for Social Science and Philosophy, Academia Sinica, Taipei.

Chiu, Min-Yung

2002a Taiwan xinshiqi shidai zhu de xuyang han shoulie: liyong yachi biaozhun qu fenjia zhu han yezhu de yanyiu [A Study in the Use of Dental Criteria in Distinguishing between Domestic and Wild pigs: Evidence from the Chih-Shan-Yen Site]. *Bulletin of the Institute of History and Philology Academia Sinica* 73: 271–302.

2002b Jiazhu huo yezhu? Zailun shisanhang yizhi chutu zhu de xuyang [Domesticated or Wild Pigs? Re-examining the Pig Husbandry and Hunting at the Shih-San-Hang Site]. *Disquisitions on the Past and Present* 7:24–36.

Chou, Wan-Yao

2007 Shan zai yaobo bilang zhong: zonglun ming ren de Taiwan renshi [Ming Conceptions of Taiwan: From Silhouettes to Islands]. *Historical Inquiry* 40:93–148.

2012 *Haiyang yu zhimindi Taiwan lunji [Essays on Maritime and Colonial Taiwan]*. Linking, Taipei.

Chu, Jui-Hua, Yu-Jen Tsao, Yuan-Ju Chuang, Huang-Chi Chen, Yao-Sung Lin, and Hai-Yin Wu

2007 Taiwan diqu wailai zhong miandianxiaoshu de zuqun yichuan jiegou yu shengwu dili qiyuan [Genetic Patterns and Biogeographic Origins of the Exotic Rodent (*Rattus exulans*) in Taiwan]. *Endemic Species Research* 9:1–11.

Chu, Whei-Lee

2012 Shuli de wenming: zaikan xidadun yizhi niumatou wenhua tese [The Nephrite Ornaments in Civilization: Rethinking the Sitadun Site and the Characteristics of Niumatou Culture]. *Field Archaeology of Taiwan* 15(2): 17–46.

2016 *Taizhong shi xitun qu anhelu yizhi chutu rengu ji wenwu qingli jihua chengguo* *baogao [Final Report of the Human Remains and Artifacts Discovered from Anhelu Site, Taichung]*. Cultural Heritage Department of Taichung City, Taichung.

Chu, Whei-Lee, and Chuan-Kun Ho

2007 Taizhong shi huilai yizhi daduhui gejuyuan chutu yiwu fenxi [The Analysis of Archaeological Remains Unearthed from Metro Theatre, Taichung]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2007, Taipei.

Chu, Whei-Lee, Wen-Shu Huang, and Heng Tsai

2010 Cong huilai yizhi chutu yiwu han gu turang xingtai tantao taizhong pendi shiqian huanjing [A Reconsideration to the Paleo-Environment of the Taichung Basin Based on the Artifacts and Morphologies of Paleosoils at the Hui-Lai Site]. *Journal of Archaeology and Anthropology* 72:35–66.

Chu Whei-Lee, Ke-Hung Liu, Qi-Ming Zhao, Ke-An Ji, and Ling-Da Yen

2011 Taizhong shi dingqiaozi yizhi fajue baogao [Excavation Report of the Dingqiaozi Archaeological Site, Taichung]. Annual Meeting of Taiwan Archaeology 2010, Taitung.

Chu, Whei-Lee, and Ling-Da Yen

2016 *Taizhong shi anhelu yizhi chutu rengu yanjiu [The Analysis of Human Remains from Anholu Site, Taichung]*. R.O.C. Ministry of Science and Technology, Taipei.

Chu, Whei-Lee, Ling-Da Yen, Tsai-Hua Chang, Wei-An Wong, and Xiao-Xuan Chen

2015 Taizhong shi anhelu yizhi fajue baogao [Excavation Report of the Anhelu Site, Taichung]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2014, Taipei.

Chuan, Han-Sheng

1993 Luelun xinhanglu faxian hou de zhongguo haiwai maoyi [An Essay on the Overseas Trade of China after the Discovery of New Trade Route]. In *Zhongguo haiyang fazhan shi lunwenji [Essays on the Maritime History of China]*, Vol. 5, edited by Pin-Tsun Chang and Shih-Chi Liu, pp. 1–16. Sun-Yat-Sen Institute for Social Science and Philosophy, Academia Sinica, Taipei.

Clark, Hugh R.

1982 Quanzhou (Fujian) during the Tang-Song Interregnum, 879–978. *T'oung Pao*, *Second Series* 68:132–149.

1991 *Community, Trade and Networks: Southern Fujian Province from the Third to the Thirteenth Century.* Cambridge University Press, Cambridge.

Codding, Brian F., Judith F. Porcasi, and Terry L. Jones

2009 Explaining Prehistoric Variation in the Abundance of Large Prey: A Zooarchaeological Analysis of Deer and Rabbit Hunting along the Pecho Coast of Central California. *Journal of Anthropological Archaeology* 29:47–61.

Cooper, Roger A., Phillip A. Maxwell, James S. Crampton, Alan G. Beu, Craig M. Jones, and Bruce A. Marshall

2006 Completeness of the Fossil Record: Estimating Losses due to Small Body Size. *Geology* 34:241–244.

Cui, Jianfeng, Chuan-Kun Ho, Ke-Hung Liu, and Xiao-Hong Wu

2008 Taiwan chutu bufen gudai bolizhu de kexue fenxi [Scientific Analysis of Some Ancient Glass Beads Discovered from Taiwan]. *Relics from South* 2008(4):109–114.

Diamond, Jared M.

2000 Linguistics: Taiwan's Gift to the World. *Nature* 403:709–710.

2002 Evolution, Consequences, and Future of Plant and Animal Domestication. *Nature* 418:700–707.

Dominguez-Rodrigo, Manuel, and José Yravedra

2009 Why Are Cut Mark Frequencies in Archaeofaunal Assemblages So Variable? A Multivariate Analysis. *Journal of Archaeological Science* 36:884–894.

Drennan, Robert

2010 *Statistics for Archaeologists: A Common Sense Approach*. 2nd ed. Springer, New York.

Earle, Timothy K.

2002 The Bronze Age Economy of Thy: Finance in a Networked Chiefdom. In *Bronze Age Economics: The Beginnings of Political Economies*, edited by Timothy K. Earle, pp. 293–324. Westview Press, Boulder, Colorado.

Flecker, Michael

2010 A Ninth-Century Arab Shipwreck in Indonesia. In *Shipwrecked*, edited by Regina Krahl, John Guy, J.Keith Wilson, and Julian Raby. Smithsonian Institution, Washington, D.C.

Goddard, Michael

2000 Of Cabbages and Kin: The Value of an Analytic Distinction between Gifts and Commodities. *Critique of Anthropology* 20:137–151.

Gould, Richard A.

2011 *Archaeology and the Social History of Ships.* Cambridge University Press, New York.

Grayson, Donald K.

1979 On the Quantification of Vertebrate Archaeofaunas. In *Advances in Archaeological Method and Theory*, Vol. 2, edited by Michael B. Schiffer, pp. 199–237. Academic Press, New York.

1981 The Effect of Sample Size on Some Derived Measures in Vertebrate Faunal Analysis. *Journal of Archaeological Science* 8:77–88.

1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas.* Academic Press, Orlando, Florida.

Green, Jeremy

1983 The Song Dynasty Shipwreck at Quanzhou, Fujian Province, People's Republic of China. *The International Journal of Nautical Archaeology and Underwater Exploration* 12:253–261.

Hall, Thomas D., P. Nick Kardulias, and Christopher Chase-Dunn

2010 World-Systems Analysis and Archaeology: Continuing the Dialogue. *Journal of Archaeological Research* 4:331–378.

Ho, Chuan-Kun

1977 Taizhong xian dadu shan taidi ji zhanghua nantou xian jing bagua shan taidi shiqian wenhua diaocha baogao [A Survey on the Prehistoric Cultures of the Dadu Plateau, Taichung and the Bagua Plateau, Changhua]. In *Taiwan zheng zhuoshui xi yu dadu xi liuyu kaogu diaocha baogao [Archaeological Survey of the Zhuoshui and Dadu River Basins, Taiwan]*. Papers of Institute of History and Philology, Academic Sinica, Vol. 70, edited by Kwang-Chih, Chang, pp. 27–64. Institute of History and Philology, Academic Sinica, Taipei.

2004a Penghu haigou Taiwan luqiao dongwuqun [Taiwan Landbridge Fauna in the Penghu Channel]. *Geology* 23(3):71–75.

2004b *Taiwan de shiqian wenhua [The Prehistoric Cultures of Taiwan]*. Yuan Zu, Taipei.

Ho, Chuan-Kun, and Whei-Lee Chu

2002 Taizhong shi huilaili yizhi diyi ci fajue baogao [Report on the First Excavation at Huilaili Site, Taichung]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2002, Taipei.

2004 *Taizhong shi gugenhan meishuguan xin shizheng zhongxin yudingki ji huilaili yizhi shi jue qimo baogao [Final Report of the Trial Excavations at the Guggenheim Museum, New City Hall, and Huilaili, Taichung]*. National Museum of Natural Science, Taichung.

2005 *Xiaolai de guxiang: taizhong shi huilai yizhi [Xiaolai's Hometown: The Huilai Archaeological Site of Taichung City]*. National Museum of Natural Science, Taichung.

2009 *Taizhong shi huilai yizhi chutu yiwu zhi fenxi yanjiu jihua chengguo baogao [The Analysis of Prehistoric Artifacts Discovered from Huilai Archaeological Site, Taichung]*. National Museum of Natural Science, Taichung.

Ho, Chuan-Kun, Whei-Lee Chu, and Zheng-Zhang Huang

2004 *Nanshikeng shiqian yiji [The Prehistoric Nanshikeng Site]*. National Museum of Natural Science, Taichung.

Ho, Chuan-Kun, and Ke-Hung Liu

2005a *Taizhong xian shalu zhen nanshikeng yizhi qiangjiu fajue gongzuo qimo baogao [Final Report of the Excavation at Nanshikeng Site in Taichung County]*. National Museum of Natural Science, Taichung.

2005b *Luliao yizhi biaoben tujian [An Illustrated Book of Artifacts from Luliao Archaeological Site]*. National Museum of Natural Science, Taichung.

2005c Taizhong xian shalu zhen luliao yizhi chutu de yusui zhu ji bolizhu [The Agate Beads and Glass Beads Discovered from Luliao Site, Shalu, Taichung]. Paper presented at the

Seminar of Foreign Substances in Taiwan: Beads and Penannular Jade Ring, Taipei.

2006 *Taizhong Xian yingpu yizhi fajue baogao [Excavation Report of the Yinpu Site in Taichung County]*. National Museum of Natural Science, Taichung.

Ho, Chuan-Kun, Ke-Hung Liu, and How-Wei Chen

1998 *Taizhong xian qingshui zhen qingshui yizhi diaocha ji kaogu fajue baogao [Archaeological Survey and Excavation Report of the Qingshui Site, Qingshui, Taichung]*. National Museum of Natural Science, Taichung.

Ho, Chuan-Kun, Ke-Hung Liu, and Ling-Da Yen

2006 Taizhong xian luliao yizhi de fushen zang [The Prone Burial at the Luliao Site, Taichung]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2006, Taichung.

Ho, Chuan-Kun, and Ling-Da Yen

2007 Zi Taiwan zhongbu fanziyuan wenhua zangsu qian tan shiqian renqun hudong [A Brief Discussion about the Interactions between Prehistoric Populations Based on the Evidence of Fanziyuan Burials in Central Taiwan]. Bulletin 261, National Museum of Natural Science, Taichung.

Hockett, Bryan

2005 Middle and Late Holocene Hunting in the Great Basin: A Critical Review of the Debate and Future Prospects. *American Antiquity* 70:713–731.

Holt, Julie Zimmermann

1996 Beyond Optimization: Alternative Ways of Examining Animal Exploitation. *World Archaeology* 28:89–109.

Hsiao, Ching-Kai

2008 *Taizhong shi jingji zhi [The Chorography of Taichung City: Economy]*. Taizhong City Government, Taichung.

Hsieh, Ellen

2012 Qiwulan yizhi shang wenhuaceng de wailai taoci: yige lishi kaoguxue de yanjiu [A Historical Archaeological Study of Exotic Ceramics from the Ki-Wu-Lan Site]. *Journal of*

Archaeology and Anthropology 76:33–60.

Hu, Cheng-Heng, Chia-Rong Chen, and Ying Wang

1994 Taiwan meihualu de caishi xingwei jiqi yu jijie zhi guanxi [Seasonal Changes of the Foraging Behavior of Formosan Sika Deer (*Cervus nippon taiouanus*)]. *Biology Bulletin of NTNU* 29:21–26.

Hu, Chia-Yu

2012 Taiwan nandao minzu bolizhu shipin de kua wenhua fenxi bijiao: duiyu xingshi jiazhi yu wuzhi xing de yixie sikao [Comparative Analysis of Glass Beads Used among Austronesian Groups in Taiwan: Some Thoughts on Forms, Values and Materiality]. *Journal of Archaeology and Anthropology* 76:97–134.

Huang, Chun-Yan

2003 *Song dai haiwai maoyi [The Overseas Trade of Song Dynasty]*. Social Sciences Academic Press, Beijing.

Huang, Shu-Jing

1999 [1736] *Tai hai shih cha lu [A Tour of Duty in the Taiwan Sea]*. Taiwan Historica, Nantou, Taiwan.

Hung, Hsiao-Chun

2004 A Sourcing Study of Taiwan Stone Adzes. *Bulletin of the Indo-Pacific Prehistory Association* 24:57–70.

2005 Shi lun feilubin bolizhu jian lun Taiwan bolizhu [A Discussion of the Glass Beads from the Philippines and Taiwan]. Paper presented at the Seminar of Foreign Substances in Taiwan: Beads and Penannular Jade Ring, Taipei.

Hung, Hsiao-Chun, and Chin-Yung Chao

2016 Taiwan's Early Metal Age and Southeast Asian Trading Systems. *Antiquity* 90: 1537–1551.

Hung, Hsiao-Chun, Yoshiyuki Iizuka, Peter Bellwood, Kim Dung Nguyen, Bérénice Bellina, Praon Silapanth, Eusebio Dizon, Rey Santiago, Ipoi Datan, and Jonathan H. Manton

2007 Ancient Jades Map 3,000 Years of Prehistoric Exchange in Southeast Asia. *PNAS*

104:19745–19750.

Hung, Li-Wan

1992 Daan dadu xi jian kentuo shi yanyiu 1683–1874 [Research on the Developmental History of the Area between Daan and Dadu Rivers in 1683–1874]. *Taiwan Historica* 43(3):165–260.

2003 Dadu zhuoshui liang xi liuyu zhi pingpu shequn guanxi [Communal Relations of the Plains Aborigines in the Dadu and Zhuoshui River Basins]. In *Proceedings of the Symposium on Changhua, 2003*. National Changhua University of Education, Changhua.

2009 *Shou fan shehui wangluo yu jiti yishi: Taiwan zhongbu pingpu zuqun lishi bianqian (1700–1900) [The Social Network and Collective Consciousness of Shufan: The Historical Change of Plains Aborigines in Central Taiwan (1700–1900)]*. Linking, Taipei.

Jiang, Shu-Sheng

1984 Meihualu yu Taiwan zaoqi lishi guanxi zhi yanjiu [A Study of Sika Deer and Early History of Taiwan]. In *Bulletin of Symposium on Reintroduction of Formosan Sika Deer,* pp. 3–62. Kenting National Park, Pingtung, Taiwan.

Jiao, Tianlong

2007 *The Neolithic of Southeast China: Cultural Transformation and Regional Interaction on the Coast.* Cambridge Press, New York.

Jones, George T., and Robert D. Leonard

1989 The Concept of Diversity: An Introduction. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 1–3. Cambridge University Press, Cambridge.

Ju, Yu-Ten, and Jai-Chyi Pei

2014 *Yangmingshan guojia gongyuan zhengui xiyou dongwu shexiangmao zhi diaocha [Final Report of the Survey on Endangered Civets in the Yangmingshan National Park]*. Yangmingshan National Park, Taipei.

Junker, Laura Lee

1999 *Raiding, Trading, and Feasting: The Political Economy of Philippine Chiefdoms.* University of Hawai'i Press, Honolulu.

Kang, Heejung

2015 Kunlun and Kunlun Slaves as Buddhists in the Eyes of the Tang Chinese. *KEMANUSIAAN: The Asian Journal of Humanities*: 22(1):27–52.

Kang, Peter

2003 Huanjing kongjian yu quyu: dilixue guandian xia shiqi shiji zhongye daduwang tongzhi de xiaozhang [Environment, Space and Region: Geographical Perspective on the Quataongh Regime during the Mid-seventeenth Century]. *Humanitas Taiwanica* 59:97–116.

Kano, Tadao

1952 Taiwan xianshi shidai de wenhua ceng [Cultural Layers of Prehistoric Taiwan]. Translated by Wen-Hsun Sung. *Taiwan Historica* 3:59–62.

Kaufman, Daniel

1998 Measuring Archaeological Diversity: An Application of the Jackknife Technique. *American Antiquity* 63:73–85.

Kintigh, Keith W.

1984 Measuring Archaeological Diversity by Comparison with Simulated Assemblages. *American Antiquity* 49:44–54.

1989 Sample Size, Significance, and Measures of Diversity. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 25–36. Cambridge University Press, Cambridge.

Klein, Richard G., and Kathryn Cruz-Uribe

1984 *The Analysis of Animal Bones from Archaeological Sites.* The University of Chicago Press, Chicago.

Koike, Hiroko, and Noriyuki Ohtaishi

1985 Prehistoric Hunting Pressure Estimated by the Age Composition of Excavated Sika Deer (*Cervus Nippon*) Using the Annual Layer of Tooth Cement. *Journal of Archaeological Science* 12:443–456.

Kuo, Su-Chiu

2010a Cong kaogu ziliao kan paiwan wenhua de qiyuan wenti [The Origin of Paiwan Cultural Traits from Archaeological Evidence]. In *2009 International Symposium on Austronesian Studies*, pp. 185–220, edited by Masegseg Z. Gadu and Hsiu-Man Lin. National Museum of Prehistory, Taitung, Taiwan.

2010b Taizhong shi zhongxing daxue (dingqiaozi yizhi) kaogu shi jue baogao [Trial Excavation at the Dingqiaozi Site, NCHU, Taichung]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2009, Taipei.

Lapham, Heather A.

2005 *Hunting for Hides: Deerskins, Status, and Cultural Change in the Protohistoric Appalachians.* The University of Alabama Press, Tuscaloosa, Alabama.

Lee, Cheng-Yi, Maa-Ling Chen, Peter Ditchfield, A. Mark Pollarda, Li-Hung Lin, Pei-Ling Wang, Hsiu-Man Lin, Ching-Hua Lo, and Hsi-Kuei Tsai

2017 Dietary Reconstruction of the Iron Age Population at the Fantzuyuan Site, Taiwan, Revealed by Isotopic Analysis on Human and Faunal Bone Collagen. *Archaeological Research in Asia* 9:34–43.

Lee, Kun-Siu

2005a Jiuxianglan yizhi chutu de bolizhi biaoben ji qi xiangguan wenti chu tan [Glass Materials from the Jiuxianglan Site and the Relevant Research Questions]. Paper presented at Seminar of Foreign Substances in Taiwan: Beads and Penannular Jade Ring, Taipei.

2005b *Taidong xian jiuxianglan yizhi qiangjiu fajue jihua qimo baogao [Report on the Salvage Excavations at Jiuxianglan Site, Taitung]*. Taitung County Government, Taitung, Taiwan.

2007 *Taidong xian jiuxianglan yizhi qiangjiu fajue dier qi jihua qimo baogao [Report on the Salvage Excavations at Jiuxianglan Site, Taitung—the Second Season]*. Taitung County Government, Taitung, Taiwan.

2015 Jiuxianglan yizhi chutu de shayan zhumo ji xi laiyuan tantao [Sandstone Molds from Jiuxianglan, Taitung and Their Origin: A Preliminary Consideration]. *Field Archaeology of Taiwan* 18: 31–71.

Li, Feng, Zhen-Hua Luo, Chun-Lin Li, Chun-Wang Li, and Zhi-Gang Jiang

2013 Gu bei jie gouhuan shixing de shengwu dili moshi: gouhuan shi qiuyin zhuanshizhe ma? [Biogeographic Pattern of Badgers' Diet in the Palearctic Realm: Do Badgers Eat Earthworms Only?]. *Chinese Science Bulletin* 58:1565–1572.

Li, Fuxue

1987 Quanzhou wan song dai hai chuan shang beilei de yanyiu [A Study of Shell Remains on the Song Shipwreck at Quanzhou Harbor]. In *Quanzhou wan song dai hai chuan fajue yu yanjiu [The Excavation and Study of the Song Shipwreck at Quanzhou Harbor]*, edited by Quanzhou Maritime Museum, pp. 140–146. China Ocean Press, Beijing.

Li, Jen-Kuei

2000 *Taiwan pingpuzu de lishi yu hudong [The History and Interaction of the Plain Aborigines in Taiwan]*. Changmin, Taipei.

Li, Kuang-Ti

1997 Change and Stability in the Dietary System of a Prehistoric Coastal Population in Southern Taiwan. Ph.D. Dissertation, Department of Anthropology, Arizona State University, Tempe.

2005 Lun kending shiqian juluo yizhi de beilei caiji jiqi gudai shuiti huanjing de yiyi [Discussion of Prehistoric Kenting Inhabitants' Shellfish Gathering Strategy and Paleoenvironmental Implications]. *Journal of Austronesian Studies* 1(2):47–63.

2013 First Farmers and Their Coastal Adaptation in Prehistoric Taiwan. In *A Companion to Chinese Archaeology*, edited by Anne P. Underhill, pp. 612–633. Blackwell Publishing, Oxford.

Li, Kuang-Ti, Kuan-Yi Li, Yu-Ten Ju, and Cheng-Hwa Tsang

2015 Shiqian shidai Taiwan nanbu diqu de yezhu yu jiazhu: jian lun jiazhu zuowei nandao yuzu qianxi han kuosan de yanzheng biaoji [Wild Boars and Domestic Pigs in Prehistoric Southern Taiwan: Some Point of Views on Domestic Pigs as a Verification Mark to the Migration and Dispersal of Austronesian Speaking People]. *Bulletin of the Institute of History and Philology Academia Sinica* 86:607–678.

Lien, Chao-Mei

1998 Qi shiji dao shier shiji de Taiwan: Taiwan tieqi shidai wenhua ji xiangguan wenti [Taiwan in the 7th Century to the 12th Century: Major Characteristics of the Iron Age of

Taiwan]. *Journal of Archaeology and Anthropology* 53:1–11.

2003 Beinan yuqi yanjiu [A Study of Jade Artifacts from Beinan, Taiwan]. In *Taiwan xinshiqi shidai beinan yanjiu lunwenji [Research Papers on Neolithic Beinan, Taiwan],* pp. 113–135. National Museum of History, Taipei.

Liew, Ping-Mei, and Meng-Long Hsieh

2000 Late Holocene (2 ka) Sea Level, River Discharge and Climate Interrelationship in the Taiwan Region. *Journal of Asian Earth Sciences* 18:499–505.

Liew, Ping-Mei, and Shu-Yue Huang

1994 A 5000-Year Pollen Record from Chitsai Lake, Central Taiwan. *Journal of Terrestrial, Atmospheric and Oceanic Sciences* 5:411–419.

Liew, Ping-Mei, Meng-Huan Wu, Cheng-Yi Lee, Chiou-Lian Chang, and Teh-Quei Lee

2014 Recent 4000 Years of Climatic Trends Based on Pollen Records from Lakes and a Bog in Taiwan. *Quaternary International* 349:105–112.

Lin, Chao-Qi

1957 *Taiwan dixing [Topography of Taiwan]*. Historical Research Committee of Taiwan, Nantou, Taiwan.

Lin, Hsiu-Man

1997 Shisanhang yizhi chutu dongwu guge zhi chubu fenxi: yi zhu xiaegu wei li [A Preliminary Analysis of the Faunal Remains from Shisanhang Site: A Case Study of Pig Mandibles]. M.A. Thesis, Department of Anthropology, National Taiwan University, Taipei.

Lin, Shu-Fen, Ping-Mei Liew, and Tzu-Hua Lai

2004 Late Holocene Pollen Sequence of the Ilan Plain, Northeastern Taiwan, and its Environmental and Climatic Implications. *Journal of Terrestrial, Atmospheric and Oceanic Sciences* 15(2):221–237.

Ling, Shun-Sheng

1970 *Zhongguo yuangu yu taipingyang yindu liang yang de fanfa gechuan fangshou han louchuan de yanjiu* [A Study of the Raft, Outrigger, Double and Deck Canoes of Ancient China, the Pacific and the Indian Oceans]. Papers of Institute of Ethnology, Academia

Sinica Vol. 16. Institute of Ethnology, Academia Sinica, Taipei.

Liu, Ke-Hung

2013a *Taizhong shi shalu qu nanshigeng yizhi diaocha shi jue jihua qimo baogao [Final Report of the Trial Excavation at Nanshikeng Site, Shalu, Taichung]*. National Museum of Natural Science, Taichung.

2013b *Taizhong shi shaluqu nanshikeng yizhi qiangjiu fajue jihua qimo baogao [Final Report of the Rescue Excavation at Nanshikeng Site, Shalu, Taichung]*. National Museum of Natural Science, Taichung.

Liu, Ts'ui-Jung

1998 Han Migration and the Settlement of Taiwan: The Onset of Environmental Change. In *Sediments of Time: Environment and Society in Chinese History*, edited by Mark Elvin and Ts'ui-Jung Liu, pp. 165–199. Cambridge University Press, Cambridge.

Liu, Yi-Chang

1999 *Cunzai de weizhi: taizhong diqu de kaogu yizhi yu shiqian wenhua [The Existing Unknown: The Archaeological Sites and Prehistoric Cultures of Taichung]*. Taichung County Culture Center, Taichung.

2002a *Taiwan yuanzhumin shi: shiqian pian [The History of Taiwan Aboriginies: Prehistory]*. Taiwan Historica of Academia Historica, Taipei.

2002b *Danshui he kou de shiqian wenhua yu zuqun [The Prehistoric Cultures and Populations along the Estuary of Tanshiu River]*. Shihsanhang Museum of Archaeology, Taipei.

2005 Cong yuqi dao boli manao: Taiwan shiqian zhuangshi qiwu de bianqian [From Jade to Glass and Agate: The Change of Prehistoric Jewelry in Taiwan]. Paper presented at the Seminar of Foreign Substances in Taiwan: Beads and Penannular Jade Ring, Taipei.

2006 Taiwan kaoguxue yu yuanzhumin yanjiu [The Discipline of Taiwanese Archaeology and Studies of Indigenous People Groups]. *Journal of Archaeology and Anthropology* 66:70–93.

2016 Yuqi de jiaohuan tixi yanjiu: zhizao yu ziyuan kongzhi [Analysis of the Trade and Exchange of Jade Ware: Production and Resource management]. In *Taiwan Shiqianshi Zhuanlun [Essays on Taiwan Prehistory]*, edited by Yi-Chang Liu, pp. 83–112. Linking, Taipei.

Liu, Yi-Chang, Hong-Min Zeng, and Jia-Yu Li

2007 Fanziyuan wenhua de zai jiantao [Rethinking the Fanziyuan Culture]. Paper Presented at the Annual Meeting of Taiwan Archaeology 2006, Taichung.

Lubinski, Patrick M., and Christopher J. O'Brien

2001 Observations on Seasonality and Mortality from a Recent Catastrophic Death Assemblage. *Journal of Archaeological Science* 28:833–842.

Lupo, Karen D.

2007 Evolutionary Foraging Models in Zooarchaeological Analysis: Recent Applications and Future Challenges. *Journal of Archaeological Research* 15:143–189.

Lupo, Karen D., and James F. O'Connell

2002 Cut and Tooth Mark Distribution on Large Animal Bones: Ethnoarchaeological Data from the Hadza and Their Implications for Current Ideas about Early Human Carnivory. *Journal of Archaeological Science* 29:85–109.

Lyman, R. Lee

1987 Archaeofaunas and Butchery Studies: A Taphonomic Perspective. In *Advances in Archaeological Method and Theory,* Vol. 10, edited by Michael B. Schiffer, pp. 249–337. Academic Press, San Diego.

1994 *Vertebrate Taphonomy. Cambridge Manuals in Archaeology.* Cambridge University Press, Cambirdge.

2002 Taxonomic Identification of Zooarchaeological Remains. *The Review of Archaeology* 23(2):13–20.

2005 Analyzing Cutmarks: Lessons from Artiodactyl Remains in the Northwestern United States. *Journal of Archaeological Science* 32:1722–1732.

2008 *Quantitative Paleozoology.* Cambridge University Press, Cambridge.

Ma, Xie-Qun

1996 *Kending guojia gongyuan sheding fuyu qu Taiwan yetu shengtai diaocha [Survey on the Ecology of Formosan Hare in Sheding, Kenting National Park]*. Kenting National Park, Pingtung, Taiwan.

Mao, Xiu-Juan

2003 Taiwan xinan bu xinhua qiu lingdi qu niechi dongwu huashi yachi zhi yanjiu [Teeth of Rodent Fossils in Shin-Hua Hill Area, Southwestern Taiwan]. M.A. Thesis, Department of Earth Science, National Cheng Kung University, Tainan.

Marean, Curtis W.

1991 Measuring the Post-depositional Destruction of Bone in Archaeological Assemblages. *Journal of Archaeological Science* 18:677–694.

Matisoo-Smith, E., and J. H. Robins

2004 Origins and Dispersals of Pacific Peoples: Evidence from mtDNA Phylogenies of the Pacific Rat. *Proceedings of National Academy of Sciences* 101: 9167–9172.

Mauss, Marcel

1967 [1925] *The Gift: Forms and Functions of Exchange in Archaic Societies*. Translated by Ian Cunnison. W. W. Norton & Company, New York.

McCullough, Dale R.

1974 Status of Larger Mammals in Taiwan: A Report to World Wildlife Fund, Washington, D.C., U.S.A. R.O.C. Tourism Bureau, Ministry of Communications, Taipei.

Monks, Gregory G.

1981 Seasonality Studies. In *Advances in Archaeological Method and Theory*, Vol. 4, edited by Michael B. Schiffer, pp. 177–240. Academic Press, New York.

Morris, Ian

1986 Gift and Commodity in Archaic Greece. *Man* 21:1–17.

Nakamura, Takashi

1994 Helan shidai de Taiwan fanshe hukou biao [The Census of Formosan Aborigines during the Dutch Period]. Translated by Mi-Cha Wu and Xian-Yao Xu. *The Taiwan Folkways* 44(1):197–234.

1997 *Helan shidai Taiwan shi yanjiu shang juan: gaishuo chanye [Research on the History of Dutch Taiwan, Vol. 1: Introduction and Production]*. Daw Shiang, Taipei.

National Chung Hsing University

1976 *Taizhong xian shi nantou xian turang diaocha baogao [Soils of Taichung and Nantou]*. National Chung Hsing University, Taichung.

Ohtaishi, Noriyuki

1980 Determination of Sex, Age and Death-season of Recovered Remains of Sika Deer (*Cervus nippon*) by Jaw and Tooth-cement. *Archeology and Natural Sciences* 13:51–74.

Oka, Rahul, and Chapurukha M. Kusimba

2008 The Archaeology of Trading Systems, Part 1: Towards a New Trade Synthesis. *Journal of Archaeological Research* 16:339–395.

Osteen, Mark

2002 Gift or Commodity? In *The Question of the Gift: Essays across Disciplines*, edited by Mark Osteen. New York: Routledge.

Pei, Jai-Chyi

2010 Lukai zu de shoulie zhishi yu wenhua: chuantong shengtai zhishi de jiazhi [Hunting Knowledge and Culture of Rukai: Values of Traditional Knowledge in Ecology]. *Taiwan Indigenous Studies Review* 8:67–84.

Pei, K., R. D. Taber, B. W. O'Gara, and Y. Wang

1995 Breeding Cycle of the Formosan Reeves' Muntjac (*Muntiacus reevesi micrurus*) in northern Taiwan, Republic of China. *Mammalia* 59:223–228.

Pezzuti, Juarez C. B., Jackson Pantoja Lima, Daniely Félix da Silva, and Alpina Begossi

2010 Uses and Taboos of Turtles and Tortoises along Rio Negro, Amazon Basin. *Journal of Ethnobiology* 30:153–168.

Pietrusewsky, Michael, Adam Lauer, Cheng-Hwa Tsang, Kuang-ti Li, and Michele Toomay Douglas

2013 Dental Indicators of Health in Early Neolithic and Iron Age Skeletons from Taiwan. *Journal of Austronesian Studies* 4(2):1–33.

Pietrusewsky, Michael, and Cheng-Hwa Tsang

2003 A Preliminary Assessment of Health and Disease in Human Skeletal Remains from

Shi-San-Hang: A Prehistoric Aboriginal Site on Taiwan. *Anthropological Science* 111: 204–223.

Polanyi, Karl

1957 The Economy as an Instituted Process. In *Trade and Market in the Early Empires: Economies in History and Theory*, edited by Karl Polanyi, Conrad M. Arensberg, and Harry W. Pearson, pp. 243–270. The Free Press, Glencoe, Illinois.

Qingshui District Government

2013 *Chongxiu qingshui zhen zhi [The History of Qingshui Township]*. Qingshui District Government, Taichung.

Quanzhou Collaborative Archaeological Team

1975 Quanzhou wan song dai hai chuan fajue jian bao [A Brief Excavation Report of the Song Shipwreck at Quanzhou Harbor]. *Wenwu* 10:1–18.

1987 Quanzhou wan song dai hai chuan fajue baogao [Excavation Report of the Song Shipwreck at Quanzhou Harbor]. In *Quanzhou wan song dai hai chuan fajue yu yanjiu [The Excavation and Study of the Song Shipwreck at Quanzhou Harbor]*, edited by Quanzhou Maritime Museum, pp. 1–74. China Ocean Press, Beijing.

Reitz, Elizabeth J., and Elizabeth S. Wing

2008 *Zooarchaeology.* 2nd ed. Cambridge University Press, Cambridge.

Renfrew, Colin

1975 Trade as Action at a Distance: Questions of Integration and Communication. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 3–60. University of New Mexico Press, Albuquerque.

1977 Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory,* edited by Timothy K. Earle and Jonathan E. Ericson, pp. 71–90. Academic Press, New York.

Rolett, Barry V.

2007 Southeast China and the Emergence of Austronesian Seafaring. In *Lost Maritime Cultures: China and the Pacific*, edited by Tianlong Jiao, pp. 54–61. Bishop Museum Press, Honolulu.

Rolett, Barry V., Wei-Chun Chen, and John M. Sinton

2000 Taiwan, Neolithic seafaring, and Austronesian Origins. *Antiquity* 74:62–74.

Rosenswig, Robert M.

2007 Beyond Identifying Elites: Feasting as a Means to Understand Early Middle Formative Society on the Pacific Coast of Mexico. *Journal of Anthropological Archaeology* 26:1–27.

Sahlins, Marshall

1972 On the Sociology of Primitive Exchange. In *Stone Age Economics*, pp. 185–230. Aldine Publishing Company, Chicago.

Schiffer, Michael B.

1983 Toward the Identification of Formation Processes. *American Antiquity* 48:675–706.

Schmitt, Dave N., and Karen D. Lupo

2008 Do Faunal Remains Reflect Socioeconomic Status? An Ethnoarchaeological Study among Central African Farmers in the Northern Congo Basin. *Journal of Anthropological Archaeology* 27:315–325.

Schottenhammer, Angela

2011 Introduction and Historical Context. In *Taiwan: A Bridge between the East and South China Seas*, edited by Angela Schottenhammer, pp. 1–8. Harrassowitz Verlag, Wiesbaden, Germany.

2012 The "China Seas" in World History: A General Outline of the Role of Chinese and East Asian Maritime Space from its Origins to c. 1800. *Journal of Marine and Island Cultures* 1:63–86.

Sen, Tansen

2014 Maritime Southeast Asia between South Asia and China to the Sixteenth Century. *TRaNS: Trans-Regional and -National Studies of Southeast Asia* 2:31–59.

Shalu Town Government

1994 *Shalu zhen zhi [The Chorography of Shalu Town]*. Shalu Town Government, Taichung.

Sheng, Qing-Yi

1962 Taiwan sheng bei haian shiqian yizhi diaocha baogao [Archaeological Survey of the Prehistoric Sites on the North Coast of Taiwan]. *Taiwan Historica* 13(3):60–152.

Shepherd, John Robert

1993 *Statecraft and Political Economy on the Taiwan Frontier, 1600–1800.* Stanford University Press, Stanford.

Sherratt, Andrew, and Susan Sherratt

1991 From Luxuries to Commodities: The Nature of Mediterranean Bronze Age Trading Systems. In *Bronze Age Trade in the Mediterranean*, edited by N. H. Gale, pp. 351–384. Oxford University Press, Oxford.

Simpson, George Gaylord, Anne Roe, and Richard C. Lewontin

2003 *Quantitative Zoology*. Revised ed. Dover Publications, New York.

Song, Wen-Xun, and Kwang-Chih Chang

1954 Taizhong xian shuiwei xi pan shiqian yizhi shi jue baogao [The Trial Excavation at a Prehistoric Site on the Riverside of Shuiwei Stream, Taichung]. *Journal of Archaeology and Anthropology* 3:26–38.

Stiner, Mary C.

1990 The Use of Mortality Patterns in Archaeological Studies of Hominid Predatory Adaptations. *Journal of Anthropological Archaeology* 9:305–351.

Su, Horng-Jye

1985 Taiwan meihualu tianran shengyu dizhi zhiqun fenxi ji qi zai kending guojia gongyuan nei fuyu didian zhi kanxuan [Vegetation Analysis of the Natural Habitat of Formosan Sika Deer and Suggestion for Reintroduction to Kenting National Park]. In *Bulletin of Symposium on Reintroduction of Formosan Sika Deer*, pp. 63–101. Kenting National Park, Pingtung, Taiwan.

Swinhoe, Robert

1862 On the Mammals of the Island of Formosa (China). In *Proceedings of the Scientific Meetings of the Zoological Society of London for the Year 1862*, pp. 347–365. Zoological Society of London, London.

1870 Catalogue of the Mammals of China (South of the River Yangtsze) and of the Island of Formosa. In *Proceedings of the Scientific Meetings of the Zoological Society of London for the Year 1870*, pp. 615–653. Zoological Society of London, London.

Tan, Pei-Hua, and Ya-Chi Tseng

2012 1997 dao 2010 nian Taiwan diqu wendu de tezheng [The Characteristics of Temperature in Taiwan during 1997–2010]. *Atmospheric Sciences* 40:371–405.

Tang, Wen-Ji

1995 *Fujian gudai jingji shi [The Economic History of Ancient Fujian]*. Fujian Education Press, Fuzhou.

Ten, Tansen

2014 Maritime Southeast Asia between South Asia and China to the Sixteenth Century. *TRaNS: Trans-Regional and -National Studies of Southeast Asia* 2:31–59.

Thomas, David H.

1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34:392–401.

Tsang, Cheng-Hwa

1995 *Taiwan kaogu [Taiwan Archaeology]*. R.O.C. Council for Cultural Affairs, Executive Yuan, Taipei.

2000 Recent Advances in the Iron Age Archaeology of Taiwan. *Bulletin of the Indo-Pacific Prehistory Association* 20:153–158.

2012 Zai lun nandao yuzu de qiyuan yu kuosan wenti [Once Again on the Austronesian Origin and Dispersal]. *Journal of Austronesian Studies* 3(1): 87–119.

2016 Penghu Qimei dao shiqian xuanwuyan shiqi gongye yu qi maoyi tixi [The Prehistoric Production and Trade of Basalt on the Qimei Island, Penghu]. In *Taiwan shiqianshi zhuanlun [Essays on Taiwan Prehistory]*, edited by Yi-Chang Liu, pp. 59–82. Linking, Taipei.

Tsang, Cheng-Hwa, and Hsiao-Chun Hung

2001 Penhu qimei san shiqian shiqi zhizochang de faxian he chubu yanjiu [A Preliminary Study of Three Lithic Workshops Found on the Qimei Island, Penghu]. *Bulletin of the Institute of History and Philology* 72:889–940.

Tsang, Cheng-Hwa, and Kuang-Ti Li

2013 *Nanke de gu wenming* [Archaeological Heritages in Tainan Science Park of Taiwan]. National Museum of Prehistory, Taitung, Taiwan.

Tsang, Cheng-Hwa, Kuang-Ti Li, and Zheng-Yi Zhu

2006 *Xian min lu ji: nanke kaogu faxian zhuanji [The Archaeological Discovery of Tainan Science Park]*. Tainan County Government, Tainan.

Tsang, Cheng-Hwa, and Yi-Chang Liu

2001 *Shisanhing yizhi qiangjiu yu chubu yanjiu [The Salvage Excavation and Preliminary Analysis of Shisanhang Site]*. Taipei County Government, Taipei.

Tsao, Yung-Ho

2000 *Zhongguo haiyang shi lunji [Essays on the Maritime History of China]*. Linking, Taipei.

2002 *Taiwan zaoqi lishi yanjiu xuji [Sequel to the Research on Early Historical Taiwan]*. Linking, Taipei.

2011 *Jinshi Taiwan lupi maoyi kao [A Study of Deerskin Trade in Early Modern Taiwan]*. Yuan Liou, Taipei.

Tsuchida, Shigeru

1982 A Comparative Vocabulary of Austronesian Language of Sinicized Ethnic Groups in Taiwan, Part I: West Taiwan. *Memoirs of the Faculty of Letters, University of Tokyo,* No.7. University of Tokyo, Tokyo.

Val, Aurore, and Jean-Baptiste Mallye

2011 Small Carnivore Skinning by Professionals: Skeletal Modifications and Implications for the European Upper Palaeolithic. *Journal of Taphonomy* 9(4):221–243.

Wang, Kuan-Wen

2016 Cultural and Socio-economic Interaction Reflected by Glass Beads in Early Iron Age Taiwan. Ph.D. Dissertation, Department of Archaeology, The University of Sheffield, Sheffield, UK.

Wang, L. C., H. Behling, T. Q. Lee, H. C. Li, C. A. Huh, L. J. Shiau, and Y. P. Chang

2014 Late Holocene Environmental Reconstructions and Their Implications on Flood Events, Typhoon, and Agricultural Activities in NE Taiwan. *Climate of the Past* 10: 1857–1869.

Wang, Su-Chin, and Yi-Chang Liu

2007 Shiqi shiji qian hou Taiwan bolizhu shi yu yancao yandou de shuru wangluo: yi ge xin de jiaohuan jieduan [The Import Networks of Tobacco, Pipes, and Glass Bead Ornaments into Taiwan circa the Seventeenth Century: A New Phase of Exchange]. *Taida Journal of Art History* 22:51–90.

Wang, Yi

1985 Taiwan meihualu zhi xingwei yanjiu [Research on the Behavior of Formosan Sika Deer]. In *Bulletin of Symposium on Reintroduction of Formosan Sika Deer,* pp, 102–179. Kenting National Park, Pingtung, Taiwan.

1999 Taiwan meihualu fuyu jihua [The Reintroduction Project of Formosan Sika Deer]. In *Bulletin of Symposium on Reintroduction of Formosan Sika Deer,* pp. 29–38. Kenting National Park, Pingtung, Taiwan.

2010 *Kending guojia gongyuan ji linjin diqu Taiwan meihualu diaocha jihua ji qi zuqun jingying guanli tantao [A Survey of Formosan Sika Deer in Kenting National Park and Its Vicinity and Discussion of Population Management]*. Kenting National Park, Pingtung, Taiwan.

Wilson, J. Keith, and Michael Flecker

2010 Dating the Belitung Shipwreck. In *Shipwrecked*, edited by Regina Krahl, John Guy, J.Keith Wilson, and Julian Raby. Smithsonian Institution, Washington, D.C.

Wu, Hsin-Ju

2009 Shoulie yu weihai fangzhi dui Taiwan yezhu (*Sus Scrofa Taivanus*) zuqun yingxiang zhi tantao [Impact of Hunting and Crop Damage Prevention on Formosan Wild Boar *(Sus* *scrofa taivanus)* Population]. Ph.D. Dissertation, Department of Life Science, National Taiwan Normal University, Taipei.

Xu, Mei-Zhi

2000 *Paiwan zu de liuli zhu [Glass Beads of Paiwan]*. Dawshiang, Taipei.

Yeh, Mei-Chen

2005 *Beinan yizhi shiban guan yanjiu: Yi 1993–1994 nian fajue ziliao weili [A Study of Slate Coffins at Beinan Site: Based on the Excavation in 1993–1994]*. Tatung County Government, Tatung.

Yen, Ling-Da

2006 Taiwan zhongbu tieqi shidai renqun lixianti DNA yanjiu: yi fanziyuan luliao huilai yizhi weili [Three Case Studies for mtDNA Analyses of the Iron Age People in Central Taiwan]. M.A. Thesis, Department of Anthropology, Tzu Chi University, Hualien.

Yen, Ming-Cheng, and Tsing-Chang Chen

2000 Short Communication: Seasonal Variation of the Rainfall over Taiwan. *International Journal of Climatology* 20:803–809.

Yu, Yong-He

1996 [1700] *Pi hai ji you [The Small Sea Travel Records]*. Taiwan Historica, Nantou, Taiwan.

Zhou, Zhong-Xuan

2005 [1717] *Juluo xian zhi [The Chorography of Juluo County]*. R.O.C. Council for Cultural Affairs, Executive Yuan, Taipei.

Zhuang, Weiji, and Jinghui Zhuang

1987 Quanzhou song chuan jiegou de lishi fenxi [A Historical Analysis of the Structure of Song Shipwreck at Quanzhou]. In *Quanzhou wan song dai hai chuan fajue yu yanjiu [The Excavation and Study of the Song Shipwreck at Quanzhou Harbor]*, edited by Quanzhou Maritime Museum, pp. 81–86. China Ocean Press, Beijing.