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**Subsistence and Feasting in the Bronze Age:
Zooarchaeological Evidence from a Chinese City Site**

by

YI, Hailin

A dissertation submitted in fulfillment of the requirements of the degree of
Doctor of Philosophy

in the Department of Archaeology

Durham University

2024

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ABSTRACT

This dissertation investigates the role of animals in subsistence, craft production, ritual, and especially feasting practices at the Ancient Capital of the Zheng and Han States (ZHGC), a key urban center in the Central Plains of China during the Eastern Zhou period. Based on 10,053 animal bone specimens from twelve excavation points, this research applies zooarchaeological and stable isotope analysis to explore how animals contributed to the city's daily life, economy, and ritual systems.

The faunal assemblage reveals a dominance of domesticated pigs, cattle, and sheep/goats. Pigs were mainly consumed in daily contexts, while cattle held more ritual importance. Isotopic and age pattern analyses indicate differentiated management strategies: pigs were raised using both penning and free-ranging methods; cattle were foddered with millet by-products; and sheep primarily grazed on wild plants. These findings reflect an organized subsistence system integrating millet agriculture and livestock husbandry. Beyond consumption, animal bones were repurposed for handicraft production. Worked bones, mainly from cattle, deer, and sheep, show evidence of household-based industries, possibly alongside larger official production. The variety of production stages and tool marks suggests standardized workflows and the use of metal tools. Animals also played important roles in sacrificial contexts. Dogs, pigs, and sheep were commonly deposited in low-ranking burials and sacrificial pits, while cattle appeared more selectively, indicating elite-controlled access. Horses, associated with warfare and royal authority, were found only in the highest-status contexts.

A central focus of this study is the identification of feasting events through faunal remains. Four distinct cases were interpreted as feasting episodes based on species selection, butchery patterns, preservation, and depositional context. These ranged from grand banquets serving hundreds to small family gatherings. Cattle and sheep dominated these events,

reflecting their ritual and ideological significance. By applying feasting theory to the archaeological record, this study introduces a new methodology for recognizing feasting behavior in Chinese contexts and demonstrates how such events were deeply embedded in the social and political fabric of ZHGC.

Finally, the dissertation traces diachronic changes in the social roles of animals, particularly the rising prominence of cattle as both an economic and ritual resource. This is evident in meat supply, foddering practices, artifact production, and sacrifice. The preference for female cattle in ritual contexts, contrasting with earlier roles of males as draft animals, may reflect shifting gendered divisions in livestock use during the Zhou dynasty.

This study makes two major contributions: it fills a significant zooarchaeological gap in Chinese urban archaeology by systematically analyzing faunal materials beyond elite contexts, and it pioneers the application of feasting theory in Chinese archaeology, offering new perspectives on ritual and social life through animal remains.

Key Words: Zooarchaeology; Feasting; Bronze Age China; Subsistence economy; Ritual practices; Stable isotope analysis

Table of Contents

CHAPTER 1 Introduction	1
Section 1 Research Background	1
1. Zhou Dynasty and the Age of Confucius	1
2. Eastern Zhou vassal states and the Zheng Han Ancient City (ZHGC)	4
3. The Zhou ritual system and its collapse	6
4. The historiographical orientation of Chinese archaeology	8
Section 2 Material Acquisition and Research Questions	9
Section 3 Originality and contribution	11
Section 4 Chapter Layout	13
CHAPTER 2 Methods	14
Section 1 Material Analysis	14
1. Collection	14
2. Identification	15
3. Measurement	16
4. Dataset establishment	16
Section 2 Age Determination	17
1. Tooth eruption and wear	17
1.1 Domestic pigs and wild boars	17
1.2 Sheep/goat	19
1.3 Cattle	19
2. Epiphyseal fusion	21
Section 3 Sex Determination	24
Section 4 Taphonomy Processes	25
1. Weathering	25
2. Heating	26
3. Manipulation by animals	27
Section 5 Pathology	28
Section 6 Butchery, Fracture, and Fragmentation	29
1. Butchery	29
2. Fracture and Fragmentation	29
Section 7 Quantitative Methods	32
1. Number of identified specimens (NISP)	32
2. Minimum number of elements (MNE)	32
3. Minimum number of individuals (MNI)	33
4. MAU and MAU %	33
5. Meat Weight (MTWT)	34

Section 8 Carbon and Nitrogen Stable Isotopic Analysis	36
1. Principles and interpretation	36
2. Lab protocol	39
2.1 Preprocess	39
2.2 Testing	39
CHAPTER 3 The Capital of Zheng and Han States	41
Section 1 General Introduction	43
Section 2 Modern Natural Environment	47
Section 3 Establishment and Occupation History	51
1. The stage of Zheng (769-375 BC, Spring and Autumn Period)	51
2. The stage of Han (375-230 BC, Warring States Period)	55
Section 4 Finding History	58
Section 5 Previous Studies	62
1. Excavation reports	62
2. Thematic studies	66
2.1 Urbanism	67
2.2 Artifacts	70
2.3 Literature and epigraphy	72
2.4 Diet, Subsistence, and health	74
2.5 Handicraft production and techniques	76
2.6 Burial, sacrifice, and ritual	80
Section 6 Discussion and Conclusion	84
1. Suitability of the area and the site	84
2. Current research deficiency and envisage	86
CHAPTER 4 Materials	89
Section 1 韩宗庙 Han Zong Miao (HZM)	93
1. Excavation	93
2. Faunal Assemblage Profile	94
Section 2 郑韩路 Zheng Han Lu (ZHL)	97
1. Excavation	97
2. Faunal Assemblage Profile and Quantitative Results	98
Section 3 二工局 Er Gong Ju (EGJ)	101
1. Excavation	101
2. Faunal Assemblage Profile	102
3. Quantitative Results	102
Section 4 毛园民宅 Mao Yuan Min Zhai (MYMZ)	105
1. Excavation	105

2. Faunal Assemblage Profile and Quantitative Results	106
Section 5 供销社 Gong Xiao She (GXS)	109
1. Excavation	109
2. Faunal Assemblage Profile	110
3. Quantitative Results	113
4. Special Species	118
4.1 Chinese sturgeon (<i>Acipenser sinensis</i>)	118
4.2 Big Cat! Tiger?	123
4.3 Chinese water deer (<i>Hydropotes inermis</i>)	124
Section 6 金城路 Jin Cheng Lu (JCL)	125
1. Excavation	125
2. Faunal Assemblage Profile	126
3. Quantitative Results	129
Section 7 房地产 Fang Di Chan (FDC)	134
1. Excavation	134
2. Faunal Assemblage Profile and Quantitative Results	135
Section 8 经发区 Jing Fa Qu (JFQ)	138
1. Excavation	138
2. Faunal Assemblage Profile	139
3. Quantitative Results	141
Section 9 烟厂 Yan Chang (YC)	145
1. Excavation	145
2. Faunal Assemblage Profile	146
3. Quantitative Results	147
Section 10 热电厂 Re Dian Chang (RDC)	151
1. Excavation	151
2. Faunal Assemblage Profile and Quantitative Results	152
Section 11 家属院 Jia Shu Yuan (JSY)	155
1. Excavation	155
2. Faunal Assemblage Profile	156
3. Quantitative Results	157
Section 12 铸铜 Zhu Tong (ZT)	162
1. Excavation	162
2. Faunal Assemblage Profile and Quantitative Results	163
Section 13 Summary and Discussion	167
1. General Preservation Condition	167

2. Inter-sites Comparative Analysis	168
3. Inter-phases Comparative Analysis	170
4. Inter-taxa Analysis	173
4.1 Overall	173
4.2 Fishes, molluscs, birds, and reptiles	174
4.3 Mammals	177
5. Traces	179
6. Summary of anomaly (pathology) on bones	181
6.1 Polyodontia	182
6.2 Dental deformation	182
6.3 Linear Enamel Hypoplasia (LEH)	183
6.4 Dentition malalignment	184
6.5 Periodontal disease	185
6.6 Dental caries	186
6.7 Fracture	187
CHAPTER 5 Animals as Subsistence and Daily Consumption	189
Section 1 Domesticated or wild?	189
1.1 Quantitative proportion and pathology	191
1.2 Biometrical methods	192
1.3 Age at death	200
1.4 Diet—evidence from C/N stable isotopes	201
1.5 Conclusion	203
Section 2 Subsistence	205
1. Composition of meat acquirement and consumption	205
2. Why few fish?	209
3. Discussion and conclusion	211
Section 3 Foddering strategies and herd management	214
1. Age control	214
2. Carbon and nitrogen in bone collagen	219
3. Source of deer and “game park”	236
CHAPTER 6 Animals as Sacrifice	241
Section 1 Burials	243
1. Case study-FDC M63	243
2. Case study-FDC M66	244
3. Case study-FDC M72	246
4. Others	247
Section 2 Sacrificial pits	249

Section 3 Discussion	251
1. Summary and comparison with previous studies	251
1.1 Burials context	251
1.2 Sacrificial animal pit	253
2. Roles of animals for ritual sacrifice	254
2.1 Domestic cattle	254
2.2 Domestic sheep and pig	256
2.3 Dog and horse	257
CHAPTER 7 Animals as Handicrafts	260
Section 1 Spatial and contextual distribution	262
Section 2 Material source	264
Section 3 Workflow	267
1. Classification	267
2. Traces and tools	271
2.1 Sawing	271
2.2 Chopping	273
2.3 Grinding	274
2.4 Scraping and perforation	275
2.5 Polishing	276
2.6 Combined and unknown	276
3. Preliminary reconstruction of the process flow	277
Section 4 Related to other industries	280
Section 5 Discussion and conclusion	284
CHAPTER 8 Animals as Feasting	287
Section 1 Theoretical Framework of Feasting	288
1. What is feasting?	288
1.1 Definition of feasting	288
1.2 Classification of feasting	289
2. How feasting happened?	294
3. Why we research feasting?	297
3.1 Significance of food and feasting	297
3.2 For archaeology and archaeozoology	299
4. Feasting in anthropology and in archaeology	299
4.1 Development history	299
4.2 Balance in anthropology and in archaeology	303
Section 2 How to identify a feasting archaeologically?	306
1. Two models	307

1.1 “Two Essentials” model	307
1.2 “Workflow” model	308
2. Archaeological attributes	312
2.1 Source of meat	312
2.2 Condition of bones	316
2.3 Taphonomy and the preservation of bones	317
2.4 Distribution of bones	318
2.5 Cultural artifacts	320
2.6 Drinking	322
2.7 Auxiliary facilities	323
3. Distinguish feasting from other activities (recognition by comparison)	323
4. Discussion	327
Section 3 Current Status of Feasting Research in China and Reasons	329
1. Feasting research in China	329
1.1 Dietary archaeology and classic description	329
1.2 Ethnographic feasting in China	330
1.3 Archaeological feasting in China	333
1.4 Conclusion	336
2. “Mind the gap”—why a gap in the zooarchaeological feasting research in China?	337
2.1 Misconception of feasting	337
2.2 Induction vs. deduction: rethink on Chinese archaeology’s paradigm	338
2.3 Tradition of Chinese archaeology serving for history and for burials	339
2.4 Disconnection between zooarchaeologists and excavators	341
CHAPTER 9 Faunal Remains as Evidence for Feasting	342
Section 1 Case study: No.1 Mess-Bone Pit at RDC	343
1. Excavation	343
2. Faunal Assemblage	344
3. Discussion	353
3.1 Taphonomic condition	353
3.2 Age and sex	353
3.3 Fragmentation	354
3.4 Artificial traces	355
3.5 Element abundance	356
3.6 Special diet?	358
4. Conclusion	359
Section 2 Case study: JCL T252-H935	364
1. Archaeological Context	364

2. Faunal Assemblage	365
3. Discussion	368
Section 3 Case study: JFQ T206-H811	373
1. Archaeological Context	373
2. Faunal Assemblage	374
3. Discussion	375
Section 4 Case study: JSY T47-J7	377
1. Archaeological Context	377
2. Faunal Assemblage	378
3. Discussion	379
Section 5 Conclusion	382
1. Summary of case studies	382
2. Symbolic roles of animals in feasting	386
3. Feasting and citizen life	388
CHAPTER 10 Conclusion	391
Section 1 Retrospection of the dissertation	391
1. Animals for subsistence	392
2. Animals for handicraft	394
3. Animals for sacrifice	395
4. Animals for feasting	396
5. Status variation among animals and the establishment of the status of cattle ...	397
Section 2 “Old wine in a new bottle”— revisit the old materials for feasting	401
Section 3 Shortage and prospect	409
1. Shortcomings of this research	409
2. Prospects for the future work	411
3. Responsibilities of archaeologists	412
Bibliography	415
Appendix	456
Table 1	456

CHAPTER 1 Introduction

Section 1 Research Background

In this section, I will discuss three topics consisting of (1) the chronological background, (2) the political ecology, and (3) the ritual system in the Zhou Dynasty to establish an overall impression as a precondition to visualize the research background. A general background knowledge of these is essential for non-Chinese readers and those who are not familiar with the Chinese history, to put the subsequent research into an acceptable and understandable contextual and chronological framework.

1. Zhou Dynasty and the Age of Confucius

The Zhou Dynasty (ca. 1046 BC - 256 BC) was the longest-reigning dynasty in Chinese history, and it later came to be seen as a model of good governance in Chinese historiography. This period is notable for the establishment of the traditional Chinese ritual system, which later Confucian scholars regarded as the foundation of an ideal world order (Falkenhausen 2006: 3-4).

The Zhou Dynasty is divided into two distinct periods: the Western Zhou (c. 1046–771 BC) and the Eastern Zhou (c. 771–256 BC). During the Western Zhou period, the royal family, with the surname Ji, held military control over ancient China. Even though the authority of the Zhou royal house became increasingly symbolic during the subsequent Eastern Zhou period (771–256 BC), the political system they created persisted for several centuries in some form. By the end of the Western Zhou, the power of the Zhou kings had weakened, and the dynasty was plagued by internal conflicts and external invasions. In 771 BC, King *You* of Zhou was killed, marking the end of the Western Zhou. The Zhou royal descendants, led by King *Ping*, moved a new capital eastward, an event known as the beginning of the Eastern Zhou. During this period, the Zhou kings' authority was significantly diminished, and they relied on local feudal lords to maintain their rule.

The Eastern Zhou period is itself roughly subdivided into two periods. The first, the Spring and Autumn period (ca. 771–481 BC), saw the decentralization of power as the authority of the Zhou royal house continued to decline. This was followed by the Warring States period (ca. 481–221 BC), characterized by large-scale warfare and the consolidation of former Zhou vassal states. The Zhou Dynasty was officially brought to an end in 256 BC when it was extinguished by the state of Qin, which eventually unified China and established the imperial Qin Dynasty in 221 BC.

The “Age of Confucius” is used here to demonstrate the cultural and spiritual background of this period, which is cited from the term defined by Falkenhausen (2006) in his *Chinese Society in the Age of Confucius (1000-250 BC)*. It starts half a millennium before the eminent philosopher’s birth and roughly coincides with the eight centuries of the Zhou dynasty or, in archaeological terms, with the final two-fifths or so of China’s great Bronze Age¹.

¹ Iron was actually available in China for much of the first millennium BC, and cast-iron objects were produced on an industrial scale starting in the late sixth century BC. Despite this, the period discussed in this paper is not commonly referred to as China’s “Iron Age” by Chinese archaeologists. Instead, the entire Zhou period is typically classified as part of the Bronze Age, which is justified by the significant cultural importance of bronze objects during that time (see Falkenhausen 1999: 463).

Time	Archaeological Periods	Historical Periods Broader/ Finer Division		Synchronisms in Old World History
1050	1050	ca. 1046		End of New Kingdom (Egypt)
1000	EARLY WESTERN ZHOU	WESTERN		Aryan Invasions (India) David (d.ca. 962) (Israel)
950	950			Etruscan city states (Italy)
900	MIDDLE WESTERN ZHOU	ZHOU		Dark Age (Greece) 25th Dynasty (Egypt) Rise of Assyrian Empire (Mesopotamia, Syria)
850	850			
800	LATE WESTERN ZHOU	771		Carthage founded (814) (N. Africa)
750	770	770	770	Rome founded (753)
	EARLY SPRINGS AND AUTUMNS		TRANSITION PERIOD 722	Sargon II (enthroned 721) (Assyria)
700				Hallstatt Period (Central Europe)
650	650		SPRINGS	Assyrian invasions of Egypt (671, 663)
600	MIDDLE SPRINGS AND AUTUMNS		AND	<i>Zoroaster (ca.628-551)</i> Neobabylonian Empire (612-539)
550	550	EASTERN		Greek colonies in Sicily <i>Buddha (ca.560-480)</i> <i>Confucius (ca.551-479)</i>
500	LATE SPRINGS AND AUTUMNS		AUTUMNS	
450	450		481	Achaemenid Empire (Persia/Mesopotamia/Syria Asia Minor/Egypt)
400	EARLY WARRING STATES	ZHOU	453	<i>Socrates (ca.470-399)</i>
350	375			Peloponnesian War (431-404) (Greece)
300	MIDDLE WARRING STATES		WARRING	Roman Republic (509-21)
250	300			Alexander the Great (356-326)
200	LATE WARRING STATES	256	STATES	Mauya Empire (321-185) (India)
	221	249		First Punic War (264-241)
	QIN	QIN	221	
	206	206		Parthian Empire (Persia/Mesopotamia)

Figure 1-1-1. Chronological correlation between the Zhou Dynasty in China and the Old-World history (from Falkenhausen 2006:6).

2. Eastern Zhou vassal states and the Zheng Han Ancient City (ZHGC)

The functioning of the Zhou political mechanism centered on feudalism and the enfeoffment system, with a distinct kinship-based structure. The Zhou king distributed land and power to members of the royal clan, nobles, and meritorious officials, forming various vassal states. Under this feudal system, the Zhou king, as the supreme ruler, held the position of "the common lord of all under heaven," while the vassal states acted as regional power representatives, enjoying relatively autonomous local authority and economic independence. This system, implemented through successive enfeoffments, worked relatively well during the early Western Zhou period, maintaining a balance between centralized power and local autonomy. However, by the Spring and Autumn period, as the power of the vassal states increased, central authority gradually weakened, leading to the eventual collapse of the enfeoffment system. Narrative accounts of Zhou political history are largely concerned with the ever-shifting alliances and almost yearly wars between the various regional polities, the stronger of which absorbed the weaker in the course of time.

The focus of this study is the capital city used by two of these vassal states—Zheng (during the Spring and Autumn period) and Han (during the Warring States period)—namely, the Zheng Han Ancient City (ZHGC). The genealogical list of Royal Zhou, State of Zheng, and State of Han separately can be found in the **Figure 1-1-2**.

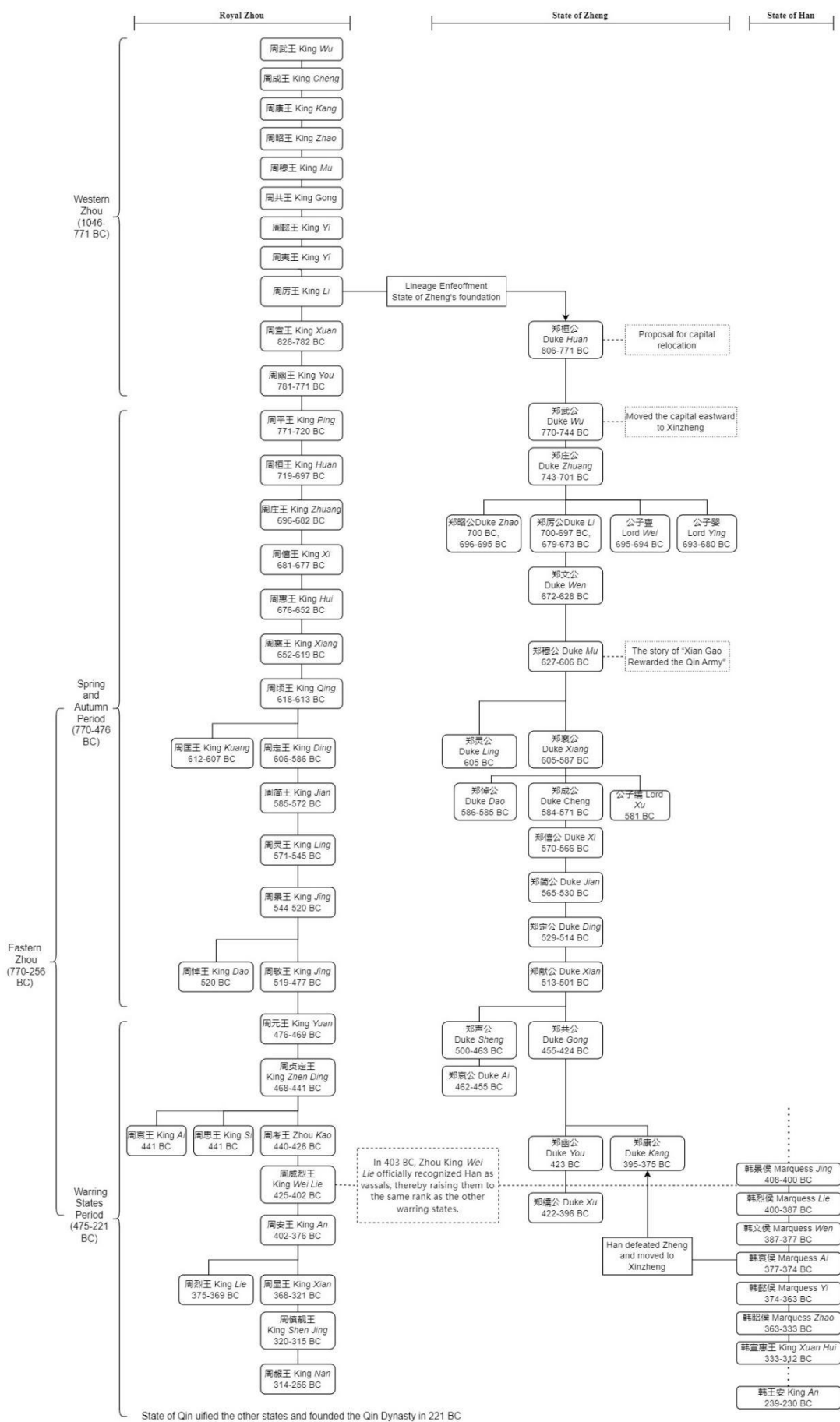


Figure 1-1-2. Genealogical list of Royal Zhou, State of Zheng, and State of Han separately and their several significant connections and interaction. The solid black lines indicate the succession of titles, the solid black arrow means a subject's action to another, while the dotted line links the events happening at the certain reign. The precise dates of each monarch's reign may be slightly different when referring to different sources and some dates have faced challenges (Keenan 2002; Stephenson 2008). Due to the discrepancies in the traditional dating, the Xia-Shang-Zhou Chronology Project, the *Cambridge History of Ancient China* (XSZCP 2000; Shaughnessy 1999), the dates for Western Zhou kings from King *Wu* to King *Li* have been omitted for the sake of caution. The remaining part of the genealogical list provides estimated time nodes to offer readers a clearer understanding of the reign lengths and the sequence of political power transitions. Concerning the title used in the chart, the title of “king” was held by the figurehead rulers of the Royal Zhou dynasty, while the rulers of most states held the titles equivalent to “duke” or “marquess”. A major exception was the State of Chu, whose rulers were called kings a King *Wu* of Chu started using the title c. 703 BC. In 344 BC the rulers of Qi and Wei mutually recognized each other as “kings”, in effect declaring their independence from the Zhou court. This marked a major turning point: unlike those in the Spring and Autumn period, the new generation of rulers ascending the thrones in the Warring States period would not entertain even the pretense of being vassals of the Zhou dynasty, instead proclaiming themselves fully independent kingdoms.

3. The Zhou ritual system and its collapse

During the Zhou dynasty, an elaborate system of rituals was established to maintain the privileges of the ruling class and the hierarchical structure of society. This system permeated daily life, sacrificial ceremonies, and state affairs. Two of the most important aspects of this ritual system were the *ding*-using system, and the animal sacrifice system.

The *ding* (鼎) was one of the most important ritual vessels of the Zhou dynasty. Its original practical function was to cook food, especially meat, for sacrificial and feasting purposes. Over time, the *ding* became a key symbol of power, status, and noble identity. The number, size, and use of *ding* directly reflected the user's social rank: the Son of Heaven (Zhou King) was entitled to use nine *ding* (symbolizing his supreme authority over all), the feudal lords (heads of vassal states) could use seven, high-ranking officials and nobles could use five, and the *Shi* class (lower nobles and civil or military officers) could use three. This *ding*-using system symbolized the rigid aristocratic hierarchy—the more *ding* a person was allowed, the higher their social standing and the greater their power. Any violation of this *ding* system was considered a serious breach of ritual propriety and a challenge to the established social order.



Figure 1-1-3. Set of bronze vessels (*ding* and *gui*) from Tomb 2001 at Sanmenxia site (Henan). Probably early to mid-eighth century BC. First row: set of seven *dings*; second row: set of six *guis*. *Gui* is the most typical combinational vessel of *ding*, generally, the number of *gui* is matched with that of *ding*, for example, 9 *dings* with 8 *guis*, 7 *dings* with 6 *guis* (adapted from Falkenhausen 2006: 107, Figure 20).

Another important aspect of the Zhou ritual system was the use of animals in sacrificial ceremonies. When sacrificing to ancestors, gods, or spirits of the earth and sky, the type, number, and quality of the animals had to strictly follow ritual regulations. Sacrifices could generally be divided into: Grand Sacrifices (called “Tai Lao”, for major state ceremonies or at the level of the Son of Heaven, sacrifices involved cattle, sheep, and pigs, with cattle considered the most prestigious offering), Second Grand Sacrifices (called “Shao Lao”, for less significant rites, usually sheep and pigs were used), and the general sacrifices (nobles or high-ranking officials might use smaller animals, such as pigs, for family or clan rituals).

These ritual practices were designed to reinforce central authority and the legitimacy of the ruling elite. However, as the power of the Zhou king waned at the end of the Western Zhou period, this system began to collapse. Regional vassal states rose in power and started disregarding the established ritual hierarchy.

During the Eastern Zhou Period, with the increasing frequency of warfare and intensified land annexation, the traditional aristocratic class began to decline. Many nobles, whose power had been passed down through hereditary lines, lost their economic and political influence, while a new class of landowners and merchants emerged. The ritual

system, once a tool to protect aristocratic privileges, crumbled alongside the decline of the aristocracy. The social upheavals of this period, including wars and reforms, allowed lower-class individuals to rise through military merit or political change. Especially in the Warring States period, reforms in various states granted the common people more political and economic rights. These changes disrupted the traditional social hierarchy and led to the further disintegration of the ritual system.

Although Confucian scholars in the late Spring and Autumn Period and the Warring States Period, such as Confucius himself, attempted to rebuild the social order through the revival of the ritual and music system, the restoration of this system was difficult to achieve within the historical trajectory of the Eastern Zhou Dynasty. Instead, it was replaced by the turbulent situation of interstate rivalry during the Warring States Period.

4. The historiographical orientation of Chinese archaeology

Unlike the studies in Paleolithic and Neolithic ages, Chinese archaeological research in the historic period rests heavily on documentary records. Nowhere else in the world is archaeology as closely enmeshed in a millennia-old living tradition of national history (Falkenhausen 2006). This is a pertinent and accurate review of the development direction of Chinese archaeology. For a long time, the goal of Chinese archaeology was to “*Zheng Jing Bu Shi* 正经补史” (prove historic documentary recording and supply with evidences for history). This resulted from the early practice of Chinese archaeology, such as the excavation of Yinxu, which aimed to provide direct evidence of the indigenous nature of Chinese civilization to ward off the narrative of “the western origin of Chinese civilization” (e.g., Anderson 1923). This direction has formed the cornerstone of Chinese archaeology and its associated archaeological education for the past century. Even now, this is somehow a “latent rule” that every Chinese archaeologist knows but more or less cannot avoid in their academic career, especially for those do the historic period research.

Section 2 Material Acquisition and Research Questions

The acquisition of archaeological material is crucial for zooarchaeological research, and my journey to gather research materials during my PhD was both challenging and arduous. During my time as a graduate student in China, I encountered a Neolithic site that I believed might be related to feasting rituals. At the same time, I discovered that there was a surprising lack of zooarchaeological research on feasting in China. This sparked my passion for feasting studies and strengthened my resolve to continue this research during my PhD. However, a single site was insufficient to support the content of my dissertation, so I needed to find additional material. Unfortunately, in the first year of my PhD (2019-2020), the Covid-19 pandemic struck, interrupting all my lab training and coursework. After much deliberation, I decided that I should prioritize returning to China to search for materials. In October 2020, I returned to China to seek opportunities. However, due to the pandemic, many archaeological excavations and materials were also restricted in China. During 2020-2021, I contacted several potential sources of materials and participated in two excavation projects, but none yielded significant results.

Finally, in October 2021, a PhD colleague from Durham University, who was working on human bone identification at a site, informed me of a large batch of animal bone materials stored in a warehouse and recommended me to the excavation leader. These materials were from the Zheng Han Ancient City (ZHGC), dating back to the Bronze Age, rather than the Neolithic materials I initially sought, so I had low expectations. However, during the identification process, I was pleasantly surprised to discover many assemblages with potential for feasting research. As a result, I decided to use the animal bones from ZHGC for my PhD dissertation. After six months of on-site identification, I returned to the Durham in April 2022 with data, images, and isotope samples to conduct isotope analysis and start to write my dissertation.

Based on the materials available, the tasks I could realistically complete during my PhD, and my passion for feasting research, this dissertation aims to address the following research questions:

1. What is the overall composition and quantitative analysis of the animal bones from this batch of materials?
2. What does the subsistence economy of the residents within the city reveal? This includes how residents sustained themselves, the degree of animal domestication, and the most important sources of meat.
3. What is the role of animals in ritual practices? Were animals used in rituals, and did different animals serve specific purposes? Are there hierarchical or symbolic differences among the animals?
4. What insights can we gain into the production and use of worked bones? Can we preliminarily explore the operational model of handicraft production within the city?
5. Did feasting take place within the Bronze Age city site? How can we identify evidence of feasting events archaeologically? If feasting occurred, what did it look like, when did it happen, what was the scale, and who hosted and participate in it? Was feasting exclusive to the high-ranking nobility?
6. What is the current state of feasting research in China, and how can the examples in this dissertation contribute to the broader study of feasting in China?

Section 3 Originality and contribution

The originality and contribution of this dissertation lie in two key areas:

Zooarchaeological Perspective: This study is the first to systematically organize and analyse the animal bone materials from the ancient city of Zheng-Han, which were excavated intermittently over nearly 30 years and accumulated from different excavation sites. Based on the current published literature on the site, zooarchaeological work has been relatively neglected compared to other areas of research. Much attention has been drawn to the horse skeletons found in high-status tombs and the sacrificial animals of the elites, while the everyday consumption has been largely overlooked. The material analysed in this dissertation, primarily from contexts such as refuse pits associated with daily consumption, fills this gap in the existing research, which has predominantly focused on elite consumption. Additionally, the existing zooarchaeological studies of Zheng-Han have mostly centered on descriptive accounts of the material, lacking deeper analysis. This study, by applying various methodologies—including traditional zooarchaeology and stable isotope analysis—conducts a comparative study of remains from different periods and locations to pursue a more in-depth and detailed investigation. Furthermore, the existing research on faunal and human remains often revolves around isolated site materials, resulting in a fragmented and disconnected body of work. By gathering the material from 12 different excavation sites within Zheng-Han, this dissertation provides a more comprehensive understanding of the entire city's situation. It also allows for the exploration of internal differences from a spatial distribution perspective.

Theoretical Innovation: The paper contributes to the theory of feasting, a subject that has been extensively discussed on the global stage with a well-established theoretical framework and numerous archaeological case studies. However, in China, the discussion of feasting and the acceptance of this concept among archaeologists is still quite limited, with

few available case studies for reference. This dissertation offers a comprehensive review of the feasting theory framework and uses it as the theoretical foundation for the analysis of feasting events within the city site. The analysis of the reasons for the delayed development in feasting studies of China is groundbreaking. This study also represents the most detailed pioneer attempt to systematically apply feasting zooarchaeological attributes within the context of Chinese archaeology.

Section 4 Chapter Layout

The dissertation is comprised of ten chapters. In this chapter, I have introduced my research background and the research questions. This dissertation aims to explore the faunal assemblage from a Bronze Age city site, the Capital City of the Zheng and Han States.

Chapter 2 highlights the methodology used in this study, and **Chapter 3** provides an overview of the studied site, covering aspects such as geographic location, natural environment, establishment and occupation history, inner city layout, and a literature review of previous publications. **Chapter 4** presents a detailed analysis of the animal remains from twelve different sites within the city. This includes information on species, sex, age, pathology, and traces. A qualitative and quantitative analysis is conducted for each site's faunal assemblage. In the final section, I conduct the inter-site, inter-phase, and inter-taxa analysis separately, summarizing the findings.

Chapters 5, 6, and 7 are key to providing readers with a comprehensive understanding of both the material and spiritual aspects of the city's inhabitants. Chapter 5 focuses on subsistence, Chapter 6 contextually examines the use of sacrificial animals in burials and sacrificial pits, and Chapter 7 explores bone working and handicrafts. These three chapters lay a solid foundation for the discussion of feasting in later chapters.

Chapters 8 and 9 focus on feasting, representing the core and most significant achievements of this work. In Chapter 8, I conduct an extensive literature review, establish a theoretical framework for the study of feasting from various perspective, and objectively analyse the challenges and reasons behind the lack of research on feasting in China. In Chapter 9, I apply these theoretical frameworks to four case studies, addressing the gaps in previous research.

The dissertation concludes with **Chapter 10**, where I synthesize the current findings and propose prospects for future research.

CHAPTER 2 Methods

Section 1 Material Analysis

1. Collection

The acquisition of animal remains primarily refers to the collection of animal bones and related remains (such as faeces, fur, etc.) during archaeological fieldwork. There are three collection methods: comprehensive collection, sampling collection, and whole extraction. Comprehensive collection involves manually gathering all visible animal remains within a given excavation unit; sampling collection entails taking soil samples from tombs, pits, wells, house foundations, etc., and using sieving or flotation to retrieve tiny animal remains; whole extraction is applied to complete animal skeletons, deliberately arranged animal parts, or animal remains that are difficult to extract on-site, generally using a box to carefully remove them intact. The faunal materials from the Zheng Han Ancient City (ZHGC) discussed in this paper were excavated between the 1970s and 1990s. During this period, Chinese archaeological practices were not yet fully scientific, and standardized, so only visible animal bones were collected during excavation, without the use of flotation or sieving that is necessary in every fieldwork now.

When collecting animal remains, excavators would bag the finds from each unit separately, with labels inside the bags recording the site name, excavation unit (feature), identification number, collector's name, and date of collection, while also filling out the excavation record of context². In some cases, special phenomena such as complete skeletons or concentrated bone deposits were discovered. These required preliminary identification,

² As far as I know, in field excavations in the UK and other countries, archaeologists typically record the exact GPS coordinates of each animal bone and pottery shard, mark their locations on a map, and photograph them. However, in China, the volume of archaeological material is immense, and there is often a shortage of personnel. Archaeological tasks, especially those related to infrastructure projects, are quite heavy and demanding. As a result, except for Paleolithic sites and certain proactive excavation projects, only complete (or nearly complete) artifacts and special animal remains (such as intact antlers or bone tools) are usually mapped and photographed on site.

detailed documentation, and photographs on site before collection. The camera used at that time was an old-style film camera (Figure 2-1-1).



Figure 2-1-1. Films recording important features and remains during the excavation work of ZHGC in the last century, the scanning work has not finished (photo taken by the author).

2. Identification

The identifications of the faunal remains were performed with the help of some reference atlases and pictorial manuals including *Atlas of Animal Bones* (Schmid 1972); *Atlas for identification of foetal skeletal elements of Cattle, Horse, Sheep and Pig, Part 2* (Prummel, 1987); and *A Manual for The Identification of Bird Bones from Archaeological Sites* (Cohen & Serjeantson 2015). In addition, I also benefited from the photos of modern fresh-water mollusc reference collection provided by Dr. Wang Juan of the Henan Provincial Institute of Cultural Relics and Archaeology, and some specific examples at the Durham University. The Latin terminology that was used in the thesis is based on the book *Zooarchaeology of China*

(Yuan 2015: Appendix 1). The access to an extensive and well-organized reference collection is vital to any archaeozoological study. It is through comparisons with the reference skeletons that the fragmentary bones can be identified to elements, sides and species.

3. Measurement

Measurements on bones from the materials have been taken with digital callipers according to the guidelines given by the biometrics manual *A Guide to the Measurement of Animal Bones from Archaeological Sites* (von den Driesch 1976). Electronic scales were used for weighing, and labels were made for every specimen.

4. Dataset establishment

Afterwards, all the information for each faunal specimen was recorded in digital databases, including background details, species, elements, number, sides, weight, fusion condition, preservation status, sex, age, cut marks, traces of working, and various measurements. This facilitates future data consolidation and quantitative analysis. Due to the age of the materials, some original labels were damaged or illegible. I promptly communicated with the excavators to ensure the accuracy of the original information. In rare cases, bones from different context units cannot distinguished and some wrong dating were found. They were separately labeled and excluded from subsequent analyses. Type samples and notable specimens, such as those with pathological evidence or traces, were drawn or photographed. The camera used for photography, a Nikon D850 with a 24-120mm lens, was provided by Researcher Cai from the Xinzheng Archaeological Unit of the Henan Provincial Institute of Cultural Relics and Archaeology.

Section 2 Age Determination

1. Tooth eruption and wear

The application of the science of ageing an animal by using the appearance of its teeth likely dates back to the early days of animal husbandry (Silver 1963). Although the eruption ages may vary between breeds (Silver 1969; Reiland 1978; Bull & Payne 1982; Carter & Magnell 2007), and the rate of tooth wear can differ due to some factors (Healy & Ludwig 1965; Grant 1978, 1982; Deniz & Payne 1982; Magnell 2006; Carter & Magnell 2007), age estimation based on tooth eruption and wear levels remains the most widely used and reliable method among zooarchaeologists.

1.1 Domestic pigs and wild boars

For the tooth eruption rate in *Sus*, there has been a long-standing assumption that modern domestic pigs exhibit faster dental development than their wild ancestors, supposedly due to intensive breeding practices and better nutrition. However, Legge (2013) challenged this notion, suggesting that this belief largely stems from flawed early data that has been repeatedly cited without proper scrutiny. Upon reviewing studies on domestic pigs, feral pigs descended from domestics, captive wild boars, and free-ranging wild boars, Legge concluded that the hypothesis of accelerated dental eruption in modern domestic pigs remains speculative and lacks robust evidence. In fact, when closely examined, both domestic and wild pigs display remarkably similar molar eruption timelines. This finding is corroborated by Rowley-Conwy (2001). Despite differences in tooth wear caused by varying diets and habits, the eruption times in both domestic and wild pigs appear to be consistent. Additionally, there are no significant differences in eruption timing between male and female pigs (Magnell 2006).

This study adopts the tooth eruption and wear stage timeline established by Rowley-Conwy (2001: Table 1, after Higham 1967: Appendix B) for age estimation of pigs, while

also incorporating O'Connor's corresponding age-stage classifications (such as juvenile, adult, etc.) for the subsequent analysis (see **Table 2-2-1**). The tooth enamel wear stages are based on Grant's well-known scheme (1982). To minimize the potential impact of breed differences among regions, the study also references Ma's (2005, 2007) standards (the age range for each stage is much broader), which are based on modern pig breeds in Henan, China. This standard generally aligns with Rowley-Conwy's (2001) framework. For teeth not explicitly mentioned in this standard, such as incisors and canines, I referred to the eruption timeline summarized by Magnell (2006) as supplement (see **Table 2-2-2**).

Table 2-2-1.

Stages of pig dental development and their ages (Rowley-Conwy 2001: Table 1) used in this study, along with age stage defined by O'Connor (1991:250 Table 67).

Age stage	Dental condition	Approximate age (O'Connor stage)
A	Deciduous teeth in stage E	Neonatal
B	Deciduous teeth in stage a	2-4 months (juvenile)
C	M1 in stage E	4-5 months (juvenile)
D	M1 in stage h/U	5-6 months (juvenile)
E	M1 in stage a	7-8 months (immature)
F	M2 in stage E	9-10 months (immature)
G	M2 in stage h/U/a	10-12 months (immature)
H	P2-P4 in stage E	12-14 months (subadult)
I	P2-P4 in stage a	16-17 months (subadult)
J	M3 in stage E	17-19 months (subadult)
K	M3 in stage h/U	20-21 months (subadult)
L	M3 in stage a	21-23 months (adult)
M	M3 in stage b	24-26 months (adult)
N	M3 in stage $\geq c$	≥ 27 months (elderly)

Note:

V- Tooth visible in perforation in jaw but cusp tips not yet level with jawbone

E- cusp tips about level with jawbone

h- top of tooth about half erupted

U- erupted to about full height, not wear

Table 2-2-2.

The tooth eruption time summarized by Magnell (2006) according to Matschke (1967), with adjustment of the eruption of the third molar and the eruption of the distal cusps of the third molar from Boitani and Mattei (2001).

Age group (months)	Tooth eruption

0-2	di ₁₃ dc ₁ dp ₃₄
5-6	di ₁₂₃ dc ₁ dp ₂₃₄ , M ₁ erupting
7-8	di ₁₂₃ dc ₁ dp ₂₃₄ M ₁
9-11	di ₁₂ dp ₂₃₄ I ₃ C ₁ (P ₁) M ₁
12-13	di ₁₂ dp ₂₃₄ I ₃ C ₁ (P ₁) M ₁ , M ₂ erupting
14-18	I ₁ di ₂ I ₃ C ₁ (P ₁) P ₂₃₄ M ₁ M ₂
19-24	I ₁₂₃ C ₁ (P ₁) P ₂₃₄ M ₁ M ₂ , M ₃ mesial cusps are erupting
25-36	I ₁₂₃ C ₁ (P ₁) P ₂₃₄ M ₁ M ₂ , M ₃ distal cusps are erupting
> 36	I ₁₂₃ C ₁ (P ₁) P ₂₃₄ M ₁ M ₂ , M ₃

1.2 Sheep/goat

The ageing of sheep and goats referred to the work of Rowley-Conwy (1997), which based on the image of wear stage from Deniz and Payne (1982), as shown in the **Table 2-2-3**, and O'Connor's corresponding stages were also applied.

Table 2-2-3.

Stages of sheep/goat dental development and their ages (Rowley-Conwy 1997) used in this study, along with O'Connor's stages (1991:250 Table 67).

Age stage	Dental condition	Approximate age (O'Connor stage)
A	dp4 still unworn	0-2 months (neonatal)
B	dp4 in wear, M1 unworn	2-6 months (juvenile)
C	M1 in wear, M2 unworn	6-12 months (immature)
D	M2 in wear, M3 unworn	1-2 years (subadult)
E	M3 in wear, stage 4 or below	2-3 years (adult-1)
F	M3 in wear, stages 5-9	3-4 years (adult-2)
G	M3 in stage 10, M2 in stage 8	4-6 years (adult-3)
H	M3 in stage 10, M2 ≥ stage 9	6-8 years (adult-3)
I	M3 > stage 10	8-10 years (elderly)

1.3 Cattle

In this study, the most classic standard for ageing cattle set up by Halstead (1985) was used (see **Table 2-2-4**). Jones and Sadler (2012a) have done a comprehensive review of the published sources for age at death in cattle and they also created the cement/enamel junction (CEJ) and root arch position method (Jones & Sadler 2012b) for the age estimation of older cattle individuals. It was adopted as a supplement for some very old cases (see **Table 2-2-5**).

Table 2-2-4.

The ascribing ages to the stages of cattle (Halstead 1985) with O' Connor's stage.

Age stage	Dental condition	Approximate age (O'Connor stage)
A	Dp4 still unworn	0-1 month (neonatal)
B	Dp4 in wear, M1 unworn	1-8 months (juvenile)
C	M1 in wear, M2 unworn	8-18 months (immature)
D	M2 in wear, M3 unworn	18-30 months (subadult)
E	M3 in wear, 3 rd element unworn	30-36 month (Adult-1)
F	M3 3 rd element in wear, <stage g	Young adult (Adult-1)
G	M3 in stage g	Adult-2
H	M3 in stage h-j	Adult-3
I	M3 > stage j	senile

Table 2-2-5.

The cement/enamel junction (CEJ) and root arch position method for cattle age estimation (Jones & Sadler 2012b).

Age stage	Dental condition	Approximate age
Omitted, generally same as Halstead's		
F	M3 3 rd element in wear, <stage g	34-43 month
G	M3 ≥ stage g, M2/M3 at q	40 month - 6.5 years
H	M2 at xyz (CEJ stage), M3 at q	5-10 years
I	M3 > stage j	7-20+ years
J	M3 at xyz, < stage m	8-16 years
K	M3 at z, > stage m	14-20+ years

Definitions of the cement/enamel junction (CEJ) and root arch position

q	The CEJ is below the alveolar border buccally and lingually (cheek and tongue side).
x	The CEJ is level or within 1 mm at any point of the alveolar border buccally or lingually, for any of the tooth elements (pillars).
y	The CEJ is above the alveolar border, buccally or lingually; and the root arch is still below.
z	The root arch is visible above the alveolar border, lingually and/or buccally.

2. Epiphyseal fusion

Zeder has done a fabulous summary (2006) of the data of sheep from Silver (1969) and Moran & O'Connor (1994), of goats from Noddle (1974) and Bullock & Rackham (1982). Then she revised the long bone fusion sequence and ages for sheep and goats based on the epiphyseal fusion condition in FMNH (Field Museum of Natural History in Chicago) sheep and goats, as follows (see **Figure 2-2-1**). This was used in this study.

As for other animals, the Silver's standard of post-cranial epiphyseal fusion time of horses, cattle, pigs, and dogs (Silver 1963:252 Table A) was applied in the study (**Table 2-2-6**). Some small adjustments were made due to the mistakes found in the original data (the fusion time of the first phalanx). Although some zooarchaeologists have emphasized that we should be cautious when quoting Silver's data, at least for sheep and goats as well as pigs (quote of Zeder from web source, 2015, see URL in the reference), it still seems credible for cattle, dogs, and horses. In addition, the aging standard of pigs according to the tooth eruption and wear has been established quite well, which can narrow the age down to a shorter time span. In the practical application, zooarchaeologists can estimate the age of pigs more precisely based on tooth than long bone epiphyseal fusion. Thus, the rates of *Sus*'s long bone fusion are rarely used when there are enough tooth samples. But when applicable, Silver's standard will be referred to.

Goats				Sheep			
Group	Bone	Order	Estimated Age ¹	Group	Bone	Order	Estimated Age
A	P. Rad ²	1	0–6	A	P. Rad	1	0–6
B	D. Hum	2	6–12	B	D. Hum	2	6–12
B	Pelvis	2	6–12	B	Pelvis	2	6–12
B	Scap	2	6–12	B	Scap	2	6–12
C	2Phl	3	12–18	C	2Phl	3	12–18
C	1Phla	4	12–18	C	1Phla	4	12–18
D	D. Tib	5	18–30	D	D. Tib	5	18–30
D	D. Mc	6	18–30	D	D. Mc	6	18–30
D	D..Mtl	6	18–30	D	D..Mtl	6	18–30
E	Calc	7	30–48	E	Calc	7	30–48
E	P. Fmr	8	30–48	E	P. Fmr	8	30–48
E	D. Fmr	8	30–48	E	D. Fmr	8	30–48
E	P. Ulna	8	30–48	E	P. Ulna	8	30–48
E	D. Rad	8	30–48	E	D. Rad	9	30–48
E	P. Tib	8	30–48	E	P. Tib	9	30–48
F	P. Hum ³	9	48+	F	P. Hum	10	48+
G	P. Hum ⁴	10	48++	G	P. Hum	11	48++

Figure 2-2-1. The long bone fusion sequence and ages for sheep and goats based on the epiphyseal fusion. The superscripts indicate: 1. age in months, 2. element abbreviations, 3. early fusion, 4. late fusion or fully fused (from Zeder 2006).

Table 2-2-6.

Age estimation according to the post-cranial epiphyseal fusion of horses, cattle, pigs, and dogs (adjusted from Silver 1963: Table A).

Bone element	Fusion Age (months)			
	Horse	Cattle	Pig	Dog
Scapula	20	7-10	12	6-7
Proximal humerus	36-42	42-48	42	15
Distal humerus	15-18	12-18	12	8-9
Proximal radius	15-18	12-18	12	11-12
Distal radius	42	42-48	42	11-12
Proximal ulna	42	all at 42-38	36-42	9-10
Distal ulna	before birth		-	11-12
Proximal metacarpal	before birth	before birth	before birth	before birth
Distal metacarpal	15-18	24-30	24	8
Proximal 1 st phalanx	13-15	18	24	7
Distal 1 st phalanx	before birth	before birth	unknown	before birth
Proximal 2 nd phalanx	9-12	before birth	12	7

Distal 2 nd phalanx	before birth	18	before birth	before birth
3 rd Phalanx	Partly ossified at birth			
Pelvis (main bones)	18-24	7-10	12	6
Proximal femur	36-42	42	42	18
Distal femur	36-42	28-42	42	18
Proximal tibia	36-42	28-42	42	18
Distal tibia	20-24	24-30	24	13-16
Calcaneus	36	36-42	24-30	13-16
Proximal metatarsal	before birth	before birth	before birth	before birth
Distal metatarsal	16-20	27-36	27	10

Section 3 Sex Determination

Determining the sex of animal remains is a critical component of understanding past human-animal interactions, the composition of animal groups, and the exploitation strategy. Mainly the following three ways were used in this study.

1. Morphological differences

One of the most common methods is the identification of morphological differences between male and female skeletal remains. Sexual dimorphism, where the two sexes differ in size and shape, is evident in many species. For example, the canines of male pigs were much more robust than those of female pigs (Vretemark 1997: 48); and the average length of male water deer (*Hydropotes inermis*) tusks (upper canine) is about 8 cm, while the average length of female's is only around 0.5 cm, most of the tusks found from the archaeological sites tend to belong to males.

2. Presence of sex-specific features

Certain skeletal features are present only in males or females and this is also the most straightforward and strongest method that were most used. The most common elements are antlers and horns (Vretemark 1997: 45-46). In some species of deer and *Bos*, males typically have antlers, while females do not (though there are exceptions like in reindeer where both sexes may have antlers, while in Chinese water deer where neither sex has antlers).

3. Biometrical analysis

Biometrical analysis involves taking precise measurements of skeletal elements. Then checking if there is separation between sexes or comparing them to established databases or standards where sex-related differences are well-documented. Certain bones, such as the humerus, femur, and metapodia, can exhibit distinct size differences between males and females in some species, and statistical techniques (like discriminant analysis) can be applied to differentiate between the sexes.

Section 4 Taphonomy Processes

1. Weathering

Most research on the subject deals with bone weathering on the soil surface, but weathering caused by chemical and biological agents also affects the bones in the ground (White & Hannus 1983). These processes result in bone surface deterioration that is often impossible to distinguish from the weathering of bones lying on the ground surface. It is therefore practical to use the word “weathering” to describe the collective result of both processes.

The weathering stage scale established by Behrensmeyer (1978) in her article *Taphonomic and ecologic information from bone weathering* illustrated not only a continuous process of destruction by weathering, but also described real stages that have comparably short intermediary transition phases. The system with its six stages is simple to use and has become a standard within many taphonomic studies (see **Table 2-4-1**). According to Behrensmeyer (1978) the most severe signs of weathering must cover more than one square centimeter of the bone's surface to be registered. Edges or areas with physical damage should be ignored. Since all soft tissue and marrow is usually long gone in an archaeological bone material (and not necessarily as the result of weathering), these parts of the descriptions were not taken into consideration in this study.

Table 2-4-1.
Bone weathering stages set up by Behrensmeyer (1978).

Stage	Description
0	Bone surface shows no signs of cracking or flaking due to weathering.
1	Bone shows cracking, normally parallel to the fiber structure (e.g., longitudinal in long bones). Articular surfaces may show mosaic cracking of covering tissue as well as in the bone itself.

-
2	Outermost concentric thin layers of bone show flaking, usually associated with cracks, in that the bone edge along the cracks tend to separate and flake first. Long thin flakes, with one or more sides still attached to the bone, are common in the initial part of stage 2. Deeper and more extensive flaking follows, until most of the outermost bone is gone. Crack edges are usually angular in cross-section.
3	Bone surface is characterized by patches of rough, homogeneously weathered compact bone, resulting in a fibrous texture. In these patches, all the external, concentrically layered bone has been removed. Gradually the patches extend to cover the entire bone surface. Weathering does not penetrate deeper than 1.0-1.5 mm at this stage, and bone fibers are still firmly attached to each other. Crack edges usually are rounded in cross-section.
4	The bone surface is coarsely fibrous and rough in texture; large and small splinters occur and may be loose enough to fall away from the bone when it is moved. Weathering penetrates into inner cavities. Cracks are open and have splintered or rounded edges.
5	Bone is falling apart in situ, with large splinters lying around what remains of the whole, which is fragile and easily broken by moving. Original bone shape may be difficult to determine. Cancellous bone usually exposed, when present, and may outlast all traces of the former more compact, outer parts of the bones.
-

2. Heating

Burnt bone is commonly recovered from archaeological sites, where it may represent the remains of consumed animals or the cremated residue of human or animal occupants. Whether burnt in situ during cooking or later when rubbish was set on fire, non-human burnt bone typically provides direct evidence of the animal's utilization by humans as food or fuel. Burn marks can be observed on the surface of burnt bones, displaying varying colors. Studies have demonstrated that changes in both the color and microscopic morphology of burnt bones and teeth can be divided into five stages, each associated with a specific temperature range (Shipman et al. 1984; Nicholson 1993). In addition, the specific colour changes equivalent to the maximum temperature the bone had been exposed to that were summarized by Lyman (1994a: 384-392) and were also referred to in this study. The varying degrees of burning might reflect different methods of bone usage by human.

3. Manipulation by animals

Numerous practical experiments, ethnographic studies, and observations of animals in the wild have shown how various species can manipulate bones in different ways, including moving, gnawing, crushing, licking, and swallowing them when the opportunity arises. These processes can significantly impact bone assemblages. While dogs are often the primary agents involved, wild carnivores, rodents, birds, ungulates, and pigs can also contribute to bone manipulation. Identifying and quantifying animal interactions with bones is a crucial aspect of understanding the taphonomic history of an assemblage. Evidence of such taphonomic processes can help determine how long the bones were exposed.

Two main types, carnivore-gnawing and rodent-gnawing, were studied and recorded in this study based on prior research into identifying and documenting such activities (Haynes 1980, 1983; Lyman 1994a: 206-212; Thilderqvist 2013:20) because they are the most evident and most recognizable in bone assemblages.

Section 5 Pathology

Pathological analysis of animal bones in zooarchaeology provides valuable insights into past animal management, patterns of use, and human–animal relationships. This approach primarily relies on macroscopic examination, using the naked eye and magnification tools to identify structural abnormalities on bone surfaces, such as exostoses, degenerative joint changes, healed fractures, and dental pathologies (Baker & Brothwell 1980). Some key literatures and atlas with detailed pictures of animal cases were used for identification reference in this study, e.g. *Animal diseases in archaeology* (Baker & Brothwell 1980), *Non-human paleopathology* (Thomas 2012), *Dental Disorders in Wild and Domestic Pigs (*Sus Scrofa*): A Review* (Okandeji et al. 2023), etc. Furthermore, comparative anatomical analysis with modern reference collections is also crucial for distinguishing pathological modifications from taphonomic or anatomical variation (O'Connor, 2000). These are two main methods used in the thesis. Lesions are typically classified into categories including traumatic, degenerative, infectious, and developmental, following established diagnostic frameworks (Dobney & Reilly 1988, Vann & Thomas 2006). Furthermore, the interpretation of pathological data is contextualised through integration with age, sex, skeletal element, and archaeological provenance, revealing the associations between pathological conditions and human activities, such as traction use, human care, or specialized husbandry strategies. Such analysis ultimately contributes to a more nuanced understanding of the economic and cultural roles of animals in past societies.

Section 6 Butchery, Fracture, and Fragmentation

1. Butchery

Based on Lyman's (1987) definition, the term "butchery" refers to marks related to "the human reduction and modification of an animal carcass into consumable parts", where "consumable" broadly refers to "all forms of use of carcass products" later (Lyman 1987: 252). Butchery analysis in zooarchaeology is a key methodological approach for reconstructing animal processing techniques, subsistence strategies, and broader socioeconomic practices. This involves the identification and interpretation of anthropogenic modifications on animal bones, particularly cut marks, chop marks, percussion marks, and scrape marks, which result from activity stages such as skinning, dismembering, filleting, and marrow consumption (Binford 1981).

These marks are examined and observed macroscopically, often with the aid of hand lenses or low-power microscopy, and are recorded based on their location, orientation, morphology, and distribution across anatomical elements. In this study, butchery and craft-related marks were identified and noted using an extensive recording system developed by Binford (1981: appendix 2). Experimental archaeology plays a crucial role in establishing diagnostic criteria for different types of butchery traces, especially in distinguishing tool types (e.g. stone vs metal) and butchery techniques (Jones 1980). Additionally, particular attention must be paid to differentiating anthropogenic marks from above taphonomic processes, such as marrow breakage vs. trampling (e.g. Binford's criteria for identifying bones broken for marrow by humans, 1981: 148-166).

2. Fracture and Fragmentation

Regarding the recording of bone fragmentation and fracture location, the relatively good preservation of faunal remains at this site means that many bones are fairly complete. For these better-preserved specimens, a tripartite division method (e.g. proximal, distal, and

the diaphysis) and terminology based on skeletal orientation (e.g. anterior, lateral) was employed.

However, for many of the more fragmented bones, a more refined recording system can be adopted, the zonation system developed by Dobney and Reilly (1988). This method divides skeletal elements into a series of standardized zones (see Dobney & Reilly 1988: Fig. 7–22), thereby allowing for more precise identification of fragment provenance based on specific zone numbers (Serjeantson 1991). This recording method involving MNE and MAU facilitates study of the relationship between survivorship and volume density, and it enhances inter-site and inter-species comparisons (Morlan 1994). Moreover, the zonation system facilitates both the quantification of fragmentation intensity and the accurate recording of pathologies or modifications, including cut marks, burn traces, or other taphonomic indicators.

In addition, more advanced analytical methods or systems for bone fracture and fragmentation are recommended in the future work. The Fracture Freshness Index (FFI) proposed by Outram (1998) offers a rapid and effective means of assessing fracture freshness, which can be particularly useful when evaluating breakage patterns. When used alongside the aforementioned zonation system, the FFI enhances the interpretive potential of the assemblage (Knüsel & Outram, 2004: 87), especially in relation to “indeterminate” fragments that might otherwise yield minimal data due to poor identifiability (Outram, 2001). The method of “fracture history profiles” shows the sequences of fracture and fragmentation and provides an assessment of the carcass processing traditions specifically related to bone marrow and grease extraction (Johnson et al. 2016). When encountering co-mingled assemblages of human and animal bones (such as JSY-J6, JFQ-H851, JFQ-H803, GXS-H866 in this study), a fully integrated approach encompassing identification, ageing, quantification, fragmentation, bone fracture analysis, post-depositional taphonomy and evidence of human-

induced butchery/trauma and other modifications is proposed by Outram et al. (2005) to permit direct comparison of the patterning in the human and animal assemblages.

Section 7 Quantitative Methods

1. Number of identified specimens (NISP)

The Number of Identifiable Specimens (NISP), as its name suggests, refers to the count of identifiable animal bones recovered from an archaeological site and serves as the most basic unit for calculating faunal remains and evaluating the abundance (Lyman 1994b). Since it is termed “identifiable”, the specimens must possess certain taxonomic structural features that allow identification. Generally, zooarchaeologists include those animal bones that can be identified at least to the taxonomic level of subfamily, if not to the level of genus or species, in the NISP count (Zeder 1991:79). It is important to distinguish between the “Number of Specimens” (NSP) and the “Number of Identifiable Specimens” (NISP). NSP includes bones, teeth, and their fragments that are considered classification units, as well as specimens that are not included in the classification units. Therefore, NSP encompasses both identifiable and unidentifiable specimens. In this paper, NSP might be expressed as “number of bones” or “number of specimens”, and any calculated figure using NISP is specifically noted. (Lyman 2004b, 2008)

2. Minimum number of elements (MNE)

MNE stands for Minimum Number of Elements. It is a quantification method used to estimate the smallest number of individual skeletal elements (bones or parts of bones) present in a faunal assemblage. MNE is calculated by identifying bone fragments, then counting the minimum number of specific skeletal elements that could account for the fragments found. For example, if several fragments from left femurs are identified, MNE will estimate the minimum number of left femurs present based on the most complete overlapping parts. MNE helps zooarchaeologists assess the degree of bone fragmentation and provides insight into the skeletal representation of animal remains at an archaeological site.

3. Minimum number of individuals (MNI)

Minimum Number of Individuals (MNI) is the term for the minimum number of individual animals necessary to account for some set of identified faunal remains; it is a derived unit because it may or may not take individual variation such as age, sex, or size into account (Lyman 1994b). The MNI addresses issues that cannot be resolved by relying solely on the NISP, particularly in situations where the independence of samples needs to be considered. MNI is defined by identifying the most frequently occurring skeletal element of a species within a specific unit, which can range from different archaeological features to broad chronological divisions. The method for calculating MNI is as follows: if two anatomical specimens overlap, they must represent two distinct individuals; if two specimens do not overlap anatomically and might naturally articulate, they may belong to the same individual; if there is no overlap and they cannot naturally articulate, they are considered part of the same individual unless there are differences in size, age, or sex. If no such differences are apparent, whether they belong to the same individual remains unknown, and they are counted as one individual in the MNI calculation.

4. MAU and MAU %

Minimum Animal Units (MAU) allows zooarchaeologists to account for the varying frequencies of different bones and to understand the degree to which each skeletal element is represented in the assemblage. This helps in analyzing how complete or fragmented the skeletons of the animals are, which can provide insights into butchering, transport, or scavenging behavior (Binford 1984:50). The calculation formula is:

$$\text{MAU} = \text{MNE} / \text{number of elements in one complete skeleton}$$

MAU% expresses the representation of a particular skeletal element as a percentage of its expected occurrence in a complete skeleton. It helps compare the abundance of different bones within an assemblage and across different assemblages. By converting MAU

into a percentage, zooarchaeologists can easily see which skeletal parts are over- or under-represented in the assemblage. This helps in identifying patterns in the processing, transportation, or preservation of bones. For example, if a site has a higher percentage of limb bones relative to axial elements (such as vertebrae), it may indicate preferential transport of meaty limbs to the site. The calculation formula of MAU% is:

$$\text{MAU\%} = (\text{MAU for an element} / \text{MAU for the most abundant element}) \times 100\%.$$

5. Meat Weight (MTWT)

The approach used here relies upon a mean weight of usable meat (MTWT) for each species or other taxonomic group. The estimation of MTWT is a helpful method to evaluate the meat resource contribution of animals with fully considering the differences in body size and functional roles among different animals. Exactly which parts of an animal's carcass are "usable" as meat depends upon a range of factors, both physical and cultural (Reitz & Wing 2008: 233-242). There is little problem with excluding bone and hide, but there is considerable cultural variation in which components of viscera would be excluded from consumption. The values adopted for each class of animals here are conservative estimates of what is likely to have been usable meat in the Chinese setting. Details of these values and the rationale for their selection are given in the relevant chapters below.

Generally, two methods proposed by White (1953) and Reed (1963) were used for the MTWT estimation. Reed's method involves calculating the bone weight of mammals from the assemblage, which accounts for 7.5% of the live animal body weight, with 50% of the live body weight considered as usable meat. Later, this ratio was further refined to 50%-70% depending on different species by Casteel (1978). However, this approach heavily relies on all the bones being collected during excavation, and the preservation condition of the bones. Moreover, the identification results can significantly impact the final calculations when comparing meat quantities between different species. As for White's method, it is based on

the MNI. For long-legged mammals, edible meat weight (MTWT) = animal live weight (LWT) * MNI * 50%; for birds and short-legged mammals, edible meat weight (MTWT) = animal live weight (LWT) * MNI * 70%. The latter was chosen for this study because it is more feasible for our materials from a closed settlement site, and the calculation results are much more realistic since it considers the importance of providing meat from medium-/large-sized mammals (He et al. 2009).

Section 8 Carbon and Nitrogen Stable Isotopic Analysis

1. Principles and interpretation

According to the most important principle “you are what you eat” proposed by Kohn (1999), isotopic composition of an individual's tissues, such as bones, reflects the isotopic composition of their diet over time. Thus, stable isotopes of carbon (^{12}C and ^{13}C) and nitrogen (^{14}N and ^{15}N) are commonly used in archaeological studies to infer the types of foods people and animals consumed.

Carbon ($\delta^{13}\text{C}$) stable isotope analysis is mainly used to estimate the proportions of so called C_3 (e.g., wheat, barley, rice, most fruits and vegetables) versus C_4 plants (e.g., maize, cane sugar, millets, chenopods, sorghums and amaranths) and to distinguish between the consumption of marine versus terrestrial organisms in an individual's diet. C_3 plants have $\delta^{13}\text{C}$ values averaging about -26.5‰, while values for C_4 species average about -12.5‰. The bone collagen from herbivores that subsist only on C_3 grasses will give a $\delta^{13}\text{C}$ value of ca. -21.5‰. If the diet were based only on C_4 grasses then the value would be ca. -7.5‰. If a modern individual consumes both C_3 and C_4 species, the $\delta^{13}\text{C}$ value for its collagen will lie somewhere between -21.5 and -7.5‰. The $\delta^{13}\text{C}$ values of marine plants usually lie in an intermediate position between the values of terrestrial C_3 and C_4 plants, depending on their carbon sources. Therefore, marine fauna usually has carbon isotopic values that are less negative than those of terrestrial animals feeding on C_3 -based foods and more negative than those feeding on C_4 -based foods. Freshwater aquatic foodwebs appear to have C_3 -like carbon isotopic compositions. A small (approximately 0.5-2‰) enrichment for carbon isotopic values occurs in each step of a food chain (Bocherens et al. 2003).

The nitrogen stable isotope ($\delta^{15}\text{N}$) analysis identifies the trophic level of an individual. Nitrogen in organisms is primarily obtained from protein, with meat being a protein-rich food source, while plant-based foods contain relatively lower protein levels, having minimal

impact on $\delta^{15}\text{N}$ values in bone collagen. Consequently, $\delta^{15}\text{N}$ values in bone collagen are closely related to the consumption of meat. The fractionation effect results in a ca. 3-5‰ increase in $\delta^{15}\text{N}$ as an individual ascends each step of a food chain. Studies have shown that herbivores have $\delta^{15}\text{N}$ values of ca. 3-7‰; primary carnivores and various fish species exhibit $\delta^{15}\text{N}$ values of ca. 9-12‰; omnivores have $\delta^{15}\text{N}$ values of ca. 7-9‰; and secondary carnivores have the highest $\delta^{15}\text{N}$ values. The nitrogen levels of a consumer will increase when relying more heavily on aquatic resources. Animals consuming marine plants can even have $\delta^{15}\text{N}$ values as high as ca. $14.8 \pm 2.5\text{‰}$ (Bocherens et al. 1994, 2003).

In addition to the influence of photosynthetic pathways and trophic level, several other environmental and physiological factors can significantly affect $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in plant and animal tissues. These factors were taken into account during isotopic data interpretation in this study to avoid over-attribution of variation to dietary or ecological shifts.

Environmental variables such as water availability, latitude, altitude, light intensity and soil salinity have all been shown to influence plant carbon isotope ratios (Stevens et al., 2025; Diefendorf et al., 2010; Lightfoot et al., 2020; Ubierna et al., 2013), particularly in C_3 plants (O’Leary, 1988). The “canopy effect” is also known to produce depleted $\delta^{13}\text{C}$ values in understory plants due to isotopically lighter CO_2 recycling in forested environments (e.g. Sonesson et al., 1992; Vogel, 1978). Nitrogen isotope values are highly responsive to local nitrogen cycling regimes, microbial interactions, and nutrient availability. Open nitrogen cycles, often associated with arid or warm regions, tend to produce elevated $\delta^{15}\text{N}$ values in both plants and animals, while closed cycles in wetter or colder climates may result in lower values (Craine et al., 2009). In addition to environmental variability, inter-species, intra-species and intra-plant differences are apparent in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values as well as predictable physiological differences between plant functional types (Craine et al., 2015; Stevens et al., 2025). Moreover, physiological factors in animals, including metabolic stress, nutritional

status, and life-history stages such as pregnancy or lactation, can influence nitrogen isotope ratios independent of dietary input (Ambrose, 1991; Stevens et al., 2025). In light of these variables, interpretations of isotopic data in this study were contextualized with reference to environmental and physiological conditions where possible. Modern isotopic baselines, environmental proxies, and archaeological context were used to constrain and support interpretations of dietary and ecological behavior.

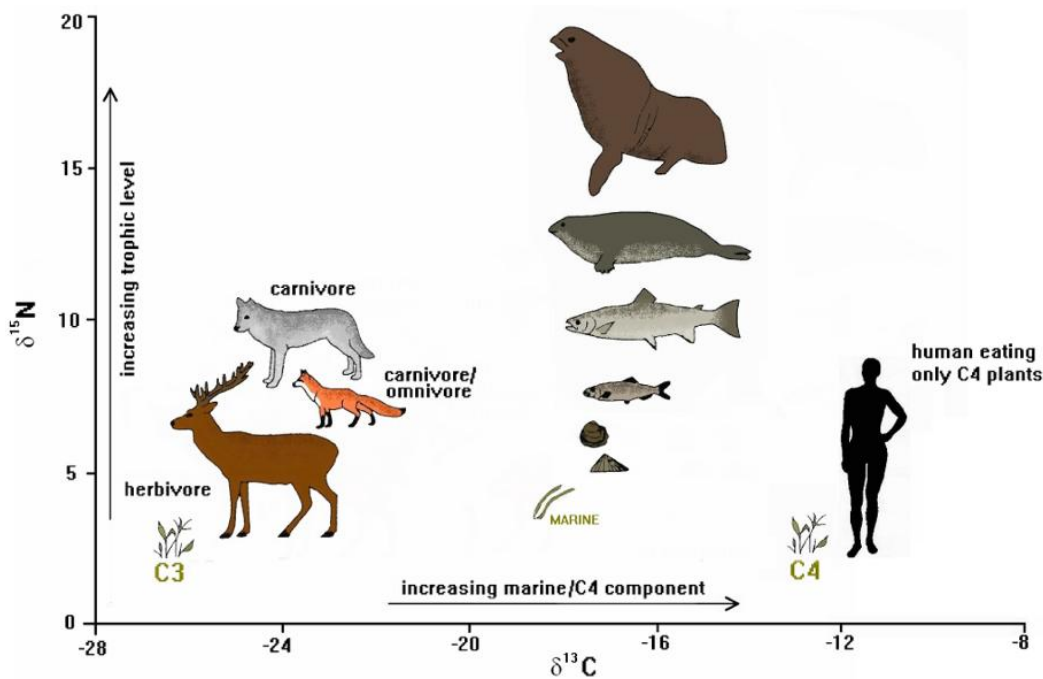


Figure 2-8-1. Simplified summary of stable carbon and nitrogen values for terrestrial and marine ecosystems (values are for flesh; to convert to bone collagen values, 5‰ should be added to $\delta^{13}\text{C}$ values; $\delta^{15}\text{N}$ values are the same for flesh and bone). (Adapted from Schulting 1998).

C:N value is one of the primary indications of the degree of preservation of bone protein (collagen) and/or contamination by soil organic substances. According to van Klinken (1999: 691), the characteristic %C values of intact collagens are 34.8 ± 8.8 (1 σ) wt %C; the nitrogen content of intact collagen is between 11 and 16 wt %. The recommended values for C: N atomic values are between 2.9 - 3.6, indicating a low probability of diagenesis (DeNiro, 1985).

2. Lab protocol

2.1 Preprocess

Suitable bone fragments were first sawn off from the specimens and then cleaned of surface contamination using a diamond-tipped dental rotary drill. The preparation work was undertaken at Durham University's Department of Archaeology. All collagen purification followed standard extraction methodology (Longin, 1971; DeNiro, 1985; Ambrose & DeNiro, 1986). Samples were all analysed at Durham University's Stable Isotope Biogeochemistry Laboratory (SIBL), which strictly adheres to rigorous international quality control guidelines through the application of international reference standards.

2.2 Testing

Each $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ sample was weighed to the nearest 0.001mg into a 6*4 tin capsule on a Mettler Toledo XP6 microbalance, then combusted using a Costech Elemental Analyser (ECS 4010) connected to a Thermo Scientific Delta V Advantage isotope ratio mass spectrometer. The $\delta^{13}\text{C}$ isotope ratios were corrected for ^{17}O and are reported in standard delta (δ) notation in per mil (‰) relative to Vienna Pee Dee Belemnite (VPDB) and $\delta^{15}\text{N}$ isotope ratios are reported against atmospheric nitrogen (AIR). Isotopic accuracy was monitored through routine analyses of in-house standards, calibrated against international standards (e.g., IAEA-600, IAEA-CH-3, IAEA-CH-6, IAEA-N-1, IAEA-N-2, NBS 19, USGS24, USGS40). International and in-house standards are run daily and provided a linear range for $\delta^{13}\text{C}$ between -46‰ and $+3\text{‰}$ and in $\delta^{15}\text{N}$ between -4.5‰ and $+20.4\text{‰}$. Analytical uncertainty in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope analysis was typically $\pm 0.1\text{‰}$ (2 s.d.) for replicate analyses of the international standards and $< 0.2\text{‰}$ (2 s.d.) on replicate sample analysis. Total organic carbon and nitrogen data was obtained as part of the isotopic analysis using the internal standard, glutamic acid (40.82 wt % C, 9.52 wt % N). Alpha cellulose and

IVA urea were analysed throughout the sequence and reported $\delta^{13}\text{C}$ standard errors of $\pm 0.2\text{‰}$ (2 s.d.) and for IVA urea $\delta^{15}\text{N}$ of $\pm 0.2\text{‰}$ (2 s.d.).

CHAPTER 3 The Capital of Zheng and Han States

“溱与洧，方涣涣兮。士与女，方秉蕳兮。”

“Zhen and Wei (two rivers’ names) are long and long, and the rivers flow far away.

Men and women travel outside the city, holding orchid grass for good luck.”

——《诗经·郑风·溱洧》 *Shijing · Zhengfeng · Zhenwei*

This is an archaic poem describing the image of spring outings of young men and women wandering along the banks of River *Zhen* (溱) and *Wei* (洧) on the Shangsi Festival (上巳节, as known as Double Third Festival, celebrated on the third day of the third month of the Chinese calendar) in the State of Zheng. According to the customs of the State of Zheng in the Spring and Autumn Period, on this day, people would wash away the dirt in the water flowing eastward, exorcising bad luck, and pray for happiness and peace. Young men and women also take this opportunity to tell each other their hearts and express their love. An unknown folk poet sang this festival of spring with love and passion, recording the joy and ordinary happiness of the people. Although the small and weak State of Zheng was often invaded by other states with great powers during the Spring and Autumn Period, and the state rulers were not insightful enough, for ordinary people, this spring day still made them feel joyful and satisfied. Holding orchids and peonies in their hands, they have longing and confidence for a better life. The two rivers *Zhen* and *Wei* mentioned in the poem are also two rivers that are crucial to the Capital of Zheng and Han State site that we will introduce in this article. The vassal king of the State of Zheng made use of these two rivers as a natural barrier and established the initial form of the entire capital by the junction of the two rivers. Now when we are walking along the old waterways again, looking up at the ancient city walls that have guarded the capital for 3,000 years still standing above the

ground, I cannot help thinking if we could also feel the atmosphere and the thriving spring depicted in that poem.

This chapter serves as a preliminary window into understanding this magnificent city site and the history of East Zhou. In this chapter, we will provide a comprehensive overview of the site, covering various aspects including the site's modern natural environment, the history of its occupation based on relevant historical records, the history of its discovery, and a summary of archaeological findings and related research results up to now. This will lay the foundation for our subsequent research.

Section 1 General Introduction

The Capital of Zheng and Han States (Zheng Han Gu Cheng 郑韩故城 in Chinese, abbreviated as ZHGC, also translated as Ancient Xinzheng City in some previously published articles), located in Xinzheng City, Henan Province, China, lying exactly underneath the modern Xinzheng downtown. It is a marvelous ancient capital city built at the junction between the Huangshui River (earlier called River *Zhen* 溱水) and Shuangji River (earlier called River *Wei* 洧水) in Eastern Zhou Period. In 769 BC, Duke *Wu* of the State of Zheng (郑武公) moved eastward and settled here as the new capital; and in 375 BC, Marquess *Ai* of the State of Han (韩哀侯) conquered the State of Zheng and migrated here. The city was established as the capital of the State of Zheng and the State of Han for approximately 540 years, this is why it is called “the Capital of Zheng and Han State”.

The ancient city is roughly an irregular rectangle shape, visually like an ox horn shape (see **Figure 3-1-1**), about 5,000 meters (about 3.11 mi) long from east to west, and about 4,500 meters (about 2.8 mi) wide from north to south. The city’s circumference is about 19 kilometers (about 11.81 mi), delineating an area of about 22 square kilometers (about the area of JFK Airport). Until today, intermittent remnants of the ancient city wall are still left on the ground. The wall’s height is about 10 meters, the highest part of which is 16 meters. The base width of the wall is 40-60 meters, and the top width is 2-5 meters (data comes from the measurement of existing ancient city walls, due to thousands of years of wind and rain damage to the wall, we do not know the exact figure of the original above-ground width). The city wall is made of rammed earth, with the base built during the Zheng occupational period and the top part added by the State of Han later.

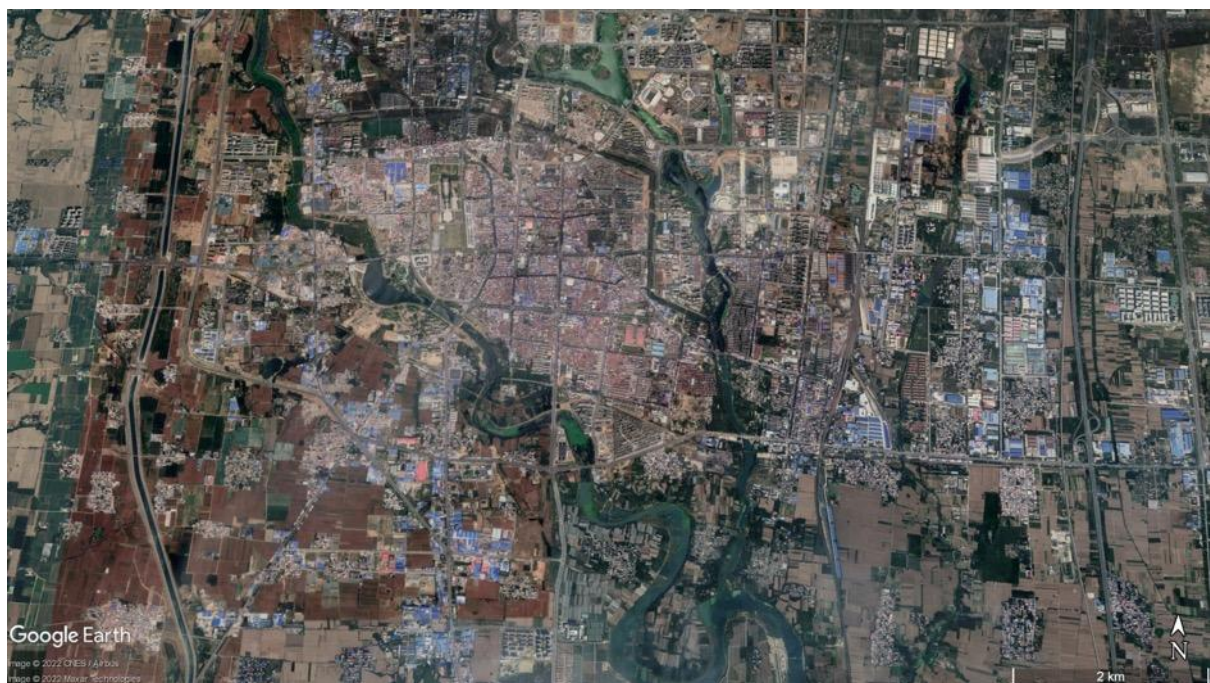
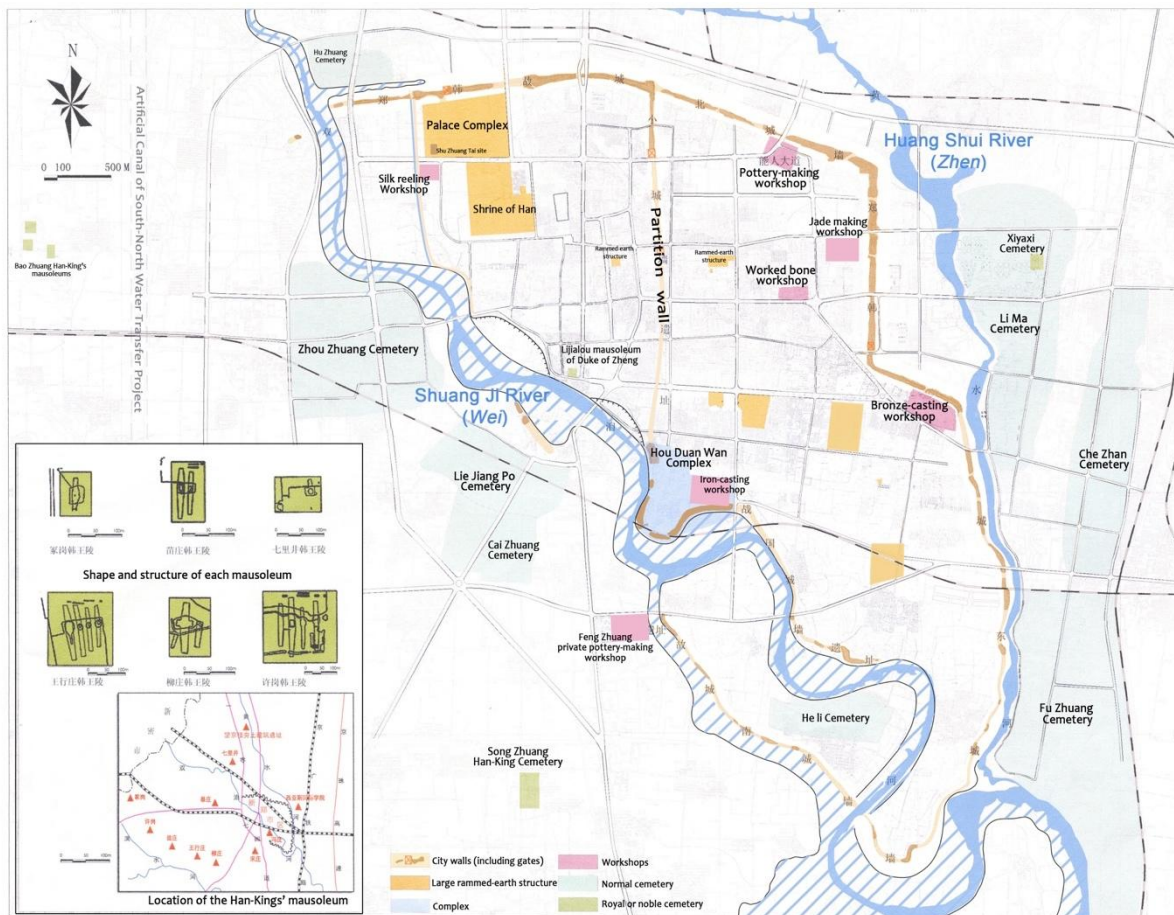


Figure 3-1-1. Plain shape map of ZHGC and aerial photo of present Xinzheng city (source: Google Earth).

A clear and designed layout can be observed within the city. There is a north-south dividing wall lying in the center by the west, separating the city into the western part and the

eastern part. The western city is the main noble palace area, with a north-south rectangular plain, whose north wall is about 2,400 meters (about 1.49 mi) long. The length from north to south is about 4,300 meters (about 2.67 mi) long, covering an area of about 10.3 square kilometers. Archaeological excavation work found the palaces and aristocratic residences (some buildings were thought to be ancestral temples by the later excavators, related research results are not published yet) of the two states were both concentrated here. Correspondingly, the eastern city is the outer city with an irregular shape. The north wall of it is about 1,800 meters (about 1.12 mi) long, the east wall is about 5,100 meters (about 3.17 mi) long, and no south wall remains above the surface with only part of the base buried underground, covering an area of about 9.2 square kilometers. In terms of function, the eastern city is a civilian residential, military stationing, workshop, and sacrifice ritual area. There are large-scale building complexes during the State of Zheng ruling period, such as the ruins of sanctuaries and the burials of aristocrats, accompanied with many sacrificial offerings like bronze ceremonial instruments and chariot-horse pits. Bronze-casting, iron-casting, jade-making, worked bone and other workshop remains are also distributed here. Besides the mentioned interior area, there are also several large civilian cemeteries scattered outside the city.

The magnitude of the Zheng and Han State's capital was substantial, rivaled in its time only by the *Xian Yang* (咸阳) of the State of Qin and the *Ying Du* (郢都) of the State of Chu. Throughout the Spring and Autumn Period and the Warring States Period, it stood as a prominent political, military, economic, and cultural hub within the Central Plains. This city, situated centrally among various states, commanded strategic routes in all directions and assimilated progressive cultural and technological influences from neighboring states. Consequently, it frequently faced invasions from neighboring powers, rendering it an attractive target for military tacticians.

The comprehensive archaeological efforts spanning decades here have unearthed a wealth of invaluable cultural artifacts, structures, and other distinctive discoveries. These findings offer a portal into the intricate sociopolitical and socioeconomic framework, spiritual realm, ritual practices, societal disparities, as well as the interaction between nature and human activities during this tumultuous and conflict-ridden era, these will be introduced in the following sections.

Section 2 Modern Natural Environment

The environment and landscape play a pivotal role in understanding archaeological sites. Environmental archaeologists employ various archaeological remnants with environmental indicators, notably faunal remains (bones and feces), plant remains (seeds, charcoal, pollen, and spores), soil, and even biomolecules, to reconstruct the paleoenvironment and landscape surrounding the site (Jones 2011). Such evidence offers archaeologists insights into the emergence and transformation of human-influenced environments, ancient adaptive strategies, and economic activities (Branch 2014). However, before delving into paleoenvironmental research, comprehending the present environmental conditions of the site is equally crucial as a reference, enabling readers to grasp a comprehensive overview of the site.

This premise significantly facilitates subsequent endeavours, including the identification of some specific species (according to the geographical distribution), reconstruction of the landscape, processing of isotopic materials (bones' preservation is greatly influenced by the soil texture and the underground water level), analysis and explanation of isotopic data, comparison of historical climate with the present, etc. Therefore, introducing the contemporary natural environment stands as an essential step. Moreover, due to the overlapping correlation between the underground city site and the modern Xinzheng downtown, the subsequent sections primarily focus on Xinzheng city.

Xinzheng City, the location of ZHGC, is categorized as a county-level city under the administration of Henan Province. Historically, this region was an integral part of Zhengzhou, the provincial capital of Henan. In 1994, the Henan Provincial Council authorized the establishment of Xinzheng as an autonomous municipality. Positioned at the heart of inland Henan, its geographical coordinates fall within 34°16' to 34°39' N latitude and 113°30' to

113°54' E longitude, encompassing a total land area of 873 square kilometers (**Figure 3-2-1**).

As of the census of 2021, the permanent population of Xinzheng reached 1.202 million.

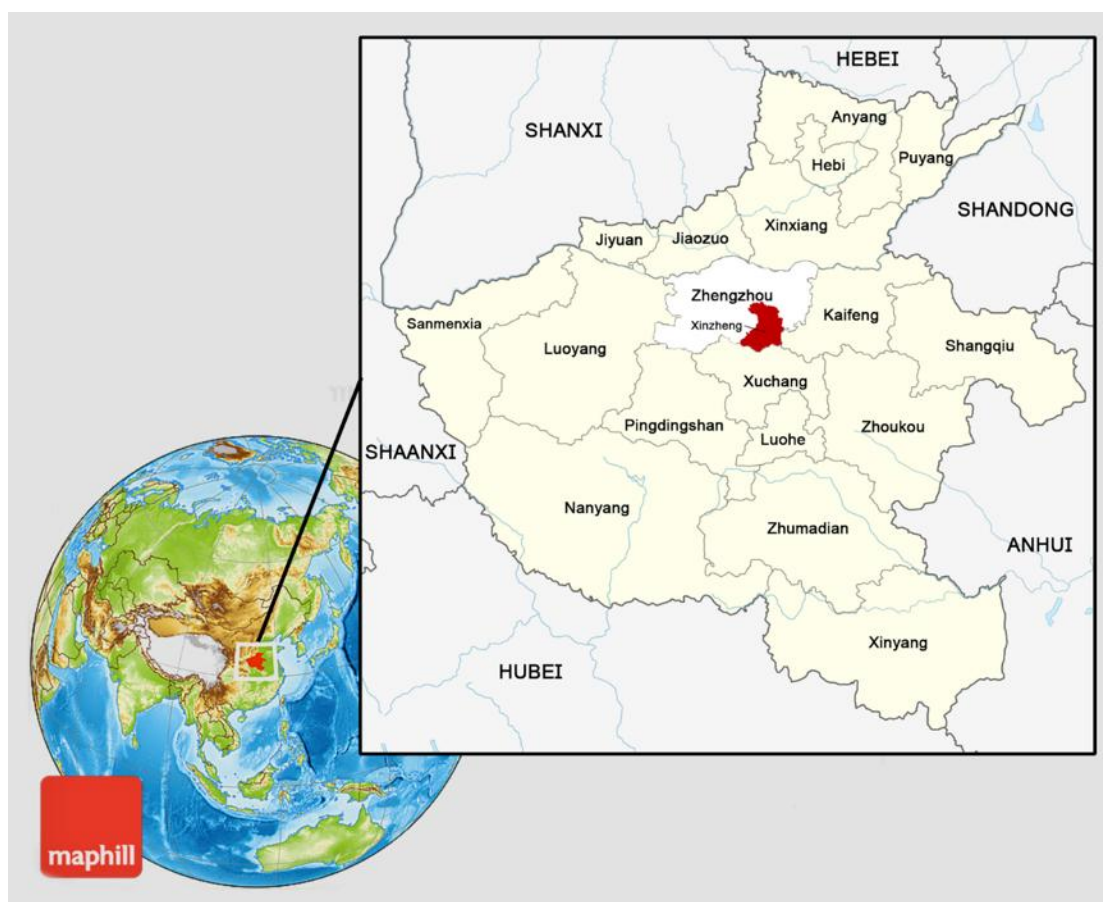


Figure 3-2-1. The location of Henan province, Zhengzhou (white area including red on the right) and Xinzheng (red area on the right). Adapted from the maps from Wikipedia (access on 2022, November 17. In *Wikipedia*. <https://en.wikipedia.org/wiki/Xinzheng>) and Maphill.

In terms of landform, the site is located within the North China Plain, lying in the transitional area between the western mountainous area and the eastern plains (**Figure 3-2-2**). The general topography is higher in the west and lower in the east, with elevated terrain in the center and lower areas to the north and south. Mountains and hills are primarily situated in the southwest and west, belonging to the eastern fringe of the *Song Mountains* (嵩山). Most peaks have elevations below 400 meters above sea level, with relative height differences of less than 200 meters, being classified as hilly landforms. Downland terrain distributed around is believed to have formed from early piedmont proluvial inclined fans shaped by the river

erosion. Most of the plains are concentrated on the ancient terraces of the Yellow River in the east, comprising small-scale banded alluvial plains on both banks of several rivers. A substantial portion of the city area is covered by Cenozoic Quaternary loess, although certain areas have witnessed soil erosion (Xinzheng Municipal Government, 2019).

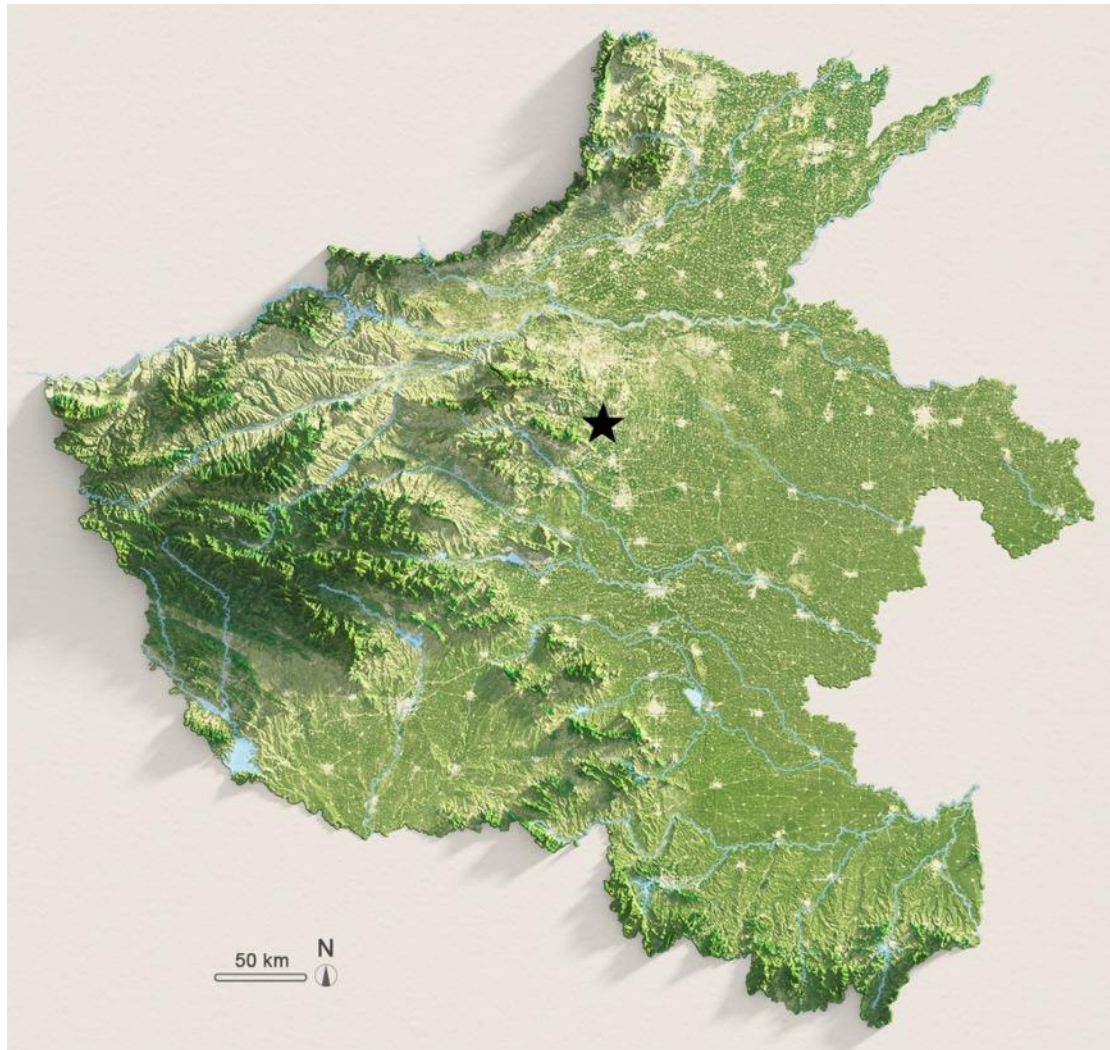


Figure 3-2-2. The black star indicates the location of the ZHGC site on the Henan Province's stereoscopic geomorphic map. The image clearly illustrates that the site exactly stands on the transition zone from mountain to plain landform. Adapted from the base map source from WeChat official account: Institute of Planet.

Regarding the hydrography, Xinzheng City is situated within the middle reaches of the Yellow River³. The rivers within its territory belong to the Ying River and Jialu River

³ The intertwining Yellow River and Huai River systems, historically, have had situations where these two rivers connected. Thus, it can be challenging to distinguish them clearly. In a broader sense, we tend to categorize them as part of the middle reaches of the Yellow River, given the Yellow River's higher recognition.

systems. Among them, two rivers that form natural boundaries for the ancient city are of particular significance. The first is the Shuang Ji River, historically known as *Wei* (left one in Figure 3-1-1). It is the largest river in Xinzheng, stretching for 35.5 kilometers and covering a watershed area of 239 square kilometers within Xinzheng. The other significant river is the Huang Shui River, also known as *Zhen* (right one in Figure 3-1-1). This river originates from the mountains in the northwest, with a total length of 29.4 kilometers and a catchment area of 110 square kilometers. Unfortunately, due to modern industrial pollution, both rivers have been unable to maintain healthy ecosystems, and they no longer support aquatic life (Xinzheng Municipal Government, 2019).

Concerning the climate, Xinzheng city experiences a monsoon-influenced, warm temperature continental climate, with cool, dry winters and hot, humid summers. Spring and autumn are dry and abbreviated transition periods. The four seasons are distinct, rain and heat occur at the same time. The main disastrous weather is drought, flood, wind, hail, etc. The city has an annual average temperature of 14.2 °C (57.6 °F), with the historical maximum temperature of 42.5 °C (108.5 °F), and the historical minimum temperature of - 17.9 °C (- 0.2 °F). Rainfall is primarily produced by the monsoon low during summer; in winter, when the vast Siberian High dominates due to radiative cooling from further north, the area receives little precipitation. During the summer season, the city is also often affected by tropical depressions, which bring additional amounts of rain. The annual average precipitation is 676.1 mm (26.6 in) (Xinzheng Municipal Government, 2019).

Additionally, Xinzheng's modern agriculture involves the cultivation of maize, cotton, tobacco, and other industrial crops. The city is well known for its jujube or Chinese Date.

Section 3 Establishment and Occupation History

1. The stage of Zheng (769-375 BC, Spring and Autumn Period)

The State of Zheng was originally enfeoffed by the Zhou King *Xuan* with the land located in Hua County, Shaanxi Province. During the reign of King *Xuan*, the Zhou Kingdom was still strong and owned the prestige of governing states. Then when King *You* ascended the throne, the power of the Zhou court declined gradually, which also led to frequent invasions by many surrounding nomadic tribes. At that time, Duke *Huan*, the monarch of the State of Zheng, thought insightfully that he could no longer depend on the Royal Zhou, and decided to leave the original fiefdom and move the capital to the east. An imperial astronomer and historiographer suggested moving to the intersectional area of rivers, which was close to the State of Guo and Kuai. He also mentioned that the rulers of these two states were greedy for personal profits and not popular with their people. Thus, if the capital was moved here, the State of Zheng would easily claim the allegiance of the citizens of these two states, which would strengthen the state's power greatly. In 769 BC, Duke *Wu* of Zheng moved the capital to the confluence of River *Zhen* and *Wei*, that is, the place where the ZHGC locates nowadays (Han & Chen 2019). On account of the close distance southeast towards the State of Guo and Kuai, subsequently, Guo and Kuai were soon conquered by the State of Zheng.

Actually, the new territory selected by Zheng was criticized by *Ban Gu* 班固, a historian of the Eastern Han Dynasty. He ever described the territory as "*narrow and dangerous, living with ancient mountains* 山狭而险, 山居古汲" in the epitome masterpiece *Book of Former Han-Treatise on Geography* (*Han Shu · Di Li Zhi* 汉书 · 地理志, about 200 AD). This was not the best choice for fertile land and was not competitive enough among surrounding states. As the natural geomorphic conditions mentioned in the last section, the capital is in the east of mountains which spread eastward, inevitably causing many

residents might live on the hillside or high hill. Moreover, the landform of hillsides is not perfect for agricultural cultivation, and crops are not as easy to grow as on the plains, especially for rice cultivation, as Zhang Yi, a strategist in the Warring States period, pointed out. Fortunately, this is not the case in all of Zheng's territory. The land in the west is relatively flat and suitable for people living and crop planting.

The prosperity of the State of Zheng benefited from the surrounding water resources and waterways. River *Wei* flowed through the south of the capital from west to east, and River *Zhen* flowed outside the east of the capital from north to south. We can conclude from the eulogizing poem in the opening that these two rivers might have a certain depth, but they were not so deep because horses and carriages could pass. The place after the two rivers merged became deep enough to sail. The river channel volume of *Records of the Grand Historian* (Chinese name is *Shiji* 史记) records that the artificial watercourses “*Hong Gou*” 鸿沟 was constructed at this time, which connected several major water systems. Although the State of Zheng was not directly connected, it could gain profits from these two rivers that linked to the major rivers. The developed water transportation also greatly promoted the economic and commercial development of the capital city. *Shijing·Zhengfeng·Chuqidongmen* (诗经·郑风·出其东门) sang “*Out of the east gate, there are crowds of women like clouds*” (“出其东门，有女如云”). Some philologists interpreted that the place outside the east gate is the crowded dock, so many people come and go here (Shi 1998), which I think is very reasonable. We can also find some clues from the archaeological excavation of the site. The confluence of the *Zhen* and *Wei* rivers is in the southeast corner of the ancient city (see **Figure 3-1-1**), and the section of the eastern city wall beside the river *Zhen* is quite long, so we can infer that the berthing place of ships might be just somewhere outside this section of the eastern city wall.

The merchant group of Zheng was famous and prestigious at that time. The most famous one is the story of "Xian Gao Rewarded the Qin Army" (*Xian Gao Kao Shi*). In the first reign year of Duke *Mu* of Zheng, the State of Qin planned to sneak attack the State of Zheng. The expeditionary Qin army had already marched about to enter the State of Zheng. Meanwhile, a merchant of the State of Zheng, Xian Gao, went out to do business, who happened to encounter the Qin army. He sensitively perceived Qin's offensive intention, and immediately gave the Qin army four pieces of leather and twelve cows as gifts without hesitation. The State of Qin had thought that the State of Zheng had no idea about the sneak attack plan. But an ordinary merchant could reward the hostile army with luxury stuffs, they assumed that the State of Zheng not only knew, but also could be well-prepared. The commander of Qin decided to withdraw the army to return finally. Thanks to this, the State of Zheng could avoid the threat of subjugation luckily. The merchant's righteous act of saving the state has always been praised widely, which also shows the high status of the merchant in the State of Zheng. In addition, the merchant community and the governing class of Zheng reached a common value and formed a recognized behavior system. The merchants were also characterized by a set of internal consensual customary rules and rights. They obeyed the rule "*Er Wu Wo Pan* 尔无我叛" (the merchants should not betray the state), at the same time, the rulers should not buy or sell by force, nor should they ask about the wealth of the merchants. From a historical perspective, there is no doubt that the flourishing merchant groups and market trading greatly promoted the prosperity and development of the capital of Zheng.

Every coin has two sides. The advantageous position of the city in the central region of the Central Plains also brought about many troubles. The Central Plains are flat and unimpeded, with many neighboring states (**Figure 3-3-1**). According to historic literature, the State of Zheng had conflicts and battles with the surrounding vassal states such as Wei, Song, Chen, and even the Royal Zhou court. In the early Spring and Autumn period, it was also

invaded by the northern savage tribes (*Bei Rong* 北戎). Moreover, during the Spring and Autumn period, the two most powerful states, Jin and Chu, fought for the hegemony for a long time, while Zheng, exactly located between the two countries, inevitably was frequently affected. Some historians have made count according to *Zuo Zhuan*, there were approximately 12 battles of all sizes happening in the capital of Zheng during the Spring and Autumn period, but most of them did not happen inside the capital, just the kind of army at the gate. The capital city experienced numerous battles, large or small. But even if the army had broken into the city, it did not cause any severe damages. The city has maintained a relatively peaceful, stable, and prosperous status, which is what lucky and rare, especially during the turbulent Spring and Autumn period.

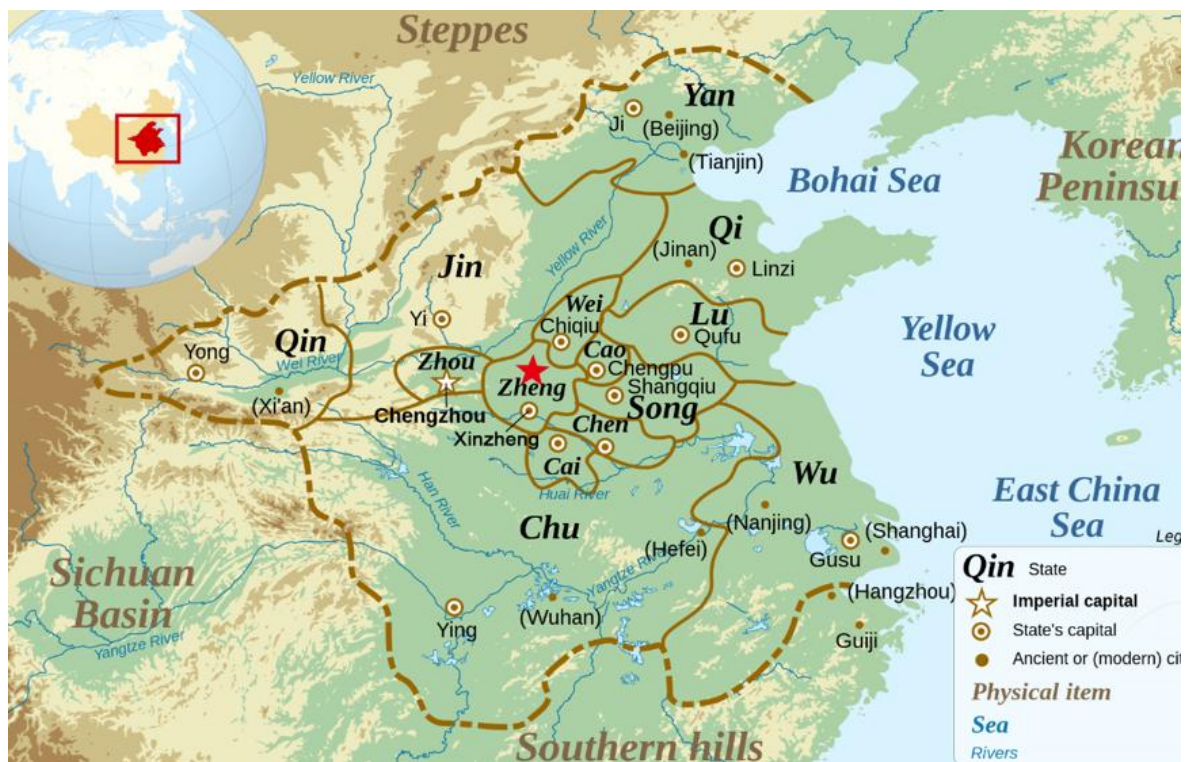


Figure 3-3-1. Territory distribution of Royal Zhou and states on the Chinese plain during the late Spring and Autumn period (about 5th century BC). The red star is for highlighting Zheng. It is obvious that the State of Zheng lay in the most central position among the states, which means that the State of Zheng would inevitably experience some direct or indirect warfare and clashes and was passively involved in, even if these conflicts were not between Zheng and others. (Adapted from: In Wikipedia. Access on 2023, January 28).

2. The stage of Han (375-230 BC, Warring States Period)

About the rising of the State of Han, we need to speak of the partition of the State of Jin first. The State of Jin was listed among the most powerful hegemonies during the Spring and Autumn period. However, the rulers of Jin had steadily lost political powers since the middle of the 6th century BC to their nominally subordinate nobles and military commanders, a situation arising from the traditions of the Jin which forbade the enfeoffment of relatives of the ducal house. This allowed other clans to gain fiefs and military authority, and decades of internecine struggle led to the establishment of four major families, the Han, Zhao, Wei and Zhi. The Battle of Jinyang saw the allied Han, Zhao and Wei destroy the Zhi family (453 BC) and their lands were distributed among them. With this, they became the "de facto" rulers of most of Jin's territory, though this situation would not be officially recognized until half a century later. The political vacuum created by the Jin's division ended in 403 BC, the Zhou court under King *Wei Lie* officially recognized Zhao, Wei and Han as immediate vassals, thereby raising them to the same rank as the other warring states. The capital of Han at the time was in Pingyang (roughly now Linfen, Shanxi Province).

Han's original territory was divided from Jin. It was described as “*Biao Li Shan He* 表里山河” (roughly interpreted as “situated at the foot of a hill and beside a river”), which implies that this is a place with numerous mountains, with many dangers and obstacles. Although the State of Han could gain strategic advantages by virtue of this terrain, which is easy to defend and difficult to be attacked, it also brought such defects as inconvenient transportation and limited expansion. Compared with the rich Middle and Lower reaches of the Yellow River with crisscross waterways and fertile lands, the capital of Han at this time was somewhat dwarfed. Therefore, Han's ruler chose Zheng's capital as the target of capital relocation.

In 375 BC, the army of the State of Han wiped out Zheng and moved its capital to Xinzheng. This event was clearly recorded in historical books such as *Shiji · Han Shijia* 史记·韩世家, *Book of Former Han-Treatise on Geography*, and *Zizhi Tongjian* 资治通鉴.

However, due to the central location, Han is surrounded by other counterparts just like what Zheng ever experienced (**Figure 3-3-2**), its development was limited, and due to its smallest land area, it kept being attacked by the other six states. When Marquess *Zhao* was in power, he appointed a reformer, Shen Buhai, to carry out a reform policy of centralization strengthening and armaments reorganization, which greatly increased the state strength of Han, to keep peace and stability for more than ten years.

Unfortunately, after the brief prosperity of the reign of Marquess *Zhao*, the State of Han declined rapidly and was repeatedly bullied. At the end of the Warring States period, the Han became a buffer area for the warfare between the states Qin and Qi. Finally, the State of Han could not escape from the dilemma of being surrounded and bullied by neighboring states. In 230 BC, Han was destroyed by Qin. Xinzheng, finished its duty as a state capital ultimately, was included in the territory of Qin.

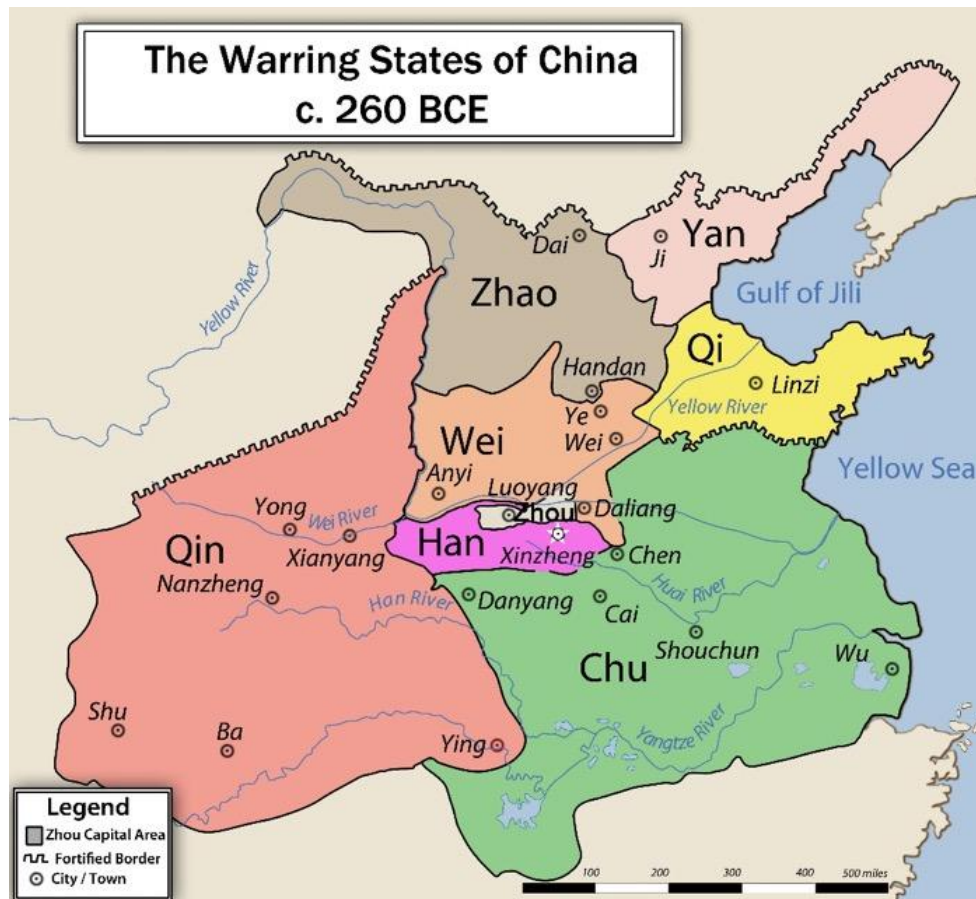


Figure 3-3-2. It shows the territory distribution of seven powerful hegemonies (Qi, Chu, Qin, Yan, Zhao, Wei, Han) and Royal Zhou court during the Warring States period. Han is in rose area with white star shows Xinzheng's location, and Royal Zhou court's capital area only left the poorly small piece stuck in the middle of Han and Wei. At the time, the Royal Zhou had lost the control of other states and its authority as a common lord. Meanwhile, the Han in the encirclement ring was being gradually gnawed away by the other hegemonical counterparts (Adapted from: In *Wikipedia*. Access on 2023 January 29).

Section 4 Finding History

In August 1923, a retired military officer named Li Rui was digging a well in his old house in Xinzheng city. As the workers excavated to a depth of over 10 meters underground, they stumbled upon four pieces of bronze wares. Jin Yun'e, the commander of the 14th Division of the Northern Warlords stationed in Zhengzhou, recognized the significance of these heavy bronze artifacts and decided that they should be preserved for the nation. He organized soldiers to continue the excavation and discovered that these bronze items originated from a large tomb.

During the initial digging stage, more than 70 pieces of bronze implements, including bronze *Ding* (a type of tripodal pot), bronze *Li* (a kind of tripodal cooking vessel), and others, were uncovered and transported by the soldiers for safekeeping. The excavation work continued until October 5th, resulting in the recovery of over 1,500 pieces of bronze vessels, fragments of bronze, pottery, and shell coins. Among these treasures, there were a pair of remarkable "lotus and crane square *hu*" (**Figure 3-4-1**). The ancient tomb in which these items were found became famous as the Lijialou Mausoleum of the Duke of Zheng.



Figure 3-4-1. Lotus and crane square *hu* (莲鹤方壶), used as wine or water container, were excavated by a pair from the Lijialou Mausoleum of the Duke of Zheng. One is now collected in the Palace Museum in Beijing, and the other in the Henan Museum (Source from The Palace Museum official online site: <https://www.dpm.org.cn/collection/bronze/234667.html>).

The discovery of these bronze wares in 1923 attracted widespread attention from scholars both in China and abroad. Experts such as Mr. Qiu Shanyuan from the Peking History Museum, Professor Ma Heng from Peking University, and Professor C. W. Bishop from the Smithsonian Institution in United States all provided on-site guidance during the excavation. However, due to the limited development of archaeological knowledge and the lack of professional excavation experience in China at that time, no on-site records were kept during the excavation. As a result, the specific locations of the bronze wares, the burial structures, and the layers' formations are not available to us.

It's noteworthy that Li Ji (also known as Li Chi), known as the "Father of Chinese archaeology", also personally visited the excavation. Li Ji earned his doctorate in anthropology from Harvard University in 1923 and returned to China. In October of the same year, he hurried to Xinzheng with the support of Ding Wenjiang, the secretary-general of the Chinese Archaeological Society, and conducted a small-scale trial excavation. Li Ji's work was focused on human bone fragments, which he compared with the findings of human bones by Bishop. This experience at ZHGC served as a foundational step in Li Ji's archaeological fieldwork in China. He later authored the article "*Bones in Xinzheng*" (Li 1926) based on this research.

In May 1966, following the establishment of the People's Republic of China, archaeologists from the Henan Provincial Institute of Cultural Relics and Archaeology revisited the Lijialou tomb in Xinzheng. The substantial tomb was believed to belong to a male noble of the State of Zheng. During the 1960s, the Henan Provincial Institute of Cultural Relics and Archaeology established an archaeological unit in Xinzheng, initiating continuous archaeological exploration and excavation efforts. Over 39 years, these endeavours led to a series of noteworthy archaeological discoveries.

This period saw new findings emerge consistently, offering valuable insights into the cultural landscape of ZHGC. Drilling and general surveys provided a preliminary understanding of cultural distribution in the region, and subsequent excavations uncovered significant sites, including palaces, shrines, iron/bronze casting facilities, and various rammed earth foundation. In 1961, ZHGC was designated as one of the first key cultural relics under national protection.

During the 1970s, excavations were conducted at several sites, such as the Baimiaofan Bronze Weapon Pit, the Houduanwan Noble Cemetery, and the Cangcheng Noble Cemetery. These efforts yielded over 220 bronze weapons, among which inscribed weapons provided invaluable insights into the technology, organization, military systems, and historical geography of the State of Han.

In the 1980s, the Xinzheng archaeological unit continued its excavation activities, uncovering sites like the Heli Cemetery, the western palace site, the coin-mould making site, Spring and Autumn chariot pits at the Lima Cemetery, and ongoing work at the Houduanwan Cemetery.

The 1990s brought new discoveries, including three sacrificial sites of similar age and nature at different locations. These sites yielded 28 storage pits filled with bronze ritual instruments, as well as 470 pieces of ritual vessels from the State of Zheng. One of these sites was rated among China's top 10 new archaeological discoveries in 1997. In April 2001, ZHGC was listed as one of the 100 Major Archaeological Discoveries of the 20th century.

Entering the 21st century, excavations have included both proactive and rescue projects. Discovering both official and private pottery-making workshops has been of great significance for understanding the productivity and socioeconomic status of two States during two periods. The excavation of the Xinghong Garden Cemetery and the Thermal Power Plant Cemetery (which will be included in our studies) revealed the first complete insights into a

public cemetery dominated by low-level nobles and civilians from the late Western Zhou Period to the mid Warring States Period, shedding light on urban layout and funeral system in ZHGC.

In recent decades, the Xinzheng Archaeological Unit continued to conduct archaeological excavation projects to support of the creation of the ZHGC archaeological site park and modern urban design. These projects included investigations at the Northern Gate, the Southern City Wall, No. 3 chariot and horse pit, Shuanglou Cemetery, Tianli Cemetery, etc., covering an area of over 100,000 square meters. The excavations revealed a range of remains dating from the Eastern Zhou Dynasty to the Song Dynasty, including roads, barbicans, burials, ash pits, pottery kilns, and chariot-horse pits. Tens of thousands of cultural artifacts, including jade, bronze, pottery, and bone items, were unearthed (Fan 2019). Notably, in April 2018, new discoveries within ZHGC were recognized as one of the National Top Ten Archaeological New Discoveries of 2017.

Section 5 Previous Studies

Since the discovery of the Zheng and Han States' Capital, there has been a continuous influx of publications. These publications can be broadly categorized into two types based on their content and presentation: archaeological excavation reports and research articles.

1. Excavation reports

The archaeological excavation reports, which serve as the foundational research material and primary information source, are spearheaded, authored, edited, and published by the Henan Provincial Institute of Relics and Archaeology and its affiliated unit located in Xinzheng.

Until now, there have been six comprehensive archaeological excavation reports published, including *The Sacrifice Site of Zheng in Xinzheng* (HPICRA 2006), *The Cemeteries at the Xinghong Garden and the Thermal Power Plant in the Ancient Capital City of Zheng and Han* (HPIRA 2007), *Xiayasi Cemetery of the Eastern Zhou Period in Xinzheng* (HPICRA 2012), *Shuanglou Cemetery of the Zhou Dynasty in Xinzheng* (HPICRA 2016), *Tianli Cemetery of the Zhou Dynasty in Xinzheng* (HPICRA 2018), *Gaolou Cemetery of the Eastern Zhou Period in Xinzheng* (HPICRA 2020). Here, we mainly introduce the first two reports in detail because they were within the city and related to what we will discuss in this study. Some detailed information of the other comprehensive/brief reports would also be involved in the following monographic literature review or other chapters.

The Sacrifice Site of Zheng in Xinzheng is a large-scale archaeological report with three volumes. From 1993 to 1997, Henan Provincial Institute of Cultural Relics and Archaeology (HPICRA) successively discovered three sacrificial sites of the State of Zheng in the eastern city including the Jincheng Road (JCL in our study) (Cai 2000), the Urban Credit Cooperatives, and the Bank of China (Xinzheng Archaeological Unit 1998; Ma & Cai 2000; Cai & Ma 2005). Among them, the sacrificial site at Bank of China was the most

abundant one (**Figure 3-5-1-a**). Eighteen bronze ritual instrument pits were found (**Figure 3-5-1-b**), although four of them were stolen. Besides, 142 bronze ritual vessels (**Figure 3-5-1-c/e**), 206 bronze chime-bells (**Figure 3-5-1-f**), and 45 horse pits were unearthed (**Figure 3-5-1-d**). The findings unearthed from the Bank of China were what *The Sacrifice Site of Zheng in Xinzheng* wrote about.

The central segment of the report concentrated on artifact and feature descriptions and carried out typological and chronological analyses. Following this, the site's nature and age, the ritual and music systems, the suspended music system (also as chime-using system), and the identity of the event host were explored. The report's author proposed that this site served as a sacrificial ground within the city of the State of Zheng. However, due to the absence of an ancestral shrine and the use of ritual music instruments instead of cattle and sheep, it was hypothesized that this location was associated with ceremonies dedicated to the God of Soil and Grain rather than ancestral worship. Regarding the hosts of these sacrificial activities, the author, based on the style and ornamentation of bronze ritual musical instruments, suggested that they were likely rulers of the State of Zheng during the middle Spring and Autumn period.

Furthermore, the report delved into the casting technology of the bronze ritual vessels, bronze chimes, and metal coins, ultimately concluding that the bronze casting technology during this period had reached a relatively high level. Some of the techniques represented bold innovations, drawing on Shang and Western Zhou traditions, and introducing unprecedented methods. The discovery of this site not only filled a void in terms of sacrificial remains dedicated to the God of Soil and Grain but also provided a wealth of substantial materials for the examination of the layout of the capital of Zheng and the typological analysis of bronze ritual objects (HPICRA 2006).



Figure 3-5-1. Portfolio of the sacrificial site at Bank of China: (a) the panorama of the site excavation (northwest-southeast); (b) archaeologists were working on T615K16 (chime pit), the upper one in the picture is Cai Quanfa, who worked as the former excavation leader of HPICRA Xinzheng Archaeological Unit and host many spectacular projects in ZHGC. Cai is also the one who generously provide me with the precious opportunity to access to the faunal materials in ZHGC; (c) the bronze ritual vessels in T605K2; (d) the intact sacrificed horse skeletons in T583 MK29 and MK44 (bottom layer), picture taken from east to west; (e) a combination of bronze *Ding* from T604K10 (No.10-18); (f) a combination of *Niu* chimes (钮钟) from T594K7 (No.A1-A10, B1-B10). Adapted from appendix pictures of the report (HPICRA 2006).

The report “*The Cemeteries at the Xinghong Garden and the Thermal Power Plant in the Ancient Capital City of Zheng and Han*” details the findings from a series of three archaeological excavations conducted between 2003 and 2005 at the Xinghong Garden and the Thermal Power Plant, covering a combined area of 3,500 square meters. These excavations unearthed a wealth of significant remains spanning from the Western Zhou to the Warring States Period. The discoveries included over 200 tombs, 200 trash pits, more than 30 wells, 3 sacrificed horse pits, a substantial rammed earth structure from the Warring States Period, a house remnant, and over 1,000 artifacts made from bronze, jade, bone, shell, pottery, and stone.

The report primarily categorizes the burials and artifacts according to typology, conducts an analysis of the combinations of funerary items, and subsequently determines their respective stages and ages. Furthermore, the report delves into the burial system and cultural origins depicted in the archaeological materials. The burials in the two cemeteries were uniformly small-sized, with none of the tomb frames exceeding 4 meters. This suggests that these were likely public cemeteries, intended mainly for low-level nobles or common people. In terms of burial form, aside from two hollow-brick tombs, the majority were shaft tombs. Niche, waist pit (**Figure 3-5-2-c**) and *ercengtai* platform⁴ (**Figure 3-5-2-a/b**) were also prevalent. Most of the tombs headed to north, and the burial objects primarily consisted of utilitarian pottery, with only a small number of tombs containing bronze vessels. Notably, some pottery ritual vessels were designed to imitate the shape of bronze wares (HPIRA 2007).

It's important to note that this report does not include studies on human bones, animal bones, or other archaeometry research. However, the animal bones uncovered from the Thermal Power Plant Cemetery (referred to as RDC in the subsequent chapters) constitute a portion of the materials used in this dissertation.

⁴ The *ercengtai* is the platform near the bottom of the tomb in the shaft tomb. The platform is often used to put funeral objects or sacrificial human. See Figure 3-5-2-a/b.

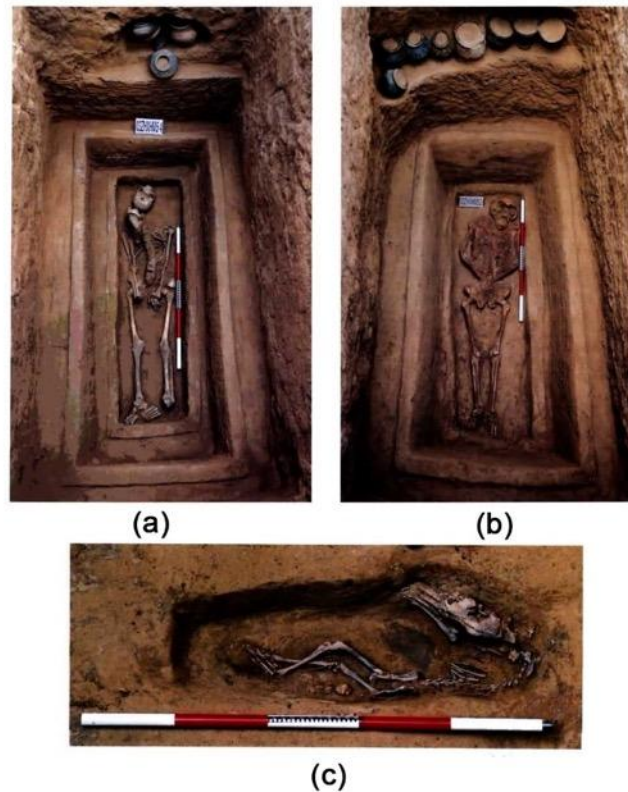


Figure 3-5-2. Portfolio of tombs at Xinghong Garden Cemetery: (a) M54 at Xinghong Garden Cemetery, with niche and *ercengtai* platform overhead; (b) M52 at Xinghong Garden Cemetery, with *ercengtai* platform overhead; (c) A waist pit with sacrificed dog in M100 at Xinghong Garden Cemetery. The waist pit got its name because it is placed under the skeleton's waist and always a dog sacrificed within it. Adapted from appendix pictures of the report (HPICRA 2007).

2. Thematic studies

The availability of first-hand materials through excavation reports has spurred a substantial body of thematic and comprehensive studies. Due to the inherent complexity and comprehensiveness of the site, the ensuing research spans a wide array of fields. To enhance organization and facilitate categorization, I have broadly classified the monographic research into six primary thematic areas. This classification draws from existing research and partly references prior standards of archaeological thematic categorization, as established by Jørgensen (2015). The six primary themes encompass urbanism, artifact, epigraphy, diet and subsistence, craftsmanship and techniques, as well as burials and ritual.

2.1 Urbanism

ZHGC, as the capital of two significant vassal states that spanned over half a century, stands as a site of immense academic value and serves as a remarkable case study for understanding ancient urbanism. Since scholarly interest in ZHGC began in the 1920s, there have been numerous achievements in this field over the past century. Current studies on urbanism approach the topic from various perspectives, including the layout and sectorization of the city, the city's shape and its historical evolution, the influence of the natural environment on the city, the histogeography of the city, the city's military defence function, and comparisons with other contemporary cities.

Drawing from both literature records and archaeological materials, many scholars have successfully reconstructed the urban layout of ZHGC and have largely reached a consensus (Qu 1991; Ma 1999; Cai 2003a; Cai 2003b; Wan 2018). Regarding the city's founding time, some scholars argue that the western city was constructed earlier than the eastern part (Qu 1991). When it comes to the urban form, academic disputes have mainly revolved around the construction time of the north-south partition wall in the central area. The traditional perspective holds that the partition wall was built by the state of Zheng in the Spring and Autumn Period, and ZHGC had a dual-city system from the beginning (Cai 2003a). Conversely, some scholars propose that the partition wall was constructed in the middle of the Warring States period by the State of Han, and it was a single-city system during the Zheng's reign (Ma 1999; Yu *et al.* 2019). A third viewpoint suggests that only a section of the partition wall was initially built in the Spring and Autumn Period based on the technical characteristics of the foundation's rammed layer. In the Warring States Period, the existing partition wall was expanded by Han, ultimately forming a double-city structure, aligned from west to east (Chen 2007).

Given its status as a capital during turbulent times, the military defence system has naturally attracted much attention from scholars (Bao 2009; Zhang 2014; Wan 2018). It is widely accepted that ZHGC possessed a robust defensive function. The ruler chose to build the city on a highland, utilized two rivers as moats, and encircled the city with a protective wall. Moreover, key sections of the city wall were equipped with barbicans (Yu *et al.* 2019), forming a multi-layered defence system (Bao 2020; Liu 2021).

Interestingly, some scholars have also explored the connection between urban construction and philosophical thought. Some have proposed that the shape and military defence system of ZHGC align with the philosophies of Chinese thinker *Mozi*, who emphasized defence. Others suggest that the construction and location of shrines for ancestors and the Soil God in ZHGC may reflect the strong spiritual beliefs of its residents and incorporate concepts of *Feng Shui* (Chinese geomancy)⁵, which serve as a form of spiritual defence (Bao 2020).

In summary, based on archaeological materials and extensive research papers, the city can be characterized as follows:

a) **Scale and Shape:** The city's scale and shape deviated from the uniformity requirement stipulated in the “*Ying Guo System*”⁶. Instead, it reflected a practical and innovative spirit, with the city wall designed in response to changes in the landforms. Notably, the city's scale exceeded the regulated level befitting the Duke of Zheng.

⁵ *Feng shui*, sometimes called Chinese geomancy, is an ancient Chinese traditional practice which claims to use energy forces to harmonize individuals with their surrounding environment. The term *feng shui* means, literally, “wind-water” (i.e., fluid). From ancient times, landscapes and bodies of water were thought to direct the flow of the universal Qi – “cosmic current” or energy – through places and structures. More broadly, *feng shui* includes astronomical, astrological, architectural, cosmological, geographical and topographical dimensions. (From Wikipedia, access on 20 Feb 2023).

⁶ According to the record in *Kao Gong Ji* (translated variously as the *Records of Examination of Craftsman*, *Book of Diverse Crafts* or *Artificers' Record*, is a classic work on science and technology in ancient China, compiled sometime between the fifth and third centuries BCE), *Ying Guo System* is the system for the construction of imperial capital in the Zhou Dynasty, which laid down the Chinese urban construction traditions such as square shape, centered palace, symmetrical layout, and following the ritual hierarchy.

b) **Functional Differentiation:** The inner city in the west primarily housed the ruler's palaces and noble residences, serving as the political centre (Cai & Ma 1996); while the outer city in the east was home to handicraft workshops, functioning as the economic centre. However, recent archaeological excavations have unveiled the complex nature of the eastern city, where significant sacrificial relics with political significance have been discovered (HPICRA 2006), along with large areas of rammed-earth buildings thought to be related to ancestral shrines (Cai 1986). This complexity is still open to debate, but the eastern and western cities do exhibit functional and class-based distinctions.

c) **Water Resource Utilization:** The city's design adeptly employed nearby water resources. Situating the city close to rivers and numerous ditches not only used river water as a natural defence barrier but also facilitated drainage, flood prevention, and the utilization of river channels for water transportation, promoting exchange and trade.

d) **Defensive Focus:** The urban construction concept prioritized the defensive function, resulting in the formation of multiple defence systems.

e) **Cemetery Locations:** The cemeteries of senior nobles from the State of Zheng were primarily situated in the south of the capital, indicating a certain "south preference" among Zheng's aristocrats. The large-scale and concentrated burials implied premeditated planning. In contrast, the State of Han's cemeteries were mainly located in the suburbs outside the city, diverging from Zheng's traditional practices.

In addition to the aforementioned studies on ZHGC as an individual site, many scholars have adopted a horizontal comparative method. They explore ZHGC and other contemporary cities through comparative studies focusing on aspects such as morphological layout, functional divisions, and historical evolution (Qu 1991; Shen 1994; Li 1997; Xu 2000; Ma 2003; Sun 2013; Xu 2017). This approach enriches our understanding of ZHGC by situating it within the broader context of its contemporaries.

2.2 Artifacts

Initially introduced to China in the 1930s, Montelian typology remains firmly entrenched in Chinese archaeological practice, characterized by its exclusivity and orthodoxy, perhaps unparalleled in its persistence elsewhere (Falkenhausen 2006). This uniqueness is primarily attributed to the scarcity of deep stratigraphic layering in China due to the extensive impact of modern agriculture and rapid urban development. Furthermore, stratigraphic excavations are rarely feasible at cemeteries and tombs, the primary sources of Zhou period archaeological evidence. Consequently, archaeological chronologies for this period primarily rely on typological seriation, infrequently supplemented by stratigraphic data. This practice has led Chinese archaeologists to place significant emphasis on the shapes and decorations of unearthed artifacts to address typological concerns and establish chronological sequences (Falkenhausen 2006). The artifact research conducted at ZHGC adheres to this tradition (Sun 2022).

Since this type of research can be repetitive and serves as the fundamental premise for subsequent studies, we will only introduce some specific research of special artifacts here.

The State of Zheng boasted a rich tradition of music, singing, and dance. Notably, striking experiments were carried out on the chime bells unearthed from the musical instrument pits at the Bank of China site (Wang 2006a). The results demonstrated that these chime bells produced precise tones with exquisite sounds, achieved through post-casting tone tuning. Most of the chime bells could produce two distinct scales, with a sound sequence structure spanning four octaves, from the lowest note to the highest. The presence of rich chromatic scales allowed them to form a seven-tone scale system, with the capacity for modulation. Even today, these chime bells can produce melodious tunes, showcasing Zheng's advanced musical development (Cai & Ma 1998; Wang 2006a).

Suspended Music: Chime-Bells in the Culture of Bronze Age China is a prominent masterpiece among comprehensive studies on the chime-bell system and ritual musical instruments. Falkenhausen (1993) approached Chinese chime materials using Western thinking, making it highly accessible to English-speaking readers.

Besides chime bells, another musical instrument, the Pottery *Xun*⁷, was also unearthed. Audio-visual experts conducted sound and scale test experiments on them (Wang 2006b).

Regarding jade objects, Zhang (2021) systematically catalogued the jade artifacts unearthed from 148 burials. Zhang's analysis suggests that ordinary individuals transcended the confines of the ritual system, as they increasingly used ritual jade *Gui*, symbolizing status, alongside jade *Jue*, representing economic capacity. This shift might indicate the emergence of a new social class and the heightened economic status of common civilians during the Eastern Zhou period.

During the excavation of the aristocratic cemetery of Zheng at Houduanwan, archaeologists made a remarkable discovery: a stunning dragon-shaped ivory cart footrest placed on a wooden chariot in the tomb passage of a king-level tomb (**Figure 3-5-3**). This ivory artifact is characterized by embossed patterns on the dragon's head, decorated with red lacquer and turquoise. The carvings exhibit extraordinary precision and finesse, implying the tomb owner's identity as a state ruler of Zheng (Ma 2014).

⁷ The Pottery *Xun*, mostly made of earth, is the oldest closed-mouth wind instrument in China. Although not as old as the bone flute found at Jiahu site dating back to 9,000 years ago (Zhang 1999), it is still one of the primitive Chinese wind instruments. It is speculated to be used to trap prey in ancient times. Archaeological materials prove that the pottery *Xun* first appeared in the Neolithic Age about 7,000 years ago (Chinese Academy of Science 1963; CPAM& Zhejiang Museum 1978) and was very popular during the Zhou Dynasty.

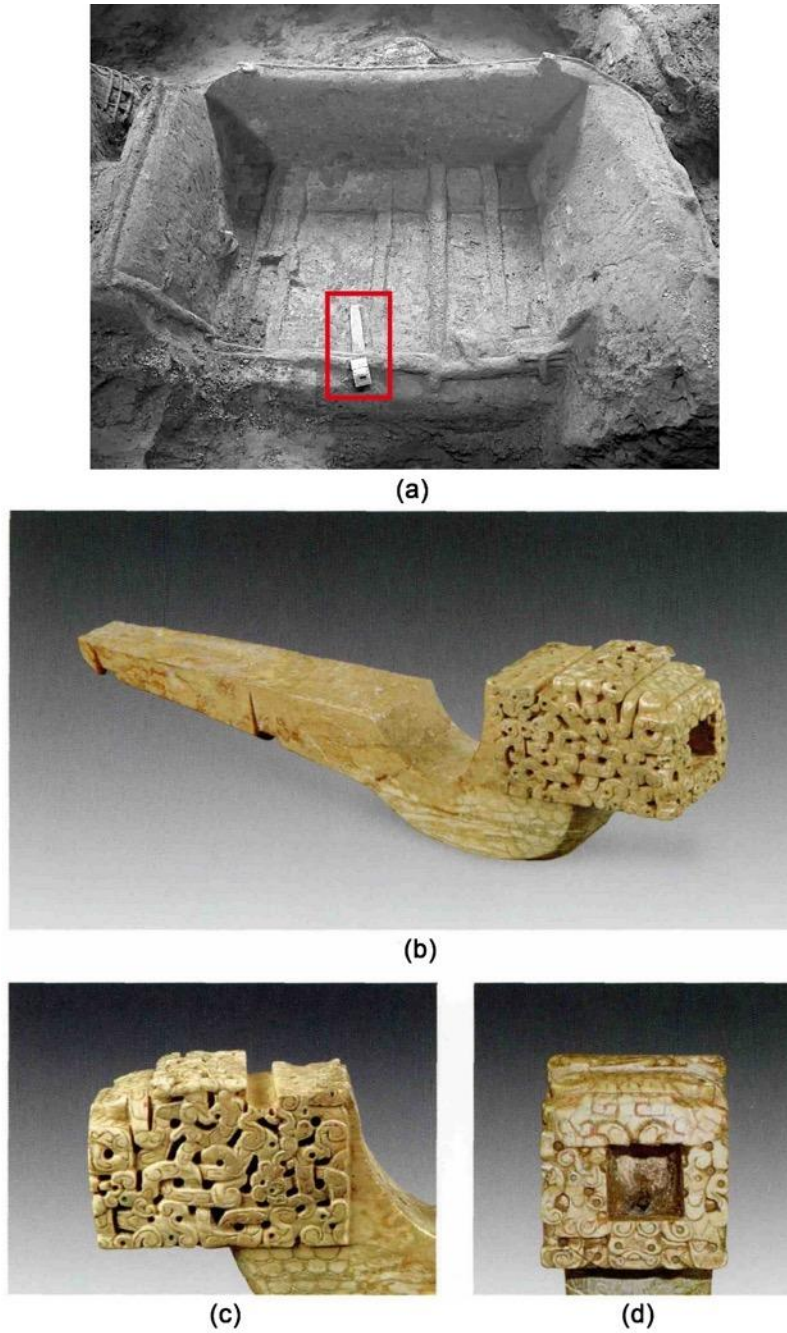


Figure 3-5-3. (a) The finding scene of the ivory cart annexation; (b) overall look; (c) the side facet of the dragon head; (d) the perforation inside dragon's mouth. Adapted from Ma 2014.

2.3 Literature and epigraphy

The understanding of the history of the State of Zheng and Han is primarily drawn from ancient literary sources such as *Guoyu* (《国语》 Discourses of the States), *Shijing* (《诗经》 Classic of Poetry), *Zhan Guo Ce* (《战国策》 Annals of the Warring States), *Shi Ji* (《史记》 Records of the Grand Historian), *Shui Jing Zhu* (《水经注》 Commentary on

the Water Classic), and others. The discovery of the Tsinghua Bamboo Slips⁸ filled the historical gap of the early history of Zheng (Ma 2016). Furthermore, many scholars have dedicated themselves to reviewing and reconstructing the cultural history of Zheng and Han based on these historical materials and have offered insights into various prominent issues (Su 2010; Li 2005).

Additionally, there are studies focused on interpreting the inscriptions found on the excavated artifacts from ZHGC. Cai (1986, 2006) conducted an interpretation of the inscriptions on pottery vessels and sherds discovered around 1984. This collection of pottery inscriptions comprises 140 characters in total, with 131 of them being decipherable. These inscriptions primarily contain the names of pottery makers, followed by place names, counting numbers, names of measuring vessels, and more. The inscriptions on the recoverable measuring vessels suggest that the production of these vessels was centrally administered by the state, both within and outside the capital. Subsequently, other scholars expanded on this research and proposed that the inscriptions indicated the existence of the *Xiangsui* System⁹ within the State of Zheng (Wang 2003).

Moreover, a remarkable discovery relates to the interpretation of a set of ink-written ledgers from the Warring States Period, which were found in a trash pit at GXS site in 1998. These accounts were inscribed on ox ribs and recorded not only the serial numbers and storage locations of goods, the individuals involved, names and quantities of the goods, but also information about loans and interest rates (Cai 2014).

⁸ The Tsinghua Bamboo Strips (清华简 *Qīnghuá jiǎn*) are a collection of Chinese texts dating to the Warring States period and written in ink on strips of bamboo, that were acquired in 2008 by Tsinghua University, China. The texts were obtained by illegal excavation and were then acquired and donated to the university by an alumnus. The very large size of the collection and the significance of the texts for scholarship make it one of the most important discoveries of early Chinese texts to date (In Wikipedia). The content of some slips represented the world's oldest example of a decimal multiplication table (Qiu 2014; Berlin 2014).

⁹ The *Xiangsui* System 乡遂制度 was a kind of grass-roots social organization system in the Western Zhou. During the Spring and Autumn Period, the Royal Zhou area, state capital and the area within the four suburbs were called "*Guo*", and the people in the "*Guo*" were called "*Guo* people"; and the outskirts were called "wild", residents there were called "wild people", or "common people".

2.4 Diet, Subsistence, and health

Several studies regarding the diet, subsistence, and health of the people in ZHGC have been conducted, primarily based on the analysis of human bones and animal bones found.

Regarding human skeletal research, Li Ji's work (1926) stands out as the earliest in this field. He concluded that the skeleton he collected belonged to a female, while Bishop's collection belonged to a male. It was suggested that these two skeletons might have been a couple buried in the same tomb. Li provided a detailed description of the human bones and conducted bioarchaeological research, which was pioneering for ZHGC's research. However, it's important to note that the conclusion of the co-tomb couple appeared somewhat arbitrary due to the lack of sufficient contextual information.

Subsequent reports on human skeleton identification are available.

One of these reports, focusing on human skeletons from the sacrificial site at the Bank of China, presented an identification result table, including information on the preservation condition, sex, and age of 60 skeletons. However, this report did not include a detailed analysis or discussion (Nakahashi & Kitagawa 2006).

Additionally, a bioarchaeological study was conducted on human skeletons from the Xiyasi Cemetery, which revealed several unusual characteristics. These included selective burial based on age and sex, taller stature among Xiyasi males, lower stature among females, evidence of a diet rich in carbohydrates, unusual dental wear¹⁰, as well as low incidence of degenerative joint diseases and traumatic injuries. Overall, the Xiyasi population appeared healthy and well-off, they were very unlikely the people participating in long-term farming, animal tending or construction, despite some individuals might work for craft production (Pechenkina 2012).

¹⁰ It is thought by Pechenkina (2012) that craftsmen frequently use teeth as tools in the handicraft production.

Similar bioarchaeological reports were also carried out on human skeletons from Shuanglou Cemetery, Tianli Cemetery, and Gaolou Cemetery (HPICRA 2016; Sun *et al.* 2018; HPICRA 2020).

Some scholars have conducted carbon and nitrogen isotopic analyses based on human and faunal bones to reconstruct human paleodiet and discuss topics such as social inequality, social hierarchy, and the dietary differences that may reflect social transitions.

Archaeometry scientists found evidence of a dietary shift of human toward C3 plant consumption during the Eastern Zhou period when compared to the $\delta^{13}\text{C}$ values of the Yangshao period (5000-2900 BC). This shift affected females to a greater extent than males. It is suggested that the introduction of newly cultivated C3 plants (including wheat, barley, and beans, initially being regarded as low status foods, provisioning the poor against famine) led to reduced consumption of animal products and increased skeletal stress markers, particularly among females. This dietary separation between males and females is thought to signify the rise of male-biased inequality in early China (Dong *et al.* 2017). The gender dietary difference is further supported by the evidence of low average stature among females (as mentioned in Pechenkina's work) and variations in burial wealth between sexes.

Additionally, carbon and nitrogen isotope analysis based on individuals excavated from city and peripheral rural sites showed status differences in human diet during the Eastern Zhou. The results indicated that nobles primarily consumed a millet-based diet with substantial animal protein, whereas burial sacrificial companions had dietary patterns like urban commoners. Rural populations consumed millet as their staple food and a similar amount of animal protein to urban people but without evidence of wheat consumption. These findings reveal a dietary dichotomy between nobles and commoners regarding staple foods and dietary differences between rural and urban populations (Zhou *et al.* 2019).

Furthermore, researchers have used human and faunal remains from sites located on the Central Plains of China to examine the differences in human diets between two different periods: the Eastern Zhou and the Hàn Dynasty. The isotopic materials representing the Eastern Zhou came from burials at various sites in ZHGC. The results indicated that most individuals in the Eastern Zhou had diets based on millet and limited animal protein. However, the diet of poorer individuals included a substantial amount of wheat, possibly as a sudden response to food pressures in their urban environment (Zhou *et al.* 2017). Nevertheless, some scholars have challenged the notion of a sudden dietary shift and suggested that the adoption of wheat agriculture was a gradual and active process influenced by climate conditions (Lee 2018).

In a similar study, the dietary shift from the Eastern Zhou to the Han Dynasty was further explored by supplementing isotopic data with evidence from a garrison site located approximately 30 kilometers north of ZHGC. The comparison revealed that urban residents generally had higher-quality diets with greater consumption of millet and meat compared to individuals from the garrison site (Yang *et al.* 2022).

2.5 Handicraft production and techniques

The studies in this part focus on various workshops, the production techniques employed in crafting bronze, iron, pottery, jade objects, as well as compositional analysis and the procurement of raw materials. Researchers investigate how these objects were made, what materials were used, and the techniques employed in their production.

Firstly, concerning the workshops, there were a series of brief reports introducing the excavation outcomes and new findings, such as the finding of the pottery-making workshop during the Warring States Period (Li 1991; Ma 2003; Cai 2003b; Ma 2004), bone working site mainly used in the Warring State Period (Xinzheng Archaeological Unit 1980; Li 1990; Cai 2003a, 2003b), bronze casting workshops (Xinzheng Archaeological Unit 1980; Hao

1984; Annal of Archaeology 1993) bronze ritual ware casting workshop in the Spring and Autumn Period (Li J. 2006), bronze ritual ware casting workshop in the Warring States Period (XCRAB 2005), iron casting workshop (Liu 1962; Xinzheng Archaeological Unit 1980), textile workshop (Cai& Ma 1996; Cai 2003b), and coin workshop (XCRAB 2005).

Based on these, some scholars summarized the findings of workshop features from ZHGC and other contemporary capitals (Wang 2010; Tang 2017; Han 2020) or referred to the workshop remains of ZHGC in their comprehensive studies on handicraft production (Tan 1999; Chen 2009).

In conclusion, some characteristics of the workshops were highlighted:

(1) Workshops were predominantly located in the eastern city of ZHGC, often arranged in a north-south line or near the river. This suggests a deliberate city planning strategy, with workshops strategically placed to optimize production and transportation.

(2) After conquering the State of Zheng, the State of Han not only inherited many of Zheng's workshops but also expanded and diversified their activities. This demonstrates the Han's efforts to enhance craft production and maintain the functional division between the eastern and western parts of the city.

(3) A wide range of workshop types existed, indicating the diversity of craftsmanship and industrial activities in ZHGC. This variety included pottery-making, bone working, bronze casting, iron casting, textile production, and coin minting.

(4) There were a full range of workshop categories and workshops were mainly manipulated and organized by the authority except the private pottery making workshop at Fengzhuang.

(5) The scale, classification, and changes of workshops witnessed the development of social productive forces, handicraft industry, business, and centralization during the Eastern Zhou.

In terms of the productive techniques of objects made of diverse materials, kinds of analysis, experiments, and testing were conducted.

First, let us start from bronzes. The microstructure of the 46 bronze ritual vessels from the Bank of China site was analyzed by means of metallographic microscope, ore microscope, scanning electron microscope, and energy spectrum analyzer (Huang& Li 2006). The results indicated this batch of bronze vessels adopted the casting methods of block casting (one-step molding) and split casting (separately cast elements and then combine), as well as using earth molds to make decorations. It also showed that the content of Sn had little change while Pb had great difference when comparing same type of ware. The authors believed that this resulted from resource-driven decisions. Sn was more precious and difficult to obtain, thus, the production cost was intentionally reduced by increasing the content of Pb and reducing the content of Sn in the production of late bronzes. The provision of bronze resources should come from the State of Chu or by trading with other states. Another case research is that 15 bronze wares were analyzed from the Cemetery at RDC by using optical microscopy and SEM-EDS. The results indicated that these artifacts were made of Cu-Sn-Pb and Cu-Sn and all of them were produced by casting and forging (Zhang *et al.* 2014).

Besides bronzes, there were also experiments for remnants left of bronze casting like the blastpipe, the adherent slags and fragments of furnace (Li 2006a).

Then, there were several pieces of research about jade objects. One of them was based on the jade objects unearthed from the sacrificial site at Bank of China. According to the texture of raw materials, this batch of jades can be divided into nephrite and other jade-like materials, among which nephrite was less and most of them were jade-like materials (quartzite, siliceous rock, marble, schist, slippery rock, etc.). The raw materials used are locally sourced (Chang 2006). The other one was the research of 60 pieces of jades from Xiyasi Cemetery. The methods of pXFR and XRD were used for chemical phase analysis and

Raman for structural analysis. The low proportion of tremolite-actinolite jades might be correlative with the generally low-level of tombs (Dong& Hu 2012). Similar technical analyses were also conducted on Tianli (Dong *et al.* 2018) and Shuanglou Cemetery (HPICRA 2016).

As for bone artifacts, some archaeologists tried to reconstruct the productive process, which typically encompasses the sequential stages of collecting raw materials, selection, rough shaping, including sawing, filing, and grinding, as well as fine shaping like drilling and carving. The raw materials used were mainly the scapula, ribs, limb bones of cattle, sheep, pigs, and deer, a few chicken, fish and other animal bones were also selected. There was obvious sawing, cutting, chiseling, filing, drilling, and grinding marks observed (Li 1990).

Nonetheless, until now, professional zooarchaeologists have yet to delve into systematic research on worked bones. Fortunately, I attended the 11th Chinese Zooarchaeological Symposium in 2021, during which I had the opportunity to listen to a presentation by the team led by Hou from HPICRA. To my delight, I learned that they were actively engaged in a study of the bone hairpins. Their endeavors encompassed experimental archaeology, with the ambitious goal of reconstructing the resource provenance and comprehensive production process. I eagerly await the publication of their research findings.

Besides, there were also metallographic experiments employed for the research of iron tools of the Warring States Period (Li 2006), this was exactly the time when iron metallurgy had developed well and was widely spread in China. We can find an interesting phenomenon that the bronze ritual vessels and instruments cast in the State of Han seemed to have experienced significant retrogression in terms of not only quantity but also technology when compared with Zheng. This seemed to be the result of the substitute of pig iron and

steel technology¹¹ because the iron metallurgical technology of the State of Han was in a leading position during the Warring States Period.

2.6 Burial, sacrifice, and ritual

In the Zhou Dynasty, the concepts of burial, sacrifice, and ritual were intricately interconnected, forming a symbiotic relationship. Burial and sacrifice represented the paramount expressions of ritual practices, with sacrifice and ritual frequently conducted with the ultimate aim of coordinating burial. Consequently, in the following discussion of many issues, these three always accompany and appear together.

Tens of thousands of burials and sacrificial sites within or outside ZHGC have been found (**Figure 3-5-4**).

In the western city within the city, there is the Spring and Autumn Period tomb at Zhengnan Road (Fan & Xu 2005). In the eastern city within the capital, there is the Lijialou mausoleum of Duke of Zheng (Yang 2001), the Xinghong Garden and Thermal Power Plant Cemeteries (HPICRA 2007), the Houduanwan Complex, as well as the Sacrificial sites at Jincheng Road (Cai 2000), Urban Credit Cooperatives, and the Bank of China (Xinzheng Archaeological Unit 1998; Ma & Cai 2000; Cai & Ma 2005; HPICRA 2006).

In the suburb area outside the capital, there are Lima Cemetery (Xiyasi Cemetery, Lijia Cemetery included) (Li 1983; HPICRA 2012), Hollow-brick cemetery at Huaxin College's new campus (Fan *et al.* 2017), Chezhan Cemetery, Fuzhuang Cemetery, Heli Cemetery (Song 1987), Liejiangpo Cemetery (Cai *et al.* 1987; Jiang *et al.* 1995), Tanghu Cemetery (1978), Shuanglou Cemetery (HPICRA 2016), Tianli Cemetery (HPICRA 2018), Gaolou Cemetery (HPICRA 2020), Zhouzhuang Cemetery, Tieling Cemetery (Hao *et al.* 2008; 2010a; 2010b; 2012a; 2012b; 2013; 2014; Yuan *et al.* 2020), Huzhuang Cemetery (Cai & Song 1987), and so on.

Autumn Period (about 500 BC) that iron implements were put into large-scale use. Because written history started before ironworking arrived in China, the term Iron Age is infrequently used.

Further outside the suburbs, there are many imperial mausoleums of Han, such as Chuanggang, Miao Zhuang, Qilijing, Wangxing Zhuang, Liuzhuang, Xugang, etc.

Overall, the cemeteries inside the city were mainly those belonging to the higher-grade nobles of the State of Zheng in the Spring and Autumn Period. The cemeteries outside the city are low-grade noble tombs and public cemeteries of Zheng, as well as all-level cemeteries of Han, from kings to the commons. But the king-level mausoleums of Han tend to be arranged further far away than other cemeteries, in the form of isolated cemetery.

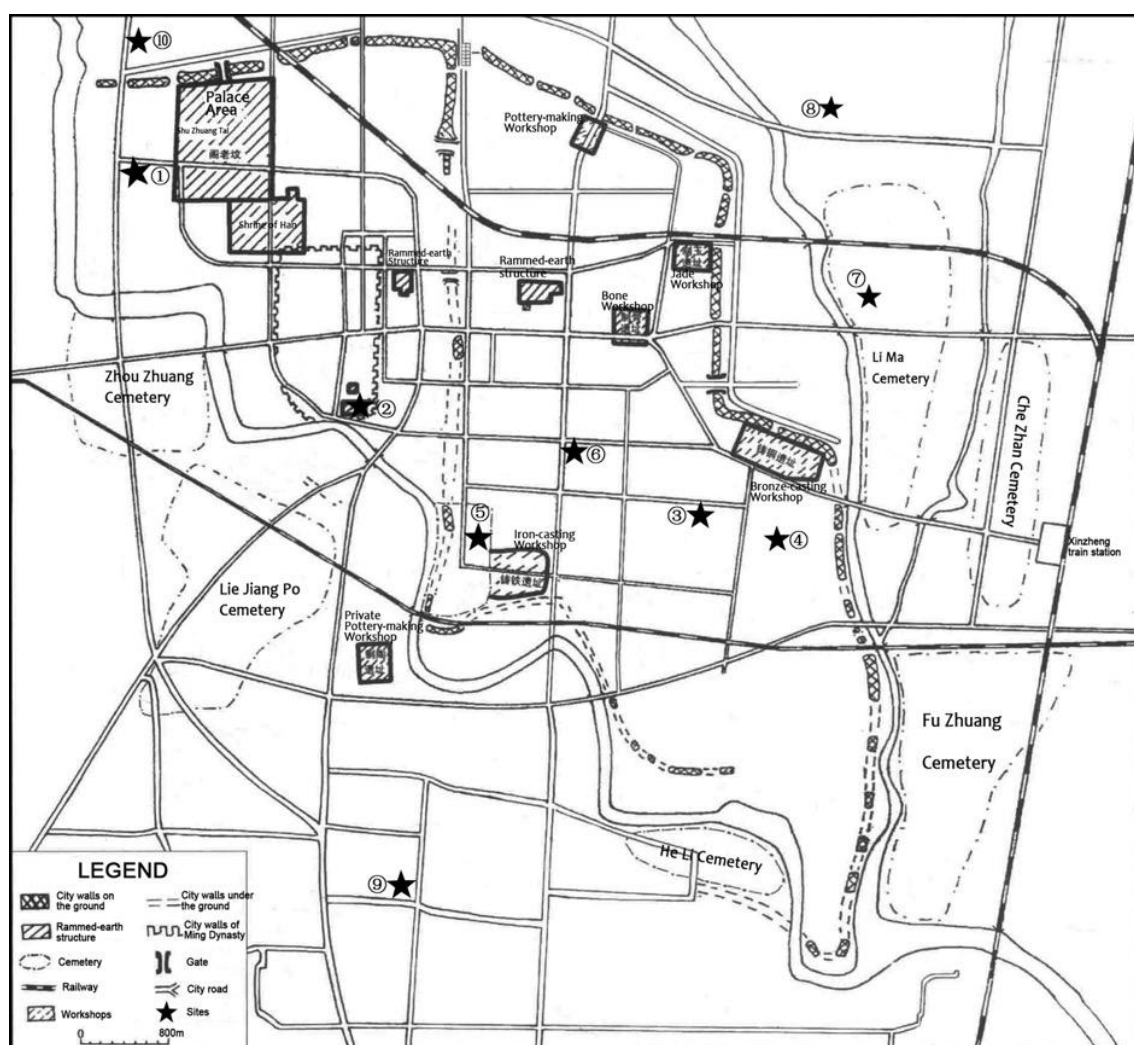


Figure 3-5-4. The locations of cemeteries and sacrificial sites mentioned in the article. ① Zhengnan Road (ZHL); ② Lijialou Mausoleum; ③ Thermal Power Plant Cemetery (RDC); ④ Xinghong Garden Cemetery; ⑤ Houduanwan Cemetery; ⑥ The Bank of China Sacrificial Site; ⑦ Xiyasi Cemetery; ⑧ Hollow-brick Cemetery at Huaxin College; ⑨ Tianli Cemetery; ⑩ Huzhuang Cemetery. Tieling Cemetery and king-level mausoleums of Han are outside the map's scope.

Regarding the thematic research on burials, scholars mainly investigated the funeral system and funeral customs. The earliest academic summary of burials came from Ye's study (1985). She proposed that the Warring States burials in the Central Plain were characterized by collective burial, heads to the north, shaft shape, and multiple coffins. Zhang (1994) classified the burials in this area by analyzing the typology and combination discipline of potteries. Hu (2003) pointed out that the funeral customs of the Zheng and Han were the closest to the Luoyang area (Royal Zhou court), and were also influenced by surrounding states of Jin, Qi, and Chu. On the other hand, Zhou (2014) focused on discussing the funeral differences between Zheng and Han. In addition to the location difference, he also found that joint burials of couples were more popular in Han, while the burial system of chariots and horses in Han witnessed a steep decline when comparing with Zheng.

Additionally, many studies on the combination system and changes of daily-use potteries offered in burials were conducted (Zhao & Fan 2017; Shen & Fan 2017; Wang & Teng 2018; Li 2019).

During the Zhou Dynasty, the primary physical expressions intimately related to burial, sacrifice, and ritual were ritual bronzes and animal offerings. Ritual bronzes are not only shrine treasures, but also a sign of nobility and a symbol of the regime. Since the studies of the ritual bronzes used in burials and sacrifice have been reviewed in the above section on artifacts, we would only introduce the animals used in the ritual ceremony here.

There were two zooarchaeological reports about ritual-used animals based on the materials excavated from the sacrificial site of Zheng at the Bank of China.

The first one was about a batch of faunal assemblages excavated in 1997, including mussels, soft-shell turtles, fish, birds, dogs, tigers, weasels, horses (horses were studied independently in the next paper), pigs, large deer, sika deer, small deer, cattle, sheep, and so on, predominated by domesticated pigs and cattle. The overall proportion of domestic

animals rose in WSP in comparison with SAP, with pigs' proportion going up while cattle's down. The author thought this change was because of the function switch of this site: from a ritual sacrificial place to a mundane consumption area. Besides, different function areas used different animals for sacrifice: complete pig skeletons for building structures, horses for ritual sacrifice, and chariot-horse-dog combination for the cemetery (Luo *et al.* 2006).

The other report was exclusively about the horse skeletons from 44 horse pits. Yuan (2006) summarized that 1) all the horses consistently head west and rump east, and the horseback faces south and north, north is more; 2) most horse pits were placed in order; 3) the size and age of horses from the same pit were consistent, while differences occurred among different pits. However, Chen (2019) has suggested that these horse pits were not used for sacrificial rituals but were killed and buried in one single event because of some accidental events (such as external invasion or internal turmoil). I do not agree with this because this explanation is obviously far from the well-organized situation in horse pits.

Additionally, there is a report discussing the animal bones unearthed from ceramic ritual vessels buried within eight tombs in the Shuanglou Cemetery. According to the identification results, they were all partial skeletal remains of pigs. Among these, six units contained bones from suckling pigs, and two units contained bones from adult individuals. To reduce the volume of the bones so it could be placed inside the vessels, it was likely that the large bones underwent meat removal and smashing processes (Cao & Wang 2016).

Besides, other sacrificial horse burials occurred in the imperial mausoleum with the chariot were also widely discussed (Zhao 2004; Zhao 2007; Wang 2011).

Section 6 Discussion and Conclusion

1. Suitability of the area and the site

Xinzheng's exceptional natural conditions and rich cultural heritage have made it an ideal settlement habitat for people across different historical periods. This legacy dated to as early as 8,000 years ago during the Early Neolithic Age when the Peiligang culture thrived in the region. The Peiligang ancestors were engaged in primitive agricultural practices and livestock husbandry, leading a settled way of life (An 1979; Ren *et al.* 1984; Han 2021).

Around 5,000 years ago, during the middle and late Yangshao Culture period, numerous archaeological sites emerged in Xinzheng (Cai *et al.* 2005; Wei 2012). In the Late Neolithic age around 4,000 BC, nine Longshan Cultural sites, with the Gulongzhai site being the most prominent, were discovered. Gulongzhai site stood as the largest and best-preserved Late Longshan Culture city in the Central Plains (Cai& Ma 2002; Du 2010).

Transitioning into the Xia era, Xinzheng became a part of *Yu Zhou* 豫州. During the Shang Dynasty, it was located to the south of the Shang capital. Subsequently, in the Zhou Dynasty, Xinzheng was successively the capital of the states of Zheng and Han. An essential piece of evidence came from a pottery sherd found in a pottery-making workshop at Nengren Road, bearing two large seal script characters "Xin" "Zheng". This object, dating back to at least around 230 BC, verifies that this place was known as Xinzheng (Ma 2003). Throughout the subsequent historical period, Xinzheng remained a highly coveted and strategically significant region in the heart of the Central Plains, drawing the attention of rulers and military strategists.

Over the past five decades, scientific archaeological investigations and excavations in ZHGC have made remarkable progress. A comprehensive understanding of the distribution and significance of various archaeological remains and burial sites both within and outside

the city has gradually crystallized. Each passing year has seen the enrichment of research materials and the deepening of comprehension.

ZHGC was originally constructed in the early Spring and Autumn Period, with subsequent expansions and enhancements carried out by the State of Han during the Warring States Period. These developments resulted in a sprawling walled city characterized by high walls, deep moats, and formidable fortifications. Both the Zheng and Han city layouts adhered to the inner-outer city system.

The discovery of shrine and sacrificial site remains in both states aligns closely with literature records in terms of layout and cultural connotations. A variety of workshops were also uncovered, highlighting Zheng's exceptional proficiency in bronze casting and Han's reputation for highly advanced iron-casting technology among the vassal states.

From the perspective of burials, the mausoleums of high-ranking nobles and the chariot-horse pits of Zheng were located within the city limits. In contrast, Han's mausoleums were positioned on the outskirts of the capital. The abundant collection of bronze ritual vessels and musical instruments unearthed from tombs and sacrificial sites holds profound significance for the study of the ritual and funeral systems practiced in two states.

In conclusion, ZHGC stands as a remarkable archaeological site, characterized by its exceptional preservation, expansive scale, and well-defined layout. The long-term archaeological efforts conducted have yielded a diverse array of artifacts and substantial research achievements, which were endorsed by literary records and filled some blank at the same time. Undoubtedly, it is a rare and invaluable resource for the ancient urban archaeology.

2. Current research deficiency and envisage

At the same time, there are many shortcomings and deficiencies in the existing research of ZHGC. Referring to the literature review mentioned above, it is not difficult to find that there has been a conspicuous absence of archaeobotanical data and research published by now. This deficiency can be predominantly attributed to the historical context of the excavations. During the last century, Chinese archaeology was still in its nascent stage, and the recognition of the significance of micro-remains such as soil and plant seeds was lacking. Consequently, no systematic soil-sampling or related activities were introduced into the fieldwork, resulting in an absence of flotation for plant remains.

Similarly, although the quantity of faunal remains unearthed at various sites was quite considerable, zooarchaeological work has been in a relatively blank condition compared to other studies, especially compared to artifact research. Existing zooarchaeological research of ZHGC is mainly based on material description rather than in-depth discussions. It seems that most of the attention has been distracted by the horse skeletons buried in high-level tombs, overshadowing the relatively fewer studies dedicated to other animals, even though cattle and sheep are also symbols of class in the literature.

In addition, the current research displays a kind of tendency of focusing more on the burial and sacrificial animals of the elites, while overlooking the mundane meat consumption by the ordinary and common people. This inclination raises a critical concern, as it may inadvertently lead to historiographical approaches dominated by elitism or an upper-class perspective. To ensure a more comprehensive and equitable understanding of the past, it is crucial to emphasize the need for balanced zooarchaeological research that considers both elite and common dietary practices and foodways. This approach can help to offer a more holistic perspective on the dietary habits, livelihoods, and social structures of ancient inhabitants of the ZHGC.

Furthermore, the existing studies on faunal and human remains are frequently centered on materials from isolated sites. These studies, for the most part, lack comprehensive analysis, creating a fragmented and disconnected body of work. This situation isn't confined to the realm of bioarchaeological research; rather, it pervades various domains of ZHGC research. Presently, it appears that research in all aspects of the ZHGC is characterized by a kind of status of fragmentation, more or less.

But the fact we are confronting is that the discovery of ZHGC has witnessed the 100-year finding history and succession of generations of leadership. This brought two major challenges. The site itself, with its complicated layout, various features, substantial artifacts, as well as the replacement of two states, all make the site a super mega project. Another challenge came from some practical issues left over from history, such as the lack of early records, incomplete collection of archaeological materials, different names used before and after, countless document records, as well as a wealth of original data and materials are still waiting for sorting and recording.

All these intricacies and challenges cannot be ignored or dismissed. Therefore, studying the ZHGC from a comprehensive perspective remains an immensely demanding task. The resolution of these challenges is contingent upon the continuous and unwavering efforts of numerous dedicated archaeologists.

The last point to note is the use of historical literatures in the study of ZHGC. These documents can indeed be a valuable resource, providing evidence and direction for archaeological inquiries. However, this is a double-edged sword, they can also pose certain potential danger, including the risk of falling into the trap of "documentarianism" — that is, overly relying on written records and neglecting other archaeological evidence when solving problems.

In Chinese archaeology, there is a tradition of "archaeological works for supplementing history," which underscores the interplay between these two disciplines. The previous debate over "archeology as history vs. archaeology as anthropology" within the Chinese archaeological academia underscores the complexity of this relationship (which can be found in the Chapter One).

In archaeological research of historical periods, achieving a balance between historical documents and archaeological findings is a constant challenge. Researchers must strive to use historical literature as a tool to enrich their understanding, rather than being unduly influenced or constrained by it. This needs our more considerations.

CHAPTER 4 Materials

The research materials for this dissertation are derived from the animal bone assemblages excavated from a total of twelve excavation sites within the Capital City of Zheng and Han States (Zheng Han Gu Cheng, ZHGC), including 韩宗庙 (Han Zong Miao, HZM), 郑韩路 (Zheng Han Lu, ZHL), 二工局(Er Gong Ju, EGJ), 毛园民宅 (Mao Yuan Min Zhai, MYMZ), 供销社 (Gong Xiao She, GXS), 金城路 (Jin Cheng Lu, JCL), 房地产 (Fang Di Chan, FDC), 经发区 (Jing Fa Qu, JFQ), 烟厂 (Yan Chang, YC), 热电厂 (Re Dian Chang, RDC), 家属院 (Jia Shu Yuan, JSY), and 铸铜 (Zhu Tong, ZT) site. Apart from HZM and ZT, all these sites are named based on their modern place name during the archaeological excavation. The name of HZM means the Shrine of Han State, and ZT means bronze-casting workshop, so these two were named based on their archaeological contents. For the sake of convenience, the subsequent text will utilize abbreviations of the initial letters to refer to the site names.

Most of these excavations initially dated back to the 1990s. The limitations of the era have resulted in a lack of the scientific methodologies of archaeological excavation. In the twelve archaeological sites, the absence of systematic soil sieving and flotation unavoidably led to the loss of a significant number of small bone remains and plant samples. Thus, it is noted that these assemblages will likely be biased towards larger animals.

These twelve excavation sites are scattered across different locations within the ancient capital city. While some of the excavation sites may have adjacent geographical positions, they were excavated in different years, and their stratigraphic contexts and chronological periods varied. Therefore, we treat each of these twelve sites as independent archaeological entities to facilitate subsequent data collecting, calculations, and relevant quantitative analyses.

Clearly, this batch of research material constitutes a substantial and noteworthy sample size. To comprehensively present them, my first task is to provide detailed descriptions of the twelve archaeological sites, including their geographic locations, excavation history, stratigraphic and archaeological contexts, as well as other pertinent information.

Furthermore, given the complexity of the materials, it would be impractical to segregate the profile of the animal bone assemblages unearthed therein from the description of the excavation sites. Such an approach would create a disjunction in the article, hindering readers from establishing a close association between the faunal materials and their archaeological context.

Consequently, in this chapter, I intend to employ a framework whereby each of the twelve excavation sites serves as an individual section. Each site will be given an intra-site profile that encompass three core components: an introduction to the excavation (comprising its location, excavation process, stratigraphy, and chronology, along with significant artifacts and features), an introduction of the faunal assemblage (taxa, sex, age, etc.), and the preliminary quantitative results and analyses.

Finally, there will be an inter-sites section, Section 13, to summarize all these twelve sites and faunal assemblages found therein, integrating and comparing the data derived from the above twelve site sections. Some monographic summary, such as age, sex, traces, and pathology, will also be presented in this section because sometimes the data from single site is not large enough to have a statistical significance. I believe this general-specific-general structure is the best way to display a huge series of complicated data that contains the variety of location, periods, taxa and quantitative standards.

Due to the small number of animal bone specimens excavated at some sites and the limited availability of secondary information such as age structure and sex composition,

presenting this information separately for each site in every section may appear fragmented and sometimes lacks statistical and analytical significance. Therefore, details regarding the preservation condition, traces (including artificial marks and canine/rodent gnawing), pathology, and inter-sites/phases/taxa comparisons will all be put in Section 13 to be consolidated and analysed comprehensively from a big picture.

In the following introduction, different period stages and substages will be involved, which may bring some confusion for readers who are not familiar with Chinese historic chronology. Therefore, for the clearness and consistency of illustrating, I have compiled all the chronological stages covered in this chapter and the whole research as follows for easy reference (see **Table 4-0-1**). Among them, several stages were not included in the sequence coding due to their low occurrence frequency, instead, their names were directly used, for example, West Han, East Han, and Song strata only appeared at HZM, as well as Erlitou stratum only appeared at YC. For the frequently occurring stages, a code was employed for each stage for convenience throughout the paper. Furthermore, approximate absolute dates for each stage were provided.

Table 4-0-1
Chronological table of stages and corresponding absolute dating in ZHGC

Code	Stages	Absolute dating
Erlitou	Erlitou	1735 BC- 1530 BC
W. Zhou	West Zhou Dynasty	1046 BC- 771BC
I	Early Spring and Autumn Period	770 BC- 476 BC
I -1	anterior phase of Early Spring and Autumn Period	
I -2	posterior phase of Early Spring and Autumn Period	
II	Mid Spring and Autumn Period	
II -1	anterior phase of Mid Spring and Autumn Period	
II -2	posterior phase of Mid Spring and Autumn Period	
III	Late Spring and Autumn Period	
III -1	anterior phase of Late Spring and Autumn Period	
III -2	posterior phase of Late Spring and Autumn Period	
IV	Early Warring States Period	547 BC - 221 BC

V	Mid Warring States Period	
V-1	anterior phase of Mid Warring States Period	
V-2	posterior phase of Mid Warring States Period	
VI	Late Warring States Period	
VI-1	anterior phase of Late Warring States Period	
VI-2	posterior phase of Late Warring States Period	
W. Han	West Han Dynasty	202 BC- 9 BC
E. Han	East Han Dynasty	AD 25- 220
Song	Song Dynasty	AD 960- 1279

Note: Regarding absolute dating, only information about two major time periods, the Spring and Autumn Period (SAP) and the Warring States Period (WSP), was provided here. This is because, in practice, the substages and sub-substages within these two periods were archaeologically divided based on pottery typology, that level of absolute dating information cannot be given. Moreover, while there might be slight discrepancies in specific time nodes, such as the starting and ending time of Erlitou, and the dividing time between SAP and WSP, these differences do not affect the integrity of our research.

The sequence of presenting the twelve sites will adhere to their relative geographic locations, proceeding from west to east ordinally: 1. HZM; 2. ZHL; 3. EGJ; 4. MYMZ; 5. GX5; 6. JCL; 7. FDC; 8. JFQ; 9. YC; 10. RDC; 11. JSY; 12. ZT (referring to **Figure 4-0-1**).

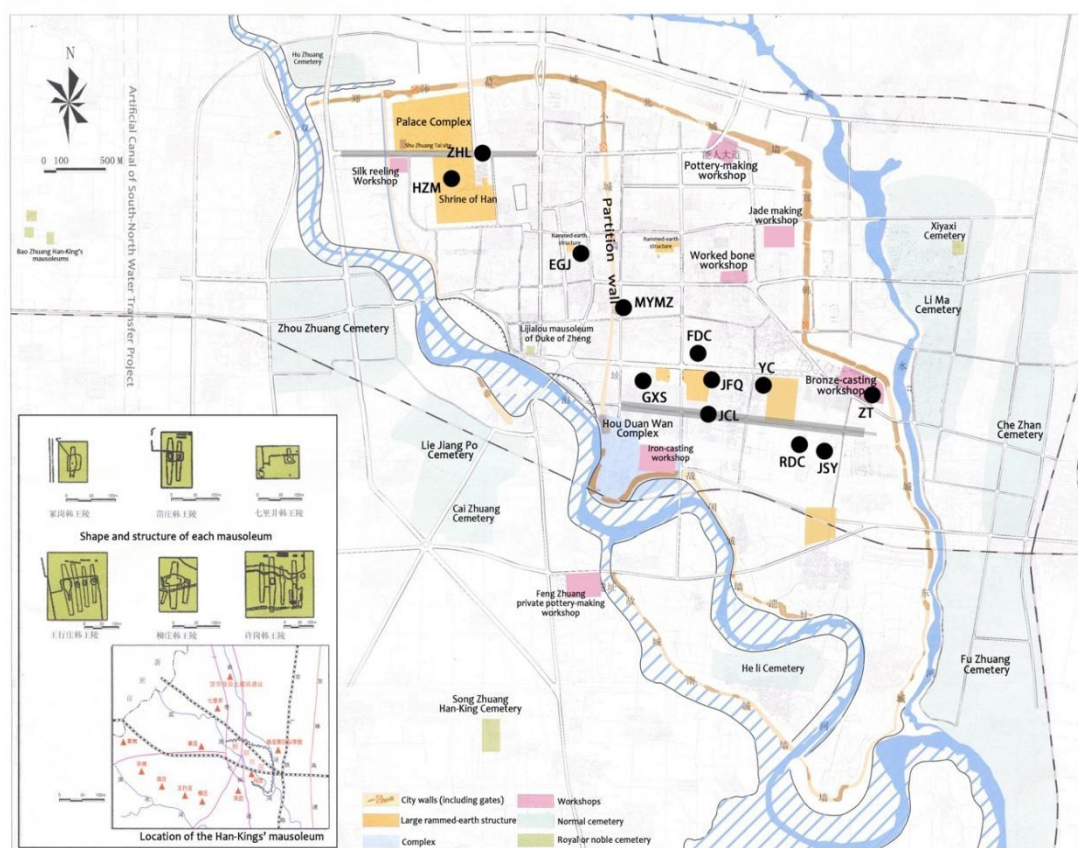


Figure 4-0-1. The layout of twelve sites in the ZHGC.

Section 1 韩宗庙 Han Zong Miao (HZM)

1. Excavation

The HZM (abbreviation of *Han Zong Miao*, means the shrine temple of Han State) site is located in the southern part of the western city (inner city), slightly to the east (**Figure 4-1-1**). In 1963, extensive archaeological coring investigations were conducted by Xinzheng Archaeological Unit in ZHGC. During this exploration, a complex of Warring States period, approximately 500 meters east-west and 320 meters north-south, was discovered. Inside the complex, a large, rammed earth structure foundation with an area of about 10,000 square meters was found. At that time, the excavators believed it to be a noble palace and named it the "Palace Area".

To accurately delineate the defended area of this palace area, from 1997 to 1998, a total of 28 10×10-meter trial excavation units, two 5×3 units, three 10×2 meter trenches, as well as one 3×3, one 4×4, one 6×6, and one 9×9 unit were excavated, covering a total excavation area of 3226 square meters. The cultural layers included the Eastern Hàn layer, Western Hàn layer, and the rammed earth foundation from the mid-Warring States period, measuring 114 meters north-south and 97 meters east-west. In some places, there are extremely thin, patchy layers from the late Warring States period.

An important discovery within unit T3089 is a huge uncarved stone monument, located at the center of the platform. According to the location of this site, which is directly in front of the Han Kingdom palace, and the pottery inscriptions found, this site was thought to be the shrine temple of the Han State and renamed as HZM. Most of unearthed remains were dated to the Hàn Dynasty, including ash pits, wells, roads, pottery kilns, and sporadic burials. Relatively few artifacts and animal bones from the Eastern Zhou period were unearthed.

Based on features of the site, it is speculated that the buildings at this location were destroyed during the Qin conquest of Han, and subsequently abandoned. During the Hàn

Dynasty, numerous kilns were continuously built in the area, to make bricks and tiles, completely altering and destroyed the original rammed earth foundation from the Eastern Zhou period.

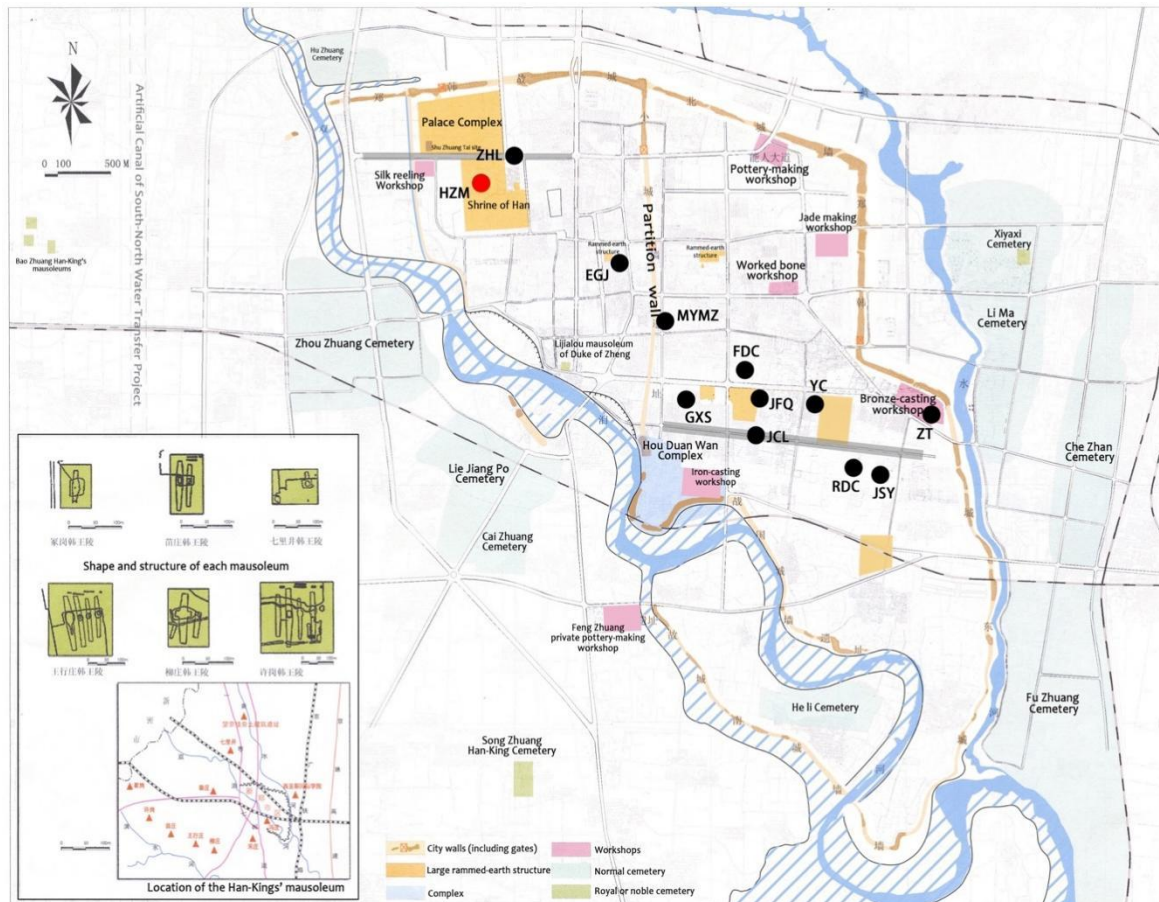


Figure 4-1-1. The location of HZM site (red dot).

2. Faunal Assemblage Profile

The animal bone remains unearthed at HZM amount to a total of 56 specimens, with a combined weight of 2695.6 grams. These bones can be attributed to four different periods. In the Middle Warring States stage, there were 2 specimens with a total weight of 16.7 grams; the Western Han period yielded 12 specimens weighing 548.1 grams; the Eastern Han stage provided 40 specimens, weighing 2062.3 grams; and 2 specimens were from the Song dynasty, weighing 68.5 grams.

All the excavated faunal remains belong to medium or large-sized mammals. Among the medium-sized mammal remains, there were 27 specimens. The identifiable species included dogs, pigs, sheep/goats, and deer, with pigs being the most prevalent. As for the large-sized mammal remains, there were 29 specimens, with identifiable species being cattle and horses, with cattle being predominant.

Regarding the archaeological context, the animal bone remains from this site were found in four different archaeological features. 19 specimens were unearthed from stratigraphic layers, 17 from ash pits, 18 from test pits, and 2 from the rammed earth of the stone stele.

In terms of quantitative analysis, calculation results of Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI) are summarized as **Table 4-1-1**. The NISP for all the remains adds up to 27, accounting for 48.2% of the total. It is obvious that both NISP and MNI reached their highest values in the Eastern Han period. Additionally, among all animal species, pigs exhibited the highest NISP (17, accounting for 68%) and MNI (6, accounting for 67%) values (**Figure 4-1-2**). The MNI for pigs was determined by mandibles, and the age distribution of six pig individuals are as follows: one aged 12-14 months, one aged 16-17 months, one aged 17-19 months, two aged 20-21 months (one is male), and one aged older than 27 months.

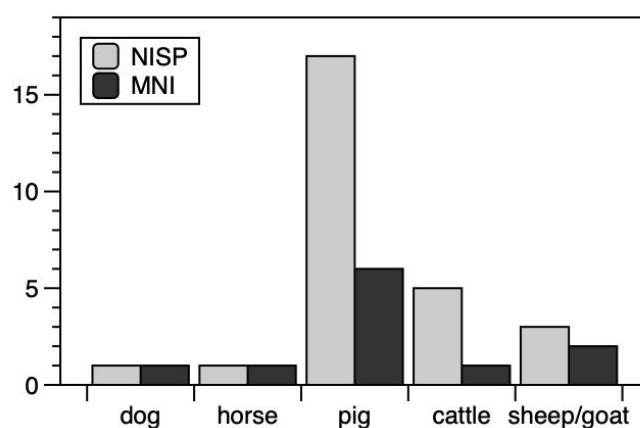


Figure 4-1-2. The number distribution of the taxa at HZM.

Table 4-1-1*Summary of NISP and MNI of the faunal assemblage at HZM*

Taxa	W. Han		E. Han		Song	
	NISP	MNI	NISP	MNI	NISP	MNI
<i>Canis familiaris</i>	0	0	0	0	1	1
<i>Equus caballus</i>	0	0	1	1	0	0
<i>Sus scrofa</i> sp.	0	0	17	6	0	0
<i>Bos taurus</i>	0	0	5	1	0	0
Caprinae (<i>Capra/Ovis</i>)	1	1	2	1	0	0
Total (stage)	1	1	25	9	1	1
Total (whole site)	NISP=27, MNI=11					

Section 2 郑韩路 Zheng Han Lu (ZHL)

1. Excavation

The ZHL site is located in the northern part of the western city (inner city), more than 600 meters north of the inner city's north wall. Although the map only marks a single point location, the actual excavation area extends along the east-west road indicated, measuring 1,400 meters east-west and 58 meters north-south (**Figure 4-2-1**).

Excavation began on April 8, 1995, and concluded on August 9 of the same year. Thirteen units were excavated, uncovering 30 burials from the Spring and Autumn to the Song Dynasty, eight Eastern Zhou ash pits, two wells, a section of the west wall of the palace area with city gate, a road, and a segment of the outer moat. Additionally, a silk-spinning and textile workshop was discovered. The majority of the features are from the Warring States period, with fewer from the Spring and Autumn period.

One important discovery of this excavation is the identification of the west wall and gate from the Warring States period, as well as the road leading to the inner city. Furthermore, the silk-spinning and textile workshop found on the south side of the road outside the west city is extremely rare among the Eastern Zhou states. It is not only the first one to be found but also remarkably well-preserved, making it highly significant. However, the site yielded relatively few animal bones.

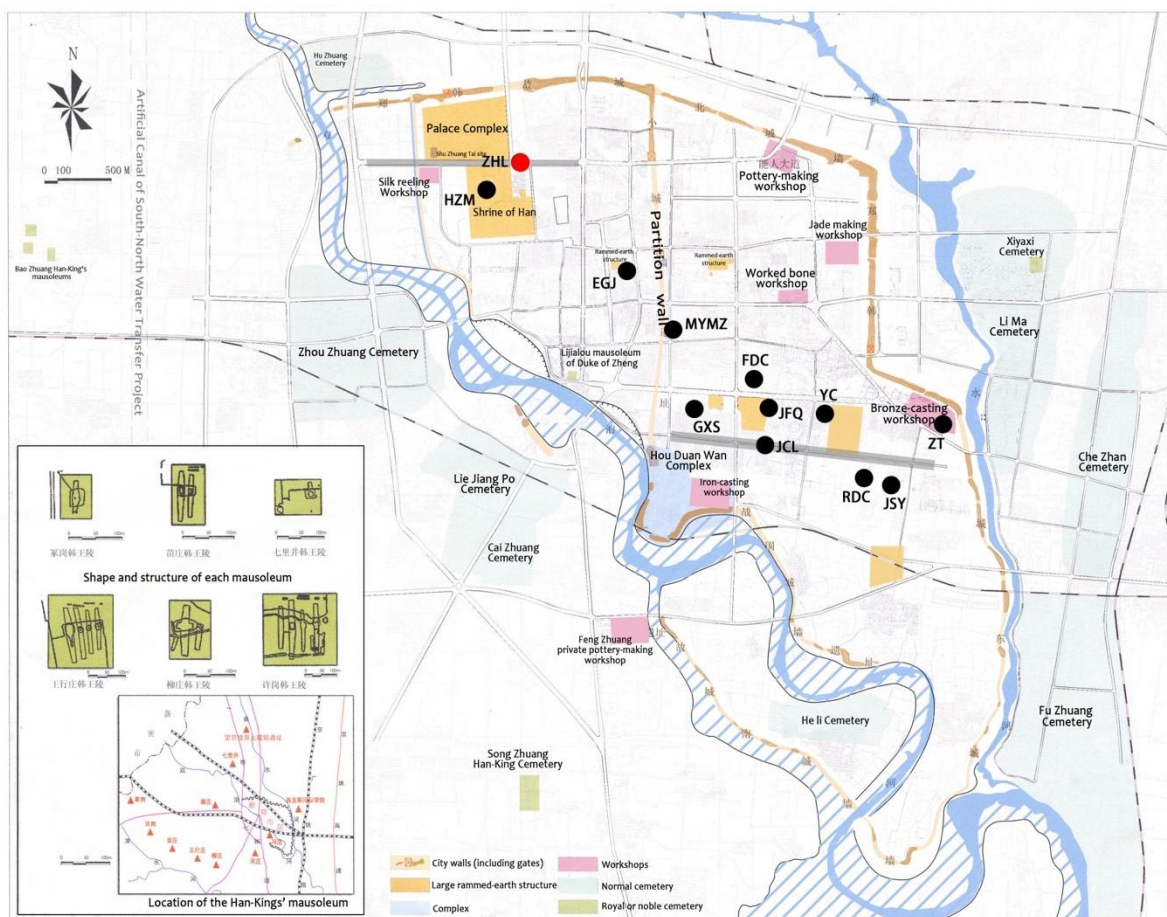


Figure 4-2-1. The location of ZHL site (red dot and the grey part).

2. Faunal Assemblage Profile and Quantitative Results

The faunal assemblage found at ZHL comprises a total of 14 specimens, with a combined weight of 1,536.4 grams, among which NISP is 8, accounting for 57.1%. The recognized animals include pigs, sika deer, large deer, cattle, and Caprinae. The assemblage's number distribution of taxonomical and chronological classifications can be clearly demonstrated in **Figure 4-2-2** and **Table 4-2-1**. The animal remains at this site are notably scarce, with sporadic occurrences and relatively even distributions across each stage and species. Regarding the archaeological context, the animal bone remains from this site was found in either layer (3, accounting for 21.4%) or ash pit (11, accounting for 78.6%).

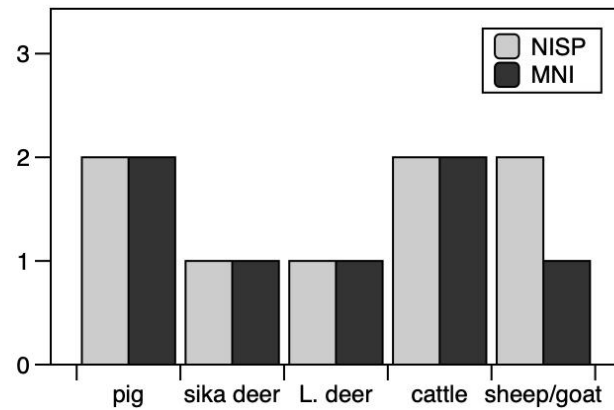


Figure 4-2-2. The NISP and MNI distribution of the taxa at ZHL. "Large-sized deer" is abbreviated as "L. deer".

A few specimens are worthy of some individual elaboration. Within the T53 H144 of the stage IV, one horn core of goat was sawed off at the root as raw material (**Figure 4-2-3-B**), one right mandible with P3-M3 of Caprinae aged 3-4 years old, and one pig right mandible with dp3-M1 aging 5-6 months old. In addition, one right mandible with dp2-M1 aging 5-6 months old. In addition, one right mandible with dp2-M1 (M1 is erupting) of large deer from H144 has been taken photo as a reference sample (**Figure 4-2-3-A**).

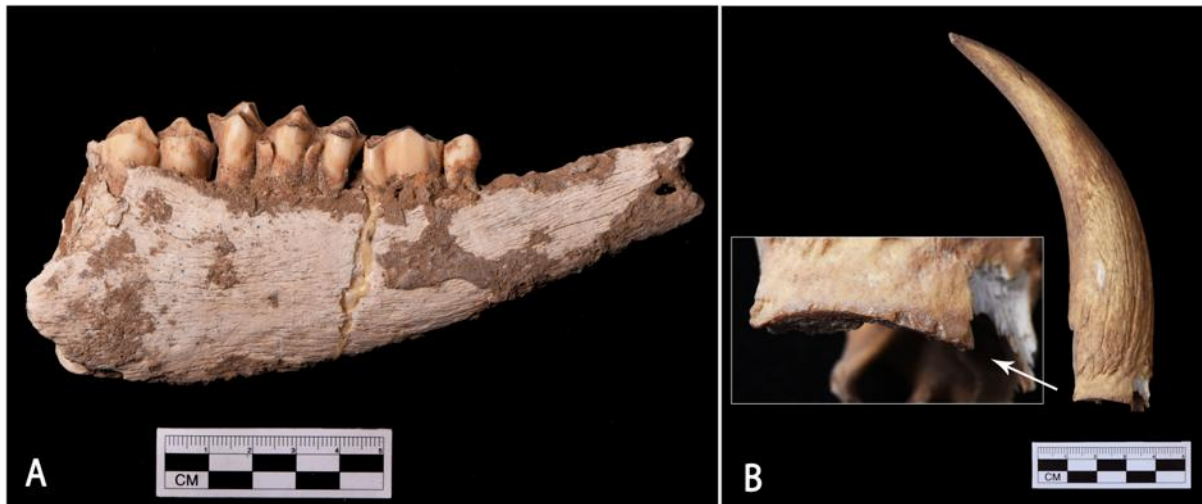


Figure 4-2-3. A: mandible with lower dp2-M1 (R) of large deer (T53 H144 ZHL). B: horn core of *Capra aegagrus hircus* (domestic goat) (T53 H144 ZHL). Smooth sawing mark at the root indicates that this is a piece of raw material for handicraft.

Table 4-2-1.
Summary of NISP and MNI of the faunal assemblage at ZHL

Taxa	IV		V		VI	
			V -2		VI -1	
	NISP	MNI	NISP	MNI	NISP	MNI
<i>Sus scrofa</i> sp.	1	1	0	0	1	1
<i>Cervus nippon</i>	0	0	1	1	0	0
Large-sized Cervidae	1	1	0	0	0	0
<i>Bos taurus</i>	2	2	0	0	0	0
Caprinae (<i>Capra/Ovis</i>)	2	1	0	0	0	0
Total (stage)	6	5	1	1	1	1
Total (whole site)	NISP=8, MNI=7					

Section 3 二工局 Er Gong Ju (EGJ)

1. Excavation

The EGJ site is in the central-northern part of the eastern city (outer city), close to the partition wall to the east (**Figure 4-3-1**). This area, originally used for vegetable cultivation, features relatively flat terrain. In 1990, drilling exploration revealed remains of ash pits and rammed earth foundations in Eastern Zhou. From July to August 1991, the Xinzheng Archaeological Unit conducted a re-examining excavation, and four 10x10 meter units were designated. The excavation at this site marked the first discovery of extensive rammed earth foundations, along with seven small sacrificial pits with animal skeletons in it. The excavators speculated that this area possibly served as a ceremonial architectural site.

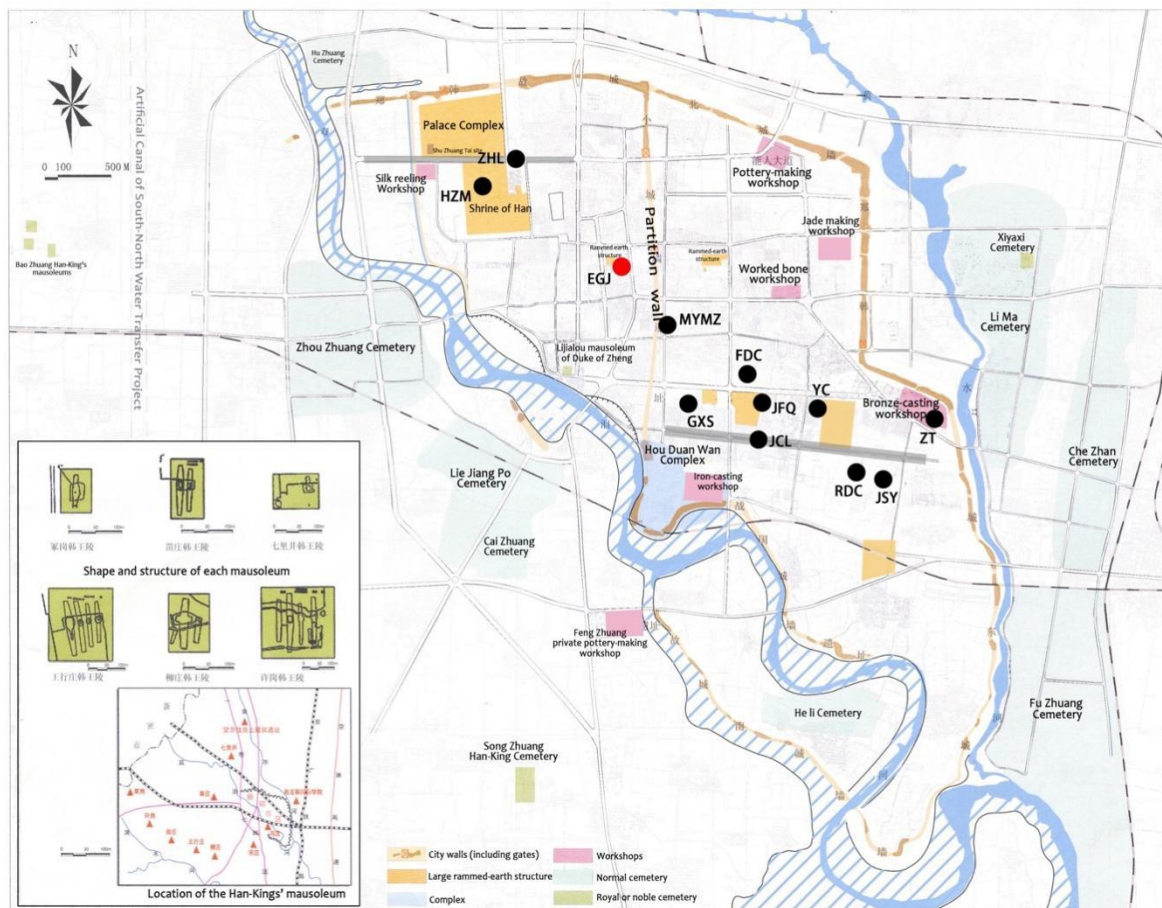


Figure 4-3-1. The location of EGJ site (red dot).

2. Faunal Assemblage Profile

The total number of faunal remains unearthed at EGJ is 716, with a combined weight of 21,221 grams.

The finding of animal bones at this site only appeared in the stage Ⅲ, Ⅳ, and Ⅵ. There were 7 specimens weighing 176 grams in stage Ⅲ; 624 specimens weighing 18,122 grams in stage Ⅳ; and in total 85 specimens weighing 2,923 grams in stage Ⅵ.

From the perspective of the taxa, apart from one piece of debris that cannot tell taxon and two possible small-sized mammal ribs, the rest belonged to either medium-sized or large-sized mammals. The total number of medium-sized mammal remains was 284 (6,448 grams), with identifiable species including dogs, pigs, small deer, middle deer, and Caprinae, among which pigs were still the most predominant. As for the large-sized mammals, there are 429 specimens (14,740 grams), with identifiable species being horses and cattle, the overwhelming majority of which were cattle.

Regarding the excavation context, the faunal remains were found in three kinds of archaeological features including strata, ash pits, and foundation base pit. In total of 119 specimens were unearthed from diverse strata (16.6%), 185 specimens from ash pits (25.8%), and 410 specimens from foundation base pits (57.3%). Animal bones excavated from the foundation base pits will be paid more attention because they possibly resulted from the ritual usage related to the structure building practices.

3. Quantitative Results

The calculation results of NISP and MNI of EGJ are summarized as **Table 4-3-1**.

The NISP for all the remains adds up to 642, accounting for 89.7% of the total. This NISP ratio was relatively higher compared to other sites. I believe this is not due to any uniqueness in this batch of materials but rather stems from differences between zooarchaeologists. For the whole identification work of EGJ and a part of the upcoming YC

site, they were completed with the assistance of another colleague. During the process of integrating the database, I noticed that in cases where there were ambiguities in species identification, such as with ribs, vertebrae, or broken bones, my identification style tends to be more conservative. Although I might have a general impression that a particular specimen most likely belongs to a specific species, due to the lack of clear identifying features, I often tend to categorize it into a higher taxonomic level for a safer classification. By contrast, my colleague's style was more aggressive, of course, it is possibly because of his superior identification skills. As a result, this site showed a higher proportion of identifiable specimens, and the same phenomenon may apply to the YC site as well.

Both NISP and MNI reached their highest values during the stage IV mainly because all sacrificial pits with abundant faunal assemblages all came from this phase. The detailed information concerning the age/sex of pigs and cattle within the stage IV and VI will be given as follows.

Pigs (*Sus scrofa* sp.). The total number of pigs bones excavated from the stage IV was 202, representing a minimum of ten distinct individuals, among which two were female individuals. Seven individuals that can be age estimated consisted of four aged 16-17 months old, two aged 24-26 months old, and one aged over 27 months old. Four individuals from the stage VI included one aged 10-12 months old, one aged 12-14 months old, one aged 20-21 months old, and one aged over 27 months old.

Cattle (*Bos taurus*). The 304 cattle bones from the stage IV revealed the appearance of seven individuals, where six individuals that can be aged, including one 0-6-month-old calf, one 5-18-month-old juvenile, two 16-28-month-old young adult, one aged 40 mon.-6.5 yrs. old, and one 5-10-year-old elder individual.

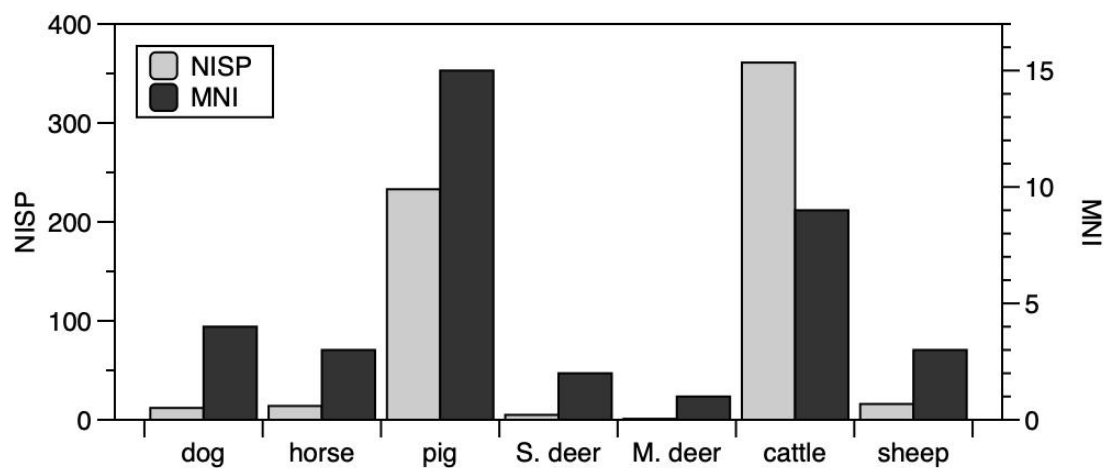


Figure 4-3-2. The number distribution of the taxa at EGJ. "Small-sized deer" is abbreviated as "S. deer", similarly, "middle-sized deer" as "M. deer".

Table 4-3-1.
Summary of NISP and MNI of the faunal assemblage at EGJ

Taxa	III		IV		VI	
	NISP	MNI	NISP	MNI	NISP	MNI
<i>Canis familiaris</i>	1	1	8	1	3	2
<i>Equus caballus</i>	1	1	12	1	1	1
<i>Sus scrofa</i> sp.	2	1	202	10	29	4
Small-sized Cervidae	0	0	4	1	1	1
Middle-sized Cervidae	0	0	1	1	0	0
<i>Bos taurus</i>	2	1	340	7	19	1
<i>Ovis aries</i>	0	0	11	2	5	1
Total (stage)	6	4	578	23	58	10
Total (whole site)	NISP=642, MNI=37					

Section 4 毛园民宅 Mao Yuan Min Zhai (MYMZ)

1. Excavation

The MYMZ site is located in the central-western part of the eastern city (outer city) of ZHGC, including a section of the partition wall (**Figure 4-4-1**). It was originally surrounded by residential houses on the east, west, and north sides, and the terrain was flat. Early coring work revealed scattered rammed earth wall foundations here. From August 1997 to March 1998, the Xinzheng Archaeological Unit conducted an exploratory excavation by opening a 35-meter-long trench to dissect the wall.

The rammed earth wall uncovered in this excavation should be a segment of the partition wall separating the eastern and western cities. Although it has been extensively damaged by several Song Dynasty pottery kilns, the excavation revealed that there were two late Spring and Autumn period foundation pits underneath the wall. These pits suggest that there was a preparation phase involving levelling the ground before constructing the wall, which indicates that the construction of this partition wall had been planned during the late Spring and Autumn period. In preparation, the ground was levelled and compacted, with pristine soil as the base for the construction. If the ground was uneven, it would be filled and compacted to create a smooth surface before walling.

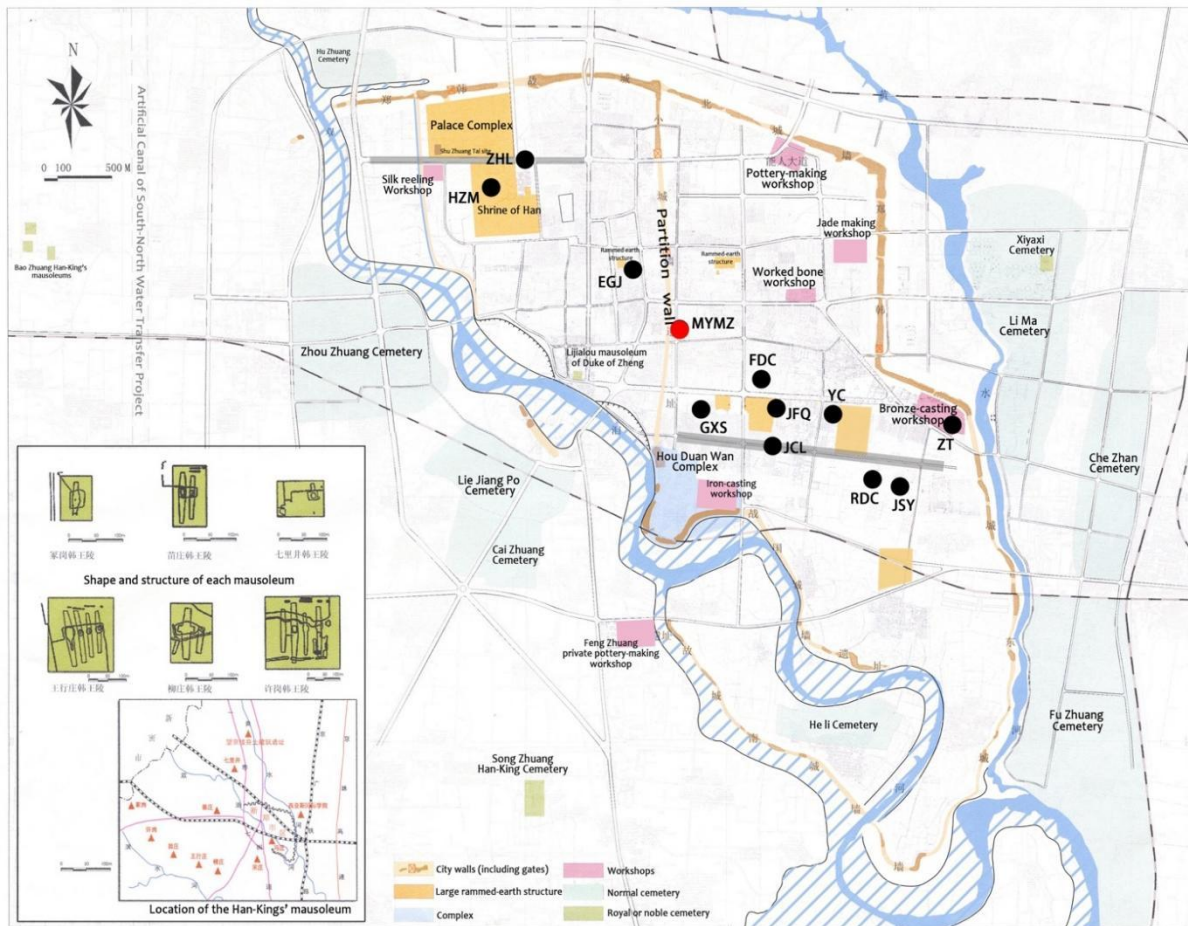


Figure 4-4-1. The location of MYMZ site (red dot).

2. Faunal Assemblage Profile and Quantitative Results

The amount of faunal material at MYMZ is quite small, containing a total of only 16 specimens weighing 1647.9 grams. The taxa composition is quite simple as well, including five pig specimens (including one left mandible with C and M3, three mandible fragments, and one right tibia) representing at least one individual aging 20-21 months old; one left scapula of Caprinae; seven cattle specimens (including one left mandible with M2-M3, one right mandible with P4-M3, one mandible fragment, two pelvic bones, one metacarpal, one right proximal femur) representing at least two individuals, one of which was aged 26-36 months old. The rest three specimens belonged to unidentifiable large mammals.

As far as the archaeological context, as previously discussed, the core accumulation at this site comprised a section of rammed earth city wall. Consequently, all animal bone remains derived from the rammed earth dating back to the early Warring States period.

The question of why these animal bones were found within the rammed earth raises inquiries of answering at which stage they were introduced: during the earth-borrowing process, mixed in during ramming, or left as refuse during the city wall's use? Precise answers to this question have yet to be provided by the excavators.

From my point of view, establishing the chronological relationship between the appearance of animal bone remains and the construction of the rammed-earth city wall is crucial, as archaeologists determined the dating information of the animal remains mainly based on the construction timing of the wall foundation. However, in practice, it is very possible that the consumption and deposition of animal bones did not necessarily coincide with the construction of the city wall. Thus, I tend to keep cautious consideration when using these specimens as they might have some dating error. However, given the limited quantity of specimens, despite their possible inherent limitations, their impact on our mass-data macroscopic analysis of the entire capital city is likely to be marginal.

As a result, in the subsequent horizontal and vertical analyses of overall city, these specimens will continue to be incorporated within the purview of our study.

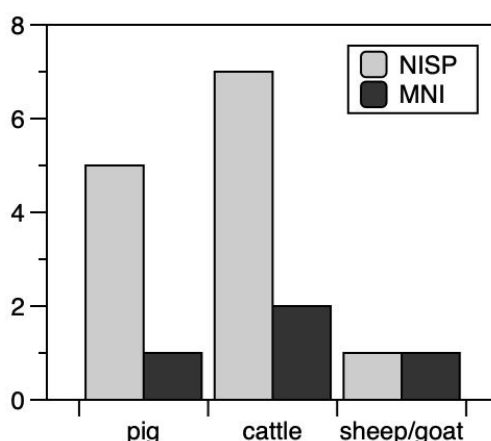


Figure 4-4-2. The number distribution of the taxa at MYMZ.

Table 4-4-1*Summary of NISP and MNI of the faunal assemblage at MYMZ*

IV		
Taxa	NISP	MNI
<i>Sus scrofa</i> sp.	5	1
<i>Bos taurus</i>	7	2
Caprinae (<i>Capra/Ovis</i>)	1	1
Total	13	4

Section 5 供销社 Gong Xiao She (GXS)

1. Excavation

The GXS site is situated in the central part of the eastern city (outer city), adjacent to Jincheng Road (JCL) to the south and adjacent to the Bank of China Sacrificial Site to the southeast (**Figure 4-5-1**). The site area measures 107 meters in length from north to south, 92 meters in width from east to west, with a total area of 9,844 square meters. Excavations were conducted from July 1999 to January 2000, covering 13 units and one trial trench. The discovered features mainly consisted of Spring and Autumn period and Warring States period ash pits and wells, with a large quantity of animal bones unearthed.

Two significant discoveries were made during this excavation. Firstly, the finding and identification of the exceptionally large grain storage pit, H822, where at the bottom, reed mats, wooden boards, and carbonized grains of millet were found. This finding provided a critical clue for locating the recorded "Cang Cheng" (Barn City), and later, based on this, archaeologists discovered the exact location of this, which is just over 300 meters south of this site. Additionally, a pit containing ledgers inscribed with ink-writing on ox ribs was unearthed here, and the results of interpreting the inscriptions have been published (Cai 2014).

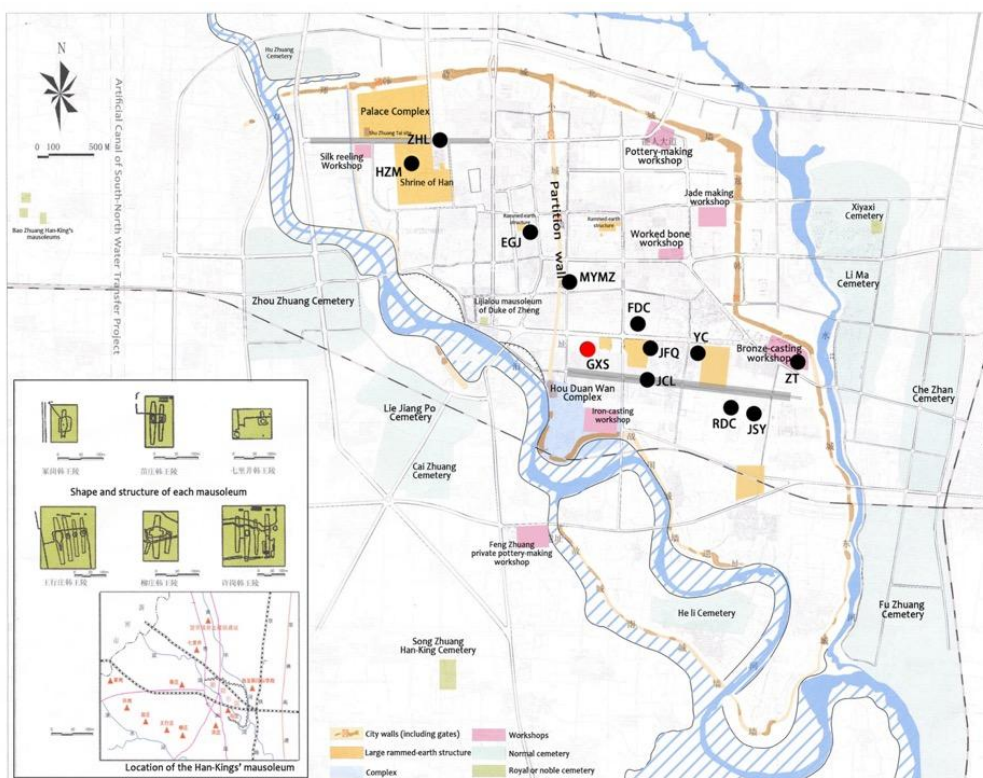


Figure 4-5-1. The location of GXS site (red dot).

2. Faunal Assemblage Profile

GXS has a very large faunal assemblage, with a total of 3,348 animal bone remains excavated from this site, weighing 160,790.1 grams, which is the largest data volume among twelve sites. Additionally, four human bones, including three cranial fragmentations and one leg bone, were found from strata and pits, which were not counted in our following statistics.

In terms of stages, the finding of animal bones occurred across the entire Eastern Zhou period (from the stage I to stage VI). The specific number distribution is as follow. A total of 795 specimens were found from stage I, weighing 41,916.6 grams. There were 473 specimens with a total weight of 21,549.7 grams in the stage II. An assemblage of 377 specimens weighing 25,832 grams were unearthed in stage III; 64 specimens weighing 4,025 grams in stage IV; 27 specimens weighing 3055.5 grams in the phase V. Furthermore, the stage VI had the most substantial harvest, with 1592 specimens weighing 64,411.3 grams being excavated.

Concerning the taxa, GXS is also featured by the highest diversity of faunal remains among twelve sites, including freshwater mollusc, fish, reptile, birds, small-, medium-, and large-sized mammals. After 13 fragments that cannot be identified to taxon are excluded, the number distribution of various taxa is listed as follows. There are 8 specimens of freshwater molluscs which can be identified as *Cuneopsis*, *Hyriopsis cumingii* (freshwater pearl mussel) (**Figure 4-5-2-A**), and *Lamprotula*. There are 9 ichthyic specimens of freshwater species unearthed, where two specimens belong to the fragmented scute of *Acipenser sinensis* (Chinese sturgeon), which would be introduced separately later. The specimens of reptile come from *Pelodiscus sinensis* (Chinese softshell turtle), among which one is the plastron (**Figure 4-5-2-B**) and three are carapace fragments. The six bird class specimens consist of three *Gallus gallus domesticus* (domestic chicken) specimens (**Figure 4-5-2-C/D**) and three *Anser cygnoides* (domestic goose) specimens (**Figure 4-5-2-E/F**), which were all found from the stage VI. There are only five specimens from the range of small-sized mammals, including one badger's mandible (**Figure 4-5-3-B**) and two rabbit pelvic bones (**Figure 4-5-3-D**). The total number of medium-sized mammal remains is 1,984 (66,566.8 grams), with identifiable species including dog, pig, river deer, sika deer, sheep/goat, and likely tiger, among which pigs are the most predominant. The astragalus of tiger will be discussed separately as following. As for the large-sized mammals, there are 1,318 specimens (92816.8 grams), with identifiable species being Père David's deer, cattle (**Figure 4-5-3-H**) and horses, among which cattle are the most predominant.

Regarding the archaeological context, the animal bone remains from this site were found in five kinds of archaeological features including strata, pits, wells, ditch, and the burial. There were 1,100 specimens unearthed from strata (32.9%), 1,786 specimens from diverse ash pits (53.3%), which is the largest part, 435 specimens from well features (13.0%), 20 specimens from the ditch G1 (0.6%), and 9 specimens from the burial M147 (0.3%).



Figure 4-5-2. Portfolio of specimens from taxa of mollusk, reptile, and bird at GXS. (A): *Hyriopsis cumingii* (freshwater pearl mussel). Ventral rim. Stage II. (B): *Pelodiscus sinensis* (Chinese softshell turtle). Plastron. Stage I. (C): *Gallus gallus domesticus* (domestic chicken). Femur (R). Stage VI. (D): *Gallus gallus domesticus* (domestic chicken). Keel (carina). Stage VI. (E): *Anser cygnoides* (domestic goose). Distal tibia. Stage VI. (F): *Anser cygnoides* (domestic goose). Distal ulna (L). Stage VI.



Figure 4-5-3. Portfolio of mammal assemblage at GXS. (A): *Sus scrofa* sp. (pig). Female. A pair of mandibles with dentition. (B): *Meles leucurus* (Asian badger). Mandible with P3-M1 (L). Stage I. (C): *Sus scrofa* sp. (pig). Male. Maxillary with I1-I3, C, P1-M1(R). (D): *Lepus* sp. (rabbit). Two hip bones (R). Stage VI. (E): sheep skull. (F): *Sus scrofa* sp. (pig). Scapula (L). (G): *Ovis aries* (sheep). Horn core (R). (H): *Bos taurus* (cattle). Broken skull with a pair of horn cores. (I): *Cervus nippon* (sika deer). Stag. A complete antler.

3. Quantitative Results

The calculation results of NISP and MNI of JCL are summarized as **Table 4-5-1**.

The NISP for all the remains adds up to 1908, accounting for 57.0% of the total.

Among stages, it is obvious that both NISP and MNI reached their highest values during the

stage VI, and then I and II followed. These top three stages were all dominated by pigs and cattle. In terms of taxa diversity, the stage II was the highest with 13 identifiable species being found, and stage I and VI followed closely, with 12 different species being found. When talking about the quantitative performance of different animals, the Figure 4-5-5 clearly illustrated that pig had the unparalleled predominance from the dimension of both NISP and MNI, cattle followed, then was followed by sheep/goats, dogs and sika deer also had relatively good totals. Following, I will provide detailed quantitative/age/sex introductions for pig, cattle, and Caprinae successively.

Pigs (*Sus scrofa* sp.). The quantitative data for pigs are obviously the most significant, with the largest NISP and MNI. In the stage I, minimum 24 individuals were represented by 210 specimens. There were several specimens that might belong to wild boars based on the morphological characteristics. However, we do not separate them here. Among the 24 individuals, there were eight females and five males, and 20 individuals can be aged, including one individual aged 4-5 months old, four aged 9-10 months old, three aged 12-14 months old, one aged 17-19 months old, seven aged 20-26 months old, and four aged over 27 months. Within stage II, according to the mandible's MNE, 149 specimens revealed the presence of at least 19 individuals, including two females and three male individuals. The age distribution was the following: two individuals aged in the stage starting at birth, one aged 2-4 months old, two aged 4-5 months old, two aged 5-6 months old, two aged 9-10 months old, one aged 12-14 months old, two aged 16-19 months old, three aged 20-23 months old, two aged 24-26 months old, and two aged over 27 months old. In stage III, the MNI was calculated as 10 based on the left humeri specimens. There were five individuals that can be age estimated, including one aged 12-14 months old, one aged 17-19 months old, one aged 20-21 months old, and two aged older than 27 months. In the stage IV, there were only 11

specimens representing a minimum of two individuals, aging 9-10 months old and 24-26 months old (male) separately. During the phase V , three right humeri indicated the presence of at least three individuals, within which there was one aged 12-14 months old. The stage VI yielded the highest number of pig specimens, totalling 448, representing at least 53 individuals. Among these, 20 were male and 12 were female individuals, and 45 individuals can be ageing estimated, the age distribution of this pig group is illustrated in the **Figure 4-5-4** to demonstrate it vividly due to the large data mass.

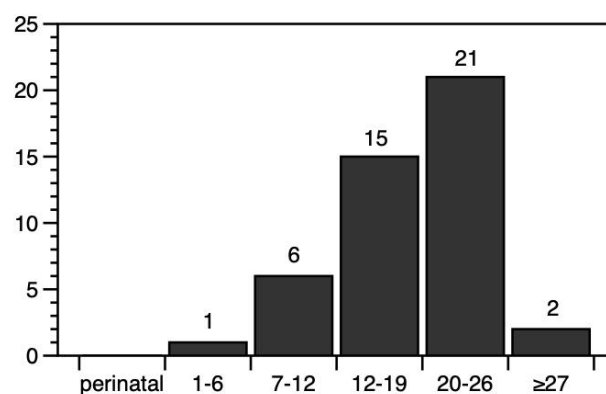


Figure 4-5-4. The age distribution of 45 pig individuals of stage VI at GXS site.

Cattle (*Bos taurus*). In the stage I , there were a minimum of ten individuals. Based on teeth specimens, they included one juvenile individual aged 5-18 months old, one aged 16-28 months old, one aged about 5-10 yrs. old, and one senile individual aged 7-20+ yrs. old. Within stage II , at least four individuals were represented by the 58 specimens, among which one was aged 16-28 months old. In stage III , the MNI was four, with two individuals which can be age estimated, including one aged 5-18 months old and one aged 26-36 months old. In the stage IV , the MNI was one, which was aged 5-10 yrs. old. During the phase V , the one individual was aged 16-28 months old. The stage VI is the most abundant one, with 212 specimens indicating the existence of a minimum of 14 individuals.

Caprinae (*Capra/Ovis*). In the stage I , according to the right tibias, there were 34 specimens representing at least four individuals, with two individuals aged 6-12 months old. Within stage II , a minimum of three individuals were represented. During the stage III , there were 19 Caprinae specimens found, indicating the presence of four individuals, including one aged 1-2 yrs. old, one aged 3-4 yrs. old, and two aged 6-8 yrs. old. In the stage IV and V , there was only one and two specimens separately. The stage VI is still the most abundant one, with 83 specimens representing a minimum of 26 individuals. This large MNI figure was caused by the finding of relatively abundant mandible specimens from strata and pits. These individuals were composed of seven individuals aged 1-2 yrs. old, two aged 2-3 yrs. old, five aged 3-4 yrs. old, one aged 4-6 yrs. old, six aged 6-8 yrs. old, and five aged 6-12 yrs. old.

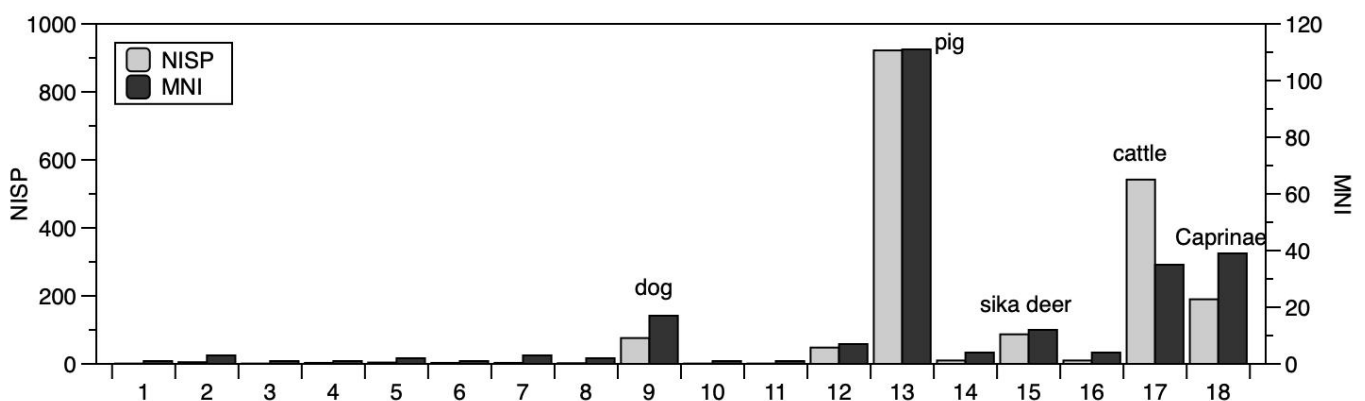


Figure 4-5-5. The NISP and MNI distribution of the taxa at GXS. Several species with conspicuous values have been labeled in the chart, the animal categories represented by the numbers correspond as follows: 1- Cuneopsis; 2- freshwater pearl mussel (*Hyriopsis cumingii*); 3- Lamprotula; 4- Chinese sturgeon (*Acipenser sinensis*); 5- softshell turtle (*Pelodiscus sinensis*); 6- chicken (*Gallus gallus domesticus*); 7- goose (*Anser cygnoides*); 8- rabbit (*Lepus* sp.); 9- dog; 10- Asian badger (*Meles leucurus*); 11- tiger (*Panthera tigris*); 12- horse (*Equus caballus*); 13- pig (*Sus scrofa* sp.); 14- Chinese water deer (*Hydropotes inermis*); 15- sika deer (*Cervus nippon*); 16- Père David's deer (*Elaphurus davidianus*); 17- cattle (*Bos taurus*); 18- Caprinae (*Capra/Ovis*).

Table 4-5-1

Summary of NISP and MNI of the faunal assemblage at GXS

Taxa	I		II		III		IV		V		VI	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Cuneopsis</i>	0	0	1	1	0	0	0	0	0	0	0	0
<i>Hyriopsis cumingii</i>	2	1	2	1	0	0	0	0	0	0	1	1
<i>Lamprotula</i>	0	0	1	1	0	0	0	0	0	0	0	0
<i>Acipenser sinensis</i>	2	1	0	0	0	0	0	0	0	0	0	0
<i>Pelodiscus sinensis</i>	2	1	2	1	0	0	0	0	0	0	0	0
<i>Gallus gallus domesticus</i>	0	0	0	0	0	0	0	0	0	0	3	1
<i>Anser cygnoides</i>	0	0	0	0	0	0	0	0	0	0	3	3
<i>Lepus</i> sp.	0	0	0	0	0	0	0	0	0	0	2	2
<i>Canis familiaris</i>	6	2	8	2	3	1	0	0	0	0	59	12
<i>Meles leucurus</i>	1	1	0	0	0	0	0	0	0	0	0	0
<i>Panthera tigris</i>	0	0	1	1	0	0	0	0	0	0	0	0
<i>Equus caballus</i>	8	1	4	1	1	1	1	1	0	0	34	3
<i>Sus scrofa</i> sp.	210	24	149	19	95	10	11	2	9	3	448	53
<i>Hydropotes inermis</i>	2	1	3	1	0	0	3	1	0	0	2	1
<i>Cervus nippon</i>	21	2	23	2	22	3	2	1	3	1	16	3
<i>Elaphurus davidianus</i>	2	1	2	1	1	1	0	0	0	0	5	1
<i>Bos taurus</i>	172	10	58	4	76	5	15	1	9	1	212	14
Caprinae (<i>Capra/Ovis</i>)	34	4	51	3	19	4	1	1	2	1	83	26
Total (stage)	462	49	305	38	217	25	33	7	23	6	868	120
Total (whole site)	NISP=1908, MNI=245											

4. Special Species

As the site with the most diverse assemblage of unearthed animal remains, the GXS site has yielded several species that are unique. The following will provide some detailed introduction and extensional information of these distinctive specimens.

4.1 Chinese sturgeon (*Acipenser sinensis*)

Sturgeon is a kind of primitive and distinctive fish. Within the subclass Chondrostei, they stand out as unique because their skeletal structure is predominantly cartilaginous. Sturgeons lack vertebral centra and instead possess five rows of scutes, which serve as protective plates, rather than the typical scales found in other bony fishes. Besides one median dorsal row, there is a lateral and ventral row on each side of the body, with the number of scutes depending on row and species.

Owing to their cartilaginous nature, the internal skeletons of sturgeons tend to decompose rapidly during natural burial processes. Therefore, sturgeon remains are rarely found in archaeological sites. Conversely, the external bony scute can be preserved. Here, we have discovered two sturgeon scute specimens from the early Spring and Autumn periods, and relatively intact one was shown in **Figure 4-5-6**.

Settling down the problem concerning the specific species of the sturgeon scute is crucial for further discussion. We can find more clues from the biogeographic historic distribution of various sturgeons.



Figure 4-5-6. The sturgeon scute specimen found from T230 H911 at GXS.

In China, there are seven species of wild sturgeon. They are distributed in various river basins and water bodies across the country. These species are as follows:

1. Amur sturgeon (*Acipenser schrenckii*), found in the Heilongjiang (Amur), Songhua, and Ussuri River basins.
2. Kaluga sturgeon (*Huso dauricus*), found in the Heilongjiang (Amur), Songhua, and Ussuri River basins,
3. Sakhalin Sturgeon (*Acipenser mikadoi*), found in the Amur River Basin and Sakhalin water area.
4. Chinese sturgeon (*Acipenser sinensis*), found in the Yangtze and Jinsha River basins.
5. Dabry's sturgeon (*Acipenser dabryanus*), found in the Yangtze River basin.
6. Barbel sturgeon (*Acipenser nudiventris*), found in water bodies in Yining, Xinjiang.
7. Siberian sturgeon (*Acipenser baerii*), found in the Irtysh River, Lake Balkhash.

It seems that none of these species are distributed in the Yellow River basin. However, among these species, Chinese sturgeon (*Acipenser sinensis*) has historical records of being

found in the southwestern part of South Korea, the western part of Kyushu in Japan, and the Yellow River in China (The IUCN Red List 2022). Although the Chinese sturgeon is extinct from the Yellow River basin nowadays, the scute specimens of sturgeon discovered at the site are most likely attributed to the Chinese sturgeon (**Figure 4-5-7**).



Figure 4-5-7. The image of Chinese sturgeon (*Acipenser sinensis*).

The discovery of this specimen is of great significance because it represents the first zooarchaeological evidence of the Chinese sturgeon (*Acipenser sinensis*) in the Yellow River basin. In this area, some sturgeon remains were found but not identified to specific species (e.g. Li 2018). Prior archaeological discoveries of the Chinese sturgeon in China were primarily concentrated in the Three Gorges region of Yangtze River basin. According to the published results, as of 2019, archaeological materials of the Chinese sturgeon (*Acipenser sinensis*) had not been discovered in regions outside of the Three Gorges area in China (Deng & Deng 1997; Chang & Wu 2019). In the excavations of the Three Gorges archaeological project, Chinese sturgeon scutes were found in several sites, including the Nanmuyuan Neolithic site in Badong, Hubei (Yuan & Yang 2006), the Dianzitou Neolithic site in Badong, Hubei (Wu 2007), as well as remains from the Shang, Zhou, and Han periods at the Dongmentou site in Zigui, Hubei (Wu & Meng 2010), remains from Xia, Shang, and Zhou periods at the Buzhuanghe site in Zigui, Hubei (Wu & Lu 2008), the Heguangzui Shang-Dynasty site in Zigui, Hubei (Wu 2003), the Maliutuo Eastern Zhou site at Wanxian, Chongqing (Tang 2003), and the Lanjiazhai site in Wushan, Chongqing (Chang & Wu 2019).

It is challenging to identify Chinese sturgeon scute due to their common fragmentation condition, lack of distinct morphological features, and the inherent complexity of identifying their specific growth locations. Previously, only one Chinese sturgeon bone plate, found at the Lanjiazhai site, could be confidently identified as the last scute of the dorsal row (Chang & Wu 2019).

As for the scute shown in the **Figure 4-5-6**, we can just suppose it to be a dorsal one according to the general trend of shape due to its partial breakage.

Regarding the provenance of Chinese sturgeons, although the site is not located in the river delta or estuary region where sturgeons spend most of their lives feeding, they are anadromous bottom-feeders (Deng & Deng 1997). Thus, the discovery of Chinese sturgeon remains in this area suggests that they might have come from individuals that migrated upstream for spawning purposes during the autumn (Li 2017).

However, it is also possible that it could have been the result of trade and exchange activities. The cartilage in sturgeon can be processed and consumed, known for its delicious taste and rich nutritional value. It has been considered a delicacy in Chinese banquets since ancient times and is popularly referred to as "crispy gold" in folk culture (Chang & Wu 2019). Thus, sturgeon might be precious exchange goods at the time. Furthermore, according to historical records, during the Spring and Autumn Period, merchants and commercial activities of the State of Zheng were the most active among the nations. Coincidentally, sturgeon remains were only found in the early Spring and Autumn periods, which seems to make this hypothesis even more reliable.

What other information can we get from the bony scute specimen? Thieren and Van Neer (2016) evaluated several traditional and geometric morphometric approaches to the size reconstruction of European and Atlantic sturgeon base on isolated scutes, and they concluded that the isolated scute cannot provide very accurate sturgeon length reconstructions due to the

wide variation among scutes within one row. However, the scute dimension and shape can act as an indication for wider size classes. According to the model of TL reconstitutions for dorsal scute proposed by Desse-Berset (2011):

$$TL = 2.52 M1_{\text{mean excl. D1}} - 15.54, R^2 = 0.96$$

Residual length (M1: B-D) for the specimen in **Figure 4-5-8** is measured as 56.6mm. TL is calculated as 127.092cm, which conforms to the size range of Chinese sturgeon. Actually, due to the partly broken edge, the size of specimen was undermeasured, leading to the underestimation of size reconstruction. This sturgeon individual should be larger than we have estimated.

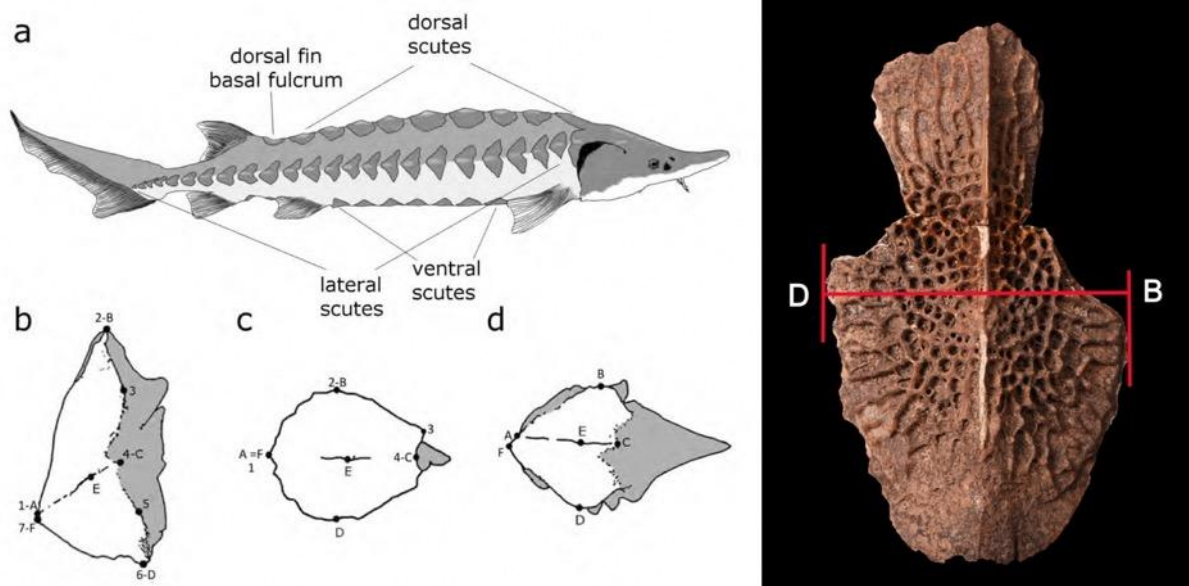


Figure 4-5-8. Left part is the overview of the scutes. a. Complete individual with the dorsal, lateral, and ventral scutes; b. Isolated right lateral scute; c. Isolated dorsal scute; d. Isolated right ventral scute (Thieren & Van Neer 2016). Right part is the scute sample, and its residual length (B-D) used in body length reconstruction.

Some limitation has been recognized. Previous research showed that differences in scute size among species and individuals have been confirmed (Magnin, 1964; Desse-Berset, 2011; Wuertz *et al.*, 2011). The model here was constructed based on the measurement data from nine Atlantic sturgeon (*A. oxyrinchus*) specimens. However, this is the only one model that we can refer to.

4.2 Big Cat! Tiger?

One large calcaneus (**Figure 4-5-9**) was found from GXS T240 J155 (well feature). Based on the morphology, it was undoubtedly thought to belong to a Felid. According to the size comparison with another archaeological tiger finding (Ren *et al.* 2015), additionally, there was also a tiger distal humerus (residual length is 87.94mm, BD is 62.48 mm) reported by a previous zooarchaeological research of ZHGC (Luo *et al.* 2006). Thus, I think it might belong to a tiger (*Panthera tigris*).

Tiger is the largest cat species, once ranging widely across the forests and riverine grasslands of Asia. China holds significance in the origin and evolution of tigers, a conclusion supported by both fossil records and genetic evidence (Qiu, 1998; Luo *et al.*, 2004). Despite this historical prominence, wild tigers are currently classified as endangered in China.

However, when I consulted Prof. Hu Songmei, who is the expert of rare animals, with the photo, some of them believed that the specimen's size was slightly smaller than that of a tiger. Although I consider this could be due to finer subspecies differences or individual variations, for the sake of academic rigor, I temporarily hold a reserved stance on judging this specimen as a tiger. Additionally, in the materials organized this time, only this one large cat specimen was found, so issues of its origin and usage cannot be further speculated currently.



Figure 4-5-9. Four views of the left calcaneus of suspected tiger (GXS T240 J155, II).

4.3 Chinese water deer (*Hydropotes inermis*)

Chinese water deer typically have body length of 91-103 cm and weigh around 14-17 kg. They are the only species of true deer without antlers. The typical habitats of Chinese water deer are river shores and coastal areas with shelter such as reed and other tall grasses. They are currently found only in the Yangzi River valley and in Korea and have disappeared from the Yellow River valley (Sheng 1992; Sheng& Ohtaishi 1999; Smith& Xie 2008).

The most prominent feature is males' well-developed upper canines, which protrude outside the mouth. There were two Chinese water deer's upper canines found in ZHGC, both from the GXS site (**Figure 4-5-10**).

Ornaments made from these large canine teeth, are commonly found in Chinese archaeological sites. The tradition of holding canine teeth by the tomb owner prevailed in the Dawenkou Culture (3,500-2,500 BC) of Lower Yellow River Basin (Yuan *et al.* 2020). Regarding the discovery of two tusks found here, since they were unearthed from the stratum and show no signs of processing, there seems to be no evidence suggesting their connection to any specific customs or rituals.



Figure 4-5-10. Two upper canines of Chinese water deer (top one is from GXS T237②, VI-1; bottom one is from GXS T231⑧, I-1) and the appearance of a cute Chinese water deer.

Section 6 金城路 Jin Cheng Lu (JCL)

1. Excavation

The Jincheng Road (JCL) Site is located in the central-southern part of the eastern city, was discovered during road construction. Its scope extends along the east-west road, with a total length of 1400 meters and a width of 25 meters from north to south (**Figure 4-6-1**). Because the construction company conducted unauthorized construction without approval from the cultural heritage department, a bronze ritual vessel pit was destroyed by the bulldozer, leading to the irreversible result of many bronze square pots, wine vessels, and tripods being pressed and damaged. Therefore, the Cultural Relics Bureau ordered the HPICRA to carry out rescue excavation.

Excavation began in May 1993 and concluded on August 20th, involving 21 units and one trial trench. The cultural deposits mainly consisted of Warring States and Spring and Autumn period ash pits and wells. A total of 37 wells, 67 ash pits, 52 tombs, 1 ash trench, 1 pottery kiln, 3 horse pits from the mid Spring and Autumn period, as well as one bronze ritual pit and one bronze musical instrument pit were unearthed. The faunal assemblage from this site is quite considerable.

The archaeological findings indicate that, during the Spring and Autumn period, this site primarily served as a ritual and sacrificial area related to Zheng State. Apart from the ritual vessel pit that was damaged, another pit containing 16 bronze vessels (6 *Ding*, 4 *Gui*, 4 *Li*, and two water vessels) and a bronze musical instrument pit (with one set of *Bo* chime-bells and 2 sets of *Niu* chime-bells) were found, accompanied by a horse pit on its west side.

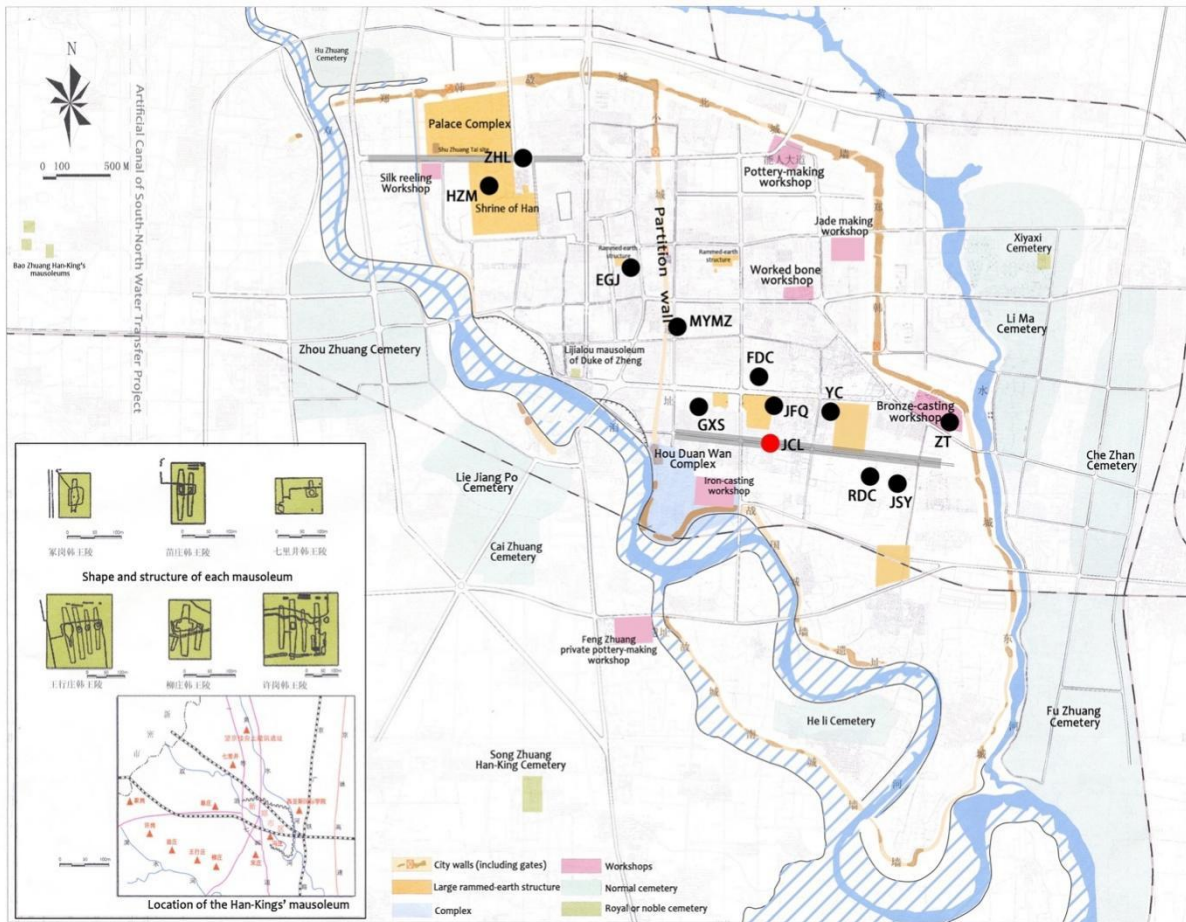


Figure 4-6-1. The location of JCL site (red dot and grey part).

2. Faunal Assemblage Profile

The total number of animal bone remains unearthed at JCL site is 1640, with a combined weight of 44,903.1 grams. This is a quite considerable dataset not only from the perspective of number, but also from the perspective of the variety of taxa, periods, and archaeological contexts, therefore, the materials from this site hold a wealth of research potential and provide with numerous variables that can be explored in depth.

In terms of stages, the presence of animal bones spans the entire Zhou Dynasty, including West Zhou, the Spring and Autumn Period, the Warring States Period, among which the East Zhou is the main part. A total of 162 specimens were found from West Zhou stage, weighing 3,680.7 grams. There were 55 specimens with a total weight of 3,270.5 grams in the stage I ; a total of 17 specimens weighing 1,426.4 grams in stage II ; 11

specimens weighing 599.5 grams in stage III; 83 specimens weighing 4,466.8 grams in stage IV; 262 specimens weighing 4,545.4 grams in the phase V-1; 194 specimens weighing 5,349.6 grams in the phase V-2. The stage VI is the most abundant one, with 569 specimens weighing 15,842.2 grams in phase VI-1 and 287 specimens weighing 5,722 grams in phase VI-2.

Concerning the taxa, faunal remains contain freshwater mollusc, fish, reptile, birds, medium-sized mammals, large-sized mammals. Here, apart from 52 fragments that cannot be identified to taxon, the number distribution of various taxa is as follows. There are two specimens of freshwater molluscs where one is identified as *Hyriopsis cumingii* (freshwater pearl mussel) and another as *Lamprotula* (**Figure 4-6-2-A**), as well as two bones of large-sized fish that might belong to black carp (**Figure 4-6-2-B/C**). The specimen of reptile is a plastron of *Mauremys reevesii* (Reeves' turtle) (**Figure 4-6-2-F**). The four bird class specimens consist of *Anser cygnoides* (domestic goose) (**Figure 4-6-2-D**) and *Gallus gallus domesticus* (domestic chicken) (**Figure 4-6-2-E**). The total number of medium-sized mammal remains is 830 (13,454.9 grams), with identifiable species including dogs, pigs, red muntjac, sika deer, sheep/goats, among which pigs are the most predominant. As for the large-sized mammals, there are 749 specimens (31,224.4 grams), with identifiable species being Père David's deer, cattle (**Figure 4-6-2-H**) and horses, among which cattle are undoubtedly the most predominant.

Regarding the archaeological context, the animal bone remains from this site were found in five kinds of archaeological features including strata, normal pits, wells, ash trench, and a sacrificial horse pit. There were 425 specimens unearthed from strata (25.9%), 871 specimens from diverse ash pits (53.1%), 271 specimens from wells (16.5%), 53 specimens from an ash trench (3.2%), and 17 specimens from filling soil of the horse pit (1.0%). Clearly,

ash pits were the most bone-abundant feature and over half of the faunal remains were excavated from a variety of pits.



Figure 4-6-2. Portfolio of the faunal assemblage of JCL. A: *Lamprotula*, right shell. J138 upper filling deposit. Western Zhou; B: *Mylopharyngodon piceus* (black carp), opercle bone (L). Ash trench. Stage I ;

C: *Mylopharyngodon piceus* (black carp), cleithrum (L). Ash trench. Stage I ; D: *Anser cygnoides* (domestic goose), tibia (L). T243 J160. Phase V -1; E: *Gallus gallus domesticus* (domestic chicken), tarsometatarsus (L). T243 J160. Phase V -1; F: *Mauremys reevesii* (Reeves' turtle), plastron fragment. J138 upper filling deposit. Western Zhou. G: *Sus scrofa* (pig), a pair of humeri, a limb bone, a pair of tibias, and a right femur, representing a suckling individual. J138 upper filling deposit. Western Zhou; H: *Bos taurus* (cattle), four horn cores. T241 northern②. Phase VI-1; I: *Ovis aries* (sheep), three horn cores. T248 H924. Stage IV .

3. Quantitative Results

The calculation results of NISP and MNI of JCL are summarized as **Table 4-6-1**.

The NISP for all the remains adds up to 798, accounting for 48.7% of the total. Among stages, it is obvious that both NISP and MNI reached their highest values during the stage VI, dominated by cattle, pigs, and Caprinae successively, and then V followed, dominated by Caprinae and pigs. Meanwhile, the stage V -1 exhibited the most abundance of animal diversity, with 7 identifiable species being found. In terms of the quantitative represent of different animals, we can find that cattle, sheep/goat, and pigs were distinctly predominant (illustrated in **Figure 4-6-3**). I will provide detailed introductions for these three animals as follows.

Pigs (*Sus scrofa* sp.). The quantity of pig bones ranked among the top three at this site in terms of abundance. Despite having a lower NISP compared to cattle and sheep, the discovery of numerous age-identifiable pig mandible specimens ensured that MNI calculations were not significantly underestimated. Additionally, Pigs are the animals that appeared most frequently in all periods. During the Western Zhou period, the nine pig bone specimens, all derived from the upper part of filling deposit of J138, represented the presence of at least two individuals based on long bone epiphyseal fusion. One was an individual less than 6 months old, likely a suckling piglet (**Figure 4-6-2-G**), while the other was an adult aged over 18 months. In the stage I , the eight unearthed pig bone specimens, according to humeral element, signified a minimum of two individuals. In the stage II , four specimens

unearthed from the horse pit deposit represented at least one 12-14-month-old individual. From the phase III, nine specimens implied the presence of at least one individual, estimated to be 20-26 months old based on the eruption and wear of lower third molar. In the phase IV, 13 pig bone specimens represented a minimum of two individuals, as determined by lower teeth: one aged 12-14 months and another 17-19 months. The phase V-1, marked by a higher frequency of pig bone finds, contained 42 specimens indicating the presence of at least 5 individuals. These encompassed one 9-10-month-old, one 17-19-month-old, two 21-23-month-old, and one aged 24-26 months individuals. Among these, the 15 specimens from the ash pit T252 H935 were of particular interest due to their association with a large concentration of sheep bones, potentially linked to communal feasting, which would be analysed in Chapter 7. In the phase V-2, five specimens represented at least one female individual. In the VI-1 phase, calculation based on mandibular specimens revealed a minimum of four individuals among 35 pig bones. Their age distribution included one 17-19-month-old, one 20-21-month-old, and two individuals over 27 months, one of which was female. Similarly, in the VI-2 phase, a minimum of 4 individuals were identified based on mandibular specimens among 35 pig bone specimens, one aged 7-8 months, one 9-10 months, one 17-19 months, and one 21-23 months.

Cattle (*Bos taurus*). The quantitative data for cattle are the most significant, with the largest NISP and MNI. During the Western Zhou period, based on the ulna-radius bones, 27 specimens represented at least 2 individuals, one of which is an old adult individual aged 5-10 years. In the stage I, 20 specimens indicated at least 2 individuals, both estimated to be senile individuals aged 7-20 years. In the stage II, only one specimen of right proximal tibia was found. Within the phase IV, based on the MNE of ulna-radius element, 18 specimens represented a minimum of 4 individuals. Among these, two individuals seemed young with

incomplete epiphyseal fusion, while one was a senile individual aged 7-20 years. In the phase V -1, the minimum number of individuals was calculated as two, one of which was a juvenile aged 6-12 months. In the V -2 phase, based on the scapulae, 84 specimens represented at least 4 individuals. During the phase VI-1, according to the left maxilla's MNE, 151 specimens revealed the presence of at least 7 individuals. Four concentrated cattle horn cores were unearthed from the layer and were photographed as reference. In the VI-2 phase, the MNI of 34 specimens was calculated as 2.

Caprinae (*Capra hircus/Ovis aries*). In contrast to other sites, it is striking that the quantitative data of the Caprinae at JCL site revealed a unique and prominent pattern. Caprinae specimens exhibited the second largest MNI with 22 individuals in total and the second largest NISP with 241. In most sites, Caprinae, as a commonly domesticated animal, has consistently maintained a decent presence, however, this is the first instance where it has surpassed pigs to dominate this site. This must be related to some special reasons.

Caprinae bones began to appear at JCL site in the II stage, with only one specimen of a left metacarpal. In the phase III, there were only two specimens, including one left scapula and one right metatarsal. In the stage IV, based on the metatarsals' MNE, it was determined that 10 specimens represented at least two individuals, with one individual being 6-8 years old. Additionally, there were three horn core specimens that could further be identified as sheep (*Ovis aries*) (shown in **Figure 4-6-2-I**).

The phase V -1 yielded the highest number of excavated sheep bone specimens, totalling 104, representing at least 6 individuals. Among these, 101 pieces were all excavated from the ash pit T252 H935, a seemingly special deposit of Caprinae bones that was predominantly composed of limb bones. It is preliminarily believed that this deposit might be caused by feasting consumption. The occurrence of this concentrated deposit of Caprinae

bones precisely addressed the question we raised earlier: why there was an unusually high number of Caprinae bones at this site. In turn, this abnormally high number, differing from the mundane consumption remains in other sites, exactly became straightforward and compelling evidence that H935 should be regarded as a special consumption deposit. This elevated and anomalous quantity might even have influenced the overall representation of Caprinae remains in the entire site. H935 will be presented as a case study with more details in Chapter 7.

All sheep bone specimens in the phase V-2 were excavated from the stratigraphic layers, with 57 specimens representing at least 5 individuals. In the phase VI-1, according to the right metatarsals, it was determined that at least 3 individuals were present, including one aged 4-6 years and one aged 6-12 years. In the phase VI-2, 41 specimens represented at least 4 individuals, including one aged 6-8 years, one aged 6-12 years, and one aged 8-10 years.

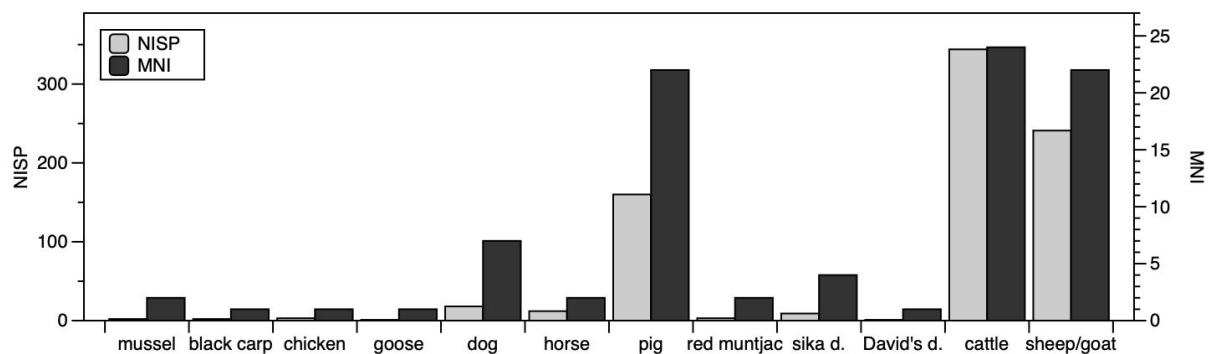


Figure 4-6-3. The NISP and MNI distribution of the taxa at JCL.

Table 4-6-1
Summary of NISP and MNI of the faunal assemblage at JCL

	W. Zhou		I		II		III		IV		V				VI			
											V -1		V -2		VI -1		VI -2	
Taxa	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Hyriopsis cumingii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>Lamprotula</i>	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mylopharyngodon piceus</i>	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Mauremys reevesii</i>	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Gallus gallus domesticus</i>	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0
<i>Anser cygnoides</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Canis familiaris</i>	0	0	2	1	0	0	0	0	6	2	2	1	1	1	0	0	7	2
<i>Equus caballus</i>	0	0	0	0	11	1	0	0	0	0	0	0	0	0	0	0	1	1
<i>Sus scrofa</i> sp.	9	2	8	2	4	1	9	1	13	2	42	5	5	1	35	4	35	4
<i>Muntiacus munijak</i>	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	1	0	0
<i>Cervus nippon</i>	0	0	2	1	0	0	0	0	3	1	3	1	0	0	1	1	0	0
<i>Elaphurus davidianus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
<i>Bos taurus</i>	27	2	20	2	1	1	0	0	18	4	9	2	84	4	151	7	34	2
Caprinae (<i>Capra/Ovis</i>)	0	0	0	0	1	1	2	1	10	2	104	6	57	5	26	3	41	4
Total (stage)	38	6	33	7	17	4	11	2	50	11	164	17	148	12	215	16	119	14
Total (whole site)	NISP=798, MNI=91																	

Section 7 房地产 Fang Di Chan (FDC)

1. Excavation

The FDC site is in the central part of the eastern city (outer city). Based on previous archaeological trial drilling data, archaeological excavation by the Xinzheng Archaeological Unit began in March 1992 and concluded in May of the same year. The archaeological team arranged 22 units of different sizes and discovered a total of 16 burials and 2 small horse-chariot pits. The distribution of strata at the site was relatively scattered, with varying thicknesses and complexity. In many units, cultural remains from different periods were found just below the ploughed soil layer. Important discoveries from this excavation included two likely large barns, one small aristocratic tomb, and two chariot-horse sacrificial pits. The results indicate that the site is primarily a burial area, and the unearthed animal bones mainly come from these burials.

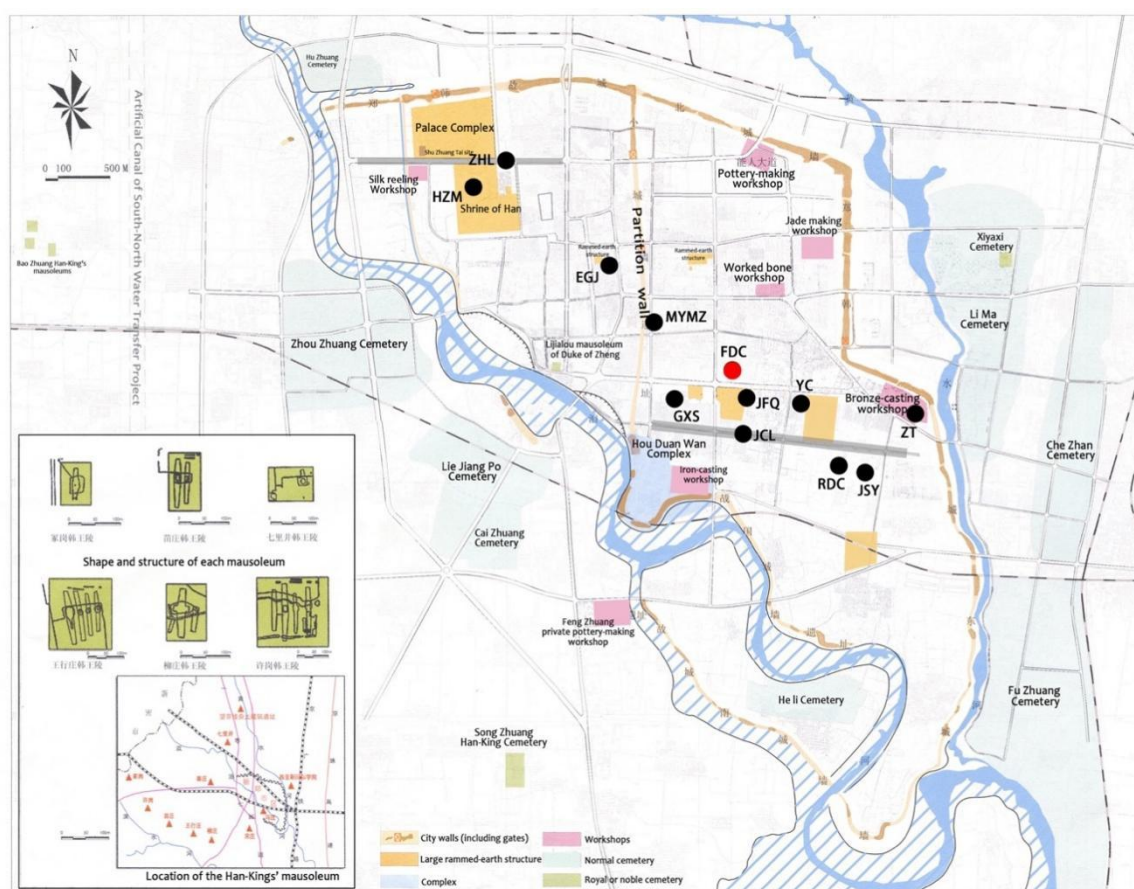


Figure 4-7-1. The location of FDC site (red dot).

2. Faunal Assemblage Profile and Quantitative Results

The faunal remains unearthed at FDC amount to a total of 176 specimens, with a combined weight of 1987.4 grams. The faunal assemblage can be attributed to three stages. In the Middle Spring and Autumn Period, there were 92 specimens with a total weight of 1011.9 grams; the Late Spring and Autumn Period provided 67 specimens weighing 351.7 grams; and 17 specimens were from the Middle Warring States Period, weighing 623.8 grams.

All the unearthed animal bones come from medium or large-sized mammals. Among the medium-sized mammal remains, there were 167 specimens. The identifiable species included dogs, pigs, and sheep, among which dogs were the most predominant. As for large-sized mammal remains, there were only 9 cattle specimens.

Regarding the archaeological context, the sources of animal bones were diverse, from 5 different archaeological features including pits (8), stratum (1), well (9), sacrificial horse pit (35), and burials (123). Among these, the animal remains from burials can be further categorized into those being found from burial fill soil (16), those from burial ditch or waist pit¹² (92), those from burial side-box (5), and those within burial pottery vessels (10). Considering the above, it becomes evident that faunal remains at FDC are primarily associated with specialized interments as offerings or sacrifice within special features. Compared to the leftovers that are indicative of mundane consumption from stratigraphy and ash pits, these specimens exhibit more completeness and independence.

In terms of quantitative analysis, calculation results of NISP and MNI are summarized as **Table 4-7-1**.

The NISP for all the remains adds up to 167, accounting for 94.9% of the total. The occurrence of unusually high NISP% value is strongly correlated with the predominance of

¹² Waist pits are typically found beneath the waist area of the tomb owner, hence the name. The waist pit is a kind of popular feature in the ancient burial tradition in northern China. It originated in the late Neolithic, became prevalent during the Shang and Western Zhou dynasties, and gradually declined during the Eastern Zhou, almost disappearing after the Warring States Period. Typically, these pits contained sacrificial offerings or complete animal skeletons, and human sacrifices are also found in higher-grade burial waist pits.

burials at this site. Animal remains associated with burial sacrifices usually consist of complete skeletons or intact meat-bearing portions. These remains are also less susceptible to disturbance and damage, making them highly easy for taxon identification.

The two canine specimens in stage II came from distinct sources: one was from the skeletal remains of burial M63, while the other was uncovered from the No.3 horse pit. Both sets of dog skeletons exhibited comprehensive features, encompassing the cranium to the vertebrae and extending to the limbs. Furthermore, the canine individual present in the stage III was recovered from the waist pit of M66. This complete skeleton was estimated to be approximately 4 to 5 months old based on tooth eruption.

The pig bones from the stage II were all discovered within the burial M63. Among them, a semi-complete young pig skeleton with limb and rib bones was found inside a burial pottery vessel. Additionally, scattered pig bone specimens were also discovered within the burial fill soil of this tomb. The MNI of pigs in the stage V was calculated by mandible specimens: one aged 9-10 months, and one aged over 27 months.

The specimens of cattle were all fragmented and loose bones. The sheep bones of the stage III came from two parts: a right rib segment as offering for the burial M72 (11) and a left foreleg found in the side box of burial M66 (5). Despite excavated from different burials, we cannot tell the independence of these two bone sets, therefore, the minimum number of individuals (MNI) is calculated as one.

The descriptions and images of faunal offerings from the burials mentioned above at FDC will be presented in detail in the Section 3 of Chapter 5.

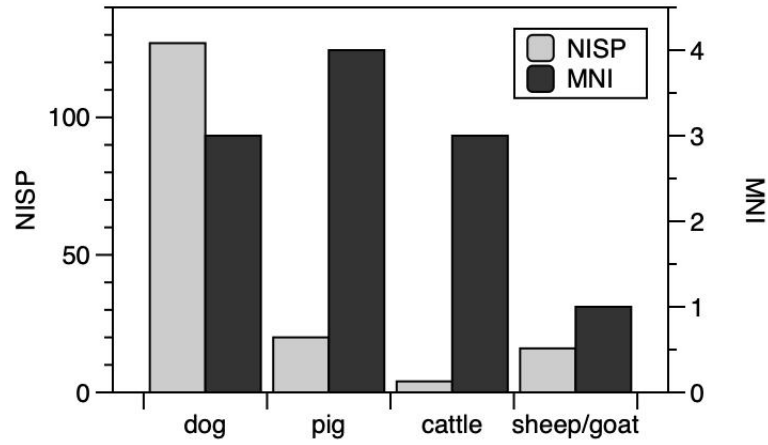


Figure 4-7-2. The NISP and MNI distribution of the taxa at FDC.

Table 4-7-1

Summary of NISP and MNI of the faunal assemblage at FDC

Taxa	II		III		V	
	NISP	MNI	NISP	MNI	NISP	MNI
<i>Canis familiaris</i>	77	2	50	1	0	0
<i>Sus scrofa</i> sp.	12	2	0	0	8	2
<i>Bos taurus</i>	1	1	1	1	2	1
<i>Ovis aries</i>	0	0	16	1	0	0
Total (stage)	90	5	67	3	10	3
Total (whole site)	NISP=167, MNI=11					

Section 8 经发区 Jing Fa Qu (JFQ)

1. Excavation

The JFQ site is lying in the central-southern part of the eastern city of ZHGC (**Figure 4-8-1**). Archaeological excavations from March to May 1993 mainly revealed ash pits, wells, and other remains in the continuous layers from the Spring and Autumn to the Warring States period, where a large number of animal bones were discovered.

One significant find was a coin-mould pit, unearthing a batch of coins from the Han, Zhao, and Wei states during the Warring States period. This discovery not only addressed gaps in the history of coins but also provided new data for studying the economic relationships among the three states and insights into the production and imitation of coin moulds and coinage technology.

Furthermore, the excavation of the JFQ site laid the foundation for the discovery of the Bank of China Sacrificial site. Archaeologists found three Spring and Autumn horse sacrificial pits in the western part of the site. As these horse pits were of much higher hierarchical level than those burials in the vicinity, it raised the excavators' alertness. Upon further investigation of the already excavated site, archaeologists discovered more horse burial pits, leading to the ultimate discovery of the Bank of China sacrificial site of the Zheng state.

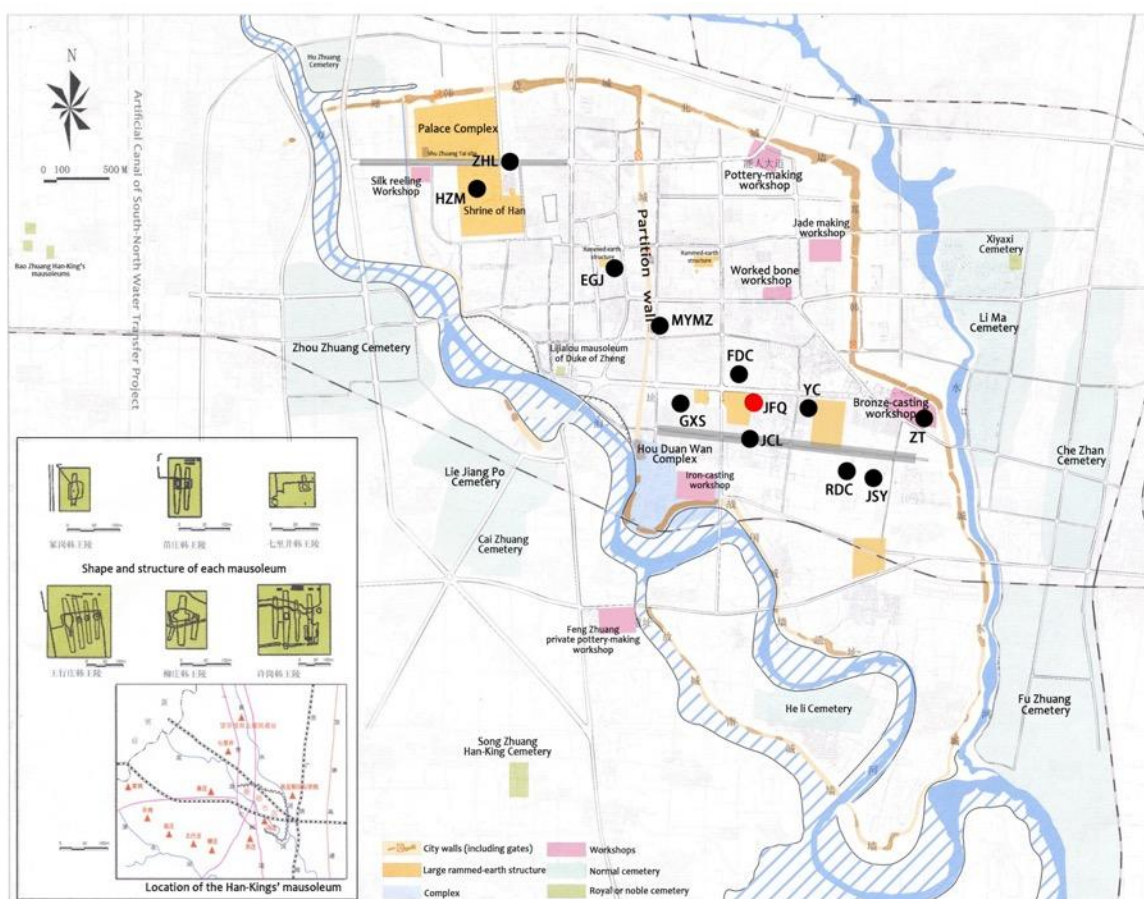


Figure 4-8-1. The location of JFQ site (red dot).

2. Faunal Assemblage Profile

The total number of animal bone remains unearthed at JFQ is 1353, with a combined weight of 61,298.6 grams. Additionally, four human bones, including three cranial fragmentations and one leg bone, were found from strata and pits, which were not counted in our following statistics.

The appearance of animal bones at this site spans the entire Eastern Zhou period, encompassing the early, middle, and late stages of the Spring and Autumn Period, as well as the early, middle, and late stages of the Warring States Period. There were 24 specimens with a total weight of 1,606.3 grams in the stage I; a total of 87 specimens weighing 3,089.5 grams in stage II; 61 specimens weighing 5,587.5 grams in stage III; 135 specimens

weighing 8,504.3 grams in stage IV; 273 specimens weighing 13,264.8 grams in stage V; and there were 773 specimens weighing 29,246.2 grams in stage VI.

In terms of the taxa, generally, faunal remains belong to fish, birds, medium-sized mammals, large-sized mammals and debris. Here, apart from one freshwater fish's quadrate bone, one left coracoid of domestic chicken (**Figure 4-8-2**), and 76 debris that cannot tell taxon, the others exclusively belong to medium-sized or large-sized mammals. The total number of medium-sized mammal remains is 447 (16,837.7 grams), with identifiable species including dogs (31), pigs (217), sheep/goats (43), small-sized deer (2), and sika deer (22), among which pigs are the most predominant. As for the large-sized mammals, there are 828 specimens (43,966.1 grams), with identifiable species being Père David's deer (7), cattle (289) and horses (154), among which cattle are the most predominant.



Figure 4-8-2. *Gallus gallus domesticus* (domestic chicken). JFQ T207 H803 (pit). Coracoid (Left). It was found during the anterior phase of Late Warring States Period (VI-2). This is the only one specimen of chicken at JFQ. It can be observed that there are two cutting traces left on the proximal end, indicating this might be caused during the dismembering practices for consuming.

Regarding the archaeological context, the animal bone remains from this site were found in four kinds of archaeological features including layers, pits, wells, and a trench. There were 475 specimens unearthed from layers (35.1%), 815 specimens from diverse pits (60.2%), 60 specimens from wells (4.4%), and 3 specimens from an ash trench (0.2%). It is

obvious that the majority of faunal remains were excavated from a variety of pits, where the pit H803, is speculated to be special because there was an almost complete horse skeleton in it, which will be discussed individually in Chapter 5 ritual part.

3. Quantitative Results

The calculation results of NISP and MNI of JFQ are summarized as **Table 4-8-1**.

The NISP for all the remains adds up to 765, accounting for 56.5% of the total. Among stages, it is obvious that both NISP and MNI reached their highest values during the stage VI, dominated by cattle, horses, and pigs successively, and then V followed, dominated by pigs and cattle. Meanwhile, the stage VI exhibited not only the highest quantity, but also the most diverse range of animal species. It contained all the forementioned animal species that were discovered at this site. In terms of the quantitative performance of different animals, we can easily find that two animals, pigs and cattle, owned the highest values of NISP and MNI respectively, and Caprinae, horses and dogs also have certain numbers (illustrated in **Figure 4-8-3**). Regarding the large disparity between two quantitative standards of horse, it can be attributed to the discovery of a complete horse skeleton found from T207 H803 during the stage VI, leading the phenomenon that 142 identifiable specimens belong to the same one individual aged approximately 12-13 years old. Following, I will give sequentially divided introduction of pigs and cattle.

Pigs (*Sus scrofa* sp.). The pig remains appeared across each phase at JFQ, with the second-highest count in terms of NISP (217, constituting 28.4%) and the highest MNI (35, constituting 40.2%). In the stage I, four specimens found represented at least one individual, among which one left mandible with M2-M3 allows an estimated aging of 12-14 months. During the stage II, the minimum number of individuals (MNI) is determined based on four left mandibles, including one individual estimated to be 20-21 months old, as well as a suckling individual. This suckling pig seemed to comprise a relatively complete skeleton

when discarded, but many parts were missing. Within the stage III, according to right mandible specimens, fourteen specimens represented at least three individuals, including one individual estimated to be 24-26 months old and two individuals older than 27 months. In the stage IV, based on right mandible with teeth specimens, at least seven individuals were recognised, with aging estimation distributed as follows: one individual aged 4-5 months old, one 9-10 months old, two 10-12 months old, one 12-14 months old, one 24-26 months old, and one aged older than 27 months. During the phase V, based on right mandible with teeth specimens, the calculation of MNI indicated that 60 specimens represented at least nine individuals. Among these, seven pigs' ages can be estimated, including two individuals aged 9-10 months old, three aged 16-19 months old, and two aged 20-21 months old. The stage VI exhibited the highest number of pig bone remains, with a calculated MNI of 11 based on mandible with teeth specimens. The aging distribution of these individuals is as follows: 9-10 months old (one individual), 12-14 months old (two individuals), 15-19 months old (three individuals), 20-23 months old (two individuals), 24-26 months old (one individual), and older than 27 months (two individuals). Additionally, based on the size and morphology of lower canines, it can be identified that among these individuals, there were two males and three females.

Cattle (*Bos taurus*). The cattle bones were also found from every stage at the site, occupying the highest value of NISP (289, constituting 37.8%) and the second highest MNI (17, constituting 19.5%) among species. Within the stage I, seven specimens represented at least one young adult individual, with the estimated age of one right mandible with M1-M3 being 34-42 months old. The specimens from the phase II represented at least one individual. In the phase III, based on metacarpal specimens, at least two individuals were represented by ten specimens, with one being an adult cattle individual aged between 40 months and 6.5

years roughly. During the stage IV, according to three right radius bones, it can be determined that 25 specimens from this period represented at least three individuals including one relatively young individual, one mature individual aged between 40 months and 6.5 years, and one senile individual aged about 7-20 years old, exhibiting a larger body size. In the stage V, based on right calcaneus specimens, the minimum number of individuals (MNI) was calculated as 5, including two young adults aged 16-28 months and one senile individual aged 7-20 years old. The stage VI also marked a period with the highest number of cattle specimens. Based on left calcaneus specimens, these 188 specimens represented at least five individuals. Among them, one complete juvenile skeletal remains were unearthed in T206 H811, with the age estimated between 15-18 months based on tooth wear and long bone epiphyseal fusion. Detailed descriptions and in-depth analyses of this pit and cattle bones therein will be presented in the Chapter 7.

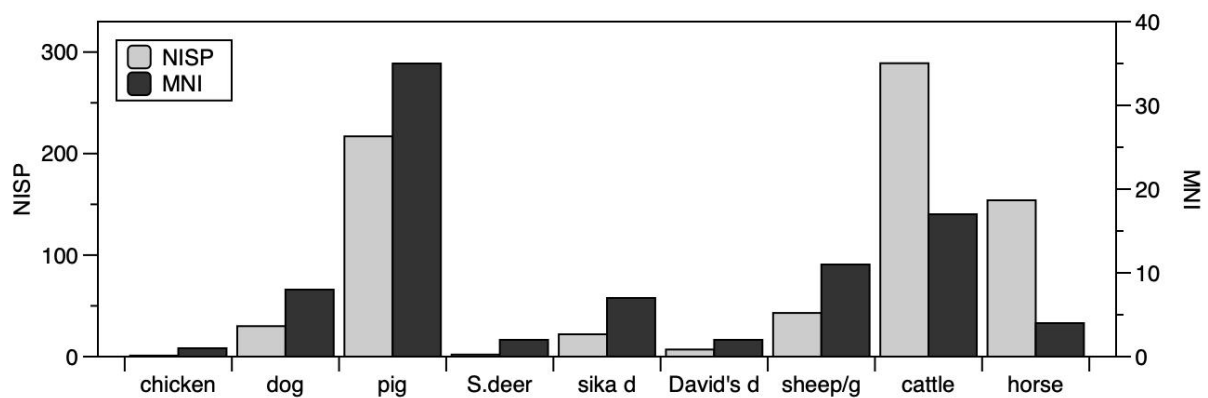


Figure 4-8-3. The NISP and MNI distribution of the taxa at JFQ. "Small-sized deer" is abbreviated as "S. deer", "sika deer" as "sika d.", and "Père David's deer" as "David's d.".

Table 4-8-1

Summary of NISP and MNI of the faunal assemblage at JFQ

	I		II		III		IV		V		VI	
Taxa	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Gallus gallus domesticus</i>	0	0	0	0	0	0	0	0	0	0	1	1
<i>Canis familiaris</i>	0	0	0	0	2	1	4	2	13	3	11	2
<i>Equus caballus</i>	0	0	0	0	6	1	3	1	0	0	145	2
<i>Sus scrofa</i> sp.	4	1	17	4	14	3	32	7	60	9	90	11
Small-sized Cervidae	0	0	0	0	0	0	0	0	1	1	1	1
<i>Cervus nippon</i>	1	1	2	1	3	1	2	1	3	1	11	2
<i>Elaphurus davidianus</i>	0	0	0	0	0	0	0	0	2	1	5	1
<i>Bos taurus</i>	7	1	5	1	10	2	25	3	54	5	188	5
Caprinae (<i>Capra/Ovis</i>)	1	1	5	2	2	1	4	2	12	2	19	3
Total (stage)	13	4	29	8	37	9	70	16	145	22	471	28
Total	NISP=765, MNI=87											

Section 9 烟厂 Yan Chang (YC)

1. Excavation

The YC site is located in the south-eastern part of the eastern city, adjacent to JFQ site to the northwest (**Figure 4-9-1**), covering an area of 266 square meters. Archaeological excavations were initiated in October 1993 and concluded in May 1994 to support infrastructure projects. The site was explored with 68 different-sized units, with around 40 tombs, over 100 ash pits, 4 small house foundations, and 64 wells being discovered. Abundant artifacts and animal bones were unearthed, with particularly noteworthy, superimposed relationships among various features and layers, as well as corresponding potsherds, providing rich material evidence for the typological reconstruction.

The discovery of an Erlitou Culture well in this site is considered the first within ZHGC, making it highly significant. Additionally, a clan cemetery from the Eastern Zhou period, where differences in burial goods among dozens of Eastern Zhou burials revealed varying social statuses among the clansmen within the lineage.

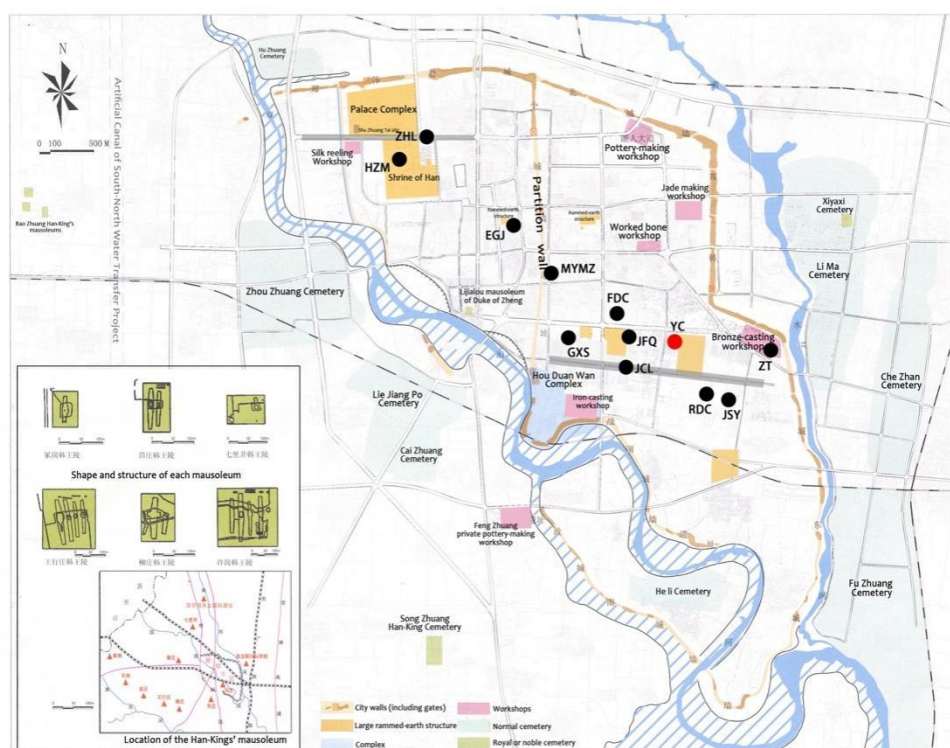


Figure 4-9-1. The location of YC site (red dot).

2. Faunal Assemblage Profile

The total number of faunal remains unearthed at YC is 764, with a combined weight of 43,448 grams. However, there were 14 specimens found from strata with dating issues or from the disturbed layer, so they were excluded temporarily from our study targets. Thus, the actual total number is 750, with a total weight of 42,707 gram.

The appearance of animal bones at this site spans the Eilitou stage, West Zhou, and most phases of East Zhou except the early Spring and Autumn. There were 9 specimens with a total weight of 1,304 grams in the Erlitou stage; only 2 specimens weighing 98 grams in the West Zhou; a total of 36 specimens weighing 2,531 grams in stage II; 174 specimens weighing 9,557.8 grams in stage III; 155 specimens weighing 9,163.1 grams in stage IV; 74 specimens weighing 4,435 grams in stage V-1; 21 specimens weighing 1,020 grams in stage V-2; 218 specimens weighing 11,030.1 grams in stage VI-1, and there were 61 specimens weighing 3,568 grams in stage VI-2.

In terms of the taxa, apart from five fragments that cannot be identified to taxon, animal bones belonged to either medium-sized or large-sized mammals. The total number of medium-sized mammal remains was 332 (13,334 grams), with identifiable species including dogs, pigs, roe deer, sika deer, and sheep/goats, among which pigs were the most predominant. As for the large-sized mammals, there are 413 specimens (29,331 grams), with identifiable species being horses, Père David's deer, and cattle, among which cattle were the most predominant.

Regarding the archaeological context, the faunal remains were found in six kinds of archaeological features including strata, ash pits, wells, house structure, burials, and a sacrificial horse pit. There were 283 specimens unearthed from strata (37.7%), 208 specimens from diverse pits (27.7%), 213 specimens from wells (28.4%), 29 specimens from houses

(3.9%), 12 specimens from burials, and 5 specimens from filling deposit of horse pit (horse skeleton not included).

3. Quantitative Results

The calculation results of NISP and MNI of YC are summarized as **Table 4-9-1**.

The NISP for all the remains added up to 642, accounting for 85.6% of the total. The similar reason for this high %NISP has been given in the EGJ part.

Among stages, similarly, it was still the stage VI that possessed the largest NISP and MNI values, dominated by pigs, cattle, and horse, then the stage IV and III followed.

Figure 4-9-2 showed that pig and cattle had the obvious predominance among taxa. Following, I will provide detailed quantitative and age/sex introductions for pig and cattle separately.

Pigs (*Sus scrofa* sp.) had the largest MNI and the second NISP. In the stage Erilitou, there were eight pig specimens, with seven being mandibles, representing at least four individuals. Among these, one male and one female, and the age distribution was consisting of one aged 17-19 months old, one aged 21-23 months old, and two aged over 27 months old. Within stage II, a minimum of two individuals were represented by twelve specimens, including one aged 20-21 months old and one aged over 27 months old. In stage III, there were 38 specimens indicating the appearance of five individuals based on the mandibular elements, including one aged 4-5 months, one aged 24-26 months, and one aged over 27 months old. In the stage IV, 56 specimens represented at least 6 different individuals, including one piglet found in a pottery tripod, as well as one aged 17-19 months old, two aged 20-21 months old, two aged over 27 months old, with two individuals being female. During the phase V -1, 15 specimens revealed the appearance of distinct five individuals (one 9-10-month-old, two 10-12-month-old, one 17-19-month-old, and two 27-month-old individuals), such a big MNI figure resulted from the abundance of mandible specimens.

These five individuals contained two males. In the phase V-2, two individuals were represented by eleven specimens, with one aged 9-10 months old and one aged older than 27 months. The stage VI was the most abundant one, with 71 specimens representing 9 distinct individuals (two males and one female) in the VI-1 phase, and 23 specimens representing 5 individuals (one male and four females) in the VI-2 phase. The age distribution of VI-1 phase was as follows: one aged 9-10 months old, two aged 16-19 months old, one aged 20-21 months old, and in total five aged over 27 months old. The identifiable age distribution of VI-2 phase consisted of one aged 17-19 months old, one aged 21-23 months old, and one aged over 27 months old.

Cattle (*Bos taurus*) had the largest NISP and second largest MNI values among taxa. The introduction of specimens from the stage Erlitou, Western Zhou, II, V-1/-2, and VI-2 were omitted here due to either the scarcity of number or the lack of secondary information like age/sex. In stage III, a minimum of three individuals were represented by 47 specimens based on the MNE of femur and tibia elements. In the stage IV, 55 specimens showed the appearance of five distinct individuals, among which there was one individual aged 40 mon. - 6.5 yrs. old. The stage VI-1 is the most abundant one, with 65 specimens, representing minimum of four individuals according to the ulna/radius elements. It is quite weird that the finding of mandibles is rare. This resulted in the lack of age identification, which might further lead to the underestimation of MNI to some extent.

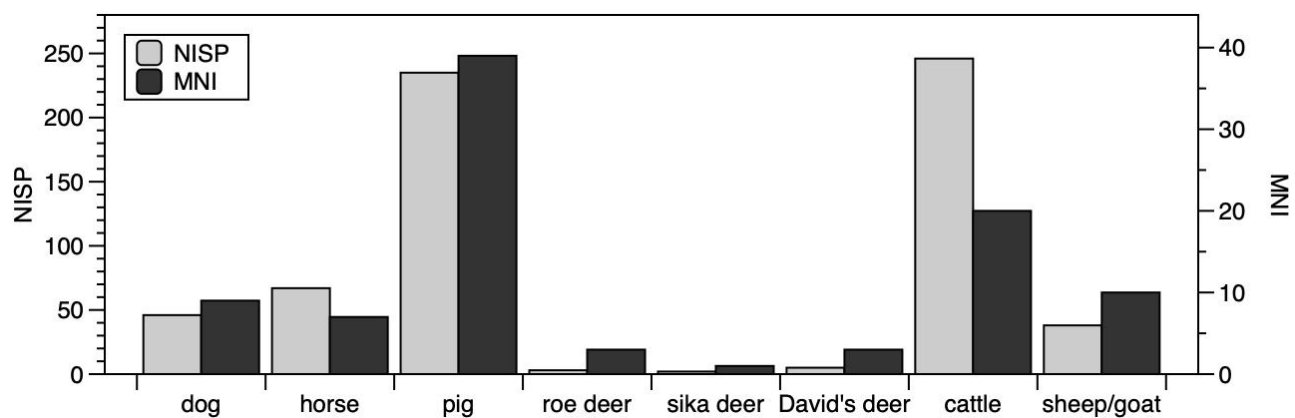


Figure 4-9-2. The NISP and MNI distribution of the taxa at YC.

Table 4-9-1

Summary of NISP and MNI of the faunal assemblage at YC.

	Erlitou		W. Zhou		II		III		IV		V				VI			
											V -1		V -2		VI -1		VI -2	
Taxa	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Canis familiaris</i>	0	0	0	0	3	1	10	1	4	1	13	3	5	1	10	1	1	1
<i>Equus caballus</i>	0	0	0	0	0	0	32	2	6	2	1	1	0	0	23	1	5	1
<i>Sus scrofa</i> sp.	8	4	1	1	12	2	38	5	56	6	15	5	11	2	71	9	23	5
<i>Capreolus capreolus</i>	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	1	0	0
<i>Cervus nippon</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
<i>Elaphurus davidianus</i>	0	0	0	0	0	0	2	1	1	1	0	0	0	0	2	1	0	0
<i>Bos taurus</i>	1	1	1	1	12	2	47	3	55	5	41	2	4	1	65	4	20	1
Caprinae (<i>Capra/Ovis</i>)	0	0	0	0	4	3	5	1	14	3	3	1	0	0	12	2	0	0
Total (stage)	9	5	2	2	32	9	134	13	137	19	73	12	20	4	186	20	49	8
Total (whole site)	NISP=642, MNI=92																	

Section 10 热电厂 Re Dian Chang (RDC)

1. Excavation

The RDC site is located in the south-eastern part of the eastern city, adjacent to Jincheng Road (JCL) to the north and the JSY site to the west (**Figure 4-10-1**). The site covers an area of approximately 90,000 square meters. The terrain of the site appears a turtle-back shape with a central uplift, elevated 1-1.4 meters above the surrounding ground. The southern part of the site features a gully slope, creating a terrace terrain.

Archaeological excavations were conducted by the Xinzheng Archaeological Unit from March to June 1996. A total of 47 units were opened, revealing 64 ash pits, 13 wells, 21 pottery kilns, over 100 tombs, 3 chariot and horse pits, and a rammed earth foundation. The date of this foundation is not later than the early Warring States period.

Analysis of the distribution of features suggests that from the late Western Zhou period to the early Spring and Autumn period, this area functioned as a workshop zone for pottery handicrafts, maintaining a relatively large scale until the middle Spring and Autumn period when pottery production ceased. After this, the function of the site changed, and it began to be used as a clan cemetery. Most of the burials were small, with few medium to large-sized tombs. High-ranking tombs have undergone severe looting, where chariot and horse pits with two chariots were found, possibly suggesting a burial level comparable to that of a vassal lord. The rammed earth foundation in the cemetery might be the above-ground structure related to burials.

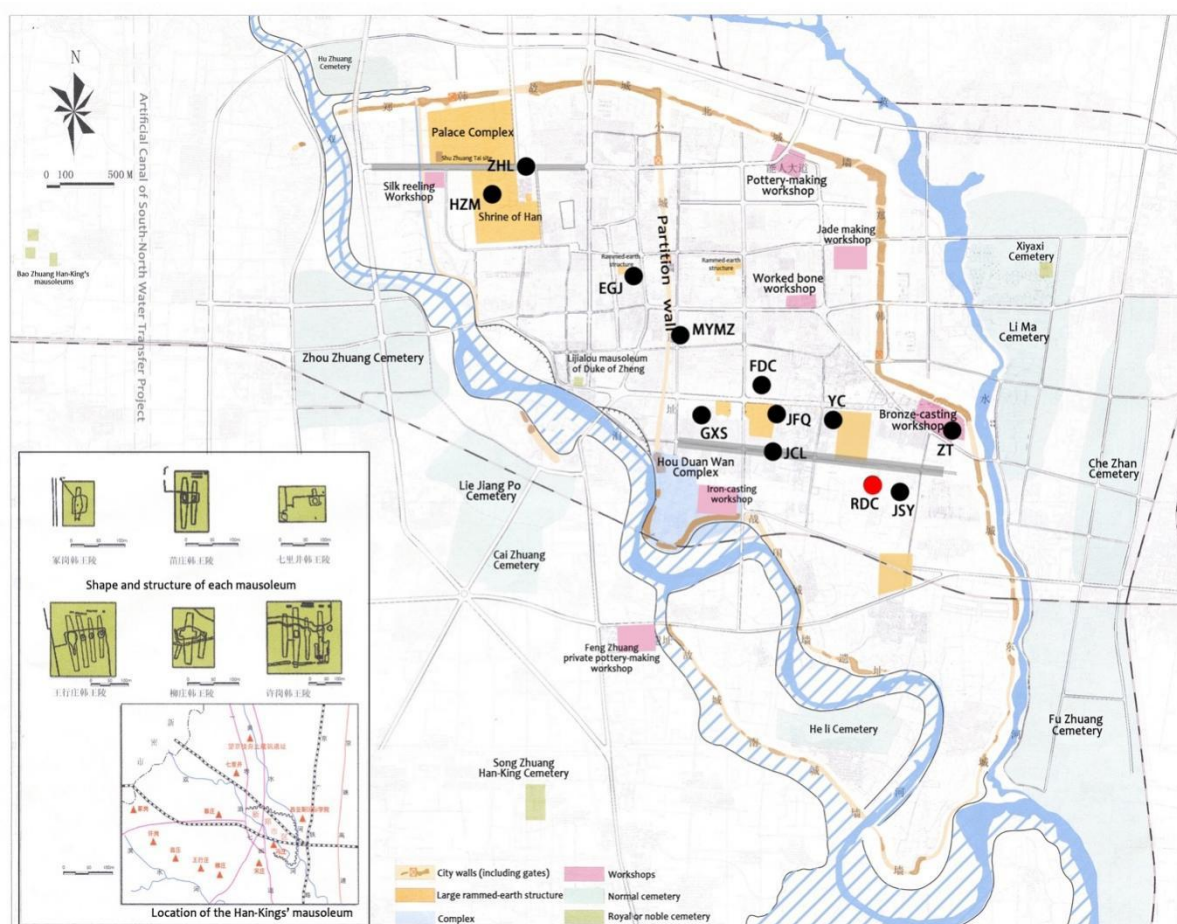


Figure 4-10-1. The location of RDC site (red dot).

2. Faunal Assemblage Profile and Quantitative Results

The total number of animal bone remains unearthed at RDC site is 548, with a combined weight of 27,519.1 grams.

The particularity of the animal assemblage at this site lies in the fact that the majority of bones were excavated from a unique feature named as the "No.1 Mess-bone Pit" from which a total of 501 bone specimens (91.4% of the total) were recovered. Due to the possible feasting ritual nature of this bone pit (this will be under detailed discussion in the Chapter 7), the bones within were considered to have relative independence. Meanwhile, the lack of pottery remains in this pit hindered precise dating (lacking radiocarbon dating result). Therefore, the No.1 Mess-bone Pit was treated separately for quantitative calculation and analysis.

Excluding the No.1 Mess-bone Pit, the remaining 47 bone specimens were distributed chronologically as follows: there was only one antler tool specimen found in the stage I , weighing 282.2 grams; a total of 9 specimens weighing 1,007 grams in stage II ; 3 specimens weighing 182.2 grams in stage III; 17 specimens weighing 867.5 grams in stage IV; 8 specimens weighing 599.6 grams in the stage V ; and 9 specimens weighing 939.7 grams in phase VI-1.

Concerning the taxa, faunal remains contained freshwater mollusc (*Hyriopsis cumingii*), medium-sized mammals with identifiable species including dogs, pigs, sika deer, sheep/goats, and large-sized mammals with identifiable species being Père David's deer, horse, and cattle. Among these, cattle showed its predominance, especially in the No.1 Mess-bone Pit.

Regarding the archaeological context, apart from the No.1 Mess-bone Pit (91.4%), the remaining were mainly found from strata (25, 4.6%), normal ash pits (15, 2.7%), and wells (7, 1.3%).

The calculation results of NISP and MNI of RDC are shown in Table 4-10-1. The NISP for all the remains adds up to 342, accounting for 62.4% of the total. The detailed condition of the faunal assemblage from the No. 1 Mess-bone Pit will be demonstrated in the Chapter 7 as a crucial case study of feasting ritual.

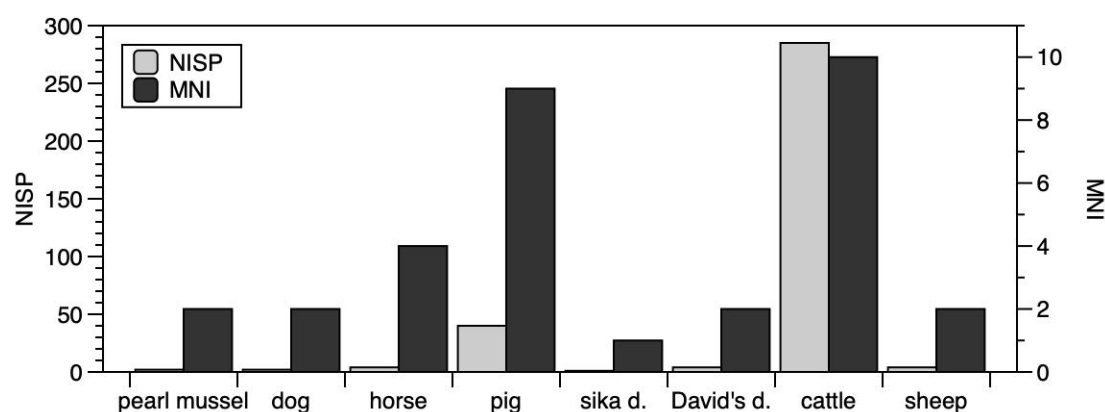


Figure 4-10-2. The NISP and MNI distribution of the taxa at RDC.

Table 4-10-1

Summary of NISP and MNI of the faunal assemblage at RDC (No.1 Mess-bone Pit separately)

Taxa	I		II		III		IV		V		VI-1	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Hyriopsis cumingii</i>	0	0	1	1	0	0	1	1	0	0	0	0
<i>Canis familiaris</i>	0	0	0	0	0	0	1	1	0	0	1	1
<i>Equus caballus</i>	0	0	0	0	1	1	1	1	1	1	1	1
<i>Sus scrofa</i> sp.	0	0	0	0	1	1	7	2	1	1	4	2
<i>Cervus nippon</i>	0	0	0	0	0	0	1	1	0	0	0	0
<i>Elaphurus davidianus</i>	1	1	3	1	0	0	0	0	0	0	0	0
<i>Bos taurus</i>	0	0	2	1	0	0	3	1	3	1	3	1
Caprinae (<i>Capra/Ovis</i>)	0	0	0	0	0	0	2	1	0	0	0	0
Total (stage)	1	1	6	3	2	2	16	8	5	3	9	5
Total	NISP=39, MNI=22											

No.1 Mess-bone Pit		
Taxa	NISP	MNI
<i>Sus scrofa</i> sp.	27	3
<i>Bos taurus</i>	274	6
Caprinae (<i>Capra/Ovis</i>)	2	1
Total	303	10

Total (whole site)

NISP=342, MNI=32

Section 11 家属院 Jia Shu Yuan (JSY)

1. Excavation

The JSY Site is located in the south-eastern part of the eastern city, with its northern boundary along Jincheng Road (JCL) and its western boundary along RDC site (**Figure 4-11-1**), covering an area of 13,083 square meters. Previous drilling explorations revealed tombs, ash pits, wells, and cultural deposits from the Eastern Zhou period.

To facilitate the construction of residential housing for the Thermal Power Plant, the Xinzheng Archaeological Unit conducted archaeological excavations at this site from September to November 2000. Nine 10x10-meter units were established, revealing 28 ash pits, 26 wells, and 11 tombs. The tombs at this site primarily date to the Spring and Autumn period and have experienced significant robbery. For example, M7 was looted four times, where grave goods were completely stolen, leaving only a waist pit with a sacrificed dog in it. However, the bones seem to have been lost and were not included in the materials compiled during this study.

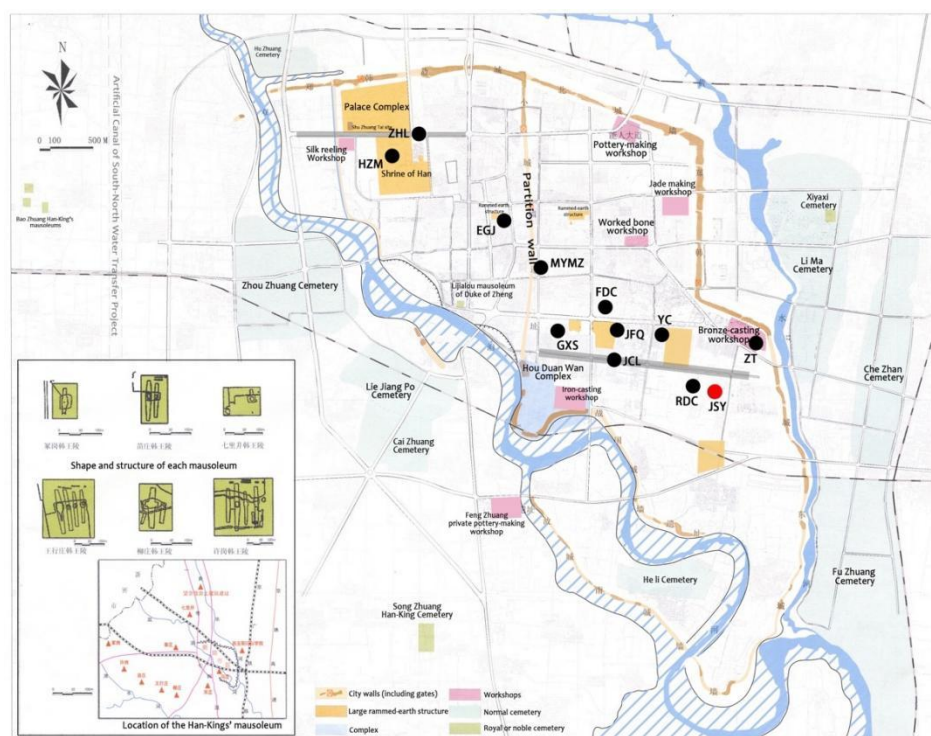


Figure 4-11-1. The location of JSY site (red dot).

2. Faunal Assemblage Profile

The total number of animal bone remains unearthed at this site is 1312, with a combined weight of 37,743.9 grams. Additionally, one human first rib was found from the well, which was not counted in our statistics.

These faunal remains can be attributed to five stages and four sub-stages including the Early Spring and Autumn Period, Late Spring and Autumn Period, Early Warring States Period, Mid Warring States Period (V -1 and V -2), and Late Warring States Period (VI-1 and VI-2). There were 38 specimens with a total weight of 1,620.7 grams in stage I ; 15 specimens weighing 671.7 grams in stage III ; 313 specimens weighing 14,099.6 grams in stage IV ; 124 specimens weighing 4,358.2 grams in stage V (including 50 specimens weighing 1195.3 grams in V -1 and 74 specimens weighing 3,162.9 grams in V-2); 822 specimens weighing 16,993.7 grams in stage VI (including 12 specimens weighing 771.9 grams in VI-1 and 810 specimens weighing 16221.8 grams in VI-2).

As for the taxa, faunal remains belong to freshwater mollusc, medium-sized mammals, large-sized mammals and others (worked bones or fragments that are unidentifiable, and worked bone specimens will be introduced in detail in Chapter 5). Here, apart from one freshwater pearl mussel and two worked bones, the rest all belong to medium-sized and large-sized mammals. The total number of medium-sized mammal remains is 376 (12,084.4 grams), with identifiable species including dogs (39), pigs (179), sheep/goats (37), small-sized deer (1) and medium-sized deer (3), among which pigs are the most predominant. As for the large-sized mammal remains, there are 933 specimens (25,645.2 grams), with identifiable species being large-sized deer (1), cattle (679) and horses (14), with cattle undoubtedly possessing the most outstanding position. The unusual abundance of cattle remains is closely linked to two unique pits T48-H10 and T55-H2 during the VI-2, where an

overwhelming majority of 530 and 67 cattle scapula fragments were discovered separately. These two pits will be regarded as special features to be conducted in-depth analysed in the handicraft part of Chapter 5.

Regarding the archaeological context, the animal bone remains from this site were found in only two kinds of archaeological features, pits and water wells. There were 942 specimens were unearthed from ash pits (57.1%), and 370 from the wells (42.9%).

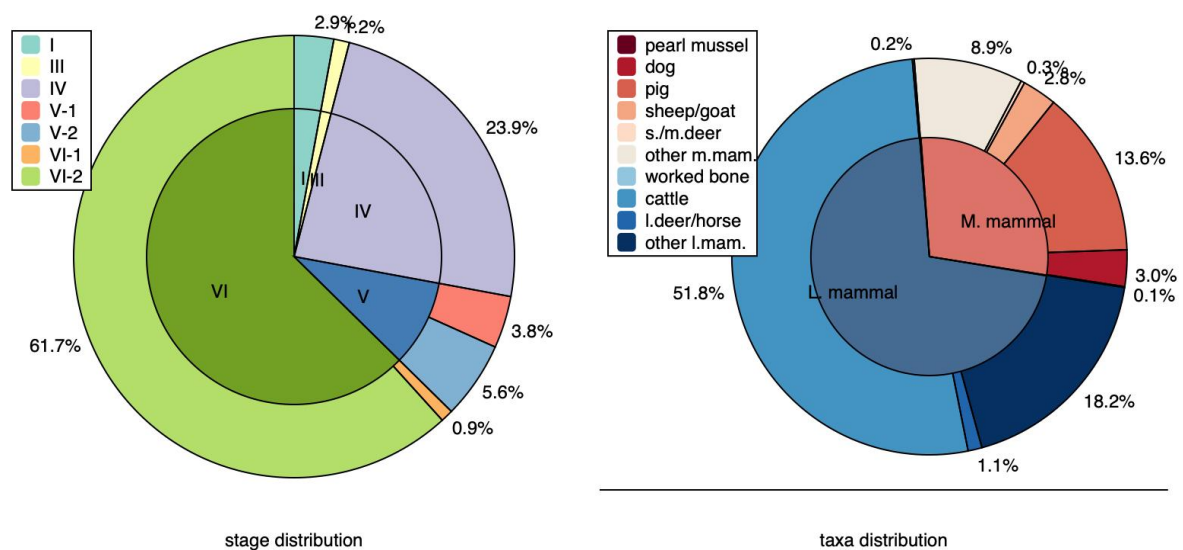


Figure 4-11-2. Distribution (percentage) of faunal remains in different stages and in different taxa at JSY. It can be easily observed that there are the most specimens in stage VI, more specifically, VI-2, and most specimens come from large mammals, especially cattle.

3. Quantitative Results

The calculation results of NISP and MNI of JSY are summarized as **Table 4-11-1**.

The total NISP is 954, accounting for 72.7% of the assemblage number. The NISP% is quite high, indicating this batch of faunal remains have relatively good preservation to be recognized. Among stages, it is obvious that both NISP and MNI reached their highest values in the VI-2, mainly dominated by cattle, and IV followed, dominated by pigs. Although the stage IV does not have the highest values, it has the highest taxa abundance, is more diverse than other stages in the aspect of animal species.

In the quantitative results of this site, four distinct animal species stand out due to their relatively notable quantities, including dogs, pigs, cattle, and sheep/goat (**Figure 4-11-3**). Consequently, I will provide detailed introductions for these four animals as follows.

Dogs (*Canis familiaris*). While the overall quantity of canine remains may not be as prominent as that of pigs and cattle, dogs have consistently been discovered across each stage. In the stage I, one right mandible with P4 and M2 was unearthed; in the stage III, one left ulna was found; in the stage IV, the MNI was determined by three left tibia specimens; in the phase V-1, four specimens might belong to the same individual excavated from a well; in the phase V-2, cranium, mandible, scapula and pelvic specimens were unearthed; in the stage VI-1, one right mandible with C, P2-M2 was found; and in the stage VI-2, the MNI was determined based on two right mandibles.

Pigs (*Sus scrofa* sp.). Pigs made appearances across each phase, securing the second-highest count in terms of NISP (179, constituting 18.8%) and MNI (29, representing 30.5%). In the stage I, the MNI was determined by 3 left humeri. In the stage III, the individual was a female one aged 12-14 months. In the stage IV, the MNI was calculated based on mandible specimens, and the age distribution of these 16 individuals were as follows: two pigs aged 2-4 months, two aged 7-8 months; three aged 9-10 months; one aged 10-12 months, one aged 12-14 months, one aged 12-17 months, three aged 20-21 months (including one female), and three aged 21-23 months (including two females). In the phase V-1, one right maxillary with P4-M3 was excavated. In the phase V-2, the minimum number of individuals was 4 according to age estimation of mandible and teeth, including one aged 9-10 months, two aged 20-21 months, and one aged over 27 months. In the phase VI-1, one left proximal tibia specimen was found. In the phase VI-2, the MNI was calculated based on three left mandibles, which were estimated 7-8-month-old, 12-14-month-old and 20-21-month-old separately.

Cattle (*Bos taurus*). Cattle also appeared in every phase and exhibited the highest values both in aspect of NISP (679, accounting for 71.2%) and MNI (35, accounting for 36.8%). In the stage I, the unearthed specimens of cattle represented a minimum of three individuals, with the age of two individuals being relatively young based on the bone fusion conditions. Within the stage III, a specimen of left distal humerus was excavated. In the stage IV, the cattle specimens unearthed represented a minimum of four individuals, including two subadult individuals, one of which was estimated to be 10-12 months old. In the phase V-1, three specimens of the metatarsal and calcaneus bones were unearthed. In the phase V-2, 7 specimens represented at least 1 individual, with the cattle individual appearing to be relatively large in size. In the phase VI-1, four specimens represented at least one individual. During the phase VI-2, as previously mentioned, the concentrated appearance of scapula fragments of cattle in ash pits T48-H10 and T55-H2, possibly associated with special functions, resulted in a substantial increase in cattle specimens during this phase. The scapula fragments from H10 were estimated to represent a minimum of 21 individuals based on relatively complete glenoid and coracoid process specimens, and scapula fragment specimens from H2 were also estimated to represent a minimum of three individuals based on the same anatomical features.

Caprinae (*Capra/Ovis*). Compared to pigs and cattle, the occurrence of sheep/goat bone remains is sporadic and relatively rare. In the phase I, only an isolated upper deciduous molar was found. In the stage III, three specimens were unearthed, all of which were metacarpal or metatarsal bones, representing a minimum of one individual. In the stage IV, according to four right humerus specimens, a calculation of 24 specimens representing at least four individuals was yielded, of which two individuals' ages can be estimated: one is 2-3 years old, and the other is 3-4 years old. In addition, there is one cranial specimen that can be

identified as sheep (*Ovis aries*) (**Figure 4-11-4**). In the phase V-1, three specimens represented at least one individual. Within the phase V-2, the calculation of MNI was based on two distal humeri. No Caprinae specimens were discovered in the stage VI.

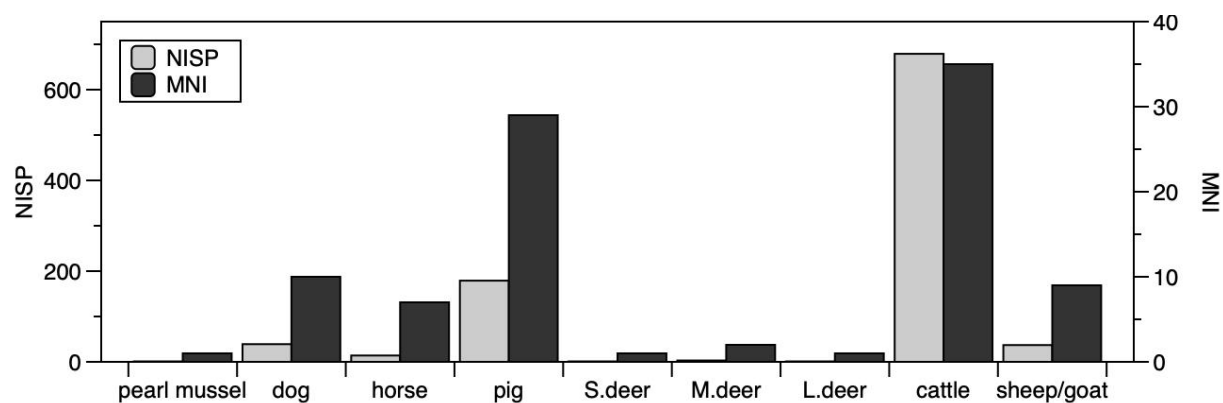


Figure 4-11-3. The number distribution of the taxa at JSY.



Figure 4-11-4. The left half cranial specimen of a female sheep individual unearthed from T47 J7 (well) at JSY site.

Table 4-11-1

Summary of NISP and MNI of the faunal assemblage at JSY

Taxa	I		III		IV		V				VI			
							V -1		V -2		VI -1		VI -2	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Hyriopsis cumingii</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>Canis familiaris</i>	1	1	1	1	20	3	4	1	5	1	1	1	7	2
<i>Equus caballus</i>	1	1	1	1	3	1	1	1	0	0	3	2	5	1
<i>Sus scrofa</i> sp.	13	3	3	1	116	16	1	1	23	4	1	1	22	3
Small-sized Cervidae	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Medium-sized Cervidae	0	0	0	0	2	1	0	0	0	0	0	0	1	1
Large-sized Cervidae	0	0	0	0	1	1	0	0	0	0	0	0	0	0
<i>Bos taurus</i>	9	3	1	1	45	4	3	1	7	1	4	1	610	24
Caprinae (<i>Capra/Ovis</i>)	1	1	3	1	24	4	3	1	6	2	0	0	0	0
Total	25	9	9	5	212	31	12	5	41	8	9	5	646	32
Total (whole site)	NISP=954, MNI=95													

Section 12 铸铜 Zhu Tong (ZT)

1. Excavation

The ZT (abbreviation of *Zhu Tong*, means copper-casting) site is located at the easternmost part of the eastern city (outer city), bordered by the east and north city walls of ZHGC, and beyond the eastern city wall lies the Huangshui River. The site has an irregular oval shape, covering a total area of 181,600 square meters, with the terrain sloping from west to east.

The site has undergone three excavations. The first excavation took place from March to April 1972, the second from December 1979 to January 26, 1980, and the third from March 1983 to May 1984. The excavations covered a total area of 797 square meters and 12 units were arranged, with 77 ash pits, 23 wells, and 5 tombs unearthed. Few animal bones were found.

Through these excavations, it was determined that the site should be a copper-casting workshop dating from the late Spring and Autumn period to the late Warring States period. The site was strategically chosen, built near the east city wall close to the river, facilitating access to water source for the casting. Excavated artifacts indicated that the workshop primarily produced agricultural tools such as ploughshares, hoes, and adzes, as well as weapons like swords and arrows. Everyday items like belt hooks were also produced occasionally. Coins were also cast here, and the discovery of Chu State coin imitations suggested close economic interactions between the State of Han and neighboring states such as Chu, Zhao, and Wei. Another important find at the site was a broken ceramic bowl with an inscription mentioning "*Zhong Zhong Da Shi*" (钟中大室 in Chinese) on it, providing crucial textual evidence for understanding the nature of the shrine temple of Han State (HZM) site.

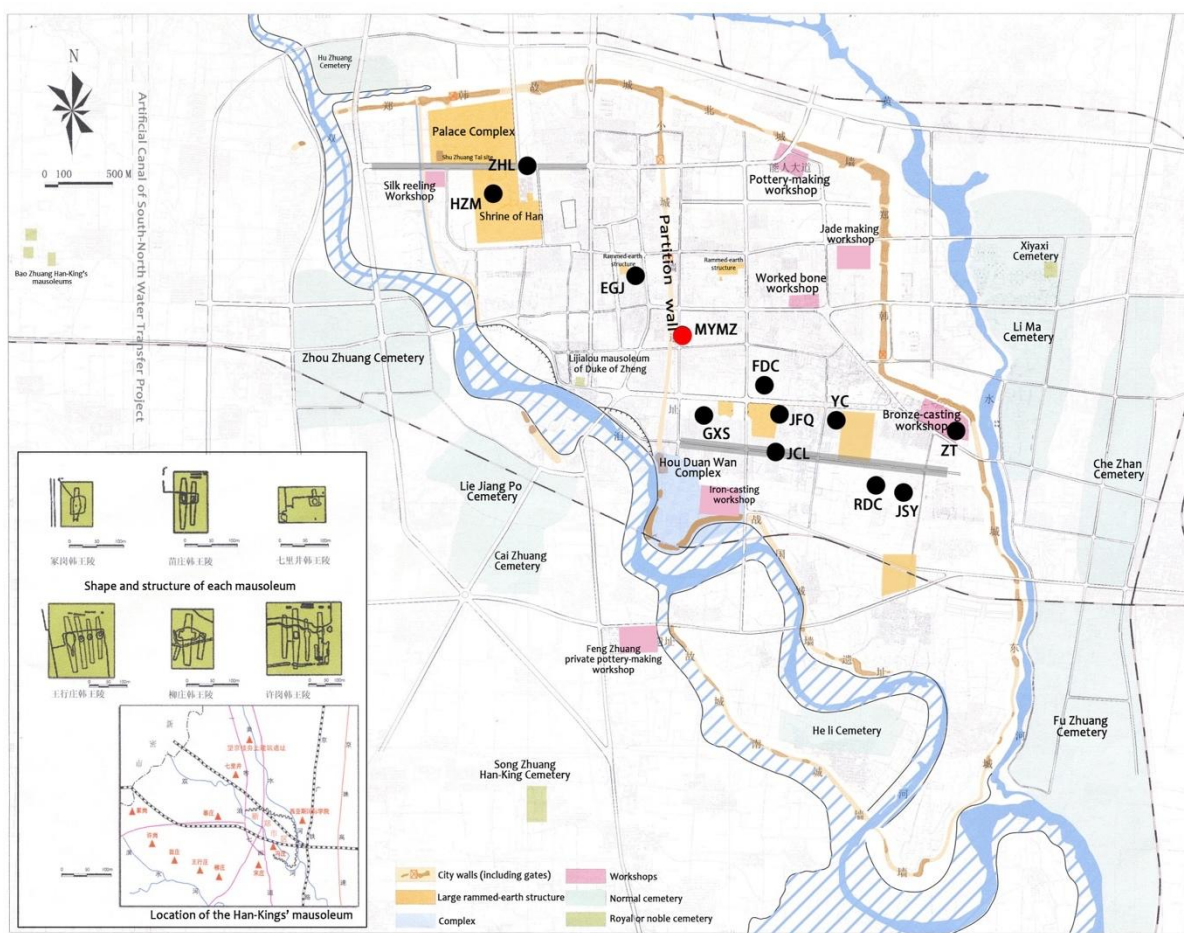


Figure 4-12-1. The location of MYMZ site (red dot).

2. Faunal Assemblage Profile and Quantitative Results

There was a total of 104 animal bone specimens excavated from ZT site, with a combined weight of 1072.4 grams. In terms of the distribution among periods, the faunal assemblage can be attributed to three stages. In the Late Spring and Autumn Period (Ⅲ), there were seven specimens with a total weight of 576.4 grams; the Middle Warring States period (Ⅴ-1) provided four specimens weighing 451 grams; and the Late Warring States Period (Ⅵ-2) is the stage when most specimens were found, with 93 specimens, but weighing only 45 grams.

Due to the unique nature of this site as a bronze-casting workshop, except for a loose isolated lower molar of cattle, all the animal bone remains unearthed from this site were constituted by waste materials from bone tool production, semi-processed bone materials, or

tiny bone sherds possibly associated with bronze casting activities. Copper artifacts, during the burial process, underwent reactions with carbon dioxide or sulphur dioxide to form basic copper carbonate or basic copper sulphate, commonly known as copper Verdigris (chemical formula written as $\text{Cu}_2(\text{OH})_2\text{CO}_3$), showing a distinctive bluish-green colour. Among the 104 specimens, there were 95 that exhibited clear greenish staining on their surfaces, indicating the infiltration of Verdigris. This suggests that these bones were in close contact with surrounding copper artifacts or copper slag during the preservation process, leading to this phenomenon. The most representative case was exemplified by T7 J14 of this site, where all the unearthed remains consisted solely of tiny animal bones, bone fragments, and slices, covering with turquoise colour (**Figure 4-12-2**). This fact also elucidates why the phase VI-2 yielded the largest number of specimens yet with an overall light bone mass. As a distinctive feature, it will be comprehensively explored in the handicraft section of Chapter 7.



Figure 4-12-2. The bone assemblage of T7 J14 at ZT site. The identifiable remains are arranged according to animal species, while the unidentifiable bone slices and bone materials are categorized based on morphological characteristics in typological classification. Elaboration of specific classification criteria can be found in Chapter 7.

Of course, while this site is primarily characterized by bone fragments and waste materials, there are still around half of the specimens (46 specimens) that can be successfully attributed to their animal source at the level of fish or mammal (class level). The calculation results of NISP and MNI are summarized as **Table 4-12-1**. The NISP for all the remains adds

up to 28, constituting a mere 26.9% of the overall assemblage. The identifiable species encompassed black carp (*Mylopharyngodon piceus*), dogs, pigs, cattle, and Caprinae, with pigs and cattle exhibiting the most pronounced presence (as illustrated in **Figure 4-12-3**).

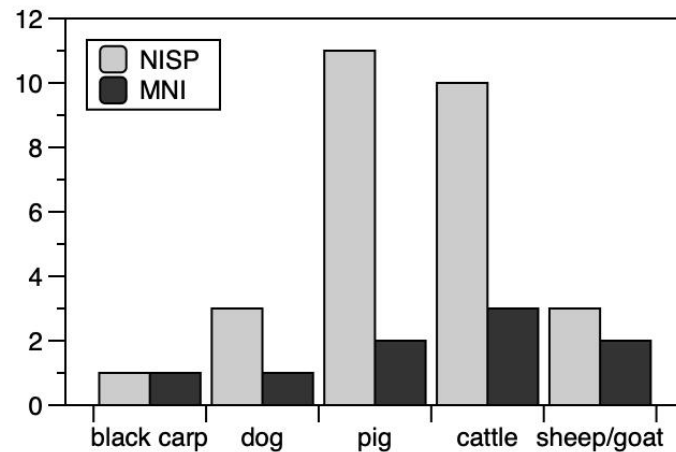


Figure 4-12-3. The NISP and MNI distribution of the taxa at ZT.

Table 4-12-1
Summary of NISP and MNI of the faunal assemblage at ZT

Taxa	III		V		VI	
	NISP	MNI	V -1		VI -2	
			NISP	MNI	NISP	MNI
<i>Mylopharyngodon piceus</i>	0	0	0	0	1	1
<i>Canis familiaris</i>	0	0	0	0	3	1
<i>Sus scrofa</i> sp.	0	0	0	0	11	2
<i>Bos taurus</i>	6	1	4	2	0	0
Caprinae (<i>Capra/Ovis</i>)	1	1	0	0	2	1
Total (stage)	7	2	4	2	17	5
Total (whole site)	NISP=28, MNI=9					

Section 13 Summary and Discussion

Summarizing the materials above, a total of 10,053 animal bone specimens weighing 410,455.5 grams were unearthed from the 12 sites included in this analysis. The total NISP was 6290, accounting for 62.57% of the assemblage.

Additionally, there were seven human bone specimens mixed among the faunal remains, which will be briefly mentioned (**Table 4-13-1**) but are not within the scope of this study. We will summarize and organize animal remains below from the perspectives of inter-sites, inter-taxa, inter-phases, traces, and the pathologies found on the faunal materials.

Table 4-13-1
Human bones mixed in the assemblage.

No.	Location	Feature	Stage	Identification result	Number
1	GXS	T227 J141	I	Skull	1
2	GXS	T225 H866	I	Left proximal femur	1
3	JFQ	TG5 H851	I	Parietal bone	1
4	JFQ	T208 ⑦	II	Tibia	1
5	JFQ	T198 ③	III	Parietal bone	1
6	JFQ	T207 H803	VI	Occipital bone	1
7	JSY	T47 J6	V	1 st rib	1
Total					7

1. General Preservation Condition

The region has a low average annual temperature, low soil humidity, and the soil conditions are alkaline, which is conducive to the preservation of animal bones. The average pH of the surface soil in the Loess Plateau is higher than in other regions of China (Liu *et al.* 2013), although Xinzheng is in the most marginal area. The soil pH value is over 8.0 here (**Figure 4-13-1**). Additionally, the area belongs to the Yellow River basin, and the deposition of river sediments has led to rapid stratigraphic accumulation. Many archaeological sites in this region are deeply buried underground (Storozum 2020), providing an excellent taphonomy environment for faunal remains.

The assemblage is generally well preserved. Based on the weathering stage scale established by Behrensmeyer (1978), over 95% of the materials could be classified into the stage 0 or 1, providing the premise for a high NISP ratio of the materials.

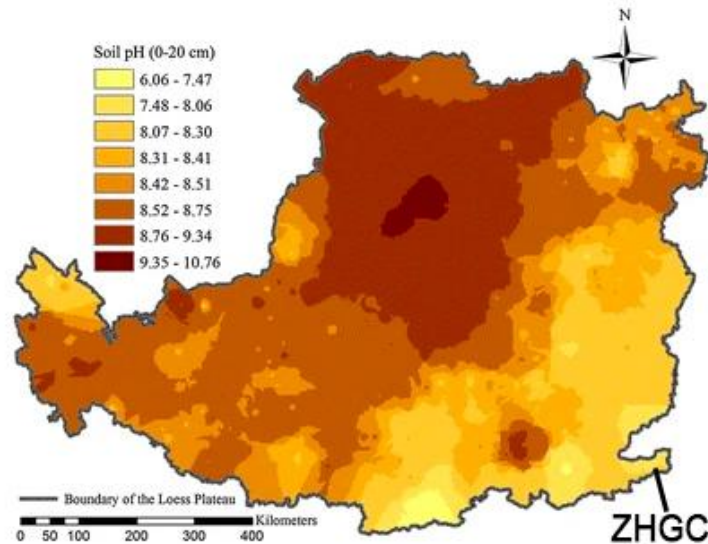


Figure 4-13-1. Interpolated maps of soil pH across the Loess Plateau of China and the location of the site (adopted from Liu *et al.* 2013).

2. Inter-sites Comparative Analysis

The most challenging aspect of the faunal materials used in this article is the multitude and dispersion of the twelve sites. Therefore, organizing and comparing the data from all the sites is crucial for gaining a clearer understanding of this batch of animal bones and effectively integrating them with the context of the sites.

In terms of the periodic distribution, as shown in **Table 4-13-2**, we can find that the Eastern Zhou period (from phase I to phase VI) layers constitute the main cultural body, with the majority of the faunal remains found during this period. There are two exceptions among the 12 sites. One is the HZM, where the shrine platform lost its Eastern Zhou stratigraphy due to later destruction by subsequent dynasties. The other exception is the MYMZ, which, being a rammed earth wall site, has remains from only one phase. The sites JFQ, JCL, GXS, and RDC own complete continuous strata of Eastern Zhou.

Table 4-13-2

Corresponding relationship of stages with faunal remains found in each site.

	HZM	JSY	JFQ	FDC	ZHL	ZT	JCL	GXS	MY MZ	RDC	YC	EGJ
Erlitou											✓	
W. Zhou							✓				✓	
I		✓	✓				✓	✓		✓		
II			✓	✓			✓	✓		✓	✓	
III		✓	✓	✓		✓	✓	✓		✓	✓	✓
IV		✓	✓		✓		✓	✓	✓	✓	✓	✓
V		✓	✓	✓	✓	✓	✓	✓		✓	✓	
VI		✓	✓		✓	✓	✓	✓		✓	✓	✓
W. Han	✓											
E. Han	✓											
Song	✓											

In terms of quantity, I have integrated the NISP and MNI of animal remains unearthed from 12 sites, as shown in the **Figure 4-13-2**. Obviously, GXS had the most abundant animal remains among the excavated sites. Generally, remains from east city were far more than that from west city. The sites in the western city area had fewer remains, although EGJ has a relatively considerable quantity. In the eastern city area, apart from the prominent GXS, other sites, including JCL, JFQ, YC, JSY, also have substantial quantities.

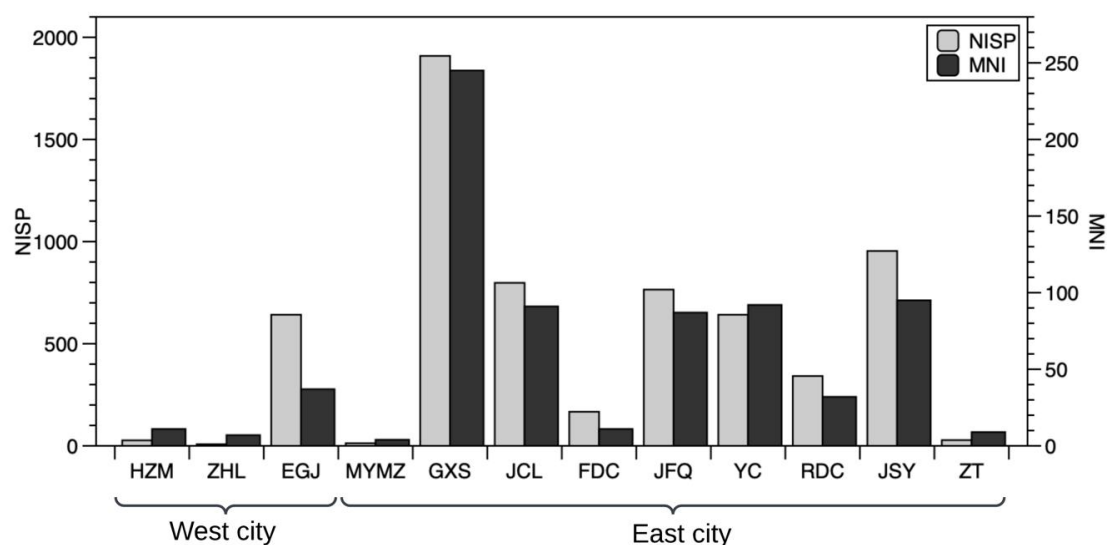


Figure 4-13-2. Summary of NISP and MNI of twelve sites in ZHGC

The quantity of animal remains is closely related to the nature of the sites themselves. Among the twelve sites, the ones with the least quantity of remains, including HZM, ZHL, MYMZ, FDC, and ZT sites, all were single-function site rather than a complex. HZM is a site of shrine structure; ZHL is burial area (where faunal remains from burials were not included in, so only few bones from pits and layers were analysed here); MYMZ is a trial site of the city wall; FDC is a concentration area for burials; and ZT is a site for bronze casting. The special functions of these sites determined that they were unlikely to have many animal bones, and the appeared animal remains were mostly associated with the nature of the sites. In contrast, sites like GXS, JFQ, JSY, etc., commonly regarded as living areas, where a large number of garbage pits and wells related to daily activities have been discovered, exhibited much more abundant animal bones.

Similarly, the richness of animal remains in the eastern city far exceeded that in the western city, aligning with the urban functional pattern where the western city served as the political centre and the eastern city as the economic production centre.

3. Inter-phases Comparative Analysis

In addition to numerous sites, this batch of materials covers multiple stages, expanding from Xia Dynasty to Song Dynasty. From a quantitative perspective, the finding of animal bones was predominantly concentrated in the Eastern Zhou period. Overall, the quantity during the Warring States Period far exceeded that of the Spring and Autumn Period. Particularly in the Late Warring States period (stage VI), the quantity of animal bones reached its peak (**Table 4-13-3**).

Table 4-13-3
Summary of total number, NISP, and MNI of stages separately

Stages	Total Number	NISP	MNI
Erlitou	9	9	5
W. Zhou	164	39	8
I	916	535	70
II	714	479	67

III	723	490	65
IV	1417	1115	124
V	1028	646	96
VI	4513	2647	263
W. Han	12	1	1
E. Han	40	25	9
Song	2	1	1
TOTAL	9538	5987	709

Note: 1. Because stages and sub-stages coexist, the data from the sub-stages are consolidated into the major stages for calculation; 2. A total of 10,051 specimens were excavated from 12 archaeological sites. However, this table does not include 12 specimens with dating issues or from disturbed layers, nor does it include the specimens from the No.1 Mess-bone pit of RDC (which comprises 501 specimens, with NISP=303, MNI=10) because it cannot be put into specific stage due to the lack of specific dating information. Therefore, the final total figure is calculated as 9,538.

The overall trend in quantities indicates a gradual increase, despite a slight decrease in the mid-Warring States period, reaching its zenith in the late Warring States period (**Figure 4-13-3**). This aligns well with the site's history of use. In the early Spring and Autumn Period, Zheng established its capital here, and the population gradually settled, witnessing the gradual development of the city. In the transition from the Spring and Autumn to the Warring States period, Han conquered Zheng, which then reused this site as capital and vigorously developed various manufacturing and handicraft industries. In the late Warring States period, Han was conquered by Qin, leading to the abandonment of city.

Can we deduce from the changes in animal bones whether the social development during the Warring States period surpassed that of the Spring and Autumn period? To answer this, we can seek evidence from other perspectives. Firstly, from a demographic standpoint, despite continuous warfare, the Warring States period was crucial for the rapid development of agriculture in ancient China, laying the foundation for subsequent agrarian civilizations. The population of various feudal states rapidly increased, experiencing a demographic boom in the early Warring States period. According to the estimates of Fan (2009) and Ge (2000), the total population during the Warring States period was around 25 to 30 million, far exceeding that of the Spring and Autumn period. Specifically for Zheng and Han, with the

latter absorbing the former and occupying this site as its capital, there was inevitably a significant increase in the resident population of Han. From the perspective of societal development, the Warring States period saw the rapid advancement of pig iron forging technology, and China started to enter the Iron Age from then. The emergence of iron tools significantly boosting societal productivity, and, as we see, the quantity of faunal remains reached a zenith at the late Warring states period.

Therefore, the answer to the above question of whether societal development during the Warring States period surpassed that of the Spring and Autumn period is affirmative. Additionally, this highlights the idea that the quantity of animal bones is positively correlated with both the contemporary population and the level of societal development. From a macro perspective, the quantity of animal bones serves as a robust indicator of societal development at that time.

As for the fluctuation in stage V, whether it is related to specific historical events or due to the excavation location, requires further data for a comprehensive explanation.

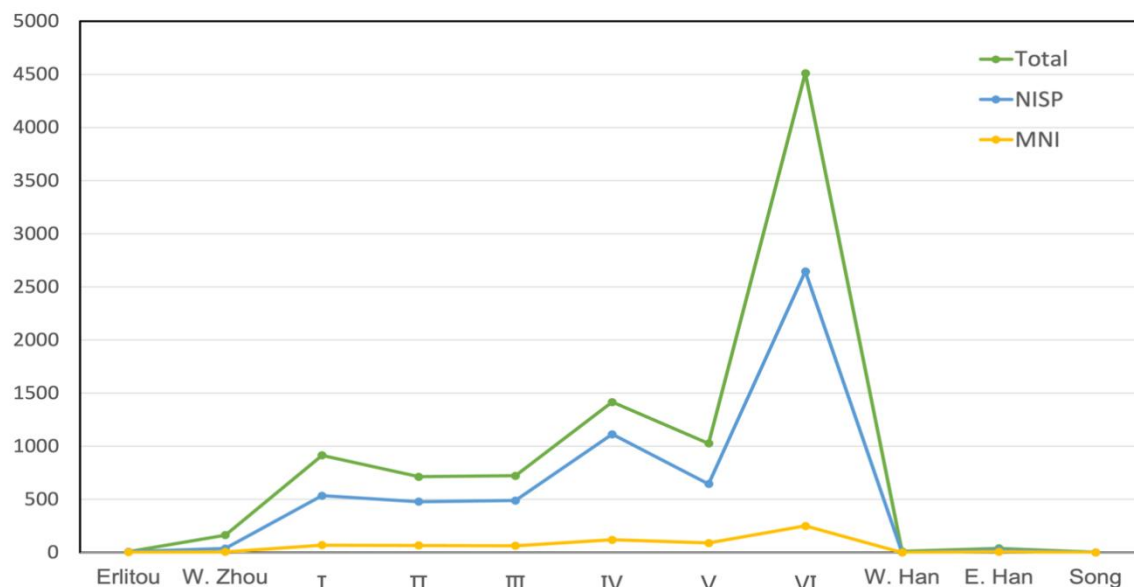


Figure 4-13-3. Variation tendency of total number, NSIP, and MNI separately during stages.

4. Inter-taxa Analysis

4.1 Overall

The faunal assemblage has a high diversity of taxa, including fishes, molluscs, birds, reptiles, and mammals. The total number and total weight of each taxon are listed below (Table 4-13-4). Mammals are the most predominant, with 9794 specimens found, accounting for 97.44% of the assemblage.

Table 4-13-4
Summary of total number and total weight of various taxa separately

Taxa	Total Number	Total Weight (g)
Fish	20	144
Mollusc	13	269.6
Bird	11	33.5
Reptile	5	36.5
Mammal	9794	409204.6
Craft	58	63.2
Fragments	150	703.7
TOTAL	10051	410455.5

Specific species of every class are listed as following:

1. Fish: Chinese sturgeon (*Acipenser sinensis*); black carp (*Mylopharyngodon piceus*).
2. Mollusc: freshwater pearl mussel (*Hyriopsis cumingii*); *Lamprotula*; *Cuneopsis*.
3. Bird: chicken (*Gallus gallus domesticus*); domesticated goose (*Anser cygnoides*).
4. Reptile: Chinese softshell turtle (*Pelodiscus sinensis*); Reeves' turtle (*Mauremys reevesii*).
5. Mammal: rabbit (*Lepus* sp.); dog (*Canis familiaris*); Asian badger (*Meles leucurus*); tiger (*Panthera tigris*); horse (*Equus caballus*); domesticated pig or wild boar (*Sus scrofa* sp.); Chinese water deer (*Hydropotes inermis*); red muntjac (*Muntiacus muntjak*); sika deer (*Cervus nippon*); Père David's deer (*Elaphurus davidianus*); cattle (*Bos taurus*); sheep (*Ovis aries*); goat (*Capra hircus*).

4.2 Fishes, molluscs, birds, and reptiles

A total of 20 specimens of the fish class are shown in the **Table 4-13-5**. In summary, we can observe two characteristics of these remains: firstly, these fish bones were all unearthed in features related to daily life, such as ash pits and wells; secondly, most of these fish bones belonged to large fish individuals, the Chinese sturgeon and black carp are both typical large freshwater fishes.

Table 4-13-5
Summary of fish bones found from ZHGC.

No.	Location	Feature	Stage	Identification result	Number	Image
1	GXS	Well	I	Chinese sturgeon-scute	1	N/A
2	GXS	Ash pit	I	Chinese sturgeon-scute	1	Fig. 4-5-6
3	GXS	Layer	I	Large fish-opercular	1	N/A
4	GXS	Well	II	Fish-head fragments	3	N/A
5	GXS	Ash pit	III	Large fish-opercular	1	N/A
6	GXS	Ash pit	VI	Fish-parietal bone	2	N/A
7	JCL	Trench	I	Black carp-opercular	1	N/A
8	JCL	Trench	I	Black carp-cleithrum	1	Fig. 4-6-2-C
9	JFQ	Ash pit	III	Large fish-quadrant	1	N/A
10	ZT	Well	VI	Black carp-tooth	1	Fig. 4-12-1
11	ZT	Well	VI	Fish-rib	3	Fig. 4-12-1
12	ZT	Well	VI	Fish-fin	4	Fig. 4-12-1
Total					20	

Similarly, among aquatic resources, there were also molluscs. A total of 13 specimens were found, summarized as in **Table 4-13-6**. The overall quantity of unearthed molluscs was quite low, and they were all freshwater species, with the majority being freshwater pearl mussels (*Hyriopsis cumingii*). This suggested that the utilization of molluscs might be limited to occasional gathering rather than being a regular food source. Additionally, the shells of molluscs are easily weathered and eroded, making it challenging to collect them in practical field work, which to a certain extent contributed to their low quantity.

Table 4-13-6
Summary of mollusc remains found from ZHGC.

No.	Location	Feature	Stage	Identification result	Number	Image
1	GXS	Ash pit	I	<i>Hyriopsis cumingii</i> -fragment	1	N/A
2	GXS	Layer	I	<i>Hyriopsis cumingii</i> -ventral rim	1	N/A
3	GXS	Layer	II	<i>Hyriopsis cumingii</i> -fragment	1	N/A
4	GXS	Layer	II	<i>Hyriopsis cumingii</i> -ventral rim	1	Fig. 4-5-2-A
5	GXS	Ash pit	II	<i>Lamprotula</i> -left shell	1	N/A
6	GXS	Layer	II	<i>Cuneopsis</i> -left shell	1	N/A
7	GXS	Layer	III	Freshwater mollusc-fragment	1	N/A
8	GXS	Layer	VI	<i>Hyriopsis cumingii</i> -fragment	1	N/A
9	JCL	Well	W. Zhou	<i>Lamprotula</i> -right shell	1	Fig. 4-6-2-A
10	JCL	Ash pit	VI	<i>Hyriopsis cumingii</i> -fragment	1	N/A
11	RDC	Ash pit	II	<i>Hyriopsis cumingii</i> -fragment	1	N/A
12	RDC	Layer	IV	<i>Hyriopsis cumingii</i> -fragment	1	N/A
13	JSY	Ash pit	VI	<i>Hyriopsis cumingii</i> -fragment	1	N/A
Total					13	

The bird bones, totalling 11 specimens, are summarized in **Table 4-13-7**. These specimens exhibit several characteristics: 1. The quantity was very few; 2. All domesticated birds; 3. They were all from contexts related to daily life; 4. They appeared relatively late, with no bird bone remains found before the mid-Warring States period.

The reptile remains, totalling 11 specimens, also show the characteristics of small quantity and mundane-related (**Table 4-13-8**). In contrast to birds, they all were found during the middle and late Warring States periods.

Table 4-13-7
Summary of bird remains found from ZHGC.

No.	Location	Feature	Stage	Identification result	Number	Image
1	GXS	Ash pit	VI	Chicken-right femur	1	Fig. 4-5-2-C
2	GXS	Ash pit	VI	Chicken-carina	1	Fig. 4-5-2-D
3	GXS	Ash pit	VI	Chicken-left tibiotarsus	1	N/A
4	GXS	Ash pit	VI	Goose-distal tibia	1	Fig. 4-5-2-E
5	GXS	Ash pit	VI	Goose-left ulna	1	Fig. 4-5-2-F
6	GXS	Ash pit	VI	Goose-left ulna	1	N/A
7	JCL	Well	V	Goose-left distal tibiotarsus	1	Fig. 4-6-2-D
8	JCL	Well	V	Chicken-left tarsometatarsus	1	Fig. 4-6-2-E
9	JCL	Well	V	Chicken-right femur	1	N/A
10	JCL	Well	V	Chicken-right tibiotarsus	1	N/A
11	JFQ	Ash pit	VI	Chicken-left coracoid	1	Fig. 4-8-2
Total					11	

Table 4-13-8
Summary of reptile remains found from ZHGC.

No.	Location	Feature	Stage	Identification result	Number	Image
1	GXS	Well	I	Softshell turtle-plastron fragment	1	Fig. 4-5-2-B
2	GXS	Ash pit	I	Softshell turtle-carapace fragment	1	N/A
3	GXS	Ash pit	II	Softshell turtle-carapace fragment	1	N/A
4	GXS	Well	II	Softshell turtle-carapace fragment	1	N/A
5	JCL	Well	W. Zhou	Reeves' turtle-plastron fragment	1	Fig. 4-6-2-F
Total					5	

In summary, several interesting phenomena can be concluded. Firstly, compared to mammal remains, remains of fishes, molluscs, birds, and reptiles were extremely rare. Secondly, these specimens only appeared in features like ash pits and wells, indicating their use for daily consumption rather than ritualistic scenarios like sacrifices or burial practices. Thirdly, in terms of temporal distribution, despite their scarcity, fish and molluscs were found in various periods. Interestingly, reptile remains were only discovered in the early stages, during the early to middle phase of the Spring and Autumn period, while birds existed only in the late stages, during the middle to late phases of the Warring States era, unexpectedly displaying a clear pattern. Could this be related to the rule changing of two states, Zheng and Han? Did the ruler of Zheng State issue a ban on reptiles due to the death of Duke *Ling* of Zheng from a bowl of turtle soup¹³, leading to the absence of reptile remains after the middle Spring and Autumn period? Did the Han State start to introduce poultry into the city for consumption? However, due to the extremely small quantity and the lack of complete materials from the entire site, the occurrence of this phenomenon might be accidental and the speculations above are still tentative.

Additionally, regarding the rarity of these remains, besides potentially lower consumption, it is very likely related to the unscientific practices of field archaeology at that

¹³ In the Spring and Autumn period, Duke *Ling* got a giant softshell turtle (鼈, yuán, *Pelochelys cantorii*) and made it a delicious soup. However, he intentionally didn't share it with the nobleman *Song*. This angered *Song*, who, in retaliation, rudely dipped his fingers directly into the soup to taste it. So, Duke *Ling* responded him with a severe punishment. *Song* held the grudge for this, and later, in collaboration with others, conspired to kill Duke *Ling* of Zheng finally. This story was recorded in the historic literature *Zuo Zhuan*.

time. In the late 20th century, methods like bioarchaeology were not universally adopted, and the collection practices did not prioritize the screening of small bones. Consequently, the small remains like fish bones, might not have been completely extracted. This also possibly explains why the fish bone specimens are all from larger species and individuals

4.3 Mammals

As the most dominant part in the animal assemblage, mammals consist of six main species: pigs, deer, cattle, sheep/goat, dogs, and horses. Regardless of their occurrence frequency or quantity distribution, pigs, cattle, and sheep/goat are the most prominent. They are found more or less in each site (**Table 4-13-9**). Through quantitative analysis, these three animals consistently rank in the top three, whether measured by NISP or MNI. However, based on NISP, the number of cattle is greater than pigs, while based on MNI, pigs outnumber cattle (**Figure 4-13-4**). I suspect this discrepancy is due to the relatively fewer mandibular specimens that can be used to determine the age of cattle compared to pigs and sheep/goat, leading to an underestimation of the MNI for cattle.

Table 4-13-9
Corresponding relationship of mammals found in each site.

Taxa	HZM	ZHL	EGJ	MY MZ	GXS	JCL	FDC	JFQ	YC	RDC	JSY	ZT
Pig	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Deer		✓	✓		✓	✓		✓	✓	✓	✓	
Cattle	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sheep/goat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dog	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓
Horse			✓		✓	✓		✓	✓	✓	✓	
Others					✓							

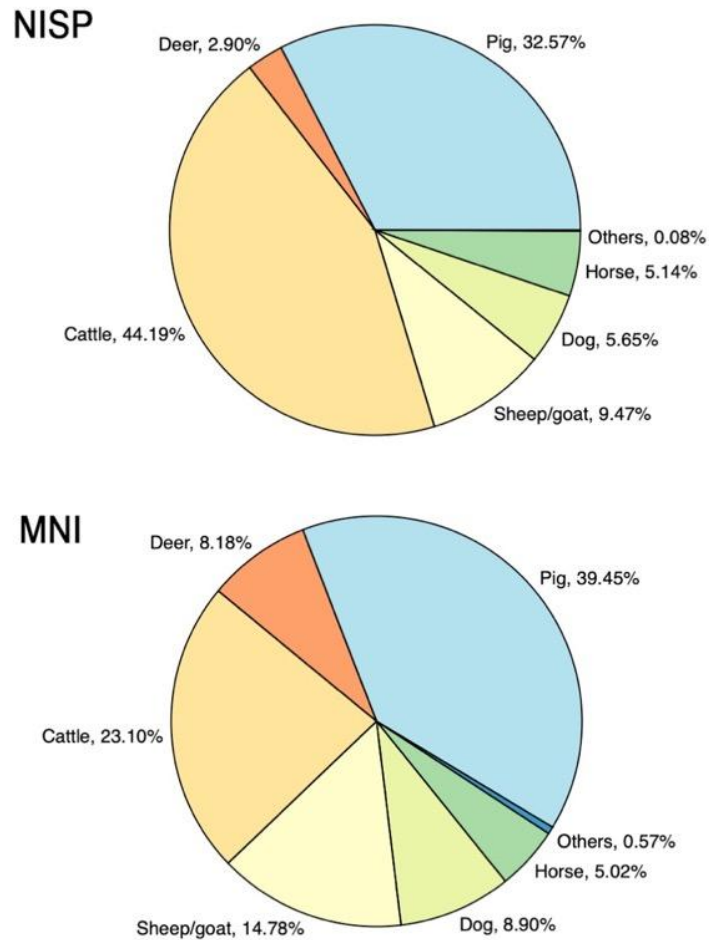


Figure 4-13-4. The NISP/MNI proportion of mammals of the overall faunal assemblage.

From the contexts of occurrence, in mundane settings like common ash pits, wells, and layers, pigs were generally more common and tended to have a numerical advantage compared to other mammals. In contrast, in special contexts such as burials and ash pits with special functions, although pigs were also present, cattle, sheep/goat, dogs, and horses were more concentrated in these scenarios. Deer, like pigs, also seemed to appear more in mundane consumption contexts.

Regarding the temporal variation of mammalian proportion, we can observe changes in the compositions of six types of mammals across main-body stages from **Figure 4-13-5 (top)**. There is a noticeable decrease in the proportion of pigs from phase I to phase VI, while the proportion of cattle has shown a general increase. This trend regarding the major

food animals might be more clearly observed from the bottom figure exclusively for pigs, cattle, and sheep/goats. The unusually large quantity of sheep observed in phase V should be directly related to the special feasting residues and this does not necessarily indicate an increased utilization of sheep during this period.

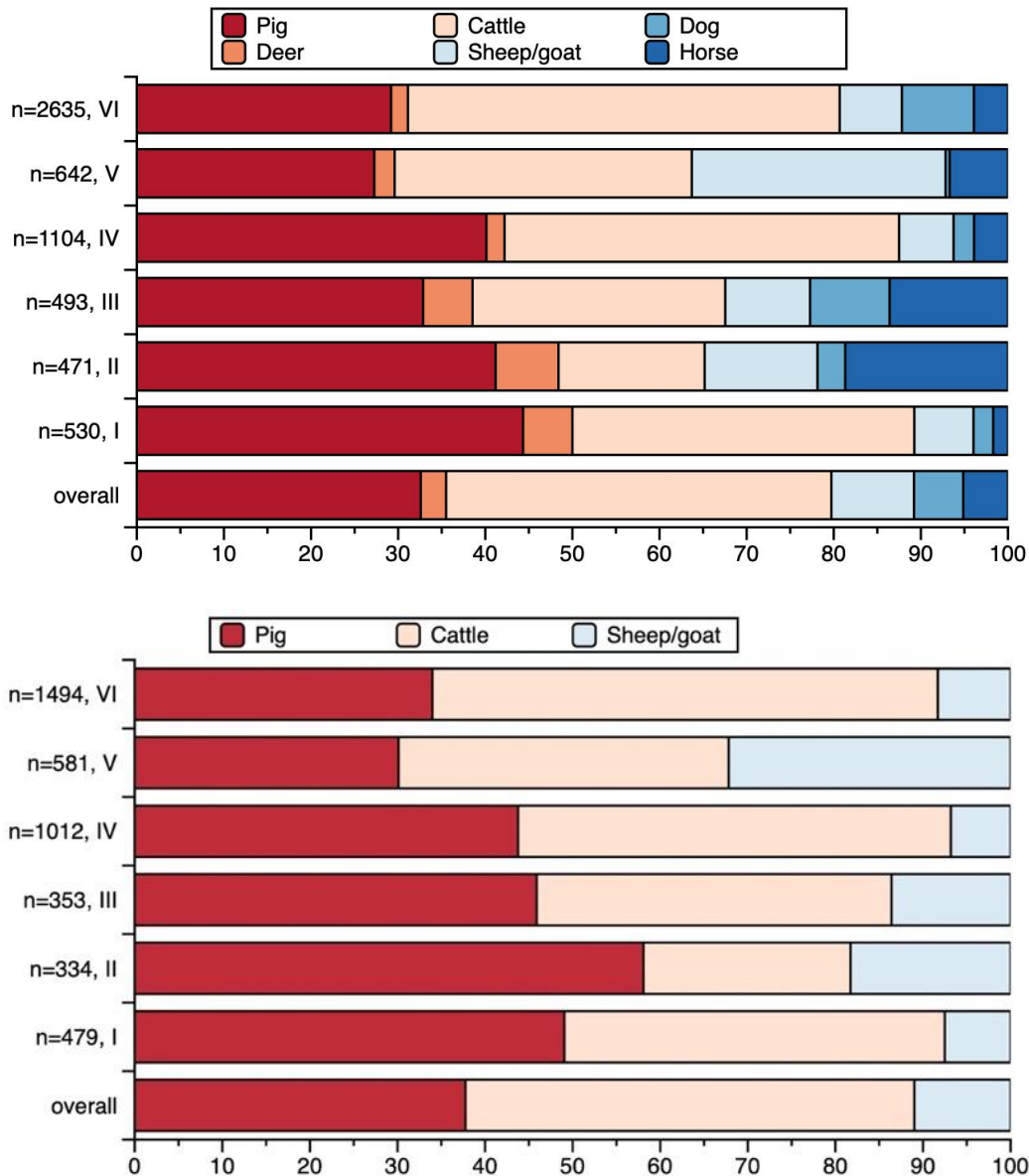


Figure 4-13-5. Top: the proportions of six main mammals in each phase and overall; bottom: proportions of three major food animals including pigs, cattle, and caprine, to show a clearer trend in terms of the taxa proportion variation of meat consumption.

5. Traces

The traces on animal bones can generally be categorized into artificial marks, marks caused by animals, and burn marks, with their distribution quantities illustrated in **Figure 4-**

13-6. Artificial traces mainly consist of cutting, sawing, and chopping marks, with chopping is the most predominant (**Figure 4-13-6-A**). Cutting marks are usually related to dismembering activities, over 70% of them happened on the articulation of limb bones. Sawing and chopping marks should be caused by the bone-processing practices. 83% of the sawing marks happened on the waste or raw materials for bone-working, and 88% of the chopping marks were found on large mammals. Regarding the animal-caused marks, they include two types, rodent gnawing and carnivore gnawing, whose proportions are illustrated in the **Figure 4-13-6-B**. As for the burning marks, 290 out of 331 specimens came from the JSY T48 H10, where many burnt cattle scapula fragments were found, contributing to the high number of burning traces. Excluding those from H10, burning traces are not as widespread as other marks.

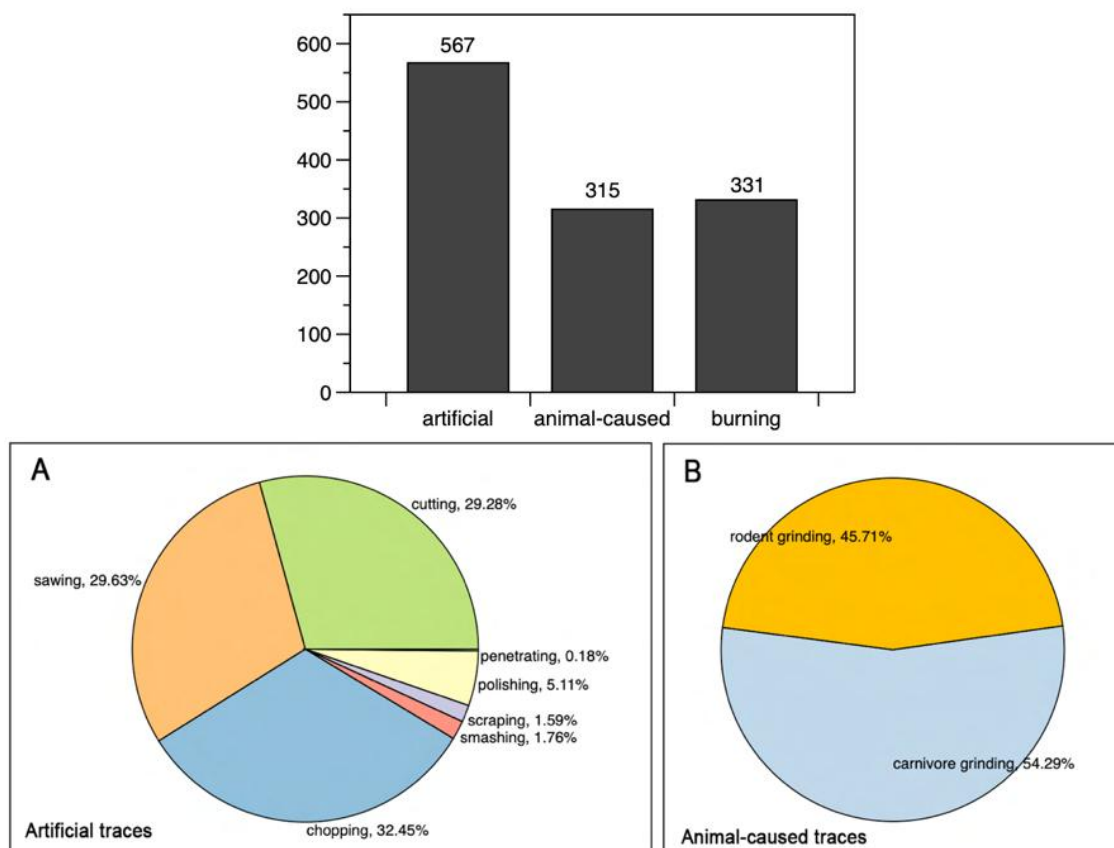


Figure. 4-13-6. The numbers of three kinds of traces and the proportion distribution within artificial (A) and animal-caused (B) kinds.



Figure 4-13-7. Illustrations of several traces. A. Cutting (filleting?) marks on cattle's rib; B. Chopping marks on cattle's collum mandibulae; C. Sawing marks (raw material taking) on Père David's deer's antler base; D. Rodent grinding marks on the posterior facet of distal humerus of pig; E. Carnivore grinding marks on the lateral condyle of cattle's proximal tibia.

6. Summary of anomaly (pathology) on bones

Overall, the number of pathological phenomena in this batch of animal bone materials is quite small, with only 10 cases identified. Among these observed pathologies, 6 are related to teeth, primarily in domestic pigs, some of which may be attributed to domestication. All anomalies occurred on domestic animals. Considering inbreeding, low genetic heterozygosity, and other genetic determinants of dental anomalies, domestic animals are considered more likely to have anomalies than wild animals because of artificial selection for breeds (Anthony & Lewis, 1961; Sofaer, 1975). At least from the perspective of bone, the assemblage appeared to be in a generally healthy condition. Some specific cases will be introduced as follows.

6.1 Polyodontia

One left maxillary of pig with upper P1-P4 from the No.1 Mess-bone Pit (RDC) was found to have an extra upper P1 (Figure lost). Supernumerary teeth are congenital in origin and usually result from the splitting of a bud or from local hyperactivity of the dental lamina, resulting in the formation of additional tooth germs (Zinoviev, 2010; Malmsten *et al.*, 2015). Polyodontia has been reported in both domestic and wild pigs (Okandeji *et al.*, 2023).

Normally, due to the lack of space for a supernumerary tooth, it could be found to be rotated perpendicular to the direction of the teeth row or displaced to a different location in the dental arch, which could result in malocclusion or crowding (Garvey *et al.*, 1999). But because the situation here is a supernumerary P1 at the forefront, the overall dentition was not affected.

6.2 Dental deformation

There was one pig specimen of dental deformation found from T231 J144 (stage VI) at the GXS site. It is a pair of mandibles with (L) P4-M3 and (R) P4-M3, with right lower P4 exhibiting the deformation with a curvature towards the lingual side on the posterior (**Figure 4-13-8**). I assume it might be caused by an external trauma or the individual physiological difference.



Figure 4-13-8. The dental deformation of lower P4 of a domesticated pig.

6.3 Linear Enamel Hypoplasia (LEH)

Linear enamel hypoplasia (LEH), commonly recognised as one or more grooves on the surfaces of tooth crown of human, is known to reflect a range of pathological conditions, both of nutritional and infectious nature. However, this pathology was also visible on the tooth crowns of numerous archaeological pigs' teeth, which may indicate a period of nutritional stress in a pig individual's life. Some researchers have done many studies concerning LEH occurrence on archaeological pig specimens and related methodologies of recording and interpretation (Dobney and Ervynck, 1998, 2000; Dobney *et al.*, 2004; Dobney *et al.*, 2007; Pike-Tay *et al.*, 2016).

Here, only one pig specimen of mandible with lower M1-M3 excavated from T195 H770 (stage IV) at JFQ site was found with LEH on the M2 (Figure lost). Some researchers suggested that "a period of under nutrition encountered during the first winter of the animals' life is thought to be the main causal factor for the occurrence of the single distinct LEH peak noted on the M2" (Dobney *et al.*, 2007). Thus, this pig individual might experience a food shortage during its first winter. However, due to the single case, the food shortage was not a common phenomenon.

6.4 Dentition malalignment

Dental crowding is defined as misalignment of the teeth due to insufficient space for them to erupt in the correct place (Horwitz & Davidovitz, 1992; Miles & Grigson, 2003). Feldhamer & McCann (2004) proposed that reduced frequency of rotated teeth in the mandible may be associated with the high incidence of missing lower first premolars. Oligodonty of P1 may leave more space in the mandibular molariform arcade, reducing crowding and subsequent rotational anomalies in the remaining cheekteeth. Like LEH, dentition malalignment occurring on pig teeth is sometimes regarded as an evidence of pig domestication. During the process of domestication, domestic pigs exhibit a reduction in the length of the snout and skull compared to wild boars. However, due to the slower rate of change in tooth size compared to the mandible, tooth crowding occurs, resulting in misalignment of the dentition (Yuan *et al.* 2010).

There was a specimen of right mandible with lower M1-M3 of a domesticated pig unearthed from T195 H760 at JFQ site (stage V). The alveolus of lower P2-P4 were kept although teeth were missing. **Figure 4-13-9** shows that the dentition appears a clear malalignment, lower M1 and M2 were crowded by the erupting M3, causing a distortion in the direction of their growth and slight rotation of M3.



Figure 4-13-9. The illustration of domestic pig's dentition malalignment.

6.5 Periodontal disease

The tissues surrounding and supporting tooth roots, including the alveolar process, periodontal ligament, cementum, and gum, are collectively called the periodontium. Diseases affecting these tissues are termed periodontal diseases, typically starting with gingivitis, an inflammatory condition of the gum margin (Miles & Grigson, 2003). The periodontal disease is quite commonly found on the archaeological animal bones.

Here, I found a piece of fragmented mandible with lower M1-M2 (L) of *Bos taurus* (cattle) from T205 ② (stage V) at JFQ site (**Figure 4-13-10**). The lower P4 is erupting to replace dp4. Slight periodontal disease with alveolar crest atrophy is found at the posterior dedendum of the fourth deciduous premolar that has not been replaced. I assume this might be caused by the inflammation.



Figure 4-13-10. The illustration of periodontal inflammation on cattle's mandible.

6.6 Dental caries

The development of dental caries requires sugars and bacteria to be present (Okandeji *et al.*, 2023). There is a close association between caries and individual's diet, especially the consumption of high-starch and high-sugar foods. In ancient societies, dental caries was more prevalent in populations primarily engaged in agriculture owing to greater reliance on carbohydrate-rich crop plants. Similarly, this phenomenon is more frequently observed in archaeological domestic pig specimens but is absent in wild boars (Yuan 2010). Consequently, some archaeologists consider the increased prevalence of dental caries as evidence of animal domestication, particularly in pigs (Zeder 2015).

Dental caries was found on the lower M2 of a fragmented right mandible with M2-M3 of domestic pig from T236 H924 (stage III) at GXS site (figure lost).

6.7 Fracture

Fractures are a common and serious traumatic injury. Fractures happening on animals are usually caused by impacts or falls from height during daily activities, or some external anthropogenic hitting. If the individual did not die due to the open fracture, some fracture healing traces will be left. The healing traces usually implies that the injured animal has been treated and taken care of after the fracture, although some severe open fracture can heal naturally.

Figure 4-13-11 showed bone swelling in the middle of the rib body of a large mammal (most likely to be cattle or horse) found from T5 J136 at JFQ site. It showed an old fracture (status post fracturam) with the loss of the cortical bone tissue and enthesophytes in the middle of the defect (Trbojević Vukičević *et al.*, 2023).

There is another specimen related to fracture. It is a right tibia of domestic pig found from T237② (stage VI) at GXS site (**Figure 4-13-12**). A patch appeared on the medial side of the diaphysis, which I assume is the aftermath of a light closed fracture healing.



Figure 4-13-11. The illustration of an old fracture on a large mammal's rib.



Figure 4-13-12. The illustration of closed fracture healing on the tibia diaphysis of a pig.

CHAPTER 5 Animals as Subsistence and Daily Consumption

This chapter is the “subsistence” part, serving two critical roles. Firstly, they fulfil the most fundamental tasks in archaeology: reconstructing the daily lives of the ancient people, including aspects such as their dietary habits, livestock management, economic activities. It helps us understand how they survived, lived, and thrived their lives. Secondly, they provide a comparative reference framework for the subsequent contents in Chapters 8 and 9, which delve into the topic of “feasting”. These two roles are relatively independent yet intricately connected, mutually complementing each other. It is because only when we have a clear understanding of what constitutes ordinary and mundane consumption can we recognize what is extraordinary and unusual.

Section 1 Domesticated or wild?

In the assemblage of animal bones studied here, mammals possess the most pronounced position, accounting for over 97% of the whole assemblage. Determining whether these mammals are domesticated or not is crucial for reconstructing the subsistence mode within ZHGC. The most prominent six mammal species found at the site include dogs, cattle, sheep, deer, horses, and pigs. Except for different-sized deer, which remained wild species, evidence of domestication and the establishment of breeding practices for the other five species has been commonly identified during the Bronze Age China (Flad 2007; Yuan 2008).

The domestication of dogs was a complex process involving multiple regions and genetically diverse populations. Recent ancient DNA evidence suggests that East Asian domestic dogs likely originated from dog populations in northeastern Eurasia during the Last Glacial Maximum (LGM), particularly in Siberia (Bergström et al., 2022), followed by subsequent dispersal events within East Asia. Western Eurasian maternal lineages began to exert a genetic influence on East Asian dogs from around 4,000 years ago (Zhang et al.,

2024). The earliest archaeological evidence of domesticated dogs in China dates to approximately 10,000 years ago, at the Nanzhuangtou site in Xushui County, Hebei Province (Yuan, 2008). While some mitochondrial DNA studies suggested that the domestication of dogs in China began around 14,000 years ago in the Yangtze River Basin (Pang et al. 2009), this contradicts morphological evidence from zooarchaeology. As such, I adopt a cautious and tentative stance regarding this claim. Nevertheless, by the Bronze Age, domesticated dogs had become a common and well-integrated component of human settlements across China.

Based on ancient DNA research, domesticated cattle and caprines were introduced from West Asia via northwest China (Chen et al. 2006; Cai 2014). The earliest zooarchaeological evidence of cattle, sheep, and goats was found in the Gansu-Qinghai region dating to c. 3,600-3,000 BC (Flad et al. 2007; Yuan et al. 2007; Flad et al. 2009; Brunson 2020). Subsequently, they gradually spread and, around 4,500 to 4,000 years ago, expanded to the middle and lower reaches of the Yellow River, where ZHGC is located, rising in frequency through time. (Lyu et al. 2017).

The new genetic evidence reveals that the Western Eurasian steppes as the homeland of modern domestic horses (Librado et al. 2021). Modern domestic horses ultimately replaced almost all other local populations as they expanded rapidly across Eurasia from about 2200 BCE (Librado et al. 2024). Like cattle and caprines, domestic horses in China were also introduced from neighbouring regions, and they arrived in China by c.1370 BC (Yuan & Flad 2006; Yuan et al. 2007; Flad et al. 2007). Then domestic horses spread to the Yellow River basin and were widely used in the long-term mobility and warfares across the country.

As for pigs, both archaeological and genetic evidence demonstrate that China was one of the early independent centers of pig domestication around the world (Yuan & Flad 2002;

Larson 2010). A series of zooarchaeological researches indicates domesticated pigs appeared in China during the early Neolithic. Pig remains from Jiahu site in Henan Province, dating to as early as 9,000 BP, exhibited tooth morphological changes and age pattern associated with domestication (Luo & Zhang 2008), which might be the earliest archaeological evidence of pig domestication in China. Subsequently, domestic pigs spread, and pig husbandry became the most predominant aspect of subsistence in the middle and lower reaches of the Yellow River during late Neolithic and Bronze Age.

Based on the previous discussion and the identification results, we can confidently assert that the remains of dogs, cattle, sheep/goats, and horses unearthed at the site are domesticated animals. However, concerning pigs, despite the widespread and mature practice of domestic pig rearing during the Eastern Zhou period, some wild morphological indications have been detected in the specimens. What could these wild indications mean? Is it indicative of the capture of purely wild boars, the presence of some individuals in a semi-domesticated status, or the possibility of different groups at the site? In the following analysis, we will focus on examining and discussing the nature of the pig remains excavated at the site.

1.1 Quantitative proportion and pathology

Based on the three quantitative indicators NISP, MNI, and bone weight (BWT) shown in **Table 5-1-1**, we can see that NISP% and MNI% of pigs are both over 30% (32.57% and 39.45% separately), which conforms to the standard of frequency of domestic pigs proposed by some Chinese scholars (anyone of NISP/MNI/MWT% over 30% proposed by Luo 2012). What is more, in spite of being rare, some classic pathologies that might be related with domestication have been detected, including the Linear Enamel Hypoplasia (LEH) and dentition malalignment on the teeth specimens (detailed cases introduction can be found in the Chapter 4).

To sum up, both quantitative and pathological signatures indicate the presence of domestic pigs in the faunal assemblage. However, whether the population consists solely of domestic pigs, a mixture of domestic and wild groups, or individuals in a semi-domesticated status, is uncertain. If it is a mixed population, it is also unknown whether there is a clear separation between them, and the approximate proportions of each group are also unknown. To explore these issues, we need the following methods to provide additional supports.

Table 5-1-1
Summary of quantitative proportions of main mammals at ZHGC.

Taxon	NISP	%	MNI	%	BWT (g)	%
Pig	2042	32.57	275	39.45	81495.3	25.98
Cattle	2772	44.19	161	23.10	169228.2	53.94
Sheep/goat	594	9.47	103	14.78	13871.9	4.42
Deer	182	2.90	57	8.18	11196.6	3.57
Horse	322	5.14	35	5.02	31126.9	9.92
Dog	354	5.65	62	8.90	6793.3	2.17

1.2 Biometrical methods

Morphological markers, like paedomorphic features (i.e. braincase reduction, tooth crowding and tooth length reduction and body size reduction), have been used primarily to document domestic animals, especially for pig domestication (Flannery 1983; Payne & Bull 1988; Albarella 2002; Ervynck et al. 2002); with those markers claimed to be an evolutionary response to changes in behaviour habits and living environment caused by animal husbandry, which can be detected through biometric analysis. It has been argued by many zooarchaeologists that measurements of animal bones from archaeological sites can provide valuable insights for distinguishing taxa, morphological types, sexes, and age groups (Boessneck & von den Driesch 1978; Albarella 2002; Albarella & Payne 2005; Rowley-Conwy et al. 2012).

One of the most well-established pieces of evidence is the reduction in the size of M3 (Davis 1981:137; Ervynck et al. 2002). During identification, all lower M3 specimens with

lengths over 39 mm and upper M3 specimens with lengths over 36 mm were classified as wild boars (see **Figure 5-1-1**). These criteria are based on previous research on pig domestication (e.g., Rüttimeyer 1862; Boessneck 1963; Jarman 1972), although they may present challenges when applied to different breeds or regions.



Figure 5-1-1. Tooth specimens of probable wild boars, including five specimens of lower M3 whose lengths are over 39 mm (no.1-5), and one of upper M3 whose length is over 40mm (no.6): 1. right mandible with M1-M3 at GXS-T236③ in phase I (46.61mm, SIBL 22-1791); 2. right mandible with M2-M3 at GXS-T236③ in phase I (41.95mm, SIBL 22-1792); 3. right mandible with M2-M3 at GXS-T241 ② phase I (39.18mm); 4. right mandible with M3 at GXS-T241 ② phase I (43.97mm); 5. loose left lower M3 at GXS-T241 ② phase I (40.89mm); 6. loose right upper M3 at GXS-T241 ② phase I (40.27mm).

The results of tooth measurements depicted in **Figure 5-1-2** clearly reveal the presence of two populations, characterized by the clustering of small-sized individuals in the bottom left and scattered distribution of several large-sized individuals in the top right. This clustering is particularly evident for the lower M3 due to the larger dataset. It is important to note that while the labels "domestic" and "wild" are used, this does not indicate a definitive classification. Rather, it reflects a highly likely outcome based on the measurements. There may be an ambiguous range between "domestic" and "wild" due to the presence of oversized or undersized individuals, as well as feral, hybrid, or semi-domestic forms.

M3 remains a useful tooth, but its measurements are not suggested to be used in isolation (Albarella and Payne 2005: 596–597). Apart from M3, the widths of the first two lower molars, tibia BdP, and astragalus GLI are known to show little age and sex dependence,

making them useful for comparing assemblages (Albarella & Payne 2005; Rowley-Conwy et al. 2012). However, there are only three available astragalus GLI measurements (35.97/38.45/38.88mm) obtained in total. The sample size is too small to be statistically significant, so astragalus GLI is excluded. Additionally, distal humerus and proximal radius are very common from the archaeological site, so humerus Bd and radius BpP will be included.

Through the **Figure 5-1-3**, we can find that both widths of first two molars and three postcranial measurements exhibit a size variation trend that is essentially consistent with that of upper/lower M3, demonstrating a tight group of many domestic individuals and a scattered presence of larger-sized outliers. However, the separation between domestic and wild ones is relatively clear only for the M3 measurements, there is no certain standard for other elements to makes it difficult to draw a clear line. This means that the possibility that some represent hybrids with other species or with domestic or feral animals cannot be ruled out.

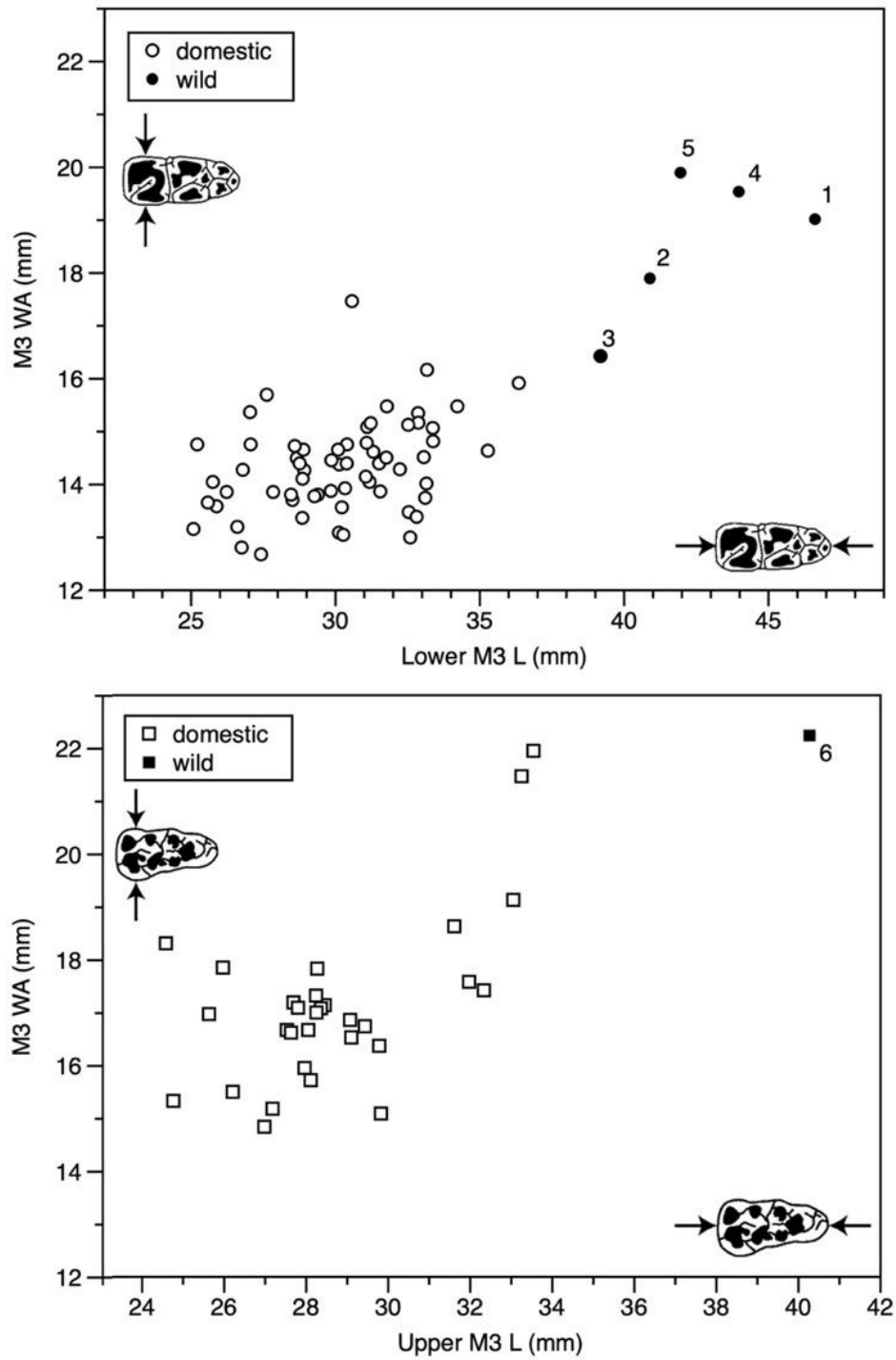


Figure 5-1-2. Illustration of M3 size of *Sus* and possible wild/domestic groups division. The “domestic” and “wild” labels in the legend only indicate the identification results, and there might be a blurred range (especially for those upper M3s whose lengths ranging from 31-34 mm) in the middle. The wild individuals marked with numbers in the graph correspond to the specimens shown in Figure 5-1-1.

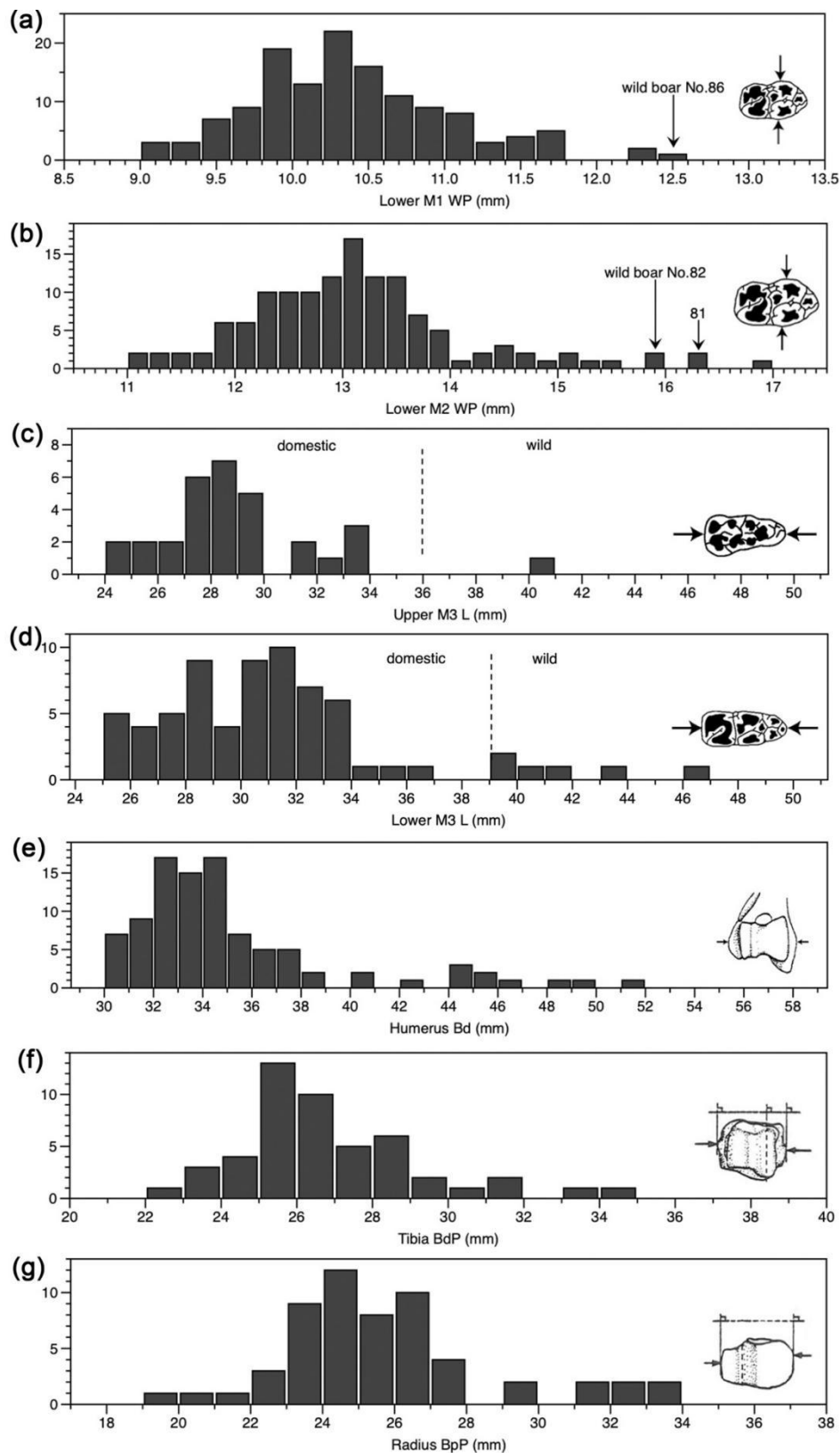


Figure 5-1-3. Measurement distribution of *Sus* (including domestic and wild pigs) teeth and postcranial bones including (a) lower M1 WP (posterior width), (b) lower M2 WP, (c) upper M3 length, (d) lower M3 length, (e) humerus Bd, (f) tibia BdP, and (g) radius BpP. The tooth specimens morphologically identified as wild boars (based on M3) were labelled (see Appendix Table 1-a/b), and the separation between wild and domestic is noted in the two M3 graphs. The original datasets of the graphs can be found from the Appendix Table 1.

In addition, pig measurements can be considered statistically. The mean and the standard deviation (SD) of the measurement datasets are calculated, and based on these, Pearson's coefficient of variation (V) is calculated: it is the ratio of the standard deviation to the mean. The higher the coefficient of variation, the greater the level of dispersion around the mean. This measures size variation independent of the absolute size of the specimens (Payne & Bull 1988: 29). This statistical method has been accepted and widely applied in the pig domestication research (e.g. Albarella & Payne 2005; Rowley-Conwy et al. 2012; Evin et al. 2013; Wang et al. 2015). In the calculation, certain teeth attributes of wild individuals identified according to the M3 measurements have been excluded from the analysis to further explore that if there would be other population divergence within the group. But for limb measurements, some single large individuals which might indicate wild and semi-domesticated individuals were included because the situation is unclear.

The statistical results for ZHGC are presented in **Table 5-1-2**. The V values of Durrington Walls (Albarella & Payne 2005) and Kızılcahamam are also listed as useful baselines for comparison (see **Table 5-1-2: V1, V2**) as they have been proven to be composed by the single population of domestic pig. Some comparable data of measurements from various sites (Rowley-Conwy et al. 2012: Table 1 and Table 2) showed that lower M3 lengths in many assemblages where a single population is (e.g. Seeberg Burgäschisee-Süd, Ringkloster, Troldebjerg) likely produce a V around 5 to 7. In comparison, the V values of ZHGC are obviously higher than the Kızılcahamam and Durrington Walls series. Even though the V values decrease substantially after excluding definite wild individuals of teeth samples (lower M3 has V of 8.8 for length and 8.0 for WA, upper M3 has V of 7.9 for length and 8.8 for WA), they are still slightly larger than expected for a single population.

The V values of the ZHGC sample indicate two main points. Firstly, the very high V observed in both teeth and post-cranial bones suggest the presence of at least two distinct

populations, domesticated and wild (see tooth data with superscript a). Secondly, even after excluding confirmed wild individuals, the remaining group still lacks the purity of a single population. The V values of the teeth fall within an ambiguous range (6-8 for M1/M2, 8-9 for M3), slightly higher than those of a single population, but not as large as those with clear separation or bimodal distributions (e.g., V of 16.7 for Starčevo, V of 26.0 for Selevac, and V of 14.9 for Egozswil). I attribute this situation primarily to the presence of a blurred range in the middle of wild and domestic, as mentioned earlier regarding Figure 5-1-2. As for the interpretation of this intermediate range, I propose three possibilities. Firstly, there might be some wild individuals that were not excluded, or there might be wild ones with smaller size, making them relatively difficult to be detectable. Secondly, besides the clearly defined domesticated and wild populations, there may exist an intermediate-sized group at ZHGC, possibly in a semi-domesticated situation or representing a different breed. This can be inferred from the illustration of upper M3 shown in **Figure 5-1-3-c**, where a clear separation exists at 30-31mm. The third interpretation is that the age-related shortening (especially for M1/M2 lengths) or lengthening (especially for limbs) of measurements would result in increased deviation in the sample data and consequently larger V, although we have tried to avoid this when selecting the elements.

For the three explanations mentioned, I lean towards a combination of the first and third possibilities. When excluding wild boar individuals, the judgment is solely based on the measurement standard of M3. This means that only specimens with M1/M2 measurements connected to M3 were identified as wild and then excluded. Many isolated molars or dentitions without M3 were included in the calculation of V, despite having large measurements, as shown in Figure 5-1-3, such as lower M1 WP measurements larger than 12mm and lower M2 WP measurements ranging from 15-17mm. Omitting these measurements would bring the V for lower M1 WP down to 5.8 from 6.2 and the V for lower

M2 WP down to 5.9 from 7.5, which are closer to the values of a single population. Moreover, it is evident that age significantly influences bone size. While the widths of the first two lower molars and tibia BdP are less affected, humerus Bd and radius BpP show larger age-related variations. It's challenging to discern whether the long dispersed "tail" in Figure 5-1-3-e/g belongs to old domestic pigs or wild individuals.

Regarding the possibility of another "intermediate" population, while there are some subtle clues, these representations can also be explained by the other two interpretations. Additionally, this can only be inferred from the upper M3 length, which lacks ubiquity.

Table 5-1-2.
Metrical attributes of pig teeth/bones from ZHGC and the V values from Durrington Walls (V1) and Kızılcahamam (V2) (Rowley-Conwy et al. 2012: Table 1) populations for comparison. The original dataset for ZHGC can be found from Appendix Table 1.

Element		n	Range	Mean	SD	V	V1	V2
Lower M1 ^a	L	142	12.36-18.92	15.43	1.07	7.0	5.2	6.3
	WA	129	8.08-11.36	9.59	0.60	6.3	4.5	3.4
	WP	135	9.14-12.57	10.40	0.66	6.4	5.0	3.7
Lower M1 ^b	L	141	12.36-18.92	15.42	1.06	6.9		
	WA	128	8.08-11.36	9.58	0.59	6.2		
	WP	134	9.14-12.36	10.38	0.64	6.2		
Lower M2 ^a	L	134	17.20-24.31	19.86	1.38	6.9	4.6	3.7
	WA	126	10.94-16.20	12.82	0.99	7.7	4.3	3.4
	WP	133	11.17-16.85	13.15	1.04	7.9	4.5	3.7
Lower M2 ^b	L	132	17.20-24.31	19.82	1.33	6.7		
	WA	124	10.94-16.20	12.77	0.93	7.3		
	WP	131	11.17-16.85	13.10	0.98	7.5		
Lower M3 ^a	L	69	25.08-46.61	31.12	4.16	13.36	5.5	-
	WA	85	12.68-19.90	14.77	1.51	10.23	6.0	-
Lower M3 ^b	L	64	25.08-36.35	30.23	2.65	8.8		
	WA	80	12.68-18.64	14.53	1.17	8.0		
Upper M3 ^a	L	35	24.58-40.27	29.07	2.96	10.2	6.3	-
	WA	36	14.84-22.24	17.28	1.71	9.9	4.4	-
Upper M3 ^b	L	34	24.58-33.54	28.74	2.26	7.9		
	WA	35	14.84-21.95	17.14	1.51	8.8		
Humerus ^{cd}	Bd	96	30.34-51.71	35.16	4.41	12.5	5.0	5.9
Radius ^{cd}	BpP	57	19.50-33.62	25.78	3.00	11.6	5.8	5.6
Tibia ^{cd}	BdP	49	22.70-34.98	26.90	2.44	9.1	4.5	4.9

- a. All available data included.*
- b. The specimens morphologically identified as wild boars have been excluded.*
- c. Fusing and fused bones are included.*
- d. Single large (possibly wild) individuals included*

1.3 Age at death

Besides metrical methods, age at death is often discussed as a possible means of distinguishing wild from domestic animals (Zeder 2006; 2008). The assumption is that domestic animals are killed younger, because people can control and manage their slaughter to maximize productivity. Such demographic analysis has been applied to some pig domestication research by Chinese zooarchaeologists (e.g. Qi et al. 2006; Luo & Zhang 2008; Yi 2019; Song et al. 2020).

Using the standard in the Chapter 2 (after Rowley-Conwy 2001: Table1), the death age of pigs in ZHGC is given in the **Table 5-1-3**. It is evident that the age intervals of “12-21 months” and “21-26 months” are the most prevalent, comprising over 60% of all aged individuals. This suggests that most pigs were slaughtered at approximately one to two years old. This aligns with the killing pattern of groups primarily involved in domestication because experienced pig breeders typically cull domesticated pigs around one year old to maximize meat yield (Luo 2012: 34). Similar slaughtering strategies have been observed in various archaeological case studies with pig domestication happening. However, the age distribution of pigs in ZHGC appears to exhibit a slightly older pattern than purely domestic pig groups, primarily due to the relatively high proportion of individuals older than 27 months. This might be caused by the mixing-in of wild boar individuals. This is further supported by the fact that all identifiable wild boar specimens were aged over 24 months, comprising two individuals in the 24-26 months category and two individuals older than 27 months.

It is noted that this method has been questioned by some scholars who argued that “the consideration of age at death is likely to be less helpful in pigs than in other species”

(Rowley-Conwy et al. 2012: 27-28) and that hunting would also lead to a high juvenile kill, whether seasonal hunting (Rowley-Conwy 1993; Legge & Rowley-Conwy 2000) or one-year-round hunting (Rowley-Conwy 1998, 1999). Therefore, I prefer to treat the death age as a supporting argument here, considered alongside other lines of evidence.

Table 5-1-3
*The age distribution of *Sus* (including domestic pigs and wild boars) within ZHGC.*

Age (mon.)	neonatal	1-6	7-12	12-21	21-26	≥27
n	2	12	37	83	47	35
%	0.93	5.56	17.13	38.43	21.76	16.20

1.4 Diet—evidence from C/N stable isotopes

The stable carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$) isotope values of *Sus* bone and teeth can provide a valuable proxy for pig diets under human control (Hu et al. 2009). Compared to wild boars, domestic pigs typically inhabit more controlled environments influenced by humans, leading to differences in their diets. Stable isotope ratios of nitrogen and carbon reveal different aspects of the diet. A higher $\delta^{15}\text{N}$ ratio suggests a higher position in the food chain, potentially indicating a greater intake of animal products. Meanwhile, an increase in $\delta^{13}\text{C}$ may indicate a diet rich in either marine foods or C4 plants. Given that the earliest agricultural crops in China (specifically North China) were primarily millets (*Setaria italica* and *Panicum miliaceum*) (Zhao 2011; Liu & Chen 2012), which are C4 plants, the higher $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ ratios are thus always regarded as the indicator of domestication of pigs, which has been argued by many papers (e.g. You et al. 2024; Zhang et al. 2021). Stable isotopic analysis is becoming increasingly valuable for understanding early agriculture and the diet of early pigs in East Asia (Yuan & Flad 2002; Hu et al. 2006; Hu 2018).

For ZHGC, an inland site far from the sea (approximately 250km), human and animals' diets can largely exclude the influence of marine food (with the exception of long-distance trade involving marine products, which is unlikely given the absence of such remains at the site). Therefore, $\delta^{13}\text{C}$ ratios are much influenced by the consumption of C3 or

C4 plants. It is generally believed that the feed for domestic pigs should primarily consist of by-products of crops, including husks and shells of grains, as well as remnants of human food. Sometimes domestic pigs are even fed human feces. As local agricultural crops primarily consist of C4 plants like millet, feeding domestic pigs with daily human leftovers would yield higher $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ ratios.

A total of 36 *Sus* samples were selected for the stable carbon and nitrogen isotope analysis of bone collagen, including 34 domestic (likely) pigs and 2 wild boar samples. The results corroborate the previous morphological identification findings (see **Figure 5-1-5-A**). The two wild boar individuals (mean values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are -15.21 and 5.73‰ separately) exhibited overall characteristics of lower $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios compared to domestic pigs (mean values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are -13.01 and 6.47‰ separately). However, the scatter plot does not show an absolute separation between domestic pigs and wild boars (**Figure 5-1-5-B**). Like some of the domestic individuals, the $\delta^{13}\text{C}$ ratios of the two wild boar individuals fall within the range indicating some C4 plants in the diet overall. Despite exhibiting strong morphological signals of wildness, the diet pattern of these two do not show a clear difference from the domestic signature. Without clear morphological indicators, differentiating these wild boar individuals solely based on diet would be challenging.

However, we need to aware that, being omnivores, both wild boar and domestic pigs can consume a wide variety of foods (Groot Bruinderink et al. 1994; Masseti 2007), so the diet patterns are potentially complex. The blurred boundary between domestic and wild boar diets suggests two possibilities. One is that the wild boars found at the site may have been foraging near human habitation, stealing agricultural millets. The other is some domestic pigs were raised in a free-ranging manner, which might result in some intake of wild C3 plants to their diets. Of course, it is very possible this is the result of a combination of both influences.

No matter what, it is speculated that the activities of a few wild boars might be closely linked to human, leading to their capture and presence at the site.

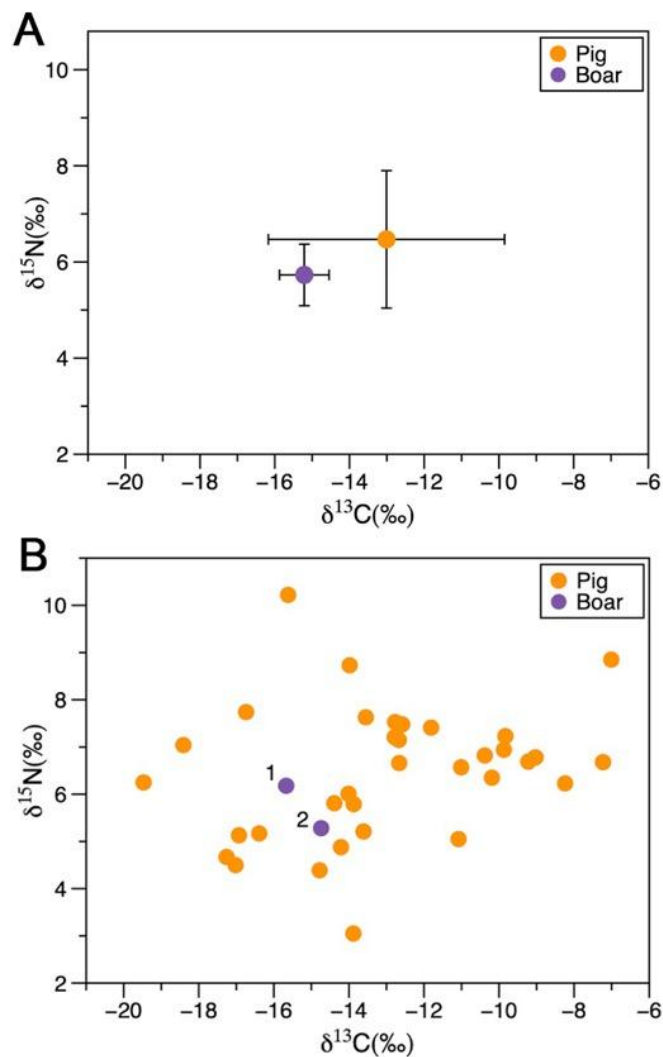


Figure 5-1-5. Stable C/N isotope values of *Sus* (pigs and wild boars) from ZHGC. (A) Error bar chart illustrating the mean value and standard deviation of two groups; (B) the scatter plot showing values for every sample.

1.5 Conclusion

Based on the metrical methods primarily, along with several other pieces of evidence (Table 5-1-4), we can confidently assert that there were domestic pigs present in the *Sus* population of the ZHGC, and domestic ones constituted the vast majority. There were also a very small number of clearly identifiable wild boar individuals mixed in. Although the two populations showed significant differences in morphological measurements, their dietary

differences were not substantial. Therefore, it is speculated that the wandering range of wild boars may have been closely related to human settlements.

Table 5-1-4

Summary of approaches applied for distinguishing pig domestication and conclusions

Approach	Result	Conclusion
Quantitative proportion	NISP% and MNI % over 30%	Domestic exist
Pathology	LEH and dentition malalignment	Domestic exist
Biometrical	Two populations	Wild and domestic coexist, and domestic dominant
Age at death	1-2 yrs. are majority	Maybe domestic pattern
Diet	C4 diet	Domestic

Section 2 Subsistence

1. Composition of meat acquirement and consumption

Although the quantitative composition of animals has been provided above (Table 5-1-1), considering the differences in body size and functional roles among different animals, we also need to introduce the concept of Meat Weight (MTWT) to quantify the specific contributions of animals to meat consumption and subsistence and subsistence of people.

When estimating available meat weight from faunal remains excavated at archaeological sites, two commonly used methods are those proposed by White (1953) and Reed (1963). Reed's method involves calculating the bone weight of mammals from the assemblage, which accounts for 7.5% of the live animal body weight, with 50% of the live body weight considered as usable meat. Later, this ratio was further refined to 50%-70% depending on different species by Casteel (1978). However, this approach heavily relies on all the bones being collected during excavation, and the preservation condition of the bones. Moreover, the identification results can significantly impact the final calculations when comparing meat quantities among different species. As for White's method, it is based on the MNI. For long-legged mammals, edible meat weight (MTWT) = animal live weight (LWT) * MNI * 50%; for birds and short-legged mammals, edible meat weight (MTWT) = animal live weight (LWT) * MNI * 70%. Comparatively, the latter is more feasible in closed settlement sites like ZHGC, and the calculation results are much more realistic since it considers the importance of providing meat from medium-/large-sized mammals (He et al. 2009). Additionally, to counteract the limitations of White's method, I attempted to consider differences in animal live body weight among individuals of the same species, particularly in different sexes and ages (Smith 1975). For several domesticated animals, age has a greater impact on weight than sex. Additionally, there are more individuals for which age can be determined compared to sex. Therefore, I chose to mainly take age into consideration when

calculating meat weight to mitigate some bias. Age categories were mainly classified as “juvenile” and “adult”, being a conservative estimate for age “unknown” individuals using mean values. Data on live animal weights were primarily referenced from sources such as *Fauna Sinica (Mammalia)* (Gao et al. 1987), *The Deer in China* (Sheng 1992), *Wild Mammals in China* (Sheng et al. 1999), *Cattle in China* (Qiu 1992), and *The Domestication, Raising and Ritual Use of Pig in Ancient China* (Luo 2012).

Table 5-2-1
Summary of live weight (LWT) and usable meat weight (MTWT) of distinct species with age difference taken into consideration.

Taxon	Age	LWT (kg)	MTWT (kg)
Pig (Luo 2012:53)	Juvenile	70	50
	Adult	100	70
	Unknown	85	60
Cattle (Qiu 1992)	Juvenile	200	100
	Adult	300	150
	Unknown	450	225
Sheep/goat (Luo 2012:53)	Juvenile	20	10
	Adult	40	20
	Unknown	30	15
Small deer (Sheng 1992:164)	-	25	12.5
Medium deer (Sheng 1992:202)	-	120	60
Large deer (Sheng 1992:225)	-	180	90
Horse (Luo 2012:53)	-	300	150
Dog	Juvenile	10	5
	Adult	20	10
Badger (Sheng et al. 1999)	-	6	3
Rabbit (Sheng et al. 1999)	-	2	1.4
Chicken	-	2	1.4
Goose	-	5	3.5

Note: a). In ancient societies, the production yield of domestic animals was likely much lower compared to modern animal husbandry practices. Therefore, when referring to some modern data, conservative estimates were chosen for the weights of pigs, cattle, and sheep/goat. For example, the weight range for pigs was 100-200 kg, with the lower limit of this range chosen as a reference. b). Because the only specific species of large-sized deer identified at the site is Père David’s deer (*Elaphurus davidianus*), its weight data is used for large deer, similarly, sika deer (*Cervus nippon*)’s data is used for medium-sized deer. As for small-sized deer, Chinese water deer (*Hydropotes inermis*), red muntjac (*Muntiacus muntjak*), and roe deer (*Capreolus capreolus*) were all found at the site, I select the 25kg of red muntjac (*Muntiacus muntjak*) who has an intermediate value to represent the average weight data for small-sized deer. c). For the sake of convenience in calculations, some results were rounded to integers.

Based on the data summarized above, usable meat weights (MTWT) of different animals were estimated in **Table 5-2-2**. It is obvious that cattle and pigs are the two largest

sources of meat. The edible meat weight provided by cattle is the most predominant, reaching approximately 32,675 kg, accounting for 53.43% of the total. Following is the pig, contributing 17,740 kg of meat, representing 29.01% of the total yield. The MTWT values of horses, deer, and sheep/goat each constitutes less than 10%, approximately 8.58%, 5.19%, and 2.75% respectively. The quantities of small wild animals and birds are nearly negligible.

Table 5-2-2
Estimation of usable meat weight and proportions

Taxon	Age	n	MTWT_{per} (kg)	MTWT_{total} (kg)	Total (kg)	%
Pig	Juvenile	51	50	2550	17740	29.01%
	Adult	175	70	12250		
	Unknown	49	60	2940		
Cattle	Juvenile	14	100	1400	32675	53.43%
	Adult	24	150	3600		
	Unknown	123	225	27675		
Sheep/goat	Juvenile	10	10	100	1685	2.75%
	Adult	38	20	760		
	Unknown	55	15	825		
Small deer	-	14	12.5	175	3175	5.19%
Medium deer	-	29	60	1740		
Large deer	-	14	90	1260		
Horse	-	35	150	5250	5250	8.58%
Dog	Juvenile	2	5	10	610	1.00%
	Adult	60	10	600		
Badger	-	1	3	3	3	< 0.1%
Rabbit	-	2	1.4	2.8	2.8	
Chicken	-	3	1.4	4.2	4.2	
Goose	-	4	3.5	14	14	
TOTAL					61159	100%

Note: for pigs, 12-month was considered as the age boundary for dividing minors and adults as they typically reach their average weight by that age even though they normally do not reach dental maturity (i.e. all permanent teeth in wear) until older than two years old. Sheep ditto. The criteria such as “juvenile” and “adult” were used during the age estimation of cattle, so they can be directly distinguished here. More detailed age distribution of them can be found from Table 5-1-7 in the following.

Based on archaeological evidence, at least since the Yinxu II Culture (Late Shang Dynasty, around 1250-1200 BC), cattle began to surpass pigs in providing meat, thereby replacing pigs as the primary source of meat that had been prevalent since the beginning of agriculture in the Central Plain of China (Li 2009). ZHGC followed this pattern, with cattle supplied with much more meat than pigs. However, although the MTWT proportion of cattle is larger than of pigs, this does not mean consuming cattle meat become the uppermost

protein resource for the common people. This is because pigs and cattle served distinct roles in feudal social culture. Cattle, introduced as a meat source in the late Neolithic period, were predominantly controlled by the noble class during the Bronze Age. Their consumption was not part of daily dietary habits but rather was associated with ritual activities like sacrifice (Lyu 2015, 2019). However, because the cattle remains found at the site are scattered and fragmented, lacking some special features (such as concentrated accumulation of mandibles, or entire skeletons would indicate non-consumption), even if they were used for ritual feasting (which will be discussed in detail in the next two chapters), these cattle remains can be considered to contribute to people's subsistence and diet. Therefore, this high proportion of cattle is believed to reflect the reality of meat provision to consumption.

While horses rank third in terms of meat quantity, they were the least likely to be consumed among species. The privilege of not being considered food for equids is due to their role in warfare (Price 2020). In the archaeological findings of Bronze Age China, the majority of equid remains were found buried whole, sometimes companied with chariot, indicating their special role as sacrificial warhorses or road horses (e.g. Ye 1974; Olsen 1988:176-178; Lu 1993; Yuan 2006; Beckman 2016; Zhang et al. 2023). The ZHGC is no exception to this pattern. Numerous sacrificial horse pits have been excavated within the city, such as those at the Houduanwan complex, Urban Credit Cooperatives and the Bank of China sacrificial site (Xinzheng Archaeological Unit 1998; Ma & Cai 2000; Cai & Ma 2005; HPICRA 2006), as well as Xinghong Garden and Thermal Power Plant Cemeteries (HPICRA 2007). Among them, numerous horse pits sacrificed for the Zheng noble cemetery in Houduanwan complex are particularly impressive (**Figure 5-2-1**). The presence or absence of sacrificial horse pits, as well as the number of horses sacrificed, have become powerful evidence for determining the rank of burials and social level of tomb owners. However, since

the horse bones found in this study were mostly scattered in ash pits, there is a possibility that they were occasionally consumed. Thus, their potential meat contribution was also calculated.

Although pigs were also used in some ritual-related practices (Cao & Wang 2016), pigs are more likely to be a common meat source accessible to ordinary people when comparing with cattle and horses. This differential treatments on pigs and other animals can be seen in the archaeological contexts of their remains. In mundane settings like common ash pits, wells, and layers, pigs were generally more common and tended to have a numerical advantage compared to other mammals. In contrast, in special contexts such as burials and ash pits with special functions, although pigs were also present, cattle, sheep/goat, dogs, and horses were more concentrated in these scenarios. Deer, like pigs, also seemed to appear more in mundane consumption scenes.

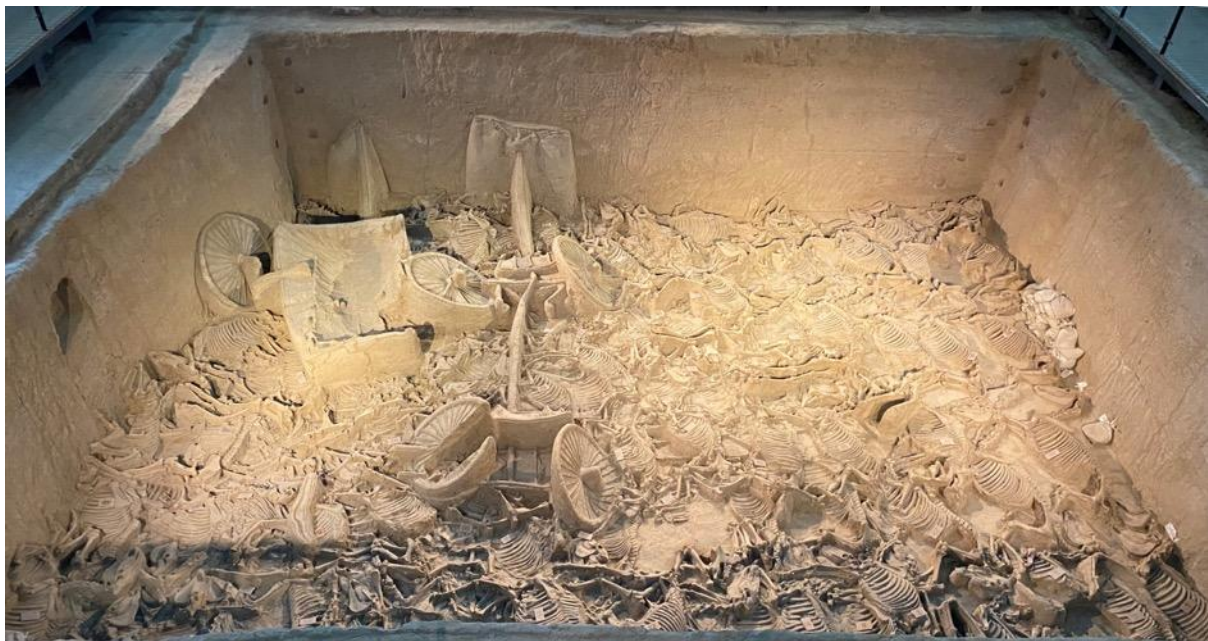


Figure 5-2-1. The scene photo of the No.3 horse-chariot sacrificial pit affiliated to the mausoleum of Duke of Zheng, containing four chariots and 122 complete horse skeletons in it. Currently, the Xinzheng Chariot-Horse Pit Museum has been built *in situ*.

2. Why few fish?

Based on the experience, the quantity of fish bone remains is quite low for a food source. Previously, only one fish bone was mentioned in zooarchaeological reports, identified

only to the class level (Luo *et al.* 2006). Does this indicate that people of ZHGC did not consume fish, or only consumed fish very sparingly?

From the historical records, it is evident that fishing was quite popular, and the consumption of fish was a common phenomenon during the Spring and Autumn Period and the Warring States Period in ancient China. The *Shijing (Classic of Poetry)* contains dozens of poems that explicitly mention fishing and hunting of ordinary people. These poems describe a wide variety of species caught and the methods employed, indicating the developed nature of fishing culture during that era (Chen 2010a). For example, there is a verse “岂其食鱼，必河之鲂...岂其食鱼，必河之鲤” (meaning is that ‘does one have to eat bream or carp in order to eat fresh fish?’) This indicates that bream and carp are delicious, but it also implies that many other varieties of fish are also available. In the *Spring and Autumn Annals of Wu and Yue*, it is recorded that “吴王闻三师将至，治鱼为鲙”. King of Wu used raw fish slices as a reward to welcome the triumphant return of his army. It is suggested that fish cuisine was served as a high-level delicacy on the nobility's dining tables. Additionally, there are also ancient literatures detailing how fish was cooked and what dipping sauces fish were paired with. The *Book of Rites* records that people ate fish with spring onions in spring and with mustard in autumn, reflecting the meticulousness in fish culinary practices.

Based on this argument, it is concluded that various fishes were consumed by people of Zheng and Han. The consumption of fish prevailed among the elite group. Certain delicacies, such as sturgeon, were even considered privileges and symbols of aristocratic status. Access to these resources may have been more restricted to the elite class.

Regarding the fact that the fish bones found in this excavation were fewer than expected, as we discussed in the previous chapter, it is likely due to the limitations of the excavation practices because sieving was not carried out, which resulted in the omission of

some smaller bones. Similarly, this reason can also explain the relative scarcity of other small and fragile aquatic remains, such as those of mollusks.

However, it is noted that these aquatic resources (including fish, aquatic mollusks, and reptiles) contributed far less to the protein supply in the city's subsistence economy compared to domesticated livestock. In fact, the scarcity of these remains in the excavation process actually indicates that they were not abundant. Large concentrations of fish bones and shell middens are typically hard to miss in archaeological excavations, even if hindered by lacking a scientific excavation system.

3. Discussion and conclusion

The animal assemblage from the ZHGC includes all “six livestock” in China, indicating a stable subsistence economy primarily based on livestock husbandry within the city. Among the domesticated animals, cattle and pigs provided the majority of the meat resources, with cattle made the most predominant contribution.

In addition to being used as a protein source, different domesticated animals were imbued with various symbolic values. Compared to cattle, caprines, horses, and dogs, pigs were considered the most common and mundane (further discussion on the ritual use of different animals will be talked about in Section 3 of this chapter). Additionally, the by-product values of each animal endowed them with different utilization methods and social significance. Price (2020) eloquently explained this:

“... the secondary products revolution to full fruition and solidified the transformation of cattle, sheep, and goats into animals that embodied wealth. Later this privilege extended to equids for their role in warfare. While institutional forms of wealth excluded pigs, urbanism offered a new and ideal ecological niche for pig husbandry. Pigs became especially important among the urban lower classes, perhaps as a type of ‘informal economy’.”

However, meat consumption remained primarily the privilege of the nobility and elite classes, with ordinary citizens having access to very limited proteins. The presence of wild species within the faunal assemblage suggested that people supplemented their diet by hunting and fishing in the suburban areas. Compared to mammals, the utilization of aquatic resources was less significant. The appearance of poultry was relatively late, with eleven specimens found only in the V and VI stages (**Table 4-13-7**). Similarly, the previous zooarchaeological report identified two bird bones dating to the Warring States period (Luo et al. 2006). Does this indicate that poultry farming in ZHGC began only from the mid Warring States period? To address this question, more materials and evidence are needed.

Interestingly, it is observed that pig M3s with larger measurements, morphologically identified as wild species, were exclusively found in stage I (see the caption of **Figure 5-1-1**). This period corresponded to the initial occupation and establishment of the capital city. This might suggest that wild boars could be more frequently hunted and brought into the city by citizens as the extra supplement of meat resource during the early phase of city usage. Coincidentally, not only wild boar, but also fish (6/12) and reptiles (5/5) mostly appeared in the earlier phases (as listed in **Table 4-13-6/8**). Additionally, two specimens of badger and tiger were both found in stage I.

It is assumed that, at the initial stage of the city's establishment, the overall operation and the lifestyle of its inhabitants were likely still in an exploratory phase, lacking stable behavior patterns and internal systems. This would lead to a short-term diversification of dietary sources. As the city developed and its internal environment stabilized, the range of consumed animal species would become more homogeneous. This observation aligns with some of the underlying logic of “Broad Spectrum Revolution” (BSR) hypothesis proposed by Flannery in 1969, which posits that humans increased their dietary breadth to alleviate dual pressures from the environment and population increases (Flannery 1969). However, the

survival pressure faced by the inhabitants of ZHGC was short-term, resulting in a brief period of dietary expansion followed by a focus on agricultural development.

For enclosed city sites like the ZHGC, the selection of food types and their consumption levels are significantly influenced by the internal progress of urban development and the population size. Population expansion would lead to greater demand for food within the city, thereby further stimulating the development of animal husbandry and agricultural production. Additionally, the impact of warfare is also profound. The external environment of conflict can greatly inhibit the development of agricultural production to some extent, leading to food scarcity and the introduction of wild species, consequently resulting in the disappearance of privileges associated with certain exclusive foods among the nobility. Thus, the variation of faunal remains can effectively reflect the overall social situation at the time.

Section 3 Foddering strategies and herd management

In agrarian societies, livestock are closely intertwined with people's subsistence. In this integrated process, the strategies adopted by people for the foddering and managing animals hold significance (Finucane et al. 2006; Vaiglova et al. 2021). By analyzing the methods of feeding and managing livestock, we can gain insights into the economic structure, social organization, and level of technological development of ancient societies. Regarding the faunal assemblage from the ZHGC, we will explore the following three aspects.

1. Age control

The death age distributions of the sheep/goat, cattle, and pig assemblages are summarized in **Table 5-3-1**. The corresponding relationship between actual ages and stages referred to the standard set up by O'Connor (1991:250 Table 67).

Table 5-3-1
The age distribution (actual ages and stages) of sheep/goat, cattle, and pigs.

Sheep /Goat	Age	6-12 mon. (immature)	1-2 yrs. (subadult)	2-3 yrs. (adult-1)	3-4 yrs. (adult-2)	4-6 yrs. (adult-3)	>6 yrs. (elderly)
n=48	n	10	8	3	8	7	12
	%	20.83	16.67	6.25	16.67	14.58	25.00
Pigs	Age (mon.)	Neonatal	1-6 (juvenile)	7-12 (immature)	12-21 (subadult)	21-26 (adult)	≥27 (elderly)
n=216	n	2	12	37	83	47	35
	%	0.93	5.56	17.13	38.43	21.76	16.20
Cattle	Age	1-8 mon. (juvenile)	8-18 mon. (immature)	18-30 mon. (subadult)	30-40 mon. (adult 1)	40 mon.- 6.5 yrs. (adult-2/3)	7-20+yrs. (elderly)
n=38	n	3	11	7	3	8	6
	%	7.89	28.95	18.42	7.89	21.05	15.79

In terms of the age distribution of the three taxa separately, it is evident that three animals display different patterns (**Figure 5-3-1-A**). The age distribution of sheep exhibits a U-shaped pattern, with fewer individuals in the middle and more at both ends; whereas the age distribution curves for pigs show a bell-shaped pattern, with more individuals in the middle (i.e. the range of “12-21 months”) and fewer at both ends. Comparatively, the age

pattern of cattle exhibits a bimodal curve with two peaks (i.e. two ranges of “8-18 months” and “40 months- 6.5 years”).

Regarding the overall age structure comparison (**Figure 5-3-1-B**), it can be observed that the age distribution of sheep tends to be older, with few very young individuals, while that of cattle tends to be younger, with immature individuals are most predominant. Pigs' ages are concentrated in the subadult and adult stages, consistent with our previous analysis that pigs were slaughtered at an appropriate age to obtain the highest meat yield.

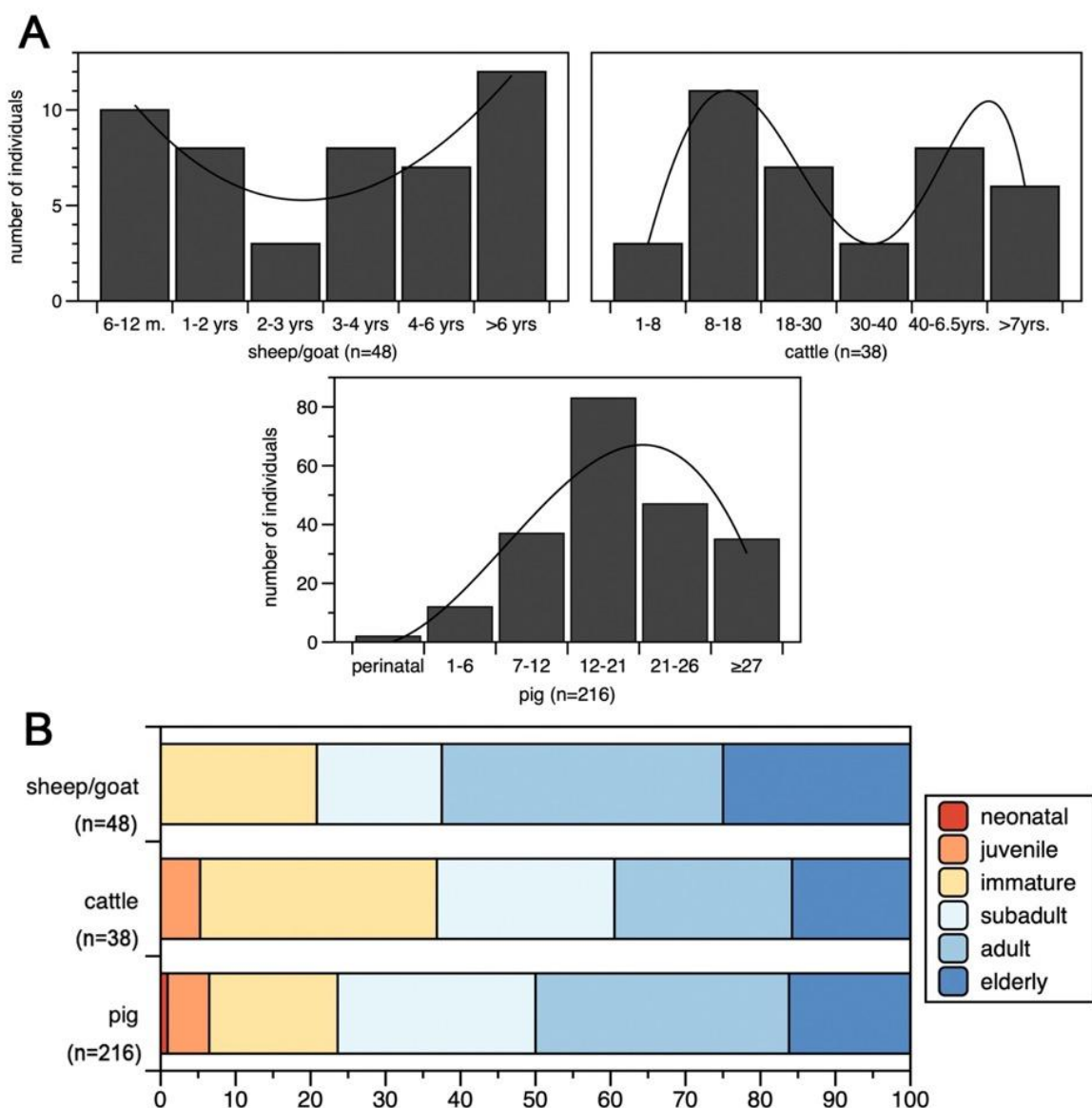


Figure 5-3-1. Age pattern of three major domesticated animals. (A) Separate age distribution of sheep/goat, cattle, and pigs. Three overall trend curves exhibit the “U” shape, bimodal shape, and bell shape patterns for sheep/goat, cattle, and pig respectively. (B) The comparison of age patterns among three animals using the age stages.

The difference in age pattern between the three taxa results from their different values. Sheep/goat, although they were initially domesticated during the Neolithic probably for their primary products (meat, hide and bone), more intensive exploitation was conducted for secondary animal products (milk, wool and traction) later. Sometimes by-products contributed more to their overall value than meat resources (Sherratt 1983). Hence, their age distribution tends to be older for their continuous by-product supply. Pigs, mainly used for meat consumption, approximately 80% of the total were killed during the three middle stages that were suitable for meat yield.

As for cattle, the bimodal age pattern might suggest their dual functional contribution of both providing primary products and traction. The substantial draft power supplied by cattle was extremely significant for ancient Chinese agricultural society, especially during the Spring and Autumn Periods when new metal (i.e. iron) tools were introduced, and the agricultural production rapidly developed (Min et al. [Eds] 1991:110-111). Regarding the use of cattle traction, there were two aspects: cattle wagons and cattle ploughing, which are clearly documented in ancient texts:

“我任我犂，我车我牛。” [If you carry the goods, I will pull the cart; if you drive the cart, I will lead the cattle.] (*Book of Songs, Xiaoya, Shumiao*).

“宗庙之牺，为畎亩之勤。” [The livestock that were originally used for sacrifices in temples have now become the main toil in the fields.] (*Discourses of the States, Jin IX*).

More directly, “秦以牛田之。” [Qin State used cattle for ploughing.] (*Records of the Grand Historian, Zhao Family*).

The first reference provides a specific depiction of cattle wagons in the Zhou literature, while the latter two texts serve as strong evidence of cattle ploughing. Additionally, there has been much zooarchaeological evidence suggesting that cattle were widely used for transportation and agricultural activities during the Bronze Age (Brunson 2011; Lin et al.

2018; Lin 2022). The need for traction suggests that more older individuals should have been kept for providing draft force, which reasonably explains the peak on the right of the bimodal pattern. Regarding the peak on the left, aside from being consumed as food, it is also highly likely due to the ritualistic use of domestic cattle. A considerable proportion of the ageable individuals came from ritual-related deposits, such as No.1 Mess-bone Pit (where six of the twelve immature individuals came from) and several foundation pits. These individuals are more likely to be killed at a younger age due to their ritual use. Therefore, the dual function of cattle leads to a bimodal distribution of age at death.

Here, it is necessary to briefly address the question of early milk consumption in China, in order to better understand regional preferences in the exploitation of secondary products from cattle and sheep, and to clarify the underlying economic logic of subsistence strategies in the Central Plains.

Despite the widespread use of dairy products in many ancient societies, evidence for milk exploitation during the Spring and Autumn and Warring States periods in ancient China remains extremely limited. To date, no direct archaeological confirmation—such as lipid residue analysis of ceramic vessels—has been found to indicate the use of dairy products in the Central Plains or its surrounding agricultural regions. Most existing evidence for early dairying in China comes from Bronze Age sites in the northwest—a region that also represents the earliest area of cattle and caprine introduction from West Asia. The earliest identified animal milk proteins were found in the dental calculus of individuals from the Xiaohe Cemetery (3930–3400 BP) in Xinjiang, where they are associated with well-preserved mummies (Yang et al., 2014; Zhang et al., 2023). Additionally, dairy lipids have been detected in potsherds from the Liujiawa site (2720–2426 BP) in Shaanxi Province (Han et al., 2022). Besides, lipid residue analysis of pottery from the Gongtang site on the northeastern Tibetan Plateau also yielded evidence for dairy product usage around 3000 cal

BP, representing the earliest such data in that region (Zhang et al., 2023). These sites are all located in sparsely populated upland grassland environments and are associated with mobile pastoralist communities.

Similarly, zooarchaeological indicators typically associated with dairying—such as a high proportion of adult females in livestock herds or increased mortality among neonatal animals suggesting early weaning—have not been systematically identified in faunal assemblages from Eastern Zhou contexts. Although the caprine age profiles above suggested the exploitation of some secondary products, no further evidence points specifically to dairy use. Moreover, textual sources from the Spring and Autumn and Warring States periods contain little to no mention of milk or dairy consumption. In terms of literature, the term *lao* (酪), often translated as a type of fermented milk product or cheese, only appeared later in Han dynasty texts (after 202 BCE), and is generally associated with ethnic minorities or frontier populations in the north.

Thus, it may be inferred that in the agricultural societies of the Central Plains during this period, cattle and sheep/goats were primarily valued for ritual purposes and meat production. When it came to secondary products, wool and traction appear to have been preferred over milk. Dairy products did not play a prominent role in the dietary system of the region, which reflects broader cultural and ecological adaptations that did not encourage the development of dairying traditions usually accompanying with cattle/caprine husbandry in the Europe or West Asia. While future research—particularly lipid residue analysis and targeted kill-off pattern of faunal remains—may shed further light on this question, current evidence does not support the existence of systematic milk exploitation during the Spring and Autumn and Warring States periods.

Furthermore, the abundance of ageable pig individuals makes it possible to investigate whether the age at death of pigs changes through the six phases. According to **Figure 5-3-2**,

while there are fluctuations in the age distribution of pigs over different periods with some phases showing a tendency towards younger ages and others towards older ages, there does not seem to be a consistent chronological trend. Particularly in phase V, the age results for pigs are notably skewed towards the younger end. However, looking at the overall picture, no clear trend in diachronic changes has been observed. It is important to note that, due to the dominance in the number of individuals in the phase VI, the age distribution of this phase significantly influences the overall age structure. This also explains why the overall age pattern closely resembles that of the phase VI.

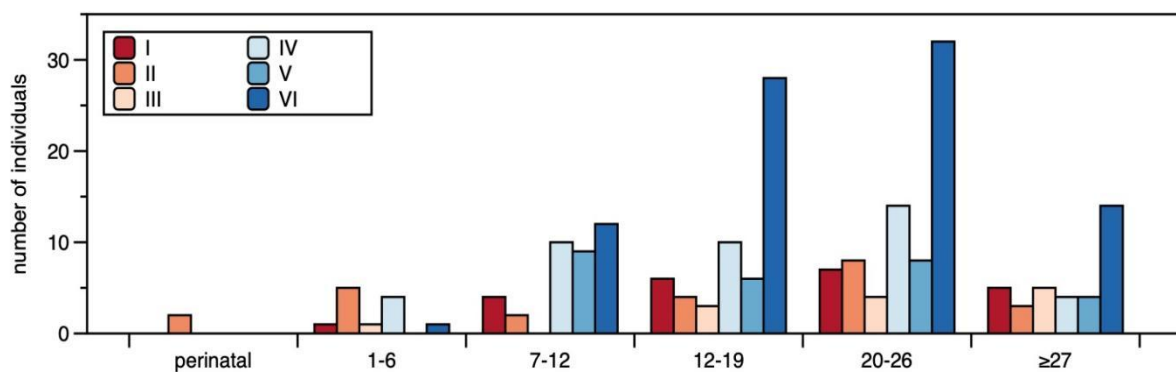


Figure 5-3-2. The pig's age distribution of six stages during the Eastern Zhou period, numbers on the horizontal axis are ages in months.

In summary, it is concluded that different age control strategies were adopted for domestic animals with distinct roles to achieve different functions. In addition, there seems to be no diachronic variability concerning age pattern of pigs, indicating the age control strategy for pig kept relatively stable during this period.

2. Carbon and nitrogen in bone collagen

Biochemical indicators, such as stable nitrogen and carbon isotopes, have demonstrated significant potential in elucidating dietary shifts, particularly in populations under strong human selection or management where there is an increase in protein consumption and domestic C4 plants (Barton et al., 2009; Guan et al., 2007; Loesch et al., 2006; Minagawa et al., 2005). While further experiments and references are suggested to

refine our understanding and explanation of these complex processes (Albarella et al. 2006; Balasse 2002), dietary reconstruction based on C/N isotopes remains a robust method for gaining insights into the husbandry strategies of ancient societies (Hu et al. 2009, 2014; Hu 2018).

2.1 Materials and methods

In total 94 bone collagen samples were selected from nine of the twelve sites, including HZM, RDC, ZHL, FDC, YC, JFQ, JCL, JSY, and GXS. Of the remaining three sites, MYMZ was excluded because of the few specimens and the context of city wall with possible dating problems; ZT was excluded because most bones were worked; and EGJ was overlooked due to a mistake. These specimens are indirectly dated, with the greatest confidence context or site age given, ranging from Han to East Zhou (stage I - VI) periods. Although the occupation time of ZHGC was during the East Zhou, several samples from the Han dynasty were included for the further possible temporal comparison. Several taxa were sampled: domestic pigs (*Sus scrofa domesticus*) and wild boars (*Sus scrofa*), dog (*Canis familiaris*), horse (*Equus caballus*), sika deer (*Cervus nippon*), Chinese water deer (*Hydropotes inermis*), rabbit (*Lepus* sp.), tiger (*Panthera tigris*), cattle (*Bos taurus*), and sheep/goat (*Capra* sp./*Ovis* sp.). Cattle were all considered domestic and domestic ovicaprids could not be differentiated to genus on morphological grounds. Additionally, three human bones were also sampled for comparative analysis.

Wherever possible, a Minimum Number of Individuals-based (MNI - Casteel and Grayson, 1977) sampling approach was taken for each phase at each site to ensure the independence of each sample. Wild species like deer, rabbit, and tiger were selected for building the baseline of the natural environment.

Suitable bone fragments were first sawn off from the specimens and then cleaned of surface contamination using a diamond-tipped dental rotary drill. The preparation work was

undertaken at Durham University's Department of Archaeology. All collagen purification followed standard extraction methodology (Longin, 1971; DeNiro, 1985; Ambrose & DeNiro, 1986). Samples were all analysed at Durham University's Archaeological Stable Isotope lab, which strictly adheres to rigorous international quality control guidelines through the application of international reference standards. Each $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ sample was weighed to the nearest 0.001mg into a 6*4 tin capsule on a Mettler Toledo XP6 microbalance, then combusted using a Costech Elemental Analyser (ECS 4010) connected to a Thermo Scientific Delta V Advantage isotope ratio mass spectrometer. The $\delta^{13}\text{C}$ isotope ratios were corrected for ^{17}O and are reported in standard delta (δ) notation in per mil (‰) relative to Vienna Pee Dee Belemnite (VPDB) and $\delta^{15}\text{N}$ isotope ratios are reported against atmospheric nitrogen (AIR). Isotopic accuracy was monitored through routine analyses of in-house standards, calibrated against international standards (e.g., IAEA-600, IAEA-CH-3, IAEA-CH-6, IAEA-N-1, IAEA-N-2, NBS 19, USGS24, USGS40). International and in-house standards are run daily and provided a linear range for $\delta^{13}\text{C}$ between -46 ‰ and $+3$ ‰ and in $\delta^{15}\text{N}$ between -4.5 ‰ and $+20.4$ ‰. Analytical uncertainty in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope analysis was typically ± 0.1 ‰ (2 s.d.) for replicate analyses of the international standards and < 0.2 ‰ (2 s.d.) on replicate sample analysis. Total organic carbon and nitrogen data was obtained as part of the isotopic analysis using the internal standard, glutamic acid (40.82 wt % C, 9.52 wt % N). Alpha cellulose and IVA urea were analysed throughout the sequence and reported $\delta^{13}\text{C}$ standard errors of ± 0.2 ‰ (2 s.d.) and for IVA urea $\delta^{15}\text{N}$ of ± 0.2 ‰ (2 s.d.). Only data with atomic carbon to nitrogen ratios in the range 2.9–3.6, indicating low probability of diagenesis (DeNiro, 1985), are interpreted.

2.2 Results

In all, 91 isotope data were obtained while three samples failed due to the low collagen yield rate (sample 1748/22, 1783/22, and 1893/22), and 90 out of 91 isotope

measurements had acceptable atomic ratios of carbon to nitrogen and therefore had no indications of diagenesis (**Table 5-3-2**) (DeNiro, 1985), while one (sample 1789/22) were excluded as it was outside the acceptable range.

Table 5-3-2.
Samples and isotope data from ZHGC (struck-through samples omitted from discussion).

LAB ID	Site	Age	Taxa	Element	Side	$\delta^{13}\text{C}\text{‰}$	$\delta^{15}\text{N}\text{‰}$	Atomic C:N
1720/22	FDC	III	dog	humerus	R	-8.23	7.20	3.4
1721/22	HZM	East Han	pig	mandible pair	/	-15.62	10.22	3.3
1722/22	HZM	East Han	pig	mandible	R	-18.41	7.04	3.3
1723/22	HZM	East Han	pig	radius	R	-13.98	8.73	3.4
1724/22	HZM	East Han	cattle	metacarpal	/	-12.73	6.44	3.4
1725/22	HZM	East Han	cattle	scapula	L	-11.44	7.01	3.4
1726/22	HZM	West Han	sheep/goat	radius	L	-18.58	6.60	3.4
1727/22	RDC	II	cattle	humerus	L	-7.12	6.03	3.4
1728/22	RDC	III	pig	ulna	L	-16.74	7.74	3.2
1729/22	RDC	Unknown	pig	humerus	R	-13.87	5.79	3.4
1730/22	RDC	Unknown	pig	humerus	R	-12.58	7.48	3.3
1731/22	RDC	Unknown	cattle	scapula	L	-10.43	6.94	3.4
1732/22	RDC	Unknown	cattle	scapula	L	-13.00	9.70	3.5
1733/22	RDC	Unknown	cattle	scapula	L	-12.56	5.01	3.1
1734/22	RDC	Unknown	cattle	scapula	L	-11.87	6.39	2.9
1735/22	RDC	Unknown	cattle	scapula	L	-9.46	5.76	3.2
1736/22	RDC	Unknown	cattle	scapula	L	-14.27	6.53	2.9
1737/22	ZHL	IV	pig	mandible	R	-14.01	6.01	3.3
1738/22	ZHL	IV	sheep/goat	mandible	R	-16.31	5.55	3.2
1739/22	FDC	V -2	pig	mandible	L	-13.88	3.05	3.3
1740/22	FDC	III -2	sheep/goat	rib	L	-13.94	5.94	3.4
1741/22	FDC	III	sheep	ulna	L	-16.15	6.96	3.3
1742/22	FDC	II -2	pig	tibia	L	-14.39	5.81	3.1
1743/22	FDC	II -2	dog	femur	L	-14.52	4.99	3.3
1744/22	FDC	II	dog	rib	/	-10.54	7.46	3.5
1745/22	YC	IV	pig	mandible	R	-8.24	6.23	3.4
1746/22	YC	IV	pig	mandible	R	-7.23	6.68	3.3
1747/22	JFQ	II	human	ulna	L	-8.90	8.73	3.0
1749/22	FDC	III	human	mandible pair	/	-8.98	8.85	3.4
1750/22	JCL	West Zhou	pig	ulna	R	-16.39	5.17	3.5
1751/22	JCL	West Zhou	cattle	mandible	R	-14.26	4.02	3.0
1752/22	JCL	I	water deer	scapula	R	-21.01	4.58	3.5
1753/22	JCL	I	dog	tibia	L	-9.54	6.33	3.5
1754/22	JCL	I	sika deer	humerus	R	-17.94	4.53	3.5
1755/22	JCL	I	pig	tibia	R	-9.83	7.23	3.4
1756/22	JCL	I	cattle	mandible	L	-8.73	7.48	3.4
1757/22	JCL	IV	pig	humerus	R	-9.22	6.69	3.5
1758/22	JCL	IV	sheep/goat	metatarsal	L	-15.37	7.48	3.4
1759/22	JCL	IV	pig	humerus	R	-17.02	4.50	3.5
1760/22	JCL	IV	cattle	mandible	L	-10.77	8.29	3.2
1761/22	JCL	V -2	sheep/goat	femur	R	-18.52	7.62	3.6
1762/22	JCL	V -2	sheep/goat	femur	R	-17.52	7.88	3.0

1763/22	JCL	V	sheep/goat	femur	L	-19.29	7.07	3.2
1764/22	JCL	V	sheep/goat	femur	L	-17.70	10.23	3.0
1765/22	JCL	VI-1	cattle	scapula	R	-10.34	6.29	3.4
1766/22	JCL	VI-2	pig	humerus	L	-14.21	4.88	3.3
1767/22	JCL	VI-2	sheep/goat	humerus	R	-16.37	4.91	3.4
1768/22	JCL	VI-2	sheep/goat	humerus	R	-17.25	6.26	3.4
1769/22	JFQ	I	cattle	radius	R	-11.35	6.36	3.3
1770/22	JFQ	I	pig	mandible	L	-11.01	6.57	3.1
1771/22	JFQ	III	pig	mandible	R	-12.77	7.53	3.5
1772/22	JFQ	IV	cattle	mandible	R	-10.75	7.25	3.5
1773/22	JFQ	IV	pig	tibia	R	-11.81	7.41	3.2
1774/22	JFQ	IV	dog	mandible	R	-15.00	5.10	3.1
1775/22	JFQ	IV	sheep/goat	metacarpal	R	-12.66	6.43	3.3
1776/22	JFQ	V	pig	mandible	R	-13.61	5.21	3.4
1777/22	JFQ	V	cattle	mandible	R	-9.46	7.65	3.3
1778/22	JFQ	VI-2	pig	mandible	L	-12.67	7.15	3.4
1779/22	JFQ	VI-2	sheep/goat	mandible	R	-14.42	4.56	3.5
1780/22	JFQ	VI-1	horse	humerus	R	-15.71	3.37	3.5
1781/22	JSY	I	pig	mandible pair	/	-12.66	6.66	3.4
1782/22	JSY	IV	pig	mandible	R	-7.01	8.85	3.4
1783/22	JSY	IV	pig	mandible pair	/	-14.78	4.39	3.3
1784/22	JSY	VI-2	pig	mandible	L	-13.55	7.63	3.5
1785/22	GXS	I	horse	mandible	R	-15.75	4.03	3.5
1786/22	GXS	I	sika deer	femur	R	-19.64	5.80	3.5
1788/22	GXS	I	dog	ulna	R	-8.12	6.13	3.5
1790/22	GXS	I	pig	mandible	R	-10.19	6.35	3.3
1791/22	GXS	I	wild boar	mandible	R	-15.67	6.18	3.5
1792/22	GXS	I	wild boar	mandible	R	-14.74	5.28	3.5
1794/22	GXS	II	sheep/goat	radius	L	-18.43	8.61	3.2
1795/22	GXS	II	pig	mandible pair	/	-12.78	7.21	3.4
1796/22	GXS	II	pig	mandible pair	/	-16.93	5.13	3.6
1797/22	GXS	III	pig	humerus	L	-10.38	6.82	3.6
1798/22	GXS	III	pig	humerus	R	-9.87	6.94	3.5
1799/22	GXS	III	cattle	metatarsal	L	-10.25	5.33	3.5
1800/22	GXS	IV	cattle	mandible	L	-8.16	6.38	3.4
1801/22	GXS	IV	sika deer	humerus	R	-17.22	3.95	3.5
1802/22	GXS	V	sheep/goat	femur	L	-21.44	3.63	3.4
1803/22	GXS	V	pig	humerus	R	-17.26	4.67	3.4
1804/22	GXS	V	sika deer	femur	L	-20.62	3.51	3.6
1805/22	GXS	V-2	pig	humerus	R	-19.47	6.25	3.3
1806/22	GXS	VI-1	rabbit	pelvis	R	-17.65	4.71	3.3
1807/22	GXS	VI-1	cattle	radius	R	-11.32	9.14	3.5
1808/22	GXS	VI-1	sheep/goat	mandible	R	-19.69	7.32	3.2
1809/22	GXS	VI-1	sheep/goat	mandible	R	-18.27	5.30	3.0
1810/22	GXS	VI-1	sheep/goat	mandible	R	-16.21	7.50	3.0
1811/22	GXS	VI-1	dog	mandible	R	-15.05	5.68	3.2
1812/22	GXS	VI-1	pig	mandible pair	/	-11.08	5.05	3.5
1813/22	GXS	VI-1	pig	mandible pair	/	-9.03	6.78	3.4
~~1748/22~~	~~JFQ~~	~~VI-1~~	~~human~~	~~femur~~	~~R~~	~~-~~	~~-~~	~~-~~
~~1787/22~~	~~GXS~~	~~I~~	~~cattle~~	~~mandible~~	~~L~~	~~-~~	~~-~~	~~-~~
~~1789/22~~	~~GXS~~	~~I~~	~~pig~~	~~mandible~~	~~R~~	~~-15.96~~	~~3.89~~	~~3.9~~

1793/22	GXS	II	tiger/leopard	calcaneus	L	-	-	-

Deer and rabbits were selected as the baseline reflecting the local natural environment. However, considering the possible impact of humans on the natural environment, more evidence has been introduced as reference material to ensure that the observed dietary values of wild species not the result of already-present human modification of the landscape. Firstly, in the earlier Wangjinglou site (Xia and Shang Dynasty, about 1600-1300 BC) in Xinzheng, deer remains were found with $\delta^{13}\text{C}$ values ranging from -22.2‰ to -19.5‰, which was considered to reflect the real natural vegetation of wild C3 plant being predominant in that area (Chen et al. 2018). This is similar to the values for deer in this study, which range from -21.01‰ to -17.22‰. Additionally, Bird & Pousai (1997) indicated that in regions where the annual average temperature is below 15°C, the contribution of C4 plants to natural vegetation is negligible. The annual average temperature in Xinzheng is 14.2°C (57.6°F) (Xinzheng Municipal Government, 2019). Therefore, the local natural vegetation should primarily consist of C3 plants. The $\delta^{13}\text{C}$ values for the deer and rabbit who consumed wild C3 plants in this study can be used as a baseline to reflect the natural vegetation conditions, and there seems no evidence of human intervention in their diet.

The 90 usable isotope measurements are illustrated in **Figure 5-3-3**.

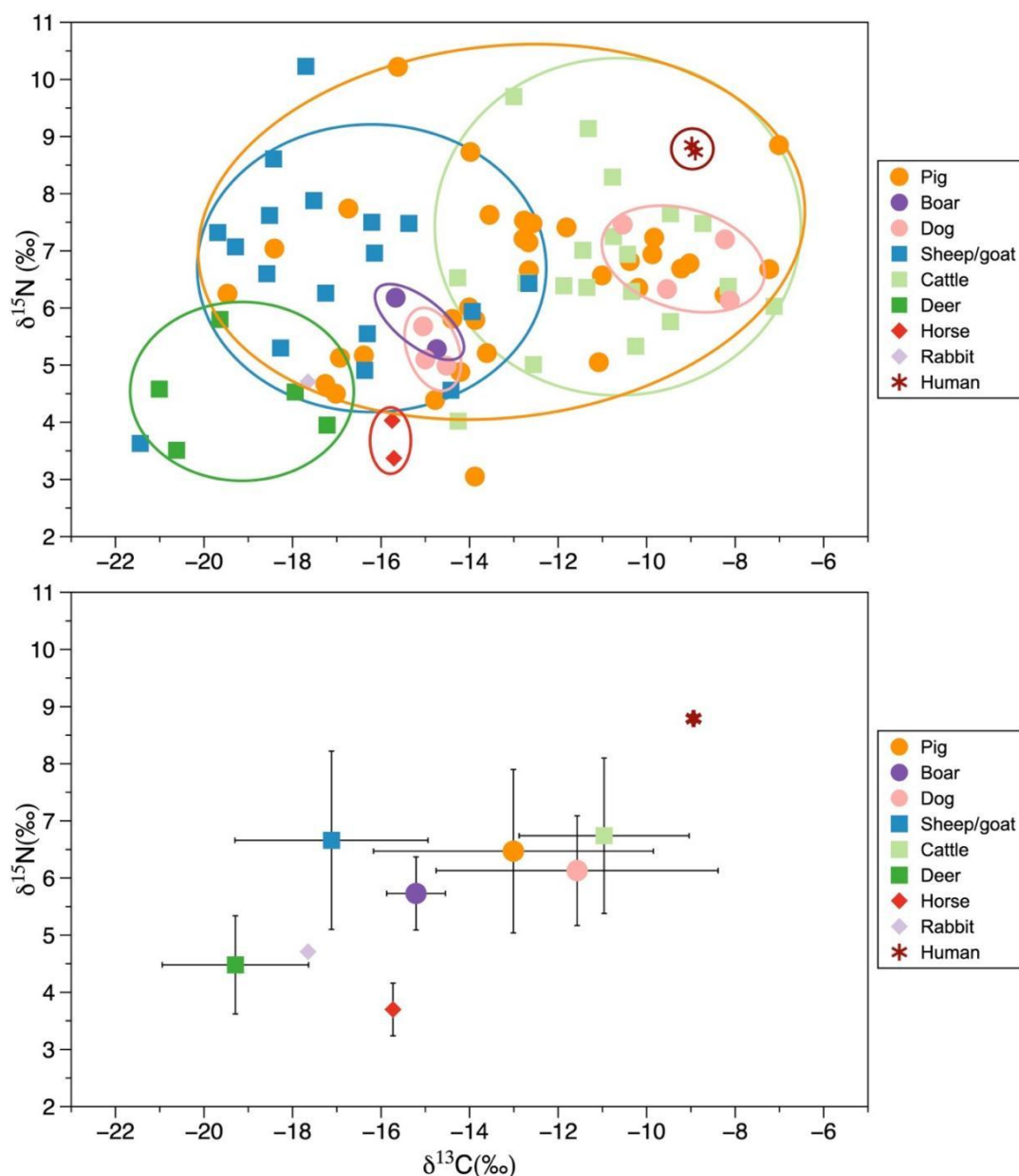


Figure 5-3-3. Bone collagen carbon and nitrogen isotope data of ZHGC fauna and human. Top: scatter diagram of each sample; bottom: mean and error bar chart of each taxon.

Based solely on $\delta^{15}\text{N}$ values (see **Figure 5-3-4**), it is evident that humans, omnivores, and herbivores all have $\delta^{15}\text{N}$ values below 10‰, indicating they did not consume marine plants or animals (van der Merwe et al. 1981). Thus, the food sources at the site were mainly terrestrial plants. The highest $\delta^{15}\text{N}$ values among the faunas are found in cattle, ovicaprids, and pigs, with mean values are 6.74 ‰, 6.66‰, and 6.47‰, respectively. In contrast, the $\delta^{15}\text{N}$ values for dogs are surprisingly low, ranging from 4.99‰ to 7.46‰. There may be two

reasons for this. Firstly, the existence of two groups of dogs is implied by the isotopic results, with the group having poorer nutritional status pulling down the overall dog values (discussed in detail later). The second reason is that part of the pigs' and the herbivores' fodder may have included a certain number of by-products of manured crops, which could raise their $\delta^{15}\text{N}$ values (Boggard et al. 2013; Fraser et al. 2011). This could also explain the several abnormal pig/cattle/ovicaprid individuals with extremely high $\delta^{15}\text{N}$ values shown in the **Figure 5-3-3**.

In terms of the $\delta^{13}\text{C}$ values, the differentiation among various species is more distinct (**Figure 5-3-4**). According to archaeobotanical studies, the primary agricultural crops in North China were millets (*Setaria italica* and *Panicum miliaceum*), which are C4 plants (Zhao 2011; Liu & Chen 2012). The stable carbon isotope values of the two human samples are -8.98‰ and -8.90‰, indicating a diet predominantly composed of C4 crops (mainly millets). Among the faunal assemblages, cattle, dogs, and pigs have the highest $\delta^{13}\text{C}$ measurements, with mean values of -10.96‰, -11.57‰, and -13.01‰, respectively, indicating that the diets of these three animals were also primarily based on C4 plants. The C4 intake for pigs and dogs likely came from human leftovers, while the C4 intake for cattle probably resulted from millet by-products as fodder (Hu 2018). In addition, although both ovicaprids and deer have diets primarily relied on C3 plants, as domesticated animals, the stable carbon isotope values for ovicaprids displayed a mixed pattern influenced by human agricultural activities to some extent (Dai et al. 2016). As for the leftmost ovicaprid individual with a lower value than deer, it is possible that this specimen was misidentified.

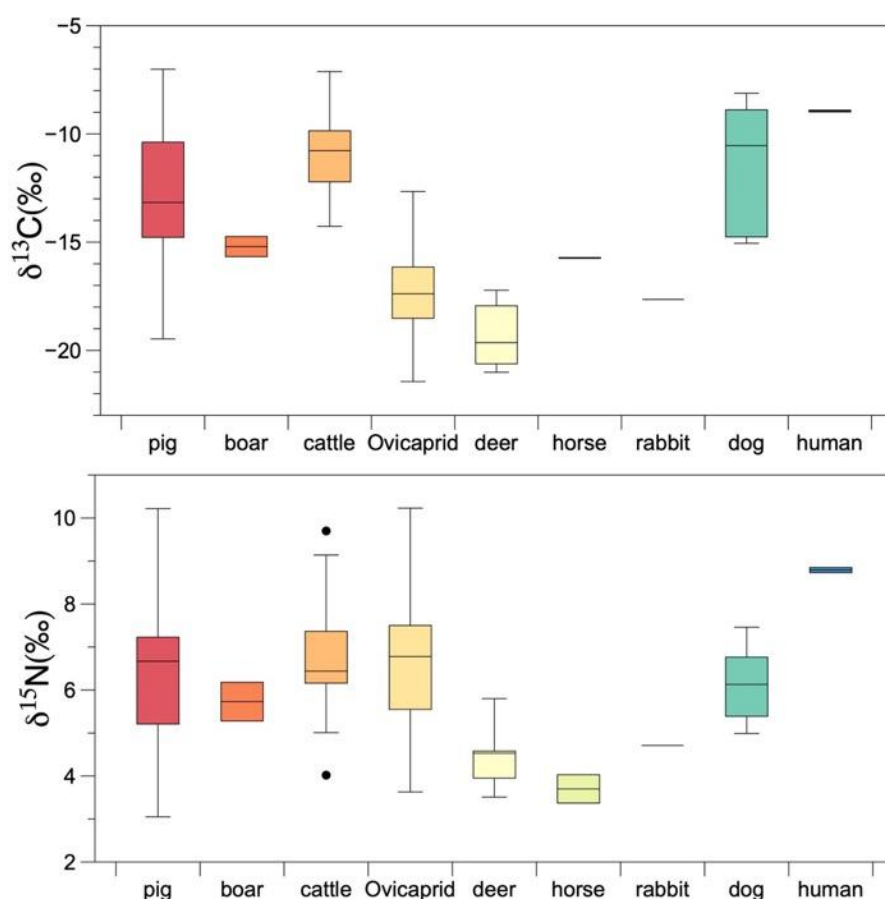


Figure 5-3-4. Box plot showing the distribution trend of C and N isotope data of species.

The range of variation within the data generated in this study is shown in **Table 5-3-3**. Besides boars, horses, and rabbits with few samples, lowest $\delta^{13}\text{C}$ variation is among the deer, at 1.65‰ (n=5), although this is combined data from two different species. It is concluded that sika deer and Chinese water deer lived in similar environments and had similar diets. The highest variation is among the dog, at 3.18‰ (n=7). Pigs follow closely, at 3.16‰ (n=34). Ovicaprids (variation = 2.18‰, n=18) and cattle (variation = 1.92‰, n=19) are intermediate. The wide $\delta^{13}\text{C}$ ranges of dogs and pigs might be related to human foddering strategies, which will be discussed in detail in the following. The ovicaprids, which could not be determined to species show a range of variation above 2‰, probably stemming from the inclusion in the sample of both sheep and goats, animals that consume different types of vegetative foods

(Gron & Rowley-Conwy 2017). The range of variation in $\delta^{15}\text{N}$ values is more uniform across taxa, with ovicaprids showing the largest range of variation at 1.56‰.

Table 5-3-3
The variation within the data (all values in ‰)

Taxa	n	$\delta^{13}\text{C}$ Mean	Min	Max	SD	$\delta^{15}\text{N}$ Mean	Min	Max	SD
Pig	34	-13.01	-19.47	-7.01	3.16	6.47	3.05	10.22	1.43
Boar	2	-15.21	-15.67	-14.74	0.66	5.73	5.28	6.18	0.64
Cattle	19	-10.96	-14.27	-7.12	1.92	6.74	4.02	9.70	1.36
Sheep/goat	18	-17.12	-21.44	-12.66	2.18	6.66	3.63	10.23	1.56
Dog	7	-11.57	-15.05	-8.12	3.18	6.13	4.99	7.46	0.96
Horse	2	-15.73	-15.75	-15.71	0.03	3.70	3.37	4.03	0.46
Deer	5	-19.29	-21.01	-17.22	1.65	4.48	3.51	5.80	0.86
Rabbit	1	-17.65	-17.65	-17.65	0.00	4.71	4.71	4.71	0.00
Human	2	-8.94	-8.98	-8.90	0.06	8.79	8.73	8.85	0.08

2.3 Two groups of dogs

From **Figure 5-3-3**, we can clearly see that the dog samples form two distinctly separate groups. The differences between these two groups are quite significant (t-test results are $p_{\delta^{13}\text{C}}=0.00042 < 0.01$, and $p_{\delta^{15}\text{N}}=0.0157 < 0.05$). The presence of these two groups is also the reason why dogs exhibit the highest $\delta^{13}\text{C}$ variation. To better observe these two groups, **Figure 5-3-5-A** was constructed, removing the herbivores, and retaining only humans and omnivores, which were thought to have diets more closely related to dogs. Each data point is labeled with its corresponding sample's Lab ID.

Two dietary patterns were reflected by the two groups. Four dog individuals in Group 2 have average values for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ($-9.11 \pm 3.16\text{‰}$ for carbon, $6.78 \pm 0.65\text{‰}$ for nitrogen, respectively) closest to humans among the fauna, which can be seen in **Figure 5-3-5-B**. This dietary similarity strongly suggests that these dogs were being fed on human leftovers based on C4 plants, and these dogs had a close relationship with humans. By contrast, the isotopic measurements of the three dog individuals in Group 1 are closer to those of wild boars, with both $\delta^{13}\text{C}$ ($=-14.86 \pm 0.29\text{‰}$) and $\delta^{15}\text{N}$ ($=5.25 \pm 0.37\text{‰}$) values being negative.

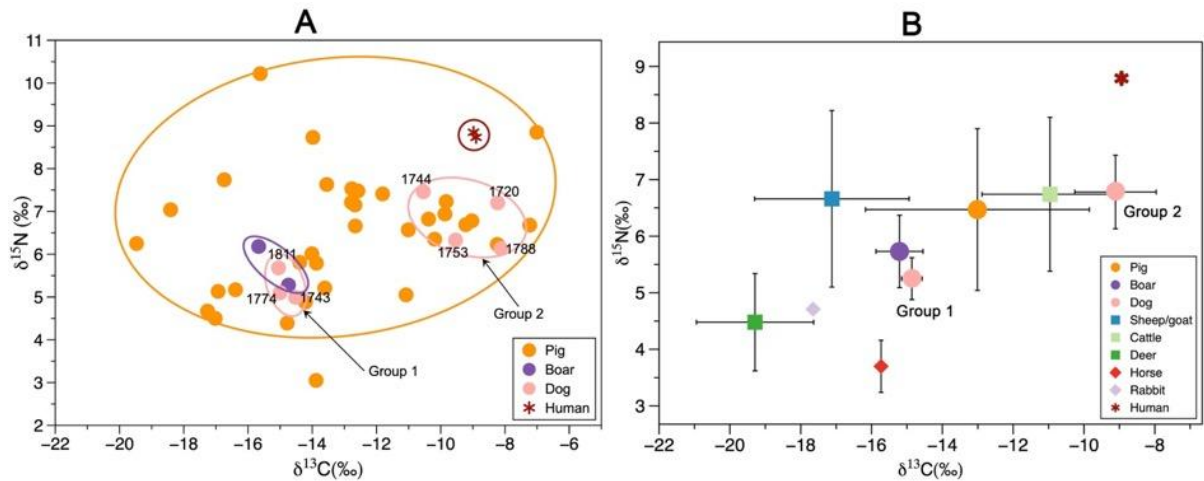


Figure 5-3-5. The existence of two groups of dogs with distinct diets.

Table 5-3-4.

Contextual information of dog individuals and the variation within the data in two groups.

LAB ID	Taxa	Site	Age	Feature	Element	Side	Group		
1743/22	Dog	FDC	II -2	M63	femur	L	1		
1774/22	Dog	JFQ	IV	H825	mandible with C, P1-P3	R	1		
1811/22	Dog	GXS	VI -1	H941		mandible	R	1	
1720/22	Dog	FDC	III	M66 waist-pit	humerus	R	2		
1744/22	Dog	FDC	II	No.3 horse pit	rib	-	2		
1753/22	Dog	JCL	I	Eastern ditch 3	Distal tibia	L	2		
1788/22	Dog	GXS	I	③A	ulna	R	2		
Group	n	δ ¹³ C Mean	Min	Max	SD	δ ¹⁵ N Mean	Min	Max	SD
1	3	-14.86	-15.05	-14.52	0.29	5.25	4.99	5.68	0.37
2	4	-9.11	-10.54	-8.12	1.15	6.78	6.13	7.46	0.65

Two hypotheses can be put forward to account for the two different dietary patterns mentioned above. One hypothesis is based on the varying relationships between dogs and humans, reflecting their affiliative nature, while the other is about different foddering choices on the part of the dogs.

1. The first hypothesis suggests that the dogs in Group 2 were closely integrated into human households, whereas the dogs in Group 1 were not. Dogs in Group 2 with a similar diet to humans are considered to play an important part in human society, such as working and hunting animals, pets and so on (Hu 2018). Similar conclusions have

been obtained from numerous isotope studies on humans and dogs spanning from the Late Neolithic to the Zhou Dynasty (Chen et al. 2012, 2016, 2017; Hou et al. 2013a, b; Zhang & Zhao 2015; Dai et al. 2016). By contrast, dogs in Group 1 might be homeless and ownerless, likely being stray or feral dogs with a relatively low status. This is why their isotope data showed a much more undernourished pattern. This hypothesis can also be supported to a certain extent by the archaeological contexts (**Table 5-3-4**). In Group 1, 2/3 individuals were found in ash pits, possibly killed for consumption. In contrast, In Group 2, the majority (3/4) received some form of special treatment, such as in a burial waste pit (likely as pet) and a sacrificial horse pit (likely as hunting companion). However, sample 1743/22 from Group 1 was also found as a sacrificial animal in a tomb, making this contextual evidence somewhat tenuous.

2. The second hypothesis is that both groups of individuals were domestic dogs, however, they were fed different types of food by humans. Dogs in Group 1 were fed household refuse or other foods dominated by C4 plants, which does not require much elaboration. As for the individuals in Group 2, they might have had a more C3 plant-based diet. Previous scholars have discussed cases of plant-eating dogs during the Bronze Age in Iberian Peninsula (Albizuri et al 2021). Their feed might have included nitrogen-fixing plants, such as legumes, which would further lower their $\delta^{15}\text{N}$ values. Studies show that nitrogen-fixers have $\delta^{15}\text{N}$ values similar to atmospheric levels, lower $\delta^{15}\text{N}$ values than other plants (Delwiche & Steyn 1970; Wada et al. 1975; Ambrose 1986). Additionally, in another paper concerning the ZHGC isotope study, it is suggested that beans were newly cultivated C3 plants initially regarded as low-status foods, providing sustenance for the poor during famines at that time (Dong et al.

2017). Therefore, for ordinary households, feeding dogs with beans would be an economical and effective strategy.

From the temporal perspective, two groups both contain individuals from the Spring and Autumn Period and the Warring States Period, thus, the differentiation of dogs' diets may not result from some diachronic changes of human practices.

More dog specimens and data will be included in future work, providing further evidence to support or refute the above hypotheses. Additionally, the results of this study also show that the application of the “canine surrogacy approach” (CSA), which is the assumption that dog bone collagen as well as other tissues can be used as a suitable proxy material for addressing questions relating to human dietary practices (Guiry 2012; Guiry & Grimes 2013), may be unreliable. At least, it does not work in ZHGC.

2.4 Broad range of pigs

Among all the taxa, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of domestic pigs ($n = 34$) range most widely, from -19.47 to -7.01 ‰ (variation = 3.16 ‰) for carbon, and from 3.05 to 10.22 ‰ (variation = 1.43 ‰) for nitrogen, respectively. Although the inclusion of wild individuals could explain a few extreme specimens, the overall diet range seems still broad, suggesting a mixed diet of both C3 and C4 signatures.

We can explain this situation from two perspectives: the food types and the management methods.

Firstly, although C4 plants (millet) were the main crops cultivated locally, some C3 crop plants, including soybeans (*Glycine max*), wheat (*Triticum aestivum*), and barley (*Hordeum vulgare*), were newly cultivated in ZHGC. They were initially regarded as coarse foodstuffs, provisioning the poor against famine, and the isotope research of human skeletons from ZHGC indicated that low $\delta^{15}\text{N}$ values of females could be also a consequence of a larger proportion of legumes in their diet (Dong et al. 2017). Thus, these foods were also likely

added to pig feed, resulting in the pigs' overall diet containing signatures from both C3 and C4 plants.

Additionally, different management methods could also result in the complexity of pig diets. On the one hand, free-range pigs could consume wild plants, thus introducing wild C3 plants into their diet, leading to the negative $\delta^{13}\text{C}$ values (Dai et al. 2019). Evidence of free-range domestic pigs in ancient China can be found in many images (e.g. **Figure 5-3-6**). On the other hand, pigs kept in enclosures, consuming human leftovers, show isotope values similar to those of humans (Chen et al. 2012, 2016, 2017a; Hou et al., 2013a, b; Zhang & Zhao 2015; Hu 2018), resulting in higher $\delta^{13}\text{C}$ values. In fact, a more practical approach would likely be a flexible combination of penning and free-range feeding. The ancient agricultural text *Qimin Yaoshu* (Essential Techniques for the Welfare of the People, 544 CE) states that “圈不厌小，圈小肥疾；处不厌秽，泥秽得避暑。春夏草生，随时放牧，八九十月放而不饲，所有糟糠，则畜待穹冬春初” (“Pens should be small, as small pens fatten pigs quickly; pigs should be kept in dirty places, as muddy areas help them avoid the heat. In spring and summer, let them graze when grass is abundant, stop feeding them in the eighth and ninth months, and use the available chaff and bran to keep them through the harsh winter and early spring”). This indicates that people at the time were aware of the benefits of combining free ranging with penning, adjusting feeding and management methods according to the seasons to effectively save fodder. Therefore, I hypothesize that the pigs at ZHGC were likely managed under a flexible managing strategy combining penning and free ranging.

Additionally, besides the external husbandry practices by humans, the intrinsic nature of pigs should be noted. The gregarious nature and omnivorous diet of pigs make them extremely adaptable. They can thrive in diverse environments and exhibit a wide range of dietary preferences. From tethering together to free range, these various husbandry practices may result in differences in dietary habits. However, such remarkable adaptability may

weaken and obscure significant human intervention in the dietary reconstruction of ancient pigs. This might be why pigs' diet in our analysis showed a relatively extensive range, although most of them have been proven to be domesticated and under human control, rather than showing a clear artificial dietary pattern like Group 2 dog and cattle.

In summary, the historical context of ZHGC allows for various husbandry practices and the availability of multiple food sources. Coupled with the omnivorous nature of pigs, this makes interpreting their diet exceptionally challenging. While we may not obtain a definitive answer to this issue, the overall complexity and the coexistence of multiple possible management strategies highlight the uniqueness of this site.



Figure 5-3-6. A part of a handscroll painting *Along the River During the Qingming Festival* [清明上河图] by the Song dynasty painter Zhang Zeduan (AD 1085–1145), depicting the bustling scene of the capital, Bianliang (Kaifeng), where seven free-range domestic pigs are shown strolling leisurely on the street, seemingly accustomed to moving through the alleys.

2.5 Diverse foddering of cattle and ovicaprids

According to the data, the mean values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements of cattle are $-10.96 \pm 1.92\text{‰}$ and $6.74 \pm 1.36\text{‰}$, those of Ovicaprid are $-17.12 \pm 2.18\text{‰}$ and $6.66 \pm 1.56\text{‰}$. The results of the independent samples t-test for the $\delta^{13}\text{C}$ data between cattle and ovicaprids

suggests that there is a statistically significant difference ($p=0.00 < 0.05$), while there is no statistically significant difference in the $\delta^{15}\text{N}$ values ($p=0.8720 > 0.05$).

As domestic animals, the significant dietary differences in $\delta^{13}\text{C}$ between these two herbivores should be attributed to the combined influence of their physiological feeding habits and agriculture-based strategies. Based on their $\delta^{13}\text{C}$ measurements, sheep/goat primarily consumed wild C3 plants. This is because that their physiological characteristics enable them to effectively graze on low-lying wild grasses, which significantly enhances their feeding efficiency when raised in free-range systems. In comparison, cattle lack this ability of grazing low grasses and have a much larger food intake requirement. Thus, during periods when millet agriculture was predominant, feeding strategies that prioritized millet by-products, supplemented with grass and grains, were considered the most economical and effective for feeding cattle (Chen et al. 2012, 2016). This conforms to the stable carbon isotope measurements of cattle displaying more C4 signatures in this study. Some scholars believed that the cattle husbandry gradually developed into a by-product industry dependent on millet agricultural production (Chen 2021).

Previous isotopic studies on animals from China's late Neolithic period (e.g., Dai et al. 2016; Chen et al. 2017b; Yang et al. 2020) and the Bronze Age (e.g. Chen et al. 2012, 2016, 2018) also show similar dietary patterns in cattle, ovicaprids, and cattle-ovicaprids to this study. This indicates that such cattle and sheep feeding structures have shown strong stability and resilience within the context of agricultural cultivation. Even in contemporary rural areas, grazing and stall-feeding remain the primary methods for rearing sheep and cattle, respectively. Currently, isotopic studies on the different feeding and management strategies for cattle and sheep are mainly concentrated in the Central Plains. Whether similar strategies existed in other regions requires further evidence.

2.6 Temporal variation of pig raising and the changing status of animals

As we can see, the pig isotope values show a relatively wide range, making it necessary to explore whether this variation is linked to intra-site diachronic differences or spatial differences in feeding practices. The pig samples analyzed span four different periods, with the Spring and Autumn Period (SAP) and the Warring States Period (WSP) being the two main phases of occupation at the ZHGC site. From the **Figure 5-3-7-left**, we observe that the isotope values from different periods are mixed together without any clear separation or significant differences. This suggests that over the relatively short time frame of the Eastern Zhou period, pig husbandry practices remained largely consistent. The data points to a complex feeding system, where multiple feeding strategies coexisted throughout the period. Meanwhile, there is no clear difference shown among sites and locations (see **Figure 5-3-7-right**).

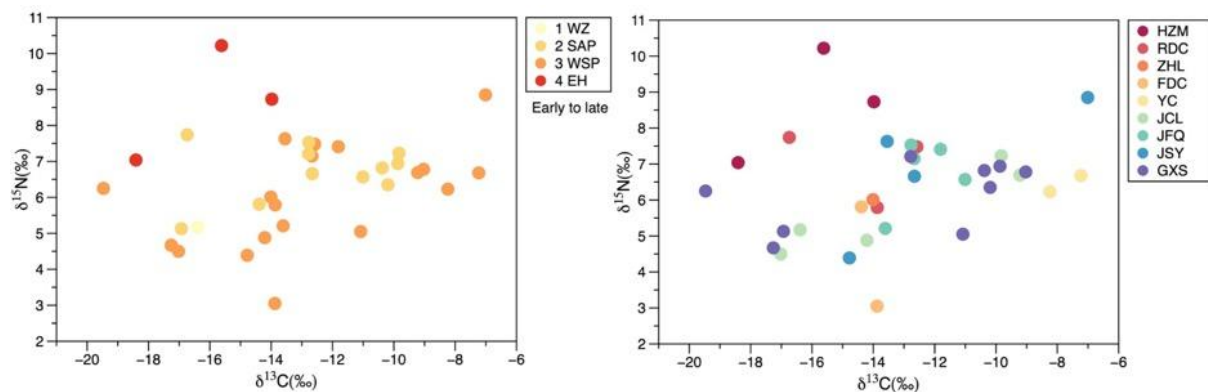


Figure 5-3-7. Pig isotope data grouping according to ages (left) and sites (right).

However, when a greater dimension of time is introduced, interesting thing can be found. Compared with the local Neolithic *Sus* groups, ZHGC (Bronze Age) pigs has a clear lower $\delta^{13}\text{C}$ value. $\delta^{13}\text{C}$ values of Eastern Zhou pigs were much more negative than those of Yangshao monogastric (Mdn= -13.01‰ , $n= 34$ vs. Mdn= -7.4‰ , $n= 7$) (yangshao data source from Dong et al. 2017).

It is indicated that the pig feeding intensification with C4 (mainly indicate agricultural crops, millet) from the Neolithic to Bronze Age, at least in ZHGC, was weakening. This trend indicates that in the earlier stages of pig domestication, there was greater reliance on cultivated crops for feeding. However, by the Bronze Age, as pig domestication became more established, the intensity of control over pig feeding practices lessened. Foddering strategies diversified, reflecting a shift to more varied feeding practices. This is evident in the reduced dietary similarity between humans and pigs. In contrast, cattle replaced pigs as the more intensively managed livestock during this period. Cattle were increasingly fed with cultivated crops and byproducts, as indicated by the higher C isotope values. This shift is further supported by the quantitative analysis of excavated pig and cattle bones presented in the previous chapter, showing a decrease in the proportion of pig remains from early to late phases, while the proportion of cattle increased overall.

3. Source of deer and “game park”

North China region where the ZHGC located was once home to a wide variety of deer species, most of which thrived in lowland mixed forests and river valleys (Brunson & Lander 2023). The number of deer in the animal assemblage is not great. But despite constituting a minority compared to the dominant domestic animals (NISP%=2.9%, MNI%=8.2%), their absolute numbers (NISP=182, MNI=57) and ubiquity (present in all stages I - VI and in 8 out of 12 sites) are not negligible.

For exploring the source of the deer species present in the site (i.e. how deer came into the site), a four-quadrant model was constructed (**Figure 5-3-8**). It involves considering two main variables: the behavioral agents involved and the motivations driving their actions. The acting subjects can be divided into civilians and elites, while motivations can be either proactive or passive. By intersecting these factors, four possibilities or categories are proposed regarding how deer remains were brought into the site.

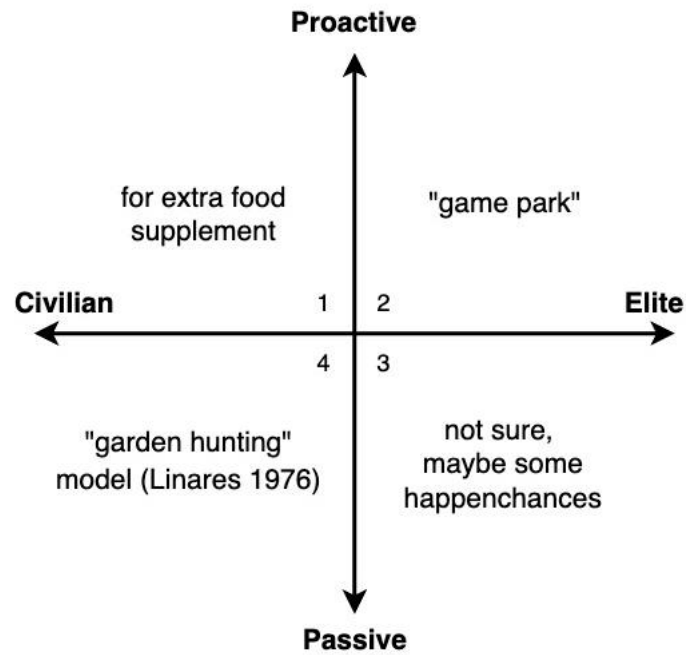


Figure 5-3-8. Four possible patterns of the source of deer.

In the first quadrant, where "civilian" and "proactive" intersect, people pursue the deer likely for an occasional food supplement. At the time, access to meat resources was primarily a privilege of the elite class. The slaughter of a domestic animal was a major decision for households operating at subsistence level, leaving commoners to struggle to obtain sufficient nutrition and protein. As a result, commoners proactively ventured into nearby forests to forage for wild game as a crucial means of obtaining protein. Deer species with considerable meat were suitable targets. However, this behaviour is only a random one-off event rather than a continuous harvest because the agricultural produce was still waiting for them.

The "garden hunting" model proposed by Linares (1976) can provide a valuable framework for understanding the fourth quadrant where "civilian" and "passive" intersect. This model suggests that as agricultural societies devote more time to farming activities, they have less time for hunting, leading to a shift in meat procurement strategies. Farmers may hunt animals attracted to the edges of their gardens and fields, creating a symbiotic relationship where humans opportunistically take advantage of animals living in and around settlements. This model has been applied to understand subsistence practices in both ancient

and contemporary farming societies across the Americas (VanDerwarker 2006:149–151). Similarly, this symbiotic relationship of “garden hunting” may also be applicable to many sites in North China, as discussed by Brunson and Lander (2023). This can be considered a strategy for diversifying available resources, which is a risk management strategy practiced in many agricultural societies (Halstead & O’Shea 1989; Brunson & Lander 2023). But in essence, this is a kind of passive waiting activity auxiliary to the main agricultural production.

For the two quadrants on the right, they were both led by the elite. As the capital city of the states during the Eastern Zhou period, their vicinity generally featured royal game parks (Luo et al. 2006). Many historical literary sources, such as the *Classic of Poetry (Shijing)* and the *Spring and Autumn Annals*, contained numerous accounts of royal game parks and vivid hunting scenes during the Zhou dynasty (Chen 2010b), and oracle bone inscriptions from the Shang dynasty also recorded frequent royal hunting activities held in these gardens (Chang 2012; Yang 2016). Royal game parks usually housed some exotic or common wild animals to provide entertainment for the elite groups.

This can effectively explain the proactive behavior of the elite group in the third quadrant, which I have termed the “game park” (GP) model. Compared to the “garden hunting” (GH) model in the fourth quadrant, although the two names are similar and result in comparable zooarchaeological outcomes (i.e. the inclusion of a small but noticeable number of wild species within the predominantly domestic animal assemblages at the sites), their motivations and natures differ significantly. Essentially, “GH” model is a risk minimisation strategy aimed at offsetting food shortages, while the “game park” appears in affluent societies, reflecting food abundance to a certain extent. It is an entertainment-oriented animal management strategy by the privileged class, premised on food sufficiency.

In fact, concerning the proactive hunting expeditions of the elite class during the Chinese Bronze Age, besides practical (e.g. utilizing the meat, fur, bones, and antlers of the

prey for royal consumption) and recreational purposes (Chen 1988:552), it is also likely to be related to military (e.g. training the populace in martial skills through hunting) and ceremonial activities, which have been widely discussed by many scholars (Yao 1981; Meng 1983; Chang 2012). However, considering the specific circumstances of the ZHGC materials, most of the deer specimens appeared sporadically in the remains associated with daily consumption. Therefore, regarding the interpretation of the third quadrant, I am more inclined to view the deer remains unearthed from ZHGC as activities related to daily entertainment in the game park.

The wild animal remains excavated from the site, including various-sized deer such as Pere David's deer, sika deer, and muntjac, as well as rabbits, wild boars, and even tigers, could have potentially originated from the game parks. However, it is essential to exercise caution when determining whether these wild animals reflected the true natural ancient environment (Luo et al. 2006) and if they could be introduced as a baseline reference in isotope studies because they might be artificially fed. Additionally, this "game park" hunting is an interpretive model characterized by the feudal culture with clear hierarchy, and its applicability should be assessed based on the specific situation of the site. Moreover, game park would lose its privilege under extreme conditions like wartime.

As for the third quadrant caused by the elite passively, I assume it might be related to occasional accidental events, which do not need further discussion.

So, which of the previously mentioned sources did the deer and the other wild species at ZHGC actually come from? In fact, I believe all three possibilities are quite likely. For a feudal state capital like ZHGC, located at the intersection of rapid economic production and turbulent times, these explanations are all very reasonable. First, the consumption-level differences drove commoners to seek additional supplies. This situation could lead to commoners actively hunting wild animals to obtain extra nutritional resources. Secondly, the

presence of extensive farmlands would attract wild animals into human settlements, aligning with the "garden hunting" model. Lastly, the elite class's demand for hunting as entertainment would also result in wild animals being captured and brought back into the city.

Therefore, all three explanations are reasonable under the circumstance of ZHGC. The purpose of establishing this four-quadrant model is to list all possible explanations as comprehensively as possible. When it comes to specific remains from particular features, we might be able to attribute them to a specific cause based on the contextual background.

CHAPTER 6 Animals as Sacrifice

In this chapter, we will discuss the ritual use of animals, primarily focusing on contexts like burial offerings. However, this section, to a certain extent, also serves the same reference purpose as Chapter 5, albeit narrowing the range within the context of ritual practices. When unusual phenomena arise, it prompts us to distinguish different types of ritualistic uses. It leads to the question why some remains might be interpreted as feasting rather than other ritual scenarios. Only when we are acutely aware of the patterns of animal remains used for burial offering, for sacrifice, for ancestor worship, for deity veneration, or for foundation-laying ceremonies, etc., can we become more sensitive and have a clearer perspective when it comes to identifying and analysing other unique but distinct remains associated with feasting.

Worldwide, it is commonly argued that rulers used sacrifice in rites as symbols of royalty and tools for consolidating power, particularly in early state-level societies (Gibbons, 2012; Watts et al., 2016). In China, various forms of sacrifice were crucial to state affairs throughout the Bronze Age according to historical evidence. One most frequently-quoted line is from the *Zuozhuan* (The Zuo Tradition¹⁴), stating that “国之大事，在祀与戎” (the most major affairs of the state are sacrifice and war). Animals played a crucial role in these sacrificial rituals (Sterckx, 2002: 57-64). Both elite and common classes employed animals in their ceremonial practices, involving species that matched their social status (Chang, 1980; Yuan & Flad, 2005). The best archaeological contexts for investigating this pattern of animal use are burials and sacrificial pits. In the collection of faunal remains discussed in this study, most excavation sites were located in residential areas, and only a few burials were uncovered, mainly at the FDC site in the eastern city, which should be a noble cemetery of the Spring and Autumn Period (SAP). The sacrificial pits were all found in the western city at

¹⁴ A detailed chronicle of the Springs and Autumns period (770–481 BCE) that was compiled during the subsequent Warring States era (480–221 BCE).

the EGJ site. In this section, I will present a few case studies, along with previously published materials, to provide a preliminary overview of the ritual use of animals in burials and sacrificial pits, analysing the symbolism of diverse animals and the spiritual life of ZHGC residents.

Section 1 Burials

1. Case study-FDC M63

M63 is a shaft burial at the FDC site. The opening of the burial is approximately one meter below the ground surface. The burial measures 3 meters in length, 1.5 meters in width, and 1.7 meters in depth. Its plan takes a rectangular shape. Inside the burial, a set of human skeletal remains was discovered, with the head oriented southward and the body in a supine-straight position. Preliminary identification at the excavation site suggested the skeleton was female and over 50 years old (source from excavator's in-situ records rather than professional forensic osteological lab work). The burial featured a single-layer wooden coffin, which had decomposed into charcoal ash. Grave goods accompanying the burial included one copper vessel cups, two pottery jars, two pottery *dou* (high-footed shallow dish), one pottery bowl, and one pottery tripod vessel *li* (containing pig bones). A strip-shaped ditch was found underneath the coffin, within which a sacrificed dog was unearthed. Based on the stratigraphic context and the typological characteristics of the burial artifacts, it is suggested that this burial dated back to the middle Spring and Autumn period (stage II).

The dog skeleton unearthed from the ditch is illustrated in **Figure 6-1-1**. Although many elements are missing, it is still evident that the burial included an entire dog. Similarly, the pig remains found in the vessel also belong to one single individual (see **Figure 6-1-2**). Based on the epiphyseal fusion of the bones, particularly the unfused coracoid process of the scapula, it is estimated that the pig was a young individual, likely less than one year old. Based on the elements present, it is likely that only selected parts were deposited, including the left part of the thorax, left leg, and right leg, rather than the entire skeleton. This selection was probably made to fit within the confines of the vessel because the diameter of the pottery *li* is only 15cm.

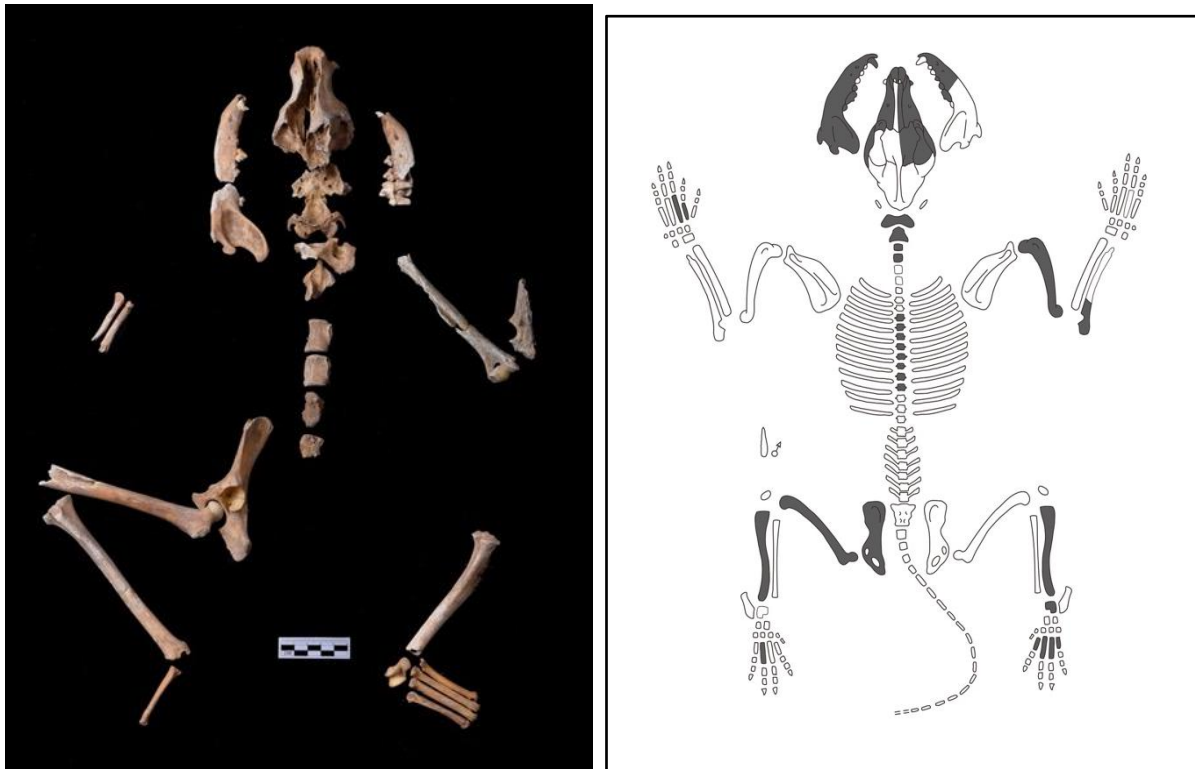


Figure 6-1-1. Photo (left) and schematic view (right) of the dog elements (shaded parts) from the bottom ditch of burial M63 at FDC site.

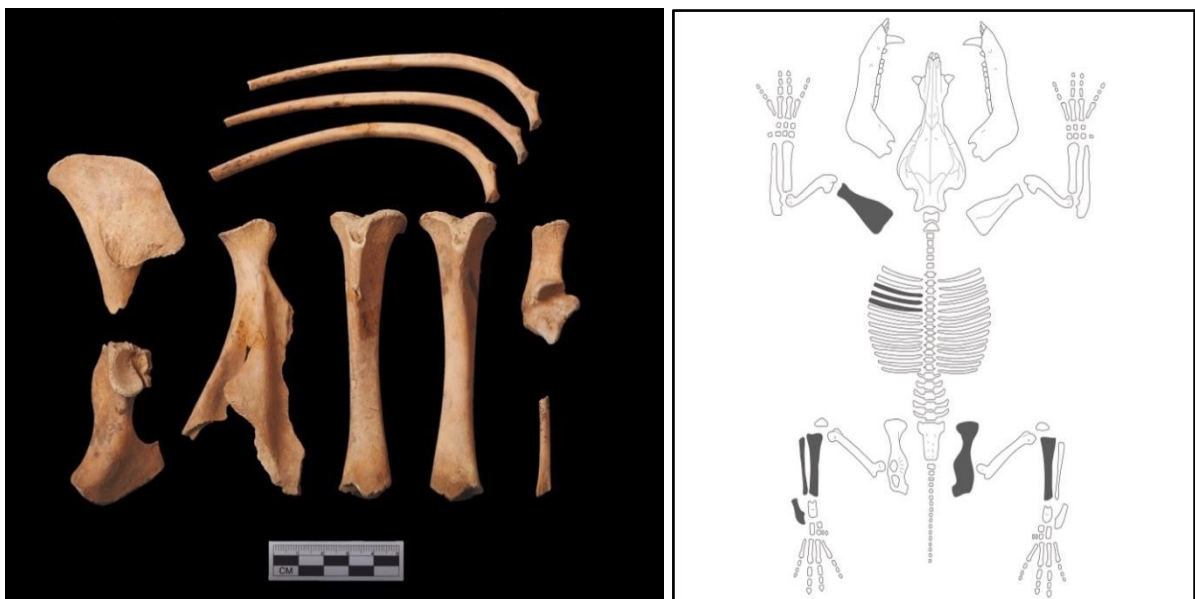


Figure 6-1-2. Photo (left) and schematic view (right) of the pig elements (shaded parts) from the pottery *Li* (M63:3) in the burial M63 at FDC site.

2. Case study-FDC M66

M66 is also a shaft burial located in the FDC site, approximately 5 meters northwest of M63. The burial measures 3 meters in length, 1.8 meters in width, and 1.7 meters in depth,

with a rectangular plan. The human skeleton in M66 was positioned with the head oriented southward, facing west, and the body in a supine, extended position. On-site forensic osteological analysis indicated that the individual was a male in old age, as suggested by the severe tooth wear. Although no burial goods were recovered, the tomb's structure—a coffin within an outer coffin—along with the presence of a side box on the west side and a waist-pit beneath the body containing a dog, suggests that the tomb owner had a certain status. Based on the stratigraphic relationship of this tomb with other features, it is estimated to date to the late Spring and Autumn period (stage III).

The dog skeleton from the pit is illustrated in **Figure 6-1-3**. Based on the tooth eruption, the estimated age of the dog is about 4 months old. As for the faunal remains found in the west side box, they consist of the entire left foreleg of a sheep/goat (from the scapula to the metacarpal), as shown in **Figure 6-1-4**. This offering should serve as a meat provision for the afterlife of the tomb owner, symbolizing wealth and status.

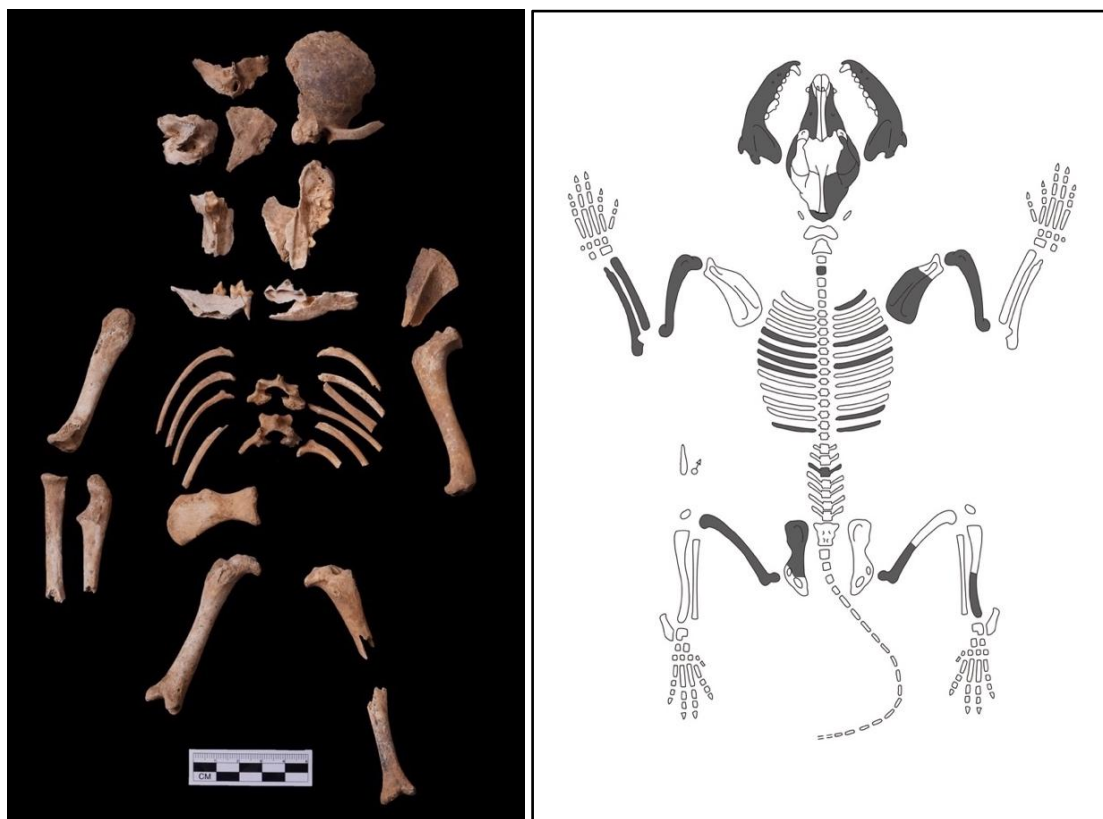


Figure 6-1-3. Photo (left) and schematic view (right) of the dog elements (shaded parts) from the waist pit of burial M66 at FDC site.

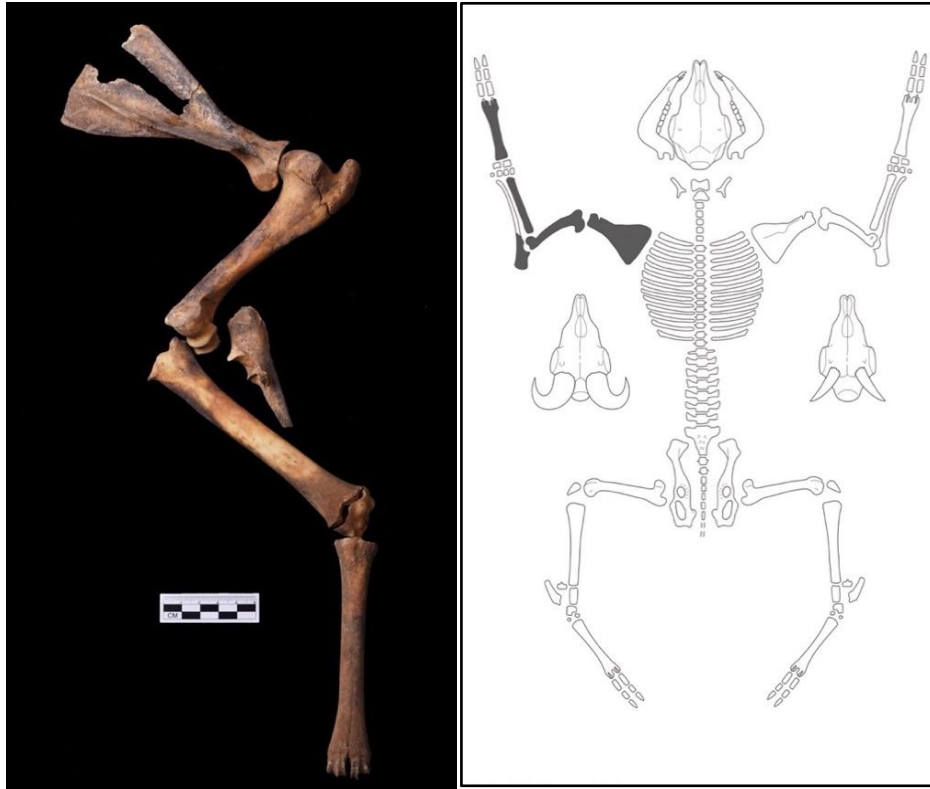


Figure 6-1-4. Photo (left) and schematic view (right) of the sheep/goat elements (shaded parts) from side box of burial M66 at FDC site.

3. Case study-FDC M72

M72 is a rectangular shaft burial at the FDC site, which was disturbed by another burial, M68. The burial measures 2.17 meters in length, 1.5 meters in width, and 2.4 meters in depth. Inside the tomb, there is a single coffin, with a remaining length of 1.99 meters, width of 1.09 meters, and a height of approximately 0.4 meters. A niche is made on the northern wall of the tomb, containing four pottery vessels: one water jar, one *li*, and two *dou*. Based on the typological characteristics of the grave goods, this burial has been dated to the late Spring and Autumn period (stage III). Due to the disturbance by M68 and potential looting activities, no human bones or other remains were found.

Among the materials from our study, animal bones were uncovered from M72. As shown in **Figure 6-1-5**, they consist of a right scapula and 11 ribs from a sheep, which likely represent an entire right side of a lamb rib rack. There is some discrepancy between the

original excavation record and the actual remains. The original excavation records indicated that, apart from the four pottery vessels, no other remains were discovered. This suggests that the lamb rib rack may have been placed inside one of the pottery vessels (most likely in the *li*, which is a cooking vessel) and were only retrieved later during the cleaning of the vessels. However, the label on the bones does not specify the exact origin among the grave goods, leaving some uncertainty about the precise placement of the faunal remains in the burial context.

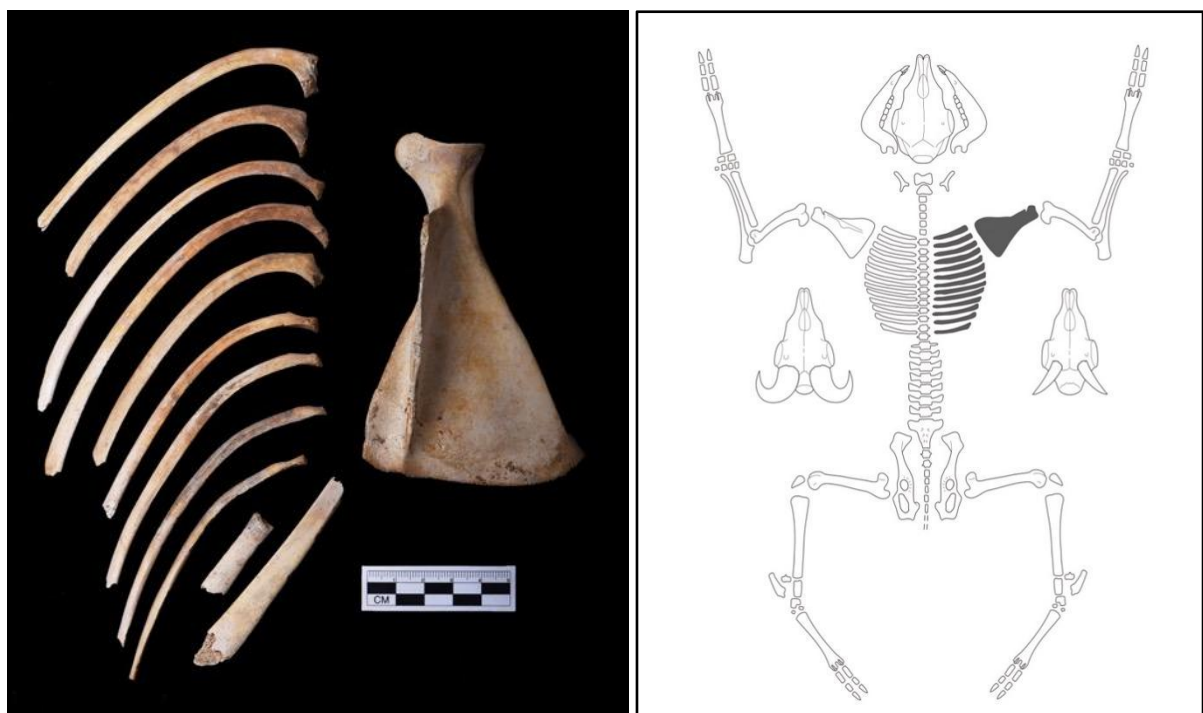


Figure 6-1-5. Photo (left) and schematic view (right) of the sheep/goat elements (shaded parts) from burial M72 at FDC site.

4. Others

In addition, faunal remains were found in other three burials; however, due to the small quantity and the lack of photographic documentation, they are only briefly described together here.

M243 from the YC site is a small burial dating to the late Spring and Autumn period (stage III). A pit was found underneath the human skeleton. Owing to poor preservation, only

a dog skull (with L/R upper I1 - M2) and mandible (with L/R lower I1 - M3), as well as four bone fragments, were recovered. It is speculated that a whole dog may have been buried.

M272 from the YC site is an early Warring States period (stage IV) tomb. Five pig bones were found inside a pottery *li* (tripod cooking vessel) buried as a grave good, including a left scapula, two ribs, and two thoracic vertebrae spines. They all probably come from the same immature individual, the exact age being unknown, but based on the size and fusion condition of the bones, it is similar to the one from the M63's *li*.

M147 from the GXS site is a small burial dating to the mid Spring and Autumn period (stage II), with nine animal bones recovered from the earthen fill. These include a right pelvic bone and two scapula fragments of medium-sized deer, a loose upper molar of ovicaprid, a left proximal femur of a medium-sized mammal, as well as four limb fragments of large mammals. Based on the taxa and skeletal elements, as well as the excavation context, these bones do not appear to belong to a single individual or the specific body part that aforementioned cases showed. It is therefore suggested that they were more likely mixed into the burial fill or entered the deposit through post-burial disturbance and did not serve as deliberate grave goods.

Section 2 Sacrificial pits

The sacrificial pits in this study were all concentrated in the T107 excavation unit at the EGJ site. According to excavation records, eight sacrificial pits were identified in T107, labelled DK1 to DK8. These pits were located in the same stratigraphic layer, and all dated to the early Warring States period (stage IV). The faunal remains from DK2 to DK7 were included in our analysis¹⁵.

The original excavation records for DK2 are missing. The preservation of the bones in this pit was poor and highly fragmented, with only some ribs, vertebrae, and parts of the limbs recognizable. However, it is assumed that this pit contained a relatively complete skeleton of cattle, though it is uncertain whether the head was included.

DK3 was in the southern part of the western half of the unit, and it had a rectangular shape, measuring 1.26 meters in length and 0.48 to 0.52 meters in width. It contained three complete cattle individuals. Based on the original records, it is assumed that two of the cattle were stacked together, while the third was placed beside them. Dental eruption and wear suggest that one was 0-6 months old, while the other two were 16-28 months old. No horns were found.

DK4, also in the southern part of the western half of the unit, was rectangular and measured 1.16 meters in length and 0.5 to 0.52 meters in width. It contained one pig and one cattle skeleton. The pig was a partial skeleton with only ribs and limbs, but the cattle skeleton might have been complete. The cattle mandible with lower dp2-dp3 indicates a young individual, likely around one year old. No horns were found.

DK5, located in the southern part of the western half of T107, had a semi-circular shape, with a radius of 0.4 meters, though half of the pit was cut by ash pit H445. The soil was hard, and it contained a complete pig skeleton estimated to be over two years old.

¹⁵ Animal bones of DK1 and DK8 are missing during the storage.

DK6, located in the southern part of T107, was circular with a diameter of 0.46 meters. The pit contained a complete bovine skeleton, identified as female and aged 5-10 months.

DK7, also in the southern part of T107, had an oval shape. The northeastern part of the pit was disturbed by H445, leaving a remaining length of 0.48 meters and a width of 0.38 meters. Due to the disturbance, the bone preservation was poor, with only a few vertebrae and bone fragments of cattle remaining, and it is unclear whether the skeleton was complete.

Clearly, these sacrificial pits were concentrated in a relatively small area. Although in-situ photographs and the spatial distribution of these animal pits are not available, we can make informed speculations based on previously published materials. In the report on the Bank of China sacrificial site of the Zheng state (Luo et al., 2006), five sacrificial pits were found southwest of the rammed-earth foundation of structure F5. These included one large rectangular pit in the center, with four smaller pits partially surrounding it. The large pit contained cattle and pig bones, while the smaller pits contained pig remains. Similarly, at the EGJ site, there were two large rectangular pits (DK3 and DK4) that contained two or more animals, while the other pits were circular or oval-shaped and contained only one animal. Furthermore, these pits were also located near the foundation of a rammed-earth structure. This suggests that the sacrificial pits at EGJ likely followed a similar spatial pattern, where smaller pits encircled a central larger pit. The fact that all these sacrificial pits are from the same stratigraphic layer suggests they were likely part of the same foundational ritual event. Given their location in the western part of the city, an area primarily associated with the king's palace and sacred or ancestral temples, it is plausible that these pits were intended to serve a high-status building project. The sacrificed animals were likely designed to honor the gods or ancestors, aiming to secure divine favor and blessings for the construction project, which would have been of great significance to the ruling elite.

Section 3 Discussion

1. Summary and comparison with previous studies

According to the cases above, the faunal remains excavated from the burials can be categorized into three types: those mixed in the earth fill, those placed inside offering vessels, and complete skeletons buried entire. The latter two types were intentionally interred to satisfy spiritual or ritual needs, while the former was not, meaning that M147 will not be included in our subsequent discussions.

Table 6-3-1
Summary of the sacrificial faunal remains from two contexts.

Type	No.	Location	Era	Taxa	Description
Burial, ditch	M63	FDC	II	dog	Entire individual
Burial, vessel	M63	FDC	II	pig	Selected sections, young
Burial, waist-pit	M66	FDC	III	dog	4-month-old
Burial, side box	M66	FDC	III	sheep	Left forelimb
Burial, vessel	M72	FDC	III	sheep	Right rib rack
Burial, waist-pit	M243	YC	III	dog	Entire individual
Burial, vessel	M272	YC	IV	pig	Selected section, young
Sacrificial pit	DK2	EGJ	IV	cattle	Relatively entire
Sacrificial pit	DK3	EGJ	IV	3 cattle	One is 0-6 months old, two are 16-28 months old
Sacrificial pit	DK4	EGJ	IV	pig+cattle	Cattle is complete, pig not
Sacrificial pit	DK5	EGJ	IV	pig	Over 2 years old
Sacrificial pit	DK6	EGJ	IV	cattle	Female, 5-10 months old
Sacrificial pit	DK7	EGJ	IV	cattle	Not sure if complete

Based on the summary in **Table 6-3-1**, we can explore the patterns of animal sacrifice usage in ritual activities within the city.

1.1 Burials context

Dogs were always buried as whole animals, often placed in waist-pits, which is exclusively found in the context of burials. This indicates that the ritual use of dogs had significance only in relation to humans, serving primarily their owners, rather than being offered to ancestors or deities in other sacrificial ceremonies.

Other animal bones were treated as grave goods placed in the side box or within burial vessels. The animals found in cooking vessel, especially *li*, were exclusively pigs, highlighting the role of pigs as a primary source of meat for humans. Additionally, pig bones placed in these potteries tended to come from young individuals. In this study, both of two cases where tripod *li* containing pig bones (M63 and M147) featured remains from immature individuals. Furthermore, previous evidence from the Shuanglou cemetery show that 6 out of 8 grave goods included juvenile pigs (Cao & Wang 2016), indicating that the usage of young animals, was a common practice. As for the reasons behind this phenomenon, I suggest two possible explanations: first, it may reflect the Zhou people's ritual preference for offering young animals (Cao 2008); second, from a practical standpoint, young individuals were more economical, and their smaller size made them easier to place within vessels.

The animals discovered inside vessels, particularly food containers, were likely processed or cooked prior to burial. For example, in the case of the pig remains found in the pottery *li* from M63, although all the bones came from the same individual, the size of the vessel makes it unlikely that even a juvenile pig could have been placed inside whole. Instead, only parts of the pig were likely deposited in the pot. Other burial evidence in ZHGC supports this interpretation. For instance, in the Shuanglou cemetery, a right hind limb and part of the left ribs of an adult pig were found in the pottery *li* vessel from M129 (**Figure 6-3-1-A**), and a right forelimb of an adult pig was discovered in the *ding* vessel from M242 (see **Figure 6-3-1-B**). Based on the size and depth of these vessels, it would have been difficult to place these large cuts of meat inside without processing them first. Notably, the humerus found in the *ding* from M242 had distinct cut marks, likely indicating that the meat had been removed from the bone using tools. The femur from M129 was also fractured into several pieces in the midshaft, suggesting it may have been broken by striking it with a heavy object. Archaeologists proposed that these processing methods were employed to reduce the size of

the meat portions to fit within the vessels (Cao & Wang 2016). Regarding this, further molecular evidence could be obtained in future research by conducting transmission electron microscopy (TEM) analysis of bone collagen, which could determine whether the bones were heated prior to burial (Koon et al. 2003; Koon 2012).

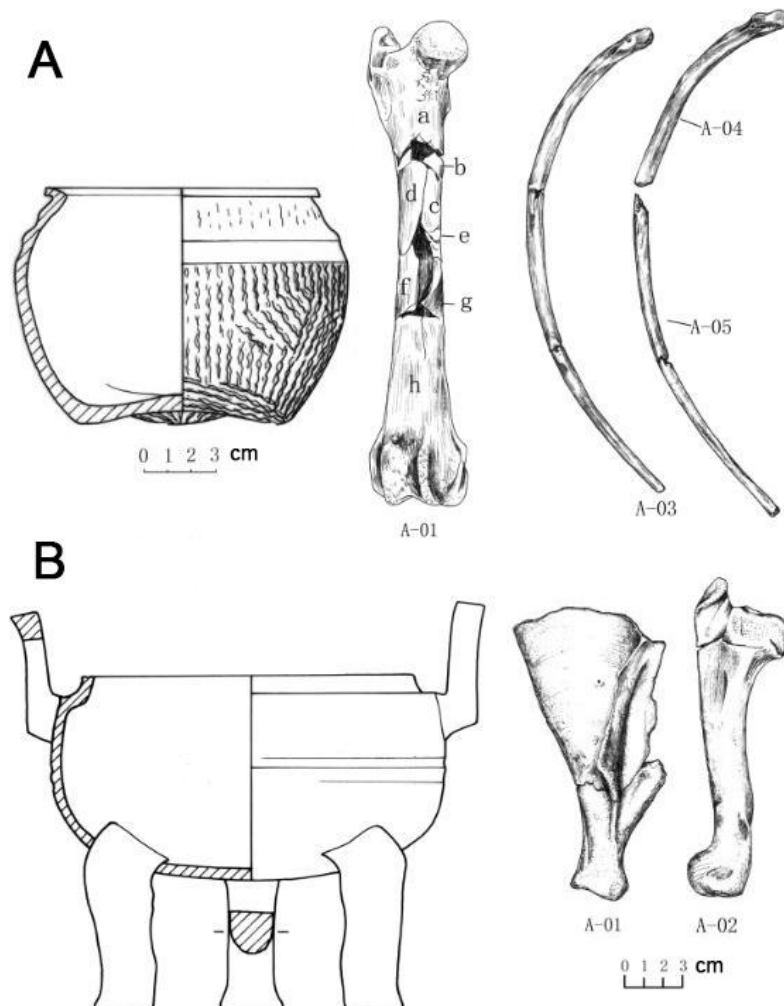


Figure 6-3-1. The two burial vessels with large adult pig bones and their corresponding sizes in Shuanglou Cemetery of ZHGC. A. Burial M129:4 Pottery *Li* and pig femur (R) and ribs (L); B. Burial M242:1 Potter *Ding* and pig scapula (R) and humerus (R). (source from Cao & Wang 2016)

1.2 Sacrificial animal pit

Regarding the animal sacrifice pits, the species composition is relatively simple, mainly consisting of cattle and pigs, although there are variations in the quantity and completeness of the skeletons across different pits. Overall, cattle appear to hold a higher status than pigs, as evidenced by the two large central sacrificial pits where cattle dominate.

Additionally, in a previously published report on the Bank of China sacrificial site, a sacrificial pit containing an entire horse was discovered south of building foundation F4 (Luo et al. 2006). In summary, cattle, pigs, and horses would all be used for the entire-skeleton sacrifice for the major events like construction of large-scale projects, and among them cattle are of the most significance. In this process, the preference for employing younger individuals was also represented, such as the calves used in DK3 and DK6 in this study.

2. Roles of animals for ritual sacrifice

2.1 Domestic cattle

Domestic cattle, introduced in China during the late Neolithic period, began to be used in sacrificial rituals. For instance, complete cattle pits were found from the Pingliangtai site (4500-4000 BP) (Yuan 2015:97); and the most remarkable discovery was made at the Shantaisi site (4500-4000 BP), where nine complete cattle skeletons were found neatly arranged in a sacrificial pit (see **Figure 6-3-2**), located about 30 meters south of a house foundation (Zhang & Zhang 1997).



Figure 6-3-2. Cattle skeletons found from H39 at the Shantaisi site in Zhecheng, Henan, which was thought as a sacrificial event. However, in my view, the possibility of mass death of plague cannot be omitted (source from Zhang & Zhang 1997: appendix figure 2).

The use of cattle as a symbol of social rank can be traced back to the Yinxu period (1250-1046 BCE), where cattle were commonly found in Grade II burials but rarely in Grade III burials (Liu et al. 2020). This idea of attributing social value to domestic cattle became even more explicit during the Eastern Zhou period. According to the *Yili* (Book of Etiquette and Ceremonial), the Zhou king can use nine bronze *ding* vessels containing animals such as cattle, sheep/goat, pigs, and fish for sacrifices, while senior officials were limited to five bronze *ding* without the use of cattle, only sheep/goat, pigs, and fish (Ruan, 1980: 1059–60; Yu & Gao, 1978). Domestic cattle were, therefore, the primary and most important offering in the highest form of sacrificial ceremony, known as “*tai-lao*” (the grandest sacrifice), performed by the king. The term “牺牲” (sacrifice) in hieroglyphic Chinese also reflects the importance of cattle, as both characters derive from the radical of “cattle” on the left, with 牲 originally referring to cattle used in rituals (Shuowen Jiezi: Cow Section, 100CE).



Figure 6-3-3. This shows five bronze *ding* containing animal bones from M11 at the Hejiabei site during West Zhou, where in total seven *ding* were found, indicating this burial belonged to a duke or equivalent level noble (source from Liu et al. 2020: Fig.6).

At several FDC burials in our study, no evidence of cattle was found, with pigs being the primary offerings, indicating that these Spring and Autumn period burials belonged to individuals of lower rank noble. In contrast, the presence of numerous cattle in sacrificial pits next to the EGJ foundation suggests that these pits served very high-ranking structures, possibly commissioned by the highest ruling authority in the city.

Additionally, cattle were highly valued for their practical use as a significant source of meat, making them the most common animal for high-level consumption. Thus, in comparison to horses, cattle were more frequently used in sacrificial contexts. This is due to the fact that cattle could not only be offered as meat in vessels placed in tombs for the deceased, they also could be buried whole as offerings to ancestors and deities. This dual role highlights both the nutritional and spiritual value of cattle, reflecting their importance in both daily sustenance and ritual practices.

2.2 Domestic sheep and pig

The sheep appeared in two burial instances, both involving certain anatomical parts with more meat, clearly intended as food offerings. According to Zhou ritual regulations, sheep were categorized as "*shao-lao*" (the second grand sacrifice), second only to cattle in importance among sacrificial animals for meat. Although over time, the strictness of ritual practices became gradually looser, especially during the Warring States period, and the use of sheep as sacrificial offerings became more flexible, the symbolic significance of sheep in rituals persisted. Their presence in burials still suggests that the deceased likely held a certain level of social status.

Pigs were the most common sacrificial animals. As one of the earliest domesticated animals raised for meat, domestic pigs were widely used in ritual sacrifices across China, becoming the most prevalent burial and sacrificial animal during the Neolithic period (Yuan 2015). The ritual use of pigs in the Neolithic era was not limited to whole pig sacrifices in

pits but also included the interment of whole pigs, pig skulls, jaws, and canine teeth within graves (Yuan 2015: 188–216). Scholars have differing interpretations of these practices. Some argue that burying pig skulls or jaws symbolized personal wealth, indicating the emergence of private ownership in prehistory (Tong 1975; Shan & Shi 1976; Wang 1996; Yuan 2015:216). Others link it to primitive religious beliefs, suggesting that these offerings were used to ward off evil spirits and protect the soul of the deceased (Wang 1981; Harunari 1993).

By the Bronze Age, with the introduction of cattle and sheep, pigs had largely lost their symbolic association with privilege and just kept the role as the most common and basic source of meat. In the burials of ZHGC, pigs were found exclusively in food containers, intended to provide offerings for the deceased in the afterlife. During this period, pigs primarily served as supplementary offerings to the more prestigious animals such as cattle and sheep.

2.3 Dog and horse

The reason for grouping dogs and horses together is that, unlike the other three animals, they were generally not used as food. This resulted in their usage and the symbolism they represented being distinct from those of other animals. Dogs and horses were more often regarded as companions or pets, reflecting their role as sacrifices in a spiritual rather than nutritional context. Therefore, in burial contexts, they were never placed in food vessels as offerings like pigs but were always interred whole.

Warhorses, in particular, epitomized the two most significant affairs of the state—war and sacrifice. Therefore, using horses for sacrifice, symbolized both warfare and ritual, making them a perfect representation of the highest state power. This is also why no chariot-horse pits or similar remains were found in our study materials, as such pits typically appeared only in the tombs of high-ranking nobles or kings. According to incomplete

statistics, at several high-ranking aristocratic cemeteries within ZHGC, such as the Houduanwan complex in the southern part of the city, the Spring and Autumn aristocratic cemetery at Cangcheng, and several royal tombs outside the city, 205 chariot pits have been discovered, yielding over 1,135 horse skeletons (Gu 2023). Furthermore, there are also cases where horses and dogs were found together. In some chariot pits in the Houduanwan complex, dogs were buried alongside horses, likely attempting to recreate scenes of the king's hunting expeditions during his lifetime (**Figure 6-3-4**).

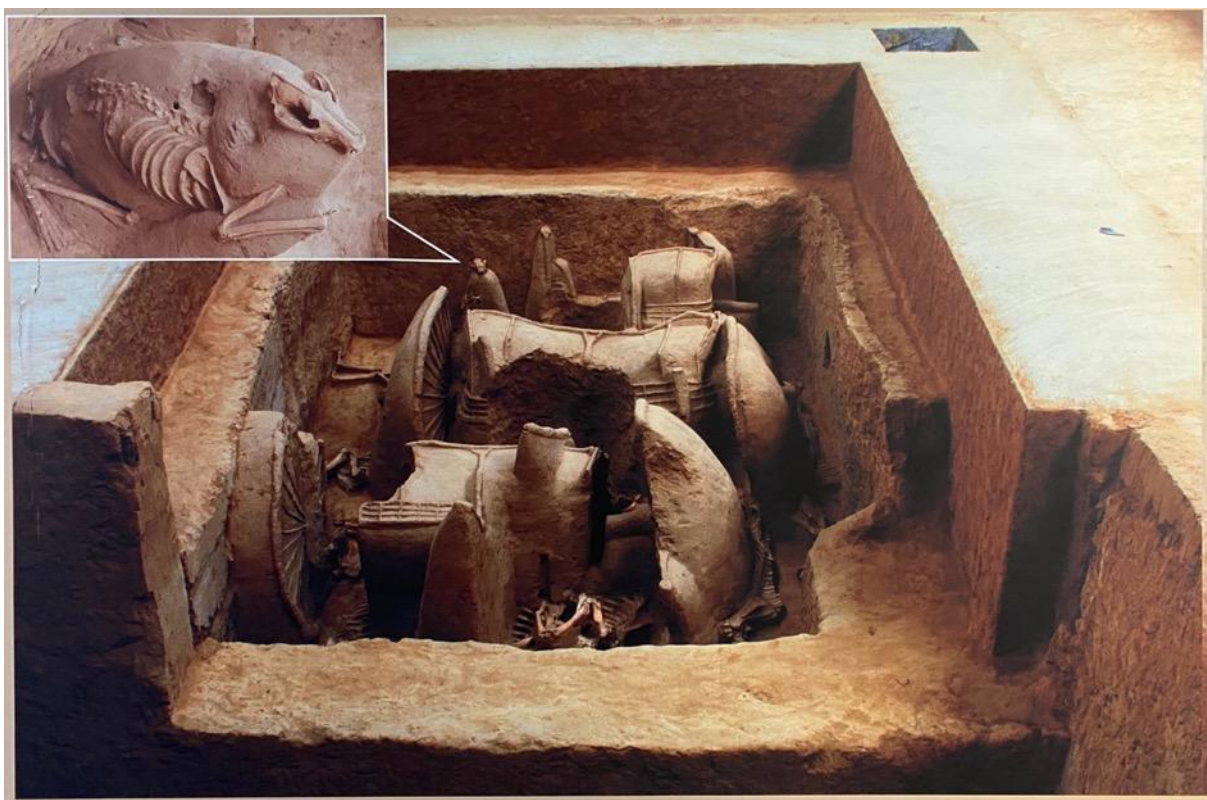


Figure 6-3-4. The sacrificial dog in the horse-chariot pit in Houduanwan complex (source from the illustration in the ZHGC museum exhibition, photo taken by the author).

In addition to not being consumed, dogs in sacrificial contexts exhibit a more personal and intimate role. The Zhou people had a strong affinity for hunting, and hounds were an essential part of these activities. Through long periods of working together, a deep bond and mutual understanding would develop between the dog and its owner, making the dog a treasured companion. Dogs were frequently buried in close proximity to their owners, beneath the waist, symbolizing the owner's practice of bringing the dog along during hunting

expeditions. The presence of waist-pits is widely regarded by scholars as a reflection of the burial owner's engagement in hunting during their lifetime and the aim of “treating death like life” (Yang 2004; Liu 2011; Guo 2014; Chen 2023). From the cases examined in this study, the presence of dogs in burials did not appear to be closely tied to the social rank or status of the deceased. Dogs were found both in small aristocratic graves (FDC burials) and in large royal tombs (according to published materials), suggesting that the inclusion of dogs in the waist-pits of the burials primarily reflects the personal relationship between the owner and the dog, rather than serving as a marker of wealth or social standing.

CHAPTER 7 Animals as Handicrafts

In the eastern sector of the city, among numerous handicraft industrial areas, there was a specialized workshop for making bone tools and objects. This indicated that the use of animal bones as raw materials for manufacturing various tools and everyday items had become essential part of the residents' urban life. Moreover, these bone-making practices likely had established complete and systematic operational procedures, operated at some scale, and evolved into a standardized and specialized production. The archaeological materials unearthed from this worked bone workshop were quite impressive. There was a large number of finished, semi-finished, and defective products of bone artifacts, including beads, rings, coins, figures, and needles, among which bone beads were the most predominant (**Figure 7-0-1**). Currently, these materials are under systematic study by archaeologists from the Henan Provincial Institute of Cultural Relics and Archaeology (*pers. comm.*)

In the assemblage studied here, some worked bone specimens related to handicraft production have also been discovered in various other locations. The artificial processing traces on these bones provided valuable clues for reconstructing the handicraft industry during the Eastern Zhou. In this chapter, I will analyze and study these worked bones in terms of their spatial and contextual distribution, raw material, and process flow, and then to explore the close links and interaction among handicraft industries.



Figure 7-0-1. Portfolio of bone artifacts from the bone-working workshop in ZHGC (image source from *pers. comm.* Hou).

Section 1 Spatial and contextual distribution

The number of specimens related to bone working practices in this set of materials is not very large, totaling 245 pieces, which accounts for approximately 2.69% of the total number of specimens from ZHGC. Since complete bone artifacts were collected separately during the excavation and were not included in this study, the specimens analyzed below were all raw materials, waste materials, and semi-finished or defective products related to bone working.

Firstly, the distribution of these specimens was statistically analyzed in **Table 7-1-1**. Sub table (a) and (b) represent the site (location) and feature distribution respectively.

Table 7-1-1.
(a) Site distribution of worked bones.

Site	GXS	JFQ	FDC	YC	RDC	JSY	JCL	ZT
n	69	10	1	39	5	28	14	79
%	28.16	4.08	0.41	15.92	2.04	11.43	5.71	32.24
Self %	2.06	0.74	0.57	5.10	0.91	2.13	0.85	75.96

Note: “%” stands for the proportion of worked bones from each site relative to the total number of worked bones of ZHGC. “Self %” stands for the proportion of worked bones relative to the total number of faunal remains at each site, in order to assess the abundance of worked bones of each site.

(b) Feature distribution of worked bones.

Features	Layers	Ash pits	Wells	Burial	Trench
n	52	87	102 (J14:70)	2	2
%	21.22	35.51	41.63	0.82	0.82

Overall, worked bones remains were found from eight out of twelve sites. Based on **Table 7-1-1(a)**, ZT (bronze-casting site), GXS, and YC are the three sites where most worked bones were unearthed. Although the absolute numbers of worked bones at GXS and YC sites are considerable, their relative proportions (self %) are quite small (2.06% and 5.10% respectively) due to the large overall quantities of animal remains at these two sites, indicating that worked bones appeared only sporadically. In contrast, the ZT site showed a completely different scenario. The abundance of worked bones at the ZT site reached 76%,

indicating that worked bones were very common here and this site might be closely related to the bone-working industry.

Regarding the feature distribution shown in **Table 7-1-1-(b)**, it can be observed that the overwhelming majority of worked bones came from layers, ash pits, and wells, which are considered mundane archaeological contexts associated with routine life.

Section 2 Material source

By analyzing the sources of these specimens related to bone working, we can gain a better understanding of bone crafting methods and procedures.

From a taxonomic perspective (**Table 7-2-1**), at least about 58% of the specimens originate from large mammals, including cattle, horses, and large-sized deer. Among these, cattle bones are the primary source of raw material for bone working, accounting for 27.35% of the total. Specimens categorized as "unknown" are typically those finely processed bone materials or semi-finished products that have lost identifiable taxonomic characteristics, making it impossible to determine their specific animal origin.

Table 7-2-1.
Taxa source of worked bones.

Taxa	Mollusk	Cattle	Horse	Deer	Caprine	L. M.	M. M.	Unknown
n	1	67	18	18	7	57	17	60
%	0.41	27.35	7.35	7.35	2.86	23.27	6.94	24.49

Note: "L. M." abbreviates for "large-sized mammals", and "M. M." stands for "medium-sized mammals".

From the perspective of anatomical element distribution, the majority of the worked bones originated from the limb bones of mammals (**Table 7-2-2** and **Figure 7-2-1-A**). Limb bones and limb fragments together accounted for about 60% of all specimens (n=147). Among the limb bones, metapodials (n=38, 15.51%) and ulna/radius (n=36, 14.69%) are predominant, followed by femur and tibia. These bones typically exhibit straight, long, and smooth characteristics (compared to the humerus) and have strong diaphyses (compared to the scapula). Given the flourishing bone bead manufacturing in the ZHGC, a portion of these bones were very likely residues from bead production or something long and slim, like hairpins and needles.

Furthermore, antler and horn remain also form a notable proportion among the elements. Based on experience, ribs were very likely used for producing bone spatula, which were thought to have been used as spoons (Wang 1990).

More specifically, the element distributions for each species are illustrated in **Figure 7-2-1-B**. The compositions of cattle and horse bones were more complex, with ulna/radius and metapodials being dominant, both accounting for over 60%. Although cattle provided horns, their proportion was not as high compared to long bones. By contrast, deer and caprines show a much simpler proportion, consisting exclusively of antler/horn and metapodials, where the proportion of antler/horn is predominant (83.33% and 71.43%, respectively).

In summary, we can conclude that domestic cattle were the primary source of bone material among species. Deer and sheep mainly contributed to the bone-working industry by providing antler and horn material, whereas cattle and horses contributed more tough long bones.

Table 7-2-2.
Element distribution of overall worked bones.

Element	Skull+ antler/horn	Mandible	Scapula	Humerus	Ulna/radius	Femur	Tibia
n	23	3	1	5	36	10	10
%	9.39	1.22	0.41	2.04	14.69	4.08	4.08
Element	Metapodial	Foot	Rib	Limb fragment	Unknown	Shell	
n	38	2	9	47	60	1	
%	15.51	0.82	3.67	19.18	24.49	0.41	

Note: (1) Metapodial includes metacarpal and metatarsal, sometimes these two were not distinguished, especially for the situation when only the distal parts existed. (2) For adult herbivores, ulna and radius were usually fused, thus, these two were combined here. (3) “Foot” bones include the tip bones such as astragalus and phalanx.

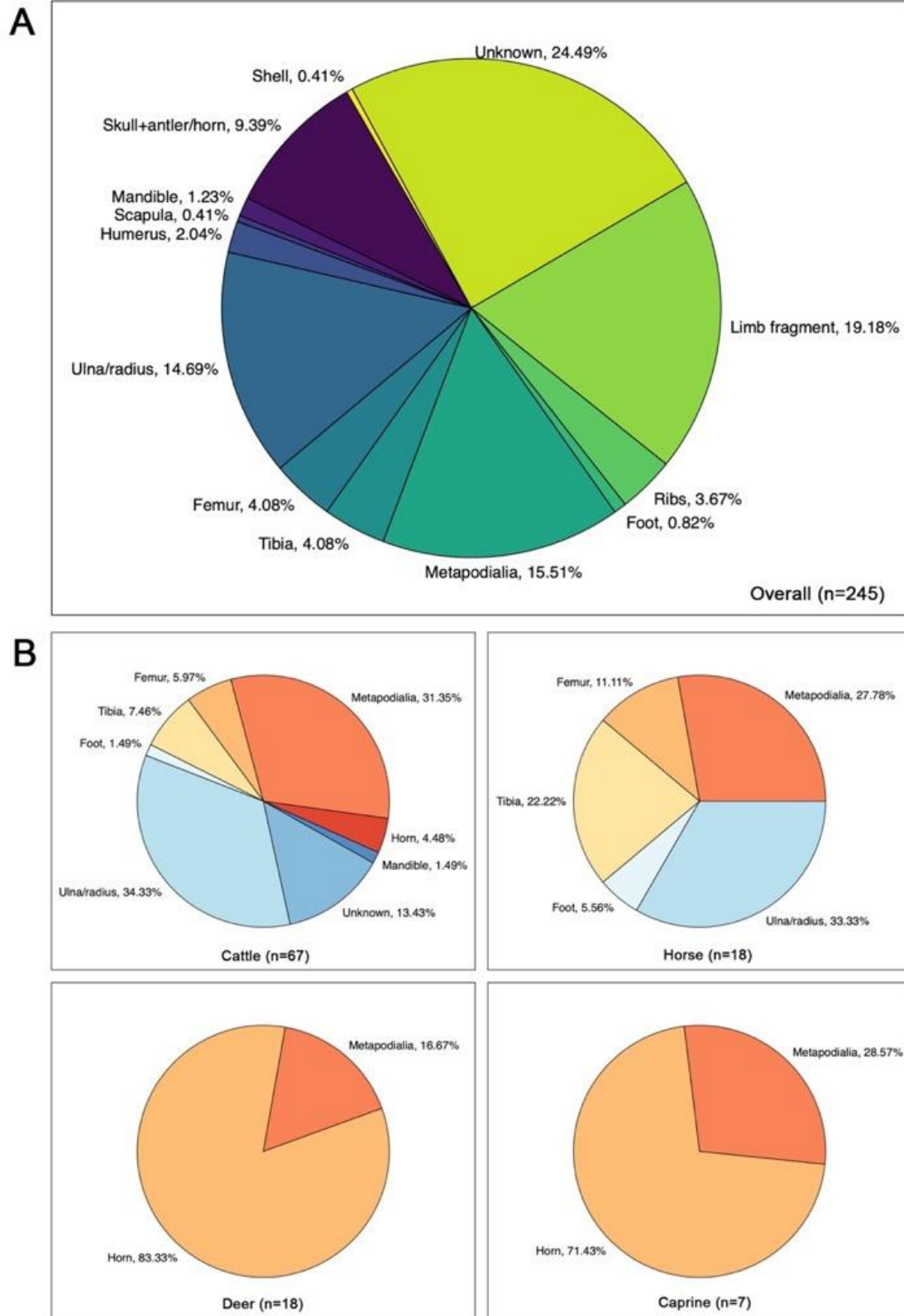


Figure 7-2-1. Illustration of the element distribution of ZHGC worked bones in terms of (A) the overall assemblage and (B) four major species including cattle, horse, deer, and caprine.

Section 3 Workflow

1. Classification

Based on their functions and properties, the 245 specimens can be categorized into the following stages:

a. Raw material. A total of 78 specimens were found, including 64 bones and 13 antlers/horns. In archaeological materials, defining raw material based on the action of "selection" alone makes it difficult to distinguish whether a particular bone was chosen as raw material for bone-working or merely as consumption residue, because there are no indicative marks such as sawing marks. Some certain special contexts, such as the large-scale accumulation of antlers/horns and long bones in a bone-working workshop, with distribution showing clear selection patterns (e.g., the mass bone-working industry at Yuntang bone-working locus in Zhouyuan [Zhao 2017]), can provide clues. Additionally, based on ethnographic materials from the *Li* ethnic group in Hainan, China, people would wash and scrub the bones before making bone tools. After selecting suitable raw materials, they soak them in water and expose them to sunlight for fermentation. This process aims to accelerate the decomposition of meat and tendons on the bones, making them easier to scrape off (Song 1994). Such preprocessing of bone materials also results in the accumulation of a large number of raw materials. However, these kinds of contexts were not found in ZHGC. Therefore, in this study, these “primary” raw materials (those that merely were selected to distinguish from other residues) was not listed as a separate category. In other words, every bone could potentially be this kind of “primary” raw material. In the classification, raw materials are those that exhibit clear signs of artificial traces.



Figure 7-3-1. Raw material of cattle horn with simple trimming (JCL H876, Western Zhou).

b. Blank. A total of 74 specimens were found, including 59 processed bone materials that could have been used as carving tools (from ZT J14, detailed in the following part). Blank materials were those specimens that were further processed from raw materials into more regular-shape blanks.



Figure 7-3-2. Portfolio of blanks. A. Triangular wedge-shaped slices (cattle, GXS T241 H945, I); B. Antler slice (Père David's deer, GXS T230 J143, VI-2); C. Metatarsal slice (cattle, FDC H609, V -2); D. Ulna/radius slices (cattle, JCL H876, Western Zhou).

c. Finished or semi-finished products. A total of 6 specimens were recognized, including one bone awl (**Figure 7-3-3-B**), one bone spatula (**Figure 7-3-3-C**), one likely shell knife (**Figure 7-3-3-D**), two antler tools, and one function-unidentified semi-finished product (**Figure 7-3-3-A**). In fact, apart from the bone awl, the others are not strictly defined finished products, as they are quite rough and only show preliminary shapes of tools. However, because some exhibit signs of use, they are classified together in this category.



Figure 7-3-3. Portfolio of finished or semi-finished products. A. Semi-finished product (JSY T54 J2, I); B. Finished bone awl (JSY T54 J2, I); C. Bone dagger (cattle rib, GXS T236 H947, II); D. Shell knife with using traces (GXS T231 ©, II).

d. Waste material. A total of 88 specimens, typically are epiphyses of long bones (Figure 7-3-4-A) or root part of antlers (Figure 7-3-4-B) that were cut or sawed off and discarded during the extraction process of raw materials.



Figure 7-3-4. Waste materials. A. Epiphyses of long bones (horse, T241 H945, I); B. Antler burr (sika deer, GXS T230 ③; I).

2. Traces and tools

Artificial traces on bones are the key to bone working research. Different traces conceal clues about the tools used and the production techniques. Details including the shape, impact point, direction, depth, length, and angle, can provide valuable information for reconstructing the methods and techniques of bone tool processing. The various types of traces will be enumerated in the following, and the possible tools used will also be discussed.

2.1 Sawing

The most common marks are sawing marks, which usually occurred when extracting raw materials from long bones and horns/antlers, or when slicing. Sawing marks accounted for about 30% of artificial marks. They were usually made near the epiphysis of the bone during the early stage of bone working. When sawing, the cutting edge of the tool moves back and forth perpendicular to the surface of the bone, with both sides of the edge contacting the bone. The notches are narrow and deep, and sawn faces are smooth, often showing

numerous fine parallel lines from the back-and-forth motion of metal saws. There were three types of sawing directions shown from the assemblage:

1. Single-direction sawing: saw straight through (the middle two sawn faces in **Figure 7-3-5-A**) or break it off near the bottom after sawing the most (the upper two sawn faces in **Figure 7-3-5-A**).
2. Opposite-direction sawing: this will leave two platforms due to misalignment (the bottom-left sawn face in **Figure 7-3-5-A**).
3. Multi-directional and ring sawing: This will leave a circular sawing mark (**Figure 7-3-5-B**) or multiple platforms (proximal end in **Figure 7-3-5-C**).

By examining the characteristics of these marks, it is possible to infer the tools used for sawing. Based on my previous experimental archaeology study, if the sawn surface is more glazing and the notch is V-shaped, it is generally considered that a long, straight-edged tool (such as a shell knife or a copper knife) was used. If the sawn surface shows dense parallel lines and the notch is flat-bottomed (**Figure 7-3-5-D**), it indicates the use of a serrated tool like copper saw.



Figure 7-3-5. Images showing sawing marks on the raw materials and blanks. A. Three antler materials with sawing marks of single-direction and opposite-direction (GXS T232 H884, VI-1); B. Sheep horns with ring-sawing marks (JFQ T195 H760, V); C. Metatarsal of cattle with both ends sawed off, the proximal end showing multi-direction sawing marks (GXS T231 H917, III-2); D. Triangular wedge-shaped slice showing the notch shape of the copper saw used (the second piece of Figure 5-2-4-A, GXS T241 H945, I).

2.2 Chopping

Although chopping marks accounted for approximately 32% of the overall artificial traces, a vast majority of them were related to the dismembering rather than bone working. For worked bones, chop marks generally appeared during the rough material-extraction stage. Antlers were chopped at the base, and when the chopping groove reached a certain depth, the material was then broken off to economize labour. Based on observation, chop marks usually

appeared disorganized, with varying lengths, depths, and angles, without regard for the integrity of the bone material. Chopping was usually done at an angle, typically forming an acute angle with the surface of the bone or antler.

From the characteristics of the chop marks on the specimens, which have flat bottoms and smooth sides, it can be inferred that the tools used had thick, heavy, and straight-edged blades, such as axes or large chopping knives. Due to the layered structure of long bones, they tend to fracture uncontrollably in a longitudinal direction under sudden external force, which is why chop marks are generally not found on long bones.



Figure 7-3-6. Waste material of an antler specimen attached to the skull, showing chopping trace at the antler base (Père David's deer, JFQ T208 ⑦, II). It can be seen that the first attempt at chopping at the antler base was then abandoned.

2.3 Grinding

Grinding marks were mostly seen on ready blanks and semi-finished products. These marks appear as a set of nearly parallel fine scraping lines, resulting from the reciprocal

straight-line grinding between the abrasive tool and the bones (see the cylindrical part in **Figure 7-3-3-A**). The tool used might be gang saws.

2.4 Scraping and perforation

Scraping marks were mostly seen on deer antlers and cattle horns. These marks were primarily intended to smooth knobby/rugged surface of antlers/horns, which is a kind of further trimming and modification of the raw material (**Figure 7-3-7**).

Perforation marks were also found on the specimen in **Figure 7-3-7**, which was a deer antler tool. It was the only one with such a perforation. The cancellous bone inside the antler material was hollowed out. Additionally, there was a rectangular perforation that runs horizontally through the antler. This artifact might have functioned as a tenon-like component. Observations suggested that this hollowing was achieved by drilling from both ends. The tools used for hollowing and perforation were likely sharp small knives.



Figure 7-3-7. Antler tool with rectangular piercing marks (GXS T230 H891, VI-1)

2.5 Polishing

Polishing marks usually appeared on the semi-finished or finished products in the final stage of bone production. These marks were characterized by a smooth, shiny surface (see the bone awl in **Figure 7-3-3-B**). The tools used for polishing might be grindstones for rough polishing, and soft organic materials such as fur or cloth for the final polishing. It is important to note that some marks that resulted from manual using or the behaviours of deer rubbing their antlers against trees can also make some surfaces smooth. Caution and recognition are required to distinguish resulting marks of these practices from intentional polishing during the production process.

2.6 Combined and unknown

Of course, as with many of the worked bones mentioned above, many specimens retained different marks, which are the composite result of multi-activities (**Figure 7-3-8**).



Figure 7-3-8. Illustration of compound traces of sawing, scraping, polishing on an antler raw material (Père David's deer, RDC T512④)

Furthermore, there is one complex and enigmatic specimen from site JSY. It is a square bone plate for the extraction of square pieces of bone (**Figure 7-3-9**). It was thought to come from the flat part of a skull (as indicated by the sutures on the left side). The method seemed to involve first sawing out a regular shape, then grinding the uneven surface smooth, and finally cutting small square bone pieces uniformly from the bone plate. The specific method of square extraction remains unclear, and the fracture on the right side suggested that the squares did not fully penetrate, which is somewhat perplexing. I am sharing this in the hope of obtaining more clues and insights.



Figure 7-3-9. The bone plate is neatly covered with square extraction marks, with the edges sawn and surfaces ground smooth. Canine gnawing marks were left on the back side after the bone plate was discarded (JSY T41 H18, V -1).

3. Preliminary reconstruction of the process flow

Based on the classification of bone/antler/horn materials and artifacts, the identification of the processing stages, the recognition of processing marks, and the possible tools used, along with previous archaeological research findings (e.g. Chen & Li 2016; Li et al. 2011; Ma 2010, 2018; Xu et al. 2021), we can roughly reconstruct the general processing

workflow. Given the large number of bone beads unearthed at the site, I will take bone beads as an example utilizing specimens excavated from the site to illustrate the processing flow of bone working, as shown in **Figure 7-3-10**.

First is the selection of materials, specifically for the primary raw materials. Strategies were adopted to select the most time- and material-efficient elements based on the shape characteristics of the target artifacts. The production of bone beads requires dense, hard parts of the bone, making the long bones (especially metacarpals and metatarsals) of domestic cattle an excellent choice. Most primary raw materials likely came from the remains of consumed animals, with a few wild deer antlers possibly collected from the wild.

Next is the preparation of materials, referring to the pre-treatment of raw materials. After obtaining suitable bones, they might be repeatedly soaked and sun-dried to accelerate the cleaning and degreasing process (Song 1994). For large or connected raw materials, methods such as sawing, chopping, and smashing would be used for segmentation and disassembly. Specifically for making bone beads, both epiphyses of metapodials were neatly sawn off, leaving only the diaphysis. This would generate a large amount of waste, and most of the waste materials found at the site came from this stage.

Following this, the raw materials would be shaped into billets of specific forms or sizes. Some scholars have summarized that the process of cutting rough billets adhered to the principle of “taking based on shape, saving time and labor” (Li et al. 2011). Using wedging and sawing methods, the bones were divided into slices, and further segmented as needed. The bone slices were then trimmed using scraping or grinding methods to obtain blanks. As shown in the figure, to prepare the cylindrical or near-cylindrical shapes required for making bone beads or coins, the billets were ground accordingly. Although no related remains have been found, it is hypothesized that the shaped bone materials would then be further sawn into short cylindrical segments to get semi-finished products.

Finally, drilling, carving, and other decorative procedures would be applied, followed by polishing with materials like fur to achieve the finished products.

Due to the limitations of the available materials, we have a relatively small number of worked bones, resulting in some gaps in the reconstructed processing workflow, especially in the stages from semi-finished to finished products. The specimens illustrated in the workflow may not necessarily be the remnants of bead-making. The workflow's completeness requires more supplementary materials for refinement in the future. However, overall, the bone tool production chain appears to be closed loop. With just around 200 specimens (1/3 are waste materials), we can reconstruct an approximation of the entire manufacturing process.

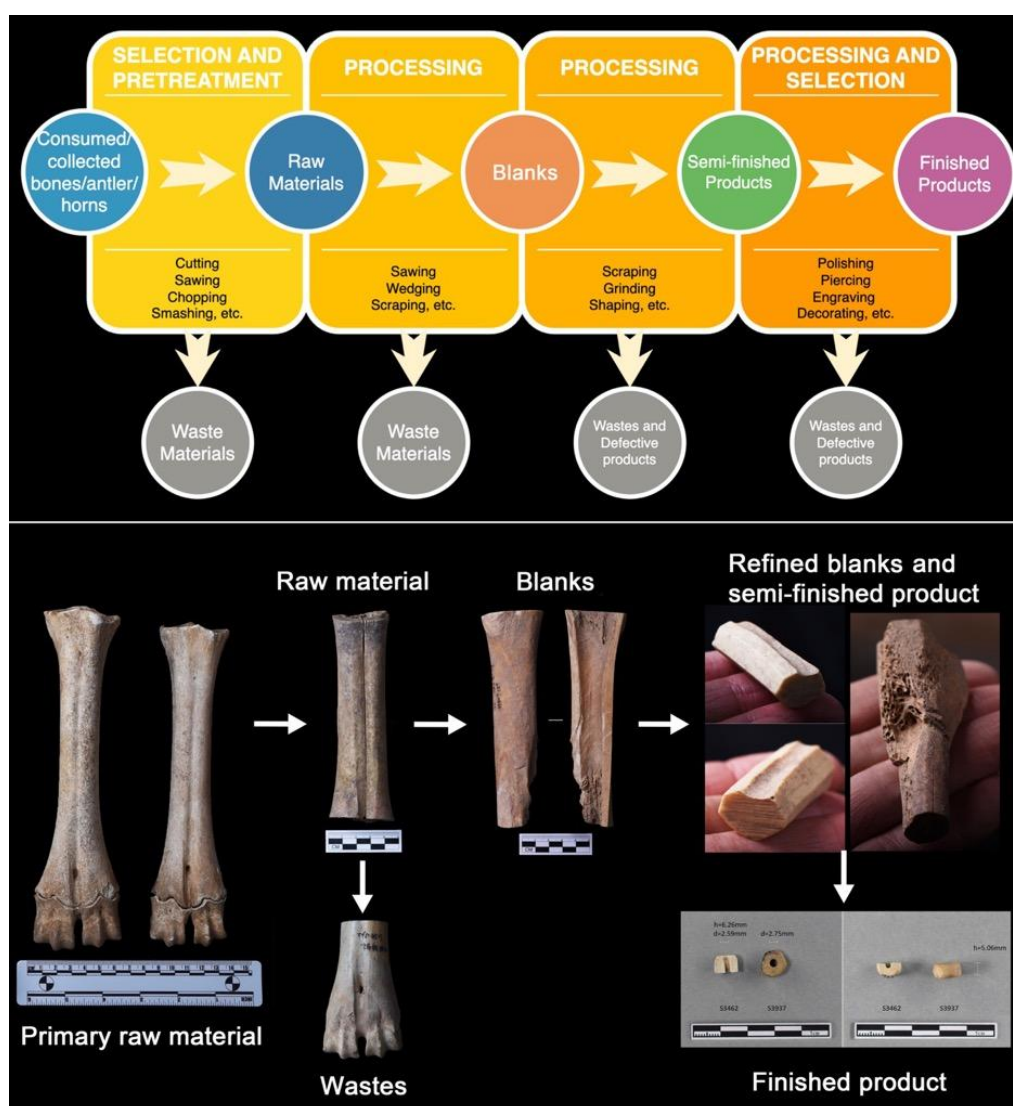


Figure 7-3-10. Diagram of the general workflow of bone working and the reconstruction of the process flow of beads based on the real specimens in ZHGC.

Section 4 Related to other industries

Although there are no materials from bone-working workshops, faunal remains from another handicraft workshop in the eastern part of the city— a bronze casting workshop (ZT site) are available. This is a very special location. Although the number of unearthed animal bones was small, with only 103 bone specimens, apart from one loose mandibular tooth of cattle, the rest were either raw materials and waste products with processing marks (79/103, some specimens can be seen in **Figure 7-4-1**) or remains related to handicraft production (23/103).



Figure 7-4-1. Waste products from bone working excavated from ZT site. 1. Distal metacarpal (cattle, T4 ④, V-1); 2. Distal metacarpal (cattle, T2 H4, V-1); 3. Distal metacarpal (cattle, T4 ④, V-1); 4. Distal metatarsal (cattle, T4 ④, V-1).

Among them, the feature J14 (a well) is particularly noteworthy. A total of 93 specimens were unearthed, all of which were stained green resulting from contact with copper. 24 pieces that could be identified to species were selected out first (see **Figure 7-4-2**), including 3 dog specimens (two lower incisors, one lower M1), 11 pig specimens (all loose incisors and canines), 2 herbivore lower incisors, and 8 fish specimens (including 1 pharyngeal tooth of black carp and 7 ribs or fin bones of fish). Additionally, there were 11 limb bone fragments of medium-sized mammals and 3 unidentifiable fragments.

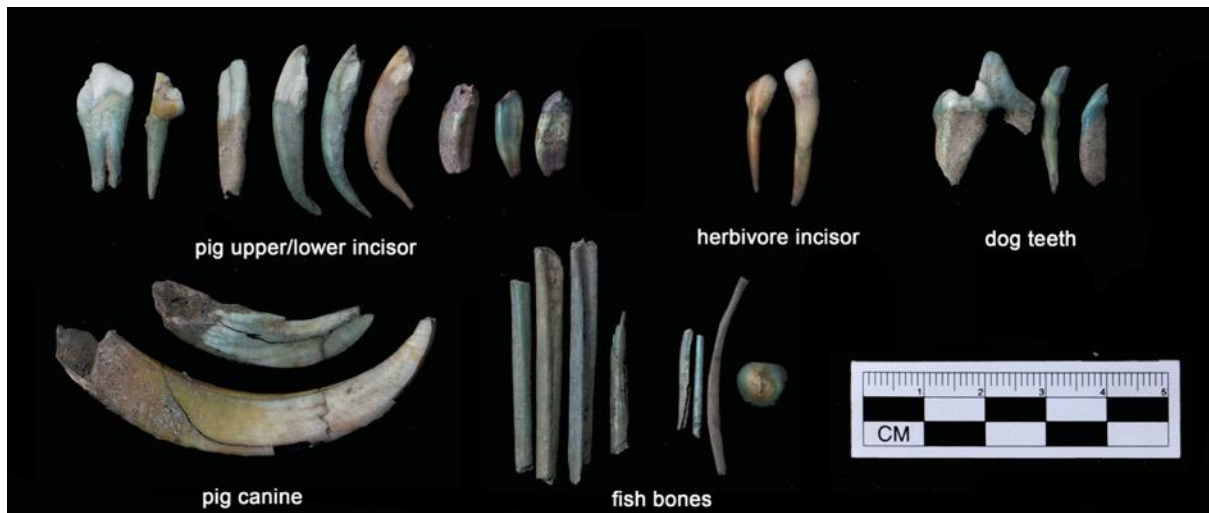


Figure 7-4-2. Portfolio of identifiable specimens from J14 at ZT site.

The remaining 55 finely processed bone materials were typologically classified based on their shapes into five types: Type I (thin cylinder) 2 pieces, Type II (thin triangular bone slices) 6 pieces, Type III (thin strip-shaped bone slices) 32 pieces, Type IV (thick strip-shaped bone slices) 13 pieces, and Type V (thick square/triangular bone slices) 2 pieces. All of them were artificially processed, some with clear grinding marks left on the smooth surface (**Figure 7-4-3**).

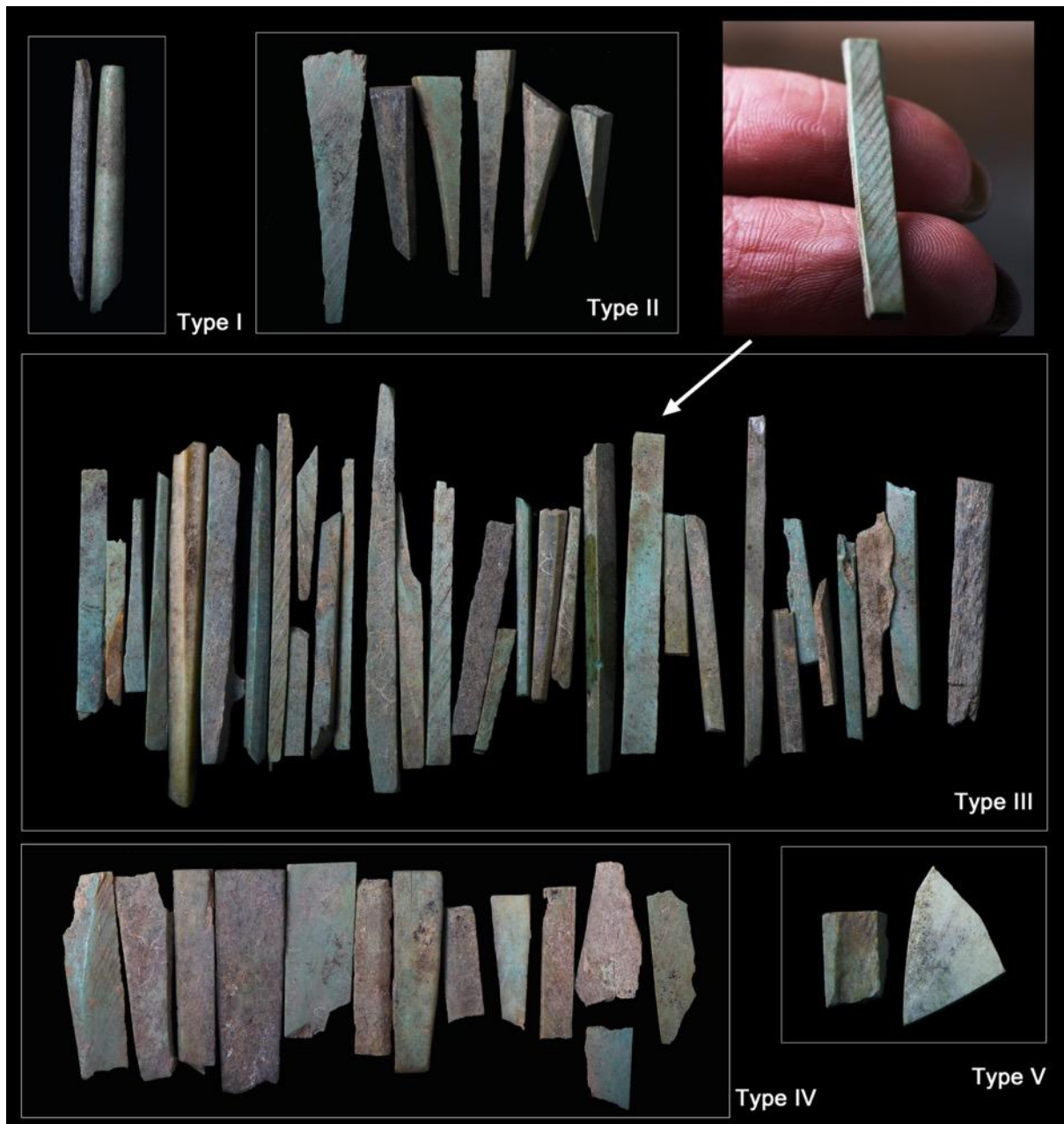


Figure 7-4-3. Portfolio of five types of bone slices from J14 at ZT site (see Figure 4-12-1 in the Chapter 4 for images with scale), and the fine grinding marks made by copper saw on them.

The specific purpose of this set of materials (worked bones) remains a perplexing question, but they share two prominent characteristics that help in solving the problem. Firstly, these specimens originated from the location of a bronze-casting workshop and have long been in contact with bronze objects during burial, resulting in being green-stained due to copper rust corrosion, indicating their likely connection to bronze production. Secondly, whether they were natural teeth, waste products, or bone slices with artificial traces, they

were almost all elongated and pointed, suggesting that these items of this shape were intentionally selected and served a special purpose.

Combining these two points, it is reasonable to infer that they were specifically chosen by craftsmen for carving patterns on the pottery moulds used for bronze casting. I argue that those finely processed bone slices might come from the elimination of the production rather than specifically be made for carving.

Section 5 Discussion and conclusion

The spatial distribution of worked bone remains exhibits two notable characteristics: one is the wide distributional range, with findings in eight out of twelve sites, although the quantity discovered at each site is relatively small; and the other one is that the contexts in which these artifacts were found are primarily associated with daily life, such as layers, ash pits, and wells, where the contents are generally a mix of scattered worked bones and other remains of daily consumption. This indicates that the bone handicraft practices likely took place within ordinary households. While specialized official bone tool workshops, possibly controlled by the elite, existed in the city and were responsible for most of the mass production and supply of products, meanwhile, small-scale household production also coexisted to meet the daily needs of ordinary people. This suggests a dual system of official and private production in the bone artifacts manufacturing industry.

However, whether these household-produced artifacts were for internal family use or intended for trade and circulation remains to be further explored with more evidence. Based on the currently available materials of low quality, it seems more likely that these tools were produced for self-sufficiency within the household.

In ZHGC, the raw materials used for bone production were primarily sourced from domestic cattle. The expansion of domesticated cattle numbers led to cattle bones becoming the primary source for bone artifact production, replacing the dominance of deer bones that had prevailed before the Shang Dynasty in the Central Plains (Li et al. 2011). Long bones of cattle (mainly metacarpals/metatarsals and ulna/radius, but also including tibias, femurs, and other parts) became the most selected materials, and cattle horns were also utilized. Similar strategies for bone material selection were found in many contemporary bone-working site during the Bronze Age (Ma et al. 2015).

During the Bronze Age, domestic cattle provided abundant high-quality materials for bone tool production. The emergence of bone workshops, along with the use of metal tools, led to the large-scale, specialized, standardized, and complex production of bone tools. From the burial goods in some published reports, it can be observed that the official level of worked bone production in ZHGC, both in terms of scale and craftsmanship, far exceeded what we have seen from the assemblage examined here. While the focus is often on large-scale professional workshops, the limitations of available materials allowed us to serendipitously discover the existence of small-scale family or individual production. Although this small-scale household production might not be standardized, not reaching the level of craft specialization (Costin 1991), it followed a socially recognized production method, effectively mimicking some standardized artisan techniques. This can be glimpsed from the use of similar processing tools and methods, as well as a consistent process of material selection, material extraction, rough processing, and fine processing with other specialized workshops (e.g. Li et al. 2010, 2011; Fu 2015; Chen & Li 2016; Zhao 2017; Ma 2018). From a technical perspective, although the production scale was small, the use of metal tools in bone working was quite evident. The application of metal tools such as copper saws in the household or individual production within ZHGC facilitated the expansion and democratization of technology in bone production. This not only greatly increased production efficiency but also provided the objective technical conditions necessary for the transition of bone artifact production from public to private spheres. It has been argued that the earliest application of copper saws in China appeared in the early Shang Dynasty around 1600 BC (Ma 2018).

Moreover, the application range of worked bones was extensive. They were used not only as agricultural tools and daily necessities (such as beads, hairpin and needles) but also intersected with other handicrafts as means of production. Copper tools were cast to produce

bone tools, which in turn were used to process copper artifacts. This intersection ingeniously reflects social complexity, indicating that production resources were fluid and sustainable within the society. For instance, the "engraving knives" found at the ZT site, even if defective or waste materials from bone tool production, could be sorted and appropriately utilized elsewhere. This fully demonstrates the internal fluidity and a coherent operational mechanism within this society. And this high reutilization rate of worked bones precisely reflects the characteristics of small-scale individual handicraft production (Ma et al. 2015; Ma 2018).

CHAPTER 8 Animals as Feasting

Feasting is ubiquitous in human society. It spans from weekly college formal dinners at Durham University to annual festivals (such as New Year's Eve, Spring Festival, Lantern Festival, Qingming Festival, Dragon Boat Festival, Mid-Autumn Festival in China). It encompasses life events from birth to death, including weddings, promotions, migration, harvest, religious feasts such as The Lord's Supper and Holy Communion, and more. Feasting truly permeates every facet of our lives.

In this process, meat consumption has always been the centrepiece of feasting. Therefore, exploring this social mechanism from the perspective of archaeology, especially zooarchaeology, is not only feasible but also essential. This chapter will summarize and clarify the theoretical framework of feasting and explore methods and attributes for identifying feasting rituals in archaeological remains, especially in faunal materials. This will provide a thorough and comprehensive theoretical foundation for the next chapter's exploration of feasting ritual remains at the ZHGC.

It's worth noting that studying feasting through faunal remains is a hot topic globally. However, in China, this field seems to have encountered a bottleneck in development, with significant gaps in available data. Therefore, based on a summary of current research on feasting in China, I will also attempt to analyse the reasons behind this phenomenon.

Section 1 Theoretical Framework of Feasting

1. What is feasting?

1.1 Definition of feasting

The process of defining feasting has witnessed a long and winding road since it attracted anthropologists' and archaeologists' attention. During the recent proliferation of feasting literature, it has been defined in various ways by different researchers (e.g., Bray, ed. 2003; Dietler 2001; Hayden 2001, 2014; Kirth 2001; Perodie 2001; Wiessner 2001; Hayden & Villeneuve 2011; Mills 2004; Twiss 2007a, 2008; Wiessner & Schiefenhövel 1996).

Some commonly cited definitions are like “forms of ritual activity that involve the communal consumption of food and drink” (Dietler 2001); “occasions consciously distinguished from everyday meals, often by a greater number of participants and more food and drink” (Twiss, 2008); “a larger-than-quotidian meal that often incorporates distinctive foods, labor-intensive modes of preparation, and special-purpose serving utensils” (Smith 2015); and “any sharing of special food (in quality, preparation, or quantity) by two or more people for a special (not every day) event” (Hayden 2001), which later was amended by Hayden (2014) as “any sharing between two or more people of a meal featuring some special foods or unusual quantities of foods (i.e., foods or quantities not generally served at daily meals) hosted for a special purpose or occasion”.

In my understanding, the definition of feasting can be categorized into two levels: a broad one and a narrow one. Broadly speaking, feasting is any communal non-daily food consumption. In a narrow sense, feasting incorporates more cultural symbols. It is prefixed with words like "ritual", involves the consumption of unusual (in quantity or type) food, utilizes special utensils, is organized for specific purposes or occasions as a group event. However, regardless of the broad or narrow definition, two factors are necessary conditions. Firstly, feasting must involve multiple individuals, i.e., two or more participants, as the

essence of feasting lies in the sharing of food, requiring interaction between different people. Regarding the feasting's scale, some researchers even proposed to exclude some small-sized social gathering meals, which was not supported by Hayden (2014) because he thinks such a definition would exclude most of our family meal for celebrating festivals like Thanksgiving and Christmas dinner. I totally agree with him on it. Additionally, it's hard to define below how many people can be called small-sized, but stubbornly fixating on this detail will bring the issue to an extremely boring direction. Secondly, feasting must distinguish itself from everyday meals in terms of food consumption behavior, although the dialectical relationship between these two is very subtle and it is frequently discussed by scholars (Douglas 1975; Twiss 2007a). In fact, these two necessary conditions often tend to imply and naturally lead to various cultural factors that happened in a narrow sense.

Therefore, drawing on previous research, in this paper, I would prefer to adopt the broad definition to describe feasting. Here, I define feasting as any sharing between two or more people of a meal that is consciously distinguished from everyday meals. The additional conditions in the narrow definition, I believe, are more meaningful in providing a general direction for identifying feasting in anthropology and archaeology.

In addition, I also want to mention several words that are always relevant to feasting when describing it. When reading the feasting literature, you will easily notice that the feasting word is always connected with the words like “lavish”, “prestige”, and “surplus”, etc. Ethnographically, feasting often focus on consuming “meat” rather than staple food (e.g., Dietler 1996). Although these won't be included in the definition, they can provide with valuable impression concerning feasting on us.

1.2 Classification of feasting

Besides definition, the classification of feasting is also a complicated question to settle. In recent times, feasts have varied greatly in scale, form, and symbolic significance.

The methods and thoughts the classification of feasts has varied depending on researchers' study purposes, individual interests, theoretical framework, background, and what questions they want to use the feast to settle. According to reintegrating the previous research of this issue, there are several reasonable categorization systems (**Figure 8-1-1**) as following:

1. The most straightforward and easiest way is to classify feasts in terms of the specific pretexts, which is also be called emic types by Hayden (2001), including funeral, marriages, births, harvests, house building, making war or ending war, ancestor worships, and so on.
2. In terms of size and scale, four categories of were proposed by Hayden (2001): minimally distinctive feasts, promotional or alliance feasts, competitive feasts, and tribute feasts. The minimally distinctive feasts consisted small-scale household (less than 10 people) or lineage events (10-50 people) involving under 50 people, with no special paraphernalia and the consumption of everyday foodstuffs. Promotional or alliance feasts were larger-scale lineage or clan affairs, usually involving special preparation and serving vessels, and perhaps temporary architectural facilities. Competitive feasts were similar to the foregoing but still larger in scale, with more prestige vessels and permanent specialized structures. Tribute feasts were the largest scale, typical of chiefdoms or early states, which were often held in honour of polity deities. Based on this, one more scale of feast, the invisible feasts, was suggested to be added into the category before minimally distinctive feasts. This is a kind of small-scale household or social events that we cannot find evident archaeological remains. Despite invisibility, we know they happened, and existed widespread. It is quite meaningful as it fills in a cognitive necessity when we make conceptual generalizations and classifications about feasts.

3. From the perspective of function, feasting can be categorized as hosting for alliance and cooperation, for economic benefits, or for status/power display. This approach mainly focused on what kind of practical purpose or benefits (underlying motives) that can be acquired from hosting feasts. It is proposed (2001) and refined (2014) by Hayden to focus on the relationship between feasts and community dynamics.
4. Classifying feasts according to calendrical or seasonal events like New year, solstices, *jieqi*¹⁶(Chinese solar term), versus life events like birth, marriage, and death, to which one could add political events, such as lineages, households, or communities.
5. Certain single function versus multiple functions, with the later one was commonly served (Clarke, 2001).
6. In the terms of sponsors of feasts, single individual/household sponsor versus multiple sponsors, or according to the social statuses of sponsors, including the leader, elites, community members, and guests.
7. Social relations involved in feasts, such as empowering/ entrepreneurial feasts, patron-role feasts, work feasts, and diacritical feasts (Dietler 2001).
8. Rowley-Conwy (2018) classified feasting from a much more narrow but more practical view, zooarchaeological remains, into four categories based on the archaeological attributes: over the top (OTT) feasts (high status); ritually charged garbage (RCG) feasts (often religious); small but special (SBS) feasts (nevertheless sometimes visible); and was this feasting? (WTF, referring ones that are equivocal).

Besides these, there were also classification standards concerning the long-term or immediate obtaining, obligatory return or not (Perodie 2001), archaeological signatures (Hayden 2001), social relationships between guest and host, and so on. Recently, with the

¹⁶ *Jieqi* (solar term) is any of twenty-four periods in traditional Chinese lunisolar calendars that matches a particular astronomical event or signifies some natural phenomenon. The points are spaced 15° apart along the ecliptic and are used by lunisolar calendars to stay synchronized with the seasons. It reflects the seasonal and climatic changes and has an indicative effect on the agricultural production process; thus, it is crucial for ancient agrarian societies.

creation of theoretical methodologies, the model involving dual dimensions of group size and level of sociopolitical competition was put forward by Kassabaum (2019) to conceptualize and categorize feasts.

No matter how it is classified, I believe the essence of feasting is complex, much like any social behaviors. We need to proceed with caution, avoiding the oversimplified dichotomy of feasting, especially when categorizing it from a functional perspective. Feasts simultaneously serve as arenas for competition between individuals, and arenas for social integration (Twiss 2008, 2015; Rowley-Conwy 2018). “One motive or another is often forefronted, but multiple functions are commonly served” (Twiss 2008:419).

When choosing the classification in the research, I cannot agree more on Hayden’s idea that “there are no ‘right’ classification, there is only more or less useful or insightful classification——classifications that are better or worse for answering specific questions or dealing with specific issues” (Hayden 2014). The only standard to judge the effectiveness of a categorization is to put it into the practice and to see if it can serve for our final topic and question.

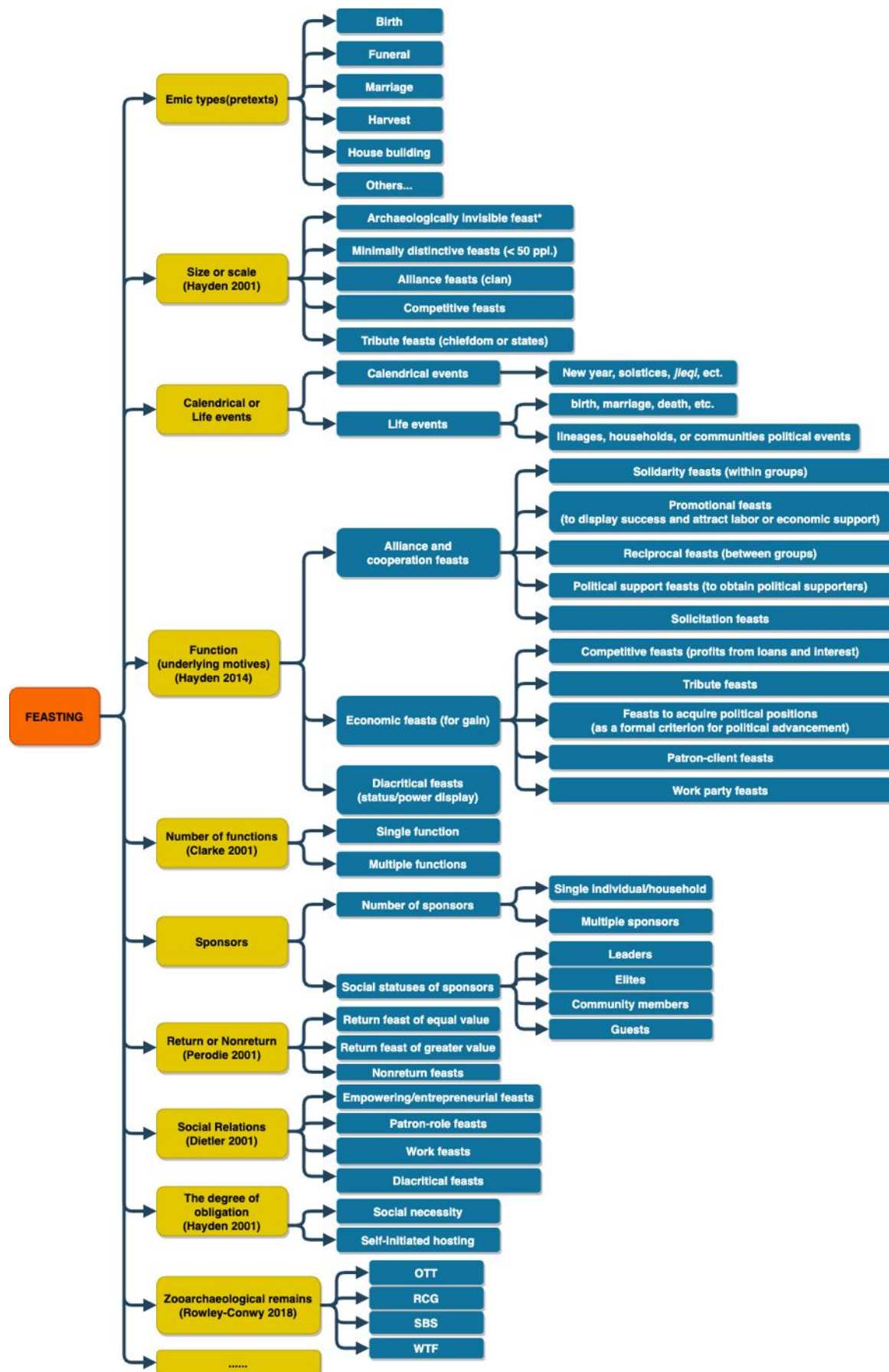


Figure 8-1-1. The diagram of several categorization methods of feasting.

2. How feasting happened?

This part briefly talks about how feasting originally happened and then how it evolved. It is commonly accepted that feasting derived from the behaviour of food-sharing among non-kin, and generally, feasting should also be regarded as a form of food sharing. Villeneuve (2014) introduced food sharing in terms of the inherent and genetic nature and instinct of sharing food succeeding from our ancestors, and our genetic relatives, chimpanzee groups, also display this kind of similar behaviours within ecological association. My review of the theoretical part concerning this mainly refers to his work. Several models were proposed to explain the motivation of sharing food beyond the kin group, such as social explanation (Gurven et al. 2000; Stanford 2001; de Waal 1997), tolerated theft and sharing under pressure theory (Gilby 2006), reciprocal altruism (Trivers 1971) in form of Tit-for-tat, bargaining, variance reduction, and Risk reduction reciprocity (RRR), as well as reputation enhancement (Gurven et al. 2000) and political models.

The hunting-gathering communities are known for their generosity and willingness for reciprocity, which is widely acknowledged and accepted by many anthropologists (McArthur 1960; Sahlins 2013). Sharing food is not only a social form for foragers but also a selective strategy. Hunting for meat resources is a somewhat unpredictable way of obtaining protein, and some hunters may return empty-handed at times. During such instances, neighbours or relatives would share their harvests with them (specific motivation that can be explained using the model of food sharing mentioned earlier). In addition, the hunters are often mobile communities, lacking the concept of personal property and storage possibly (Gusinde 1961; Sahlins 2013), at least for early hunting-gathering groups. They tended to exhibit a lack of desire and greed, as excessive personal property could become a burden during the mobility. Therefore, when a hunter has a recent bountiful harvest, resulting in

surplus, they always choose to share the food with others. This might be considered as the embryonic form of the early feasting in the human society.

Building upon the foundation of early food sharing, people added more cultural and social attributes and dynamics to this behaviour, competition or cooperation, intra-group or inter-group, group-interest-oriented or individual-interest-oriented, making it evolve into what we now recognize as feasting.

“What may appear to be lavish ‘give-aways’ of food and drink are actually, in large part, carefully calculated expenditures through which practical socio-political strategies are pursued.” (Adams 2004). Adams’s valuation for feasting practices somehow seems to resonate with the famous narration by Stefan Zweig: “...*life never gives anything for nothing, and that a price is always exacted for what fate bestows.*” When a sponsor provides food, drinks, and a venue for a feast, what do they gain in return? Similarly, while guests enjoy complimentary food, what obligations do they have in return? The underlying dynamics in these interactions seem to be the driving force that sustains the social mechanism of feasting over an extended period. In his most famous work, Marcel Mauss (1967) describes a celebration feast after the birth of a child where, the hosting couple did not become richer or poorer because the appearance of gift exchanging, and the gathering to congratulate the birth brought a sense of deep respect for them. Similarly, in Chinese banquets, especially during the most two significant events, weddings and funeral rites, this phenomenon becomes more pronounced because guests are obligatory to return red pocket¹⁷ for the feasts. In this situation, feasts actually serve as channels for the circulation of wealth. While overall wealth may not increase or decrease, material goods circulate, relationships solidify, and bonds deepen through these gatherings.

¹⁷ Red pocket is a traditional Chinese cultural method of gift-giving, typically used during specific holidays or celebratory occasions. It involves placing a certain amount of money inside a red envelope and presenting it to family or friends.

During the process, the significance of meat was emphasized, especially the political aspect. Within the chimpanzee groups, food sharing typically involves highly-quality foods that are difficult to acquire or highly valued (Villeneuve 2014). Nishida's well-known theory (Nishida *et al.* 1992) assumed that meat sharing may be highly political compared with other resources. In addition to the high protein, meat is characterized by its attributes of costly acquirement and controllable distribution (Melis *et al.* 2011). Thus, meat seems to become a key to stimulating the appearance of feasting, and this is also why we need to explore more "animals as feasting" in the chapter title.

Some other interesting thoughts regarding the inception of, or factors that influence, feasting are also worth being discussed. For example, compared with attracting people to contribute to the bonding, is the exclusivity a kind of underlying logic of hosting a feast? The origin of feasting came from the food-sharing, so does it mean that society with more food-sharing, such as hunter-gathering communities, will feature more feasts? Another example, the underlying logic of feast is surplus, the abundance of resources, so does it mean that feasting cannot result from the societies with population pressure or stress condition? Hayden (2014: 6) strongly believed that "feasting system did not develop or thrive under the stress condition". In addition, what would result in the persistence or change of feasting? Hayden & Villeneuve (2011) also proposed the expectation from ethnoarchaeological exploration for this: ".....it will also be important to create models to explain why large-scale traditional feasts persist, intensify, or fade away under changing modern economic or other conditions."

For this question, the expansion of Kwakiutl potlatch in the Northwest Coast after white contact seems a fabulous example:

"Before that time the potlatch seems to have been a relatively modest affair compared to what it later became.....the Kwakiutl gave away such presents as food, furs, skins, and wooden boxes and bowls, but in relatively fewer numbers than they would later.

This expansion was owed in part to the movement of tribes into confederacies such as that at Fort Rupert, where they could potlatch more actively with other tribes. As well, throughout the late nineteenth century, the Kwakiutl participated in the white company by working for wages as fishermen and in canneries, and in the process acquired considerable expendable wealth that was distributed at potlatches. Kwakiutl social structure was also affected by the decline in their population due to infectious diseases, creating an uncertain ranking order, and making necessary the more competitive potlatches, at which hosts literally destroyed vast amounts of goods in order to be seen as the most prosperous and thus the highest ranking” (Codere 1950).

From it, we can find three critical factors that would result in the expansion of potlatch practices: a) increase of external links with other communities, b) increase of expendable wealth, and c) instability of the inner social structure. Of course, this condition is forced by the exotic invasion of strong modern culture carrying some destroying threats, which is relatively rare in ancient cultures, though, it provided valuable insights for understanding of the potlatch’s, and further extending to feasting’s operation mechanism and inherent motivation.

3. Why we research feasting?

3.1 Significance of food and feasting

It is widely recognized by anthropologists that “food is good to think” (Lévi-Strauss 1963). Looking beyond its role as a subsistence resource, the process of selecting, preparing, consuming, and discarding food reflects the distinction between human's meal and animal's fodder. This distinction lies at the core of understanding what makes a human distinctly human. In essence, it manifests the presence of culture or not (Lévi-Strauss 1963; Jones 2008). Furthermore, most archaeological discussions of food as a socially charged material stem from the current emphasis on feasting (Kassabaum 2019).

Feasting is ubiquitous in both ancient and modern societies. Twiss (2008: 418) pointed that “Feasting is a universal human phenomenon.” This practice transcends geographical and sociocultural boundaries with a global distribution, signifying a shared human experience (Dietler & Hayden 2001:2; Hastorf 2017:216). Cultures worldwide have historically utilized feasting as a means of celebration, social bonding, and the expression of hospitality. Whether through religious ceremonies, traditional festivals, or communal gatherings, the act of feasting remains a widespread and fundamental aspect of human culture, reflecting our inherent inclination to come together, share food, and celebrate shared experiences.

Hayden emphasized the significance of feasting in aspect of culture and society. “In fact, up until the Industrial Revolution, there may have been no other more powerful engine of cultural change than feasts.” (Hayden 2014:1). He also mentioned “.....feasting in most traditional societies is often the most valued aspect of cultural life.” (Hayden 2014:4)

Hayden (2014) searched for the theoretical supports from the perspective of other subjects, such as Zahavis’s well-known handicap principle (1999) in behavioural ecology and the costly signalling theory (McAndrew 2019) in evolutionary psychology. He also proposed that the most profound significance of feasting is that “no other species in the world has the unlimited ability to transform surplus food production to promote self-interests in this way or to create increasingly complex forms of organization from immediate, competitive food acquisition.....feasts really do constitute a new ecological paradigm on earth” (Hayden 2014:19). This impressive view brings the interpretation of feasting to a totally new level.

Whichever explanation is endorsed, there is widespread agreement that feasts play important roles in establishing social identities and memories, creating political power and inequalities, gender identities, accomplishing work, and developing prestige technologies, possibly including domesticates (Hayden & Villeneuve 2011; Hayden 2014).

3.2 For archaeology and archaeozoology

Feasting is archaeologically identifiable. It is a kind of behaviour that can leave recognizable and diagnostic material remains in the archaeological record (Hayden 2014). Therefore, as archaeologists, we have both the obligation and responsibility to identify and analyze it.

More specifically, in terms of archaeozoology, previous studies tended to focus on subsistence economy, actually this is a relatively superficial and cliché topic in spite of extreme significance. Many studies stopped here without further exploration. Topics like feasting provide an opportunity for archaeozoologists to switch their discussion focus from “subsistence economy” to “political economy” (Sahlins 2013) or “status economy” (Firth 1959), from the basic to the next level, especially when stepping into exploring some questions derived from the society complexity with surplus production, social division of labour, social organization, inequality, redistributive economies, ritual, and religion. In addition, some scholars suggested that feasting is the motivation and context of one of the most crucial missions of zooarchaeology, the domestication of plants and animals (Bender 1978, 1985; Jennbert 1985, 1987; Hayden 1990, 2001, 2009b; Clarke 2001; Adams 2004, 2007a, b; Russell & Martin 2005; Hayden & Villeneuve 2010) and intensification of agriculture (Brookfield 1972). Having a better understanding of feasting has become a necessary premise to explore the inherent mechanism of domestication.

4. Feasting in anthropology and in archaeology

4.1 Development history

Regarding the history and evolution of feasting studies in anthropology and archaeology over the past century, Hayden and Villeneuve (2011) reviewed literatures of this progress in the masterpiece named *A Century of Feasting Studies*. My review of the development history of feasting before 2010 mainly draws on this.

In the early stage, some essential foundation of feasting theory existed in ethnographies, which established basic explanatory models for the following anthropological and archaeological interpretation. Feasts were described in some early classical literature focusing on elite hosts (Bullitt 1969:56–58; Wolkstein & Kramer 1983:13; Waley 1996:316; the Viking chief's funeral feast [Montgomery 2000]; Sherratt 2004). With the creation of colonies by European countries, some indigenous lavish feasts were encountered and then outlawed as economically backward, where the famous Potlatch in northwest coastal American was included (Hayden & Villeneuve 2011). As a pioneer who anthropologically documented the Northwest Coast potlatch system, Franz Boas established it as dominant in anthropology until the mid-twentieth century, shaping ethnographic accounts of feasts into largely descriptive and theoretical narratives (Codere 1950; Boas 1966). Other ethnographic studies concerning feasting also were conducted by Boas's followers, some emphasized the competitive function of feasting (e.g., White Deer Skin Feast in California [Goldschmidt & Driver 1943]), some underlined the productivity-increasing purpose (e.g., lavish feasts among the Chin [Stevenson 1943:137-138] and the Nagas [Simoons 1968:112, 128]), and others paid more attention to feasting's role in acquiring political power (Stevenson 1943; McIlwraith 1948).

During the mid-twentieth century, structural functionalism became the mainstream, and feasting was explained as enhancing social solidarity (Firth 1951:230-231; Rosman & Rubel 1971), whereas others supported for the conflict-oriented interpretation (Codere 1950).

The periods of 1960s-1970s witnessed a blossom of interest in feasting theoretical studies. A series of ethnographic and anthropological studies guided by the functionalist ecological paradigm suggested feasting's function in resource redistribution (Piddocke 1965; Suttles 1968; Rappaport 1968; Sahlins 2013). Some European anthropologists also interpreted feasting from the motivation of gaining prestige and status (Young 1971;

Strathern 1971; Nairn 1991; Lemonnier 1990). After that, explanations serving political interests and individual motivations also emerged. They emphasized the determinative status of manipulative “aggrandizers” (Hayden 2014), who desired to utilize feasting to establish social alliance, increase production, achieve political negotiation, or create inequality (e.g., Maori Feasting [Firth 1959]; Sillitoe 1978; Ruyle 1973; Feil 1987; Weiner 1988; Wiessner 2001). There were also some new cognitive and experiential perspectives.

In archaeology, the attention to feasting came later than in anthropology, and has gone through three broad phases: an early descriptive phase; establishment of some theoretical models in the 1970s-80s; and more diversified theories from the 1990s until now.

The 1970s to 1980s is a crucial phase when some theoretical archaeological framework was established. Friedman & Rowlands (1977) and Bender (1985) answered the questions why feasting was important in prehistoric societies. It was also this period when archaeologists started to search for the prehistoric indications and archaeological evidence of lavish feasting. Meanwhile, awareness of feasting and archaeological discoveries related to feasting have been blooming around the world. In Western Europe, excavations of Neolithic and Bronze Age monuments including ditched enclosures, causewayed camps, henges, and barrows with abundant ceramic and faunal remains, were often noted and described as probable remains from feasts (Smith 1965; Wainwright & Longworth 1971; Thomas 1991). In South America, Morris (1979) was one of the first to draw upon rich ethnohistoric archives in developing models of how the Incan state used feasting to run its administrative organization and meet labour needs. His focus on elite uses of feasts to achieve political goals has expanded in more recent years (Lau 2002; Hastorf 2003; Gummerman 2010; Shimada *et al.* 2004:383, 386; Isbell & Groleau 2010). Similarly, archaeological work based heavily on ethnographic records were conducted in the Southwest United States (Wills & Crown 2004; Blinman 1989), in the Central and Southeastern United States (Seaman 1979; Welch &

Scarry 1995: 414; Kelly 2001; Yerkes 2005), and some isolated investigations such as prehistoric hunter-gatherers of Labrador (Schwarz 1996), the men's structures of the Eskimo (Sheehan 1989), and feasting remains in Philippine chiefdoms (Junker et al. 1994).

Entering the 1990s, a large number of related studies have emerged, manifested in the form of many symposiums and edited volumes concerned with feasting (Dietler & Hayden 2001). During the development years, archaeologists achieved a more diversified understanding of the dynamics involved in feasting and proposed links between feasting and some key technological innovations, including storage (Kuijt 2009), agriculture (Hayden 1990, 2009b), alcohol production (Jennings *et al.* 2005), monument construction (Iriarte 2008; Andrushko *et al.* 2011), luxury foods (Hastorf 2003; Van der Veen 2003; Yerkes 2005), etc. The high correlation between the quantity and variety of animal remains and feasting behavior has been widely acknowledged by archaeologists (Hamilakis & Konsolaki 2004; Kansa et al. 2009; Grimstead & Bayham 2010; Munro & Grosman 2010), which provides with strong theoretical support for the following feasting research from the perspective of faunal remains.

In the past decade, more scholars have stood on the shoulders of giants, delving into further exploration of the theory and application of feasting. In terms of theoretical innovation, Hayden's comprehensive work of feast theory (2014) and regional work of southeast Asia (2016), as well as O'Connor's book (2015) were published successively; Twiss (2015) established a series of comprehensive criteria for identifying feasting based on the ethnographical materials and apply it on the Levantine feasts; Smith (2015) introduced an interesting aspect, discussing about the potential for "feast failure" and suggesting that feasts almost always exhibit some shortcomings; Rowley-Conwy (2018) highlighted the role of zooarchaeological evidence of see feasting and proposed a new four-fold category of

zooarchaeological evidence for feasts; a more quantifiable dual-dimension model was also put forward to conceptualize and categorize feasts by Kassabaum (2019).

From the perspective of archaeological application of feast, copious case studies around the world emerged. In Europe, many feasting-related work were conducted around the great henge complexes in Britain (e.g., Wright et al. 2014; Craig et al. 2015; Gron et al. 2018; Madgwick et al. 2019b), and some work has also been done in Cyprus (e.g., Kouka 2011; Pilaar Birch et al. 2022). In Americas, the development of feasting's case studies was extremely prosperous, ranging among different regions and periods (e.g., Thompson & Andrus 2011; Gamble 2017; Knudson et al. 2012; Kassabaum 2014; Wallis & Blessing 2015; Miller 2019; Brown & Kelly 2015). In Western Asia, feasting case studies mainly come from Israel and Anatolia (Helwing 2003; Munro 2010; Twiss 2012; Fulton et al. 2015; Glatz 2016).

Additionally, with the introduction of emerging technologies, more previously inaccessible information points are being supplemented, enhancing the comprehensiveness of feasting research. The results are indeed exciting. For example, the multi-isotope investigations for feasting employed in the Late Neolithic Makriyalos, northern Greece (Vaiglova et al. 2018), in the fallow deer feasts at Bronze Age Cyprus (Pilaar Birch et al. 2022), in the Paracas site of southern Peru (Stanish et al. 2018), in the Neolithic Coneybury pit of Stonehenge, Wiltshire (Gron et al. 2018), in the Stonehenge environs and across Wessex (Madgwick et al. 2019b), in the Iron Age Ireland (Madgwick et al. 2019a), etc. Additionally, TEM analysis was introduced to construct prehistoric cooking practices in faunal assemblages of feasting (Faillance et al. 2020).

4.2 Balance in anthropology and in archaeology

From my personal experience, in the gradual process of understanding and contemplating feasting, I consistently perceive a peculiar sense of disconnection between the feasting in anthropology and the feasting in archaeology. This feeling primarily arises from

an imbalance or a kind of mismatch between the richness of anthropological theories and deficient archaeological practices, and the contradiction between the broad scope of definition and the narrow scope of application. Such disparities are not uncommon when attempting to bridge theoretical concepts from one discipline to practical methodologies in another, even though anthropology and archaeology are closely connected.

While the various theories proposed by anthropology and ethnology are undoubtedly fascinating, archaeologists must grapple with the challenge of balancing theories and practices. The complexity of theoretical frameworks and their associated social and political attributes may be challenging to verify in practical archaeological work. Although the viewpoint that feasting is archaeologically visible has been admitted, demonstrating the existence of feasts, and determining their types, scale, as well as roles in community dynamics and politics proves to be a complex task, acknowledged by many theorists (Hayden & Villeneuve 2011).

Defining and recognizing ritual practices within archaeological deposits pose a significant challenge when there is no literature to refer to. This often results in that an incomprehensible deposit “immediately enters the realm of ‘ritual’” (Ikram 2002) whenever archaeologists encounter difficulty in establishing a straightforward functional or practical explanation for its presence (Brück 1999; Fogelin 2007). As a form of ritual, feasting inevitably faces similar challenges.

To correct the imbalance and avoid the pitfalls of defining ritual feasting, some materially and contextually driven approaches (e.g., Renfrew 1985; Brück 1999; Gillespie 2008; Swenson 2015) were aptly suggested to better recognize and interpret ancient feasts (see also Hayden 2014:77). Combining their perspectives with my own understanding, three directions were proposed. Firstly, it underscores the importance of refining theoretical frameworks of feasting to make them more applicable in real-world archaeological contexts.

As theoretical guidance, it was suggested that considerations of feasting should avoid overinterpretation and becoming an “ill-digested archaeological interpretive fad” (Dietler & Hayden 2001). Secondly, feasting research in archaeology was advised to be creative, employing more new technologies and methods. Much more attention to documenting the faunal and botanical remains associated with suspected feasting features is also required, which has been a major deficiency in most areas (Hayden & Villeneuve 2011). Thirdly, it might also call for a collaborative effort between anthropologists and archaeologists to develop more cohesive and mutually beneficial approaches. Instead of solving the problem of imbalance, it would be better to say that the combination of theoretical and practical materials should be enhanced. Studies can also benefit from more indigenous documentation of their own feasting practices. Understanding and addressing these disparities can enhance the effectiveness of applying anthropological concepts of feasting to archaeological material remains.

Section 2 How to identify a feasting archaeologically?

Regarding the issue of identifying a feasting, there have been many ethnoarchaeologists contributing to constructing the criteria of it. Of course, due to feasting's essence, we can obtain many hints and inspirations from the ethnographic and ethnohistoric records first. Twiss (2008) made a splendid summary of feasting signatures and behaviours that commonly appear in ethnographic and ethnohistoric records, involving a wide range of cultures, areas and groups.

It is well-known that the larger the feasts, the more likely they are to be recognizable archaeologically. But what about feasts that are not so large? Can we find clues in archaeological materials for them? This needs us to set up more detailed standards of identifying feasting. Although numerous articles touch upon the archaeological interpretations of feasting (Potter 2000; Halstead & Isaakidou 2004; Hayden 2001, 2014; Dabney et al. 2004; Zhang 2015; Zhao & Li 2022), they often tend to be either rough or incomprehensive. Hayden (2014) also expressed the concern for lacking a “systematic empirical documentation of a kind that would be useful for archaeological interpretation”.

To contribute to this documentation, in the following, I will systematically list the archaeological interpretations or evidence for identifying feasting. This review will not only involve in theoretical perspectives but also strive for practical implications in specific archaeological manifestations that might occur. Among various archaeological remains, animal remains often preserve better, offering more effective information. In particular, the symbolic significance of meat is emphasized during the ritual event (Nishida *et al.* 1992; Melis *et al.* 2011; Villeneuve 2014). Therefore, the following discussion will exhaustively cover various aspects of archaeological interpretations, with a particular emphasis on the clues provided by animal remains.

1. Two models

Feasting ritual is a complicated event containing multiple factors. Identifying feasting is a nuanced task, and no single criterion uniquely serves as a diagnostic indicator. The recognition of feasting necessitates the convergence and alignment of multiple datasets. Faced with numerous possible indicators, we need to broaden our thinking to try to cover every perspective as much as possible while utilizing unified approaches to logically organize and integrate these factors. Therefore, I propose two models, also two approaches, to assist us in systematically exploring the archaeological attributes of feasting without overlooking any potential evidence.

1.1 “Two Essentials” model

The first model is the "Two Essentials" model. It is derived from the broad definition of feasting. As what was explored earlier in Section 1, the two most fundamental elements for feasting are "food sharing among two or more people" and "distinct from everyday meals". To better connect these two essentials with archaeological attributes, their meaning needs to be extended: "food sharing among two or more" implies the "one-time consumption", while "distinct from everyday meals" suggests the signature of "surplus". The latter prerequisite “surplus” has been consistently emphasized in other studies, quoting Hayden’s saying "without surplus resources, feasting would simply be unthinkable" (Hayden 2014:6). To a certain extent, when these two essentials in archaeological interpretations can be clearly demonstrated, the presence of feasting can be effectively recognized.

Continuing to dissect these two extending points, "one-time consumption" implies "one-time discard and short-term covering" and "concentrated killing”. The former can be examined through taphonomy and the distribution of animal bones, while the latter is specifically reflected in the death age pattern of animal assemblages, sex preferences, and the presence of similar patterns in anthropogenic traces. As for "surplus", I have divided it into

two aspects to expound: "quantity" and "quality". The aspect of "quantity" is primarily reflected in the quantitative calculation results of the faunal assemblages, more meaty elements, and fewer marrow extraction practices. On the other hand, "quality" is manifested based on "preciousness" and "diversity" two attribute of the consumed food. The detailed logical diagrams and inference relationships within this model are presented in **Figure 8-2-1**.

1.2 "Workflow" model

The second model is the "Workflow" model, as depicted in **Figure 8-2-2**. This model is easily comprehensible. In this framework, a feasting event is conceptualized as a process of food-human interaction. The study of food typically adheres to five stages: procurement-processing-cooking-consumption-deposition, accompanied by storage. Therefore, I utilize this pattern to investigate the attributes of feasting at each stage during the event.

For the stage "procurement", it is mainly related to the food source, such as the quantity of meat, the taxa, age, sex selection of animals, as well as if domesticated animals were specially treated before being killed, etc. The stage "processing" is, simply put, the butcher's work, focusing on the activities including dismembering, meat-taking, and so on, companying with storage practices. At this stage, we mainly investigate the artificial marks on the bone surface and whether there is a appearance of element selection. The "cooking" stage mainly involves the cooking equipment (including pots and hearth) used, the cooking methods (barbecue, steamed, or boiled), and the labour needs during the food production for feasts. The core of a feast ceremony is manifested in the stage of food "consumption", providing various aspects for exploration including the location of the event, the timing of the feast (special festivals or occasions), the nature of the food consumed (surplus consumption), beverages served (alcohol drinking), the utensils used (eating and drinking vessels), and whether the process of food consumption was accompanied by entertainment activities (performances like dancing, singing, games, drama, speeches, and even the taking of

hallucinogens, etc.) or religious rituals (ritual artifacts). Lastly, for the stage of “deposition”, the original "discard" was replaced with "deposition" to highlight not only the act of throwing away but also the taphonomic process during the deposition and post-deposition stages. Thus, the evidence can be explored in terms of the location of refuse sites, the nature of the refuse site itself, how to identify it is a single event of discard rather than a mixed one, the preservation and taphonomic condition of bones, and so on.

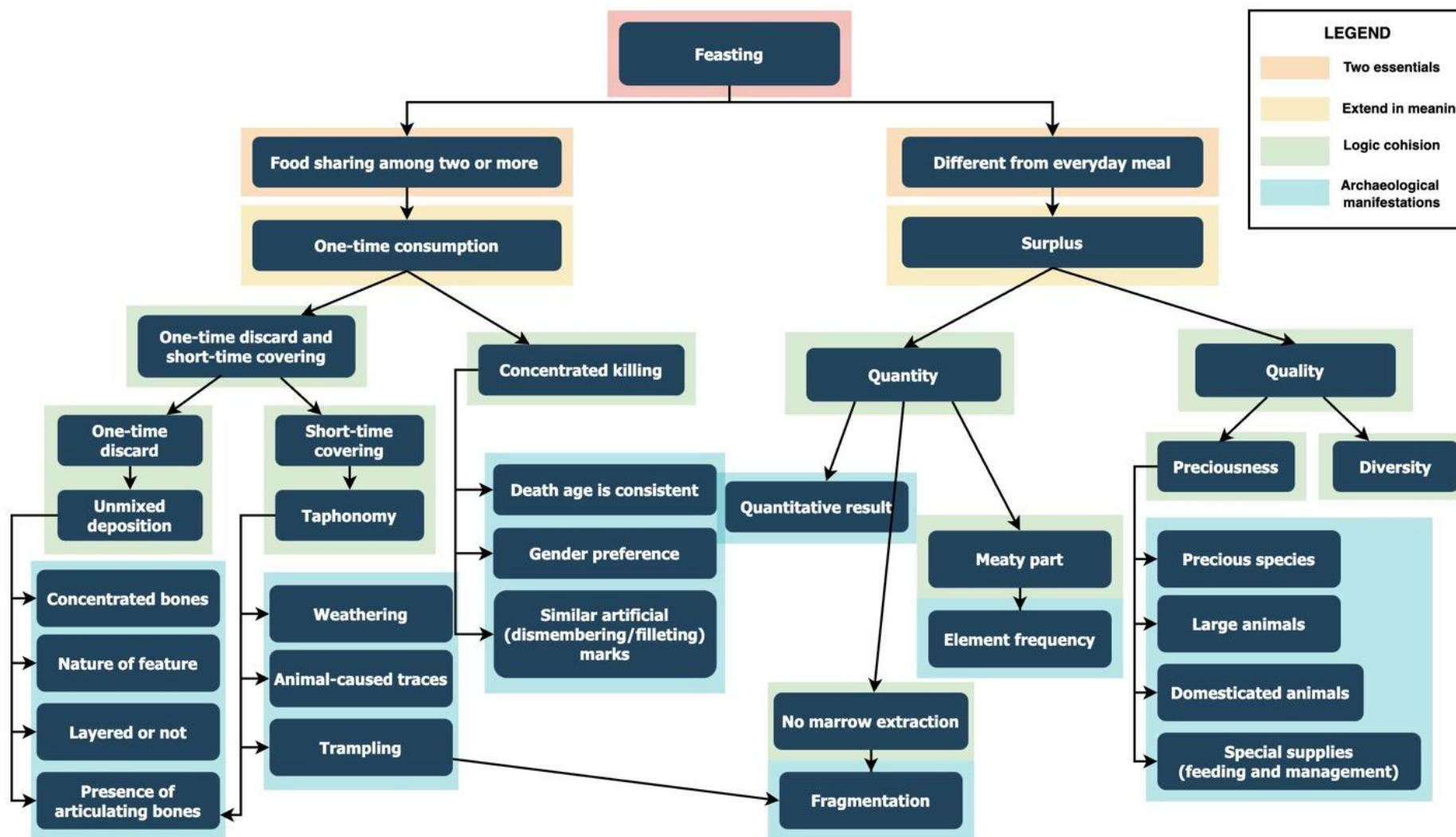


Figure 8-2-1. Diagram of the “Two Essentials” model. The approach of this model starts by systematically exploring evidence layer by layer, building upon the two fundamental elements in the definition of feasting.

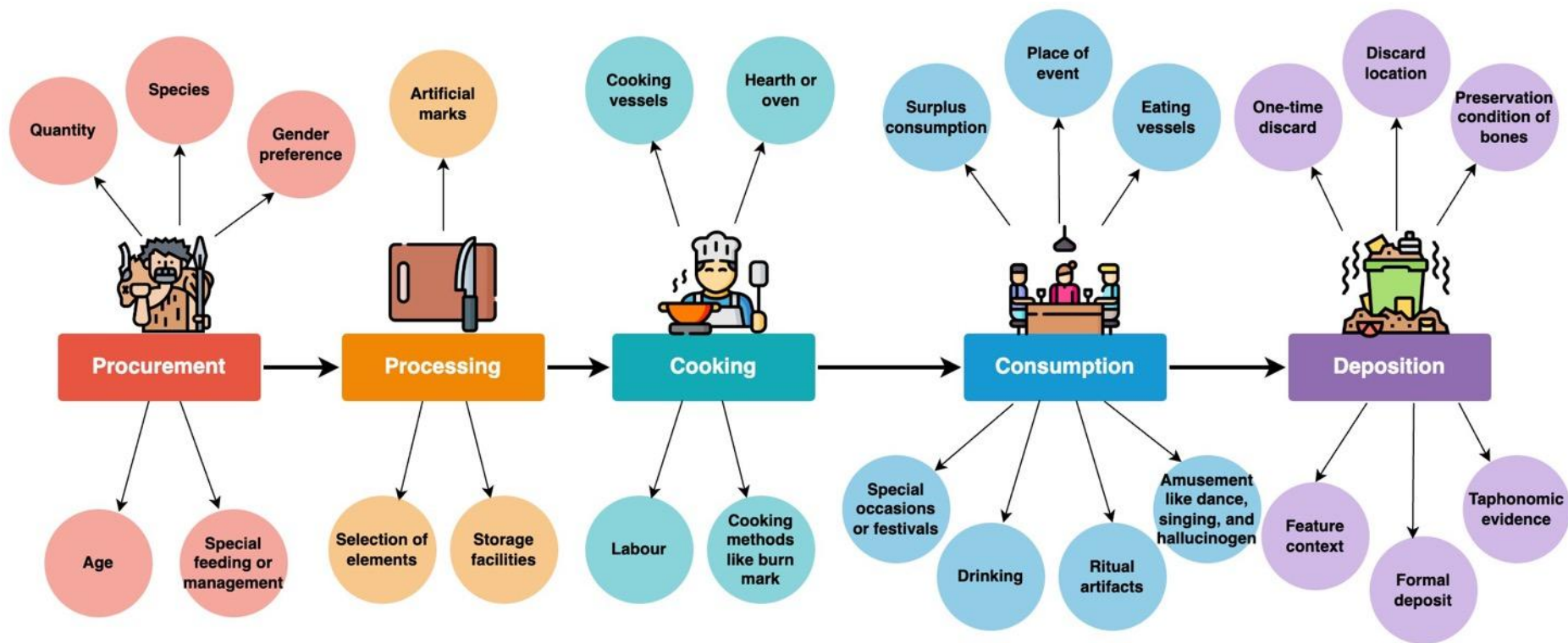


Figure 8-2-2. Diagram of the “Workflow” model. It illustrates and analyses the most likely cultural signatures or archaeological evidence in five basic process stages (procurement-processing-cooking-consumption-deposition) separately during the feasting happening.

2. Archaeological attributes

2.1 Source of meat

2.1.1 Unusual quantity of normal food

An unusually large faunal residue can be regarded as the first and the most obvious indicator for recognizing a feasting, frequently manifesting as the unusual quantity of normal meat. H. Leach (2003:452), Van der Veen (2003:411-412), Stasch (2012:360, 371), and Hastorf (2008:1393) have all pointed out that unusual quantities of normal foods may characterize feasts, especially “potluck” events. Because feasting sometimes “is a matter of more of the same (but especially more meat) rather than an occasion of meals making use of different constituents” (Goody 1982, 78). The supportive archaeological examples of this trait are also most common, such as the turkey remains at Pueblo de los Muertos (Potter 2000).

2.1.2 Unusual foods- large animals

Participants in feasting activities typically share rare animals as meat offerings. Due to the large number of guests in some big feasts, some ethnographic materials emphasized the preference for large mammals that can supply with copious amounts of meat in feasting, no matter game, or domesticated animals, as observed in groups like Enga, Chin, and Massa (Simoons & Simoons 1968; de Garine 1996: 202; Wiessner 2001). It is argued that the killing of large animals can trigger the feasting rituals, especially in the societies where people do not master the technique of meat-storing, like some hunting and pastoralist groups (Clark 2001; Knight 2001; Hayden 2003; Twiss 2008; Hayden 2014). Large animals simultaneously act as a kind of effective prestige enhancer to show off the host’s wealth strength or hunting ability. Even in meat-storing societies, significant quantities of meat could be commonly consumed within a day of killing large animals (Twiss 2008).

2.1.3 Unusual foods- domesticated animals

Some scholars consider the consumption of domesticated animals as a manifestation of the signature of catering food sources (Keswani 1994; Blanton & Taylor 1995; Hayden 2003; Twiss 2008). Although this might raise certain adaptive issues, it is quite reasonable for self-sufficient natural economy societies where the basic unit is the agricultural household. Hayden (2003: 461) noted that in southeast Asia, “domestic animals are killed only in the context of feasts and sacrifices. This ... is a behavioural pattern ... overwhelmingly common in tribal and peasant cultures throughout the world, whether in New Guinea, Crete, rural France, or Turkey...” In China, this pattern is also evident, and even today, in rural areas and among indigenous minority villages, this tradition persists (Chau 2004, 2006; Wang 2011; Abe 2020). Most households had just a few pigs, which they killed and ate only on special occasions. The highest value of the animal was its nutrient contribution to the crops that sustained China’s population for millennia. The fable of “*Zeng zi sha zhu*” (translated as “Zengzi slaughtering the pig”) during the Warring States period vividly illustrates the importance of domesticated animals to individual family under the natural economy. Zengzi (Master Zeng, student of Confucius), in order to keep his promise to his child, did not hesitate to slaughter the family pig on ordinary days, earning praise for his commitment in subsequent generations (from *Han fei zi · wai chu shuo zuo shang*, Chen 1940).

2.1.4 Unusual foods- precious animals

More elaborate feasts may involve luxury foods and precious animals. This kind of feast tends to be high-level and hosted by elites. Introducing luxury foods for catering can show off the sponsors’ power and wealth in order to facilitate cooperation or to deter potential enemies.

The luxury foods contained some imported or restricted items, such as marine fish brought inland or hunted deer in the medieval period, which have been recognized

zooarchaeologically (Metzger et al. 1970; Ervynck et al. 2003). Such items are typically found in societies with an “elaborated cuisine” (Rowley-Conwy 2018), involving a wide range of ingredients including imported ones, and a large elite with adventurous tastes (Goody 1982, 98).

2.1.5 Age and killing pattern (time indicator)

The abundant food requirements during feasting implies the need for concentrated animal slaughtering, especially in the absence of proper storage techniques. Therefore, a consistent death time of the faunal assemblage becomes a powerful indicator of "one-time consumption". This seems to be the only zooarchaeological evidence with temporal direction. We understand that special occasions are often associated with festivals, and in ancient societies, important festivals were closely related to seasons, for example, Durrington Walls provided evidence for great pig feasts that mainly occurred in winter (Wright et al. 2014). Archaeozoologists can infer the approximate season of animal death based on the age pattern of the faunal assemblage. Therefore, the killing pattern of the fauna remains not only proves the existence of feasting but may also contain valuable information about the timing of feasting events. Based on this, it may even be possible to further speculate on the motivation and function of the feasts. Overall, this is a crucial, information-rich feature in zooarchaeology for feasting studies, possessing a uniqueness and significance that other archaeological evidence cannot match.

2.1.6 Sex of animals

Uniformity of sex of the faunal assemblage is also a signal of something unusual. This may suggest a preference or tradition among sponsors (e.g., Chinese dietary traditions believe that hens are better for stews compared with roosters) or indicate a special role that these animals served during their lifetime (e.g., milking cows for the feast at the Hambledon Hill

causewayed enclosure, Legge 2008, Rowley-Conwy 2020). However, this is hard to see, mainly because sexes are always tricky to be determined.

2.1.7 Level of diversity

Some scholars have argued that the diversity of meat types in feasting activities tended to be lower than in daily consumption (Jackson & Scott 1995; VanDerwarker 1999). While this assertion may not be universally applicable, it is relevant in certain contexts. For instance, when the preparation and duration of feast events were short, the variety of animals involved tended to be more singular. At the same time, the diversity of animal types can also reflect information about the sponsors of the feast. If the feast was hosted by a single sponsor or household, the diversity of meat types is often lower. Conversely, if the feast was sponsored by attending guests, the variety would tend to be higher (e.g., Cahokia site by Kelly 2001).

Building upon the established presence of feasting, aside from the diversity of animal species, other aspects of diversity can lead to further insights. The age diversity within animal assemblages can sometimes reflected the initiation or motivation behind hosting a feast. Taking the large feasts of hunting-gatherer societies for example, whether the event was initiated on the premise of abundant resources or if it was organized with the intention of subsequently seeking ingredients for the feast can reflect two different beginnings for hosting a feast. The former might exhibit lower age diversity, while the latter, aiming to gather supplies for the feast in a short time, might overlook hunting strategies, leading to a more varied age distribution. Moreover, the introduction of molecular techniques allows us to obtain additional information regarding the provenance of animals. The diversity of provenance can reveal information about the sponsors of the feast. For example, Gron et al. (2018) utilized Sr and S stable isotopes to conjecture participants from different areas brought their meat to a gathering feast event in Coneybury.

2.1.8 Special feeding or management

According to the Chinese ancient literature *Zhou Li*, sacrificial animals were tied up in the "*lao*", and specially fed for three months to ensure their fattening before the ritual. This has been proved by the archaeological materials from the Xuechi sacrificial site, Shaanxi, where sacrificial horse ribs showed significantly higher $\delta^{13}\text{C}$ values compared to other elements, indicating a concentrated feeding of more C4 plants in the final period before slaughter (Chen et al., 2020). For rituals like feasting on special occasions (once a year or every few years), a similar practice of specially feeding and managing animals for catering would theoretically occur. The archaeological evidence for this is primarily derived from isotopic reconstructions of feasting animal diets (e.g. Madgwick *et al.* 2023). An analogous example is foie gras, the fattened liver of a goose produced by force-feeding, which became a sought-after delicacy on the tables of European nobility.

2.2 Condition of bones

2.2.1 Fragmentation

Long bones on archaeological sites are typically found fractured to facilitate marrow extraction and then further broken into small fragments for fat extraction or as fuels. Unbroken (or with low fragmentation) limb bones, however, indicate suboptimal nutrient exploitation, suggesting an abundance of meat supply that renders within-bone nutrients unnecessary. Such a meat surplus aligns with feasting scenarios, where an unusually large quantity of meat becomes available simultaneously. Archaeological sites such as the Late Neolithic Durrington Walls in southern England (Albarella & Serjeantson 2002), the Late Mycenaean Palace of Nestor at Pylos (Halstead & Isaakidou 2004), the sub-mound 51 pit at Cahokia in Illinois (Kelly 2001), the Pueblo communities in the American Southeast (Potter 2000), and the Late Archaic Azoria, Crete (Dibble 2021), are all indicative of likely feasting occurrences based on the attribute of low fragmentation of bones.

2.2.2 Artificial traces

Artificial traces on animal bones can provide four-level information for identifying feasting and studying related issues. Firstly, observing whether there are signs of dismembering or meat-removal indicates that the animal was used for meat consumption rather than being discarded for other reasons. Secondly, if these artificial traces exhibit a similar pattern, such as being found consistent in terms of location, direction, depth, or resulting from the use of same tools, it suggests that it is highly likely that a single batch of animals was slaughtered. This is because the same butcher often employs consistent slaughter patterns and habits when dealing with meat, typically for a major feast's meat supply. Thirdly, the slaughter pattern may hint at the motivation of feasts. For example, certain religious regulations dictate that animals used for special events are usually subjected to different ritual slaughter methods than those used for normal consumption (Charlton & Kaye 1985; Rahman 2017). Lastly, artificial traces can help reveal how the feasting food was cooked; for instance, meat removal leaves small cutting marks, and if it is cooked in a pot, limb bones are often segmented for easy placement, whereas if it is barbecued, long bones are rarely sawn but may show burn marks (e.g., Potter 2000).

2.2.3 Element occurrence frequency

More meaty elements, such as limb bones, are commonly found in the refuse sites of feasting. This attribute is well-supported by archaeological evidence from numerous feasting sites (e.g., Ma 2008; Ben-Shlomo et al. 2009). In zooarchaeological methods, the occurrence frequency of skeletal elements can be investigated using indicators like MNE and MAU%.

2.3 Taphonomy and the preservation of bones

2.3.1 Weathering level

The weathering mentioned here primarily refers to physical weathering, with the main influencing factor being the length of time the bones are exposed to the air during the post-

deposition. The low weathering level indicates that bones were rapidly buried after disposal, suggesting that this is likely to be the refuse from a one-time consumption event (e.g., Halstead & Isaakidou 2004; Dibble 2021).

2.3.2 Animal-influence level

The detectable animal-influence level for depositional bones mostly come from the gnawing, most frequently are canid-gnawing and rodent-gnawing traces on the bone surface. A low gnawing level suggests the low availability of material to carnivores and rodents, indicating that the refuse was rapidly buried after being discarded (e.g., Halstead & Isaakidou 2004; Wallis & Blessing 2015a, 2015b; Dibble 2021).

2.3.3 Presence of articulating or paired bones

The occurrence of articulating or paired bones is a direct indication that a particular assemblage of bones has not undergone severe post-depositional disturbance, indicating that the faunal assemblage is unmixed and one-time discarding residues. Supportive examples were found in Greece (Pappa et al. 2004), in the Neolithic and Bronze Age Knossos (Halstead & Isaakidou 2004), and in the High Pasture Cave of Island of Skye, Scotland (personal communication, Rowley-Conwy).

2.4 Distribution of bones

2.4.1 Distribution density or concentricity

Feasting involved the consumption of a large amount of meat, and thus, the faunal residues would exhibit a higher density and more concentrated distribution of skeletal accumulations (e.g., Metzger 1970). This essentially reflects the attribute of "large quantity" in feasts. When the animal assemblage at a site was substantial and exhibited a complex distribution, examining the internal distribution density and concentration level within the site becomes a rapid and effective method to narrow down the scope to find feasting residues.

2.4.2 Context of deposition

The context of a faunal deposit, such as whether it is found in an ash pit or a house and whether it exhibits layering, can provide insights into how animal bones were discarded—whether it was a short-term or long-term process and if it occurred once or multiple times (e.g., Wallis & Blessing 2015a, 2015b). This information can provide robust evidence for distinguishing between the lavish consumption of feasting and everyday dietary practices. Rapid accumulation events of a large number of bones often indicate the presence of feasting, as feasting activities typically involve an ample, sometimes extravagant, supply of meat that is consumed quickly, resulting in a large amount of waste generated at once. In contrast, ordinary mundane consumption requires an extended period to accumulate a richer burial deposit (Hayden 1996), which was often expressed in archaeological contexts as stratification in pits or trenches.

2.4.3 Formal deposition?

Formal deposition, the phenomenon that archaeological items were deliberately placed in ‘structured’ or ‘special’ deposits, has long been suggested for the British Neolithic (Rowley-Conwy & Owen 2011). Its specific archaeological manifestations might be “vertical sides”, “chalk rubble”, “bones packed against the walls”, “wickerwork lining”, “bowl-shaped” (Manby 1974). The earliest statement was from the ditches of the Early Neolithic causewayed enclosure at Windmill Hill (Smith 1965, 20), this was also found at other Late Neolithic monument sites (e.g. Thomas 1999) and Rudston Wold pits. Rowley-Conwy and Owen (2011) argued that this kind of formal or “structured” deposition of animal bones might indicate a single event of ritual consumption and deliberate disposal—feasting.

2.4.4 Special locations or links with other features

Examining the special location of faunal deposit and their coexistence with other features can reveal crucial information about the place, scale, host’s identity, as well as the

purpose and nature of the communal event. Central plaza, palace, monuments, large houses/rooms with leveled ground (e.g., the great kiva used by Pueblo people in Chaco Canyon, **Figure 6-2-3**), or other sacred or public space (e.g., Metzger 1970), provide suitable venues for hosting large public events. Such feasting events often involved a large scale and numerous participants and may have a cooperative function for strengthening community cohesion (Wiessner 2001). Additionally, a large animal bone assemblage near the foundations of large buildings is very likely to be the remnants of rites held to celebrate the commencement, completion, or subsequent use of the structure.



Figure 8-2-3. The overlook of Pueblo Bonito (left) and great kiva (right) in Chaco Culture National Historical Park, northern New Mexico, USA. It was built by the Ancestral Puebloans who occupied the structure between AD 828 and 1126. Photo were taken by the author when visiting.

2.5 Cultural artifacts

2.5.1 cooking and eating vessels.

Cooking and eating food are the most pivotal part of feasting activities, naturally leaving behind for various cooking pots and serving vessels. An unusual variety of cooking or serving equipment can be present (Powers & Powers 1984; Clarke 2001; Twiss 2008). Given the concentration of participants in feasting events, the number of utensils used for cooking and serving food is typically substantial. More specifically, the quantity of serving vessels may surpass that of cooking pots (VanDerwarker 1999). At the same time, these implements are expected to be larger than those used for domestic cooking to accommodate

more food or larger-sized dishes (e.g., Potter 2000). This is evident in ethnographical studies, such as the discovery of large feasting vessels with diameters exceeding 26 feet in Akha feasts (Clarke 2001) and the Puebloans large stew bowls and pots (Mills 2007).

2.5.2 ritual and performance items

According to ethnographical records, feasts are frequently characterized by singing, dancing, drama, music, games, orations, or other kinds of performances (e.g., Rappaport 1968; Powers & Powers 1984; Jonaitis 1991; de Garine 1996; DeBoer 2001; Dietler 2001; Kirch 2001; Wiessner 2001). In the Northwest Pacific Coast, a vivid description of the potlatch scene can be seen. “I sat in the big house, eyes filled with smoke from the central fire...”, “powerfully delivered orations memorializing deceased individuals filled the house.....”, “...the food was extraordinary: venison stew, grilled eulachon, salmon sandwiches, home-made breads and cakes”, “the tastes, the smell of smoke, the buzz of the crowd, the beating of drums, the swirling movement of the dancers, the bright red yarn headbands that everyone, even I, wore through part of the celebration, all became part of a single sensation of belonging.” “...the gift-giving touched me in a completely unpredictable way...”, “it took nearly an hour just to bring all the boxes containing potlatch goods out and place them on the big house floor...” (Jonaitis 1991).

Consequently, feasts are potentially marked by a greater possibility of finding ritual and performance items, such as masks, scepters, instruments, vessels with special shapes, sacred figurines (e.g., anthropomorphic plank-figure fragments at Troullia village in Cyprus [Metzger et al. 1970]; sacred stones and figure brought in Enga feasting site [Wiessner 2001]), religious paraphernalia (Perodie 2001), and, of course, the prepared goods for gift-giving if applicable. The appearance of items related to perfume, opium or other hallucinogens is also reasonable for feasting performance to heighten the blissful vibe (e.g., Bunimovitz & Lederman 2016). Sometimes, to emphasize the special nature of the event, intricate

decorations are applied to utensils, signifying their role as dedicated implements for ritual activities (e.g., decorated ceramics in Prehispanic Philippines, Junker 2001). Additionally, the destruction of wealth or prestige items is likely to happen at these feasts (e.g., destroying canoes, blankets, and other properties during the Kwakiutl potlatch [Boas 1966]).

2.6 Drinking

2.6.1 brewing/drinking artifacts.

During the feast rituals, eating meat is always accompanied by beverage drinking, whether in ancient or modern societies. The significant role of beverage drinking during the feasting rituals has been widely recognized (Jennings et al. 2005; Dietler 1990, 2006; Twiss 2008; Liu 2021). The production and consumption of alcohol or other beverages (like cacao) are often archaeologically visible via artifacts associated with brewing, such as ceramic strainers or jars with distinctively eroded interiors, or artifacts associated with consumption, such as cylinder jars, long straws or drinking horns (Katz & Voigt 1986; Dietler 1990, 2001; Arthur 2003; Jennings et al., 2005; Crown et al. 2015). Archaeological examples can be found from ceramic vessels of Chicha feasting drinking in the prehistoric Andes (Jennings 2004; Jennings et al. 2005), cylinder jars of cacao and holly beverage drinking in Chaco Canyon (Crown et al. 2015; Crown 2018), as well as the flat-base amphorae and conical-base amphorae for beer fermentation along the Neolithic middle Yellow River in China (Liu 2021; Liu et al. 2020a, 2020b).

2.6.2 organic residues

Another line of archaeological evidence associated with beverage consumption comes from the residue analysis inside ceramics. Organic residues found inside fermentation and drinking vessels provide the most direct evidence for beverage consumption and can even reconstruct the production methods of the beverage (McGovern et al. 2005; Crown et al. 2015; Liu 2021; Liu et al. 2022).

It should be noted that the presence of drinking remains (both residues and brewing vessels) does not necessarily imply the presence of feasting; it might only indicate the discovery of a brewery or remnants from other drinking activities. However, if evidence of drinking was found concurrently with animal remains of feasting, it would form an extremely convincing combination. Furthermore, the current discovery of beverage residues in archaeological sites can be used to infer the possible presence of feasting animal remains at the same site, providing feasible directions for narrowing down the search for feasting activities in the future.

2.7 Auxiliary facilities

The animal bone remains left from feasting activities did not exist in isolation. Ethnographic studies indicate that feasting sites would leave behind some immovable features, along with auxiliary facilities to ensure the successful execution of feasting events. These may include open-air hearths or ovens (e.g., Ben-Shlomo et al. 2009), food storage facilities (such as cellars or refrigerators, and even animal pens, which can be regarded as a facility for storage on-the-hoof [Twiss 2008:419]), temporary structures, and more (Knight 2001). Furthermore, although we cannot directly prove it through archaeological evidence, the ample labour and effective social organizational structure are also prerequisites for ensuring the smooth conduct of feasting. This requires the introduction of more evidence from paleo-demography and social archaeology. The issue of gender roles manifested in feasting of the American Southwest has also been discussed (Potter 2000).

3. Distinguish feasting from other activities (recognition by comparison)

As mentioned earlier, the definition of feasting is somewhat confusing. The complexity of theoretical frameworks inevitably leads to challenges in distinguishing feasting from similar archaeological remains, either conceptually or in terms of archaeological manifestations. Hayden and Villeneuve (2011: 440) also pointed out that “middle-range

material correlates have received surprisingly little attention”. Distinctions between rituals, feasting, sacrifices, offerings, and other similar phenomena are generally undefined. Therefore, in addition to defining feasting and summarizing characteristics of it, conducting comparative analyses of the abundant faunal assemblage resulting from feasting and other behaviors or purposes becomes crucial. This helps to clarify the distinctive features that allow us to identify feasting confidently and successfully.

3.1 Feasting versus Potlatch

Potlatch is very similar to what we define as “feast” in terms of the occasion and reason in which the events take place. Although similar, feasts and potlatches were clearly distinguished in terms of some socio-behaviors. According to Jonaitis (1991), “feast was a gathering to which people were invited to share foods, while a potlatch was one to which they were invited to receive “gifts” (perhaps better defined as payments) of nonperishable goods—property. A potlatch was usually accompanied by one or more feasts, but a feast could be given without a potlatch.” But what we need to realize is that this is only a conceptual difference which means that we can just separate them from theoretically anthropological aspect rather than from archaeological material findings.

3.2 Feasting versus sacrifice

The concepts of feasting and sacrificial activities are often blurred, especially in the early stages of human civilization. Many scholars intertwine these concepts in their descriptions or explanations. This is because, to some extent, sacrifice of animal meat is often also a form of banquet, but its primary recipients are ancestors, gods, and spirits, rather than living people (e.g. in Roman sacrifices, the priests thought that the gods mainly liked the smell of roasting meat. So, via the sacrifice, the gods got the smoke, and the people could eat the meat). The main distinction between two of them lies here.

Apart from significant festivals, occasions, or behaviours with the intention of people, many feasting events derived their motivation or occasion from sacrifice associated with deities or ancestors originally. Feasting is often an expression of sacrifice; on the other hand, sacrifice is the motive and context for holding feasting. These two aspects were mutually influenced in the ancient societies. Generally, a banquet is integrated into the entire set of sacrifice activities. People engage in eating meat, presenting offerings, primitive dances, and other activities as a means of worshiping deities. Furthermore, the primary motivation for many festivals came from the worship of ancestors and deities, such as Qingming (Tomb-sweeping) Festival in China, Thanksgiving in the Christian world, the Day of the Dead in Mexico, etc.

Archaeologically, the animal bone remains from feasting are left after being consumed by people; in contrast, those from sacrifice are never consumed and characterized by specific body parts (such as mandibles, right forelimbs), complete or relatively complete skeletons. Additionally, they are often found in association with specific features such as burials or building foundation. Totally new, unused, and over daily level ceremonial objects would also be involved in sacrifice, and in the case of ZHGC, this is manifested in a complete set of bronze vessels, bronze chime-bells and sacrificial horses.

3.3 Feasting versus large dumping place of common waste

In field archaeology, a large bone refuse pit seems to be the most primary and direct evidence suggesting feasting. However, at the same time, it is well known that ancient people sometimes disposed of everyday consumption waste in one pit or trench continuously. Although the quantity of waste from daily animal consumption in each instance may be small, the accumulation over time can result in a considerable deposit of animal remains. Differentiating between the two—ritual bones or common waste—is a crucial aspect of identifying feasting. In archaeology, there are several distinctions between the two.

- Large common waste pit would usually be stratified as this deposition was formed for a long time, while feasting was a one-time discard.
- Common waste would show a relatively higher diversity of species composition, while feasting was consistent.
- Common waste would show a much higher fragmented level of bones as people need to maximize the nutrition intake, while feasting wastes were relatively intact implying a surplus.
- Common waste would show a heavier weathering condition as these refuses experienced long-time exposure, while feasting waste was preserved well.
- Common waste showed more human/animal-caused marks on bones, such as tramping and dog/mouse grinding marks, while feasting hardly.
- Many other daily necessities would appear in common waste debris, not in feasting debris.

3.4 Feasting versus slaughterhouse

As for a slaughterhouse, it is also a place where a large number of animal bones would be found. A key archaeological criterion for differentiating feasting remains and slaughtering remains is the faunal element occurrence frequency. More heads, hooves, lower jaws and other parts with less meat would be left in the slaughterhouse while elements with more meat would be consumed by feasting. Additionally, the faunal assemblage of the former might exhibit a higher level of weathering.

3.5 Feasting versus food-sharing

The discussion about these two mainly focuses on the abstract conceptual level. Feasting derived from food-sharing originally and is essentially a form of food-sharing. The relationship between the two is that the latter encompasses the former. For instance, when generous sharing of today's hunt occurred among Stone Age hunters, and if it just involved

sharing raw meat during butchering, it remains food-sharing. However, if the host provided cooked food and drink to invite people to gather around to consume it, this might constitute the prototype of a feast. Food-sharing describes the process of redistribution, while feasting emphasizes the synchronous consumption of food among people. The key differentiator between the two lies in the simultaneity of food consumption and the rituality or purpose endowed in feasting practices.

3.6 Feasting versus trophy accumulation

Hayden (2016) has argued that the trophying of certain bones can be indicative of feasting and may be observable in archaeological contexts. However, Rowley-Conwy (2018: 5) offers a contrasting viewpoint, stating, "While arrays may result from feasting, they certainly do not have to – and in particular, trophy arrays give no indication of the scale of any feast." Some large feasts indeed could lead to numerous items being trophied at one time. Nevertheless, the archaeological deposit of trophy arrays is often the outcome of long-term, or even multi-generational accumulation, comprising singular non-meat elements of animals, such as pig mandibles (e.g., Gotland site by Rowley-Conwy & Dobney 2007; New Guinea groups by Rowley-Conwy 2018: Table 1 & 2), cattle skulls (bucrania) (Pearson 2010; Robin 2017) and water buffalo horns (Adams 2005). These trophy accumulations are distinct from the one-time meat consumptions associated with feasting events that we defined here. If introducing the trophy bones as an attribute of a feasting, it might inevitably cause some confusedness. Of course, some feasts are indeed companied with trophy arrays display (Clarke 2001, Twiss 2008), it should be noted, however, that trophy bones are not the faunal refuse results of the feast consumption, they are two separate events.

4. Discussion

The summarized archaeological attributes of feasting, along with comparisons with similar behaviours above, reveal a highly intricate concept that spans various aspects, ranging

from animals to plants, from utilitarian ceramics to ceremonial items. It should be noted that, despite many features displaying convincing ritual signals to highlight the event's distinctiveness, such as the use of specialized prestige items and the presence of luxury ingredients, we need to be clear that these attributes are acting as embellishments and need not be necessary conditions for identifying feasting. Many attributes actually exist in parallel or are mutually substituted. Grasping the essence and core aspects of feasting, such as "one-time mass consumption," "surplus", or "food sharing", to assembly the evidence package, is the key to effectively extracting information from archaeological data.

Section 3 Current Status of Feasting Research in China and Reasons

1. Feasting research in China

1.1 Dietary archaeology and classic description

China, with its rich culinary culture and traditions, intertwines the concept of "eating" with various aspects of social life, ranging from everyday activities to events across different social classes, such as weddings, funerals, festivals, family gatherings, and political ceremonies. In fact, there has been a long history of research on dietary archaeology in China (Wang 1994, Xu 1996; Chang ed. 1977), exploring perspectives that include, but are not limited to, pottery, bronze artifacts, animals, plants, human bones, images (e.g., Dahuting mural painting **Figure 8-3-1**), and some latest methods like lipid residue analysis (e.g., Zhang et al. 2020; Zhang et al. 2022; Sun et al. 2023). Simultaneously, concepts like "Gourmet Politics" or "Cooking Politics" have gained prevalence, especially in studies addressing early state formation and the origins of civilizations (Li 2018; He 2021).



Figure 8-3-1. An ancient mural painting of a late Eastern-Han period (25-220 AD) Chinese tomb showing lively scenes of a banquet, dance and music, acrobatics, and wrestling. From the tomb of Dahuting (Chinese: 打虎亭汉墓) in Zhengzhou, Henan province, China. Source: Chinaculture.org. Accessed on 10 December 2023.

As one of the earliest classical descriptions of feasting (Hayden & Villeneuve 2011), the scene of worshippers offering ancestors wine, soup, and first fruits from the paddies in Shang China has been noticed by western scholars (Waley 1996: 316). While distant from archaeology, another field that can significantly contribute to the classic description of feasts in China is literary studies, particularly the examination of ancient feast poems (e.g., Chen 2012). This focus is primarily directed towards the poetry collection *Shijing*¹⁸.

Based on the above introduction, it is evident that Chinese archaeologists have not lacked attention to the study of foods, mundane or ritual. Research on dietary archaeology emerged early and has consistently received widespread attention. Chinese archaeologists also possess a profound understanding of the close connections between food and ancient politics, culture, and society. However, "dietary archaeology" seems to be a relatively broad concept, encompassing all aspects of residues related to eating and drinking, there is lacking a constructed theoretical framework like anthropological "feasting theory" to guide archaeological studies. In other words, the majority of existing work focuses on studying "food and diet" rather than the "feasting".

1.2 Ethnographic feasting in China

China, with its vast territory and diverse ethnic groups, preserves numerous dietary traditions and customs across different regions, providing fertile lands for ethnographical studies. Many ethnological and anthropological investigations included detailed records of feasting, such as representative local dishes, preparation methods, and the processes and scales of special festival feasts (e.g. Han Chinese farmer feasts in Xiangxi [Chau 2004, 2006]; the Hani group in Yunnan [Abe 2020]; the Bai group in Yunnan [Wang 2011]). Among these, the pivotal role of pigs in feasting events were always highlighted, especially for the winter feasts. In various rural areas of China, pig feasts have long served as essential rituals

¹⁸ The *Classic of Poetry*, also *Shijing* or *Shih-ching*, translated variously as the *Book of Songs*, *Book of Odes*, or simply known as the *Odes* or *Poetry* (詩; *Shī*), is the oldest existing collection of Chinese poetry, comprising 305 works dating from the 11th to 7th centuries BC (from Wikipedia, access on Jan 5, 2024).

fostering reciprocal exchanges among interdependent farming households. Referred to as “*sha nian zhu*” (roughly translated as “annual killing of pigs”), these annual reciprocal feasts traditionally played a crucial role in maintaining community identities, providing mutual aid, and strengthening social bonds. In Northeast China, pig feasts are known as “*shā zhū cài*” (translated as “killing-pig dishes”), featuring representative traditional dishes like pork stew with vermicelli, pickled vegetables, and blood sausage. In the eastern Sichuan, Chongqing, Guizhou, and other areas, a similar pig-eating custom persisted. Many ethnic minorities in Yunnan also attach great importance to pig slaughtering ceremonies for guest feasting. The *Yi* ethnic group in Sichuan, for example, holds a pig-slaughtering ancestral ritual before their lunar New Year feast in late October.

During a field investigation in Shuanglang Town, Dali Bai Autonomous Prefecture, anthropologists were invited by locals to partake in a pig feast. The household-host slaughtered two pigs, both of which were raised on their property in pens, each weighing around 250 pounds. They invited 12 tables of guests, with each round table accommodating 8 people, totalling approximately 96 attendees. The cooking was done on a temporarily prepared open hearth and less than 10 relatives or neighbours assisted with cooking on-site (only those who were involved in the cooking on the event day, as the pigs were slaughtered and partially prepared at a slaughterhouse the day before). The perishable parts of the pig, such as the head and internal organs, were cooked in the dishes. Excess pork was cured into bacon for consumption in the following year, and the rendered fat would be sufficient for the household's consumption throughout the following year. Other wealthier families might slaughter and prepare four to seven pigs for this feast. Meanwhile, guests reciprocated by bringing rice, eggs, and cash gifts to the hosts. The ceremonial process involved entertainments such as games, ritual dances, and other festivities. (Wang 2011)



Figure 8-3-2. Portfolio of the traditional “*sha nian zhu*” (annual killing of pig) custom and pig feasts host by rural households in Changning County, Yunnan Province, China. Photo taken by Weibo account: Chang Ning Yi Ran, access on 22 Dec. 2023.

1.3 Archaeological feasting in China

As an imported concept, the introduction of the theoretical framework of archaeological feasting was primarily accomplished through the translation of relevant articles and works. Martin Jones' s *Feast: Why humans share food* (2008) was translated into Chinese by Chen (2009). Hayden's paper arguing the relationship between plant/animal domestication and feasting (Hayden 2003), and Potter's article named "Pots, Parties and communal feasting in the American Southwest" (Potter 2000), were also translated by Chinese theoretical archaeologists (Hayden 2019; Potter 2020).

In fact, some western scholars have noticed the academic potentials of feasting studies in China, such as Nelson (2003) and Reinhart (2015), discussing the funeral feasts in Bronze Age China and feasting potteries in Yanshi Shangcheng (Shang Dynasty, 1600 BC-1045BC) separately. Despite occasional appearances of feasting-related themes, the discourses have primarily revolved around ceramic studies (Reinhart 2015, 2016, 2020; Reinhart & Edge 2020; Reinhart et al. 2018; Reinhart & Sun 2018; Reinhart & Sun 2019a, 2019b) and inscription on bronzes (e.g., He 2022). By contrast, the detailed archaeological exploration of feasting activities in China from the perspective of animal remains is much scarcer. Up to now, there were only two reliable and logically rigorous case studies focusing on the prehistoric zooarchaeological remains as references.

The first case study came from the Xipo site (belong to Middle Yangshao Culture, dating about from 6000 BP to 5500 BP), Lingbao, Henan, where Ma (2005, 2007, 2008) found that the pig remains in some ash pits like H22 (MNI=53) and H110 (MNI=23) were unusually concentrated. He analysed this set of animal bones separately from the perspectives of surface traces and fragmentation degree. The low surficial weathering levels and few animal-caused traces both pointed to the rapid covering after being discarded, suggesting this might result from large feasting events rather than the everyday consumption. In addition, the

adjacent ash pits to the structure F102 suggested a link between the two, with the significant quantity of pig bone remains within the ash pit likely being discarded refuse from feasting activities held by the occupants of the large house (Ma 2005). Additionally, the discovery of some extra-large houses, as interpreted by Ma (2008), were constructed for hosting large public events (like feasting). They were used to aim at reinforcing internal community identity and cohesion, providing indirect evidence for the occurrence of feasting activities.

In another case, the evidence chain was more complete. During the fourth phase of the Houtaomuga site (5500-5000 BP) in Jilin, concentrations of steppe bison (*Bison exiguus*¹⁹) bone remains were discovered in two ash trenches, which Zhang (2015) suggested were highly likely to be associated with prehistoric feasting activities. Firstly, the vast quantity of bison skeletons is notable, with at least 50 individuals unearthed from a single ash trench (G2) (**Figure 8-3-3**). It is considered that bison were an uncommon meat resource in the local context. Simultaneously, the distribution, low degree of weathering, and other features implied that these bone remains were the result of short-term or one-time deposition. The higher frequency of meaty elements indicated this was a consumption location rather than a butchering site. Additionally, the overall low fragmentation of bones and the presence of connected joints also indicated the result of lavish feasting activities.

¹⁹ Based on the latest paleontological result, these bison fossils were regarded as the steppe bison, *Bison priscus* (Bojanus, 1827). The thought that fossil bison from northeast China were included in the species *Bison exiguus* (Matsumoto, 1915) was thought to be problematic (Tong *et al.* 2013). FYI: the steppe bison was over 2 m (6 ft 7 in) tall, reaching 900 kg (2,000 lb) in weight (McPhee 1999).

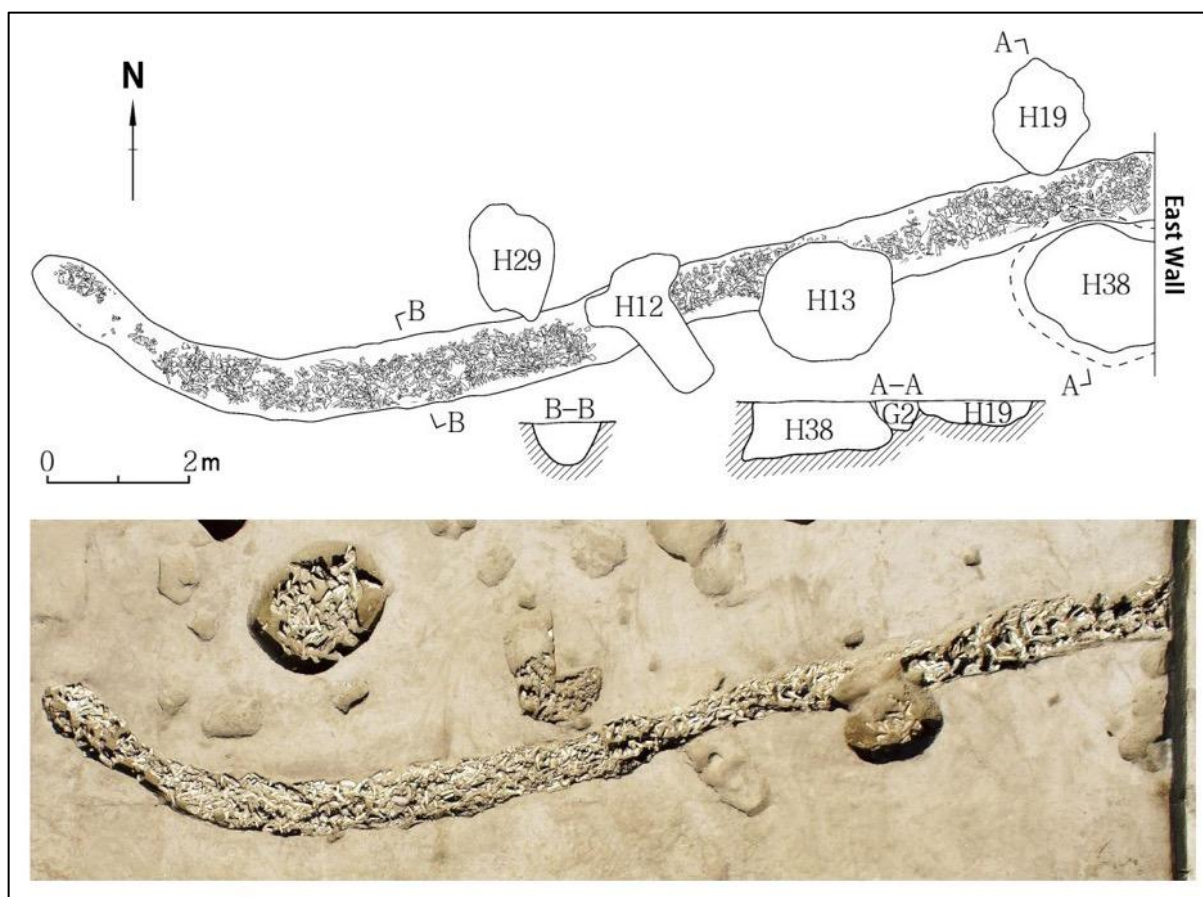


Figure 8-3-3. The plan and cross-sectional diagram of trench G2 at Houtaomuga site, with a large quantity of bison remains found within it, indicating a feasting event (adapted from Zhao et al. 2017).

After these two attempts, there was a significant gap. In recent years, there has been only one literature review regarding the prehistoric feasting concerning faunal remains in China (Zhao & Li 2022). But it did not offer any new data.

However, in a stark contrast to the scarcity of evidence from zooarchaeology, there is a well-established subfield of feasting in China: the study of alcohol. China is well-known for its distinctive techniques in alcohol fermentation, the earliest work concerning organic residues of alcohol in China was conducted by McGovern (McGovern *et al.* 2004, 2005), and then this research was carried forward by Li Liu and her team at Stanford, with most of the relevant research coming from this team. By now, there have been numerous Neolithic sites in China revealed the alcohol remains, such as Jiahu site (McGovern *et al.* 2004), Huizui site (Liu *et al.* 2019a), Guantaoyuan site (Liu *et al.* 2019b), Lingkou site (Liu *et al.* 2019b, 2020a),

Banpo site (Liu et al. 2020b), Jiangzhai site (Liu et al. 2020b), Mijiaya site (Wang et al. 2016), Xipo site (Feng et al. 2021), Dingcun site (Liu et al. 2020c), etc. The topics surrounding alcohol including the development of beer brewing methods, changing forms of fermentation vessels, symbolic meanings of surface decoration on brewing vessels were discussed, and the underlying dynamics of the intensified ritual activities involving communal drinking were also emphasized (Liu 2021).

1.4 Conclusion

In conclusion, although recent studies of the fermented beverage were witnessing a prosperous development, the overall status of feasting research in China from the perspective of zooarchaeology, remains in an exploratory stage, exhibiting certain gaps when compared to the thriving situation in other regions around the world. This is not to claim that feasting has been completely ignored in the earlier archaeological and anthropological literature, or that significant insights have not been forthcoming. However, these earlier works generally included analyses of feasts as peripheral observations: they did not generate a systematic theoretical exploration of the subject and they failed to engender a sustained archaeological pursuit of their implications. Coincidentally, this seems to be very same as the feasting's development dilemma that Dietler and Hayden (2001) ever worried about two decades ago.

Certainly, I have also carefully considered whether the situation in China differs from that in foreign countries, and whether directly applying this theoretical framework is feasible. However, the various ethnographic and archaeological evidence mentioned above clearly indicates that feasting was undoubtedly widespread in ancient China and holds significant academic potential. As for the reasons behind this gap, I will attempt to explore them based on my personal experiences in the following section.

2. “Mind the gap”—why a gap in the zooarchaeological feasting research in China?

2.1 Misconception of feasting

Firstly, let us start with the term "feast" itself. This word is widely used in daily life and carries a secular meaning. Thus, although the term "feast" may appear in some research texts, it may not be the subject we are currently discussing. This observation is equally applicable in the Chinese context.

Furthermore, there is a lack of simplification in the introduction of archaeological theory. As Hayden (2014:11) aptly puts it, "feasts are polysemous". Even in anthropological concepts, feasting can be both simple and profound. However, it seems that Chinese scholars initially grapple with the more intricate aspects of feasting theory (such as competitive feasting versus solidarity feasting). In the dissemination process, the complex anthropological theoretical framework and its disconnection from archaeological materials make feasting seem like an unattainable subject, fostering a sense of fear among recipients, thus leading them to avoid using this concept. Simultaneously, this limited goal would exacerbate the laziness of archaeologists (Taylor 1983). However, in reality, as I defined feasting in Section 1, it is an extremely easy-to-understand concept, and we all know that it is indeed widespread.

This misunderstanding of the concept of feasting exacerbates the ineffective dissemination and application of anthropological theory in China. So, when searching for faunal materials for this project in China, many excavation leaders held pessimistic or dismissive attitudes. They believed that the concept of feasting is not applicable to China (perhaps because they often first considered the complex factors in feasting, such as how to determine if it is competitive), not to mention arguing from the perspective of animal bones. However, we all know that animal bone material may provide the best way of seeing feasts in the archaeological record (Rowley-Conwy 2018). There were also some scholars suggesting that it is more practical to conduct image studies of "banquet" instead of finding faunal

materials, indicating that many people's acceptance of the concept of feasting still remains in the early classical description stage rather than in the anthropological sense of feasting.

2.2 Induction vs. deduction: rethink on Chinese archaeology's paradigm.

We must acknowledge the rapid progress in archaeological and zooarchaeological research in China over the past 20 years. However, based on my personal observations as a practitioner, a significant number of zooarchaeological reports in China still follow established paradigms guided by culture-historical archaeology. Although some Chinese scholars have pondered on these paradigm issues concerning the archaeological research (Chen 2009, 2018, 2019; Chen 2021), I believe that the Chinese academia is still, to some extent, influenced by these cognitive patterns, and meanwhile, this could also become an obstacle to the development and spread of feasting research in China.

From the fundamental perspective of scientific research methods, Chinese archaeological research relies more on inductive reasoning due to its culture-historical traditions. This approach attempts to find commonalities in archaeological materials to derive general conclusions. In contrast, the rise of Processual archaeology and Middle Range Theory in the United States in the 1960s introduced the hypothetico-deductive model to archaeological research (Binford 1962; Trigger 1989; Willey & Phillips 2001). Feasting studies rely more on deductive reasoning. For example, when encountering a large animal assemblage with ambiguous characteristics, researchers might first hypothesize that the assemblage resulted from a feast and then seek evidence from ethnographic archaeology to validate if it aligns with feasting characteristics. The neglect of feasting in the animal perspective stems precisely from these divergent logical reasoning methods. For Chinese scholars who are adept at using inductive reasoning, the proposition of "feasting" seems more like a consequence, a somewhat inverted approach.

The challenge lies in the difficulty of implementing feasting studies. As argued earlier, the concept of feasting is not universally accepted or accepted "correctly" by Chinese scholars. Consequently, when faced with a batch of potentially relevant materials, the hypothesis of feasting cannot be easily introduced in practical terms. This naturally results in a loss of the premise and direction to explore and verify it. In cases where feasting hypotheses survive, like the bison remains in the Houtaomuga site, it's not solely due to the author's strong academic acumen, but also because the feasting signal in these instances is exceptionally strong. In contrast, many materials with less pronounced signals or with multiple strong signals might be broadly categorized under the vast umbrella of "rituals".

2.3 Tradition of Chinese archaeology serving for history and for burials.

In the last century, Chinese archaeology has experienced a significant influx of Western influence, adopting Western theoretical frameworks while also cultivating its own traditions. However, two inherent traditions may hinder the broader impact of feasting research in China.

The first is the historical orientation of Chinese archaeology, lacking guidance from anthropological theories. The tendency to "emphasize material evidence over theoretical considerations" has been a persistent issue in Chinese archaeology. As someone who has been educated within the Chinese archaeological system, I deeply understand the fundamental reasons behind this. China has been experiencing rapid urbanization and numerous infrastructure projects, and the abundance of archaeological resources has earned global recognition. Consequently, Chinese archaeologists often find themselves engrossed in managing various excavation projects and organizing foundational data, leading to an overall lack of a conducive environment for theoretical absorption and innovation, although there have been some improvements in recent years. As we know, the study of feasting primarily originated from ethnography and anthropology, constituting a topic heavily reliant on

theoretical guidance. Therefore, this could be a challenge and barrier to the widespread promotion of feasting research in China.

Another potential reason is the traditional emphasis on burial research in Chinese archaeology. Nelson (2003: 65) discussed about the feasting in China as: “Rather than constituting a means of cementing alliances, producing Big Men, and organizing for war.....The evidence for graveside feasting in early Chinese society suggests that enlisting the aid of the dead was of greater importance than forming alliances with the living.”

The notion of "treating the dead as treating the living" has been ingrained in traditional Chinese culture. People believe that the deceased should be treated in death as they were in life, which was reflected in the funeral settings. To some extent, the food-related offerings in burials can indeed reflect the daily life of the living in ancient China. However, what we define as the banquet specifically provided for the dead in the context of burial, strictly should be classified as offerings or sacrifices rather than feasting. Nelson (2003: 65) also acknowledged that “it seems to be feasting of a different nature than that described in the classical anthropological literature,” indicating that the "banquet" in offerings to the deceased in burials is not the anthropological feasting we explore in this article.

The tradition in Chinese archaeological research emphasizes typological studies of artifacts and burials. Therefore, funeral artifacts and animal remains in burials are more easily noticed and can be more directly defined as ritualistic and unique. While this "treating the dead" constitutes a significant portion of ancient Chinese society, it does not mean that feasting for the living did not exist, nor that it was unimportant. On the contrary, various feastings played a crucial role in the cultural connections and socio-political ecology in ancient China, though, few of them were archaeologically recognized. I must admit that this reflects a criticism of the current development of Chinese archaeology: much of the work remains at a relatively basic and superficial level, busy dealing with relatively direct and

simple logic relationships among cultural remains. The burial offering seems to be a more straightforward ritual expression, while feasting for the living, which is more complex and requires more argumentative processes, is always being overlooked or postponed.

2.4 Disconnection between zooarchaeologists and excavators.

The importance of the original context information supplied from excavators was re-emphasized here. In sum, no matter how rigorous and imaginative the faunal analyst, the quality of zooarchaeological insights into consumption will rarely be better than the quality of information on archaeological context made available to the specialist—usually by the excavator.

However, unfortunately, due to the rapid increase in infrastructure construction in China, it is not feasible to have a zooarchaeologist at every archaeological excavation site. Faunal materials are often handled by zooarchaeologists only after the excavation is complete, or even much later. This process results in significant loss of original information, including damage to recorded data, blurred memories, or communication failure. This is particularly detrimental to feasting studies that heavily rely on excavational context. The disconnection might become a primary reason why many feasting remains were overlooked in past decades in China.

CHAPTER 9 Faunal Remains as Evidence for Feasting

With the discussion of feasting in the previous chapter as a premise and theoretical basis, in this chapter, I will apply these theoretical frameworks to some specific case studies. Several “abnormal” faunal deposits that might be correlated to feasting rituals in ZHGC will be introduced and analyzed here. As we mentioned, many of the small-scale feasting events are invisible archaeologically, because it is difficult to distinguish them from mundane refuse. Thus, the likely feasting assemblages that we will discuss in this chapter are all “abnormal” enough to be archaeologically visible. Through the context introduction, faunal assemblages’ reconstruction, details description, and any other further analysis, such as the age at death, fragmentation level, element occurrence frequency, marks on bones, and so on, it is aimed to settle down a series of questions including but not limited to “if there was ever a feasting”, “why it might be related to feasting”, “who might be the host of this event”, “what this feasting event would be held for”, and “how many people might attend”, etc.

Section 1 Case study: No.1 Mess-Bone Pit at RDC

1. Excavation

The No.1 Mess-Bone Pit was in the middle of the northern half of RDC site. The excavation area of RDC was in the south of the eastern city of ZHGC, adjacent to the road leading to Baimiaofan Village in the east, Shenzhuang farmland in the southwest, and JCL site in the north (see **Figure 9-1-1**). The terrain was slope-like as a whole, with the south, north, and east sides being high and the northwest corner being low.

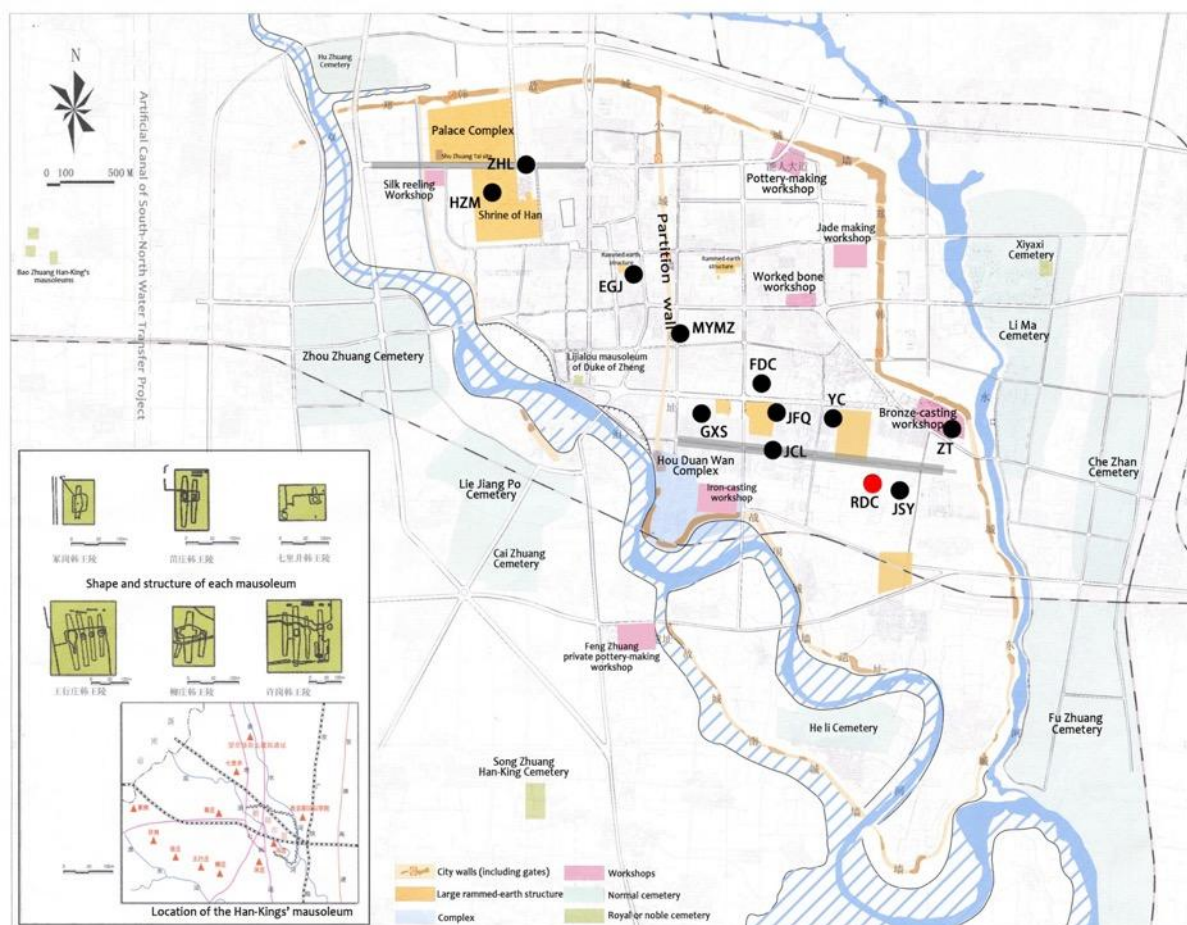


Figure 9-1-1. The location of RDC site (red dot) where No.1 Mess-Bone Pit located in.

The No.1 Mess-Bone Pit was unearthed on May 7th in 1996. The excavators first removed the upper disturbed-soil layer and dug down 0.5 meters to find the pit. The general shape of the pit is oval, 2.8 meters long and 2.6 meters wide. The northeast corner of the pit was broken by two robbery holes and an unnumbered ash pit. After cleaning them, a set of

well-preserved large-sized mammal bones were found, in a concentration. But they were all individual bones rather than complete skeletons, so it was named the No. 1 Mess-Bone Pit (**Figure 9-1-2**). There were no artefacts, like pottery sherds, found in this pit, just the animal bones. Thus, the No.1 Mess-Bone Pit cannot be dated topologically based on pottery, and radiocarbon dating is also lacking. However, based on the overlapping strata as well as the link with surrounding features, the excavators speculated that it should belong to the Warring States Period.



Figure 9-1-2. No.1 Mess-Bone Pit excavation scene and the condition of faunal assemblage in situ (*pers. comm. Cai*).

2. Faunal Assemblage

There were in total 501 faunal specimens found in the No.1 Mess-Bone Pit, weighing 23641.3g. Besides 27 pig bones and 2 phalanxes of Ovicaprids (sheep/goat), the remaining 472 specimens (accounting for 94.2%) exclusively belonged to cattle (*Bos taurus*). The information about the 27 pig bones is listed in the **Table 9-1-1**. The number of pig and caprine remains is relatively small, and given the context that this pit was looted, we cannot rule out the possibility that pig and sheep remains were accidentally introduced at a later stage. Including these 29 pig and sheep bones in the discussion before understanding the nature of the cattle bones would complicate the analysis. Therefore, the following detailed discussion will primarily focus on the cattle bones. In the conclusion, we will revisit pig and caprine bones' nature and discuss whether they came from the same event as the cattle bones.

Table 9-1-1.
Identification results of pig remains from the No.1 Mess-Bone Pit.

Element	Part	n	L	R	Weight	Fusion	Fragmentation
Maxillary	with P1-P4	1		1	17.6	-	-
Maxillary	with P4-M3	1		1	47.7	-	-
Maxillary	with P1-M3	1		1	58.8	-	-
Mandible	with P2-M1	1	1		21.4	-	-
M. fragment		4			18.9	-	-
Humerus		1		1	0	Both fused	c
Humerus		1		1	110.9	P. unfused	s
Scapula		1	1		18.7	-	h
Ulna		1	1		0	Fused	c
Ulna		1		1	0	P. unfused	s
Ulna	distal	1			56.1	Fused	h
Pelvic		3	2	1	110.9	Fused	1s1h1b
Pelvic fragments		2			22.1	-	-
Femur		1	1		0	Fused	s
Femur		2	1	1	181.7	Both unfused	c
Axis		1			18.5	-	s
Cervical vertebra		2			30.4	-	-
Thoracic vertebra		2			24.1	-	-

Note: the specimens whose weights showing “0” share the total weight with the immediately following ones. The fragmentation column demonstrates every element’s degree of fragmentation based on four levels: “c” for complete or nearly complete; “s” for slightly damaged (>3/4 left); “h” for half damaged (>1/2 left); and “b” for badly damaged (<1/2 left).

Due to the cattle in this pit being disarticulated, they were calculated as a separate assemblage rather than being put into the overall period quantification. In addition, since there was a lot of soil attached to the bones, bones were washed before the identification, so as to facilitate the subsequent matching work of the unossified diaphysis and epiphysis as well as to observe the subtle artificial marks on the surfaces (**Figure 9-1-3**). Next, the assemblage will be introduced according to anatomic elements to pave the way for the follow-up analysis and discussion.



Figure 9-1-3. The left picture is the scenario of cleaning soils on the bone surface, and the right one displays the scene where I categorized cattle bones based on elements from No.1 Mess-Bone Pit.

First, the cranial part. There are 71 cranial bones found, but because they were all fragments without any relatively complete skulls, MNE cannot be calculated, and the fusion condition of sutures cannot be recognized. As for the maxillary specimens, five were found with teeth, including one (L) with upper M1/M2, one (L) with upper M1-M3 (the M3 is erupting), one (L) with upper M1-M3 (the M3 is erupting), one (R) with upper P2, P3, dp4, M1-M2 (the P3 is erupting), as well as one (R) with upper P2 and M1 (the P2 is erupting).

Concerning the mandibles, a total of 18 specimens were found, with a Minimum Number of Elements (MNE) equal to 10 (see **Figure 9-1-4**). Specimens with teeth include three (L) with lower dp2-M2, one (L) with lower dp3-M2, one (R) with lower dp2-dp4, one (R) with lower dp2-M2, one (R) with lower dp4-M2. The tooth eruption level is uniform, all with visible M2s erupting.



Figure 9-1-4. Mandible specimens of cattle from No.1 Mess-Bone Pit. The left side displays the left mandibles and mandible fragments, four with teeth from top to bottom are: left mandible with lower dp2-M2, with lower dp3-M2, with lower dp2-M2, and with lower dp2-M2. The right part shows the right mandibles and fragments, three with teeth from top to bottom are: right mandible with lower dp3-M2, with lower dp2-dp4, and with lower dp2-M2.

Next, the limb bones. There are a total of 14 humeri, with a MNE equal to 9 (3 are left and 6 are right). As shown in the **Figure 9-1-5-A**, the proximal epiphyses of humeri are all unfused and distal epiphyses are either unfused or semi-fused (the whole distal epiphysis of one left specimen is unfused, including the trochlea and epicondyles, and most specimens with only epicondyle parts detached). A total of 10 ulnae were found, including 6 left and 4 right specimens (see **Figure 9-1-5-B**, not all ulnae were included). None of the proximal epiphyses were fused. There are 9 radius specimens found, representing a MNE of 9, with 5 left and 4 right ones. All radii are showing distal ends unfused, and two of them can be refitted (**Figure 9-1-5-C**). Scapulae are relatively more fragmented, representing a MNE of 10, with 6 left and 4 right ones (**Figure 9-1-5-D**). There are 16 femur specimens, representing a MNE of 9, with 5 left and 4 right ones. From the **Figure 9-1-6-A**, it can be seen that both proximal (including the femoral head and greater trochanter) and distal ends are unfused on all specimens, and a few epiphyses and associated diaphysis can be matched. A minimum

number of elements of 8 are represented by the 11 tibia specimens, including 4 tibias for each side. Like the femurs, the tibias all have both ends unfused, among which two epiphyses can be matched (**Figure 9-1-6-B**). As for the metacarpals and metatarsals, MNEs are calculated as 6 (3 for each side) and 7 (3 for left and 4 for right) respectively. All distal ends of metapodials are unfused and several epiphyses can be matched with their associated diaphysis (**Figure 9-1-5-E**).

For the axial skeleton, all elements have been found, including atlas vertebrae (MNE=5, see **Figure 9-1-7-D**), axis vertebrae (MNE=4, see **Figure 9-1-7-D**), other cervical vertebrae (MNE=12, see **Figure 9-1-7-D**), thoracic vertebrae (MNE=22, see **Figure 9-1-7-D**), lumbar vertebrae (MNE=20, see **Figure 9-1-7-E**), and sacral vertebrae (MNE=3, see **Figure 9-1-7-B**). Most of these specimens exhibit a surface disarticulation of the vertebral body. The three parts of the pelvic bones (ilium, ischium, and pubis) have fused. Numerous ribs were also found (NISP=74, MNE=40), but due to their fragile shape and damage during excavation, many are fragmented, making it difficult to assess the degree of fragmentation.



Figure 9-1-5. Portfolio of the cattle limb bones from No.1 Mess-Bone Pit, including (A) humeri, (B) ulnae, (C) radii, (D) scapulae, as well as (E) metacarpals and metatarsals.



Figure 9-1-6. Photographs of cattle femurs (A) and tibias (B) from the No.1 Mess-Bone Pit.

In addition, some short bones were also found, including the calcaneus (MNE=7) and astragalus (MNE=3), carpals and tarsals, phalanges (total MNE=19), as well as two patellae. Half (5/11) of the proximal ends of the first phalanges are unfused (**Figure 9-1-7-C**).

The data for the 472 cattle remains unearthed from the No.1 Mess-Bone Pit is summarized in **Table 9-1-2**. To sum up, these remains represent at least six individual cattle.

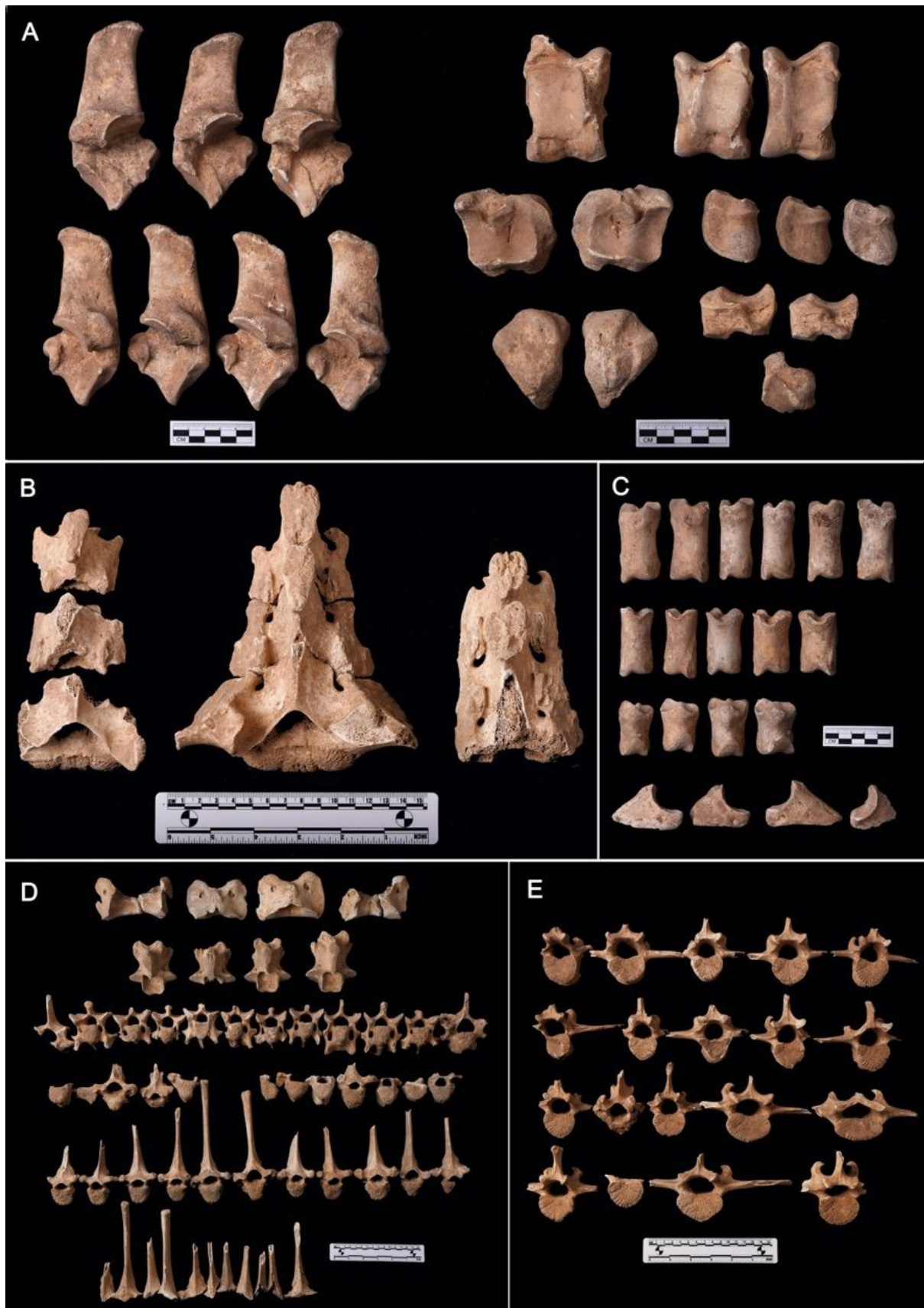


Figure 9-1-7. Portfolio of some short bones and vertebrae. Short bones include (A) calcaneus, astragalus, carpals, tarsals, and patellae, as well as (C) phalanxes. Vertebrae include (D) cervical vertebrae, thoracic vertebrae, (E) lumbar vertebrae, and (B) sacral vertebrae.

Table 9-1-2

Summary of cattle bones' quantity, fusion condition, fragmental condition, and reference images in No.1 Mess-Bone Pit

Elements	NISP	MN E	L	R	Fusion	Fragmentation	Image
Cranial bones	71	-	-	-	N/A	-	-
Maxillary	5	5	3	2	N/A	-	-
Mandible	18	10	6	4	N/A	-	7-1-4
Atlas	8	5	-	-	Fused	2c3b	7-1-7-D
Axis	4	4	-	-	Articular surface unfused	3c1s	7-1-7-D
Cervical v.	12	12	-	-	Articular surface unfused	11s1h	7-1-7-D
Thoracic v.	43	22	-	-	Articular surface unfused	9s3h10b	7-1-7-D
Lumbar v.	20	20	-	-	Articular surface unfused	17s2h1b	7-1-7-E
Rib	74	40	-	-	N/A	-	-
Sacral v.	5	3	-	-	Articular surface unfused	1s2h	7-1-7-B
Pelvic bones	13	7	5	2	All unfused	2s5h	-
Scapula	28	10	6	4	Fused	5s2h3b	7-1-5-D
Humerus	14	9	3	6	P. unfused and D. half-fused or unfused	5c2s2h	7-1-5-A
Ulna	10	10	6	4	Both sides unfused	8s2h	7-1-5-B
Radius	9	9	3	2	D. unfused	4c1s	7-1-5-C
Metacarpal	6	6	3	3	D. unfused	6c	7-1-5-E
Femur	16	9	5	4	Both ends unfused	5c1s2h1b	7-1-6-A
Patella	2	2	1	1	N/A	2c	7-1-7-A
Tibia	11	8	4	4	Both ends unfused	5c2s1h	7-1-6-B
Metatarsal	7	7	4	3	D. unfused	5c2s	7-1-5-E
Carpal	6	6	2	4	N/A	6c	7-1-7-A
Central tarsal	2	2	1	1	Fused	2c	7-1-7-A
Astragalus	3	3	1	2	N/A	3c	7-1-7-A
Calcaneus	7	7	3	4	P. unfused	7c	7-1-7-A
1 ST phalanx	11	11	-	-	Half P. unfused	10c1s	7-1-7-C
2 nd phalanx	4	4	-	-	Both ends fused	4c	7-1-7-C
3 rd phalanx	4	4	-	-	Fused	1c2s1h	7-1-7-C
TOTAL	413	235	-	-	-	-	-

Note: 1. The fusion column describes the overall condition of each element. “P” abbreviates for “proximal”, and “D” abbreviates for “distal”. 2. The fragmentation column demonstrates every element’s degree of fragmentation based on four levels: “c” for complete or nearly complete; “s” for slightly damaged (>3/4 left); “h” for half damaged (>1/2 left); and “b” for badly damaged (<1/2 left). 3. There are several kinds of specimens, including loss teeth, hyoid, unfused distal joints of metapodial (because it cannot be determined whether they belong to metacarpals or metatarsals), vertebral fragments, in total 59 specimens, are not counted here.

3. Discussion

3.1 Taphonomic condition

The assemblage is well-preserved. According to the weathering stage scale established by Behrensmeyer (1978), the entire faunal assemblage from No.1 Mess-Bone Pit displays a stage of 0, indicating that the bone surfaces show no signs of cracking or flaking due to natural weathering. In addition, there are no canine or rodent gnawing marks found on the bone surfaces. Both above signatures indicate that these bones were not exposed to the air for an extended time and were not disturbed in the post-depositional stage.

The cattle assemblage is relatively unmixed. It was shown above (in **Figure 9-1-5/6**) that many diaphyses and epiphyses of limb bones can often be refitted to form complete elements. For example, the middle three fragments in Figure 7-1-7-B refit well to form the sacral vertebrae, and there is no doubt they belong to the same element. However, a number of diaphyses and epiphyses cannot be refitted, raising the question of their associated counterparts' whereabouts. The pit was however broken into by two robber holes, which may account for the missing diaphyses and epiphyses. However, this is a later occurrence and does not affect the inherent nature of the remains. Furthermore, certain indications, such as a limited number of depositional episodes (e.g., a small 'minimum number of individuals' represented by many body parts), suggest that the bone assemblage is relatively unmixed (Dabney et al. 2004). This is also evidenced by the cattle bones, where an MNI of 6 is represented by 472 bones.

To sum up, this is a well-preserved and relatively unmixed cattle bone assemblage, covered rapidly after deposition.

3.2 Age and sex

According to the standard of age estimation based on long bone epiphysis fusion that was established by Silver (1963: 252 Table A), the six cattle individuals of the assemblage

from the No.1 Mess-Bone Pit are all aged about 18 months old. This age also accords with the tooth eruption result (Halstead 1985). The pivotal evidence for pinpoint the specific age is from the semi-fused status of the distal humeri. The surprisingly consistent mortality profile indicates that they were killed at the same time.

As for the sex, it is relatively harder to tell. However, based on the absence of any horn cores in the remains and the fact that all the discovered frontal bones are flat (showing no signs of horn growth), it is highly likely that these six cattle were all female. The consistency is also reflective in the sex composition of cattle remains.

3.3 Fragmentation

To quantify the fragmentation level of the cattle assemblage, four degrees were established, including the complete or nearly complete, slightly broken ($\geq 3/4$ left), half broken ($\geq 1/2$ left), and badly broken ($< 1/2$ left). The limb bones that are commonly used for marrow extraction and further exploitation for nutrition were those mainly focused upon. Their fragmentation degrees are illustrated in the **Figure 9-1-8**. It is evident that most of the limb bones are in a complete or nearly complete condition. The exception is the scapula, which exhibits a relatively higher level of fragmentation, largely due to its inherently fragile structure.

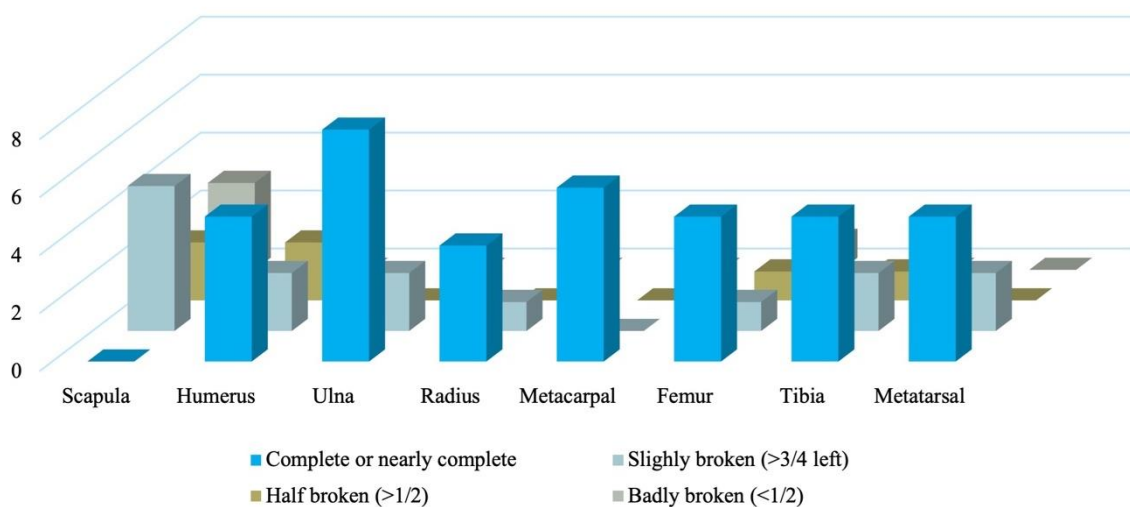


Figure 9-1-8. Distribution of fragmentation degrees for cattle long bones.

3.4 Artificial traces

By examining the surface marks on the bones, three types of artificial marks were identified on these materials.

The first type is cutting marks, characterized by shallow, short, dense, and parallel distributions. These are the most numerous and common artificial marks, found on almost every cattle limb bone. Marks located on the epiphyses, or the ramus of the mandible might be the result of disarticulation, while those on the diaphyses are more likely related to meat removal (samples in **Figure 9-1-9** except for the burnt one).

The second type is chopping marks, found on three mandibular rami, all of which were chopped at a specific angle, leaving smooth surfaces (see **Figure 9-1-4**). These are inferred to be from disarticulating the mandibles.

The third type is burning marks. The only likely burn mark was found on one metatarsal (see the middle picture in the second row), showing a blackened charred state. This indicates that the cooking method might have been by a barbecue. Of course, it is also very likely that this was the result of a coincidental fire after the event.

Overall, the artificial marks on the cattle bones point towards consumption purposes. The methods employed show consistency and were even possibly executed by the same butcher.



Figure 9-1-9. Portfolio of artificial marks left on cattle bones from No.1 Mess-Bone Pit.

3.5 Element abundance

The analysis of element frequency of cattle bones can provide insights into the nature of the remains and whether specific elements were selected for particular purposes. The measure MAU% based on MNE (Minimum Number of Elements) and MAU (Minimum Animal Units) is widely used to measure the relative abundance of elements, thereby reducing the deviation caused by transportation (Binford, 1984), regardless of sex and age. The quantitative results of MNE, MAU, and %MAU (as defined by Lyman, 1994) for cattle's

skeletal parts are presented in **Table 9-1-3**. A diagram depicting the abundance of each part (% MAU) is shown in **Figure 9-1-10**.

Although every element is present, it can be observed that two sections of the cattle skeleton have higher abundance: one is the mandible and the first two cervical vertebrae (i.e., atlas and axis), and the other is the limb bones. The high frequency of limb bones suggests that people might have selected the elements with more meat for consumption.

Table 9-1-3

The element occurrence frequency (%MAU) of cattle in the No.1 Mess-Bone Pit.

Elements	NISP	MNE	Expected	MAU	%MAU
Cranial bones	71	-	-	-	-
Maxillary	5	5	2	2.5	50
Mandible	18	10	2	5	100
Atlas	8	5	1	5	100
Axis	4	4	1	4	80
Cervical vertebra	12	12	5	2.4	48
Thoracic vertebra	43	22	13	1.7	34
Lumbar vertebra	20	20	6	3.3	66
Rib	74	40	26	1.5	30
Sacral vertebra	5	3	1	3	60
Scapula	28	10	2	5	100
Humerus	14	9	2	4.5	90
Ulna	10	10	2	5	100
Radius	9	9	2	4.5	90
Metacarpal	6	6	2	3	60
Pelvic bones	13	7	2	3.5	70
Femur	16	9	2	4.5	90
Tibia	11	8	2	4	80
Metatarsal	7	7	2	3.5	70
Carpal	6	6	12	0.5	10
Patella	2	2	2	1	20
Central tarsal	2	2	2	1	20
Astragalus	3	3	2	1.5	30
Calcaneus	7	7	2	3.5	70
1 ST phalanx	11	11	8	1.4	28
2 nd phalanx	4	4	8	0.5	10
3 rd phalanx	4	4	8	0.5	10

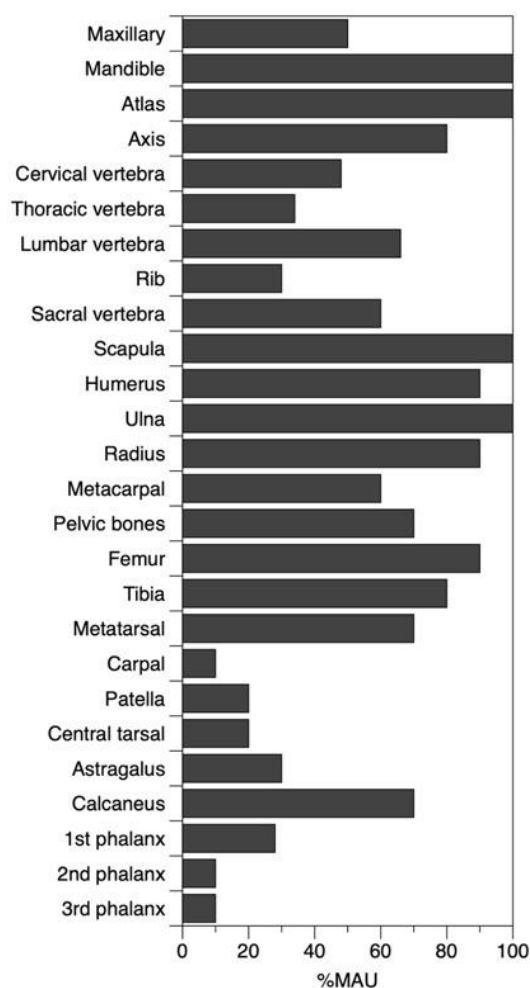


Figure 9-1-10. The distribution of cattle elements' occurrence frequencies.

3.6 Special diet?

Given the anomalous nature of the assemblage, it is necessary to examine whether these six cattle had different diets from others. Six different left scapulae were sampled for isotopic analysis. The Lab IDs for the samples, ranging from 1731/22 to 1736/22, are labeled in the **Figure 9-1-11**. Their mean values are -11.93‰ for $\delta^{13}\text{C}$ and 6.72‰ for $\delta^{15}\text{N}$ separately. Compared to the average values of the whole site's cattle group (-10.96‰ for $\delta^{13}\text{C}$ and 6.74‰ for $\delta^{15}\text{N}$ separately), six individuals from the No.1 Mess-Bone Pit show lower $\delta^{13}\text{C}$ measurements. However, this trend is not clear or strong enough to support an argument of special foddering.

Table 9-1-4.
C/N isotopic results of six cattle individuals from No.1 Mess-Bone Pit.

LAB ID	Age	Taxa	Element	Side	$\delta^{13}\text{C}\text{‰}$	$\delta^{15}\text{N}\text{‰}$	Atomic C:N
1731/22	Not sure but WSP	cattle	scapula	L	-10.43	6.94	3.4
1732/22	Not sure but WSP	cattle	scapula	L	-13.00	9.70	3.5
1733/22	Not sure but WSP	cattle	scapula	L	-12.56	5.01	3.1
1734/22	Not sure but WSP	cattle	scapula	L	-11.87	6.39	2.9
1735/22	Not sure but WSP	cattle	scapula	L	-9.46	5.76	3.2
1736/22	Not sure but WSP	cattle	scapula	L	-14.27	6.53	2.9

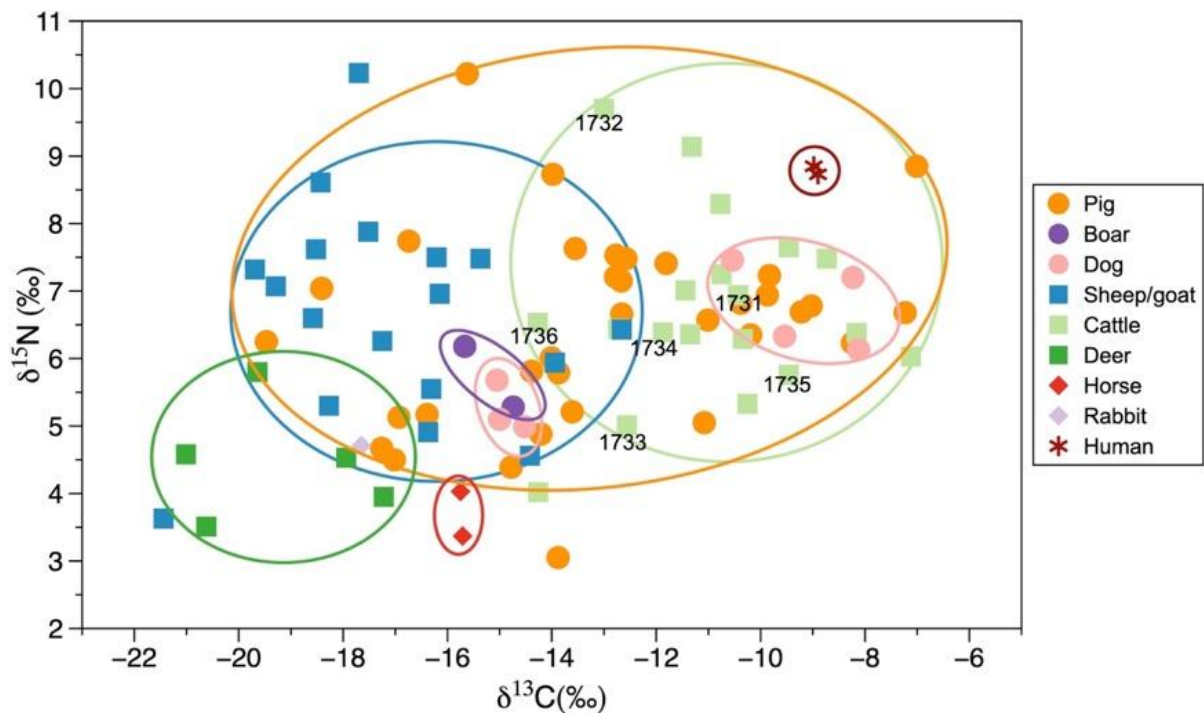


Figure 9-1-11. C/N isotope values of the six cattle individuals (labelled with Lab ID 1731-1736) from the No.1 Mess-Bone Pit.

4. Conclusion

Based on the discussion above, characteristics of the animal remains from the No. 1 Mess-Bone Pit have been summarized in **Table 9-1-5**. Using this, we will examine the feasting attributes of these remains and the reasons behind their formation.

Table 9-1-5.
The feasting indicators of the No.1 Mess-Bone Pit faunal assemblage.

Indicators	Appearance	Further implications	Stage
Taxa	Almost all cattle (472/501)	Special ritual event	Procurement
Quantification	At least 6 individuals (meat can feed	Big event	Procurement

	600 people)		
Age	Surprisingly similar, all roughly 18-month-old	Killed at one time	Procurement
Sex	Very likely exclusively females	Special selection	Procurement
Artificial traces	Similar dismembering and meat-cutting traces, mainly concentrating on the limb joints.	For consumption	Processing
Element abundance	Elements with meat are more abundant	For consumption	Processing
Fragmentation	Most limb bones are complete, and no marrow-extraction	Surplus of meat	Consumption
Cultural context	There are rammed-earth structures and cemeteries around, but no ritual vessels found from the pit	Purpose of event?	Consumption
Taphonomy	No weathering, no gnawing, the majority are well-preserved	One-time deposition and rapid covering	Deposition

From the perspective of taxa composition, the animal assemblage consists of three types of domesticated animals: cattle, pigs, and ovicaprids (sheep/goat), with cattle being the overwhelmingly dominant species. According to the *Liji* (礼记 Record of Rites), cattle, serving as the *tai-lao*²⁰太牢 (Grand Sacrifice), represented the highest rank of domesticated animal sacrifices in the Zhou dynasty's ritual system (Li 2008:20). The higher ritual rank and more valued nature of cattle was also represented in the circumstance of acting as burial offerings, which has been evidenced by many zooarchaeological cases during the Bronze Age (Liu et al. 2020). The utilization of cattle indicates that these animals were prepared for a special ritual event.

As for quantification, there are at least six individual juvenile cattle aged about 18 months old. Based on the estimation of usable meat weight (MTWT), one juvenile animal can produce about 100 kg of meat, and an adult human will consume 1 kg of beef for a meal.

²⁰ The *tai-lao* sacrifice can indicate either cattle or the combination of cattle with other domestic animals, such as sheep, pigs, dogs, and fish. However, cattle are essential; only with cattle can the sacrifice reach the *tai-lao* level.

Nutritional and energy yields provided by these six cattle can support a huge banquet of about 600 people²¹. This is indeed a large-scale ritual event.

In terms of the age and sex pattern of the cattle, as discussed above, both of them show consistency. All being 18 months old indicates that they might have been slaughtered simultaneously for the same event, and the consistency in sex implies goal-directed selection. This special selection could be due to two possibilities: one is ideological preference (such as personal taste or to meet the cultural demands of the event), and the other is out of the practical value. A very similar example comes from the Hambledon Hill causewayed enclosure in southern England (Legge 2008). Same as the No.1 Mess-Bone Pit, Legge found that most cattle from the causewayed enclosure were female and aged 18 months. He argued that people were using the surplus animals from a dairy economy. When people were deciding which 18-month females should go forward to be milking cows, these 18-month ones were the ones they rejected and therefore available for killing for a feast. However, the regime of ZHGC mainly based on the crop planting and hardly breed milking cows. Therefore, if linking sex selection to practical value, the situation here might be that more bulls were kept for traction or draft power, leading to the selection of killing cows for catering for a feast. The four attributes mentioned above pertain to the “procurement” stage of a feasting event.

The numerous dismembering and meat-cutting traces concentrating on the limb joints, as well as the abundance of the fleshy elements, both indicate the consumption purposes. Furthermore, the same pattern of artificial marks might imply the same butcher of the same event. These two attributes can be included in the “processing” stage of a feast practice.

²¹ The number of people has been conservatively estimated. Based on modern standards, butchers commonly suggest 3/4 pound (12 ounces, 340g) of beef as the main course for those with bigger appetites. However, I calculated based on 1 kg per person. Therefore, this banquet actually could have hosted more than 600 people, and that's not even considering the amount of meat the three pigs may have contributed.

Furthermore, the cattle bones generally are unfractured, especially for limb bones. As argued in the previous theoretical part, intact limb bones are characteristic of archaeological assemblages which are likely to have been the result of feasting. The low fragmentation degree of limb bones always indicates the absence of marrow extraction. This further implies a surplus of meat. Such a glut of protein is consistent with a feast, in which an unusually large amount of meat becomes available at one time. This is a “consumption” stage attribute of a feast.

Finally, from the aspect of taphonomy, the majority of faunal remains (including pig bones) are well-preserved without signs of weathering and gnawing, indicating the one-time deposition and rapid covering. This provides strong evidence for the “single deposition” stage of a feasting activity.

In summary, the whole flow of the event, from procurement to processing, to consumption, to deposition, forms a complete chain of evidence all pointed to a feasting ritual event. The only other possible reason for burying a group of young cattle together would be if they all died from an epidemic disease and were buried because people did not want to eat them. But in this case the skeletons would not be disarticulated and covering with cut marks as the assemblage was showing, thus, this possibility was eliminated.

More specifically, it is necessary to determine whether the pig and ovicaprid bones in the pit originated from the same event as the cattle. There are only two phalanges of ovicaprid, so the possibility of later mixing cannot be ruled out (either after the pit was abandoned or due to the disturbance caused by looting). Therefore, we will not over-interpret the ovicaprid remains. As for the pig bones, given that their overall condition is similar to the cattle bones—with low degrees of weathering and fragmentation (see Table 7-1-1)—and the absence of stratification in the pit, I tend to believe that these few pig bones likely came from the same feasting event as the cattle bones, possibly serving as side dishes. However, the

relatively high number of maxillaries makes this conclusion somewhat tentative. Regardless, the conclusion that the No.1 Mess-Bone Pit represents the leftover remains of a large-scale feast event is strongly supported.

In a famous historic tale, a merchant from the state of Zheng offered twelve cattle to entertain the Qin troops. This hospitality made the Qin army believe that Zheng was well-prepared for the attack, causing them to retreat without a fight. From this story, we learn that twelve cattle represented a considerable meat resource at the time, enough to entertain a large group of soldiers. It was also a significant display of wealth, sufficient for a merchant to pose as a representative of his state and deter an enemy army. Consequently, it is inferred that the six-cattle feast in the study must have also been a large-scale, high-ranking event, capable of providing a hearty meal for over 600 guests. The sponsor of the event should be wealthy enough, likely an elite person or even the king of the state. Given that the feasting event took place within the city, it was probably held with the purpose of fostering internal alliances. Additionally, the discovery of large rammed-earth platforms and burials nearby further suggests that this might be an internal solidarity ceremony conducted for special events such as ancestor or deity worship.

Section 2 Case study: JCL T252-H935

1. Archaeological Context

The excavation unit T252 is a trial trench at JCL site (**Figure 9-2-1**). On August 3, 1993, the ash pit H935 was found in the middle of T252 after clearing the surface disturbed soil. The pit is round with a diameter of 1.45 meters. It has a wider mouth and a narrower bottom, with fairly regular edges and a flat base. The mouth of the pit is 0.8 meters below the surface, and the pit itself is 0.65 meters deep. The pit shows no stratification, indicating it was filled in a single event. The filling soil was loose and dark gray, a few pottery shards and a large quantity of scattered animal bones were unearthed. No sieving and floating work has been done. The pit is dated as the earlier phase of Mid Warring States Period (phase V -1).

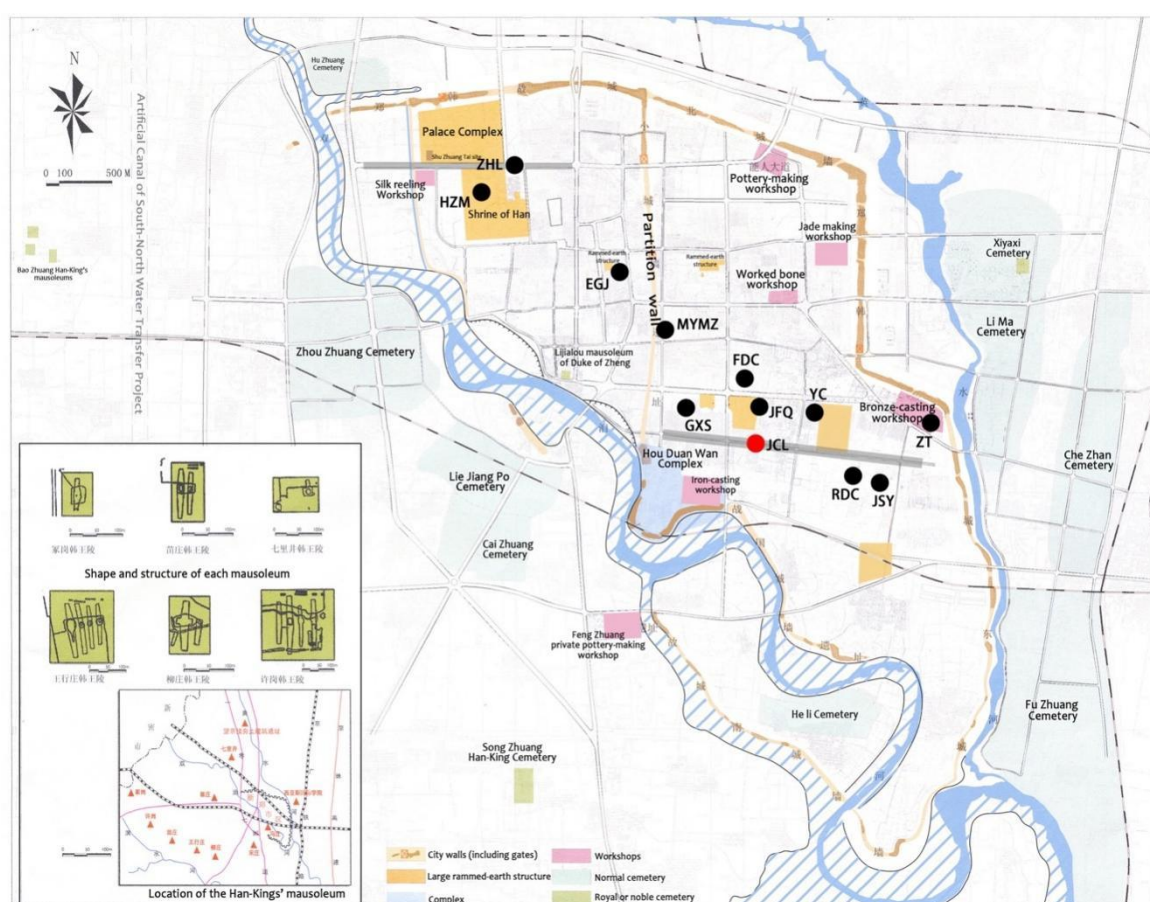


Figure 9-2-1. The location of JCL site (red dot) where pit H935 located in.

2. Faunal Assemblage

In total, 157 faunal specimens were found in pit H935, weighing 2079 grams. The overall preservation is good. The faunal assemblage includes 102 sheep (*Ovis*)/goat (*Capra*) bones, 15 pig bones, 38 medium-sized mammal bones, one loose right P₄ of cattle, and one limb fragment of large-sized mammal. Details of pig and medium mammal remains are listed in the **Table 9-2-1**.

Table 9-2-1.

Pig bones (top) and medium mammal bones (bottom) unearthed from T252-H935 at JCL site.

Element	Part	n	L	R	Weight	Fusion	Fragmentation
Maxillary	with C, P1-M3	1	1		57.4	-	-
Maxillary	with M1-M3	1	1		46.2	-	-
Mandible	with M2-M3	1	1		67.5	M3 erupting	-
Lower M3		1		1	7.1	-	-
Scapula		1	1		23.7	-	s
Humerus	distal	1		1	26.3	fused	h
Ulna/radius	proximal	1		1	23.2	unfused	h
Radius	distal	1		1	14	fused	h
4 th metacarpal		1	1		5.7	fused	c
Femur	Proximal	2	2		35.7	fused	h
Femur	distal	1		1	55.9	unfused	h
Tibia	proximal	1		1	40.6	fused	h
Tibia	distal	2	1	1	24.7	fused	b

Element	Part	n	Weight	Fusion	Fragmentation
Cranial fragments	-	2	10.4	-	b
Radius segment	distal	1	12.4	unfused	b
Tibia	distal	1	17.8	unfused	h
Ribs	-	28	87.7	-	b
Thoracic vertebra	spinous process	1	5	-	b
Limb fragments	-	5	31.7	-	b

Just as in No.1 Mess-Bone Pit, there is also one kind of predominant taxon in the H935 assemblage, which is domesticated ovicaprid, accounting for 86.3% of the identifiable specimens. Due to the lack of key identifying evidence, such as horns and skull, it is hard to distinguish specifically between goats and sheep. However, based on the proportion of identifiable sheep and goat remains found at the site, the likelihood that these specimens are

sheep is relatively high. The detailed information about the ovicaprid specimens is displayed in the **Table 9-2-2**, specimen images in the **Figure 9-2-2** and **9-2-3**.

Table 9-2-2.
Dataset of ovicaprid remains from H935 at JCL.

Element	Part	n	L	R	Weight	Fusion	Fragmentation	Image
Atlas	-	1	-	-	19.6	-	c	7-2-2
Axis	-	1	-	-	19.2	-	c	7-2-2
Cervical v.	-	6	-	-	60.5	-	4c2b	-
Thoracic v.	-	1	-	-	5.8	-	s	-
Lumbar v.	-	7	-	-	44.2	-	2s5b	-
Sacral v.	first seg.	1	-	-	20.1	unfused	c	-
Scapula	-	7	5	2	138.5	fused	4s2h1b	7-2-2
Scapula	fragment	6	-	-	12.4	-	b	-
Humerus	p.	3	1	2	60.5	fused	1h2b	7-2-2
Humerus	d.	7	5	2	111.3	fused	b	7-2-2
Ulna	p.	3	1	2	21.9	fused	h	7-2-2
Radius	p.	3	2	1	37.4	fused	2h1b	7-2-2
Radius	d.	8	4	4	119.9	fused	3h5b	7-2-2
Radius	segment	2	-	-	14.1	-	b	-
Ulna/radius	p.	2	1	1	32.2	fused	h	7-2-2
Ulna/radius	d.	1		1	11	fused	b	7-2-2
Metacarpal	-	5	2	3	86	fused	c	7-2-3-R
Femur	p.	5	3	2	81.5	fused	1h4b	7-2-3-L
Femur	d.	8	3	5	204.5	fused	1h7b	7-2-3-L
Tibia	p.	5	3	2	120.8	2 unfused	2s1h2b	7-2-3-L
Tibia	d.	7	4	3	74	1 unfused	4h3b	7-2-3-L
Fibula	d.	1	-	-	3.7	-	h	7-2-3-L
Metatarsal	-	5	3	2	82	fused	3c2s	7-2-3-R
Central tarsal	-	1		1	2.8	-	c	7-2-3-R
Astragalus	-	2	1	1	10.8	-	c	7-2-3-R
Calcaneus	-	3	2	1	22.4	fused	c	7-2-3-R
1 ST phalanx	-	1	-	-	3.1	fused	c	7-2-3-R

A minimum of 5 ovicaprid individuals is represented by the assemblage. Due to the absence of teeth, the age estimation is conducted referring to several standards of the long bone fusion sequence and ages for sheep and goats (Silver 1969; Gonzalez 1983; Zeder 2006). Although these standards exhibit slight variations across different breeds, it is generally agreed that the proximal tibias and proximal humeri are among the last bone epiphyses to fuse. Considering several standards, the fusion time for the proximal tibia and humerus is both approximately 3-4 years, with some possible variation (in some standards the fusion time for proximal humerus is later than tibia). In our sample, most long bone epiphyses are

fused except two left proximal tibias. Thus, the age of the entire ovicaprid assemblage should be 3 years or older.

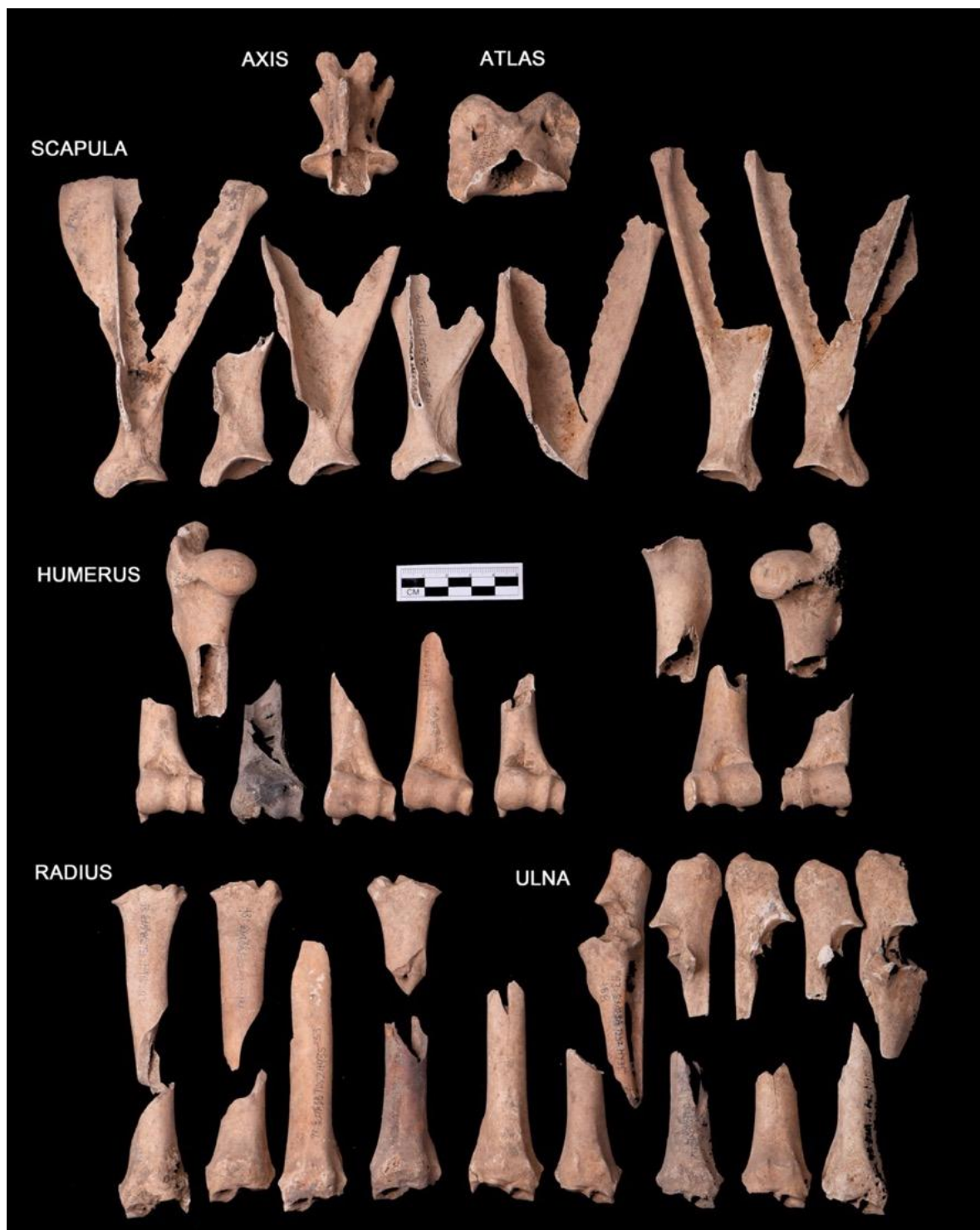


Figure 9-2-2. Portfolio of the ovicaprid bones from the H935, including atlas, axis, scapulae, humeri, radii, ulnae.

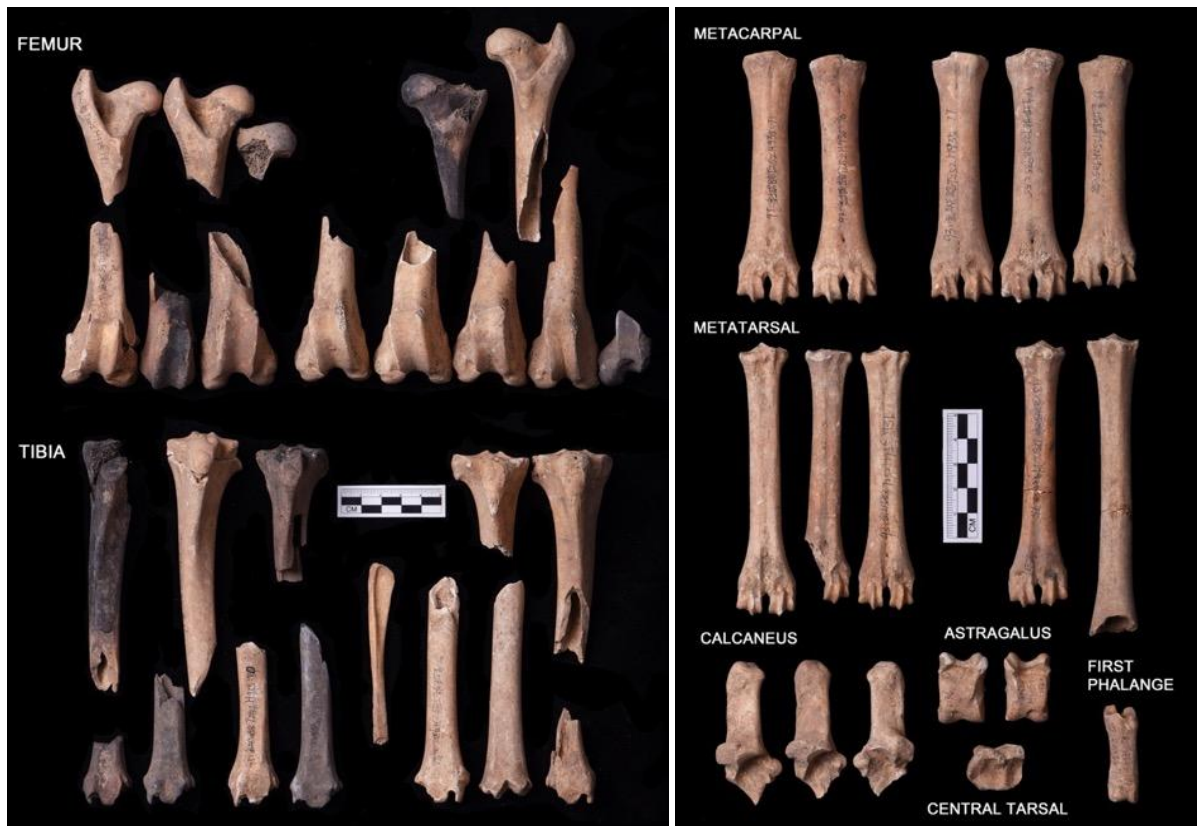


Figure 9-2-3. Portfolio of the ovicaprid bones from the H935, including femurs, tibias, and one fibula on the left photo, as well as metacarpals, metatarsals, calcanei, astragali, central tarsal, and the first phalange on the right photo. Some femurs and tibias show burn marks on the surface.

3. Discussion

Based on the original excavation record, H935 appeared to contain a single event deposit, likely rapidly buried, further supported by well-preserved animal bones without signs of weathering or carnivore/rodent gnawing.

The dominant species in this assemblage is ovicaprid, with 38 pieces of unidentifiable medium-sized mammal bones that might also belong to sheep, increasing their likely proportion in the assemblage. In the Zhou dynasty's ritual system, sheep, referred to as *shao-lao* (second grand sacrifice), were considered a high-status sacrificial animal, second only to cattle as mentioned previously. The presence of five sheep simultaneously suggests an unusual event rather than common consumption.

The ovicaprid group is mostly around 3 years old or older. Due to the lack of dental remains, precise age, especially the upper limit of the age, cannot be determined. However,

the relatively similar size ranges of the bones (see **Table 9-2-3**) may suggest a deliberate selection of animals for slaughter based on reaching a specific age or body size, which might be an optimal time for meat return. The assemblage's post-cranial nature, dominated by limb bones as shown in **Table 9-2-4** and **Figure 9-2-4**, supports a focus on meat consumption. This pattern of bone distribution, combined with the absence of cranial elements, highlights an emphasis on the edible portions of the animals, which aligns with the characteristics of a feasting or special consumption event rather than regular subsistence activities.

Table 9-2-3.

Measurements of the ovicaprids from H935. Elements with over 5 values were included.

Measurement	n	Range	Mean	STDEV	V
Humerus Bd	8	29.80~32.66	30.97	0.97	3.12
Radius Bp	5	29.91~32.36	31.20	0.94	3.01
Radius Bd	9	28.63~31.46	29.73	0.85	2.85
Femur Bd	6	37.55~39.13	38.11	0.62	1.64
Tibia Bd	6	24.04~28.03	25.65	1.33	5.20
Metacarpal L	5	93.44~102.26	99.54	3.55	3.57
Metacarpal Bp	5	21.98~23.69	22.79	0.69	3.02
Metacarpal Bd	5	25.09~27.31	25.98	0.85	3.25

Table 9-2-4.

The element abundance of ovicaprids in H935.

Elements	NISP	MNE	Exp.	MAU	%MAU
Maxillary	0	0	2	0.00	0.00
Mandible	0	0	2	0.00	0.00
Atlas	1	1	1	1.00	22.22
Axis	1	1	1	1.00	22.22
Cervical v.	6	6	5	1.20	26.67
Thoracic v.	1	1	13	0.08	1.71
Lumbar v.	7	7	6	1.17	25.93
Rib	0	0	26	0.00	0.00
Sacral v.	1	1	1	1.00	22.22
Scapula	13	7	2	3.50	77.78
Humerus	10	7	2	3.50	77.78
Ulna	6	5	2	2.50	55.56
Radius	16	9	2	4.50	100.00
Metacarpal	5	5	2	2.50	55.56
Pelvic bones	0	0	2	0.00	0.00
Femur	13	8	2	4.00	88.89
Tibia	12	8	2	4.00	88.89
Metatarsal	5	5	2	2.50	55.56
Carpals	0	0	12	0.00	0.00
Tarsal	1	1	2	0.50	11.11
Astragalus	2	2	2	1.00	22.22
Calcaneus	3	3	2	1.50	33.33
1 ST phalanx	1	1	8	0.13	2.78

2 nd phalanx	0	0	8	0.00	0.00
3 rd phalanx	0	0	8	0.00	0.00

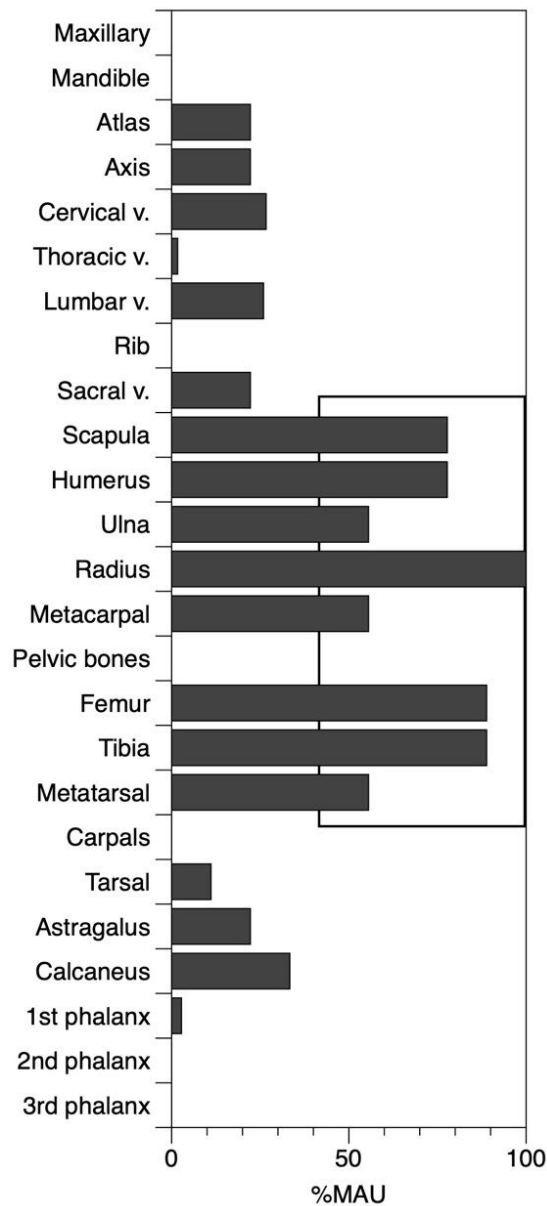


Figure 9-2-4. The distribution of element abundance of ovicaprids in H935, square indicate the elements whose %MAU was over 50%.

Meanwhile, two contradictory features in the H935 bones with typical feasting characteristics make the discussion complicated. The first contradiction concerns the lack of common artificial marks, such as cut marks, on the bones. The second concerns the high degree of fragmentation observed from Table 7-2-2's fragmentation column, which seems to contradict the luxurious and wasteful style of feasting previously discussed.

Regarding the lack of artificial marks, if we rule out the possibility of observational oversight during identification, the absence of such marks could be due to the use of cooking methods that do not require extensive cutting, such as roasting or stewing whole animals (or whole limbs). These methods would result in fewer cut marks and whole-animal roasting is also more feasible to be conducted on sheep/goat than on cattle. The most robust evidence is that we have indeed found burn marks on ten bones, although it is also possible that some of bones were stained during the burial process. In addition, it has been argued that burning renders bones more susceptible to fragmentation (Stiner et al. 1995). The high degree of fragmentation could also be explained to some extent by the cooking method. However, it is not heat alone that breaks bones, but pressure (Stiner et al. 1995). A closer look reveals that the breakage points are all located at the diaphyses of those rich in bone marrow, while the epiphyses are relatively intact. The consistently fractured elements, humerus, radius and ulna, femur, and tibia, with complete metacarpals and metatarsals, clearly indicates signs of deliberate selection through human activity. Therefore, the fragmentation is more likely due to marrow extraction during the feasting event rather than post-depositional random forces, such as trampling.

Does marrow extraction contradict the hypothesis of H935 as a feasting deposit? I believe not. As discussed earlier, absence of the marrow extracting reflects the “surplus” characteristic of lavish feasting. This raises another point: when considering “surplus”, one must consider the historical and cultural context behind it. In prehistoric times, when food was scarce, animal meat was a precious source of protein, and people would fully utilize it. Thus, not extracting marrow was seen as extravagant and wasteful. However, with the advancement of social complexity and productivity, dietary preferences and methods diversified. In the context of feudal society in ZHGC, marrow extraction might have been seen as a pursuit of culinary refinement, a trend among the elites, or reflecting the host’s and

guests' dietary preferences, rather than just meeting basic needs for subsistence and resource maximization. Thus, it is not sufficient to determine the presence of extravagant consumption solely based on whether marrow was extracted. Investigating feasting requires mutually corroborated evidence from multiple aspects.

In summary, although the H935 bones exhibit some features contradictory to typical feasting characteristics, these contradictions can be rationalized and explained satisfactorily. Overall, the ovicaprid bones in H935 still align with the main attributes of a feasting event: the consumption of a single predominant domesticated animal, accumulation of several animals from a single event, and a focus on meat consumption. Therefore, H935 very likely represents a significant feasting event, albeit with operational methods that may differ from other known traditional feasting events.

In this feasting event, ovicaprids were the central focus of the banquet. The five adult sheep provided approximately 100 kilograms of edible meat, enough to feed over 100 guests. Given the scale of this feast, it can be inferred that the event was of relatively high status, likely involving the nobility. According to the original excavation records, the excavators inferred that the animal bones might be related to a stationed military force in the area, as some army barracks were found in the surrounding vicinity. Thus, it is reasonable to speculate that this event might have been a celebratory banquet within the military camp, held to honor military achievements or other purposes, possibly hosted by the army commander or the state ruler.

Section 3 Case study: JFQ T206-H811

1. Archaeological Context

The excavation unit T206 is located in the central part of the JFQ site, which is situated in the outer city (eastern city) of ZHGC (**Figure 9-3-1**). On March 29, 1993, after clearing the fifth layer, an ash pit with animal bones was discovered, designated as H811. This was the only archaeological feature found within the T206. This pit is very shallow, rectangular in shape with upright walls and flat bottom, measuring 60 by 40 cm and only 8 cm deep. Aside from animal bones, no other artifacts or remains were found in the pit. The bones appeared in a scattered manner. No sieving work was conducted. Based on the stratigraphically overlapping relationships, it was dated to the late Warring States period.

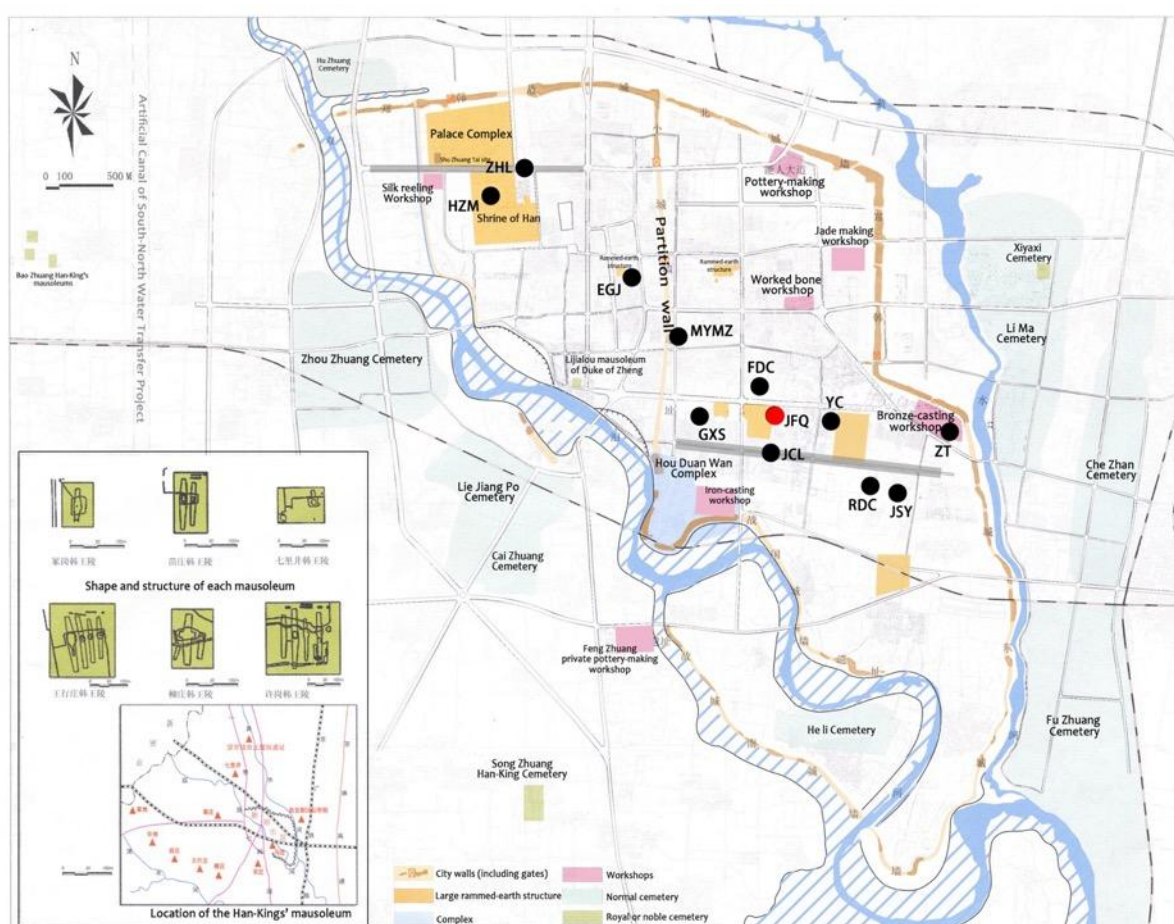


Figure 9-3-1. The location of JFQ site (red dot) where pit H811 located in.

2. Faunal Assemblage

A total of 131 animal bones were discovered in H811, weighing 2931.5 grams. Among these, there is one left mandible with M2-M3 of pig (age estimated to be about 21-27 months based on tooth wear), one pig left ilium, one second/fourth metacarpal of horse, and two cranial fragments of medium-sized mammals. The remaining animal remains are all cattle (*Bos taurus*), with a total of 126 pieces (accounting for 96.2% of the total amount) weighing 2828.9 grams (96.5%). The details of these cattle bones are shown in **Table 9-3-1**.

Table 9-3-1.
Dataset of cattle bones from H811 at JFQ.

Element	Part	n	L	R	Weight	Fusion	Frag.
Maxillary	M ¹	1	-	1	18	-	-
Mandible	No tooth	2	1	1	144	-	1h1b
Mandible	M ₁	2	1	1	47.8	-	-
Mandible	M ₂	1	-	1	22	erupting	-
Atlas	-	1	-	-	49.3	-	s
Axis	-	1	-	-	33.4	-	s
Cervical v.	-	4	-	-	118.5	Arti. surface unfused	-
Thoracic v.	-	9	-	-	148.3	Arti. surface unfused	-
Lumbar v.	-	6	-	-	116.6	Arti. surface unfused	-
Vertebra frag.	-	28	-	-	143	-	-
Ribs	-	37	-	-	235.4	-	-
Pelvic bones	-	2	1	1	53.9	-	b
Scapula	-	2	1	1	106.3	fused	h
Scapula	fragments	2	-	-	20.9	-	-
Humerus	distal	1	1	-	114.9	half-fused	h
Humerus	p. loose epiphysis	1	-	-	12.3	unfused	-
Humerus	d. loose epiphysis	1	-	-	5.8	unfused	-
Ulna	-	2	1	1	62.6	unfused	h
Radius	-	2	1	1	199	d. unfused	1c1b
Metacarpal	-	2	1	1	174.3	d. unfused	c
Femur	-	1	-	1	121.9	both unfused	s
Femur	p. loose epiphysis	1	-	-	14.6	unfused	-
Femur	d. loose epiphysis	1	-	1	86.1	unfused	-
Tibia	-	2	1	1	429.9	both unfused	c
Metatarsal	-	1	1	-	105.7	d. unfused	s
Carpals	-	2	-	-	10.7	-	-
Patella	-	1	-	1	11.9	-	c
Astragalus	-	2	1	1	80.2	-	c
Calcaneus	-	2	1	1	83	unfused	c
1 ST phalanx	-	3	-	-	30.9	p. unfused	c
2 nd phalanx	-	2	-	-	19.6	fused	c
3 rd phalanx	-	1	-	-	8.1	fused	c



Figure 9-3-2. The cattle assemblage from H811 at JCL, belonging to a juvenile individual.

Through quantitative analysis of this batch of cattle bones, the minimum number of individuals (MNI) was calculated to be 1. By observing the preservation and fusion of bones, it is not hard to find that they most probably belong to the same individual. Based on Silver's standard concerning long bone fusion (1963) and Halstead's standard concerning tooth eruption and wear (1985), this individual was supposed to be a juvenile animal approximately 15-18 months old. Sex cannot be determined due to the lack of evidence.

3. Discussion

In this case, we will continue with the previously established analytical logic to discuss whether this pit is a remnant of a feasting event.

Cattle act as the predominant species of the faunal assemblage found in H811, aligning with the characteristics of using a single, large-sized, domesticated animal for feasting purposes. Although these cattle bones show a relatively high degree of fragmentation,

closer observation reveals that most of the fractures are recent. This suggests that the bones are fragile due to the immature age and that the fracture occurred during the excavation rather than as a result of marrow extraction by ancient people. This is evidenced by the almost complete diaphyses of long bones, such as the radius, tibia, metacarpals, and metatarsals, as shown in **Figure 9-3-2**. Therefore, there was no marrow extraction post-consumption, which aligns with the surplus nature of a feasting event. The absence of skull and upper jaw bones (with only one maxillary tooth found) also suggests that the primary purpose was meat consumption. However, no artificial marks found on the bones, which makes the result somewhat unclear, it is possibly related to the cooking methods (e.g. direct poaching or whole roasting).

As for the other five non-cattle bones found in the pit, it is likely that they were inadvertently mixed during disposal rather than originating from the same consumption event with cattle, as they do not seem to have been intended for providing meat (e.g., pig mandible and horse foot bones). In addition, the shallow pit made it easier for the remains inside and outside to mingle together.

Although the number of cattle is not as impressive as the six in the No.1 Mess-bone pit, one animal can still provide considerable meat for attendees. Given that the cattle in H811 is slightly younger and therefore smaller in body size (e.g. radius Bp is 74.69 mm and metacarpal Bp is 51.10 mm compared to the average values of 80 mm and 59 mm separately of the cattle group in No.1 MBP), it is conservatively estimated that the scale of this feast could have been for 50-80 people. Given this, the organizer of this event was speculated to be likely an elite or landlord class member, and the nature of the event was probably a lineage or clan gathering to reinforce internal bonding.

Section 4 Case study: JSY T47-J7

1. Archaeological Context

Unit T47 is located in the JSY site (see **Figure 9-4-1**) in the southeastern part of ZHGC, adjacent to the RDC site on the west side. On October 11, 2000, a well was discovered in the southwestern part of the unit, labelled as J7. The well's plan was rectangular, measuring 1.15 meters in length, 1 meter in width, and 3.1 meters in depth. The well walls were vertically aligned, with four footholds left on each of the south and north walls. According to the excavation records, the fill inside the well was loose and appeared to have been filled in a single event. Artifacts such as flat tiles, tubular tiles, potshards of *dou* and *li* (two kinds of pottery vessels), as well as a small number of animal bones were found. Based on the shape of well and the typology of the artifacts unearthed, it is dated to the early Warring States period.

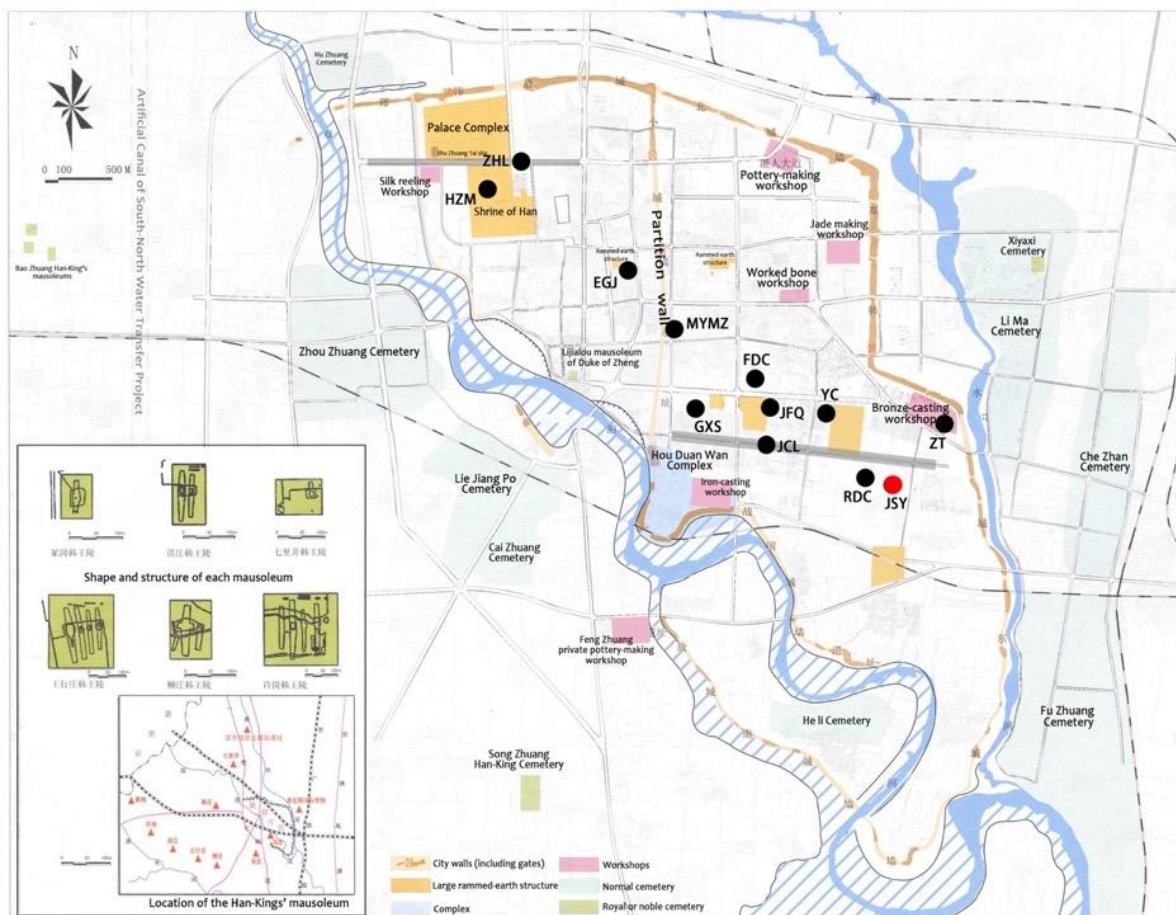


Figure 9-4-1. The location of JSY site (red dot) where well J7 located in.

2. Faunal Assemblage

The number of animal bones in J7 is relatively small, totaling 27 pieces with a combined weight of 2,455.2 grams. The assemblage can be divided into two groups. The first group consists of 7 scattered bones that might represent daily household waste. This group includes one sheep skull (see **Figure 4-11-3** in Chapter 4), one right mandible with I₃ of a horse, one distal femur fragment of a horse, and four adult cattle bones: one axis, one right distal femur (a bone-working waste material), and two scapula fragments. The second group comprises 20 pieces that, based on bone texture, come from cattle, and appear to belong to the same juvenile individual (**Figure 9-4-2**). Detailed information is provided in **Table 9-4-1**. The long bone epiphyseal fusion indicates an approximate age of 10-12 months for this juvenile individual.

Table 9-4-1.
Dataset of cattle bones of the juvenile individual from J7 at JSY.

Element	Part	n	L	R	Weight	Fusion	Frag.
Humerus	-	2	1	1	428.3	both unfused	1c1s
Radius	-	1	1	-	183.2	both unfused	c
Pelvic bones	ischium	2	1	1	228.1	unfused	s
Femur	-	2	1	1	415.3	both unfused	1c1s
Tibia	-	2	1	1	559.7	both unfused	c
Metatarsal	proximal	1	1	-	93.3	d. unfused	s
Limb frag.	-	10	-	-	37.6	-	-



Figure 9-4-2. The remains of young cattle individual including a pair of humeri, a pair of ischia, a radius, a pair of femurs, a pair of tibiae, and a metatarsal from J7 at JSY.

3. Discussion

For this case, it is crucial to begin with an understanding of the archaeological context. This case differs from the previous three, where the animal bones were excavated from rubbish pits, whereas here, they were found in a well. The animal bones and other artifacts were likely discarded into the well after it had been out of use. Given the unique circumstances of a discarded well serving as a repository for refuse, although the original excavation record suggests that the deposition occurred as a single event based on the absence of clear stratification, I believe this conclusion warrants further scrutiny. A more nuanced explanation of this “single event” should be provided.

The time span represented by two distinct events identified through field archaeology and taphonomy is typically quite long and differs significantly from the temporal scale of actual human activities, such as whether the disposal occurred as one event or two. For example, household rubbish from today and tomorrow are clearly products of two separate

events, but from a taphonomic perspective, it is nearly impossible for archaeologists to distinguish between them. Therefore, the remains within the well (including animal bones and artifacts), while undifferentiated in a broad temporal sense, are more likely to be the result of multiple distinct disposal events in practice, which were later consolidated and buried together. These disposals occurred over a relatively short period, making them taphonomically undifferentiable. This perspective rationalizes the coexistence of juvenile cattle and other animal remains within the assemblage. The presence of other scattered animal remains from household waste does not undermine the interpretation of the 20 juvenile cattle bones as originating from a single animal, and an independent single event.

In fact, when analyzing the previous three cases, we can also observe that small amounts of mixed bones appear within the animal assemblages, such as the two sheep phalanges in the No.1 Mess-bone pit, pig bones and cattle tooth in the H935, as well as non-cattle bones in the H811, which can to some extent be explained using the reasoning provided here. However, in these cases, the dominant species were represented in such overwhelmingly large proportions compared to the mixed-in bones. Moreover, the unique nature of a well as a depositional context—serving as a ready-made public refuse site after abandonment, unlike the specifically excavated rubbish pits associated with specific events—also necessitates this explanation because it would naturally lead to a greater diversity of discarded materials, particularly given the larger capacity of the well.

Having established that the young cattle limbs can be the refuse of an independent event, the argument for these remains being associated with a feasting context becomes clearer. Since the context is a well, it is plausible that the burial might occur with some delay, which could result in signs of weathering on bones, such as the longitudinal cracking observed on the right tibia. However, overall, the preservation of these bones is relatively good. The fact that they belong to the same individual and exhibit consistent preservation

suggests that they were utilized and discarded together. The assemblage consists of limb bones, and the fragmentation is relatively low. The scattered distribution of the bones and the context of the well rule out their use as sacrificial offerings or other ritualistic purposes. Therefore, these remains likely represent the result of a lavish meat consumption event. Furthermore, the amount of meat provided by the limbs of a single juvenile animal is considerable, far exceeding the needs of a regular meal. Conservatively estimated, the limbs of this juvenile cattle could provide approximately 40 kilograms of meat, sufficient to cater to a banquet for 30 to 40 people. Such a scale likely corresponds to a family feast hosted by wealthy people, such as merchants and nobles.

Section 5 Conclusion

1. Summary of case studies

Based on the theoretical framework outlined in the previous chapter, we have summarized a range of archaeological evidence, especially zooarchaeological, that can be used to measure whether a faunal assemblage is the result of a feasting event. In this chapter, through the presentation and analysis of materials from four case studies, we have successfully applied the theoretical framework to specific animal assemblages. The corresponding relationship (whether the conditions are met) between these four cases and various archaeological indicators of feasting is summarized as follow.

Table 9-5-1
The correspondence of four cases and the archaeological feasting indicators.

Feasting indicators	No.1 MBP (ash pit)	H935 (ash pit)	H811 (ash pit)	J7 (well)
Unusual quantity of meat	✓	✓	✓	✓
Low diversity of meat type	✓	✓	✓	✓
Large animals	✓	✗	✓	✓
Domesticated animals	✓	✓	✓	✓
Rare animals	✗	✗	✗	✗
Concentrated slaughter-age	✓	✗	N/A	N/A
Concentrated slaughter-sex	✓	unknown	N/A	N/A
Special feeding of animals	✗	unknown	unknown	unknown
Low Fragmentation	✓	✗	✓	✓
Artificial marks	✓	✗	✗	✗
More meaty elements	✓	✓	✓	✓
Low weathering	✓	✓	✓	✓
No layering	✓	✓	✓	✓
Presence of articulating/paired bones	✓	✓	✓	✓
Cultural artifacts	✗	✗	✗	✗
Result: feasting or not	✓	✓	✓	✓

In summary, the faunal assemblages from all four case studies represent remains of feasting, which affirms the existence of feasting in ZHGC. Among them, the bone remains from the No.1 Mess-bone Pit are the most archaeologically visible, triggering the largest

number of indicators and fitting the anthropological concept of a lavish feast. These remains exhibit strong characteristics of wasteful behaviour and food surplus. The visibility of the other three cases decreases incrementally, which corresponds to a reduction in the scale of the events they represented.

In **Table 9-5-1**, we can observe that although some attributes summarized earlier as indicative of feasting are not represented (e.g., none of the four cases contain rare ingredients or ritual artifacts) and even contradict expectations (e.g., the high degree of bone fragmentation in the sheep remains from the pit H935), when an assemblage meets the two essentials for defining a feasting event—(1) participation by more than one person and (2) a scale beyond routine consumption—it can be identified as a generalized feasting event.

Additionally, from the above analysis, we can derive some practical insights for applying these indicators. The identification of feasting relies on the corroboration of multiple attributes; the presence or absence of any single piece of evidence is not decisive. Some indicators can be mutually exclusive (e.g., domesticated animals versus rare species), but most attributes tend to support each other and work in tandem. For instance, attributes like unusual quantities of meat and low bone fragmentation both serve to demonstrate lavish consumption, while the lack of stratification and absence of weathering marks on bones both suggest rapid burial, which in turn supports the interpretation of a single-event deposition. Similarly, concentrated culling also indirectly supports the notion of a singular event.

Given the feasting nature of four assemblages has been settled, a series of next-step questions regarding “when”, “where”, “who”, “why”, and “how” of the event would be discussed (**Table 9-5-2**).

In terms of timing, it is interesting to note that all four cases are from the Warring States period under the State Han reign. Given the limited cases at present, it would be premature to conclusively assert that feasting activities only occurred during this period and

not in the Spring and Autumn period. However, the more frequent occurrence in the Warring States period is very likely linked to the rapid development of social productivity and other historical contexts of the time, such as the thorough collapse of strict hierarchy of ritual usage and the promotion of the new landlord class and the intellectual class.

Table 9-5-2
Summary of the event attributes of four feasting cases.

Attributes	No.1 MBP	H935	H811	J7
Time	WSP	Mid WSP	Late WSP	Early WSP
Season	Autumn	unknown	Summer	Winter/spring
Location	RDC	JCL	JFQ	JSY
Context	Rammed-earth structures and cemeteries around, no artifacts in the pit	Cantonment related remains around	No artifacts found in the pit	Other daily waste found in the well
Scale	>600 ppl	>100 ppl	50-80 ppl	30-40 ppl
Sponsor	Single sponsor: high-level elite like the state ruler	Single sponsor: army commander	Single sponsor: elite/landlord	Single sponsor: wealthy individual
Function	Intra-state solidarity, or for ancestor/deity worship	Celebratory banquet for military achievements	lineage or clan internal bonding.	Family festival feast

Note: WSP is the abbreviation of Warring States Period.

Moreover, as discussed earlier, the culling patterns of the faunal remains provide valuable seasonal indicators for the feasting events. The sheep in the pit H935 varied significantly in age, making further seasonal analysis impossible in this case. However, the other three cases, primarily featuring same-age cattle, which were probably seasonal breeders, offer more ideal scenarios for such an investigation. In most natural cases, cattle breeding starts in the summer so that calves are born the following spring when fresh pasture is plentiful, allowing cows to produce enough milk to sustain the newborn calves (Ball & Peters 2008: 3-4). In non-intensive livestock systems like those at ZHGC, this pattern still prevails. Based on this, the feast represented by No.1 Mess-bone Pit (with six cattle aged around 18 months) likely took place in the autumn, while the feasting events represented by the remains

at H811 (with cattle aged 15-18 months) and J7 (with cattle aged 10-12 months) likely occurred in the summer and late winter to early spring, respectively. Additionally, in No.1 Mess-bone Pit, apart from the six cattle, pigs might also have served as part of the feast. The estimated age of the pigs aligned well with the autumn timeframe suggested by the cattle remains.

The four case studies come from different excavation sites, but they are all located in the southeastern part of the city. Although most of the analyzed materials are concentrated in this area, this distribution is likely connected to the functional zoning within the city. The eastern city, serving as both a commercial and residential district, was a hub of economic activity, providing the material conditions necessary for organizing and hosting feasts. The presence of clan or family feasts suggests that this area might have been a gathering place for the elite class. Furthermore, the discovery of several large rammed-earth building foundations in this region made the existence of higher-level ritual feasts, such as those conducted by the ruling class for ancestor worship or religious ceremonies, reasonable.

As for the scales of the feasts, the numbers of potential participants have already been estimated in each case study based on the amount of consumable meat. Some scholars suggested that the total amount of animal bones typically found at a site, where organic materials are relatively well-preserved, represents much less than the bones that originally existed (Noddle 1997: 378-380; Vretemark 1997: 34-35). Therefore, when we can still easily identify a distinctive assemblage of bones 2,500 years later, it indicates that the event was likely a highly prominent activity at the time, with a scale potentially much larger than what we can currently infer.

According to the theoretical framework discussed earlier, low diversity in meat types suggests that these feasts were likely hosted by a single sponsor or household. Therefore, the four cases where three of them featured only one type of meat (with the No.1 Mess-bone Pit

potentially including two types) should all result from single-sponsor events. Based on the scale of the events and other contextual information, corresponding levels of sponsors and the specific functions of the four feasts have been proposed in each case analysis. Preliminary conclusions are summarized in the table, so there is no need to elaborate further here. It is important to note that these conclusions are just the most reasonable inferences based on the available information. For instance, for a feast like the one represented by the No.1 Mess-bone Pit, which catered to over 600 people, it is plausible that only an “aggrandizer” such as the state ruler could afford it, and the existing social hierarchy (though less rigid than before) still made large-scale consumption of cattle exclusive to the upper classes. The J7 case, involving a feast for around 30-40 people, aligns more closely with the scale of the gathering of a wealthy family. However, as new discoveries and background information emerge, the specific functions and nature of the feasts, as well as the identities of the sponsors may be subject to change.

Additionally, we must acknowledge unknown factors and uncertainties caused by missing contextual information, which make it challenging to further explore and evaluate the nature and function of these events. For instance, due to the lack of a layout plan among features, I have no idea about the exact distance between the No.1 MBP and the rammed-earth structure foundations, making it difficult to confidently assess their correlation. Hopefully, these uncertainties can be clarified in the future when the official excavation report is published.

2. Symbolic roles of animals in feasting

In feasting, the practical value and ideological significance of animals are seamlessly intertwined. The choice of animal taxa serves as a symbol to distinguish rank and wealth, reinforcing social hierarchies, not only in burial offerings (Liu et al., 2020) but also within the context of feasts. On the other hand, feasts play a critical role in endowing ideological

significance to animals as feasting creates conditions where impressions are likely to be deeply ingrained (Wiessner 2001).

From the four case studies, three taxa were involved: cattle, sheep, and pigs. The proportion of these animals used in the feasts and their symbolic roles aligned with the hierarchical order stipulated in the literature *Zhou Li* (Rites of Zhou), where cattle rank highest, followed by sheep, and pigs lowest. In three of the four cases, cattle were the central meat food. The No.1 Mess-bone Pit stood out in both quantity and quality, making it the most hierarchically significant, with pigs possibly included as supplementary meat. Although the other two cattle-based feasts were much smaller in scale, the ideological prominence of cattle indicates that these events were intended for the elite class rather than for commoners. This perfectly exemplifies the mutually reinforcing relationship between feasts and cattle: on one hand, the role of cattle as the primary feasting food highlights their ideological prominence; on the other hand, the inclusion of cattle would have, in turn, emphasized the symbolic importance of the feasts (Twiss 2008). In this context, the H935 case, which possibly involved a feast in a military barracks, logically employed sheep—a lower-ranked animal—as the primary meat source. However, given the large quantity of sheep used, this does not imply that the overall status of the feast was lower than that of H811 or J7.

In summary, cattle and sheep hold greater ritual and ideological prominence in feasting events, while pigs played a more marginal role, serving more for everyday consumption. This conclusion aligns perfectly with our earlier discussion in Chapter 5 regarding subsistence economy. Additionally, the cattle used in urban feasts were relatively young, typically aged between 1 to 1.5 years. Whether this age preference is driven by practical considerations—such as optimal meat yield at this age, or as Legge (2008) suggests, the age representing a functional shift—or whether different cattle ages also carry distinct

symbolic meanings (certain age might have special connotations), is a topic worthy of further exploration in future research.

3. Feasting and citizen life

The archaeological evidence confirms the existence of feasting activities at various levels, with diverse forms, scales, and functions. Meanwhile, these feasting activities also open a window for us into the commercial development and urban life in the ZHGC.

One notable aspect of the feasting remains in the study is the absence of ritual artifacts alongside animal bones. Previous research, influenced by anthropological studies on North American potlatch traditions, has suggested that the assemblages deriving from feasts, especially competitive displays of wealth, often include the cooking or eating vessels that were used (Potter 2000; Clarke 2001; Mills 2007), or even the deliberate destruction of ritual artifacts on-site (Boas 1966; Junker 2001). However, the feasting remains in this study show no such evidence of artifact destruction. The absence of ceremonial artifacts does not indicate a lack of feasting; rather, the evidence suggests a more practical and realistic scenario where objects were likely recovered and reused instead of being treated as disposable. This implies that such feasts were relatively secularized and integrated into citizens' daily life.

Moreover, contemporary textual sources and banquet images can provide a vivid picture of aristocratic feasts during this period as supplementary. Many passages in the *Shijing* (*Book of Songs*, 11th to 6th centuries BC) describe the lavish banquets of urban elites, illustrating the opulence of their gatherings. In such banquets, “the bells and drums are already arranged” (*Xiaoya·Tong Gong*), and the tables are laden with “clear wine in a hundred vessels” and “roasted turtle and fresh fish” (*Daya·Han Yi*), all set against the backdrop of magnificent halls, reflecting the prosperity of feasts. Additionally, some precious bronze vessels feature engraved scenes depicting grand banquet settings, such as the one in **Figure 9-5-1**. This carved image presents a panoramic view in four sections, with the main

banquet scene centred on a raised platform where the host and guests were raising their cups, attendants were serving meat from cauldrons, and musicians were playing *Zheng*²² and chime-bells while dancers performing with flowing sleeves. In the lower right corner of the third scene, one cattle with its perspective drawing of skeleton (Zhang 2018) are uniquely depicted. This emphasizes the significant role of cattle in Warring States period feasts, which exactly aligns with our earlier arguments. The usage of cattle mutually underscores this feast's lavishness and high status, with the overall imagery strongly conveying themes of conspicuous display and worldly pleasure.

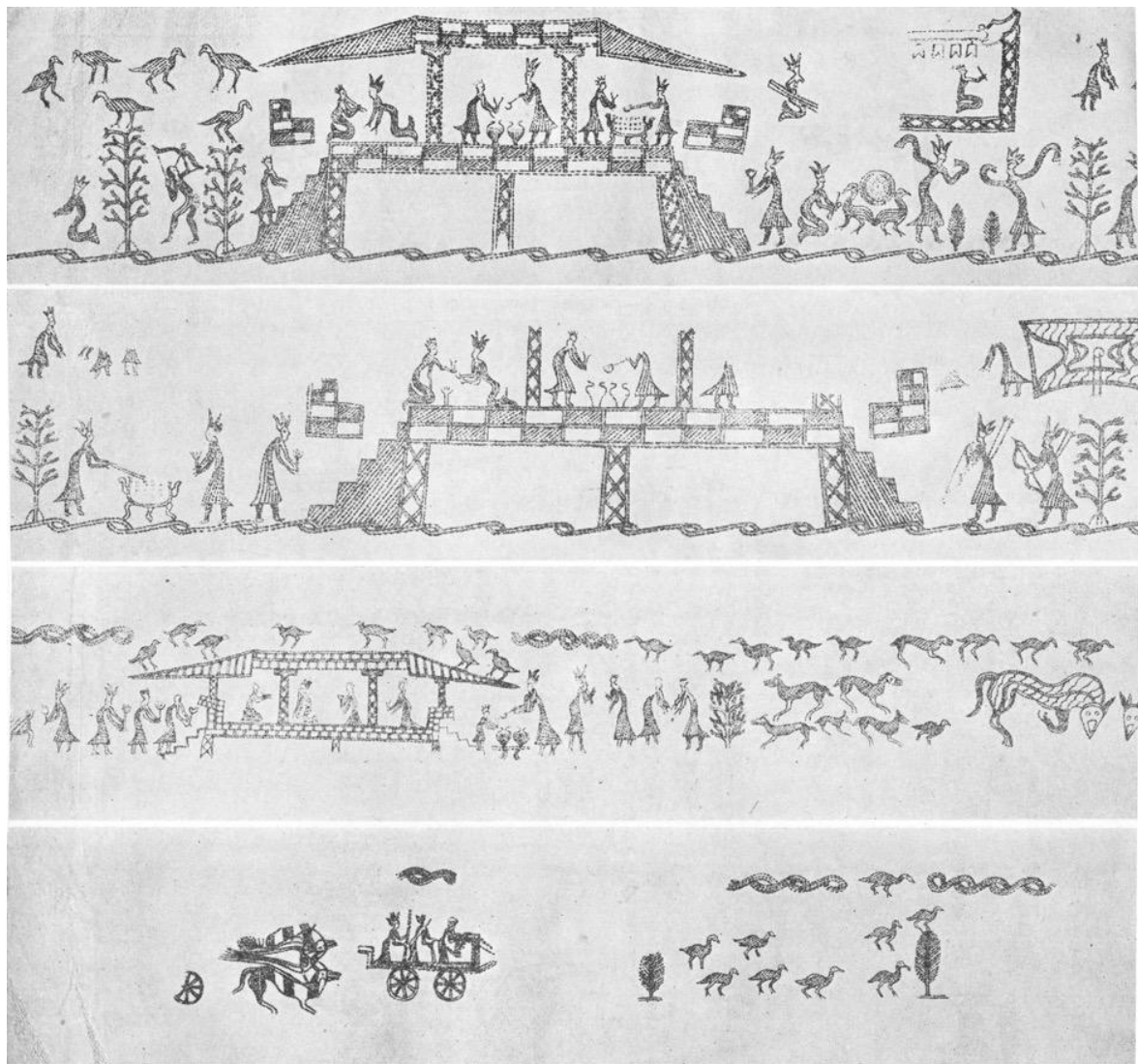


Figure 9-5-1. Feasting and hunting engraved image on the Warring States period bronze cup, Shanghai Museum collection (adapted from Ma 1961).

²² A kind of 21-or 25-stringed plucked instrument in China.

The currently visible levels of feasting suggest that feasts were primarily concentrated among the urban aristocracy, serving as a means for the elite to demonstrate their privileged status and wealth. However, broader socio-economic developments provide a different perspective. The establishment of trade markets, the use of currency (including shell and metal money), the availability of alcohol for purchase, and the thriving of private commerce (Li 1984) created favourable conditions for the emergence of extravagant feasts. These factors hint at the likely existence of smaller-scale, archaeologically invisible feasts among normal people. Feasting was not exclusive to the nobility; ordinary families also had moments of indulgence and celebration, although these smaller-scale events remain undetectable to us 2,500 years later.

CHAPTER 10 Conclusion

Section 1 Retrospection of the dissertation

The site of the Ancient Capital of the Zheng and Han States (*Zheng Han Gu Cheng*, abbreviated as ZHGC) is a significant Bronze Age urban archaeological site located in the Central Plains of China. Historically, it served as the capital of the Zheng State during the Spring and Autumn Period and the Han State during the Warring States Period. Since its accidental discovery in 1923, the mysteries of this site have gradually been unveiled. ZHGC has drawn the attention of scholars both in China and abroad due to its ingenious defensive structures (Yu *et al.* 2019; Bao 2020; Liu 2021), clear internal functional layout (Qu 1991; Ma 1999; Cai 2003a; Cai 2003b; Wan 2018), exquisite ritual artifacts (Falkenhausen 1993, 2006), high-status large tomb complexes (Zhao& Fan 2017; Shen& Fan 2017; Wang& Teng 2018; Li 2019), and accompanying horse-and-chariot pits (Zhao 2004; Zhao 2007; Wang 2011). Research on this city site has primarily focused on various thematic studies, including urbanism, artifacts, burials, and sacrificial practices, as well as comparative studies with other Bronze Age cities. However, research from the perspective of faunal and botanical remains is relatively lacking, current zooarchaeological studies show a tendency to focus on mortuary and sacrificial fauna while overlooking the everyday meat consumption of common people.

Therefore, my dissertation examines the faunal remains excavated from ZHGC, investigating them in the broader context of daily consumption (general subsistence), craft production, and ritual use. Special emphasis is placed on the practice of feasting, where both theoretical and case study analyses provide evidence for the occurrence of feasting events in the city. This focus addresses a long-standing gap in Chinese archaeology concerning the study of feasting.

A large quantity of animal bones was discovered in ZHGC during several proactive archaeological excavations between the 1970s and 2000. This study includes 10,053 animal

bone specimens (NISP = 6290, 62.57%) from twelve excavation sites as the primary material for analysis. The faunal assemblage exhibits a high diversity of taxa, including fish, mollusks, birds, reptiles, and mammals, with mammals being the most predominant. The identified mammals include rabbit (*Lepus sp.*), dog (*Canis familiaris*), Asian badger (*Meles leucurus*), tiger (*Panthera tigris*), horse (*Equus caballus*), domesticated pig and/or wild boar (*Sus scrofa sp.*), Chinese water deer (*Hydropotes inermis*), red muntjac (*Muntiacus muntjak*), sika deer (*Cervus nippon*), Père David's deer (*Elaphurus davidianus*), cattle (*Bos taurus*), sheep (*Ovis aries*), and goat (*Capra hircus*). Among them, pigs, cattle, and sheep/goat consistently rank as the top three in significance, regardless of whether evaluated by quantitative analysis (NISP and MNI) or by their spatial and temporal distribution. Over time, there is a notable decrease in the proportion of pigs, while the proportion of cattle has generally increased. The marks on the bones are primarily human-made, consisting mostly of cutting, sawing, and chopping marks, reflecting the multiple ways in which animal bones were utilized by people. Pathological traces on some bones are related to human domestication practices, illustrating the close relationship between humans and animals.

1. Animals for subsistence

Through the comprehensive discussion, it is concluded that the three major food animals, pigs, cattle, and sheep/goats, were almost all domesticated. A very small number of metrically identifiable wild boars were also mixed in. However, the minimal dietary differences between wild and domestic pigs suggested that even wild boars had close interactions with humans. Based on previous archaeobotanical studies, which indicate that the primary agricultural crops in Northern China were millets (*Setaria italica* and *Panicum miliaceum*) (Zhao 2011; Liu & Chen 2012), it can be concluded that the subsistence regime was a combination of millet cultivation and livestock husbandry within ZHGC. Among the

domesticated animals, cattle and pigs provided the majority of the meat resources, with cattle contributing the most significantly.

Moreover, a greater variety of wild species appeared in the early stages of urban use, possibly reflecting an increased dietary breadth among humans to supplement their meat consumption. Over time, however, the diversity of animal species diminished, closely tied to the completion of urban construction and the stabilization of internal systems.

In maintaining the subsistence economy, the inhabitants of ZHGC employed different management strategies for animals. Through the analysis of age patterns, we can infer that different age control strategies were used for pigs, cattle, and sheep/goats to balance their meat resources with other by-products. The wild animals, primarily deer, may come from the artificial game parks, or some occasional “garden hunting” as a kind of risk management strategy. Furthermore, dietary reconstruction based on stable $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopes, when compared with data from human residents who primarily consumed millet (C4 plants), reveals several patterns in the management of various animals:

1. Two distinct dietary patterns were observed in the dogs within the city. One group exhibited a diet closer to that of humans, while the other group differed significantly. This may indicate different relationships with humans (stray dogs vs. pet dogs) or perhaps distinct feeding practices for the dogs.
2. The isotope values of pigs showed a broad range, indicating a diverse diet. In addition to the introduction of new fodder (e.g., soybeans, wheat, and barley), pigs were likely raised by a flexible combination of penning and free-range feeding practices, reflecting the complexity and diversification of pig husbandry during this period.
3. While both sheep/goats and cattle are herbivores, they were managed using different foddering strategies. Sheep were more predominant in the ovicaprid group, as grazers,

they primarily consumed wild C3 plants, whereas cattle were fed more millet by-products, leading to higher $\delta^{13}\text{C}$ values.

In summary, the daily lives of people were closely intertwined with animals. Distinct husbandry and management strategies were employed based on the varying characteristics and functions of domesticated animals to maximize resource utilization. Even wild animals may have been subject to certain human interventions. This reflects the careful control and design of meat sources, ultimately contributing to a relatively stable subsistence mechanism within the city.

2. Animals for handicraft

In addition to being used for food, animal bones were also utilized in handicraft production after consumption. The artificial processing traces on these bones provide valuable insights into the handicraft industry during the Eastern Zhou period, playing a crucial role in reconstructing the daily production of ancient peoples. Among the 245 worked bone pieces, domestic cattle served as the primary source of raw bone material. Deer and sheep mainly contributed antler and horn material to the bone-working industry, whereas cattle and horses supplied more durable long bones. The presence of specimens at various stages of processing has allowed for the reconstruction of the bone-working workflow. This evidence indicates that a socially recognized production method was followed, effectively replicating some standardized artisan techniques. The use of metal tools in bone working was also clearly evident. However, the spatial distribution of these worked bones, as well as their generally low quality, suggested that this production was likely small-scale, household-based, and aimed at self-sufficiency. This, in turn, implies the existence of a dual system in the bone artifact manufacturing industry within the city, where official, large-scale production coexisted alongside private, domestic-scale kind.

3. Animals for sacrifice

In the study, several burial cases and animal-pit materials provide valuable insight into the ritual and sacrificial practices involving animals in ZHGC.

Sacrificial animals in the burials mainly appeared in two forms: the first is dogs, whose complete skeletons were buried in waist pits, symbolizing their spiritual bond with the deceased; the second is meat offerings, symbolizing sustenance for the afterlife. According to ancient records, among food offerings, cattle ranked the highest, followed by sheep, and then pigs and other animals. The absence of cattle in the burial materials suggests that these burials did not belong to individuals of particularly high status. Meat offerings in the burials were placed in two ways: one involved processed meat placed in grave goods, seen with both sheep and pigs, though pigs were more common; the other was directly placed in the side box. The pigs found in burial vessels often show signs of selection of young individuals.

Within the western city, there were foundation sacrificial pits for large rammed-earth structures, which were set up to seek blessing from deities and ancestors. Each pit contains the skeletal remains of one or more pigs or cattle (mostly a single animal), in varying degrees of completeness, and several pits possibly form a complex. Given that the sacrificial animals are primarily cattle, this complex likely served a construction of the highest importance.

From the cases discussed in this study, it is evident that different animals were used in specific contexts, each with distinct social values and roles, contributing to the maintenance of the Zhou dynasty's ritual system. Pigs, as the most fundamental source of meat, were the most commonly used in sacrificial rites. While some animals, like cattle and horses, were both used in high-status sacrifices, there were subtle differences in their application. Since horses were not consumed as food, their significance in warfare made them symbols of royal authority, appearing only in burial pits associated with the highest-status tombs. On the other hand, cattle, with their dual role as both providers of sustenance and as symbols of rank, had

broader applications in various sacrificial contexts compared to horses, while dogs in sacrificial contexts exhibit a more personal and intimate role related to the deceased.

4. Animals for feasting

In addition to sacrificial rites, another key aspect of ritual use of animals is feasting. Feasting is ubiquitous in human societies (Jones 2007). From an anthropological perspective, feasting originates from the sharing of food, which not only reflects the human need for social interaction and group identity but is also often regarded as a strategy (Hadjichrysanthou & Broom 2012). Therefore, the study of ancient feasting holds great significance for uncovering the spiritual world of ancient people and understanding the mechanisms of ancient societies.

Research on feasting has a long history, with various thoughts and classification systems having been developed. On this basis, the challenge lies in how to effectively apply the theoretical framework of feasting in archaeological research, a goal pursued by both anthropologists and archaeologists. Animal bone remains found in archaeological discoveries serve as the perfect object for this practice. Moreover, the introduction of feasting theory has broadened the scope of zooarchaeological research, facilitating a shift from studying “subsistence economy” to “political economy” or “status economy.” By analyzing the concept of feasting and combining it with records from ethnographic and anthropological studies, several more tangible and practicable archaeological attributes have been identified, including the source of meat, condition of the bones, taphonomic preservation, distribution, and artifacts related to drinking, entertainment, and ritual practices.

With the theoretical support outlined above, four faunal assemblages found in the eastern city have been argued to represent remnants of feasting events happening in the Warring States period. The rich information contained within the animal remains allows us to explore the details of these four feasting events. The largest and highest-ranking one occurred

near the foundation of a large rammed-earth building at the RDC site, where a high-ranking noble generously slaughtered six cattle to feast the guests. The scale of this event likely exceeded 600 people, and the purpose might have been to foster internal unity or to enhance host's status. At the JCL site, another feast was likely organized by a military commander as a victory banquet for approximately 100 people, during which five sheep were barbecued and consumed. The remains of a young cow in H811 suggested an elite lineage or clan feast of about 50-80 people. Meanwhile, the partial cattle bones discovered in the JSY well hinted at the occurrence of a family gathering.

These four feasting events, which varied in scale and social rank, not only demonstrate the occurrence of feasting but also indicate that residents of different statuses, ranging from the state ruler to ordinary wealthy families, held feasts. This ritual behaviour was deeply integrated into the life of ZHGC, reflecting the people's pursuit of both ritual significance (such as status enhancement or worship for ancestors/deity) and worldly enjoyment. Just as in sacrificial ceremonies, different animals also played distinct roles in feasting. In summary, cattle and sheep held greater ritual and ideological prominence in these feasting events, while pigs played a more marginal role.

In the past, Chinese zooarchaeologists, constrained by various objective or subjective factors, rarely applied feasting theories successfully to animal remains. These four feasting cases significantly fill the gap in Chinese feasting studies based on animal bones and strongly demonstrate the effectiveness and feasibility of this approach. Further research will help us gather more information to complete the puzzle of these four feasting narratives.

5. Status variation among animals and the establishment of the status of cattle

In this study, we directly or indirectly witnessed diachronic shifts in the status of various animals across different perspectives.

As a meat resource, domestic cattle emerged as the primary source of meat within ZHGC, a conclusion supported by the quantitative analysis and meat yield estimations we provided earlier. However, for a long period, as China's earliest independently domesticated animal, the domestic pig was the dominant contributor to the meat supply. The gradual replacement of pigs by cattle began around the Shang Dynasty (ca. 1600-1046 BC), and evidence of this transition has been found in zooarchaeological studies of some large Shang cities in the Central Plains, where the contribution of beef to the meat supply became significantly higher through time (Campbell 2011; Hou et al. 2018, 2019; Li et al. 2013). This trend continued into the Zhou Dynasty, where cattle cemented their dominant position. It is important to note, however, that although beef was abundant, it was not accessible to everyone. Cattle consumption was largely controlled by the noble class. While cattle had overtaken pigs in terms of meat contribution, social stratification still dictated who had access to this valuable resource.

From the perspective of diet and foddering, the intensification of pig feeding with C4 plants appeared to have decreased from Neolithic to Bronze Age. In contrast, cattle replaced pigs as the more intensively managed livestock and being fed a greater quantity of cultivated millets and their by-products than any other animals.

In terms of bone working, the raw materials used for bone production were primarily sourced from domestic cattle. The expansion of domesticated cattle numbers led to cattle bones becoming the primary source for bone artifact production, replacing the dominance of deer bones that had prevailed before the Shang Dynasty in the Central Plains (Li et al. 2011). Long bones of cattle (mainly metacarpals/metatarsals and ulna/radius, but also including tibias, femurs, and other parts) became the most commonly used materials, and cattle horns were also utilized.

In terms of animal sacrifice, based on previous zooarchaeological evidence, dogs and pigs were the most important sacrificial animals before the mid-Shang period. However, by the mid-Shang period, cattle had begun to predominate, and by the late Shang dynasty, cattle and horses became the most prestigious sacrificial animals (Yuan & Flad 2015). This ritual dominance of cattle and horses continued into the Western Zhou period. Although during the Eastern Zhou period, due to the collapse of the Zhou ritual system and the loss of centralized power by the Zhou court, local states could overstep their boundaries and use ritual scales traditionally reserved for the king, the societal emphasis on the ceremonial importance of cattle and horses was still preserved. Thus, cattle, as both a significant source of sustenance and a ritual offering, further reinforced its symbolic significance within the Zhou ritual system, contrasting with pigs, whose once-central role gradually diminished over time. It is assumed that the sacrifices of cattle, particularly in large numbers, were more conducive to reifying status hierarchy than was pig sacrifice (Yuan & Flad 2015).

From the aspects discussed above, it is clear that cattle played a crucial role in ZHGC throughout the Bronze Age, whether as a food source, as productive resources, or as bearers of spiritual significance. Their status steadily rose, gradually replacing pigs, which were central during the Neolithic, as the most important material resource. This shift was largely driven by the introduction of new species and the expansion of agricultural practices and the development of social productive forces. The increasing demand for labour made cattle, which could provide significant draft power, the ideal choice. As a result, slaughtering and consuming cattle became a luxurious act.

Moreover, the emphasis on cattle for their traction power can also explain an intriguing phenomenon: in all the ritual contexts discussed in this study, including sacrificial offerings and feasting events, there were no cases where bulls were definitively identified. While sex could not always be determined, in a few cases where it was clear, the remains

belonged to female cattle, and no evidence such as horns, which would clearly indicate male cattle, was found. This suggests that people preserved male cattle primarily for labour purposes, while female cattle were more commonly used in ritual activities such as feasts and sacrifices. However, during the Late Shang dynasty (ca. 1300-1046 BCE) the role of the different cattle sexes seemed the opposite. Based on morphometric models, Lin et al. (2022) observed the earliest labour employment of female cattle during this period and proposed that female cattle may have been required for traction because of the large numbers of male cattle that were sent for ritual sacrifice. It is a very interesting contrast. If further evidence supports both of these observations, it would highlight another diachronic shift in the roles of male and female cattle from the Late Shang dynasty to the Zhou dynasty (from mid to late Bronze Age in China), marking an evolution in the social functions of cattle based on their sex.

Section 2 “Old wine in a new bottle”— revisit the old materials for feasting

Chapter 8 discusses the current state and underlying reasons for the development of feasting archaeology in China, and several case studies from the Neolithic period that have already been published were highlighted. These studies demonstrate that China has a rich foundation in ethnography, history, document literature, and ancient images related to feasting, and archaeologists need to be more acute to archaeological remains, to effectively integrate these resources with archaeological evidence. This raises an important question: how can we find the remains of feasting?

Searching for feasting remains presents a paradoxical challenge, as it is somewhat of an upside-and-down problem. To a certain extent, feasting is an “outcome”, meaning that to determine whether a collection of animal bones is related to feasting, one must first undertake a comprehensive analytical process. However, obviously, it is impossible to look through every faunal assemblage. Additionally, as I previously mentioned, there is often a lack of clear definition or understanding of feasting among many Chinese archaeologists. This makes it difficult to obtain any clear message about the presence of feasting remains directly from primary excavators. A more practical and straightforward approach might involve identifying a faunal assemblage that looks “special” enough, and then investigating whether it might align with archaeological attributes of feasting. Many feasting case studies would typically result from an encounter serendipitously during routine work. Thus, finding feasting remains often requires a degree of randomness and perhaps a bit of luck.

This challenge of identifying feasting remains was the biggest obstacle I faced after selecting feasting as the topic for my doctoral dissertation. Although I was fortunate to discover a batch of “new materials” from ZHGC (with “new” referring to unpublished materials, though the excavation occurred quite some time ago) for this research, I did not know beforehand whether I would uncover feasting remains. In the process of searching for

materials, I became acutely aware of the tremendous potential of already published “old materials”. China is not lacking in evidence for feasting; rather, it is due to misunderstandings and limitations in overall research paradigms that feasting has rarely been identified and noted in previous zooarchaeological studies. Therefore, faunal assemblages that have already undergone systematic research and analysis, especially those published before the early 21st century, hold significant value for revisit, not just for feasting research, but potentially for other areas as well.

In the following, I will list several materials or sites in China that I have previously paid attention to, which hold significant potential for discovering feasting remains or conducting further research on feasting from different perspectives of hints. Some of them have been briefly suggested as being related to feasting before, such as the Jiahu site (Luo et al., 2015), but with only a brief mention rather than a detailed argument.

1. Jiahu site (7,000-5,700 BC)

The Jiahu site, located in Wuyang, Henan Province, is a crucial early Neolithic site. It has provided the earliest archaeological evidence of pig domestication in China to date (Yuan & Flad, 2002; Larson, 2010), evidenced by changes in tooth morphology and age patterns associated with domestication (Luo & Zhang, 2008). Additionally, the site yielded the world's earliest complete, playable, tightly-dated multitone musical instruments—bone flutes, which were made from the ulnae of the red-crowned crane and have 5, 6, 7 and 8 holes (Zhang et al., 1999).

During the 2001 excavation, a deer bone assemblage was discovered at the bottom of pit H460 (see **Figure 10-2-1**). Researchers suggested that this accumulation likely formed in a single event, possibly related to some kind of feasting activity (Luo et al., 2015: 369), however, they did not make a detailed argument. Furthermore, Luo et al. (2015) also noted that similar accumulations of animal bones were found in previous excavations at the Jiahu

site, such as the bone pile in the southwest corner of house F1. This is also the only site where previous researchers have specifically pointed to the possible existence of feasting. The discovery of these potential feasting-related animal deposits underscores the need to revisit Jiahu's old materials.

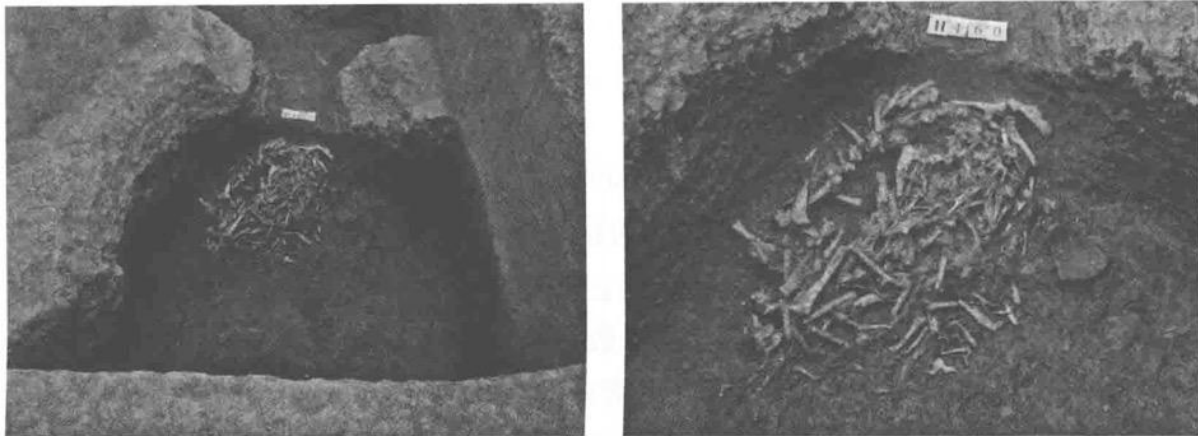


Figure 10-2-1. The deer assemblage from the H460 at Jiahu site (Luo et al., 2015: 370).

2. Jiangzhai site (5000–4000 BC)

The Jiangzhai site is an Early Yangshao period Banpo Phase village, located near the modern city of Xi'an, in Shaanxi Province (Peterson & Shelach, 2012). This site is particularly notable for the discovery of a well-organized village layout from the Jiangzhai Phase I Culture and its contributions to the study of settlement archaeology (Xi'an Banpo Museum, 1988). The excavation report of Jiangzhai is recognized as one of the most comprehensive records of Neolithic village occupation globally (Peterson & Shelach, 2012). The archaeological findings at Jiangzhai have been instrumental in arguing for the existence of matrilineal residence patterns (Xi'an Banpo Museum, 1988: 350–352) and the development of clan lineage in ancient China (Chang, 1986: 119).

During the archaeological excavations conducted between 1972 and 1979, approximately 120 complete house structures were discovered, which were grouped into five clusters positioned in different directions. Each cluster consisted of one large house and several medium and small houses, all with doorways oriented in the same direction. In the

center of the village was a communal plaza, approximately 5,000 square meters in area, around which the five groups of houses were distributed. Surrounding the outer ring of houses were moats (see **Figure 10-2-2**). Some round areas within the plaza were initially suggested to serve as a livestock pen for nighttime shelter, but this interpretation was later challenged, with some scholars proposing that it was instead the remains of ritual activities (He, 2003). The excavators believed that the five clusters of houses represented five clans, with the medium and small houses serving as residences and the large houses functioning as spaces for communal activities such as meetings, discussions, religious ceremonies, or celebrations within the clan. The entire Jiangzhai village was considered as a tribe, with the central plaza serving as the communal activity area for the five clans of the tribe (Xi'an Banpo Museum, 1988: 68-69

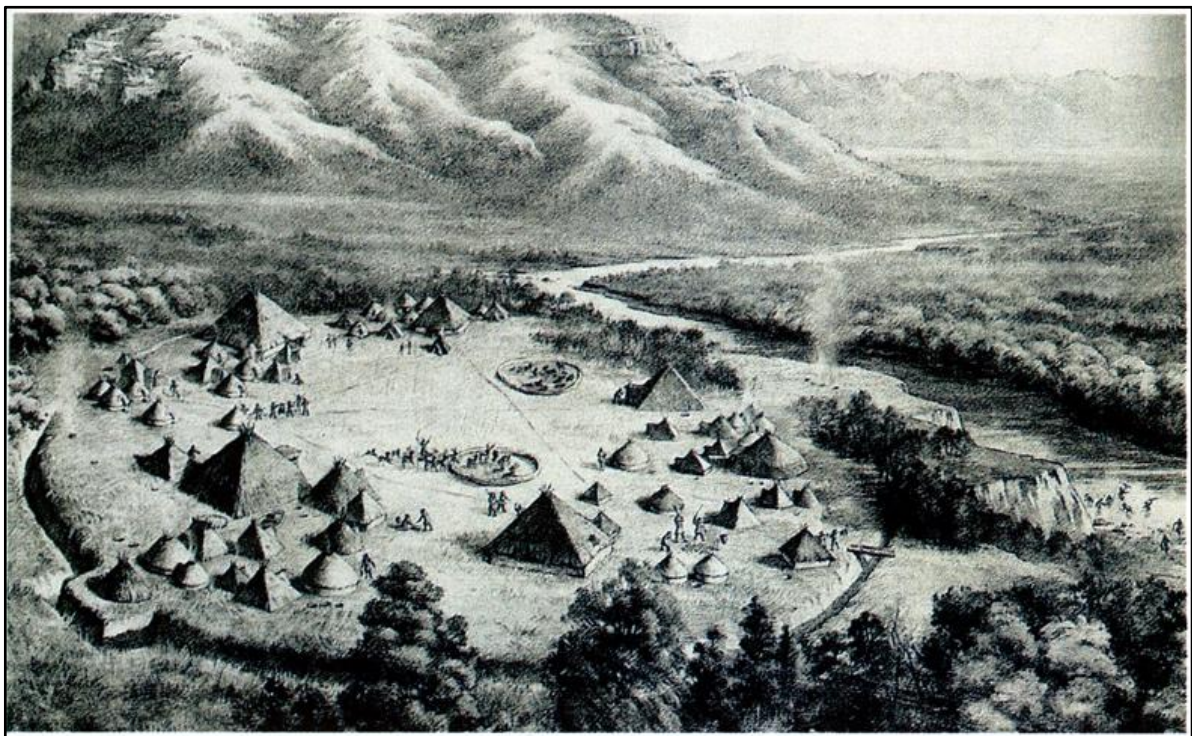


Figure 10-2-2. Landscape reconstruction of the early Jiangzhai settlement (illustration by Zhang Xiaoguang). The central area is the communal plaza used for public activities, surrounded by houses of varying sizes and grades (Xi'an Banpo Museum, 1988).

The concentric spatial arrangement of houses in Jiangzhai village provided an ideal venue for hosting feasting events of various scales. This is why I believe it is likely that

remains related to feasting could be found here. If the feasts took place within the large houses and were confined to individual clans, the level of the feasts²³ could be categorized as promotional or alliance feasts (Hayden, 2001); if multiple clans hosted feasts in the central plaza, the scale could reach the highest level of a tribute feast (Hayden, 2001). In addition, a number of conical-base amphorae unearthed from Jiangzhai site and other similar cultural sites are suggested as utensils for beer fermentation (Liu 2021; Liu et al. 2020a, 2020b).

3. Majiayao site and a series of Majiayao culture sites

The Majiayao site (3200-2400 BC), representing the Mid-Neolithic painted pottery culture of Northwest China, holds significant potential for feasting research. Many Majiayao culture sites yielded a large number of painted pottery vessels, among which several pottery basins were decorated with vivid dancing scenes depicting assembled figures holding hands with each other (**Figure 10-2-3**). It is suggested that this dancing formation closely resembles the traditional dance known as *guozhuang*²⁴ (Shui 1998:19). These potteries, adorned with dance celebration motifs, were likely produced specifically for special ritual activities. Liu (2021) has proposed that these painted basins may be associated with local drinking customs, proposing that the dancing images depicted on the basins' interior surfaces were apparently intended to be viewed from above during public activities. The combination of drinking, dancing, and ritual artifacts strongly aligns with the appearance of meat consumption during the feasting.

²³ A very conservative estimate was made. If we assume that the small houses were occupied by nuclear families, with each house accommodating 3 people, and the medium-sized houses were the residences of clan leaders, housing 4 people per household, then the large houses, being communal spaces, would not have been used for residential purposes. Based on the number of existing house structures, we can estimate the population of each clan as follows: the eastern clan likely had around 62 people, the southern clan about 60 people, the western clan around 64 people, the northwestern clan approximately 60 people, and the northern clan about 64 people.

²⁴ *Guozhuang* is a kind of dance prevailing in Zang nationality in Tibetan area. In the dance, men and women are generally in a semicircle holding hands each other to form a circle.



Figure 10-2-3. dancing scene on a basin of the Majiayao culture (Archaeology Team of Qinghai Provincial Institution of Cultural Relics, 1978: Plate 1).

4. Jinzhai site

The Jinzhai site (3200-2300 BC), is a mid to late Neolithic site in Xiaoxian County, Anhui Province, which is characterized by the finding of numerous exquisite jade artifacts from burials. During excavations conducted between 2016 and 2018, a large quantity of animal bones was unearthed from a ditch in the western excavation area of the site. The faunal assemblage is well-preserved and predominantly consisted of domesticated pigs. Notably, the pigs were of similar age, primarily between 20 to 23 months old, which differed from the skeletal remains typically associated with everyday consumption (Yi, 2019). The Jinzhai site was one of the two case studies explored in my master's thesis. The findings mentioned above led me to hypothesize that the faunal assemblage in the ditch might be related to feasting, which also inspired my interest in pursuing feasting research during my doctoral studies. However, due to the lack of additional Neolithic faunal materials for my

dissertation, the Jinzhai site was temporarily set aside. I plan to revisit and discuss these materials in detail in future research.

5. Other Bronze Age city sites

Technological advancements during the Bronze Age provided more material conditions for the emergence of feasting. Numerous Bronze Age capital sites across China hold immense potential for feasting research. These include Shang Dynasty sites such as Zhengzhou Shang City, Yanshi Shang City, Yinxu, and Panlongcheng (or Panlong city), as well as Western Zhou sites like the Zhouyuan and Fenghao sites. Additionally, the state capitals that are similar to ZHGC during the Eastern Zhou period, such as the capital of Qi in Linzi, the capital of Lu in Qufu, the Jin state site in Houma, the Zhao state site in Handan, and the Qin state site in Yongcheng, also offer significant research opportunities. These city sites are generally long-term archaeological projects, many of which are still ongoing, making access to old materials feasible. Furthermore, the continuation of these projects and latest updates in various research directions often encourage revisiting old materials.

In the end, when examining large old assemblages, we must recognize that the use of them has both advantages and disadvantages. The advantage of utilizing published materials is that they are more accessible for screening and selection, making them an ideal solution to the problem of finding materials. Furthermore, published materials generally come with comprehensive background information, and the preliminary and subsequent research on the sites is often well-established, which will be beneficial for feasting-related analysis. However, there are also drawbacks. Some old faunal assemblages may have been lost over time due to poor management as they were transferred between different institutions, as in the case of Jiahu. I attempted to contact the relevant institutions for the animal bones, but the results were not very promising. Additionally, obtaining supplementary information for these out-of-date materials can be more challenging.

Despite the various challenges, the emergence of this thesis will offer new perspectives and possibilities for future studies on feasting. The theoretical framework and case studies of feasting developed in this paper not only aim to help archaeologists gain a deeper understanding of the core of feasting rituals, thereby expanding its influence, but also hold immense practical value in terms of applicability to other archaeological sites. I believe that my research will pave the way for the burgeoning field of Chinese feasting studies, injecting fresh vitality and guiding it towards greater potential.

Section 3 Shortage and prospect

In the concluding section of my thesis, I intend to reassess my work by proposing the limitations and shortcomings in my research. Meanwhile, I will also offer some prospects for the follow-up work of the ZHGC materials related fields.

1. Shortcomings of this research

Firstly, there are some unavoidable flaws due to the limitations of the excavation era. The most significant one is the lack of sieving and flotation work during the excavation, which has been mentioned multiple times previously. The excavation of ZHGC, conducted in the last century, relied on traditional hand-picking methods, collecting only animal remains visible to the naked eye. This approach would overlook small animal bones, such as those of rodents and fish, and to some extent the smaller bones of the smaller species such as sheep/goat. However, rodent remains are crucial indicators of ancient environment, while the types and quantities of fish bones can provide valuable information on diet, trade, and other aspects of ancient life. The absence of flotation further hindered archaeobotanical research. From the perspectives of both subsistence and environmental reconstruction, the study of both fauna and flora is intertwined, corroborating each other. The lack of plant data from the site undoubtedly constrains the further expansion of animal research. Fortunately, certain areas of ZHGC are still under excavation, and in the past two decades, efforts have been made to emphasize soil sample collection and plant flotation, which would provide additional plant-related data in the future.

Another limitation stemming from the date of the excavation is the incomplete or unclear recording of some basic archaeological background information. Many of the excavation records contain ambiguities, and the visual documentation from that time is neither as comprehensive nor as detailed as modern standards require. The state of the bones upon discovery and special archaeological phenomena were not adequately recorded at the

time. Moreover, since the foundational data has not yet been published, many official site plans, artifact diagrams, and location maps of features are unavailable, which has, to some extent, hindered the possibility of thorough discussion and clear presentation, as observed in the earlier analysis.

Besides these inevitable factors, there are still several regrets regarding my personal work. Due to time constraints and the situation during the COVID-19 pandemic, I must acknowledge that I might have overlooked some subtle information, such as micro-traces requiring detailed observation. Additionally, some measurements might have been ignored, and during the hurried process of organizing the data, some photographs were lost, including two sample images illustrating dental caries and Linear Enamel Hypoplasia (LEH) of domesticated pigs. Furthermore, based on experience, even when well-preserved bone material is excavated, only a portion can be identified to species and bone element by archaeozoologists. Some mistakes of species identification might be made; for example, isotope sample #1794/22 may have mistakenly identified the radius of a small deer as that of an ovicaprid, as pointed out in Chapter 5. In terms of isotope analysis, a significant oversight was the failure to collect isotope samples from the EGJ site. Since EGJ was included later in the research, it was unknown during isotope sampling that this site was located in the western district of the city. Earlier, samples were taken from HZM and ZHL as representatives of the western district, but it was later discovered that most of the HZM samples did not correspond to the period of the city's occupation, while ZHL had only two samples. Therefore, a comparison between the eastern and western districts during the Eastern Zhou period could not be adequately conducted. If EGJ was sampled, this comparative analysis would be conducted. Additionally, although I initially proposed concepts such as urban archaeology and emphasized the differences between the eastern and western districts, I seldom spent much time discussing spatial distribution of faunal remains in my research. Although this is,

to some extent, also caused by the unavailability of context data, future work will need to try to address this gap for further discussion.

2. Prospects for the future work

ZHGC is a long-term project and there will be a lot of work to be done. Based on the study results achieved by now, I would like to offer prospects and calls for future research directions, emphasizing areas that require further exploration as well as suggesting approaches that could make up shortages and could enhance the understanding and study of feasting practices in ancient societies.

Concerning the butchery, fracture and fragmentation part, zonation system (Dobney & Rielly 1988) should be introduced to improve the recording method of fragmentation areas in the future work. If possible, current data is advised to be updated. In addition, the Fracture Freshness Index (FFI) can be employed as an effective way for estimating fractures on bones; and more integrated analytical systems for assessing fracture and fragmentation are suggested to be conducted for the future inter-site comparison.

In terms of species identification, employing the technique of Zooarchaeology by mass spectrometry (ZooMS) can significantly mitigate the errors and uncertainties associated with manual identification and subjective judgments (Buckley 2018). This technique is particularly useful for addressing challenges that require high identification accuracy for tricky samples. For instance, in the ZHGC assemblage, distinguishing between sheep and goats or determining whether the large feline calcaneus (see Figure 4-5-9 in Chapter 4) really is a tiger would benefit greatly from ZooMS analysis. Additionally, the application of ZooMS to non-mammalian assemblages has shown growing potential (Ritcher et al. 2022), which could be particularly advantageous for the specific breed identification of sturgeon scutes (see Figure 4-5-6 in Chapter 4). While ancient DNA (aDNA) analysis comes with a much higher

cost than ZooMS, it would also be useful for some critical samples for a higher precision and more information.

For the diet reconstruction based on isotopic analysis, the Bayesian mixing model, such as FRUITS (Food Reconstruction Using Isotopic Transferred Signals) can be introduced in the future work. It incorporates the capability to account for the contribution of different food fractions towards a dietary proxy signal measured in the consumer (Fernandes et al. 2014). This will help to achieve accurate and precise food intake estimates in diet reconstruction studies.

Additionally, the utility of organic residue analysis (Evershed 2008) and transmission electron microscopy (TEM) analysis of bone collagen (Koon et al. 2003; Koon 2012) can provide with invisible evidence that cannot be characterized using traditional techniques of archaeological investigation. These methods would serve as a springboard for testing more detailed archaeological hypotheses, such as those concerning the cooking practices of feasting animals (Faillance et al. 2020), and if the offering animals from burial vessels were ever cooked and heated.

Beyond the technological advancements, it is both significant and practical to revisit existing materials and data as more contextual information becomes available in the future. Numerous hypotheses await validation or refutation, including those pertaining to the spatial distribution of faunal remains, the varying functions of feasting events and the identities of their sponsors, as well as potential differences in faunal remains between the western and eastern cities.

3. Responsibilities of archaeologists

Finally, based on my previous academic experiences and firsthand insights gained during my PhD research, I have come to a profound understanding of the responsibilities borne by archaeologists. However, the “responsibility” I wish to discuss here is not merely

the traditional notion of diligence and accountability in the execution of work—most archaeologists already excel in this regard. Everyone I have encountered in the field, from archaeologists to technicians and volunteers, has demonstrated a deep passion for and respect towards the discipline, alongside an admirable work ethic and a resilient, optimistic spirit. Therefore, what I wish to emphasize is the responsibility to foster innovation and continuous self-reflection in archaeological practice.

Conventional thinking, shaped by previous training systems, often constrains our ideas. For instance, it is commonly assumed that all excavated bones are simply refuse from food consumption, with the primary purpose of nourishment (Thilderkvist 2013). This assumption can obscure the recognition of special events that is not conspicuous enough, such as the feasting remains discussed in this study. When confronted with certain questions, there is often a tendency to rely on established paths of thought, which stifles opportunities for innovative discoveries. The best way to address this dilemma is to continually update our methodologies and theoretical frameworks, and to reflect critically on previous work.

As I mentioned earlier, previously published materials hold substantial academic potential. It is not uncommon for me to realize, during the course of new research, certain oversights or areas for improvement in earlier work—whether through the identification of previously unrecognizable species or the application of newly acquired theoretical and methodological tools to fill gaps in past analyses. However, it is a pity that, due to various subjective or objective reasons, I have seldom been able to make up for these regrets. Published materials should not simply be left to gather dust in warehouses, even if they have already been the subject of scholarly attention. In an ever-evolving discipline where new technologies, methods, and theories are constantly being introduced, the ability to revisit and revitalize old materials is also a crucial responsibility that we as archaeologists must fulfil.

Bibliography

- Abe, T. (2020). Politics over Hosting Case Study of Feast in Hani, Yunnan, China. *Japanese Review of Cultural Anthropology*, 21(1), 537-541.
- Adams, R. L., (2004). An ethnoarchaeological study of feasting in Sulawesi, Indonesia. *Journal of Anthropological Archaeology*, 23(1), 56-78.
- Adams, R. L., (2005). Ethnoarchaeology in Indonesia illuminating the ancient past at Çatalhöyük? *American Antiquity* 70, 181–188.
- Adams, R. L., (2007a). Maintaining cohesion in house societies of West Sumba, Indonesia. In R. J. Beck (ed.) *The Durable House: House Society Models in Archaeology*, Carbondale: South. Ill. Univ. Press, 344–62.
- Adams, R. L., (2007b). *The megalithic tradition of West Sumba, Indonesia*. PhD thesis. Simon Fraser University, Burnaby, Br. Columbia.
- Albarella, U. (2002). Size matters: how and why biometry is still important in zooarchaeology. In Dobney K., O'Connor T. (Eds.), *Bones and the Man: Studies in Honour of Don Brothwell*, Oxbow Books, Oxford, pp. 51-62.
- Albarella, U., & Payne, S. (2005). Neolithic pigs from Durrington Walls, Wiltshire, England: a biometrical database. *Journal of Archaeological Science*, 32(4), 589-599.
- Albarella, U., & Serjeantson, D. (2002). A passion for pork: meat consumption at the British Late Neolithic site of Durrington Walls. *Consuming passions and patterns of consumption*, 33-49.
- Albizuri, S., Grandal-d' Anglade, A., Maroto, J., Oliva, M., Rodríguez, A., Terrats, N., ... & López-Cachero, F. J. (2021). Dogs that ate plants: changes in the canine diet during the late bronze age and the first iron age in the northeast Iberian Peninsula. *Journal of World Prehistory*, 34, 75-119.
- Ambrose, S. H. (1986). Stable carbon and nitrogen isotope analysis of human and animal diet in Africa. *Journal of Human Evolution*, 15(8), 707-731.
- Ambrose, S. H., & DeNiro, M. J. (1986). Reconstruction of African human diet using bone collagen carbon and nitrogen isotope ratios. *Nature*, 319(6051), 321-324.
- Ambrose, S. H., & DeNiro, M. J. (1986). The isotopic ecology of East African mammals. *Oecologia*, 69, 395-406.
- Ambrose, S. H., 1993: "Isotopic Analysis of Palaeodiets: Methodological and Interpretive Considerations". In: M. K. Sandford (ed.), *Investigations of Ancient Human Tissue: Chemical Analysis in Anthropology*, USA: Gordon and Breach Science Publishers, 59-130.
- Ambrose, S. H., B. M. Butler, D. B. Hanson, R. L. Hunter-Anderson and H. W. Kruegers, 1997: "Stable Isotopic Analysis of Human Diet in the Marianas Archipelago, Western Pacific", *American Journal of Physical Anthropology* 104, 343-361.
- An, Z. M. (1979). Peiligang, Cishan and Yangshao -- on the origin and development of Neolithic culture in Central Plains[裴李岗、磁山和仰韶——试论中原新石器文化的渊源及发展]. *Archaeology* (04),335-346+334 (in Chinese).
- Andrushko, V. A., Buzon, M. R., Gibaja, A. M., McEwan, G. F., Simonetti, A., & Creaser, R. A. (2011). Investigating a child sacrifice event from the Inca heartland. *Journal of Archaeological Science*, 38(2), 323-333.

- Anthony, D. J. & Lewis E. F. 1961. *Diseases of the pig: a handbook of the diseases of the pig, with an introduction to its husbandry*. 5th ed. Williams and Wilkins, Baltimore, MD: 1–407.
- Archaeology Team of Qinghai Provincial Institution of Cultural Relics. (1978). Qinghai Datongxian Shangsunjiazhai chutu de wudaowen caitaopen (Painted pottery basin with dancing motifs unearthed from Shangsunjiazhai in Datong County, Qinghai) *Cultural Relics* (3), 48-49. (in Chinese).
- Arthur, J.W., (2003). Brewing beer: status, wealth and ceramic use alteration among the Gamo of south-western Ethiopia. *World Archaeology* 34, 516–528.
- Baker, J. & Brothwell, D., (1980). *Animal Diseases in Archaeology*. London: Academic Press.
- Ball, P. J., & Peters, A. R. (2008). *Reproduction in cattle*. John Wiley & Sons.
- Bao, Y. (2009). *Research on the System of Military Defense of Zhenghan Ancient City*. Master's thesis, Zhengzhou University (in Chinese).
- Bao, Y. (2020). *A Comprehensive Study on the Military Defense System of Zhenghan Ancient City*. Zhengzhou: Henan People's Press (in Chinese).
- Beckman, J. (2016). Standing at the Mouth of the Grave: Chariot Fittings in Eastern Zhou Burials. *Artibus Asiae*, 76(1), 81-112.
- Behrensmeyer, A. K. (1978). Taphonomic and ecologic information from bone weathering. *Paleobiology*, 4(2), 150-162.
- Bender, B., (1978). Gatherer-hunter to farmer: A social perspective. *World archaeology*, 10(2), 204-222.
- Bender, B., (1985). Emergent tribal formations in the American midcontinent. *American Antiquity*, 50(1), 52-62.
- Ben-Shlomo, D., Hill, A., & Garfinkel, Y. (2009). Feasting between the revolutions: evidence from Chalcolithic Tel Tsaf, Israel. *Journal of Mediterranean Archaeology*, 22(2), 129.
- Bergström, A., Stanton, D.W., Taron, U.H., Frantz, L., Sinding, M.H.S., Ersmark, E., Pfrengle, S., Cassatt-Johnstone, M., Lebrasseur, O., Girdland-Flink, L. and Fernandes, D.M., 2022. Grey wolf genomic history reveals a dual ancestry of dogs. *Nature*, 607(7918), 313-320.
- Berlin, Jeremy (2014). World's oldest decimal times table found in China. *National Geographic*.
- Binford, L. R. (1981). *Bones: ancient men and modern myths*. Academic press.
- Binford, L. R. (1984). *Faunal Remains from Klasies River Mouth*. Academic Press, Orlando.
- Bird, M. I., & Pousai, P. (1997). Variations of $\delta^{13}\text{C}$ in the surface soil organic carbon pool. *Global Biogeochemical Cycles*, 11(3), 313-322.
- Blinman, E., (1989). Potluck in the protokiva: ceramics and ceremonialism in Pueblo I Villages. In *Architecture of Social Integration in Prehistoric Pueblos*, ed. W Lipe, M Hegmon, Cortez, CO: Crow Canyon Archaeol. Cent, 113–24.
- Boas, F., (1966). *Kwakiutl Ethnography*. University of Chicago Press, Chicago.
- Bocherens, H. and D. Drucker, 2003: "Trophic Level Isotopic Enrichment of Carbon and Nitrogen in Bone Collagen: Case Studies from Recent and Ancient Terrestrial Ecosystems", *International Journal of Osteoarchaeology* 13, 46-53.
- Bocherens, H., Fizet, M., & Mariotti, A. (1994). Diet, physiology and ecology of fossil mammals as inferred from stable carbon and nitrogen isotope biogeochemistry:

- implications for Pleistocene bears. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 107(3-4), 213-225.
- Boessneck, J. and von den Driesch, A. (1978). The significance of measuring animal bones from archaeological sites. In Meadow R., Zeder M. (Eds.), *Approaches to Faunal Analysis in the Middle East, Peabody Museum Bulletin*, 2, Harvard University, Cambridge, MA, pp. 25-39.
- Boessneck, J., Jéquier, J. P., & Stampfli, H. R. (1963). *Seeberg, Burgäschisee-Süd*. Stämpfli.
- Bogaard, A., Fraser, R., Heaton, T. H., Wallace, M., Vaiglova, P., Charles, M., ... & Stephan, E. (2013). Crop manuring and intensive land management by Europe's first farmers. *Proceedings of the National Academy of Sciences*, 110(31), 12589-12594.
- Branch, Nick (2014). *Environmental Archaeology: Theoretical and Practical Approaches*. London: Routledge.
- Bray, T. L. ed., (2003). *The archaeology and politics of food and feasting in early states and empires*. New York: Kluwer Academic/Plenum.
- Brookfield, H. C., (1972). Intensification and deintensification in Pacific agriculture: A theoretical approach. *Pacific viewpoint*, 13(1), 30-48.
- Brown, J. A., & Kelly, J. E. (2015). Surplus labor, ceremonial feasting, and social inequality at cahokia. *Surplus: The politics of production and the strategies of everyday life*, 221-244.
- Brown, T. A., Nelson, D. E., Vogel, J. S., & Southon, J. R. (1988). Improved collagen extraction by modified Longin method. *Radiocarbon*, 30(2), 171-177.
- Brunson, K. (2011). Shifting animal exploration in late Neolithic China: A zooarchaeological analysis of the Longshan Culture site of Taosi, Shanxi Province. In Research Center for the Archaeology During the Xia, Shang, and Zhou Dynasty, Institute of Archaeology, CASS (Eds.) Sandai Kaogu (Vol. 4). Beijing: Science Press, pp. 129-182 (in Chinese).
- Brunson, K., & Lander, B. (2023). Deer and Humans in the Early Farming Communities of the Yellow River Valley: A Symbiotic Relationship. *Human Ecology*, 51(4), 609-625.
- Brunson, K., Lele, R., Xin, Z., Xiaoling, D., Hui, W., Jing, Z., & Flad, R. (2020). Zooarchaeology, ancient mtDNA, and radiocarbon dating provide new evidence for the emergence of domestic cattle and caprines in the Tao River Valley of Gansu Province, northwest China. *Journal of Archaeological Science: Reports*, 31, 102262.
- Brück, J., (1999). Ritual and Rationality: Some Problems of Interpretation in European Archaeology. *European Journal of Archaeology* 2:313-344.
- Buckley, M. (2018). Zooarchaeology by mass spectrometry (ZooMS) collagen fingerprinting for the species identification of archaeological bone fragments. *Zooarchaeology in practice: case studies in methodology and interpretation in archaeofaunal analysis*, 227-247.
- Bull G. & Payne P. (1982). Tooth eruption and epiphyseal fusion in pigs and wild boar. In: Wilson B., Grigson C. & Payne S. (eds), *Ageing and Sexing Animal Bones from Archaeological Sites (BAR British Series 109)*, 55-71. Oxford: British Archaeological Reports.
- Bullitt, O., (1969). *Search for Sybaris*. London: J.M. Dent.

- Bullock, D. and Rackham, J., (1982). Epiphyseal fusion and tooth eruption of feral goats from Moffatdale, Dumfries and Galloway, Scotland. In Wilson et al. (eds.) *Ageing and sexing animal bones from archaeological sites* (Vol. 109, pp. 73-80). British Archaeological Reports Oxford.
- Bunimovitz, S. and Lederman, Z. (2016) "Opium or oil? Late Bronze Age Cypriot Base Ring juglets and international trade revisited," *Antiquity*. Cambridge University Press, 90(354), pp. 1552–1561. doi: 10.15184/aqy.2016.177.
- Cai, D. (2021). Ancient DNA and the Origin of Domestic Horse in China. Beijing: Science Press (in Chinese).
- Cai, D., Sun, Y., Tang, Z., Hu, S., Li, W., Zhao, X., ... & Zhou, H. (2014). The origins of Chinese domestic cattle as revealed by ancient DNA analysis. *Journal of Archaeological Science*, 41, 423-434.
- Cai, D., Tang, Z., Han, L., Speller, C. F., Yang, D. Y., Ma, X., ... & Zhou, H. (2009). Ancient DNA provides new insights into the origin of the Chinese domestic horse. *Journal of Archaeological Science*, 36(3), 835-842.
- Cai, Q. & Ma, J. (1996). Ruins and ancient tombs of Eastern Zhou Dynasty at Gaolu Road in Xinzheng City[新郑市阎老路东周遗址与古墓葬]. *Yearbook of Archaeology in China* (1996)[中国考古学年鉴]: 174-175.
- Cai, Q. & Ma, J. (1997). Eastern Zhou site at Zhenghanlu in Xinzheng [新郑市郑韩路东周遗址]. *Yearbook of Archaeology in China* (1996), 184.
- Cai, Q. & Ma, J. (1998). Bronze vessels and instruments from No.4 and No.15 pits [郑韩故城 4 号、15 号坑铜礼乐器浅析]. *Huaxia Archaeology*(04),57-62.
- Cai, Q. & Ma, J. (2002). Brief report on the excavation of Longshan Cultural City Site in the ancient city village of Xinmi City, Henan Province [河南新密市古城寨龙山文化城址发掘简报]. *Huaxia Archaeology* (02),53-82+114-116.
- Cai, Q. & Ma, J. (2005). Brief excavation report on sacrificial site of Eastern Zhou in Xinzheng city of Henan Province. *Cultural Relics* (10) (in Chinese).
- Cai, Q. & Ma, J. (2005). Eastern Zhou sacrificial site of the Zhenghan Ancient City in Xinzheng, Henan [河南新郑郑韩故城东周祭祀遗址]. *Cultural Relics* (10).
- Cai, Q. & Song, G. (1987). Investigation report of the Eastern tomb in Xizheng [新郑县辛店许岗东周墓调查简报]. *Cultural Relics of Central China* (04).
- Cai, Q. (1986). A simple explanation of pottery inscription unearthed from the Zhenghan Ancient City in recent years [近年来新郑“郑韩故城”出土陶文简释]. *Cultural Relics of Central China* (01), 76-87 (in Chinese).
- Cai, Q. (1986). The Zhenghan Ancient City site in Xinzheng. *Yearbook of Archaeology in China* (1986)[中国考古学年鉴], 150-151 (in Chinese).
- Cai, Q. (1991). The Zhenghan Ancient City site in Xinzheng. *Yearbook of Archaeology in China* (1991) [中国考古学年鉴], 230-232 (in Chinese).
- Cai, Q. (2000). The nature and some problems of copper ware hoard in Jincheng Road, Xinzheng [新郑金城路铜器窖藏性质及其若干问题], 河南省文物考古学会编《河南文物考古论集》(二), 中州古籍出版社.

- Cai, Q. (2003a). The main harvest of Zheng Han ancient City and Zheng culture archaeology [郑韩故城与郑文化考古的主要收获]. HPICRA (ed.). 群雄逐鹿两周列国文物瑰宝. Zhengzhou: Elephant Press, 202-211.
- Cai, Q. (2003b). The main harvest of Zheng Han ancient City and Zheng culture archaeology [郑韩故城与郑文化考古的主要收获]. HPICRA (ed.). 群雄逐鹿两周列国文物瑰宝. Zhengzhou: Elephant Press, 117-123.
- Cai, Q. (2006). 郑国祭祀遗址出土韩国陶量及其文字研究. In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press. pp. 1162-1170 (in Chinese).
- Cai, Q. (2014). Study of the Warring States Period Ink-written Accounts on Ox Ribs Unearthed from the Zheng and Han City-site in Xinzheng [新郑郑韩故城出土战国牛肋骨墨书账簿考]. *Huaxia Archaeology* (04), 72-84+123+2+169.
- Cai, Q., Hou, X., & Wang, W. (1987). Brief report on excavation of East Zhou tombs in Caizhuang, Xinzheng County [新郑县蔡庄东周墓葬发掘简报]. *Cultural Relics of Central China* (04).
- Cai, Q., Kou, Y., Du, P. (2005). Neolithic site investigation in Xinzheng [新郑唐户新石器时代遗址调查]. *Cultural Relics of Central China* (05), 12-23.
- Campbell, R. B., Li, Z., He, Y., & Jing, Y. (2011). Consumption, exchange and production at the Great Settlement Shang: bone-working at Tiesanlu, Anyang. *Antiquity*, 85(330), 1279-1297.
- Cao, J. & Wang, J. (2016). Identification report of animal bones unearthed in funerary vessels in the East Zhou Cemetery of Shuanglou, Zhengzhou. 郑州双楼东周墓地随葬器皿内出土动物骨骼鉴定报告. In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.). *Shuanglou Cemetery of the Zhou Dynasty in Xinzheng*. (in Chinese).
- Cao, J. (2008). Research on the animal sacrifice using system in Zhou Dynasty 周代祭祀用牲礼制考略. *Relics and Museology* (03), 18-21. (in Chinese)
- Carter, R., & Magnell, O. (2007). Age estimation of wild boar based on molariform mandibular tooth development and its application to seasonality at the Mesolithic site of Ringkloster, Denmark. In Albarella U. et al. (eds.), *Pigs and humans*, 10, 197-217.
- Casteel, R. W. & Grayson, D. K. (1977). Terminological problems in quantitative faunal analysis. *World Archaeology* 9(2): 235– 242.
- Casteel, R. W. (1978). Faunal assemblages and the “Wiegemethode” or weight method. *Journal of Field Archaeology*, 5(1), 71-77.
- Chang, K. C. (1987). *The archaeology of ancient China*. Yale University Press.
- Chang, K. C., & Chang, K. C. (2009). *ART MYTH AND RITUAL P*. Harvard University Press.
- Chang, K.C. ed., (1977). *Food in Chinese culture: Anthropological and historical perspectives*. New Haven: Yale University Press.
- Chang, Y. & Wu, X. 2019. Discovery and significance of a Chinese Sturgeon (*Acipenser sinensis*) bone at Lanjiazhai Site, Chongqing, China. *Quaternary Science* 39(6):1467-1475.
- Yuan, J. & Yang, M. 2006. Faunal research. The Office of Three Gorges

- Construction Committee of State Department, the State Bureau of Cultural Relics, et al. (ed.) *The Badong Nanmuyuan Site*. Beijing: Science Press: 139-158 (in Chinese).
- Chang, Y. (2012). Records about Hunting on Oracle Bones. *Journal of National Museum of China* (05), 40-47. (in Chinese).
- Chang, Z. (2006). Report of jade tools unearthed at the sacrificial site of Zheng State [郑国祭祀遗址出土的玉石器鉴定报告], *The Sacrifice Site of Zheng in Xinzheng* (2).
- Charlton, R., & Kaye, R. (1985). The politics of religious slaughter: An ethno-religious case study. *New Community*, 12(3), 490-503.
- Chau, A. (2004). Hosting Funerals and Temple Festivals: Folk Event Productions in Rural China. *Asian Anthropology* 3, 39-70.
- Chau, A. (2006). *Miraculous Response: Doing Popular Religion in Contemporary China*. Stanford, California: Stanford University Press.
- Chen, B. (2019). Horse Pits of Zhonghang Site in Ancient Capital City Zheng and Han States [郑韩故城中行遗址马坑性质刍议]. *Journal of National Museum of China* (04), 36-42.
- Chen, C. (2010a). Research of fishing culture in Shijing. *Agricultural Archaeology* (01), 275-279 (in Chinese).
- Chen, C. (2021). Paradigm shift and the development of archaeological cultural concepts. *Social Science in China* (09), 172-188 (in Chinese). doi:CNKI:SUN:ZSHK.0.2021-09-011.
- Chen, C. (2010b). Research of hunting culture in Shijing. *Agricultural Archaeology* (04), 378-382 (in Chinese).
- Chen, G. & Li, Z. (2016). The observation on the bone workshop remains at Erlitou site [二里头遗址制骨遗存的考察]. *Archaeology* (05), 59-70+2 (in Chinese).
- Chen, M. (1988). Summary of Yinxu Inscriptions [殷墟卜辞综述], Beijing: Zhonghua Book Company, pp. 552 (in Chinese).
- Chen, M. (2012). Feast poems in *Shijing* and the spirit of ritual culture. *Northern Literature* (04), 136 (in Chinese).
- Chen, Q. (2023). An archaeological research of the burials of waist pit of the Eastern Zhou Dynasty in Zhengzhou. 郑州地区东周腰坑墓的考古学研究——基于墓葬的历时性变化与墓主人群族属的考察. *Cultural Relics of Central China* (04), 55-62. (in Chinese).
- Chen, Q., (1940). *Han Fei Zi* [韩非子(校释)]. Zhonghua Book Company.
- Chen, S. (2009). Concept of culture in archaeology. *Archaeology* (10), 59-67+97 (in Chinese).
- Chen, S. (2018). The theoretical introspection on the Cultural-historical Archaeology: the prospect in Chinese archaeology. *Archaeology* (02), 68-78 (in Chinese).
- Chen, S. (2019). Paradigm and paradigm shift in China's archaeology research. *Zhongguo shehui kexue* 中國社會科學 (2):182-203 (in Chinese).
- Chen, S. Y., Duan, Z. Y., Sha, T., Xiangyu, J., Wu, S. F., & Zhang, Y. P. (2006). Origin, genetic diversity, and population structure of Chinese domestic sheep. *Gene*, 376(2), 216-223.

- Chen, X. (2021). The development and social changes of subsistence economy in the Neolithic period in Henan—thinking based on the research results of Carbon and Nitrogen stable isotopes. *Cultural Relics in Southern China* (01),179-190 (in Chinese).
- Chen, X., Fang, Y., Hu, Y., Hou, Y., Lv, P., Song, D... & Michael P. Richards. (2017b). Enlightenment from the stable isotopic analysis of the complication of prehistoric subsisting economy: with the Wadian site in Yuzhou, Henan taken as an example. *Huaxia Archaeology* (04),70-79+84.
- Chen, X., Guo, X., Wang, W., Hu, S., Yang, M., Wu, Y., and Hu, Y. (2017a). The subsistence patterns of the Shengedaliangsite (~4,000 yr BP) revealed by stable carbon and nitrogen isotopes in northern Shaanxi, China, *Science China: Earth Sciences*, 60(2), 268–76.
- Chen, X., Hu, S., Hu, Y., Wang, W., Ma, Y., Lv, P., & Wang, C. (2016). Raising practices of Neolithic livestock evidenced by stable isotope analysis in the Wei River valley, North China, *International Journal of Osteoarchaeology*,26(1), 42–52.
- Chen, X., You, Y. & Wu, Q. (2018). Research on the process of agricultural complexity from animal feeding practices at the Wangjinglou site in Xinzheng in the period of the Xia and Shang Dynasty. *Cultural Relics in Southern China* (02),200-207 (in Chinese).
- Chen, X., Yuan, J., Hu, Y., He, N., & Wang, C. (2012). A preliminary exploration to the domestic animal raising strategy: the evidences from Carbon and Nitrogen isotope analyses of Taosi site. *Archaeology* (09),75-82 (in Chinese).
- Chen, X., Yuan, J., Yang, M., Chen, A., Yang, M., Zuo, H. & Ma, Y. (2020) The raising strategies of horses from the Beidoufang location at the Xuechi site in Fengxiang. *Archaeology and Cultural Relics* (06),109-114 (in Chinese).
- Chinese Academy of Science& Banpo Museum [中国科学院考古研究所&半坡博物馆] (1963). *The Neolithic Village at Pan Po, Sian*[西安半坡-原始氏族公社聚落], Cultural Relics Press.
- Chisholm, B. S., 1989: "Variation in Diet Reconstructions Based on Stable Carbon Isotopic Evidence". In: T. D. Price (ed.), *The Chemistry of Prehistoric Human Bone*, Cambridge: Cambridge University Press, 10-37.
- Clark, J. G. D., (1954). *Excavations at Star Carr*. London: Cambridge University Press.
- Clark, K., (2004). *Pathology in Animal Archaeology*. BAR International Series 1354. Oxford: Archaeopress.
- Codere H. (1950). *Fighting with Property*. Seattle: University of Washington Press.
- Cohen, A. & Serjeantson, D. (2015). *A Manual for The Identification of Bird Bones from Archaeological Sites*. London: Archetype Publications Ltd.
- Costin, C. L. (1991). Craft specialization: issues in defining, documenting, and explaining the organization of production. *Archaeological method and theory*, 3, 1-56.
- CPAM., Zhejiang Provincial Museum [浙江省文物管理委员会, 浙江省博物馆] (1978). The first excavation report of Hemudu Site [河渡遗址第一期发掘报告]. *Acta Archaeologica Sinica* (01),39-94+140-155.
- Craig, O. E., Shillito, L.-M., Albarella, U., Viner-Daniels, S., Chan, B., Cleal, R., Ixer, R., Jay, M., Marshall, P., Simmons, E., Wright, E. and Pearson, M. P. (2015) “Feeding

- Stonehenge: cuisine and consumption at the Late Neolithic site of Durrington Walls,” *Antiquity*, 89(347), pp. 1096–1109.
- Craine, J. M., Brookshire, E. N. J., Cramer, M. D., Hasselquist, N. J., Koba, K., Marin-Spiotta, E., & Wang, L. (2015). Ecological interpretations of nitrogen isotope ratios of terrestrial plants and soils. *Plant and Soil*, 396, 1-26.
- Craine, J. M., Elmore, A. J., Aidar, M. P., Bustamante, M., Dawson, T. E., Hobbie, E. A., ... & Wright, I. J. (2009). Global patterns of foliar nitrogen isotopes and their relationships with climate, mycorrhizal fungi, foliar nutrient concentrations, and nitrogen availability. *New Phytologist*, 183(4), 980-992.
- Crown, P.L. (2018). Drinking performance and politics in Pueblo Bonito, Chaco Canyon. *American Antiquity*, 83(3), pp.387-406.
- Crown, P.L., Gu, J., Hurst, W.J., Ward, T.J., Bravenec, A.D., Ali, S., Kebert, L., Berch, M., Redman, E., Lyons, P.D. and Merewether, J. (2015). Ritual drinks in the pre-Hispanic US Southwest and Mexican Northwest. *Proceedings of the National Academy of Sciences*, 112(37), pp.11436-11442.
- Dabney, M. K., Halstead, P., & Thomas, P. (2004). Mycenaean feasting on Tsoungiza at ancient Nemea. In *Hesperia: The Journal of the American School of Classical Studies at Athens*, 73(2), 197-215.
- Dai, L. L., Li, Z. P., Zhao, C. Q., Yuan, J., Hou, L. L., Wang, C. S., ... & Hu, Y. W. (2016). An isotopic perspective on animal husbandry at the Xinzhai site during the initial stage of the legendary Xia Dynasty (2070–1600 BC). *International Journal of Osteoarchaeology*, 26(5), 885-896.
- Dai, L., Kan, X., & Zhang, X. (2019). An investigation into the strategy of pig husbandry combining zooarchaeological and stable isotopic approaches at Neolithic Houjiazhai, China. *International Journal of Osteoarchaeology*, 29(5), 772-785.
- de Garine, I. (1996). Food and the status quest in five African cultures. In: Wiessner, P., Schiefenhover, W. (Eds.), *Food and the Status Quest: An Interdisciplinary Perspective*. Berghahn, Oxford, pp. 193–218.
- de Waal, F. B. (1997). The chimpanzee's service economy: Food for grooming. *Evolution and Human Behavior*, 18(6), 375-386.
- DeBoer, W.R. (2001). The Big Drink: feast and forum in the Upper Amazon. In: Dietler, M., Hayden, B. (Eds.), *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Smithsonian Institution Press, Washington, D.C, pp. 215–239.
- Delwiche, C. C., & Steyn, P. L. (1970). Nitrogen isotope fractionation in soils and microbial reactions. *Environmental Science & Technology*, 4(11), 929-935.
- Deng, G. (2023). A Meager Opinion about Systems Stipulating Orientation and Position of Tomb Tunnels of Pre-Qin Tombs—Also on Clan of Tomb Occupants Buried in Yejiashan Cemetery, Family Cemetery of Marquis of Zeng State in Suizhou. [先秦墓道方位制度刍议——兼论随州叶家山曾侯墓地的族属问题]. *Huaxia Archaeology* (01), 90-101(in Chinese).
- Deng, X. & Deng, Z. 1997. Progress in the conservation biology of Chinese Sturgeon. *Zoological Research* 18(1): 113-120 (in Chinese).

- DeNiro, M. J. (1985). Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. *Nature*, 317(6040), 806-809.
- DeNiro, M. J. and C. A. Hastorf, 1985: "Alteration of $^{15}\text{N}/^{14}\text{N}$ and $^{13}\text{C}/^{12}\text{C}$ Ratios of Plant Matter during the Initial Stages of Diagenesis: Studies Utilising archaeological Specimen from Peru", *Geochimica et Cosmochimica Acta* 29, 97-115.
- Deniz E. & Payne S. (1982). Eruption and wear in the mandibular dentition as a guide to ageing Turkish Angora goats. In: Wilson B., Grigson C. & Payne S. (eds), *Ageing and Sexing Animal Bones from Archaeological Sites (BAR British Series 109)*, 155-205. Oxford: British Archaeological Reports.
- Deniz, E. and Payne, S., (1982). Eruption and wear in the mandibular dentition as a guide to ageing Turkish Angora goats. *Ageing and sexing animal bones from archaeological sites*, 109, 155-205.
- Desse-Berset, N. 2011: Discrimination of *Acipenser sturio*, *Acipenser oxyrinchus* and *Acipenser naccarii* by Morphology of Bones and Osteometry. In: Williot, P.; Rochard, E.; Desse-Berset, N.; Kirschbaum, F. & Gessner, J. (eds.): *Biology and Conservation of the European Sturgeon Acipenser sturio L. 1758. The Reunion of the European and Atlantic Sturgeons*: 23-52. Springer-Verlag, Berlin.
- Dibble, F. (2021). Bones around town: taphonomic patterns from civic feasting and residential dining contexts at Late Archaic Azoria, Crete. *Journal of Archaeological Science: Reports*, 36, 102771.
- Dietler, M. (1990). Driven by drink: the role of drinking in the political economy and the case of early Iron Age France. *Journal of anthropological archaeology*, 9(4), pp.352-406.
- Dietler, M. (1996). Feasts and Commensal Politics in the Political Economy: Food, Power and Status in Prehistoric Europe. In P. Wiessner and W. Schiefenhovel (eds), *Food and the Status Quest: An Interdisciplinary Perspective*, Berghahn, Oxford, 87-126.
- Dietler, M. (2001). Theorizing the feast: rituals of consumption, commensal politics, and power in African contexts. In M. Dietler & B. Hayden (eds.), *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Smithsonian Institution, Washington, DC, 65-114.
- Dietler, M. (2006). Alcohol: anthropological/archaeological perspectives. *Annual Review of Anthropology*, 35, 229-249.
- Dietler, M., & Hayden, B. (2001). *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Smithsonian Institution, Washington, DC.
- Dobney K, & Ervynck A. 1998. A protocol for recording linear enamel hypoplasia on archaeological pig teeth. *International Journal of Osteoarchaeology* 8: 263-274.
- Dobney K, & Ervynck A. 2000. Interpreting Developmental Stress in Archaeological Pigs: The Chronology of Linear Enamel Hypoplasia. *Journal of Archaeological Science* 27: 597-607.
- Dobney K, Albarella U, Rowley-Conwy P. 2004. The chronology and frequency of a stress marker (linear enamel hypoplasia) in recent and archaeological populations of *Sus scrofa* in north-west Europe, and the effects of early domestication. *Journal of Zoology* 264: 197-208.

- Dobney K, Ervynck A, Albarella U, Rowley-Conwy P. 2007. The transition from wild boar to domestic pig in Eurasia, illustrated by a tooth developmental defect and biometrical data. In *Pigs and Humans: 10,000 Years of Interaction*, U Albarella, K Dobney, A Ervynck, P Rowley-Conwy (eds.). Oxford University Press: Oxford; 57–82.
- Dobney, K. and Reilly, K., 1988. A method for recording information about mammal bones: The use of diagnostic zones. *Circaea*, 5(2), pp.79-96.
- Dong, J., & Hu, Y. (2012). Inspection report of jade objects unearthed in Xias Eastern Zhou Cemetery, Xinzheng [新郑西亚斯东周墓地出土玉器检测报告]. In *Xiyasi Cemetery in Xinzheng*, pp. 203-231.
- Dong, J., Liu, S., Li, Q., Hu, Y., Fan, W. (2018). Scientific and technological analysis of jade wares unearthed in Tianli Eastern Zhou Tomb in Xinzheng, Henan Province [河南新郑天利东周墓地出土玉器的科技分析研究]. In *Zhou Cemetery at Tianli in Xinzheng*, pp. 478-505.
- Dong, Y., Morgan, C., Chinenov, Y., Zhou, L., Fan, W., Ma, X., & Pechenkina, K. (2017). Shifting diets and the rise of male-biased inequality on the Central Plains of China during Eastern Zhou. *Proceedings of the National Academy of Sciences*, 114(5), 932-937.
- Dong, Y., Morgan, C., Chinenov, Y., Zhou, L., Fan, W., Ma, X., & Pechenkina, K. (2017). Shifting diets and the rise of male-biased inequality on the Central Plains of China during Eastern Zhou. *Proceedings of the National Academy of Sciences*, 114(5), 932-937.
- Douglas, M. (1975). Deciphering a meal. In: *Implicit Meanings: Essays in Anthropology*. Routledge & Paul, Boston, 249-275.
- Du, J. (2010). Research on the foundation site of large cultural architecture of Longshan Village in Xinmi [新密古城寨龙山文化大型建筑基址研究]. *Huaxia Archaeology* (01), 61-69+104.
- Dufour, E., H. Bocherens and A. Mariotti, 1999: "Palaeodietary Implications of Isotopic Variability in Eurasian Lacustrine Fish", *Journal of Archaeological Science* 26, 617-627.
- Ekaterina A. Pechenkina (2012). Bioarchaeological Analysis of Human Skeletons in the Xiyasi Cemetery, *Xiyasi Cemetery of the Eastern Zhou Period in Xinzheng*, Elephant Press, 232-261.
- Elizabeth Schmid (1972). *Atlas of Animal Bones*. Elsevier Science Ltd.
- Erlend Kirkeng Jørgensen (2015). Typifying scientific output: a bibliometric analysis of archaeological publishing across the science/humanities spectrum (2009–2013), *Danish Journal of Archaeology*, 4:2, 125-139.
- Ervynck, A., Dobney, K., Hongo, H., & Meadow, R. (2002). Born free? New evidence for the status of pigs from Çayönü Tepesi, Eastern Anatolia. *Paléorient*, 27, 47–73.
- Evershed, R. P. (2008). Organic residue analysis in archaeology: the archaeological biomarker revolution. *Archaeometry*, 50(6), 895-924.
- Evin, A., Cucchi, T., Cardini, A., Vidarsdottir, U. S., Larson, G., & Dobney, K. (2013). The long and winding road: identifying pig domestication through molar size and shape. *Journal of Archaeological Science*, 40(1), 735-743.

- Faillace, K. E., Foody, M. G. B., & Madgwick, R. (2020). Exploring the potential of TEM analysis for understanding cooking at prehistoric feasting sites. *Scientific Reports*, 10(1), 13635.
- Faillace, K. E., Foody, M. G. B., & Madgwick, R. (2020). Exploring the potential of TEM analysis for understanding cooking at prehistoric feasting sites. *Scientific Reports*, 10(1), 13635.
- Falkenhausen, L. (1999). The Waning of the Bronze Age: Material Culture and Social Developments, 770-481 B.C. In Loewe and Shaughnessy (eds.) 1999: 450- 544.
- Falkenhausen, L. (2006). Chinese Society in the Age of Confucius (1000-250 BC): The Archaeological Evidence. Cotsen Institute of Archaeology.
- Fan, W. & Xu, C. (2005). No. 6 Spring and Autumn tomb at Zhenghanlu in Xinzheng [新郑市郑韩路 6 号春秋墓]. *Cultural Relics* (08),39-46+2.
- Fan, W. (2009). *General History of China*. Beijing: People's Publishing House (in Chinese).
- Fan, W. (2019). Discoveries and Researches on Capital of Zheng and Han States in Recent Years [郑韩故城近年来重要的考古发现与研究]. *Huaxia Archaeology* (04),64-77+108.
- Fan, W. et al. (2017). The Excavation of the Brick Burial at the New Campus of the Huaxin College, Xinzheng [新郑华信学院新校区空心砖墓葬发掘简报]. *Cultural Relics of Central China* (06),18-31.
- Feil, D. (1987). *The Evolution of Highland Papua New Guinea Societies*. Cambridge: Cambridge Univ. Press.
- Feldhamer, G. A., & McCann, B. E. (2004). Dental anomalies in wild and domestic *Sus scrofa* in Illinois. *Acta Theriologica*, 49, 139-143.
- Feng, S., Liu, L., Wang, J., Levin, M. J., Li, X., & Ma, X. (2021). Red beer consumption and elite utensils: The emergence of competitive feasting in the Yangshao culture, North China. *Journal of Anthropological Archaeology*, 64, 101365.
- Fernandes R, Millard AR, Brabec M, Nadeau M-J, Grootes P (2014) Food Reconstruction Using Isotopic Transferred Signals (FRUITS): A Bayesian Model for Diet Reconstruction. *PLoS ONE* 9(2): e87436.
- Finucane, B., Agurto, P. M., & Isbell, W. H. (2006). Human and animal diet at Conchopata, Peru: stable isotope evidence for maize agriculture and animal management practices during the Middle Horizon. *Journal of Archaeological Science*, 33(12), 1766-1776.
- Firth, R. (1951). *Elements of Social Organization*. London: Watts.
- Firth, R. (1959). *Economics of the New Zealand Maori*.
- Flad, R. K. (2007). Zooarchaeological evidence for animal domestication in northwest China. *Developments in Quaternary Sciences*, 9, 167-203.
- Flad, R. K., Yuan, J., & Li, S. (2007). Zooarchaeological evidence for animal domestication in Northwest China, in D. B. Madsen, F. H. Chen, and G. Xing (eds.) *Late Quaternary Climate Change and Human Adaptation in Arid China*. Amsterdam: Elsevier. 167-204.
- Flannery, K. V. (1969). The Domestication and Exploitation of Plants and Animals, eds P. J. Ucko, G. W. Dimbleby (Aldine, Chicago, IL), pp. 73–100.

- Flannery, K. V. (1983). Early pig domestication in the Fertile Crescent: A retrospective look. In R.J. Braidwood (Ed.) *The hilly flanks and beyond: Essays on the prehistory of Southwestern Asia*, 163-188.
- Fogelin, L. (2007). The Archaeology of Religious Ritual. *Annual Review of Anthropology* 36: 55–71.
- Fraser, R. A., Bogaard, A., Heaton, T., Charles, M., Jones, G., Christensen, B. T., ... & Styring, A. K. (2011). Manuring and stable nitrogen isotope ratios in cereals and pulses: towards a new archaeobotanical approach to the inference of land use and dietary practices. *Journal of Archaeological Science*, 38(10), 2790-2804.
- Friedman, J. & Rowlands, M. (1977). Notes towards an epigenetic model of the evolution of 'civilization.' In J. Friedman & M. Rowlands (eds.). *The Evolution of Social Systems*. London: Duckworth, 201–76
- Fu, Z. (2015). The bone workshop remains and bone industry in Fenghao site. *Archaeology* (09),92-100. (in Chinese).
- Fulton, D. N., Gadot, Y., Kleiman, A., Freud, L., Lernau, O., & Lipschits, O. (2015). Feasting in Paradise: Feast Remains from the Iron Age Palace of Ramat Rahel and Their Implications. *Bulletin of the American Schools of Oriental Research*, 374(1), 29-48.
- Gamble, L. H. (2017). Feasting, ritual practices, social memory, and persistent places: new interpretations of shell mounds in southern California. *American Antiquity*, 82(3), 427-451.
- Gao, Y. et al. (eds) (1987) *Fauna Sinica (Mammalia)*. Beijing: Scientific Press (in Chinese).
- Garvey, M. T., Barry, H. J., & Blake, M. (1999). Supernumerary teeth-an overview of classification, diagnosis and management. *Journal-Canadian Dental Association*, 65(11), 612-616.
- Ge, J. 2000. History of Population in China. Shanghai: Fudan University Publishing (in Chinese)
- Gibbons A. (2012). The ultimate sacrifice. *Science* (336),834-837.
- Gilby, I. C. (2006). Meat sharing among the Gombe chimpanzees: Harassment and reciprocal exchange. *Animal Behavior* 71: 953–63.
- Gillespie S. D. (2008). History in Practice: Ritual Depositional Practices. In B. J. Mills and W. H. Walker (eds.), *Memory Work: Archaeologies of Material Practices*, SAR Press, Santa Fe, New Mexico, 109–136.
- Glatz, C. (2016). Plain Pots, Festivals and Feasting in Late Bronze Age Anatolia. In *Plain Pottery Traditions of the Eastern Mediterranean and Near East* (pp. 183-214). Routledge.
- Goldschmidt, W., & Driver, H. (1943). The Hupa white deerskin dance. *Univ. Calif. Public Am. Archaeol. Ethnol.* 35:103–31.
- Grant, A. (1978). Variation in dental attrition in mammals and its relevance to age estimation. In: Brothwell D. R., Thomas, K. D. & Clutton-Brock J. (eds), *Research Problems in Zooarchaeology*, 103–6. London: Institute of Archaeology.
- Grant, A. (1982). The use of tooth wear as a guide to the age of domestic ungulates. In: Wilson B., Grigson C. & Payne S. (eds), *Ageing and Sexing Animal Bones from*

- Archaeological Sites (BAR British Series 109)*, 91–108. Oxford: British Archaeological Reports.
- Grimstead, D. N., & Bayham, F. E. (2010). Evolutionary ecology, elite feasting, and the Hohokam: a case study from a southern Arizona platform mound. *American Antiquity*, 75(4), 841–864.
- Gron, K. J., & Rowley-Conwy, P. (2017). Herbivore diets and the anthropogenic environment of early farming in southern Scandinavia. *The Holocene*, 27(1), 98–109.
- Gron, K. J., Rowley-Conwy, P., Fernandez-Dominguez, E., Gröcke, D. R., Montgomery, J., Nowell, G. M., & Patterson, W. P. (2018). A meeting in the forest: hunters and farmers at the Coneybury ‘anomaly’, Wiltshire. In *Proceedings of the Prehistoric Society* (Vol. 84). Cambridge University Press, 111–144.
- Groot Bruinderink, G. W. T. A., Hazebroek, E., & Van Der Voot, H. (1994). Diet and condition of wild boar, *Sus scrofa scrofa*, without supplementary feeding. *Journal of Zoology*, 233(4), 631–648.
- Gu, Y. (2023, Dec 29). The horses in the chariot pit in the Zheng Han ancient city appeared dizzy before being buried. *Elephant News*. <https://wwj.henan.gov.cn/2023/12-29/2875925.html>. (in Chinese)
- Guiry, E. J., & Grimes, V. (2013). Domestic dog (*Canis familiaris*) diets among coastal Late Archaic groups of northeastern North America: a case study for the canine surrogacy approach. *Journal of Anthropological Archaeology*, 32(4), 732–745.
- Gummerman, G. (2010). Big hearths and big pots: Moche feasting on the north coast of Peru. In *Inside Ancient Kitchens*, ed. E Klarich, pp. 111–32. Boulder: Univ. Colo. Press.
- Guo, Z. (2014). The Examination of the Waist Pit Burial Custom in the Prehistoric Age. *Archaeology (06)*, 56–63. (in Chinese).
- Gurven, M., Hill, K., Kaplan, H., Hurtado, A., & Lyles, R. (2000). Food transfers among Hiwi foragers of Venezuela: tests of reciprocity. *Human ecology*, 28, 171–218.
- Gusinde, M. (1961). *The Yamana*. 5 vols. New Haven, Conn.: Human Relations Area Files. (German edition 1931.)
- Hadjichrysanthou, C., & Broom, M. (2012). When should animals share food? Game theory applied to kleptoparasitic populations with food sharing. *Behavioral Ecology*, 23(5), 977–991.
- Halstead, P. (1985). A study of mandibular teeth from Romano-British contexts at Maxey, pp. 219–224 in Pryor, F., and French, C. (eds) *Archaeology and Environment in the Lower Welland Valley, Vol 1 (East Anglian Archaeology 27)*. Norwich: East Anglian Archaeology.
- Halstead, P., & Isaakidou, V. (2004). Faunal evidence for feasting: burnt offerings from the Palace of Nestor at Pylos. In *Food, cuisine and society in prehistoric Greece*, 136–154.
- Halstead, P., & O’Shea, J. (Eds.). (1989). *Bad year economics: Cultural responses to risk and uncertainty*. Cambridge University Press.
- Hamilakis, Y., & Konsolaki, E. (2004). Pigs for the gods: burnt animal sacrifices as embodied rituals at a Mycenaean sanctuary. *Oxford journal of archaeology*, 23(2), 135–151.

- Han, B., Sun, Z., Chong, J., Lyu, N., Rao, H., & Yang, Y. (2022). Lipid residue analysis of ceramic vessels from the Liujiawa site of the Rui State (early Iron Age, north China). *Journal of Quaternary Science*, 37(1), 114-122.
- Han, D. (2020). *Research on the Foundry Workshop in the Eastern Zhou Dynasty* [东周时期冶铸作坊研究]. Master's thesis, Zhengzhou University.
- Han, G. & Chen, K. (2019). 郑国东迁考. *Journal of Zhengzhou University (Philosophy and Social Sciences Edition)* (02), 66-72.
- Han, J. (2021). The Peiligang Era and Origin of Chinese Civilizations [裴李岗时代与中国文明起源]. *Jiangnan Archaeology* (01), 50-55.
- Hao et al. (2008). 南水北调新郑铁岭墓地发掘简报. *文物春秋*(05), 40-48+2.
- Hao et al. (2010a). Excavation of M550 of Tieling Cemetery in Xinzheng City. *Cultural Relics of Central China* (05), 4-10+113-115.
- Hao et al. (2010b). Excavation of M429 of Tieling Cemetery in Xinzheng City. *Cultural Relics of Central China* (01), 4-8+117+119.
- Hao et al. (2012a). Excavation of M1404 and M1405 of Tieling Cemetery in Xinzheng City. *Cultural Relics of Central China* (02), 10-18+29+113+1.
- Hao et al. (2012b). Excavation of M709 and M722 of Tieling Cemetery in Xinzheng City. *文物春秋*(01), 34-40+71+1+81.
- Hao et al. (2013). Excavation of M1414 of Tieling Cemetery in Xinzheng City. *Cultural Relics of the East* (04), 5-20+4.
- Hao et al. (2014). Excavation of M308 of Tieling Cemetery in Xinzheng City. *Cultural Relics of Central China* (02), 4-17+2+129-133.
- Hao, B. (1984). The Zhenghan Ancient City in Xinzheng [新郑县郑韩故城遗址], *Yearbook of Archaeology in China* (1983), Cultural Relics Press (in Chinese).
- Harunari, H. (1993). 「の下顎骨懸架弥生時代化书 石の習俗」 『国立歴史民俗博物館研究報告』 (50): 71-131. (in Japanese).
- Hastorf, C. A. (2003). Andean luxury foods. *Antiquity* 77:545-54.
- Hastorf, C. A. (2017). *The Social Archaeology of Food: Thinking about Eating from Prehistory to the Present*. Cambridge University Press, Cambridge.
- Hayden, B. (1990). Nimrods, piscators, pluckers, and planters: the emergence of food production. *Journal of anthropological archaeology*, 9(1), 31-69.
- Hayden, B. (1996). Feasting in prehistoric and traditional societies. In P. Wiessner, W. Schiefenhovel (eds.), *Food and the status quest: An interdisciplinary perspective, I*, Berghahn Books, 127-148.
- Hayden, B. (2001). Fabulous Feasts: A Prolegomenon to the Importance of Feasting. In M. Dietler, & B. Hayden (eds.) *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*, Smithsonian Institution, Washington, DC, 23-64.
- Hayden, B. (2003). Were luxury foods the first domesticates? Ethnoarchaeological perspectives from Southeast Asia. *World Archaeology*, 34(3), 458-469.
- Hayden, B. (2009). The proof is in the pudding: feasting and the origins of domestication. *Current Anthropology*, 50(5), 597-601.

- Hayden, B. (2014). *The Power of Feasts: From Prehistory to the Present*. Cambridge: Cambridge University Press.
- Hayden, B. (2016). *Feasting in Southeast Asia*. Honolulu: University of Hawai'i Press.
- Hayden, B. (2019). Were luxury foods the first domesticates? Ethnoarchaeological perspectives from Southeast Asia. Translated by Y. Xi and C. Chen. *Cultural Relics in Southern China* (04), 222-225 (in Chinese).
- Hayden, B., & Villeneuve, S. (2010). Who benefits from complexity? A view from Futuna. In T. Price & G. Feinman (eds.). *Pathways to Power*. New York: Springer, 95–146.
- Hayden, B., & Villeneuve, S. (2011). A century of feasting studies. *Annual Review of Anthropology*, 40, 433-449.
- Haynes, G. (1980). Evidence of carnivore gnawing on Pleistocene and recent mammalian bones. *Paleobiology*, 6(3), 341-351.
- Haynes, G. (1983). A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb bones. *Paleobiology*, 9(2), 164-172.
- He, D. (2022). Conceptual changes in Zhou Dynasty as reflected by use of bronze ritual vessels with inscriptions recording banquets and feasts. *Huaxia Archaeology* (03), 70-78 (in Chinese). doi: 10.16143/j.cnki.1001-9928.2022.03.011.
- He, K., Jiang, C., & Chen, J. (2009). Review on two methods of meat weight estimation in zooarchaeology——example from faunal remains at Yingpanshan site. *Archaeology and Cultural Relics* (05), 95-99 (in Chinese).
- He, N. (2021). A brief talk on the phenomenon of “Gourmet Politics” in Taosi civilization. *The Central Plains Culture Research* (04), 22-28 (in Chinese).
- He, Z. (2003). Analysis of the remains of "livestock sleeping place" at Jiangzhai site [姜寨遗址“牲畜夜宿场”遗迹辨析]. *Archaeology and Cultural Relics* (02), 27-31 (in Chinese).
- Healy, W. B., & Ludwig, T. G. (1965). Wear of sheep's teeth: I. The role of ingested soil. *New Zealand Journal of Agricultural Research*, 8(4), 737-752.
- Hedges, R. E. M. and L. M. Reynard, 2007: "Nitrogen Isotopes and the Trophic Level of Humans in Archaeology", *Journal of Archaeological Science* 34, 1240-1251.
- Helwing, B. (2003). Feasts as a social dynamic in Prehistoric Western Asia-three case studies from Syria and Anatolia. *Paléorient*, 63-85.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2006). *The Sacrifice Site of Zheng in Xinzheng* 《新郑郑国祭祀遗址》（上/中/下），Zhengzhou: Elephant Press (in Chinese).
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2007). *The Cemeteries at the Xinghong Garden and the Thermal Power Plant in the Ancient Capital City of Zheng and Han* 《郑韩故城兴弘花园与热电厂墓地》，Beijing: Cultural Relics Press (in Chinese).
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2006). *The Sacrifice Site of Zheng in Xinzheng* 《新郑郑国祭祀遗址》（上/中/下），大象出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2007). *The Cemeteries at the Xinghong Garden and the Thermal Power Plant in the*

- Ancient Capital City of Zheng and Han* 《郑韩故城兴弘花园与热电厂墓地》，文物出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2012). *Xiayasi Cemetery of the Eastern Zhou Period in Xinzheng* 《新郑西亚斯东周墓地》，大象出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2016). *Shuanglou Cemetery of the Zhou Dynasty in Xinzheng* 《新郑双楼东周墓地》，大象出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2018). *Tianli Cemetery of the Zhou Dynasty in Xinzheng* 《新郑天利两周墓地》，Shanghai Classics Publishing House 上海古籍出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology [河南省文物考古研究所] (2020). *Gaolou Cemetery of the Eastern Zhou Period in Xinzheng* 《新郑郛楼两周墓地》，Shanghai Classics Publishing House 上海古籍出版社.
- Henan Provincial Institute of Cultural Relics and Archaeology, Xinzheng Archaeological Unit [河南省博物馆新郑工作站]. (1998). 郑韩故城青铜礼乐器坑与殉马坑的发掘. *Huaxia Archaeology* (04):11-24 (in Chinese).
- Henan Provincial Institute of Cultural Relics and Archaeology, Xinzheng Archaeological Unit [河南省博物馆新郑工作站] 郑韩故城青铜礼乐器坑与殉马坑的发掘. *Huaxia Archaeology* 华夏考古, 1998, (04):11-24.
- Henan Provincial Institute of Cultural Relics and Archaeology, Xinzheng Archaeological Unit [河南省博物馆新郑工作站] (1980). 《河南新郑郑韩故城的钻探与试掘简报》，《文物资料丛刊》3期，文物出版社.
- Horwitz, L. K. & Davidovitz, G. 1992. Dental pathology of wild pigs (*Sus scrofa*) from Israel. *Israel Journal of Zoology*, 38(2), 111-123.
- Hou, L., Hu, Y., Zhao, X., Li, S., Wei, D., Hou, Y., Hu, B., Lv, P., Li, T., Song, G., and Wang, C. (2013a). Human subsistence strategy at Liuzhuang site, Henan, China during the proto-Shang culture (~ 2000–1600 BC) by stable isotopic analysis, *Journal of Archaeological Science*, 40(5), 2344–51.
- Hou, L., Li, S., Hu, Y., Hou, Y., Lv, P., Cao, L., Hu, B., and Wang, C. (2013b). Preliminary exploration of feeding strategies of domestic animals during Proto-Shang Culture, *Huaxia Archaeology*, 2, 130–9, (in Chinese).
- Hou, Y., Campbell, R., Li, Z., Zhang, Y., Li, S. & He, Y. (2018). The Guandimiao bone assemblage (and what it says about the Shang economy). *Asian Perspectives*, 57(2), 281-310.
- Hou, Y., Campbell, R., Zhang, Y., & Li, S. (2019). Animal use in a Shang village: The Guandimiao zooarchaeological assemblage. *International Journal of Osteoarchaeology*, 29(2), 335-345.
- Hu, J. (2003). Burials of Zheng and Han during the Eastern Zhou [东周郑韩墓葬研究]. Master's thesis, Zhengzhou University.

- Hu, Y. (2018). Thirty-four years of stable isotopic analyses of ancient skeletons in China: An overview, progress and prospects. *Archaeometry*, 60(1), 144-156.
- Hu, Y., Hu, S., Wang, W., Wu, X., Marshall, F. B., Chen, X., Hou, L., and Wang, C. (2014). Earliest evidence for commensal processes of cat domestication, *Proceedings of the National Academy of Sciences, USA*, 111(1), 116–20.
- Hu, Y., Luan, F., Wang, S., Wang, C., and Richards, M. (2009). Preliminary attempt to distinguish the domesticated pigs from wild boars by the methods of carbon and nitrogen stable isotope analysis, *Science in China Series D: Earth Sciences*, 52(1), 85–92.
- Huang, X. & Li, X. (2006). Report on the analysis and identification of bronzes at the sacrificial site of the State of Zheng [郑国祭祀遗址青铜器的分析鉴定报告]. In *The Sacrifice Site of Zheng in Xinzheng* (2).
- Ikram, S. (2002). “Typhonic Bones: A Ritual Deposit from Saqqara?” In S. O’Day, W. Van Neer, and A. Ervynck (eds.), *Behaviour behind Bones: The Zooarchaeology of Ritual, Religion, Status and Identity*, Oxford: Oxbow, 41–46.
- Iriarte, J., Gillam, J. C., & Marozzi, O. (2008). Monumental burials and memorial feasting: an example from the southern Brazilian highlands. *Antiquity*, 82(318), 947-961.
- Isbell, W., Groleau, A. (2010). The Wari brewer woman: feasting, gender, offerings, and memory. In *Inside Ancient Kitchens: New Directions in the Study of Daily Meals and Feasts*, ed. E Klarich, pp. 191–220. Boulder: Univ. Colo. Press.
- Jackson, H. E., & Scott, S. L. (1995). The faunal record of the southeastern elite: The implications of economy, social relations, and ideology. *Southeastern Archaeology*, 103-119.
- Jaffe, Y., 2023. *Food in Ancient China*. Cambridge University Press.
- Jarman, M. R., & Wilkinson, P. (1972). Criteria of animal domestication. In E. S. Higgs (ed.), *Papers in economic prehistory* (pp. 83–96). Cambridge: Cambridge University Press.
- Jennbert, K. (1985). Neolithisation—a Scanian perspective. *Journal of Danish Archaeology* 4(1), 196-197.
- Jennbert, K. (1987). Neolithisation in the Nordic Area. *Swedish Archaeology 1981-1985*, 21-36.
- Jennings, J. (2004). La chichera y el patrón: Chicha and the energetics of feasting in the prehistoric Andes. *Archeological Papers of the American Anthropological Association*, 14(1), 241-259.
- Jennings, J., Antrobus, K., Atencio, S., Glavich, E., Johnson, R., Loffler, G., & Luu, C. (2005). “Drinking beer in a blissful mood” alcohol production, operational chains, and feasting in the ancient world. *Current Anthropology*, 46(2), 275-303.
- Jiang, N., Wang, Y. & Liu, S. (1995). Eastern Zhou burial at Dagaozhuang in Xinzheng [河南新郑大高庄东周墓]. *Cultural Relics* (03), 16-30.
- Johnson, E., 1985. Current developments in bone technology. In *Advances in archaeological method and theory*. Academic Press, pp. 157-235.
- Johnson, E.V., Parmenter, P.C. and Outram, A.K., 2016. A new approach to profiling taphonomic history through bone fracture analysis, with an example application to the

- Linearbandkeramik site of Ludwinowo 7. *Journal of Archaeological Science: Reports*, 9, pp.623-629.
- Jonaitis, A. (1991). *Chiefly feasts: the enduring Kwakiutl potlatch*. Seattle: London.
- Jones, David M., ed. (2011). *Environmental Archaeology: A guide to the theory and practice of methods from sampling and recovery to post-excavation*.
- Jones, G. G., & Sadler, P. (2012a). A review of published sources for age at death in cattle. *Environmental Archaeology*, 17(1), 1–10.
- Jones, G. G., & Sadler, P. (2012b). Age at death in cattle: methods, older cattle and known-age reference material. *Environmental Archaeology*, 17(1), 11–28.
- Jones, M. (2007). *Feast: why Humans share Food*. Oxford: Oxford University Press.
- Jones, M. (2008). *Feast: Why humans share food*. OUP Oxford.
- Jones, M. (2009). *Feast: Why humans share foods*. Translated by X. Chen. Jinan: Shandong People's Publishing House (in Chinese).
- Jones, P. R. (1980). Experimental butchery with modern stone tools and its relevance for Palaeolithic archaeology. *World Archaeology*, 12(2), 153-165.
- Junker, L. L. (2001). The evolution of ritual feasting systems in prehispanic Philippine chiefdoms. *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*, Smithsonian Institution Press, Washington, DC, 267-310.
- Junker, L. L., Mudar, K., & Schwaller, M. (1994). Social stratification, household wealth, and competitive feasting in 15th/16th-century Philippine chiefdoms. *Research in Economic Anthropology*, 15, 307-358.
- Kansa, S. W., Kennedy, A., Campbell, S., & Carter, E. (2009). Resource exploitation at Late Neolithic Domuztepe: faunal and botanical evidence. *Current Anthropology*, 50(6), 897-914.
- Kassabaum, M. C. (2014). *Feasting and communal ritual in the Lower Mississippi Valley, AD 700-1000* (Doctoral dissertation, The University of North Carolina at Chapel Hill).
- Kassabaum, M. C. (2019). A method for conceptualizing and classifying feasting: interpreting communal consumption in the archaeological record. *American Antiquity*, 84(4), 610-631.
- Katz, S.H. & Voigt, M.M. (1986). Bread and beer. *Expedition*, 28(2), p.23.
- Keenan, Douglas J. (2002). Astro-historiographic chronologies of early China are unfounded. *East Asian History*, 23: 61–68.
- Kelly, L. S. (2001). A case of ritual feasting at the Cahokia Site. In Dietler, M. & Hayden, B. (eds). *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Washington, DC: Smithsonian Institution, 334–367.
- Kirch, P. (2001). Polynesian feasting in ethnohistoric, ethnographic, and archaeological contexts. In M. Dietler, B. Hayden (eds.), *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*, Washington, DC: Smithsonian Institution, 168-184.
- Knight, V. J. (2001). Feasting and the emergence of platform mound ceremonialism in Eastern North America. In Dietler, M. & Hayden, B. (eds). *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Washington, DC: Smithsonian Institution, 311-333.

- Knudson, K. J., Gardella, K. R., & Yaeger, J. (2012). Provisioning Inka feasts at Tiwanaku, Bolivia: the geographic origins of camelids in the Pumapunku complex. *Journal of Archaeological Science*, 39(2), 479-491.
- Kohn, M.J. (1999). You are what you eat. *Science* 283: 335-336.
- Koon, H. E. (2012). Identification of cooked bone using TEM imaging of bone collagen. *Forensic Microscopy for Skeletal Tissues: Methods and Protocols*, 249-261.
- Koon, H. E., Nicholson, R. A., & Collins, M. J. (2003). A practical approach to the identification of low temperature heated bone using TEM. *Journal of Archaeological Science*, 30(11), 1393-1399.
- Kouka, O. (2011). Symbolism, ritual feasting and ethnicity in Early Bronze Age Cyprus and Anatolia, in: Karageorghis, V. & Kouka, O. (eds.), *On Cooking Pots, Drinking Cups, Loomweights and Ethnicity in Bronze Age Cyprus and Neighbouring Regions*, *International Archaeological Symposium - 6th-7th November 2010*, A.G. Leventis Foundation, 43-56.
- Kuijt, I. (2009). What do we really know about food storage, surplus and feasting in preagricultural communities? *Current Anthropology* 50(5):641-44.
- Kuzmin, Ya. V., M. P. Richards and M. Yoneda, 2002: "Palaeodietary Patterning and Radiocarbon Dating of Neolithic Populations in the Primorye Province, Russian Far East", *Ancient Biomolecules* 4(2), 53-58.
- Lander, B. 2021. *The King's Harvest: A Political Ecology of China from the First Farmers to the First Empire*. Yale University Press.
- Larson, G., Liu, R., Zhao, X., Yuan, J., Fuller, D., Barton, L., ... & Li, N. (2010). Patterns of East Asian pig domestication, migration, and turnover revealed by modern and ancient DNA. *Proceedings of the National Academy of Sciences*, 107(17), 7686-7691.
- Lau, G. F. (2002). Feasting and ancestor veneration at Chinchawas, north highlands of Ancash, Peru. *Latin American Antiquity*, 13(3), 279-304.
- Lee, C.S. (2018). An abrupt or gradual dietary shift: Comments on the paper by Zhou et al. (2017). *Journal of Archaeological Science: Reports*, 17, 79-80.
- Lee, Yun Kuen (2002). Building the chronology of early Chinese history, *Asian Perspectives*, 41 (1): 15-42.
- Legge, A. J. (2008). Livestock and Neolithic society at Hambledon Hill. In *Hambledon Hill, Dorset, England. Excavation and Survey of a Neolithic Monument Complex and its surrounding landscape (vol. 2)*, ed. R. Mercer and F. Healey, 536-585. Swindon: English Heritage.
- Legge, A. J. (2013). 'Practice with science': molar tooth eruption ages in domestic, feral and wild pigs (*Sus scrofa*). *International Journal of Osteoarchaeology*. <https://onlinelibrary.wiley.com/page/journal/10991212/homepage/News.html>.
- Legge, A. J., & Rowley-Conwy, P. (2000). The exploitation of animals. In A. M. T. Moore, G. C. Hillman, & A. J. Legge (Eds.), *Village on the Euphrates*. Oxford: University Press, pp. 475-525.
- Lemonnier, P. (1990). *Guerres et Festins*. Paris: Maison Sci. l'Homme.
- Lepiksaar, J. (1994). *Introduction to osteology of fishes for paleo- and archaeozoologists*. (Drawings by N. Lepiksaar). Göteborg.

- Lévi-Strauss, C. (1963). *Totemism*. Beacon, Boston.
- Li, D. (1983). Spring and Autumn tombs were found in Lijia village, Xinzheng County, Henan province. [河南新郑县李家村发现春秋墓]. *Archaeology* (08), 703-706+775.
- Li, D. (1990). The excavation of the bone working site of the ancient city of Zheng Han [郑韩故城制骨遗址的发掘]. *Huaxia Archaeology* (02), 43-59+81.
- Li, D. (1991). Brief report on excavation of pottery workshop ruins in Xinzheng, Henan Province [河南新郑郑韩故城制陶作坊遗迹发掘简报]. *Huaxia Archaeology* (03), 33-54+32.
- Li, J. (2006). Excavation and research of bronze ritual vessel casting site in Zheng State [郑国青铜礼器铸造遗址发掘与研究], In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press.
- Li, Ji (1926) Bones in Xinzheng. *Transactions of the Science Society of China*. Vol.3. (Original version in English). Translation version on Li, Guangmo, (ed.) (1994) *Li Ji and Tsinghua*, Tsinghua University Press, 3-18.
- Li, M. (2008). *Conquest, concord, and consumption: becoming Shang in eastern China*. University of Michigan (Ph.D).
- Li, M. (2018). *Social Memory and State Formation in Early China*. Cambridge University Press, Cambridge, 120-124.
- Li, N. (2019). *Archaeological Study on the Cultural Evolution of East Zhou Tombs in Zhengzhou Area* [郑州地区东周墓葬文化演变的考古学研究]. Master's thesis, Nanjing University.
- Li, S. (2017). *Fishes of the Yellow River*. Qingdao: China Ocean University Press (in Chinese).
- Li, X. (2006). Experimental study on metallography of some iron objects unearthed at the sacrificial site of Zheng State [郑国祭祀遗址出土部分铁器的金相实验研究], In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press.
- Li, Y. (1984). How to understand the prominent development of commodity economy in the Warring States period 怎样认识战国时期突出发展的商品经济. *Economic Science*, 6(02):63-69. (in Chinese).
- Li, Y. J. (2005). The capital and territory of the State of Zheng [郑国的都城与疆域]. *Academic Journal of Zhongzhou* (06).
- Li, Y. X. (2006a). Inspection report of the smelter relics of Zheng State sacrificial site [郑国祭祀遗址冶铸遗物检测报告], In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press.
- Li, Z. (2009). Faunal Remains Research of Yinxu. [PhD's dissertation, CASS] (in Chinese).
- Li, Z. (2018). A review of the Yinxu zooarchaeology in the last ninety years. *Cultural Relics of Central China* (05), 90-100. doi:CNKI:SUN:ZYWW.0.2018-05-010.
- Li, Z. (2018). A review of the Yinxu zooarchaeology in the last ninety years. *Cultural Relics of Central China* (05), 90-100 (in Chinese). doi:CNKI:SUN:ZYWW.0.2018-05-010.

- Li, Z. Z. (1997). The morphology of the capital cities of the Eastern Zhou Dynasty [东周列国都城的城郭形态]. *Archaeology and Cultural Relics* (03).
- Li, Z., Campbell, R., He, Y., & Yuan, J. (2010). Analysis and preliminary results of worked bone remains excavated from bone-working workshop at Tiesanlu site of Yinxu [殷墟铁三路制骨作坊遗址出土制骨遗存的分析与初步认识]. *China Culture Relics Newspaper*, 2010-9-17(7) (in Chinese).
- Li, Z., He, Y. & Roderick, C. (2011). Review and re-discussion on the study of bone workshop and bone handicraft industry in the Late Yinxu [殷墟晚期制骨作坊与制骨手工业的研究回顾与再探讨]. *Three-dynasties Archaeology* (4). Science Press, pp. 471 (in Chinese).
- Li, Z., Niu, S., He, Y. & Tang, J. (2023). On the consumption of animals at the Late-Shang-Dynasty capital 晚商都城居民的动物消费：殷墟孝民屯遗址出土动物遗存的个案分析. *Cultural Relics of Central China* (05), 108-115. (in Chinese).
- Librado, P., Khan, N., Fages, A., Kusliy, M.A., Suchan, T., Tonasso-Calvière, L., Schiavinato, S., Alioglu, D., Fromentier, A., Perdereau, A. and Aury, J.M., 2021. The origins and spread of domestic horses from the Western Eurasian steppes. *Nature*, 598(7882), pp.634-640.
- Librado, P., Tressières, G., Chauvey, L., Fages, A., Khan, N., Schiavinato, S., Calvière-Tonasso, L., Kusliy, M.A., Gaunitz, C., Liu, X. and Wagner, S., 2024. Widespread horse-based mobility arose around 2200 BCE in Eurasia. *Nature*, 631(8022), pp.819-825.
- Lin, M. (2022). *Origins of cattle traction and the making of early civilisations in North China*. Springer.
- Lin, M., Luan, F., Fang, H., Xu, H., Zhao, H., & Barker, G. (2018). Pathological evidence reveals cattle traction in North China by the early second millennium BC. *The Holocene*, 28(8), 1205-1215. <https://doi.org/10.1177/0959683618771483>
- Lin, M., Luan, F., Fang, H., Xu, H., Zhao, H., Hu, S., Qian, Y., Ma, X., & Barker, G. (2022). Bulls for sacrifice, cows for work? Morphometric models suggest that female cattle were used for traction in the Chinese Bronze Age Late Shang dynasty (ca. 1300–1046 BCE). *The Holocene*, 32(1-2), 70-80. <https://doi.org/10.1177/09596836211049976>
- Linares, O. F. (1976). “Garden hunting” in the American tropics. *Human ecology*, 4, 331-349.
- Liu, D. (1962). Henan Xinzheng Cangcheng found Warring States cast iron figurines [河南新郑仓城发现战国铸铁器泥范]. *Archaeology* (03), 165-166.
- Liu, D. (2011). Study on waist-pit dog custom in Shang Dynasty. Master’s thesis, Zhengzhou University. (in Chinese)
<https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD2012&filename=1011216103.nh>.
- Liu, L. & X. Chen. 2012. *The Archaeology of China: From the Late Paleolithic to the Early Bronze Age* (Cambridge World Archaeology). Cambridge: Cambridge University Press.
- Liu, L. (2021). Communal drinking rituals and social formations in the Yellow River valley of Neolithic China. *Journal of Anthropological Archaeology*, 63, 101310.

- Liu, L., & Liu, Z. (2023). Millet Beer Brewing in North China: Exploring Traditional Methods and their Significance in Archaeological Research. *Ethnoarchaeology*, 1-15.
- Liu, L., Li, Y., & Hou, J. (2020c). Making beer with malted cereals and qu starter in the Neolithic Yangshao culture, China. *Journal of Archaeological Science: Reports*, 29, 102134.
- Liu, L., Wang, H., Sun, H., & Chen, X. (2023). Serving red rice beer to the ancestors ca. 9000 years ago at Xiaohuangshan early Neolithic site in south China. *The Holocene*, 33(8), 1012-1020.
- Liu, L., Wang, J., & Di, N. (2020a). Cong pingdiping dao jiandiping—Huanghe zhongyou xinshiqi shiqi niangjiuqi de yanhua he niangjiu fangfa de chuancheng (From flat-base amphorae to conical-base amphorae—changes in fermentation vessels and brewing methods in Neolithic middle Yellow River region). *Zhongyuan wenwu*, 3, 94-106 (in Chinese).
- Liu, L., Wang, J., & Liu, H. (2020b). The brewing function of the first amphorae in the Neolithic Yangshao culture, North China. *Archaeological and Anthropological Sciences*, 12, 1-15.
- Liu, L., Wang, J., Chen, R. *et al.* (2022). The quest for red rice beer: transregional interactions and development of competitive feasting in Neolithic China. *Archaeological and Anthropological Science* (14), 78.
- Liu, L., Wang, J., Chen, X., & Li, Y. (2019a). Huanghe zhongyou xinshiqi shidai lujiu taohu fenxi (Analysis of Neolithic pottery strainers in the middle Yellow River valley). *Zhongyuan Wenwu*, 6, 55-61 (in Chinese).
- Liu, L., Wang, J., Levin, M. J., Sinnott-Armstrong, N., Zhao, H., Zhao, Y., ... & Zhang, T. E. (2019b). The origins of specialized pottery and diverse alcohol fermentation techniques in Early Neolithic China. *Proceedings of the National Academy of Sciences*, 116(26), 12767-12774.
- Liu, Y. *et al.* (2021). Archaeological excavation brief report of the Southern Wall at Capital of Zheng and Han states in Xinzheng in 2017 [2017 年新郑郑韩故城南城墙发掘简报]. *Huaxia Archaeology 华夏考古*(02):15-22.
- Liu, Y., Wang, Y., Flad, R., & Lei, X. (2020). Animal sacrifice in burial: Materials from China during the Shang and Western Zhou period. *Archaeological Research in Asia*, 22, 100179.
- Liu, Z. P., Shao, M. A., & Wang, Y. Q. (2013). Large-scale spatial interpolation of soil pH across the Loess Plateau, China. *Environmental Earth Sciences*, 69, 2731-2741.
- Longin, R. (1971). New method of collagen extraction for radiocarbon dating. *Nature*, 230(5291), 241-242.
- Lothar von Falkenhausen (1993). *Suspended Music: Chime-Bells in the Culture of Bronze Age China*. Berkeley and Los Angeles: University of California Press.
- Lothar von Falkenhausen (2006). *Chinese Society in the Age of Confucius (1000-250 BC): The Archaeological Evidence*. Los Angeles: Cotsen Institute of Archaeology, UCLA.
- Lu, L. (1993). Chariot and horse burials in ancient China, *Antiquity*, 67(257), pp. 824–838. doi:10.1017/S0003598X0006381X.

- Luo, S. J., Kim, J. H., Johnson, W. E., Walt, J. V. D., Martenson, J., Yuhki, N., ... & O'Brien, S. J. (2004). Phylogeography and genetic ancestry of tigers (*Panthera tigris*). *PLoS biology*, 2(12), e442.
- Luo, Y. (2012). The domestication, Raising and Ritual Use of Pig in Ancient China. Beijing: Chinese Science Press (in Chinese).
- Luo, Y., & Zhang, J. (2008) Restudy of pig bones unearthed from the Jiahu site in Wuyang county, Henan. *Archaeology* (1): 90-96 (in Chinese with English abstract).
- Luo, Y., Yang, M., Yuan, J. (2006). 郑国祭祀遗址动物骨骼研究报告 In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press. pp. 1063-1146 (in Chinese).
- Luo, Y., Yuan, J. & Yang, M. (2015). Research report on the animal remains unearthed from the seventh excavation at Jiahu site. 贾湖遗址第七次发掘出土动物遗存研究报告. In Henan Provincial Institute of Cultural Relics and Archaeology (HPICRA) & University of Science and Technology of China (USTC) (Eds). *Wuyang Jiahu* (2). Beijing: Science Press, 333-370 (in Chinese).
- Lyman, R. L. (1987). Archaeofaunas and butchery studies: a taphonomic perspective. *Advances in archaeological method and theory*, 249-337.
- Lyman, R. L. (1994). Quantitative Units and Terminology in Zooarchaeology. *American Antiquity*, 59(1), 36-71. <https://doi.org/10.2307/3085500>
- Lyman, R. L. (1994). Quantitative units and terminology in zooarchaeology. *American Antiquity*, 59(1), 36-71.
- Lyman, R. L. (1994a). *Vertebrate taphonomy*. Cambridge University Press.
- Lyman, R. L. (1994b). Quantitative units and terminology in zooarchaeology. *American Antiquity*, 59(1), 36-71.
- Lyman, R. L. (2008). *Quantitative paleozoology*. Cambridge University Press.
- Lyu, P. (2015). The zooarchaeological observation on the utilization of cattle resources of the people of the Shang Dynasty. *Archaeology* (11), 105-111 (in Chinese).
- Lyu, P. (2019). Cattle in the ancient Chinese society. *Chinese Social Sciences Today*, 2019-06-14(006). [Accessed 12 May 2024] (in Chinese).
- Lyu, P., Brunson, K., Yuan, J., & Li, Z. (2017). Zooarchaeological and genetic evidence for the origins of domestic cattle in ancient China. *Asian Perspectives*, 92-120.
- Ma, C. (1961). Rambling about the portraits on the bronzes of the Warring States Period 漫谈战国青铜器上的画像. *Cultural Relics* (10), 26-30. (in Chinese).
- Ma, J. & Cai, Q. (2000). Excavation of a sacrificial site of the Zheng State at the ruined Zheng-and-Han City in present Xinzheng City, Henan. *Archaeology* (02), 61-77+98-100 (in Chinese).
- Ma, J. & Cai, Q. (2000). Excavation of a Sacrificial Site of the Zheng State at the Ruined Zheng-and-Han City in Present Xinzheng City, Henan [河南新郑市郑韩故城郑国祭祀遗址发掘简报]. *Archaeology* (02), 61-77+98-100.
- Ma, J. (1999). Preliminary discussion of the plan layout of Zheng and Han capital [郑韩两都平面布局初论]. *中国历史地理论丛*, 1999(02), 115-129.

- Ma, J. (2003). The ruins of a large pottery workshop in the Warring States period were discovered in Zheng Han Gucheng [郑韩故城发现战国时期大型制陶作坊遗址]. *Cultural Relics of Central China*, 2003 (1).
- Ma, J. (2004). Ruins of Eastern Zhou pottery workshop in Fengzhuang, Xinzheng, Henan Province [河南新郑冯庄东周制陶作坊遗址], 2003 年中国重要考古发现. 文物出版社, pp. 75.
- Ma, J. (2014). Spring and Autumn Period ivory chariot heel unearthed in Xinzheng Zhenghan ancient city [新郑郑韩故城出土春秋时期象牙车踵]. *Cultural Relics*, No.702(11):81-83+90+2.
- Ma, N. (2016) "Zheng Wengong asks Taibo" in Tsinghua Bamboo Slips and the early history of the State of Zheng [清华简《郑文公问太伯》与郑国早期史事], *Cultural Relics* (03).
- Ma, S. (2003). *Prehistoric Cities in China* [中国史前古城], 湖北教育出版社.
- Ma, X. (2005). *Emergent social complexity in the Yangshao culture: analysis of settlement patterns and faunal remains from Lingbao, Western Henan, China (c.4900-3000 BC)*. Oxford: Archaeopress, 29-39.
- Ma, X. (2005). *Emergent Social Complexity in the Yangshao Culture: Analyses of settlement patterns and faunal remains from Lingbao, western Henan, China (c. 4900-3000 BC)*. Archaeopress.
- Ma, X. (2007). Age Composition of the Domestic Pigs of the Xipo Site in Lingbao and Related Problems 灵宝西坡遗址家猪的年龄结构及相关问题. *Huaxia Archaeology* (01), 55-74 (in Chinese).
- Ma, X. (2007). Age composition of the domestic pigs of the Xipo site in Lingbao and related problems. *Huaxia Archaeology* (01),55-74 (in Chinese).
- Ma, X. (2008). Meat consumption pattern of the Lingbao Xipo site: discovery rate, surface traces and breakage degree of different animal bones. *Huaxia Archaeology* (04),73-87+106 (in Chinese).
- Ma, X. (2010). On the issues of worked bone research in China [关于中国骨器研究的几个问题]. *Huaxia Archaeology* (02),138-142. (in Chinese).
- Ma, X. (2018). A review of bone-tool research in the last decade [近十年中国骨器研究综述]. *Cultural Relics of Central China* (02),51-56. (in Chinese).
- Ma, X., Wei, X., & Hou, Y. (2015). The research of worked bone remains from Lijiayao site, Sanmenxia [三门峡李家窑遗址出土骨料研究]. *Cultural Relics* (06),39-48.
- Madgwick, R., Esposito C., and Lamb A.L. (2023) Farming and feasting during the Bronze Age–Iron Age transition in Britain (ca. 900–500 bce): multi-isotope evidence for societal change. *Front. Environ. Archaeol.* 2:1221581. doi:10.3389/fearc.2023.1221581
- Madgwick, R., Grimes, V., Lamb, A. L., Nederbragt, A. J., Evans, J. A., & McCormick, F. (2019a). Feasting and mobility in Iron Age Ireland: Multi-isotope analysis reveals the vast catchment of Navan Fort, Ulster. *Scientific reports*, 9(1), 19792.
- Madgwick, R., Lamb, A. L., Sloane, H., Nederbragt, A. J., Albarella, U., Pearson, M. P., & Evans, J. A. (2019b). Multi-isotope analysis reveals that feasts in the Stonehenge

- environs and across Wessex drew people and animals from throughout Britain. *Science Advances*, 5(3), eaau6078.
- Magnell O. (2006). Tooth wear in wild boar (*Sus scrofa*). In: Ruscillo D. (ed.), *Recent Advances in Ageing and Sexing Animal Bones. Proceedings of the 9th ICAZ Conference, Durham 2002*, 189–203. Oxford: Oxbow Books.
- MaGnin, E. 1964: Validité d'une distinction spécifique entre les deux acipensés : *Acipenser sturio* L. d'Europe et *Acipenser oxyrinchus* d'Amérique du Nord. *Le Naturaliste Canadien* XCI (1): 5-20.
- Malmsten, A., Dalin, A. M., & Pettersson, A. (2015). Caries, periodontal disease, supernumerary teeth and other dental disorders in Swedish wild boar (*Sus scrofa*). *Journal of Comparative Pathology*, 153(1), 50-57.
- Manby, T. G. (1974). *Grooved Ware sites in the North of England*. British Archaeological Reports.
- Masetti, M. (2007). The economic role of *Sus* in early human fishing communities. In A. Albarella, K. Dobney, A. Ervynck, & P. Rowley-Conwy (Eds.), *Pigs and humans: 10,000 Years of interaction*. Oxford: Oxford University Press, pp. 156–170.
- Mauss, M. and Evans-Pritchard, E.E. (Edward E. (1967) *The gift: forms and functions of exchange in archaic societies*. New York; W.W. Norton.
- McAndrew, F.T. (2019). Costly Signaling Theory. In: Shackelford, T., Weekes-Shackelford, V. (eds) *Encyclopedia of Evolutionary Psychological Science*. Springer, Cham.
- McArthur, M. (1960). Food consumption and dietary levels of groups of aborigines living on naturally occurring foods. In C. P. Mountford (ed.) *Record of the Australian-American Scientific Expedition to Arnhem Land, Vol.2: Anthropology and Nutrition*. Melbourne: Melbourne University Press.
- McGovern, P. E., Underhill, A. P., Fang, H., Luan, F., Hall, G. R., Yu, H., ... & Feinman, G. M. (2005). Chemical identification and cultural implications of a mixed fermented beverage from late prehistoric China. *Asian Perspectives*, 249-275.
- McGovern, P. E., Zhang, J., Tang, J., Zhang, Z., Hall, G. R., Moreau, R. A., ... & Wang, C. (2004). Fermented beverages of pre-and proto-historic China. *Proceedings of the National Academy of Sciences*, 101(51), 17593-17598.
- McIlwraith, T. (1948). *The Bella Coola Indians*. Toronto: Univ. Tor. Press.
- Melis, A., A. Schneider, and M. Tomasello. (2011). Chimpanzees, *Pan troglodytes*, share food in the same way after collaborative and individual food acquisition. *Animal Behavior* 82: 485–93.
- Metzger, M. C., Ridder, E., Birch, S. E. P., Falconer, S. E., & Fall, P. L. (1970). Animal Exploitation and Community Behavior at a Middle Bronze Age Village on Cyprus. *Archaeozoology of Southwest Asia and adjacent areas XIII: proceedings of the*, 13, 113.
- Miles, A. E. W., & Grigson, C. (Eds.). 2003. *Colyer's Variations and Diseases of the Teeth of Animals*. Cambridge University Press.
- Miller, M. (2019). The Social Dimensions of Prehistoric Agavaceae Baking Pits: Feasting and Leadership in the Late Pithouse and Pueblo Period of South-Central New Mexico.

- Interaction and Connectivity in the Greater Southwest, Proceedings of the 2014 Southwest Symposium*. Edited by Harry and Roth.
- Mills, B. J. (2007). Performing the feast: Visual display and suprahousehold commensalism in the Puebloan Southwest. *American Antiquity*, 72(2), pp.210-239.
- Mills, B. J. (ed.). (2004). *Identity, Feasting, and the Archaeology of the Greater Southwest*. University Press of Colorado, Boulder.
- Min, Z., Peng, Z. & Wang, C. (Eds.) (1991). *An Illustrated History of Ancient Chinese Agricultural Science and Technology*. Beijing: Agriculture Press, pp.110-111. (in Chinese)
- Montgomery, J. (2000). Ibn Fadln and the Rsiyyah. *J. Arab. Islam. Stud.* 3:1–25.
- Moran N.C., O'Connor T.P. (1994). Age attribution in domestic sheep by skeletal and dental maturation: a pilot study of available sources. *International journal of Osteoarchaeology*. 4(4):267-85.
- Morlan, R.E., 1994. Bison bone fragmentation and survivorship: a comparative method. *Journal of Archaeological Science*, 21(6), pp.797-807.
- Morris, C. (1979). Maize beer in the economics, politics, and religion of the Inca Empire. In *Fermented Food Beverages in Nutrition*, ed. C Gastineau, W Darby, N Turner, pp. 21–35. New York: Academic.
- Munro, N. D., & Grosman, L. (2010). Early evidence (ca. 12,000 BP) for feasting at a burial cave in Israel. *Proceedings of the National Academy of Sciences*, 107(35), 15362-15366.
- Nairn, C. (1991). *Ongka's Big Moka (Kawelka)*. London: Image Media Services.
- Nakahashi Takahiro& Kitagawa Yoshikazu [中桥孝博&北川贺一] (2006). 郑国祭祀遗址人骨鉴定报告 In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng (2)*. Zhengzhou: Elephant Press. pp. 1153-1155 (in Chinese).
- Nelson, S. M. (2003). Feasting the Ancestors in Early China. In Tamara L. Bray. Kluwer (ed.) *The Archaeology and Politics of Food and Feasting in Early States and Empires*, New York: Academic/Plenum Publishers.
- Nicholson, R. A. (1993). A morphological investigation of burnt animal bone and an evaluation of its utility in archaeology. *Journal of Archaeological Science*, 20(4), 411-428.
- Nishida, T., T. Hasegawa, H. Hayaki, Y. Takahata, and S. Uehara. (1992). Meat-sharing as a coalition strategy by an alpha male chimpanzee? In *Topics in Primatology*, eds. T. Nishida, W. C. McGrew, P. Marler, M. Pickford, and F. B. M. de Waal, 159–74. Tokyo: University of Tokyo Press.
- Noddle, B. (1974). Ages of epiphyseal closure in feral and domestic goats and ages of dental eruption. *Journal of Archaeological Science*, 1(2), 195-204.
- Noddle, B. (1997). Animal Bone in Buteux, S Settlements at Skaill, Deerness, Orkney: Excavations by the late Peter Gelling of the Prehistoric, Pictish, Viking and Later Periods, 1963–1981. *Oxford: Archaeopress, British Archaeological Report British Series*, 260.

- O'Connor, K. (2015). *The never-ending feast: the anthropology and archaeology of feasting*. Bloomsbury Publishing.
- Ohtaishi, N., & Gao, Y. (1990). A review of the distribution of all species of deer (Tragulidae, Moschidae and Cervidae) in China. *Mammalian Review*, 20(2/3), 125–144.
- Okandeji, M. E., Lijoka, A. D., Atiba, F. A., Adebiyi, O. A., & Olopade, J. O. (2023). Dental Disorders in Wild and Domestic Pigs (*Sus Scrofa*): A Review. *Journal of Veterinary Dentistry*, 40(1), 47-56.
- Olsen, S. J. (1988). The horse in ancient China and its cultural influence in some other areas. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 151-189.
- Outram, A.K., 2001. A new approach to identifying bone marrow and grease exploitation. *Journal of Archaeological Science*, 28(4), pp.401–410.
- Outram, A.K., Knüsel, C.J., Knight, S. and Harding, A.F., 2005. Understanding complex fragmented assemblages of human and animal remains: a fully integrated approach. *Journal of Archaeological Science*, 32(12), pp.1699-1710.
- O'Connor, T. (1991). *Bones from 46-54 Fishergate*. London: Council for British Archaeology. (The Archaeology of York 15).
- O'Connor, T. (2000). *The Archaeology of Animal Bones*. Stroud: Sutton Publishing.
- Pang, J. F., Kluetsch, C., Zou, X. J., Zhang, A. B., Luo, L. Y., Angleby, H., ... & Savolainen, P. (2009). mtDNA data indicate a single origin for dogs south of Yangtze River, less than 16,300 years ago, from numerous wolves. *Molecular biology and evolution*, 26(12), 2849-2864.
- Pappa, M., Halstead, P., Kotsakis, K., & Urem-Kotsou, D. (2004). Evidence for large-scale feasting at Late Neolithic Makriyalos, N Greece. *Food, cuisine and society in prehistoric Greece*, 16-44.
- Parker Pearson, M. (2010). *Pastoralists, Warriors and Colonists: The Archaeology of Southern Madagascar*. Oxford: Archaeopress (British Archaeological Reports, International Series 2139).
- Parmenter, P.C., Johnson, E.V. and Outram, A.K., 2015. Inventing the Neolithic? Putting evidencebased interpretation back into the study of faunal remains from causewayed enclosures. *World Archaeology*, 47(5), pp.819-833.
- Pauketat, T. R., Kelly, L. S., Fritz, G. J., Lopinot, N. H., Elias, S., & Hargrave, E. (2002). The residues of feasting and public ritual at early Cahokia. *American Antiquity*, 67(2), 257-279.
- Payne, S. and Bull, G. (1988). Components of variation in measurements of pig bones and teeth, and the use of measurements to distinguish wild from domestic pig remains. *ArchaeoZoologia II* (1.2), 27–66.
- Perodie, J.R. (2001). Feasting for prosperity: a study of southern Northwest Coast feasting. In M. Dietler, B. Hayden (eds.) *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*, Washington, DC: Smithsonian Institution, 185-214.
- Peterson, C. E., & Shelach, G. (2012). Jiangzhai: Social and economic organization of a Middle Neolithic Chinese village. *Journal of Anthropological Archaeology*, 31(3), 265-301.
- Piddocke, S. (1965). The potlatch system of the Southern Kwakiutl: a new perspective. *Southwestern Journal of Anthropology*, 21(3), 244-264.

- Pike-Tay, A., Ma, X., Hou, Y., Liang, F., Lin, M., & Peterson, V. 2016. Combining odontochronology, tooth wear assessment, and linear enamel hypoplasia (LEH) recording to assess pig domestication in Neolithic Henan, China. *International Journal of Osteoarchaeology* 26(1), 68-77.
- Pilaar Birch, S. E., Metzger, M., Ridder, E., Porson, S., Falconer, S. E., & Fall, P. L. (2022). Herd management and subsistence practices as inferred from isotopic analysis of animals and plants at Bronze Age Politiko-Troullia, Cyprus. *Plos one*, 17(10), e0275757.
- Pollard, M., 1993: "Tales Told by Dry Bones", *Chemistry and Industry*, 359-362.
- Potter, J. M. (2020). Pots, parties, and politics: Communal feasting in the American Southwest. Translated by Y. Zhu. *Cultural Relics in Southern China* (02), 242-250,225 (in Chinese).
- Potter, J.M. (2000). Pots, parties, and politics: Communal feasting in the American Southwest. *American Antiquity* 65(3):471-92.
- Powers, W. K. & Powers, M. N. (1984). Metaphysical aspects of an Oglala food system. In: Douglas, M. (Ed.), *Food in the Social Order: Studies of Food and Festivities in Three American Communities*. Russell Sage Foundation, New York.
- Price, M. D. (2020). *Evolution of a taboo: pigs and people in the Ancient Near East*. Oxford University Press.
- Prummel, W. (1987). *Atlas for identification of foetal skeletal elements of Cattle, Horse, Sheep and Pig, Part 2*. Archaeozoologia I, 2.
- Qi, G., Lin, Z., & An, J. (2006). Identification report of faunal remains in Dadiwan site. In Gansu Provincial Institute of Cultural Relics and Archaeology (Ed.), *Qin'an Dadiwan*. Beijing: Cultural Relics Press, pp. 861-910 (in Chinese).
- Qiu, Jane. (2014). Ancient times table hidden in Chinese bamboo strips. *Nature*.
- Qiu, Z. X. (1998). Tiger, Sabre-Toothed tiger and its evolution. *Fossil*, 26, 3-6.
- Qu, Y. (1991). Research on restoration of pre-Qin capital [先秦都城复原研究]. Harbin: Heilongjiang People's Publication, pp. 412-416.
- Rahman, S. A. (2017). Religion and animal welfare—An islamic perspective. *Animals*, 7(2), 11.
- Ramsey, C. B., T. Higham, A. Bowles and R. Hedges, 2004: "Improvements to the pretreatment of bone at Oxford", *Radiocarbon* 46(1), 155-163.
- Rappaport, R. (1968). *Pigs for the Ancestors*. New Haven, CT: Yale Univ. Press.
- Reed, C. A. (1963). Osteo-archaeology. In D. Brothwell and E. Higgs (eds.), *Science in Archaeology*, pp. 204–216. Thames and Hudson, London.
- Reiland, S. (1978). Growth and skeletal development of the pig. *Acta radiologica. Supplementum*, 358, 15-22.
- Reinhart, K. (2015). Ritual feasting and empowerment at Yanshi Shangcheng. *Journal of Anthropological Archaeology*, 39, 76-109.
- Reinhart, K. (2016). Ritual and daily life in the Chinese Bronze Age: foodstuffs and bodies in depositional context at Yanshi Shangcheng. In *Exploring the Materiality of Food'Stuffs'* (pp. 264-286). Routledge.

- Reinhart, K. (2020). Analysis of grooved ceramic vessels from the early Chinese Bronze Age site of Yanshi Shangcheng: preliminary evidence of food preparation methods through starch analysis. *Journal of Archaeological Science: Reports*, 29, 101852.
- Reinhart, K., & Edge, M. D. (2020). Multivariate analysis of cooking pots from elite and “commoner” contexts at Yanshi Shangcheng: implications for the politics of daily life and development of ceramic technology in the early Bronze Age of northern China. *Archaeological and Anthropological Sciences*, 12, 1-26.
- Reinhart, K., & Sun, H. (2018). Ritual Feasting and Empowerment at Yanshi Shangcheng (No.2). *Cultural Relics in Southern China (04)*, 249-254 (in Chinese).
- Reinhart, K., & Sun, H. (2019a). Ritual Feasting and Empowerment at Yanshi Shangcheng (Third). *Cultural Relics in Southern China (01)*, 222-232+212 (in Chinese).
- Reinhart, K., & Sun, H. (2019b). Ritual Feasting and Empowerment at Yanshi Shangcheng (Fourth). *Cultural Relics in Southern China (06)*, 235-253+226 (in Chinese).
- Reinhart, K., Sun, H., & Chen, X. (2018). Ritual Feasting and Empowerment at Yanshi Shangcheng (No.1). *Cultural Relics in Southern China (03)*, 260-265+255 (in Chinese).
- Reitz, E. J. & E. S. Wing, 2008. *Zooarchaeology*. Cambridge: Cambridge University Press.
- Ren, L., Wang, Y., Li, G., Li, Q., Ma, Z., & Dong, G. (2015). Discovery of a tiger (*Panthera tigris* (L.)) skeleton from the Little Ice Age buried on the shore of Qinghai Lake, northeast Tibet Plateau. *Quaternary International*, 355, 145-152.
- Ren, W., Wang, J., & Zheng, N. (1984). Peiligang site excavation report in 1979 [1979 年裴李岗遗址发掘报告]. *Acta Archaeologica Sinica (01)*, 23-52+137-146.
- Renfrew, C. (1985). *The Archaeology of Cult: The Sanctuary at Phylakopi*. London: Thames and Hudson.
- Richter, K. K., Codlin, M. C., Seabrook, M., & Warinner, C. (2022). A primer for ZooMS applications in archaeology. *Proceedings of the National Academy of Sciences*, 119(20), e2109323119.
- Robin, G. (2017). What are Bucrania Doing in Tombs? Art and Agency in Neolithic Sardinia and Traditional South-East Asia. *European Journal of Archaeology*, 20(4): 603–635.
- Rosman, A., Rubel, P. (1971). *Feasting with Mine Enemy*. Prospect Heights, IL: Waveland Press.
- Rowley-Conwy P. (2018). Zooarchaeology and the elusive feast: from performance to aftermath. *World Archaeology* 50(2):221-41.
- Rowley-Conwy, P. & Dobney, K. (2007). Wild Boar and Domestic Pigs in Mesolithic and Neolithic Southern Scandinavia. In *Pigs and Humans. 10,000 Years of Interaction*, edited by U. Albarella, K. Dobney, A. Ervynck, and P. Rowley-Conwy, 131–155. Oxford: Oxford University Press.
- Rowley-Conwy, P. (1993). Season and reason: The case for a regional interpretation of Mesolithic settlement patterns. In G. L. Peterkin, H. Bricker, & P. Mellars (Eds.), *Hunting and animal exploitation in the later Palaeolithic and Mesolithic of Eurasia (Archaeological Papers 4)*. Washington: American Anthropological Association, pp. 179–188.

- Rowley-Conwy, P. (1997). The animal bones from Arene Candide. Final report. In R. Maggi, (ed.) *Arene Candide: Functional and environmental assessment of the Holocene sequence*, pp.153-277.
- Rowley-Conwy, P. (1998). Cemeteries, seasonality and complexity in the Ertebølle of southern Scandinavia. In M. Zvelebil, L. Domanska, & R. Dennell (Eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, pp. 193–202.
- Rowley-Conwy, P. (1999). Economic prehistory in southern Scandinavia. In J. Coles, R. M. Bewley, & P. Mellars (Eds.), *World prehistory. Studies in memory of Grahame Clark (Proceedings of the British Academy 99)*. Oxford: Oxford University Press, pp. 125–159.
- Rowley-Conwy, P. (2001). Determination of season of death in European wild boar (*Sus scrofa ferus*): a preliminary study. *Archaeopress*.
- Rowley-Conwy, P., Albarella, U. & Dobney, K. (2012). Distinguishing Wild Boar from Domestic Pigs in Prehistory: A Review of Approaches and Recent Results. *J World Prehist* **25**, 1–44.
- Rowley-Conwy, P., Gron, K. J., Bishop, R. R., Dunne, J., Evershed, R., Longford, C., ... & Treasure, E. (2020) The earliest farming in Britain: towards a new synthesis. In: Gron, K.J., Sorensen, L. and Rowley-Conwy, P., (eds.) *Farmers at the Frontier: A Pan European Perspective on Neolithisation*. Oxbow Books, Oxford, UK, pp. 401-424.
- Rowley-Conwy, P. A. & Owen, A. C. (2011). Grooved ware feasting in Yorkshire: Late Neolithic animal consumption at Rudston Wold. *Oxford Journal of Archaeology*, *30*(4), 325-367.
- Ruan, Y. 阮元. (1980). Shisan Jing Zhushu (Notes and commentaries to thirteen Confucian texts). *Beijing: Zhonghua Shuju*. (in Chinese)
- Russell, N. & Martin, L. (2005). The Çatalhöyük mammal remains. In I. Hodder (ed.), *Inhabiting Çatalhöyük: Reports From the 1995–99 Seasons*, McDonald Institute for Archaeological Research, Cambridge, 35-95.
- Ruyale, E. E. (1973). Slavery, surplus, and stratification on the Northwest Coast: The ethnoenergetics of an incipient stratification system. *Current Anthropology*, *14*(5), 603-631.
- Rütimeyer, L. (1862). Die Fauna der Pfahlbauten der Schweiz, Bürkli, Zürich (Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die Gesamten Naturwissenschaften).
- Sahlins, M. (2013). *Stone age economics*. Routledge.
- Schoeninger, M. J. & M. J. DeNiro, 1984: "Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals", *Geochimica et Cosmochimica Acta* *48*, 625-639.
- Schoeninger, M. J., M. J. DeNiro & H. Tauber (1983) $^{15}\text{N}/^{14}\text{N}$ Ratios of Bone Collagen Reflect Marine and Terrestrial Components of Prehistoric Diets, *Science* *220*, 1381-1383.
- Schulting, R. J., 1998: "Slighting the sea: Stable isotope evidence for the transition to farming in northwestern Europe", *Documenta Praehistorica* *25*, 203-218.

- Schwarz, F. (1996). Recent Indian communal feasting structures in Newfoundland and Labrador. Presented at *Can. Archaeol. Assoc. Annu. Meet. Abstr.*, Halifax.
- Seeman, M. (1979). Feasting with the dead: Ohio Hopewell charnel house ritual as a context for redistribution. In *Hopewell Archaeology, The Chillicothe Conference*, ed. D Brose, N Greber, pp. 39–46. Kent, OH: Kent State Univ. Press.
- Serjeantson, D., 1991. 'Rid grasse of bones': A taphonomic study of the bones from midden deposits at the Neolithic and Bronze age site of Runnymede, Surrey, England. *International Journal of Osteoarchaeology*, 1(2), pp.73-89.
- Shan, D. & Shi, B. (1976). The birth and germination of private ownership in ancient China from the cultural relics of Dawenkou. [从大汶口文化遗存看我国古代私有制的孕育和萌芽]. *Cultural Relics* (04),84-88. (in Chinese).
- Shaughnessy, Edward L. (1999). "Calendar and Chronology", in Loewe, Michael; Shaughnessy, Edward L. (eds.), *The Cambridge History of Ancient China*, Cambridge: Cambridge University Press, pp. 19–29.
- Sheehan, G. (1989). In the belly of the whale. *Archaeology* 42:52–64.
- Shen, Chen (1994). Early urbanization in the Eastern Zhou in China (770—221 BC): An archaeological view. *Antiquity*, 68(261), 724-744. doi:10.1017/S0003598X00047438
- Shen, X. & Fan, W. (2017). A Study of the Brick Burials of the Eastern Zhou Period at the Zhengnan Site [郑韩故城东周时期空心砖墓葬研究]. *Cultural Relics of Central China* 中原文物(06),64-68.
- Sheng, H. (ed.). (1992). *The Deer in China*. Shanghai: East China Normal University Press (in Chinese).
- Sheng, H., Kishimoto, T. & Lu, H. (1999). *Wild Mammals in China*. China Forestry Press (in Chinese).
- Sherratt, A. (1983) 'The secondary exploitation of animals in the Old World', *World Archaeology*, 15(1), pp. 90–104. doi: 10.1080/00438243.1983.9979887.
- Sherratt, S. (2004). Feasting in Homeric epic. *Hesperia: The Journal of the American School of Classical Studies at Athens*, 73(2), 301-337.
- Shi, N. (1998). Origins of Zheng Han Gu Cheng [郑韩故城溯源], *中国历史地理论丛*, 1998(04), 3-38.
- Shimada, I., Shinoda, K., Farnum, J., Corruccini, R., & Watanabe, H. (2004). An integrated analysis of pre-hispanic mortuary practices: A middle Sicn case study. *Current Anthropology*, 45(3), 369-402.
- Shipman, P., Foster, G., & Schoeninger, M. (1984). Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of archaeological science*, 11(4), 307-325.
- Shui, C. (1998). Renwu wudaowen pen – guozhuangwu ji qita (Human dancing basin, guozhuang dance and other issues). *Wenwu Tiandi*, 1 (10–15). (in Chinese).
- Sillitoe, P. (1978). Big men and war in New Guinea. *Man* 13:252–271.
- Silver I. A. (1963). The Ageing of Domestic Animals. In: Brothwell D, and Higgs E, editors. *Science in Archaeology: A Comprehensive Survey of Progress and Research*. New York: Basic Books. Pp. 250-268.

- Silver I. A. (1969). The ageing of domestic animals. In: Brothwell E & Higgs E (eds), *Science in Archaeology*, 283–302. London: Thames & Hudson.
- Simoons, F. (1968). *A Ceremonial Ox*. Madison: Univ. Wis. Press.
- Smith, A. T., & Xie, Y. (Eds.). (2008). *A guide to the mammals of China*. Princeton University Press.
- Smith, B. D., 1975. Toward a more accurate estimation of meat yield of animal species at archaeological sites. In A. D. Clason (ed.) *Archaeozoological studies*, Amsterdam: North-Holland Publishing, 99-108.
- Smith, I. (1965). *Windmill Hill and Avebury*. Oxford: Clarendon.
- Smith, M. L. (2015). “Feasts and Their Failures.” *Journal of Archaeological Method and Theory* 22: 1215–1237.
- Smith, M.L. (2015). Feasts and their failures. *Journal of Archaeological Method and Theory*, 22, pp.1215-1237.
- Sofaer, J. A. 1975. Genetic variation and tooth development. *British Medical Bulletin* 31: 107–110.
- Song, G. (1987). Brief report on excavations of East Zhou tombs in Heli Village, Xinzheng County [新郑县河李村东周墓葬发掘简报]. *Cultural Relics of Central China*(04).
- Song, Y., Yi, H. & Zhang, X. (2020). A Zooarchaeological study of the Jinzhai Site (2016-2017) in Xiaoxian County, Anhui Province. *Southeast Culture*, 2020(03):104-111 (in Chinese).
- Song, Z. (1994). Bone making technology of *Li*. *Journal of National Museum of China* (02). doi:CNKI:SUN:ZLBK.0.1994-02-013. (In Chinese).
- Stanford, C. B. (2001). A comparison of social meat-foraging by chimpanzees and human foragers. In *Meat Eating and Human Evolution*, eds. Craig B. Stanford and Henry T. Bunn, Oxford: Oxford University Press, 122–40.
- Stanish, C., Tantaleán, H., & Knudson, K. (2018). Feasting and the evolution of cooperative social organizations circa 2300 BP in Paracas culture, southern Peru. *Proceedings of the National Academy of Sciences*, 115(29), E6716-E6721.
- Stephenson, F. Richard (2008). How reliable are archaic records of large solar eclipses? *Journal for the History of Astronomy*, 39 (2): 229–250.
- Sterckx, R. (2002). *The animal and the daemon in early China*. SUNY press.
- Stevenson, H. (1943). *The Economics of the Central Chin Tribes*. Bombay: Times India Press.
- Stiner, M. C. (2001). Thirty years on the “Broad Spectrum Revolution” and paleolithic demography. *Proceedings of the National Academy of Sciences*, 98(13), 6993-6996.
- Stiner, M. C., Kuhn, S. L., Weiner, S., & Bar-Yosef, O. (1995). Differential burning, recrystallization, and fragmentation of archaeological bone. *Journal of archaeological science*, 22(2), 223-237.
- Storozum, M. J., Qin, Z., Liu, H., & Kidder, T. R. 2020. The alluvial geoarchaeology of Neihuang County, Henan Province. *Quaternary Science*, 40(2), 579-593 (in Chinese).
- Strathern, A. (1971). *The Rope of Moka*. Cambridge: Cambridge Univ. Press.
- Su, Y. (2010). *A Study on the History of Zheng in Zhou Dynasty* [周代郑国史研究], PhD dissertation, Jilin University.

- Sun, H. (2022). On Age of Chime Bells Unearthed from Sacrificial Site Discovered in Capital of Zheng and Han States, and Relevant Issues [郑韩故城祭祀遗址编钟的年代及相关问题]. *Huaxia Archaeology* (04), 97-102.
- Sun, L., Fan, W., Zhou, L., Zhu, H. (2018). 新郑天利食品厂两周墓地墓葬人骨研究, 新郑天利两周墓地, 上海古籍出版社, 358-486.
- Sun, N., Ma, Q., Han, B., & Yang, Y. (2023). New insights into the subsistence strategies of the northwest frontier of the Western Zhou Dynasty (1046–771 BCE) through pottery lipid analysis. *Archaeological and Anthropological Sciences*, 15(6), 80.
- Sun, Z. (2013). *A Research on the Layout of the Capital Cities in Eastern Zhou Dynasty* [东周列国都城城市布局形态研究]. Master's thesis, Shandong University.
- Suttles, S. (1968). Coping with abundance: subsistence on the Northwest Coast. In R Lee, I Devore (eds.) *Man the Hunter*. Chicago: Aldine de Gruyter, 56–68.
- Swenson, E. (2015). The Archaeology of Ritual. *Annual Review of Anthropology* 44:329–345.
- Tang, J. (2017). *A Study on the Handicraft Industry Remains of Zhou Period of the Central Plains* [中原地区两周手工业遗存研究]. PhD dissertation, Zhengzhou University.
- Tang, Q. 2003. Identification of animal remains collected from East Dynasty Layer of B District of Maliutuo Site, Wanzhou, Chongqing. Chongqing Bureau of Cultural Relics, et al. (ed.) *Archaeological Reports Collection on Sites in Chongqing area of Three Gorges Reservoir*. Vol.1997. Beijing: Science Press: 421 (in Chinese).
- Taylor, W. W. (1983). *A study of archeology* (No. 69). Southern Illinois University.
- Thieren, E., & Van Neer, W. 2016. Scutes for sturgeon size reconstruction: traditional and geometric morphometric techniques applied to *Acipenser sturio* and *A. oxyrinchus*. *Archaeofauna*, 25(1).
- Thilanderkvist, J. (2013). *Ritual bones or common waste: a study of Early Medieval bone deposits in Northern Europe*. Barkhuis.
- Thomas, J. (1991). *Rethinking the Neolithic*. Cambridge: Cambridge Univ. Press.
- Thomas, R. 2012 Non-human paleopathology. In J.E. Buikstra, C.A. Roberts, eds: The global history of paleopathology. Pioneers and prospects. Oxford, University Press, pp. 652-664.
- Thompson, V. D. and Andrus, C. F. T. (2011) “Evaluating Mobility, Monumentality, and Feasting at the Sapelo Island Shell Ring Complex,” *American Antiquity*. 76(2), pp. 315–343.
- Tong, H., Wang, X., & Chen, X. (2013). Late Pleistocene *Bison priscus* from Dabusu in Qian'an County, Jilin, China. *Acta Anthropologica Sinica* (04), 485-502 (in Chinese).
- Tong, Z. (1975). Exploring the private ownership and the origin of class in China from archaeological materials 从考古材料试探我国的私有制和阶级的源. *Archaeology* (04), 213-221+203. (in Chinese).
- Trbojević Vukičević, T., Korpes, K., Đuras, M., Vrbanc, Z., Javor, A., & Kolenc, M. (2023). Palaeopathological Changes in Animal Bones from Croatian Archaeological Sites from Prehistory to New Modern Period. *Veterinary Sciences*, 10(5), 361.
- Trigger, B. G. (1989). *A history of archaeological thought*. Cambridge university press.
- Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology* 46: 35–57.

- Twiss, K. C. (2007a). Home is where the hearth is: food and identity in the Neolithic Levant. In: Twiss, K.C. (Ed.), *The Archaeology of Food and Identity*. Center for Archaeological Investigations, Southern Illinois University Carbondale. Occasional Paper no 34, Carbondale, IL, 50-68.
- Twiss, K. C. (2007b). The Neolithic of the southern Levant. *Evolutionary Anthropology: Issues, News, and Reviews: Issues, News, and Reviews*, 16(1), 24-35.
- Twiss, K. C. (2008). Transformations in an early agricultural society: feasting in the southern Levantine Pre-Pottery Neolithic. *Journal of Anthropological Archaeology*, 27(4), 418-442.
- Twiss, K. C. (2008). Transformations in an early agricultural society: feasting in the southern Levantine Pre-Pottery Neolithic. *Journal of Anthropological Archaeology*, 27(4), 418-442.
- Twiss, K. C. (2012). The Complexities of Home Cooking: Public Feasts and Private Meals Inside the Çatalhöyük House. In *Between Feasts and Daily Meals: Toward an Archaeology of Commensal Spaces*, edited by Susan Pollock, pp. 53–73. *Journal for Ancient Studies Special Volume 2*.
- Twiss, K.C. (2015). Methodological and definitional issues in the archaeology of food. In *Commensality: From Everyday Food to Feast*, Londres, New Delhi, New York, Sydney, Bloomsbury, pp.89-98.
- Upex, B. and Dobney, K. 2012 More than just made cows. Exploring human-animal relationships through animal palaeopathology. In A.L. Grauer (ed) *A companion to paleopathology*. Cambridge, University Press, pp. 191-213
- Vaiglova, P., Halstead, P., Pappa, M., Triantaphyllou, S., Valamoti, S. M., Evans, J., ... & Bogaard, A. (2018). Of cattle and feasts: Multi-isotope investigation of animal husbandry and communal feasting at Neolithic Makriyalos, northern Greece. *PLoS One*, 13(6), e0194474.
- Vaiglova, P., Reid, R. E., Lightfoot, E., Pilaar Birch, S. E., Wang, H., Chen, G., ... & Liu, X. (2021). Localized management of non-indigenous animal domesticates in Northwestern China during the Bronze Age. *Scientific Reports*, 11(1), 15764.
- Van Der Merwe, N. J., Roosevelt, A. C., & Vogel, J. C. (1981). Isotopic evidence for prehistoric subsistence change at Parmana, Venezuela. *Nature*, 292(5823), 536-538.
- Van der Veen, M. (2003). When is food a luxury? *World Archaeology*, 34(3), 405-427.
- van Klinken, G. J., 1999: "Bone Collagen Quality Indicators for Palaeodietary and Radiocarbon Measurements", *Journal of Archaeological Science* 26, 687-695.
- VanDerwarker, A. M. (1999). Feasting and status at the Toqua site. *Southeastern Archaeology*, 18(1): 24-34.
- VanDerwarker, A. M. (2006). *Farming, hunting, and fishing in the Olmec world*. University of Texas Press.
- Vann, S. & Thomas, R. (2006). "A method for the systematic recording of pathological lesions in vertebrate skeletons from archaeological sites." *International Journal of Osteoarchaeology*, 16(1), 1–13.
- Vann, S. & Thomas, R., 2006. "A method for the systematic recording of pathological lesions in vertebrate skeletons from archaeological sites." *International Journal of Osteoarchaeology*, 16(1), pp. 1–13.

- Villeneuve, S. (2014). Food Sharing and the Primate Origins of Feasting. In *The Power of Feasts: From Prehistory to the Present*, 25-34.
- Von Den Driesch, A. (1976). *A guide to the measurement of animal bones from archaeological sites* (Vol. 1). Peabody museum press.
- Von den Driesch, A. (1976). *A guide to the measurement of animal bones from archaeological sites* (Vol. 1). Peabody Museum Press.
- Vretemark M (1997) Från Ben till Boskap: kosthåll och djurhållning med utgångspunkt i medeltida benmaterial från Skara. Skrifter Från Skaraborgs Länsmuseum 25. Skaraborgs Länsmuseum, Skara.
- Vretemark, M. (1997). Raw materials and urban comb manufacturing in medieval Scandinavia. In *Proceedings of the 7th ICAZ Conference*.
- Wada, E., Kadonaga, T., & Matsuo, S. (1975). ^{15}N abundance in nitrogen of naturally occurring substances and global assessment of denitrification from isotopic viewpoint. *Geochemical Journal*, 9(3), 139-148.
- Wainwright, G, Longworth I. (1971). *Durrington Wall, Excavations 1966–1968*. London: Soc. Antiq.
- Waiting for the e-journal
- Waiting for the e-journal
- Waley, A. (1996). *The Book of Songs*. New York: Grove.
- Wallis, N. J., & Blessing, M. E. (2015a). Big feasts and small scale foragers: Pit features as feast events in the American Southeast. *Journal of Anthropological Archaeology*, 39, 1-18.
- Wallis, N. J., & Blessing, M. E. (2015b). Ritualized deposition and feasting pits: bundling of animal remains in Mississippi period Florida. *Cambridge Archaeological Journal*, 25(1), 79-98.
- Wan, Junwei (2018). 郑韩故城城市形态研究(硕士学位论文,河南大学).
- Wang, H., Martin, L., Wang, W., & Hu, S. (2015). Morphometric analysis of *Sus* remains from Neolithic sites in the Wei River valley, China, with implications for domestication. *International Journal of Osteoarchaeology*, 25(6), 877-889.
- Wang, J., Liu, L., Ball, T., Yu, L., Li, Y., & Xing, F. (2016). Revealing a 5,000-y-old beer recipe in China. *Proceedings of the National Academy of Sciences*, 113(23), 6444-6448.
- Wang, K. 王凯. (2010). 郑韩故城手工业遗存的考古学研究(硕士学位论文,郑州大学).
- Wang, L. 王琳] (2003). 从郑韩故城出土陶文看先秦乡遂制度. *考古与文物*(04),50-54.
- Wang, R. (1981). The religious significance of burying pigs in the Neolithic Age: Notes on the discussion of the remains of primitive religious culture. 新石器时代葬猪的宗教意义——原始宗教文化遗存探讨札记. *Cultural Relics* (02),79-85. (in Chinese).
- Wang, R. (1990). A study of the ancient Chinese tablespoon, chopsticks, and fork. *Acta Archaeologica Sinica* (03),267-294. (in Chinese).
- Wang, R. (1994). Diet and Chinese Culture. Beijing: People's Publishing House (in Chinese).
- Wang, S. (2011). Pig feast: a study of an annual custom with community relations in Shuanglang Dali. In *Keep Memories of Ancestors' Tables--The Proceedings of 2011*

- Asian Food Cultural; Heritage Forum*. Yunnan Publishing Group Co., Ltd. and Yunnan People's Publishing House, pp.759-774 (in Chinese).
- Wang, Yu [王宇] (2011). *新郑郑国祭祀遗址相关问题研究*(硕士学位论文, 吉林大学).
- Wang, Zhen& Teng, Mingyu [王震& 滕铭予] (2018). 郑州地区东周时期郑韩陶器墓葬分期. *考古与文物*(04), 78-89.
- Wang, Zichu [王子初] (2006a). 郑国祭祀遗址出土编钟的考察和研究 In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press. pp. 951-994. (in Chinese).
- Wang, Zichu [王子初] (2006b). 郑国祭祀遗址陶坝测量报告 In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). Zhengzhou: Elephant Press. pp. 1058-1062. (in Chinese).
- Watts, J., Sheehan, O., Atkinson, Q. D., Bulbulia, J., & Gray, R. D. (2016). Ritual human sacrifice promoted and sustained the evolution of stratified societies. *Nature*, 532(7598), 228-231.
- Web page: The IUCN Red List. 2022-02-01, access on 2023-05-29.
- Weiner, A. (1988). *The Trobrianders of Papua New Guinea*. New York: Holt, Rinehart & Winston.
- Welch, P. D., & Scarry, C. M. (1995). Status-related variation in foodways in the Moundville chiefdom. *American Antiquity*, 60(3), 397-419.
- White, T. E. (1953). A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. *American antiquity*, 18(4), 396-398.
- Wiessner, P. & Schiefenhövel, W. (eds.). (1996). *Food and the status quest: an interdisciplinary perspective*. Berghahn Books.
- Wiessner, P. (2001). Of feasting and value: Enga feasts in a historical perspective (Papua New Guinea). In Dietler, M. & Hayden, B. (eds). *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*. Washington, DC: Smithsonian Institution, 115–143.
- Wiessner, P. (2001). Of feasting and value: Enga feasts in a historical perspective (Papua New Guinea). In Dietler, M., & Hayden, B. (eds) *Feasts: Archaeological and ethnographic perspectives on food, politics, and power*, 115-143.
- Willey, G.R. and Phillips, P. (2001). *Method and theory in American archaeology*. University of Alabama Press.
- Wills, W., & Crown, P. (2004). Commensal politics in the prehispanic Southwest. In Mills, B. (ed.). *Identity, Feasting and the Archaeology of the Greater Southwest*. Boulder: Univ. Press Colo, 153–72.
- Wolkstein, D., & Kramer, N. (1983). *Inanna, Queen of Heaven and Earth*. New York: Harper & Row.
- Wright, E., Viner-Daniels, S., Pearson, M. P., & Albarella, U. (2014). Age and season of pig slaughter at Late Neolithic Durrington Walls (Wiltshire, UK) as detected through a new system for recording tooth wear. *Journal of Archaeological Science*, 52, 497-514.
- Wu, X. & Lu, D. 2008. Research on fauna of Buzhuanghe Site. The Office of Three Gorges Construction Committee of State Department, the State Bureau of Cultural Relics, et al. *Zigui Buzhuanghe Site*. Beijing: Science Press: 836-878 (in Chinese).

- Wu, X. & Meng, H. 2010. Research on animal remains of Dongmengtuo Site. The Office of Three Gorges Construction Committee of State Department, the State Bureau of Cultural Relics, et al. (ed.). *Zigui Dongmentou Site*. Beijing: Science Press: 415-453 (in Chinese).
- Wu, X. 2003. Research on fauna. The Office of Three Gorges Construction Committee of State Department, the State Bureau of Cultural Relics, et al. (ed.) *Zigui Heguangzui Site*. Beijing: Science Press: 118-131 (in Chinese).
- Wu, X. 2007. *Archaeological Research on Fauna of Three Gorges*. Chongqing: Chongqing Press: 17-18 (in Chinese).
- Wuertz, S.; Reiser, S.; Gessner, J. & Kirschbaum, F. 2011: Morphological Distinction Between Juvenile Stages of the European Sturgeon *Acipenser sturio* and the Atlantic Sturgeon *Acipenser oxyrinchus*. In: Wil-liot, P.; Rochard, E.; Dese-Berset, N.; Kirschbaum, F. & Gessner, J. (eds.): *Biology and Conservation of the European Sturgeon Acipenser sturio L. 1758. The Reunion of the European and Atlantic Sturgeons*: 53- 64. Springer-Verlag, Berlin.
- Xinzheng Cultural Relics Administration Bureau [新郑市文物管理局] (2005), 新郑市文物志, 中国文史出版社, 70-71.
- Xinzheng Municipal Government, Official Archives, <https://www.xinzheng.gov.cn/zrdl.jhtml>, updated on 06/09/2019, access on 05/03/2023.
- Xi'an Banpo Museum (1988). *Jingzhai*. Beijing: Cultural Relics Press.
- XSZCP Group (2000). *The Xia-Shang-Zhou Chronology Project Report for the years 1996–2000 (abridged)* [夏商周断代工程 1996—2000 年阶段成果报告: 简本]. Beijing: World Publishing Corporation.
- Xu, Hong [许宏] (2000). 《先秦城市考古学研究》, 北京燕山出版社.
- Xu, Hong [许宏] (2017). 《先秦城邑考古》, 金城出版社、西苑出版社
- Xu, J., Zhou, J. & Yi, H. (2021). A study of bone making handicraft at the Kaizhuang site in Dongtai, Jiangsu Province[江苏东台开庄遗址制骨手工业试析]. *Southeast Culture* (03), 92-101. (in Chinese).
- Xu, P. (1996). The regionalism and fusion of Chinese food culture. *Chinese Culture: Tradition & Modernization* (01), 66-73 (in Chinese).
- Yang, B., et al. [杨博闻, 樊温泉, Melanie J Miller, Kate Pechenkina, 董豫] (2022). Dietary changes from eastern Zhou to Han dynasty at the Longhu Guomianyichang site, Henan Province [河南龙湖国棉一厂遗址东周到两汉先民食谱的转变]. *Quaternary Sciences* [第四纪研究], 42(06), 1724-1735.
- Yang, F., Wang, Q., & Wang, F. (2020). Stable carbon and nitrogen isotope evidence of human and animal diets at the Xijincheng site, Bo'ai County of Henan Province. *Quaternary Sciences*, 40(2): 418-427. doi: 10.11928/j.issn.1001-7410.2020.02.12
- Yang, H. (2004). On the origin and development of waist-pit tomb custom culture in Southwest China -- also on the origin of waist-pit tomb custom culture in China. *Journal of Chongqing Normal University Edition of Social Sciences* (05), 44-53+66. (in Chinese).

- Yang, W. (2001). A Study of the Bronzes from the Large Tomb at Lijialou, Xinzheng. *Huaxia Archaeology* (03), 73-79 (in Chinese).
- Yang, Y. (2016). A Preliminary Study of The Palace Museum Collected Oracle Bone Inscriptions on Hunting. *Palace Museum Journal* (03), 18-26+159. (in Chinese).
- Yang, Y., Shevchenko, A., Knaust, A., Abuduresule, I., Li, W., Hu, X., ... & Shevchenko, A. (2014). Proteomics evidence for kefir dairy in Early Bronze Age China. *Journal of Archaeological Science*, 45, 178-186.
- Yao, X. 姚孝遂 (1981). 《甲骨刻辞狩猎考》, 《古文字研究》第 6 辑, Beijing: Zhonghua Book Company (in Chinese).
- Ye, W. (1974). Excavation of a horse-chariot burial pits of the Warring States Period at Zhongzhou Road, Luoyang. *Archaeology* (03), 171-178+209-211 (in Chinese).
- Ye, Xiaoyan [叶小燕] (1985). 中原地区战国墓初探. *考古*(02), 161-172.
- Yerkes, R. (2005). Bone chemistry, body parts, and growth marks: evaluating Ohio Hopewell and Cahokia Mississippian seasonality, subsistence, ritual, and feasting. *American Antiquity* 70(2):241-65.
- Yi, H. (2016). *Animal Exploitation of Late Dawenkou Culture in Huai River Basin: Case Studies from Jinzhai Site and Zhaozhuang Site*. [Master's thesis, Shandong University] (in Chinese).
- Yi, H. (2019). Animal Exploitation of Late Dawenkou Culture in Huai River Basin——Case Studies from Jinzhai Site and Zhaozhuang Site 淮河流域大汶口文化晚期的动物资源利用. Master thesis, Shandong University, Jinan. (in Chinese).
- You, Y., Chen, X., Hein, A., Qin, C., Zhao, Y., Zhang, J., ... & Yuan, G. (2024). Pig domestication and human subsistence at the early Neolithic site of Guanjia (6100–5500 BC), Central China. *Archaeological and Anthropological Sciences*, 16(3), 40.
- Young, M. (1971). *Fighting with Food*. Cambridge: Cambridge Univ. Press.
- Yu, Jie *et al.* [余洁, 樊温泉&沈小芳] (2019). Archaeological excavation brief report of North Gate Site in the Spring and Autumn Period and the Warring States Period at Capital of Zheng and Han, Xinzheng, Henan [河南新郑郑韩故城北城门遗址春秋战国时期遗存发掘简报]. *Huaxia Archaeology* [华夏考古](01): 3-12+113+2.
- Yu, W., Gao, M., 1978. Zhou Dai Yong Ding Zhi Du Yan Jiu (A study of system of using bronze ding during Zhou dynasty). Beijing daxue xuebao zhexue shehui kexue ban (1), 84–98. (in Chinese).
- Yuan *et al.* [袁国林, 董建国, 蔡强, 郝红星&冯珂华] (2020). 河南新郑铁岭墓地战国仿铜陶器墓发掘简报. *Huaxia Archaeology* 华夏考古(03), 41-55.
- Yuan, B., A, R., Li, X. 2020. Teeth Remains of Chinese Water Deer (*Hydropotes inermis*) in the Dawenkou Culture. *Jiangnan Kaogu* (05):51-59 (in Chinese).
- Yuan, J. & Flad, R. K. (2002). Pig domestication in ancient China. *Antiquity*, 76(293), 724-732.
- Yuan, J. (2006). Zooarchaeological report of horse remains from sacrificial site of State of Zheng. In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng* (2). 《新郑郑国祭祀遗址》(上/中/下), Zhengzhou: Elephant Press. pp. 1147-1152 (in Chinese).

- Yuan, J. (2006). Zooarchaeological report of horse remains from sacrificial site of State of Zheng. In Henan Provincial Institute of Cultural Relics and Archaeology (Eds.) *The Sacrifice Site of Zheng in Xinzheng (2)*. Zhengzhou: Elephant Press. pp. 1147-1152 (in Chinese).
- Yuan, J. (2008) The Origins and Development of Animal Domestication in China. *Chinese Archaeology*, Vol. 8 (Issue 1), pp. 1-7.
- Yuan, J. (2015). *Zooarchaeology of China*. Beijing: Cultural Relics Press. (in Chinese)
- Yuan, J., & Flad, R. (2005). New zooarchaeological evidence for changes in Shang Dynasty animal sacrifice. *Journal of Anthropological Archaeology*, 24(3), 252-270.
- Yuan, J., & Flad, R. (2005). New zooarchaeological evidence for changes in Shang Dynasty animal sacrifice. *Journal of Anthropological Archaeology*, 24(3), 252-270.
- Yuan, J., & Flad, R. (2006). Research on early horse domestication in China. In *Equids in time and space: papers in honor of Vera Eisenmann*. Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham. Oxford: Oxbow Books. 124-131.
- Yuan, J., Huang, Y. and Yang, M. (2007). Zooarchaeological research on the Central Plains between 2500 BC and 1500 BC, in *Science for archaeology (volume 2)*. Beijing: Kexue Chubun. pp. 12-34 (in Chinese).
- Yuan, J., Luo, Y., Li, Z., Lyu, P. 2010. Standards for identifying domestic pigs. In *Zooarchaeology (1)*, Henan Provincial Institute of Cultural Relics and Archaeology (eds.). Beijing: Cultural Relics Press; 116-123 (in Chinese).
- Zahavi, A., & Zahavi, A. (1999). The handicap principle: A missing piece of Darwin's puzzle. Oxford University Press.
- Zeder, M. A. (1991). *Feeding Cities: Specialized Animal Economy in the Ancient Near East*. Smithsonian Institution Press, Washington, D.C.
- Zeder, M. A. (2006). A critical assessment of markers of initial domestication in goats (*Capra hircus*). In M. A. Zeder, D. G. Bradley, E. Emshwiller, & B. D. Smith (Eds.), *Documenting domestication: New genetic and archaeological paradigms*. Berkeley: University of California Press. pp. 181–208.
- Zeder, M. A. (2006). Reconciling rates of long bone fusion and tooth eruption and wear in sheep (*Ovis*) and goat (*Capra*). In Ruscillo D. (ed.), *Recent advances in ageing and sexing animal bones, Proceedings of the 9th ICAZ Conference, Durham 2002*. Oxbow Books, pp. 87-118, 9th ICAZ Conference.
- Zeder, M. A. (2008). Domestication and early agriculture in the Mediterranean Basin: Origins, diffusion, and impact. *Proceedings of the National Academy of Sciences*, 105(33), 11597–11604.
- Zeder, M. A. (2015). Core questions in domestication research. *Proceedings of the National Academy of Sciences*, 112(11), 3191-3198.
- Zeder, M. A. (2015). JISC MAIL ZOOARCH Archives. Access on Sep. 26, 2024.
<https://www.jiscmail.ac.uk/cgi-bin/webadmin?A2=ZOOARCH;75e51138.1507>
- Zhang, C., Wang, Y., Zhang, J., Taylor, W. T. T., Sun, F., Huang, Z., ... & Li, Y. (2023). Elite chariots and early horse transport at the Bronze Age burial site of Shijia. *Antiquity*, 97(393), 636-653.

- Zhang, Changshou & Zhang, Guangzhi. (1997). 河南商丘地区殷商文明调查发掘初步报告, *Archaeology*(4), 24-31. (in Chinese)
- Zhang, F., Ning, C., Scott, A., Fu, Q., Bjørn, R., Li, W., ... & Cui, Y. (2021). The genomic origins of the Bronze Age Tarim Basin mummies. *Nature*, 599(7884), 256-261.
- Zhang, Guoshuo (2014) 《中原文物城市防御文化研究》, 社会科学文献出版社.
- Zhang, Hongyin, Li, Xiuhui, Li, Yanxiang & Cai Quanfa [张宏英,李秀辉,李延祥&蔡全法] (2014). 郑韩故城热电厂墓地出土青铜器的初步分析. *中国文物科学研究*(01),71-75.
- Zhang, J., Harbottle, G., Wang, C., & Kong, Z. (1999). Oldest playable musical instruments found at Jiahu early Neolithic site in China. *Nature*, 401(6751), 366-368.
- Zhang, J., Harbottle, G., Wang, C. *et al.* (1999). Oldest playable musical instruments found at Jiahu early Neolithic site in China. *Nature* **401**, 366–368.
- Zhang, Ke (2021). *新郑地区东周墓葬出土玉器研究*.2021.郑州大学,MA thesis.
- Zhang, M., Song, Y., Wang, C., Sun, G., Zhuang, L., Guo, M., ... & Fu, Q. (2024). Ancient mitogenomes reveal the maternal genetic history of East Asian dogs. *Molecular Biology and Evolution*, 41(4), msae062.
- Zhang, Q., Hou, Y., Li, X., Styring, A., & Lee-Thorp, J. (2021). Stable isotopes reveal intensive pig husbandry practices in the middle Yellow River region by the Yangshao period (7000–5000 BP). *PLOS ONE*, 16(10), e0257524.
<https://doi.org/10.1371/journal.pone.0257524>
- Zhang, X. & Zhao, C. (2015). Stable isotope analysis of animal bones at the Xinzhai site. *Cultural Relics in Southern China* (04),232-240, (in Chinese).
- Zhang, Xin (1994). 郑州地区的周秦墓研究. *考古学研究*(00),166-188.
- Zhang, Y. (2018). On Feast Poems in Book of Songs and Pictures of Feasting Ceremonies at Spring and Autumn and Warring States Period 《诗经》宴飨诗与春秋战国宴乐射礼图. *Journal of South-Central University for Nationalities (Humanities and Social Science)* (03),126-130. (in Chinese).
- Zhang, Y., Dai, Q., Liu, Y., Fang, Q., Huang, X., Zhang, J., & Chen, J. (2022). Lipid residue analysis of Chinese ritual bronzes: Methodological and archaeological implications. *Journal of Archaeological Science*, 148, 105684.
- Zhang, Y., Gao, Y., Yang, J., Wang, Y., Wang, Y., Wang, C., ... & Chen, F. (2023). The early milk consumption on the Tibetan Plateau. *Science bulletin*, 68(4), 393-396.
- Zhang, Y., Zhang, D., Yang, Y., & Wu, X. (2020). Pollen and lipid analysis of coprolites from Yuhuicun and Houtieying, China: Implications for human habitats and diets. *Journal of Archaeological Science: Reports*, 29, 102135.
- Zhang, Z. (2019). *The research of faunal remains from Neolithic at Houtaomuga site (2011-2012 excavation)*. Master Thesis. Jilin University. Available at: <https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201502&filename=1015593251.nh> (Accessed: 20 Dec 2023) (in Chinese).
- Zhao, C., & Li, T. (2022). Research on feast behavior from the perspective of animal archaeology. *Cultural Relics in Southern China* (02),169-173 (in Chinese).
- Zhao, H. (2004). 东周车马埋葬制度初探 (硕士学位论文, 郑州大学).

- Zhao, H. (2007). 东周秦汉时期车马埋葬研究(博士学位论文,郑州大学).
- Zhao, H. (2017). *Mass Bone-working Industry in the Western Zhou Period (1046-771 BC)* (Doctoral dissertation, Stanford University).
- Zhao, J., Li, D., Li, Y., Huo, D., & Wang, L. (2017). The excavation of the zone A IV of the Houtaomuga site in Da'an City, Jilin. *Archaeology (11)*, 3-30 (in Chinese).
- Zhao, L. & Fan, W. (2017). 从郑国日用陶器墓看平民阶层的等级划分. *Huaxia Archaeology 华夏考古* (01), 92-99+139.
- Zhao, Z. 2011. New Archaeobotanic data for the study of the origins of agriculture in China. *Current Anthropology*, 52(4): 295–306. <https://doi.org/10.1086/659308n>.
- Zhou, J. (2014). 郑国与韩国墓葬制度比较研究(硕士学位论文,郑州大学).
- Zhou, L., Garvie-Lok, S. J., Fan, W., & Chu, X. (2017). Human diets during the social transition from territorial states to empire: Stable isotope analysis of human and animal remains from 770 BCE to 220 CE on the Central Plains of China. *Journal of Archaeological Science: Reports*, 11, 211-223.
- Zhou, L., Yang, S., Han, Z., Sun, L., & Garvie-Lok, S. J. (2019). Social stratification and human diet in the Eastern Zhou China: An isotopic view from the Central Plains. *Archaeological Research in Asia*, 20, 100162.
- Zinoviev, A. V. (2010). A supernumerary permanent mandibular premolar of wild boar (*Sus scrofa* L.) from the early medieval Novgorod, Russia. *International Journal of Osteoarchaeology*, 20(5), 586-590.

Appendix

Table 1

Metrical attributes of teeth and bones of Sus from ZHGC.

a. Lower M1							
No	Site	Period	Feature	Taxon	L	WA	WP
1	JSY	IV	J15	pig	16.09	9.61	9.93
2	JSY	IV	J15	pig	16.81	10.48	11.00
3	JSY	IV	J15	pig	16.08	9.60	10.01
4	JSY	IV	J15	pig	15.01	9.00	9.59
5	JSY	VI	J17	pig	16.31	10.59	11.34
6	JSY	IV	H21	pig	14.74	8.98	9.91
7	JSY	I	J2	pig	15.75	9.75	10.32
8	JSY	V	H11	pig	14.54	8.95	9.25
9	JSY	V	H11	pig	13.28	8.70	9.39
10	JSY	V	H13	pig	16.70	9.53	10.22
11	JSY	IV	H19	pig	15.51	9.82	10.54
12	JSY	IV	H8	pig	15.42	8.82	9.69
13	JSY	IV	H8	pig	15.61	9.27	10.05
14	JSY	VI	J16	pig	15.21	9.00	9.62
15	JSY	IV	J1	pig	14.34	9.48	9.89
16	JSY	IV	J1	pig	15.58	-	10.39
17	JSY	IV	J1	pig	15.51	8.83	9.50
18	JSY	IV	J1	pig	14.21	9.30	9.85
19	JSY	IV	J1	pig	14.88	9.37	10.40
20	JFQ	III	⑦	pig	14.10	9.11	9.89
21	JFQ	III	⑦	pig	14.66	-	-
22	JFQ	VI	H763	pig	-	-	10.70
23	JFQ	IV	H825①	pig	14.58	10.13	10.55
24	JFQ	V	H818	pig	15.37	8.49	9.57
25	JFQ	VI	J127	pig	15.74	9.69	10.51
26	JFQ	VI	J136	pig	14.89	9.11	9.99
27	JFQ	IV	H757	pig	14.87	9.24	10.04
28	JFQ	V	②	pig	14.78	9.65	9.96
29	JFQ	V	②	pig	15.28	8.73	9.52
30	JFQ	VI	H761	pig	12.96	-	-
31	JFQ	IV	H770	pig	15.15	8.51	9.19
32	JFQ	IV	H770	pig	15.48	8.47	9.37
33	JFQ	IV	H770	pig	12.36	-	-
34	JFQ	IV	②	pig	15.01	8.27	9.41
35	JFQ	VI	②	pig	15.85	9.74	10.42
36	JFQ	VI	①	pig	15.36	9.66	10.08
37	JFQ	VI	④	pig	15.95	10.27	10.93
38	JFQ	VI	④	pig	15.52	10.69	11.03
39	JFQ	VI	④	pig	17.73	11.36	11.58
40	JFQ	V	H760	pig	14.19	9.48	9.86
41	JFQ	V	H760	pig	16.79	10.11	10.73
42	JFQ	V	H760	pig	16.35	9.77	10.61

43	FDC	II	M63	pig	14.29	-	10.04
44	FDC	II	M63	pig	14.33	8.89	9.17
45	ZHL	VI	③	pig	14.06	9.63	10.57
46	HZM	East Han	H16	pig	15.98	10.42	10.18
47	HZM	East Han	H16	pig	16.34	9.79	11.10
48	HZM	East Han	H79	pig	17.04	9.68	10.88
49	JCL	V	⑤	pig	14.07	8.88	10.14
50	JCL	VI	H889	pig	15.13	9.05	10.22
51	JCL	VI	H889	pig	15.14	9.60	9.99
52	JCL	VI	H889	pig	16.46	9.65	10.30
53	JCL	VI	North②	pig	14.13	9.59	10.31
54	JCL	V	H905	pig	14.94	-	9.79
55	JCL	V	J160	pig	14.63	9.86	10.87
56	JCL	V	J160	pig	14.61	9.80	9.92
57	JCL	III	J160	pig	17.48	-	12.36
58	JCL	VI	H890	pig	15.92	10.16	11.11
59	GXS	VI	②A	pig	14.94	9.54	10.35
60	GXS	VI	②A	pig	16.01	-	10.57
61	GXS	VI	②A	pig	15.54	10.08	11.66
62	GXS	VI	②A	pig	13.68	8.92	10.38
63	GXS	VI	②A	pig	15.87	9.84	11.13
64	GXS	VI	②A	pig	14.57	9.45	9.76
65	GXS	VI	②A	pig	14.25	9.56	9.82
66	GXS	VI	②A	pig	15.03	9.15	10.03
67	GXS	VI	②A	pig	14.93	9.42	10.24
68	GXS	VI	J143	pig	15.19	9.38	10.37
69	GXS	VI	J143	pig	15.53	9.52	10.37
70	GXS	VI	J143	pig	15.94	10.18	10.50
71	GXS	I	⑦	pig	15.78	9.53	10.31
72	GXS	I	⑦	pig	16.96	10.13	11.06
73	GXS	I	⑦	pig	14.89	9.10	9.96
74	GXS	I	⑦	pig	13.52	9.37	11.71
75	GXS	VI	H938	pig	16.02	9.30	9.95
76	GXS	VI	H935	pig	15.47	10.27	11.00
77	GXS	VI	H883	pig	14.08	9.56	10.54
78	GXS	I	J149	pig	15.77	10.54	10.89
79	GXS	II	②	pig	17.71	10.84	11.72
80	GXS	II	②	pig	16.57	9.67	10.50
81	GXS	I	H945	pig	16.65	10.13	10.98
82	GXS	I	H945	pig	16.82	9.76	10.94
83	GXS	I	③	pig	15.72	9.56	10.00
84	GXS	I	③	pig	15.59	9.77	9.96
85	GXS	I	③	pig	14.37	-	-
86	GXS	I	④	wild boar	17.91	11.07	12.57
87	GXS	I	⑧	pig	17.52	11.16	12.28
88	GXS	III	④	pig	15.25	9.02	10.44
89	GXS	II	J158	pig	15.87	9.02	10.41
90	GXS	II	J158	pig	14.21	9.11	9.50
91	GXS	VI	H941	pig	14.43	9.13	9.45
92	GXS	VI	H941	pig	14.97	9.21	10.35
93	GXS	VI	H941	pig	14.70	9.62	10.60

94	GXS	VI	H941	pig	14.65	8.08	9.70
95	GXS	VI	H941	pig	15.76	9.39	10.34
96	GXS	VI	H941	pig	14.92	9.08	10.35
97	GXS	I	②	pig	18.92	10.63	11.73
98	GXS	VI	H884	pig	14.45	9.94	10.65
99	GXS	VI	H884	pig	16.19	9.96	10.81
100	GXS	VI	H884	pig	14.83	9.34	10.34
101	GXS	VI	H884	pig	14.95	9.55	10.20
102	GXS	VI	H884	pig	16.57	9.63	10.88
103	GXS	VI	H884	pig	16.16	9.75	10.16
104	GXS	VI	H884	pig	13.09	9.16	9.65
105	GXS	VI	H884	pig	16.58	9.33	10.22
106	GXS	VI	H884	pig	15.58	9.27	9.76
107	GXS	VI	H884	pig	15.49	9.38	10.37
108	GXS	VI	H884	pig	14.82	9.23	10.45
109	GXS	III	H917	pig	15.06	9.28	10.24
110	GXS	III	H924	pig	15.86	9.29	10.03
111	GXS	VI	H944	pig	17.30	9.93	10.76
112	GXS	VI	H899	pig	15.15	9.89	10.61
113	GXS	VI	J144	pig	14.45	-	-
114	GXS	VI	J144	pig	14.23	-	-
115	GXS	VI	J144	pig	17.14	10.39	11.79
116	GXS	VI	J144	pig	15.41	9.35	10.28
117	GXS	IV	H933	pig	16.17	10.20	10.98
118	GXS	VI	H918	pig	15.48	9.34	9.91
119	GXS	VI	H918	pig	14.56	8.73	9.14
120	GXS	VI	H918	pig	15.82	9.40	10.37
121	GXS	II	H949	pig	14.93	9.59	-
122	GXS	II	H949	pig	15.45	10.35	10.73
123	GXS	II	H949	pig	16.33	8.73	10.04
124	GXS	II	H949	pig	15.70	10.25	10.66
125	GXS	II	H949	pig	14.26	-	9.68
126	GXS	I	⑥	pig	17.64	9.44	9.93
127	GXS	I	H866	pig	15.56	9.63	9.93
128	GXS	VI	H928	pig	15.50	10.20	11.23
129	GXS	I	H911	pig	16.36	10.17	10.60
130	GXS	I	H911	pig	17.75	10.46	11.49
131	GXS	VI	J145	pig	15.46	9.94	10.54
132	GXS	VI	H932	pig	16.26	10.43	11.25
133	GXS	VI	H932	pig	14.94	8.90	9.87
134	GXS	VI	H885	pig	17.04	-	10.33
135	GXS	VI	H885	pig	15.81	9.49	10.61
136	GXS	VI	H885	pig	15.22	8.62	9.96
137	GXS	II	J146	pig	16.16	9.99	11.60
138	GXS	I	H872	pig	16.28	8.89	9.73
139	RDC	VI	③	pig	13.88	9.50	-
140	RDC	Unknown	No.1 MBP	pig	14.98	10.45	11.17
141	YC	IV	H1020	pig	14.90	10.17	10.72
142	YC	IV	H1020	pig	16.15	10.33	11.40
143	YC	IV	H1020	pig	14.19	10.13	10.64

b. Lower M2							
No	Site	Period	Feature	Taxon	L	WA	WP
1	JSY	IV	J15	pig	17.93	11.88	12.15
2	JSY	VI	J17	pig	22.37	14.31	14.80
3	JSY	IV	H21	pig	19.04	11.98	12.34
4	JSY	I	J2	pig	19.67	12.28	12.35
5	JSY	V	H11	pig	17.20	10.94	11.84
6	JSY	V	H11	pig	20.10	12.96	12.90
7	JSY	V	H11	pig	17.88	11.66	12.40
8	JSY	IV	H19	pig	18.75	12.57	12.99
9	JSY	III	J11	pig	20.81	12.14	12.81
10	JSY	IV	H8	pig	18.80	12.59	13.25
11	JSY	IV	H8	pig	18.53	11.75	12.01
12	JSY	VI	J16	pig	19.19	12.18	11.91
13	JSY	IV	J1	pig	21.60	13.32	14.43
14	JSY	IV	J1	pig	19.27	11.21	12.24
15	JFQ	III	⑦	pig	18.79	-	12.70
16	JFQ	III	⑦	pig	19.94	-	-
17	JFQ	VI	H763	pig	17.63	-	11.19
18	JFQ	VI	H763	pig	20.00	13.03	13.76
19	JFQ	IV	H825①	pig	19.81	13.11	13.41
20	JFQ	VI	J127	pig	21.49	13.78	13.77
21	JFQ	VI	J136	pig	19.41	12.49	12.63
22	JFQ	VI	J136	pig	19.24	12.99	13.33
23	JFQ	IV	H757	pig	19.30	11.98	12.33
24	JFQ	IV	H757	pig	-	-	13.06
25	JFQ	V	②	pig	18.15	12.18	12.75
26	JFQ	VI	H811	pig	17.31	11.28	11.39
27	JFQ	VI	H761	pig	19.94	-	13.40
28	JFQ	IV	H770	pig	18.67	12.71	13.11
29	JFQ	IV	H770	pig	-	11.71	-
30	JFQ	IV	H770	pig	-	12.09	-
31	JFQ	IV	H770	pig	20.44	12.33	13.30
32	JFQ	I	③	pig	20.68	13.66	13.25
33	JFQ	III	②	pig	19.13	11.97	12.87
34	JFQ	VI	②	pig	21.30	12.52	13.74
35	JFQ	VI	②	pig	20.45	12.12	13.27
36	JFQ	VI	①	pig	19.82	12.68	12.24
37	JFQ	VI	④	pig	20.94	13.82	13.51
38	JFQ	VI	④	pig	20.29	-	13.73
39	JFQ	II	⑦	pig	18.99	-	12.67
40	JFQ	V	H760	pig	19.24	12.53	12.54
41	JFQ	V	H760	pig	21.11	12.94	13.57
42	FDC	II	M63	pig	19.19	12.29	13.20
43	ZHL	VI	③	pig	20.03	-	12.53
44	HZM	East Han	H16	pig	20.53	13.55	12.79
45	HZM	East Han	H16	pig	20.84	13.02	13.93
46	HZM	East Han	③	pig	-	-	13.58
47	HZM	East Han	H79	pig	21.65	13.81	14.25
48	HZM	East Han	H56	pig	17.74	12.45	12.73
49	JCL	VI	H889	pig	19.18	12.03	11.87

50	JCL	VI	H889	pig	19.91	12.14	12.54
51	JCL	VI	North②	pig	19.21	13.00	13.53
52	JCL	V	J160	pig	18.94	13.30	13.35
53	JCL	V	J160	pig	20.03	12.96	13.20
54	JCL	V	J160	pig	-	-	13.36
55	JCL	III	J160	pig	23.08	15.48	16.85
56	JCL	VI	H890	pig	18.89	12.40	12.59
57	JCL	VI	H890	pig	17.62	11.75	11.35
58	JCL	V	H935	pig	20.21	13.15	13.26
59	JCL	IV	H892	pig	20.59	12.40	13.08
60	GXS	VI	②A	pig	20.04	13.20	13.03
61	GXS	VI	②A	pig	21.26	13.24	14.64
62	GXS	VI	②A	pig	18.54	12.60	13.37
63	GXS	VI	②A	pig	21.02	13.84	13.78
64	GXS	VI	②A	pig	18.07	11.57	11.17
65	GXS	VI	②A	pig	18.18	12.06	12.57
66	GXS	VI	②A	pig	19.29	12.16	13.02
67	GXS	VI	J143	pig	20.77	12.47	12.87
68	GXS	VI	J143	pig	19.57	13.35	13.15
69	GXS	I	⑦	pig	19.20	12.45	13.04
70	GXS	I	⑦	pig	19.14	11.64	11.45
71	GXS	VI	H938	pig	19.65	12.19	12.97
72	GXS	VI	H935	pig	19.09	12.93	13.74
73	GXS	VI	H935	pig	23.48	14.55	14.61
74	GXS	VI	H901	pig	19.22	12.74	13.17
75	GXS	VI	H939	pig	18.06	11.82	11.81
76	GXS	I	J149	pig	21.39	14.01	13.82
77	GXS	I	H945	pig	20.05	13.62	13.94
78	GXS	I	H945	pig	21.96	13.14	13.85
79	GXS	I	③	pig	19.54	12.67	11.91
80	GXS	I	③	pig	20.12	12.54	13.36
81	GXS	I	③	wild boar	21.22	15.85	16.36
82	GXS	I	③	wild boar	23.96	15.07	15.81
83	GXS	III	④	pig	19.55	12.15	13.13
84	GXS	II	J158	pig	20.55	12.14	-
85	GXS	II	J158	pig	19.25	12.50	12.70
86	GXS	VI	H941	pig	18.32	11.39	11.79
87	GXS	VI	H941	pig	18.53	12.30	12.90
88	GXS	VI	H941	pig	18.82	13.59	13.17
89	GXS	VI	H941	pig	19.40	12.55	13.19
90	GXS	I	②	pig	21.93	15.18	16.24
91	GXS	I	②	pig	21.55	14.39	15.15
92	GXS	VI	H884	pig	18.49	12.50	12.93
93	GXS	VI	H884	pig	21.12	13.19	13.10
94	GXS	VI	H884	pig	19.84	13.44	13.50
95	GXS	VI	H884	pig	19.47	12.72	12.54
96	GXS	VI	H884	pig	19.47	12.46	13.08
97	GXS	VI	H884	pig	19.69	11.93	11.96
98	GXS	VI	H884	pig	18.80	12.45	12.73
99	GXS	VI	H884	pig	20.13	12.82	13.14

100	GXS	I	J141	pig	19.35	12.44	12.13
101	GXS	III	H917	pig	18.90	12.01	12.90
102	GXS	III	H924	pig	21.01	13.63	14.00
103	GXS	III	H924	pig	19.47	11.98	11.47
104	GXS	VI	H944	pig	19.44	12.15	12.56
105	GXS	VI	H899	pig	18.96	11.90	12.22
106	GXS	VI	H899	pig	17.75	13.75	13.46
107	GXS	VI	J144	pig	18.09	-	12.83
108	GXS	VI	J144	pig	19.61	13.53	13.26
109	GXS	VI	H918	pig	19.63	12.27	12.76
110	GXS	VI	H918	pig	18.21	11.46	11.73
111	GXS	VI	H918	pig	20.59	13.02	12.72
112	GXS	II	H949	pig	19.41	-	12.24
113	GXS	II	H949	pig	20.16	13.44	13.56
114	GXS	II	H949	pig	20.68	11.73	13.07
115	GXS	II	H949	pig	20.40	12.36	13.47
116	GXS	II	H949	pig	20.68	13.73	13.52
117	GXS	II	H949	pig	19.16	12.39	-
118	GXS	I	⑥	pig	19.99	12.32	12.36
119	GXS	II	H915	pig	21.97	14.28	15.31
120	GXS	I	③	pig	21.48	14.16	14.53
121	GXS	I	③	pig	19.51	12.63	13.35
122	GXS	I	③	pig	19.73	-	12.51
123	GXS	VI	H928	pig	20.47	13.79	13.93
124	GXS	I	H911	pig	21.35	13.06	12.17
125	GXS	I	H911	pig	23.56	14.71	15.08
126	GXS	I	H911	pig	23.66	14.53	15.46
127	GXS	VI	J145	pig	19.85	13.92	12.88
128	GXS	VI	H932	pig	22.29	14.07	14.30
129	GXS	VI	H932	pig	19.34	12.26	12.04
130	GXS	II	H948	pig	17.98	11.14	12.58
131	GXS	VI	H885	pig	18.80	12.22	12.99
132	GXS	VI	H885	pig	19.10	11.34	12.08
133	GXS	III	③	pig	24.31	16.20	15.88
134	GXS	II	J146	pig	20.80	13.54	14.56
135	GXS	I	H872	pig	20.46	11.44	12.39
136	RDC	VI	③	pig	18.70	12.54	12.33
137	YC	IV	H1020	pig	19.63	13.05	-
138	YC	IV	H1020	pig	19.55	14.11	13.65
139	YC	IV	H1020	pig	18.97	13.02	13.52

c. Lower M3						
No	Site	Period	Feature	Taxon	L	WA
1	JSY	VI	J17	pig	34.22	15.48
2	JSY	IV	H21	pig	25.88	13.59
3	JSY	V	H11	pig	30.12	13.09
4	JSY	V	H11	pig	-	14.98
5	JSY	V	H11	pig	30.40	14.76

6	JSY	V	H11	pig	-	13.45
7	JSY	IV	H8	pig	27.04	15.37
8	JSY	IV	H8	pig	26.79	14.28
9	JSY	IV	J1	pig	30.27	13.05
10	JSY	IV	J1	pig	28.66	14.50
11	JFQ	III	⑦	pig	30.13	14.38
12	JFQ	III	⑦	pig	31.18	14.05
13	JFQ	VI	H763	pig	25.08	13.16
14	JFQ	IV	H825①	pig	28.92	14.27
15	JFQ	IV	H757	pig	29.39	13.81
16	JFQ	VI	H811	pig	27.42	12.68
17	JFQ	VI	H761	pig	29.84	13.88
18	JFQ	IV	H770	pig	28.51	13.71
19	JFQ	III	②	pig	33.15	14.02
20	JFQ	VI	①	pig	31.05	14.15
21	JFQ	VI	④	pig	-	15.28
22	JFQ	V	H760	pig	-	13.11
23	JFQ	V	H760	pig	-	13.72
24	FDC	V	J126	pig	30.33	13.93
25	ZHL	VI	③	pig	29.27	13.78
26	HZM	East Han	H16	pig	32.90	-
27	HZM	East Han	H16	pig	-	14.76
28	HZM	East Han	③	pig	36.35	15.92
29	HZM	East Han	H56	pig	33.06	14.52
30	JCL	VI	North②	pig	32.86	15.35
31	JCL	V	J160	pig	-	14.77
32	JCL	V	J160	pig	31.31	14.62
33	JCL	V	J160	pig	33.38	14.82
34	JCL	III	J160	pig	-	18.44
35	JCL	VI	H890	pig	-	13.85
36	JCL	VI	H890	pig	31.51	14.40
37	GXS	VI	②A	pig	31.08	14.79
38	GXS	VI	②A	pig	27.62	15.70
39	GXS	VI	②A	pig	26.60	13.20
40	GXS	VI	②A	pig	25.58	13.66
41	GXS	VI	J143	pig	28.46	13.81
42	GXS	VI	J143	pig	31.55	13.87
43	GXS	I	⑦	pig	32.54	13.48
44	GXS	I	⑦	pig	32.81	13.39
45	GXS	IV	H882	pig	29.86	14.46
46	GXS	VI	H935	pig	34.61	-
47	GXS	I	H946	pig	30.57	17.47
48	GXS	VI	H901	pig	25.21	14.76
49	GXS	VI	H939	pig	30.09	14.66
50	GXS	I	J149	pig	-	16.01
51	GXS	I	③	wild boar	41.95	19.90
52	GXS	I	③	wild boar	46.61	19.02
53	GXS	III	④	pig	-	14.79
54	GXS	II	J158	pig	28.89	14.66
55	GXS	VI	H941	pig	32.23	14.29
56	GXS	VI	H941	pig	31.10	15.09

57	GXS	VI	H941	pig	31.76	14.51
58	GXS	I	②	pig	-	18.28
59	GXS	I	②	wild boar	40.89	17.90
60	GXS	I	②	wild boar	43.97	19.54
61	GXS	I	②	wild boar	39.18	16.43
62	GXS	VI	H884	pig	25.75	14.05
63	GXS	VI	H884	pig	27.06	14.76
64	GXS	VI	H884	pig	-	14.57
65	GXS	III	H917	pig	32.59	13.00
66	GXS	III	H924	pig	31.22	15.16
67	GXS	VI	H944	pig	28.86	14.11
68	GXS	VI	H899	pig	28.59	14.73
69	GXS	VI	J144	pig	35.28	14.64
70	GXS	VI	H918	pig	26.75	12.81
71	GXS	II	H949	pig	-	15.69
72	GXS	II	H949	pig	30.22	13.57
73	GXS	II	H949	pig	-	15.43
74	GXS	II	H949	pig	27.84	13.86
75	GXS	II	H915	pig	33.17	16.17
76	GXS	I	③	pig	32.87	15.17
77	GXS	I	③	pig	28.76	14.40
78	GXS	I	H911	pig	-	18.64
79	GXS	VI	J145	pig	31.78	15.48
80	GXS	II	H948	pig	28.85	13.37
81	GXS	VI	H885	pig	26.23	13.86
82	GXS	II	J146	pig	32.52	15.13
83	RDC	VI	③	pig	30.39	14.40
84	YC	IV	H1020	pig	33.37	15.07
85	YC	IV	H1020	pig	-	15.05
86	YC	IV	H1020	pig	33.11	13.75
87	YC	IV	H1020	pig	-	13.00

d. Upper M3						
No	Site	Period	Feature	Taxon	L	WA
1	JSY	V	J6	pig	28.21	-
2	JSY	VI	J16	pig	29.19	-
3	JFQ	IV	H770	pig	27.18	15.18
4	JFQ	V	H760	pig	-	16.85
5	JFQ	V	H760	pig	24.58	18.31
6	FDC	V	J126	pig	-	16.97
7	HZM	East Han	H16	pig	33.05	19.13
8	JCL	V	J160	pig	27.53	16.67
9	JCL	V	H935	pig	25.97	17.85
10	JCL	V	H935	pig	25.63	16.97
11	JCL	West Zhou	J138	pig	28.05	16.67
12	GXS	VI	②A	pig	-	17.36
13	GXS	VI	②A	pig	26.98	14.84
14	GXS	VI	②A	pig	27.69	17.19
15	GXS	VI	②A	pig	29.82	15.09

16	GXS	VI	J143	pig	28.27	17.83
17	GXS	I	⑦	pig	28.45	17.14
18	GXS	VI	H937	pig	29.10	16.53
19	GXS	VI	H873	pig	26.21	15.50
20	GXS	I	J149	pig	32.33	17.42
21	GXS	I	④	pig	33.25	21.47
22	GXS	II	J158	pig	29.07	16.86
23	GXS	I	②	wild boar	40.27	22.24
24	GXS	VI	H884	pig	28.97	-
25	GXS	VI	H884	pig	29.78	16.37
26	GXS	VI	H884	pig	30.06	-
27	GXS	VI	H899	pig	28.24	17.32
28	GXS	VI	H899	pig	27.63	16.62
29	GXS	VI	H899	pig	28.36	17.08
30	GXS	VI	H899	pig	28.25	17.00
31	GXS	I	G1	pig	27.96	15.95
32	GXS	II	H878	pig	28.11	15.72
33	GXS	I	③	pig	33.54	21.95
34	GXS	VI	H928	pig	-	18.14
35	GXS	I	H911	pig	31.97	17.58
36	GXS	VI	H885	pig	-	16.43
37	GXS	VI	H885	pig	31.61	18.63
38	GXS	VI	H885	pig	29.43	16.74
39	RDC	Unknown	No.1 MBP	pig	27.80	17.09
40	RDC	Unknown	No.1 MBP	pig	24.76	15.33

e. Humerus					
No	Site	Period	Feature	Taxon	Bd
1	JSY	VI	H2	pig	34.30
2	JSY	IV	H21	pig	36.90
3	JSY	I	J2	pig	36.41
4	JSY	I	J2	pig	30.47
5	JSY	V	H11	pig	31.22
6	JSY	III	J11	pig	35.93
7	JSY	IV	J13	pig	31.40
8	JSY	IV	J18	pig	34.47
9	JSY	IV	J1	pig	31.95
10	JSY	IV	J1	pig	34.24
11	JSY	IV	J1	pig	32.73
12	JSY	IV	J1	pig	32.22
13	JSY	IV	J1	pig	34.48
14	JFQ	IV	H825①	pig	32.37
15	JFQ	VI	J127	pig	32.76
16	JFQ	II	H859	pig	37.07
17	JFQ	V	②	pig	33.10
18	JFQ	V	②	pig	32.09
19	JFQ	V	②	pig	34.37
20	JFQ	V	②	pig	32.37
21	JFQ	IV	H770	pig	30.55

22	JFQ	IV	H770	pig	33.49
23	JFQ	VI	H753	pig	33.75
24	JFQ	VI	②	pig	34.32
25	JFQ	VI	②	pig	37.90
26	JFQ	VI	①	pig	34.56
27	JFQ	VI	④	pig	37.60
28	JFQ	V	H760	pig	33.24
29	JFQ	V	H760	pig	34.50
30	JFQ	V	H760	pig	31.65
31	JCL	VI	H889	pig	32.06
32	JCL	VI	H889	pig	32.22
33	JCL	V	J160	pig	33.78
34	JCL	V	J160	pig	32.41
35	JCL	III	J160	pig	33.35
36	JCL	V	H935	pig	30.53
37	JCL	IV	H924	pig	34.78
38	JCL	IV	H924	pig	32.50
39	JCL	I	East ditch 3	pig	36.17
40	GXS	VI	②A	pig	44.53
41	GXS	VI	②A	pig	36.00
42	GXS	I	⑦	pig	34.16
43	GXS	I	⑦	pig	32.69
44	GXS	I	⑦	pig	45.57
45	GXS	II	J156	pig	31.78
46	GXS	V	②A	pig	32.78
47	GXS	V	②A	pig	45.14
48	GXS	VI	H938	pig	40.15
49	GXS	I	J149	pig	35.37
50	GXS	III	④	pig	49.50
51	GXS	II	②	pig	31.25
52	GXS	I	H945	pig	44.34
53	GXS	I	H945	pig	51.71
54	GXS	II	H947	pig	42.18
55	GXS	II	H947	pig	37.12
56	GXS	I	③	pig	35.99
57	GXS	I	③	pig	35.82
58	GXS	I	③	pig	33.07
59	GXS	I	③	pig	38.74
60	GXS	I	③	pig	33.99
61	GXS	I	④	pig	32.06
62	GXS	I	⑧	pig	40.28
63	GXS	I	⑧	pig	33.59
64	GXS	III	④	pig	31.96
65	GXS	III	④	pig	33.71
66	GXS	III	④	pig	36.08
67	GXS	III	④	pig	33.34
68	GXS	III	④	pig	34.29
69	GXS	II	J158	pig	35.95
70	GXS	II	J58	pig	48.07
71	GXS	III	⑤	pig	34.68

72	GXS	III	⑤	pig	32.64
73	GXS	III	⑤	pig	35.98
74	GXS	VI	H941	pig	30.65
75	GXS	I	②	pig	33.64
76	GXS	VI	H884	pig	32.73
77	GXS	I	J141	pig	34.00
78	GXS	III	H917	pig	33.44
79	GXS	III	H917	pig	30.76
80	GXS	VI	H944	pig	32.85
81	GXS	VI	H944	pig	35.48
82	GXS	II	H949	pig	34.75
83	GXS	II	H878	pig	44.50
84	GXS	I	H911	pig	38.43
85	GXS	II	J147	pig	37.61
86	GXS	VI	H944	pig	30.34
87	GXS	II	H948	pig	46.40
88	GXS	VI	J140	pig	31.36
89	GXS	VI	H885	pig	31.45
90	GXS	III	H908	pig	32.31
91	GXS	III	H908	pig	34.14
92	GXS	III	③	pig	30.35
93	GXS	I	H872	pig	34.04
94	RDC	IV	Trench	pig	34.84
95	RDC	VI	③	pig	33.22
96	RDC	Unknown	No.1 MBP	pig	33.46

f. Radius					
No	Site	Period	Feature	Taxon	Bd
1	JSY	IV	J1	pig	24.72
2	JSY	IV	J1	pig	26.43
3	JSY	IV	J1	pig	25.97
4	JSY	IV	J1	pig	25.96
5	JFQ	V	H818	pig	25.23
6	JFQ	VI	J127	pig	23.54
7	JFQ	VI	J127	pig	26.39
8	JFQ	III	H767	pig	24.73
9	JFQ	VI	②	pig	24.66
10	JFQ	VI	①	pig	24.20
11	JFQ	VI	④	pig	23.66
12	JFQ	VI	H803	pig	22.64
13	HZM	East Han	③	pig	24.47
14	JCL	VI	North②	pig	24.98
15	JCL	V	J160	pig	24.45
16	JCL	V	J160	pig	33.62
17	JCL	V	H935	pig	22.07
18	GXS	VI	②A	pig	24.67
19	GXS	VI	②A	pig	26.69
20	GXS	VI	J143	pig	23.86

21	GXS	I	J159	pig	26.19
22	GXS	III	J157	pig	27.47
23	GXS	IV	H882	pig	29.82
24	GXS	VI	H934	pig	25.53
25	GXS	VI	H938	pig	23.35
26	GXS	VI	H935	pig	26.82
27	GXS	VI	H873	pig	23.47
28	GXS	VI	H939	pig	23.11
29	GXS	I	J149	pig	26.52
30	GXS	I	J149	pig	26.64
31	GXS	III	④	pig	33.38
32	GXS	II	H947	pig	19.50
33	GXS	II	H947	pig	23.29
34	GXS	I	③	pig	27.07
35	GXS	III	④	pig	31.81
36	GXS	II	J158	pig	24.89
37	GXS	II	J158	pig	20.70
38	GXS	II	J158	pig	24.51
39	GXS	III	⑤	pig	32.07
40	GXS	VI	H941	pig	25.86
41	GXS	VI	H941	pig	22.69
42	GXS	VI	H941	pig	26.95
43	GXS	III	H917	pig	26.16
44	GXS	III	H917	pig	21.63
45	GXS	III	H924	pig	32.79
46	GXS	VI	H899	pig	26.55
47	GXS	VI	J144	pig	25.22
48	GXS	II	H921	pig	29.70
49	GXS	I	G1	pig	27.16
50	GXS	II	J147	pig	27.05
51	GXS	II	J147	pig	25.05
52	GXS	VI	H951	pig	24.19
53	GXS	VI	H951	pig	24.12
54	GXS	VI	H889	pig	25.68
55	GXS	VI	H885	pig	23.90
56	GXS	III	③	pig	31.60
57	GXS	II	J146	pig	23.95

g. Tibia					
No	Site	Period	Feature	Taxon	Bd
1	JSY	VI	H2	pig	28.93
2	JSY	IV	H21	pig	25.70
3	JSY	V	H11	pig	27.13
4	JSY	V	H11	pig	27.11
5	JSY	V	H11	pig	25.90
6	JSY	VI	H9	pig	26.49
7	JSY	IV	J1	pig	25.53
8	JFQ	VI	H763	pig	24.97

9	JFQ	IV	H825①	pig	23.30
10	JFQ	V	H818	pig	25.81
11	JFQ	V	H818	pig	26.53
12	JFQ	VI	H849	pig	26.66
13	JFQ	III	②	pig	25.03
14	JFQ	III	②	pig	25.13
15	JFQ	IV	H773	pig	27.00
16	JFQ	VI	②	pig	26.28
17	JFQ	II	⑦	pig	25.63
18	JCL	VI	H889	pig	26.58
19	JCL	VI	H889	pig	22.70
20	JCL	VI	H890	pig	23.21
21	JCL	V	H935	pig	23.76
22	JCL	V	H935	pig	28.20
23	JCL	IV	H924	pig	24.92
24	JCL	I	East ditch 3	pig	28.47
25	GXS	VI	②A	pig	29.27
26	GXS	VI	②A	pig	27.63
27	GXS	VI	②A	pig	25.88
28	GXS	VI	②A	pig	25.43
29	GXS	VI	②A	pig	28.99
30	GXS	VI	J143	pig	26.05
31	GXS	IV	H882	pig	31.53
32	GXS	IV	H882	pig	29.34
33	GXS	II	⑥	pig	25.61
34	GXS	II	②	pig	28.54
35	GXS	I	H945	pig	25.90
36	GXS	I	H945	pig	27.49
37	GXS	I	③	pig	26.99
38	GXS	I	⑧	pig	25.98
39	GXS	II	J158	pig	34.98
40	GXS	VI	②	pig	24.48
41	GXS	III	⑤	pig	33.02
42	GXS	VI	H941	pig	25.05
43	GXS	I	②	pig	28.13
44	GXS	I	⑥	pig	24.87
45	GXS	VI	H951	pig	26.99
46	GXS	VI	H889	pig	26.60
47	GXS	VI	H944	pig	30.66
48	GXS	II	H948	pig	31.51
49	MYMZ	IV	Wall	pig	26.44

Table 2*Basic information of isotope samples of ZHGC fauna and human.*

No	LAB ID	Site	Age	Feature	Taxa	Element	Side	Sample mass (mg)	Collagen weight (mg)	Yield rate (%)	%C	%N
1	1721/22	HZM	East Han	H56	pig	mandible pair	/	306.3	17.83	5.82	42.12	14.83
2	1722/22	HZM	East Han	H79	pig	mandible	R	654.3	72.56	11.09	35.71	12.63
3	1723/22	HZM	East Han	③	pig	radius	R	531.1	61.15	11.51	38.36	13.33
4	1724/22	HZM	East Han	③	cattle	metacarpal	/	479.2	43.07	8.99	22.36	7.68
5	1725/22	HZM	East Han	H20	cattle	scapula	L	516.8	64.95	12.57	41.47	14.39
6	1726/22	HZM	West Han	④	sheep/goat	radius	L	776.1	87.97	11.33	37.93	13.09
7	1727/22	RDC	II	J349	cattle	humerus	L	786.6	55.99	7.12	36.90	12.75
8	1728/22	RDC	III	H1564	pig	ulna	L	579.7	75.56	13.03	40.29	14.60
9	1729/22	RDC	Unknown	No.1 MBP	pig	humerus	R	452.5	47.95	10.60	41.81	14.37
10	1730/22	RDC	Unknown	No.1 MBP	pig	humerus	R	480.0	44.21	9.21	43.33	15.10
11	1731/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	534.8	55.17	10.32	42.19	14.43
12	1732/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	610.3	56.94	9.33	17.68	5.97
13	1733/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	478.0	47.02	9.84	30.47	11.39
14	1734/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	560.3	37.85	6.76	19.76	7.94
15	1735/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	463.9	13.62	2.94	25.19	9.05
16	1736/22	RDC	Unknown	No.1 MBP	cattle	scapula	L	783.4	77.39	9.88	20.24	8.26
17	1737/22	ZHL	IV	H144	pig	mandible	R	446.1	54.45	12.21	40.67	14.25
18	1738/22	ZHL	IV	H144	sheep/goat	mandible	R	475.7	67.25	14.14	41.14	14.81
19	1739/22	FDC	V -2	J126	pig	mandible	L	652.1	24.56	3.77	12.26	4.40
20	1720/22	FDC	III	M66 waist pit	dog	humerus	R	430.0	69.68	16.20	43.83	15.12
21	1740/22	FDC	III -2	M72	sheep/goat	rib	L	543.1	77.73	14.31	43.44	15.01
22	1741/22	FDC	III	M66 side box	sheep	ulna	L	792.1	125.53	15.85	40.56	14.23
23	1742/22	FDC	II -2	M63 pottery Li	pig	tibia	L	588.3	87.87	14.94	39.20	14.52
24	1743/22	FDC	II -2	M63	dog	femur	L	733.0	98.30	13.41	44.19	15.49
25	1744/22	FDC	II	No.3 horse pit	dog	4700	/	614.0	76.95	12.53	44.54	14.92
26	1745/22	YC	IV	H1020	pig	mandible	R	357.7	30.00	8.39	43.71	14.82
27	1746/22	YC	IV	H1020	pig	mandible	R	495.5	57.20	11.54	39.03	13.89

28	1747/22	JFQ	II	⑦	human	ulna	L	393.9	45.20	11.47	37.98	14.59
29	1748/22	JFQ	VI-1	J129	human	femur	R	254.7	21.01	8.25		
30	1749/22	FDC	III	M66	human	mandible pair	/	211.6	20.60	9.74	42.67	14.83
31	1750/22	JCL	West Zhou	J138	pig	ulna	R	374.6	16.24	4.34	44.05	14.60
32	1751/22	JCL	West Zhou	J138	cattle	mandible	R	528.6	45.02	8.52	48.74	18.71
33	1752/22	JCL	I	East ditch 3	water deer	scapula	R	712.8	96.49	13.54	45.45	15.04
34	1753/22	JCL	I	East ditch 3	dog	tibia	L	588.6	103.11	17.52	44.95	14.86
35	1754/22	JCL	I	East ditch 3	sika deer	humerus	R	456.1	58.95	12.92	45.49	15.35
36	1755/22	JCL	I	East ditch 3	pig	tibia	R	711.2	91.73	12.90	40.95	14.13
37	1756/22	JCL	I	East ditch 3	cattle	mandible	L	380.9	48.61	12.76	38.12	13.18
38	1757/22	JCL	IV	H906	pig	humerus	R	207.4	39.69	19.14	44.25	14.94
39	1758/22	JCL	IV	H924	sheep/goat	metatarsal	L	259.1	51.06	19.71	44.98	15.54
40	1759/22	JCL	IV	H924	pig	humerus	R	351.1	49.75	14.17	46.46	15.58
41	1760/22	JCL	IV	H924	cattle	mandible	L	226.0	24.82	10.98	42.89	15.77
42	1761/22	JCL	V-2	⑤	sheep/goat	femur	R	250.9	19.12	7.62	44.90	14.48
43	1762/22	JCL	V-2	⑤	sheep/goat	femur	R	289.9	25.95	8.95	20.59	7.97
44	1763/22	JCL	V	H935	sheep/goat	femur	L	234.3	11.36	4.85	39.94	14.45
45	1764/22	JCL	V	H935	sheep/goat	femur	L	432.9	37.28	8.61	31.75	12.31
46	1765/22	JCL	VI-1	H890	cattle	scapula	R	510.9	46.28	9.06	35.86	12.31
47	1766/22	JCL	VI-2	H889	pig	humerus	L	403.4	20.01	4.96	33.02	11.55
48	1767/22	JCL	VI-2	H889	sheep/goat	humerus	R	331.4	56.99	17.20	45.09	15.65
49	1768/22	JCL	VI-2	H889	sheep/goat	humerus	R	478.0	69.69	14.58	44.80	15.29
50	1769/22	JFQ	I	③	cattle	radius	R	367.6	7.67	2.09	43.13	15.02
51	1770/22	JFQ	I	③	pig	mandible	L	418.7	13.13	3.14	36.58	13.73
52	1771/22	JFQ	III	⑦	pig	mandible	R	841.6	110.02	13.07	46.50	15.35
53	1772/22	JFQ	IV	H825	cattle	mandible	R	805.0	85.30	10.60	30.79	10.16
54	1773/22	JFQ	IV	H825	pig	tibia	R	456.6	45.20	9.90	42.73	15.59
55	1774/22	JFQ	IV	H825	dog	mandible	R	520.8	19.11	3.67	9.05	3.38
56	1775/22	JFQ	IV	H825	sheep/goat	metacarpal	R	290.9	29.53	10.15	43.88	15.61

57	1776/22	JFQ	V	H760	pig	mandible	R	924.1	96.22	10.41	41.96	14.50
58	1777/22	JFQ	V	H760	cattle	mandible	R	719.1	79.06	10.99	45.21	15.84
59	1778/22	JFQ	VI-2	②	pig	mandible	L	352.9	17.66	5.00	44.01	15.14
60	1779/22	JFQ	VI-2	②	sheep/goat	mandible	R	515.8	22.28	4.32	38.01	12.64
94	1780/22	JFQ	VI-1	H803	horse	humerus	R	269.9	6.61	2.45	45.38	15.03
61	1781/22	JSY	I	J2	pig	mandible pair	/	330.0	33.23	10.07	46.20	15.91
62	1782/22	JSY	IV	J1	pig	mandible	R	614.3	35.72	5.81	36.17	12.53
63	1783/22	JSY	IV	J1	pig	mandible pair	/	866.1	51.64	5.96	15.55	6.17
64	1784/22	JSY	VI-2	J16	pig	mandible	L	659.7	80.12	12.14	44.15	14.73
65	1785/22	GXS	I	H900	horse	mandible	R	374.1	26.71	7.14	42.67	14.02
66	1786/22	GXS	I	③A	sika deer	femur	R	406.9	52.74	12.96	46.33	15.45
67	1787/22	GXS	I	③	cattle	mandible	L	700.1	10.04	1.43		
68	1788/22	GXS	I	③A	dog	ulna	R	389.7	51.19	13.14	45.45	15.15
69	1789/22	GXS	I	③	pig	mandible	R	599.3	13.15	2.19	9.10	2.75
70	1790/22	GXS	I	③	pig	mandible	R	342.4	17.07	4.99	34.96	12.25
71	1791/22	GXS	I	③	wild boar	mandible	R	438.8	18.28	4.17	42.83	14.43
72	1792/22	GXS	I	③	wild boar	mandible	R	397.5	44.57	11.21	43.74	14.42
73	1793/22	GXS	II	J155	tiger	calcaneus	L	310.7	16.64	5.36		
74	1794/22	GXS	II	H948	sheep/goat	radius	L	287.3	32.88	11.44	39.64	14.37
75	1795/22	GXS	II	H949	pig	mandible pair	/	325.3	23.56	7.24	47.18	16.33
76	1796/22	GXS	II	H949	pig	mandible pair	/	317.4	7.72	2.43	43.23	13.95
77	1797/22	GXS	III	H917	pig	humerus	L	500.4	73.07	14.60	47.31	15.42
78	1798/22	GXS	III	H917	pig	humerus	R	489.9	48.18	9.83	40.36	13.33
79	1799/22	GXS	III	H917	cattle	metatarsal	L	749.3	89.49	11.94	45.45	15.29
80	1800/22	GXS	IV	H933	cattle	mandible	L	329.0	58.34	17.73	47.27	16.25
81	1801/22	GXS	IV	H948	sika deer	humerus	R	646.9	52.54	8.12	46.55	15.63
82	1802/22	GXS	V	②A	sheep/goat	femur	L	276.9	34.45	12.44	46.98	16.14
83	1803/22	GXS	V	②A	pig	humerus	R	270.6	7.51	2.78	43.89	14.99
84	1804/22	GXS	V	②A	sika deer	femur	L	568.0	64.96	11.44	44.62	14.39

85	1805/22	GXS	V -2	H876	pig	humerus	R	451.9	31.30	6.93	41.45	14.73
86	1806/22	GXS	VI -1	H951	rabbit	pelvis	R	383.7	37.75	9.84	29.25	10.18
87	1807/22	GXS	VI -1	H885	cattle	radius	R	644.2	62.96	9.77	42.92	14.30
88	1808/22	GXS	VI -1	H941	sheep/goat	mandible	R	515.2	76.83	14.91	41.73	15.27
89	1809/22	GXS	VI -1	H941	sheep/goat	mandible	R	301.5	13.90	4.61	18.51	7.17
90	1810/22	GXS	VI -1	H941	sheep/goat	mandible	R	185.9	25.00	13.45	37.90	14.92
91	1811/22	GXS	VI -1	H941	dog	mandible	R	308.6	47.21	15.30	40.76	15.04
92	1812/22	GXS	VI -1	H941	pig	mandible pair	/	536.1	32.26	6.02	20.24	6.79
93	1813/22	GXS	VI -1	H941	pig	mandible pair	/	371.0	10.93	2.95	41.18	14.33

