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Meat procurement strategy from the Neolithic to the Bronze Age in the Guanzhong region of Shaanxi Province, China

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Meat procurement strategies, displaying a great variety world-widely, are ideal for examining how geography and culture shape the subsistence. We collate zooarchaeological data from 26 Neolithic and Bronze Age sites/locales in the Guanzhong region (Shaanxi Province, China), a key region of early Chinese civilization, to demonstrate the changing process of meat procurement and its associations with environmental, demographic and societal factors. Comparing the proportion of the domesticates versus wild animals, along with the proportion of the domesticated pigs versus bovids (i.e., sheep, goat, and cattle), we summarize three characteristics of the meat procurement strategy at Guanzhong. Firstly, the changing pattern of meat procurement did not follow a linear progression of shifting subsistence from hunting to husbandry, albeit involving acceleration and regression from the pre-Yangshao period to the Western Zhou dynasty. Secondly, contrasting meat procurement strategies might have been employed between central settlements and lower-ranking settlements. Thirdly, an increasing importance of domesticated bovids was evident during the pre-Zhou and Western Zhou periods. We therefore argue population size and societal form might have shaped meat procurement strategies, in addition to natural environments. Subsistence, in turn, also lays the economic foundation for social development. It was not until the pre-Zhou and Western Zhou periods, when a more stable meat procurement strategy involving utilizing a variety of the domesticates was pervasively employed in this region, that Guanzhong had gradually gained its prominence in Chinese civilization.

KEYWORDS

Guanzhong region, Neolithic, Bronze Age, meat procurement strategy, zooarchaeology

Introduction

Food serves a vital lens through which various aspects of past and present societies could be understood (Twiss, 2015). In China, a growing body of most recent research has indicated that the diversity of culinary traditions and subsistence strategies, particularly those related to food production and consumption, can be traced back to as early as prehistoric times (Liu and Reid, 2020; Taché et al., 2021), which were closely associated with regional differences in resource availability, technical tradition, economic mode,

and even attitudes toward food (Fuller and Rowlands, 2011; Liu et al., 2016; Liu and Reid, 2020). Meat procurement strategy forms a critical part of culinary traditions and subsistence strategies. Zooarchaeologists have drawn a general picture of prehistoric meat procurement strategies in China (Yuan, 1999). Zooming in on this picture, we can clearly see a growing regional diversity entangled with environmental and cultural complexity, and intertwined with different trajectories of societal development. It is therefore necessary to select key regions for study, hence rendering insights into the causes and consequences of meat procurement, and its role in the development of social complexity in various regions.

Studies in the Central Plains and the Lower Yangtze Valley provide two examples. The Central Plains was the cradle of China's first dynasties. A productive and stable agricultural system involving husbandry diversification and intensification laid the foundations for the birth of the early civilization (Yuan, 2016; Jing et al., 2020), while the collapse of the Liangzhu culture in the lower Yangtze Valley demonstrates that the imbalanced husbandry over-relying on homogenous domesticated species would have restrained population growth and prevented the formation of the multi-central political structure, making it incapable to withstand the risks imposed by natural disasters and social conflicts, and finally leading to the collapse of the Liangzhu society (Yuan et al., 2020). It is apparently seen in these two examples that there was a complicated relationship between meat procurement strategies and societal development.

Guanzhong is another vital region for the discussion of the formation and development of Chinese early civilization (Zhang, 2014; Wang, 2021). The Guanzhong region, located in the Shaanxi Province, has long been a center of ancient human activities, with Palaeolithic sites dating to at least 750,000 years ago, and 13 dynasties having built their capitals here from the West Zhou to Tang dynasties (1046 BCE- 907 CE), making it an irreplaceable role in the history of Chinese civilization (National Cultural Heritage Administration, 1998). It is also the core area of the Yangshao culture, one of the peaks of Chinese Neolithic cultures. Yangshao, known for its well-developed painted pottery, was one of the longest-continued (about 5000 BCE-3000 BCE), most widely distributed, and most far-reaching archaeological cultures in Chinese Neolithic (Liu and Chen, 2012; Wei, 2021). Thirdly, the Guanzhong region is of imperative importance in terms of cultural exchange. The Loess Plateau where the Guanzhong region is located had been a key passage for the prehistoric spread of several important crops (millet, rice and wheat) and domesticated animals (pig, cattle, goat and sheep) both across Eurasia and within East Asia. Zooarchaeological research on this region has been carried out most fully in China (Yuan, 2015), with over 20 sites have been systematically studied, providing rich datasets for us to discuss meat procurement strategies. Recognizing the importance of this region, researchers have recently shifted their focuses towards subsistence economy in Guanzhong (e.g., Zhao and Chen, 2011; Qu et al., 2018; Zong et al., 2021; Festa and Monteith, 2022). However, there is still a number of the sites that have not been covered by their datasets and a lack of discussion on the relationship between the regional subsistence economy and the corresponding societal development. In this study, we collate zooarchaeological data from 26 sites/locales in the Guanzhong region and summarize the characteristics, causes and consequences

of the meat procurement strategy, thus attempting to explore the links between meat procurement strategies and the regional trajectory of societal development.

Guanzhong: geographical and archaeological background

The Guanzhong region is a basin plain located in the central part of Shaanxi Province (Figure 1). The Wei River and its tributaries flow through this area, carrying a large amount of sediment and nutrients, gradually forming the flat and fertile Guanzhong Plain. The surrounding mountains prevent it from cold air currents, maintaining this region in a relatively warm and humid climate which is ideal for agricultural development (Shi, 1963; Compilation group of Shaanxi agricultural geography, Department of Geography and Northwest University, 1979; Nie, 1981; Jin et al., 2002).

The chronology of the regional archaeological culture from the Neolithic to the Bronze Age in Guanzhong has been clearly depicted (Institute of Archaeology, Chinese Academy of Social Sciences, 2010; Gong, 2018) (Table 1). The Laoguantai culture (5900 BCE-5000 BCE) is the earliest Neolithic culture in Guanzhong (National Cultural Heritage Administration, 1998), since which sedentary lifeway and food production had begun (Barton et al., 2009; Atahan et al., 2011). During the Laoguantai period, dogs (*Canis lupus familiaris*) and pigs (*Sus scrofa domestica*) were domesticated. The subsequent Yangshao culture was a key period for the establishment of the agricultural economy and the emergence of social complexity (Liu, 2005; Dai, 2012). The Yangshao culture was comprised of three phases: the Banpo culture (4900 BCE-3800 BCE), the Miaodigou culture (3900 BCE-3600 BCE) and the Xiwangcun culture (3600 BCE-2900 BCE). The Yangshao culture was replaced by the Longshan culture around 2900 BCE. The early Longshan period is the Miaodigou II culture (2900 BCE-2600 BCE) and the late Longshan period is the Keshengzhuang culture (2600 BCE-2000 BCE). The number of sites and settlement size generally declined compared with those of the Yangshao period and large-scaled settlements or luxurious burials were hardly found (Liu, 2005; Zhang, 2017). New domesticated species, such as cattle (*Bos taurus*), sheep (*Ovis aries*) and goat (*Capra hircus*), were introduced during the Keshengzhuang culture period (Liu et al., 2001). Xia (2070 BCE-1600 BCE), Shang (1600 BCE-1046 BCE), pre-Zhou (1300 BCE-1046 BCE), and Western Zhou (1046 BCE-771 BCE) comprise the Bronze Age culture (Expert Group of the Xia-Shang-Zhou Project, 2000; Yuan, 2019a). The Guanzhong region, being a peripheral area to the great polities in the Central Plains during the Xia-Shang period, had not become the political and economic center until the Western Zhou dynasty (National Cultural Heritage Administration, 1998; Shang-Zhou Archaeology Research Office of Shaanxi Provincial Institute of Archaeology, 2018). During the Bronze Age, domesticated horses and chicken firstly emerged in this region (Yuan, 2015).

Materials and methods

We collate published data from 26 sites/locales in the Guanzhong region. Only mammals are considered in this study,

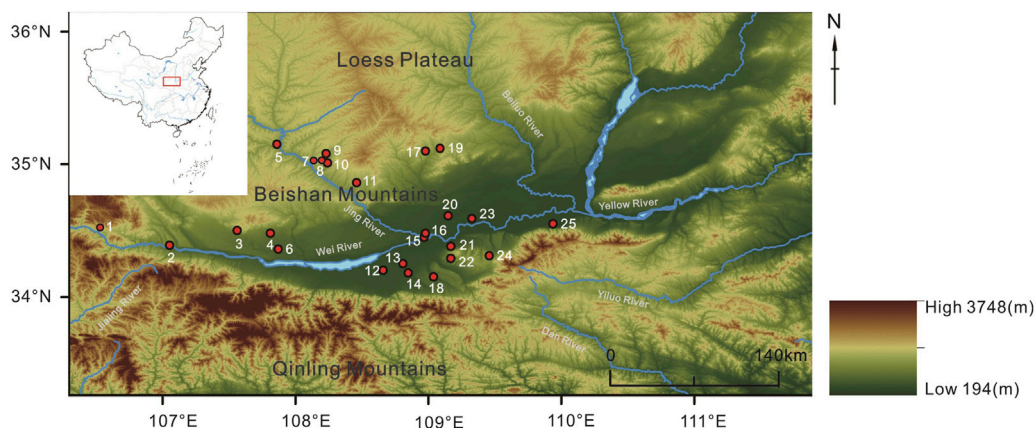


FIGURE 1

Location of the Guanzhong region and the archaeological sites/locales mentioned in this study. 1. Guantaoyuan 2. Fulinbao 3. Zhougongmiao 4. Jue workshop at Qijia 5. Nianzipo 6. Anban 7. Xitou (including the Nantou Locale) 8. Sunjia 9. Xiaweiluo 10. Zaolinhetan 11. Zaoshugou 12. Mawangcun and Dayuancun 13. Yuhuzhai 14. Gongbeiya 15. Dongying 16. Yangguanzhai 17. Beicun 18. Xinjie 19. Wayaogou 20. Baijiacun 21. Jiangzhai 22. Lingkoucun 23. Kangjia 24. Quanhucun 25. Xinglefang.

TABLE 1 The chronology of archaeological culture from the Neolithic to the Bronze Age in the Guanzhong region.

Bronze Age	—	Western Zhou	1,046–771 BCE
		Pre-Zhou	1,300–1,046 BCE
		Shang	1,600–1,046 BCE
		Xia	2,070–1,600 BCE
Neolithic Age	Longshan	Keshengzhuang culture	2,600–2,000 BCE
		Miaodigou II culture	2,900–2,600 BCE
	Yangshao	Xiwangcun culture	3,600–2,900 BCE
		Miaodigou culture	3,900–3,600 BCE
		Banpo culture	4,900–3,800 BCE
	Pre-Yangshao	Laoguantai culture	5,900–5,000 BCE

as they are better representations of meat procurement strategies considering their contribution in human diet. Number of Identified Specimens (NISP) is the primary option for quantitative analysis in this study as it is a more direct reflection of the quantity of the faunal assemblage compared with Minimum Number of Individual (MNI) which is derived from NISP and influenced by aggregation method (Lyman, 2008). Only for sites where NISP data is unavailable, we alternatively use MNI. Taking the sample size into consideration, faunal assemblages with NISP over 100 or MNI over 10 are included (Figure 1; Table 2).

Previous studies have suggested that hunting and husbandry were two major forms of meat procurement strategies in China (Yuan, 1999). We therefore calculate the proportion of the domesticated versus wild animals for each site to assess the relative reliance on hunting and husbandry in regional subsistence.

We further compare the relative abundance of the domesticated pigs and bovids (i.e., sheep, goat and cattle) in order to explore the changing husbandry practices. Pig was one of the earliest domesticates original in China while the domesticated bovids were introduced by the third

millennium BC (Yuan, 2015). The introduction of these west-Asian original domesticates would have re-shape the local subsistence to various extents (Zhang, 2017). As seen in the Gansu-Qinghai region where a transformation from agricultural towards a mixed agropastoral economy was evident (Chen, 2018). At the scenario in Guanzhong remains unclear. As a result, by calculating the proportion of the domesticated pigs versus bovids, we attempt to capture the changing progress in subsistence economy and its influence on societal development.

Studies focusing other regions have shown that settlements of different scales may use different subsistence strategies (Price et al., 2017; Yuan et al., 2020; Tao et al., 2022a; Itahashi, 2022). The settlement hierarchy in the Guanzhong region appeared at least during the middle Yangshao period (Dai, 2012). We group them into two categories: the central urban settlements over 20 ha or with walls, and those lower ranking ordinary settlements under 20 ha according to Liu’s criteria (2005) (Table 3). The patterning of zooarchaeological data from the two settlement categories are compared.

Results

The results of our analysis are summarized in Table 2; Figure 2.

During the pre-Yangshao period, all sites at Guanzhong procured meat resources mainly by hunting wild animals, supplemented by raising livestock. During the early Yangshao period, most sites still relied heavily on hunting wild animals and supplemented by raising livestock. However, there are a few sites where raising livestock was the major way to procure meat resources, suggesting a growing reliance on husbandry. During the middle Yangshao period, husbandry became the major meat procurement strategy despite the coexistence of the wild-resources exploitation. During the late Yangshao period, the level of livestock husbandry significantly declined in most sites except for the Xinjie site and a simultaneous intensification of wild animal utilization is found. Pigs and dogs were the only two domesticates in the pre-Yangshao and Yangshao periods. Husbandry and hunting co-existed during the Longshan period. During the early Longshan period, faunal assemblages

TABLE 2 Summary of the zooarchaeological data from the Neolithic to the Bronze Age sites in the Guanzhong region.

Period	Site	Archaeological culture	Species of domesticated animals	Approaches to counting	Number	Proportion of domesticated animals (%)	Proportion of pigs in domesticated animals	Proportion of domesticated bovids (sheep, goat, and cattle) in domesticated animals	Proportion of the rest domesticated animals	References
Pre-Yangshao	Baijiacun	Laoguantai culture	Pig, dog	NISP	706	37	97%	0%	3%	Zhou (1994)
	GuantaoyuanII	Laoguantai culture	Pig	NISP	148	6	100%	0%	0%	Hu (2007)
	GuantaoyuanIII	Laoguantai culture	Pig	NISP	267	3	100%	0%	0%	Hu (2007)
Early Yangshao	LingkoucunII	Lingkoucun culture	Pig	NISP	315	57	100%	0%	0%	Zhang et al. (2004)
	Jiangzhail	Banpo culture	Pig, dog	NISP	2,203	24	99%	0%	1%	Qi (1988)
	Lingkoucun III	Banpo culture	Pig	NISP	116	52	100%	0%	0%	Zhang et al. (2004)
	Wayagou	Banpo culture	Pig, dog	NISP	6,094	40	96%	0%	4%	Wang H. (2011)
	Yuhuazhail	Banpo culture	Pig	MNI	28	39	100%	0%	0%	Hu and Yang (2017)
	Jiangzhail	Shijia culture	Pig	NISP	342	13	100%	0%	0%	Qi (1988)
	Yuhuazhail	Shijia culture	Pig, dog	MNI	34	12	75%	0%	25%	Hu and Yang (2017)
Middle Yangshao	Dongying (early phase)	Miaodigou culture	Pig	NISP	205	20	100%	0%	0%	Hu (2010)
	Yangguanzhai	Miaodigou culture	Pig, dog	NISP	375	94	82%	0%	18%	Hu et al. (2011)
	Quanhucun	Miaodigou culture	Pig, dog	NISP	2,693	83	90%	0%	10%	Hu (2014)
	Xinglefang	Miaodigou culture	Pig, dog	NISP	155	95	97%	0%	3%	Hu and Yang (2019)
Middle and late Yangshao	Fulinbao	Miaodigou and Xiwangcun culture	—	NISP	180	0	—	—	—	Wu, 1993
	Gongbeiya	Miaodigou and Xiwangcun culture	Pig, dog	NISP	220	44	77%	0%	23%	Zong et al. (2021)
Late Yangshao	Jiangzhai IV	Xiwangcun culture	Pig, dog	NISP	588	16	95%	0%	5%	Qi (1988)
	Yuhuazhai IV	Xiwangcun culture	Pig	MNI	20	45	100%	0%	0%	Hu and Yang (2019)

(Continued on following page)

TABLE 2 (Continued) Summary of the zooarchaeological data from the Neolithic to the Bronze Age sites in the Guanzhong region.

Period	Site	Archaeological culture	Species of domesticated animals	Approaches to counting	Number	Proportion of domesticated animals (%)	Proportion of pigs in domesticated animals	Proportion of domesticated bovids (sheep, goat, and cattle) in domesticated animals	Proportion of the rest domesticated animals	References
	Xinjie (early phase)	Xiwangcun culture	Pig, dog	NISP	1,609	81	92%	0%	8%	Hu (2020)
Early Longshan	AnbanIII	Miaodigou IIculture	Pig, dog	NISP	1,293	73	98%	0%	2%	Hou (2016)
	Xinjie (late phase)	Miaodigou IIculture	Pig, dog	NISP	632	63	92%	0%	8%	Hu (2020)
Longshan	Xiaweiluo	Miaodigou Iland Keshengzhuang culture	Pig, dog, goat	MNI	96	70	83%	9%	8%	Zhang (2006)
	The Nantou Locale of Xitou	Miaodigou Iland Keshengzhuang culture	Pig, dog, sheep, goat, cattle	NISP	225	89	79%	17%	5%	Wang et al. (2023)
Late Longshan	JiangzhaiV	Keshengzhuang culture	Pig, dog	NISP	334	12	51%	0%	49%	Qi (1988)
	Dongying (late phase)	Keshengzhuang culture	Pig, dog, sheep, cattle	NISP	291	57	54%	39%	7%	Hu (2010)
	Kangjia	Keshengzhuang culture	Pig, dog, sheep, goat, cattle	NISP	6,585	36	55%	33%	12%	Hu (2023)
Shang	Beicun	Shang	Pig	MNI	175	27	100%	0%	0%	Cao (2001)
Pre-Zhou	Mawangcun and Dayuancun	pre-Zhou	Pig, dog, sheep/goat, cattle, chicken, horse	MNI	20	75	60%	27%	13%	Yuan and Xu (2000)
	Nianzipo	Pre-Zhou	Pig, dog, goat, cattle, chicken, horse	NISP	9,070	97	37%	55%	8%	Zhou (2007)
	Zhougongmiao	pre-Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	3,881	89	49%	48%	3%	Zhang (2012)
	Zaoshugounao	pre-Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	9,301	84	27%	62%	10%	Li (2015)
	Zaolinhetan	pre-Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	1,305	95	21%	52%	27%	Li et al. (2019)
	Sunjia	pre-Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	355	93	18%	67%	15%	Festa et al. (2023)
	Xitou	Pre-Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	236	95	19%	68%	13%	Festa et al. (2023)

(Continued on following page)

TABLE 2 (Continued) Summary of the zooarchaeological data from the Neolithic to the Bronze Age sites in the Guanzhong region.

Period	Site	Archaeological culture	Species of domesticated animals	Approaches to counting	Number	Proportion of domesticated animals (%)	Proportion of pigs in domesticated animals	Proportion of domesticated bovids (sheep, goat, and cattle) in domesticated animals	Proportion of the rest domesticated animals	References
Western Zhou	Mawangcun and Dayuancun	Western Zhou	Pig, dog, sheep/goat, cattle, chicken, horse	MNI	44	86	47%	40%	13%	Yuan and Xu (2000)
	Jue workshop at Qijia	Western Zhou	Pig, dog, sheep, goat, cattle	NISP	1,344	92	21%	65%	15%	Ma and Hou (2010)
	Zhongongmiao	Western Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	3,787	87	22%	69%	9%	Zhang (2012)
	Zaoshugounao	Western Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	331	88	41%	42%	17%	Li (2015)
	The Nantou Locale of Xitou	Western Zhou	Pig, dog, sheep, goat, cattle, horse	NISP	1,119	86	18%	72%	9%	Wang et al. (2023)

from two sites were dominated by domesticated animals, while in most late Longshan sites faunal assemblages were predominated by wild animals, indicating a declining trend in livestock raising. Pigs were still the most abundant domesticated species despite the introduction of cattle, sheep and goats. During the Shang period, the result from Beicun suggests that wild animals were predominant and pigs were the only domesticated species whereas at Laoniupo the proportion of pigs is over 60% (Zhang et al., 2007). This case indicates that there were also two meat procurement strategies during the Shang period. A remarkable change in the meat procurement strategy has been found during the pre-Zhou and Western Zhou periods when husbandry became the major way of meat procurement in all sites. Horses and chickens have been introduced by then. The domesticated bovids for the first time outnumbered pigs, indicating their growing importance.

Taking the settlement hierarchy into account, the changing of the meat procurement strategy in Guanzhong seemed to follow two intertwined clues: the chronological process and settlement hierarchy. The change of the meat procurement strategy can be roughly divided into three stages chronologically. The first stage is from the pre-Yangshao to early Yangshao periods, when no apparent settlement hierarchy appeared and most of the sites heavily relied on hunting wild animals. The second stage is the middle Yangshao period to the Shang dynasty when a contrasting pattern was observed: a heavy reliance upon husbandry among central urban settlements and exploitation of wild animals among lower ranking settlements¹. The third stage is the pre-Zhou and Western Zhou periods, during which husbandry had become the major subsistence strategy regardless of the settlement rank. The predominant domesticated taxa shifted from pigs in the first and second stages to bovids by the third stage.

The second clue is the scale of the settlement. Pearson correlation coefficient ($r = 0.3$) showed a positive correlation between the proportion of the domesticated animals and the site size, implying a potential link between husbandry intensification and urbanization.

Discussion

Characteristics of the meat procurement strategy in the Guanzhong region

Two characteristics of the meat procurement strategy in the Guanzhong region can be summarized. Firstly, from Yangshao to Shang, the two meat procurement strategies—animal husbandry and exploitation of wild resources—seemed to have coexisted for a long time, and the meat procurement strategy was closely related to the hierarchy of settlements. While central urban settlements opted to animal husbandry, residents in lower ranking settlements mainly relied on hunting wild animals. Secondly, the change of meat procurement strategy unlike followed a progressive trajectory from hunting to husbandry. Instead, it took a winding route involving husbandry intensification alternating with regression to wild resource utilization.

¹ The area of the Guantaoyuan site could not be confirmed, while the Lingkoucun site and the Dongying site were severely damaged and only a small area remains, so these sites were excluded from the discussion.

TABLE 3 Settlement hierarchy from the Neolithic to the Bronze Age in the Guanzhong region².

Site	Area (hectare)	Rank	References
Baijiacun	12	Ordinary	Institute of Archaeology, Chinese Academy of Social Sciences (1994)
Guantaoyuan	Unknown	—	
Lingkoucun	Remain 2 (seriously ruined)	—	Shaanxi Provincial Institute of Archaeology (2004)
Jiangzhai	5	Ordinary	Xi'an Banpo Museum et al. (1988)
Wayaogou	5	Ordinary	Wang et al. (2014)
Yuhuazhai	7.5	Ordinary	Xi'an Institute for the Preservation of Cultural Heritage and Archaeology (2012)
Dongying	Remain 0.9 (seriously ruined)	—	Shaanxi Provincial Institute of Archaeology et al. (2010a)
Yangguanzhai	Over 100	Central	Yang (2018)
Quanhucun	60	Central	Shaanxi Provincial Institute of Archaeology et al. (2014)
Xinglefang	28.5	Central	Shaanxi Provincial Institute of Archaeology (2019)
Fulinbao	18	Ordinary	Baoji Archaeological Team (1993)
Gongbeiya	14	Ordinary	Tang et al. (2020)
Xinjie	30	Central	Shaanxi Provincial Institute of Archaeology (2020)
Anban	70	Central	Archaeology major of School of Cultural Relics and Museum, Northwest University (2000)
Xiaweiluo	Unknown	Central	Cultural heritage and Archaeology Research Center of Northwest University et al. (2006)
Xitou	100	Central	School of Cultural Heritage et al. (2020)
Kangjia	19	Ordinary	Kangjia Archaeological Team of Shaanxi Provincial Institute of Archaeology (1992)
Beicun	18	Ordinary	Shang-Zhou Group et al. (1994)
Laoniupo	140	Central	Shaanxi Provincial Institute of Archaeology (2021)
Mawangcun and Dayuancun (Fengjing)	1,000	Central	National Cultural Heritage Administration (1998)
Nianzipo	16	Ordinary	National Cultural Heritage Administration (1998)
Zaoshugounao	300	Central	Cultural heritage and Archaeology Research Center of Northwest University et al. (2012)
Zaolinhetan	8	Ordinary	School of Cultural Heritage et al. (2019)
Jue workshop at Qijia (Zhouyuan)	3,000	Central	Shaanxi Provincial Institute of Archaeology et al. (2010b)
Zhougongmiao	130	Central	Zhouyuan Archaeological Team (2006)
Sunjia	20	Central	Li and Dou (2022)

Factors influencing the changing meat procurement pattern

The relationship between the change in the meat procurement strategy at Guanzhong and environmental variation and climate fluctuation has been much discussed (e.g., Qu et al., 2018; Festa and Monteith, 2022). Environments indeed provide a general context to explore changes of subsistence economy. There are many more

factors worthy of further consideration to decipher the interplay of subsistence and societal development.

First of all, the regional environment in Guanzhong, which was suitable for agriculture and rich in wild resources, would have supported the long-term coexistence of the two meat procurement strategies. On one hand, its flat terrain, the abundance of fertile loess, and a warm-humid climate have provided ideal conditions for agriculture. Isotope analyses have demonstrated that pig husbandry was closely related to millet cultivation in the Guanzhong region (Pechenkina et al., 2005; Chen et al., 2016a). Agricultural intensification thus seemed a twin process with pig husbandry in central China. Consequently mild environment is key to the development of husbandry. On the other hand, wild animals were abundant in Guanzhong during the prehistoric periods (Lander, 2020), among which sika deer (*Cervus nippon*) were widely utilized as evidenced by the frequent recovery of

² Mawangcun and Dayuancun is a part of Fengjing site, so we used the area data of Fengjing site; similarly, Jue workshop at Qijia is a part of Zhouyuan site, so we used the area data of Zhouyuan site; researchers did not publish the area data of Xiaweiluo site, but they defined it as a "large site" in the report, so we marked it as a "central settlement" here.

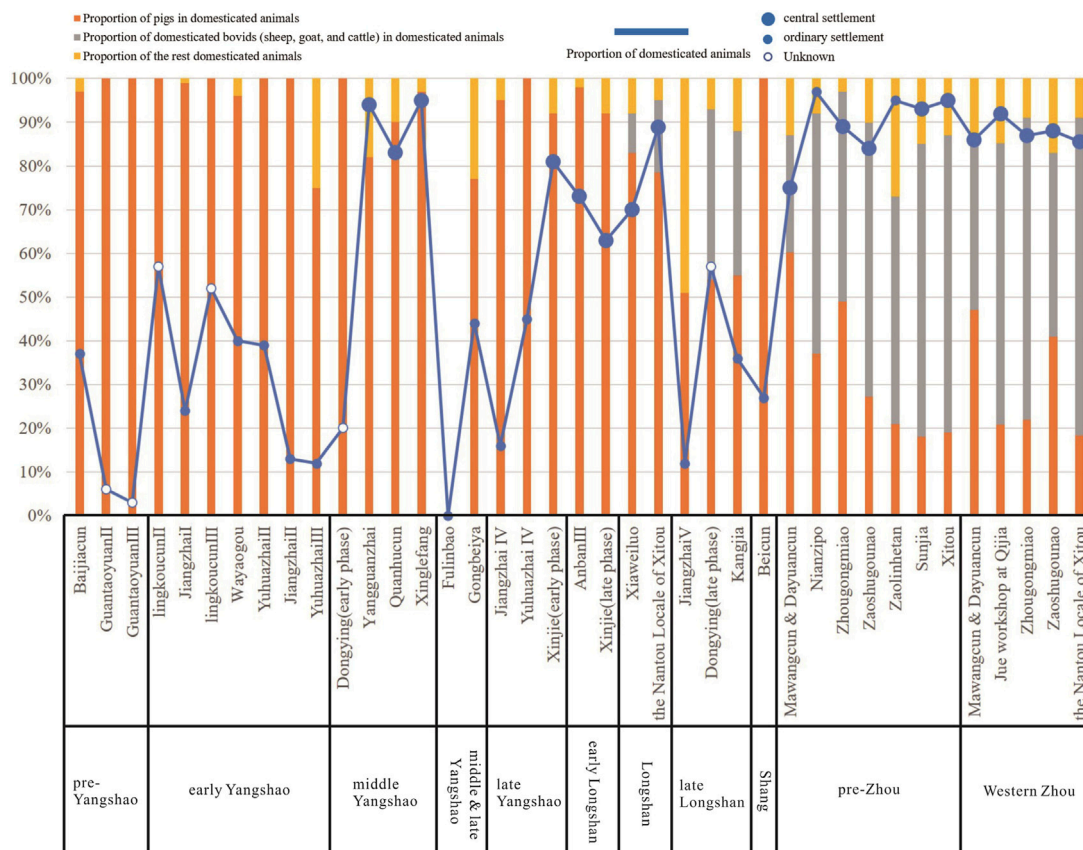


FIGURE 2 The proportion of domesticated animals in all animals, and the proportion of each kind of domesticated animals (pigs, domesticated bovids and others) in all domesticated animals in each site from the Neolithic to the Bronze Age in the Guanzhong region.

their remains in many archaeological sites during the Neolithic and the Bronze Age (Li Y. et al., 2021). It is plausible to envisage that the abundance of wild animal resources made it a reasonable choice to hunt wild animals for meat.

Population size might have influenced the change of the meat procurement strategy. Yuan (2015) proposes a “passive development theory” to explain the transformation of the meat procurement strategy in prehistoric China where two influential factors are considered: the demand for meat resources and the availability of wild animal resources. Demographic factor plays a crucial role in the adoption of a particular meat procurement strategy. This is not only because the population size affects the amount of meat that is consumed, the relationship between human settlement expansion and wildlife habitat shrinkage but also counts. The decrease in wildlife population would have increased the difficulty of hunting. The number of the Miaodigou culture sites (middle Yangshao period) in Shaanxi is more than twice that of Banpo culture (early Yangshao period) (National Cultural Heritage Administration, 1998), and the average size of the Miaodigou culture sites is almost twice that of Banpo culture, whereas the number of those large sites is more than three times that of Banpo culture (Liu, 2009). The population size can be estimated by the settlement number and size (Liu, 2005; Wang J. H., 2011). That says, during the Miaodigou culture, the population size increased

corresponding to the dramatic growth in the proportion of the domesticated animals. During the late Yangshao, Longshan, and Xia-Shang periods, when the number of sites decreased and the average site area shrunk (Weishui Team of Shaanxi Archaeological Institute, 1960; Wang and Qian, 1996; National Cultural Heritage Administration, 1998; Zhouyuan Archaeological Team, 2005; Liu, 2009; Shao, 2009; Ma, 2010; Zhouyuan Archaeological Team, 2010; Zhai, 2013; Ge, 2017; Jiang and Cui, 2017; Zhou and Cui, 2022), the proportion of the domesticated animals also declined. Guanzhong, being the political and economic center, reflowered once again during the pre-Zhou and Western Zhou periods. Not only did the number of the sites increase dramatically to over 800 (National Cultural Heritage Administration, 1998), but also the settlement density was more than twice that of the Longshan period. The settlement size also increased significantly, with the largest one exceeding 10 million square meters, forming an extremely colossal central settlement (Zhou and Cui, 2022). During this period, the meat procurement strategy shifted towards a heavy reliance on livestock. It is evident that the demographic factor had significant influences on the change of the meat procurement strategy.

The settlement hierarchy-related difference in meat procurement strategy is observed during the middle Yangshao to Shang periods, which is in agreement with the climax of the social complexity process.

In the pre-Yangshao period, the number of sites being small and most of the site sizes are between 10,000–20,000 m² (National Cultural Heritage Administration, 1998), no social differentiation is observed. Differences in the meat procurement strategy did not emerge yet. The significant disparity in settlement size began during the Miaodigou culture of the middle Yangshao period (Dai, 2012). The difference in the meat procurement strategy between central and ordinary settlements is also obvious. After the Miaodigou culture, although the growing process of social complexity dropped out in Guanzhong, a three- or four-tiered settlement hierarchy still existed (Liu, 2009). Correspondingly, two meat procurement strategies coexisted.

The dimorphic pattern in meat procurement strategy between central and ordinary settlements in Guanzhong region might have been related to the demographic factor as well. In general, large sites have a larger population and therefore greater demand for meat. Urban dwellers who were not engaged in agricultural production requires more food supplied for cities. In response to the pressure of the increasing population, some central settlements in the middle Yellow River region during the late Yangshao period increased land use efficiency and agricultural yield through different means of agricultural intensification such as mixed cropping, manuring, and expansion of farmland (Tao et al., 2022b; Yang et al., 2022). There was a simultaneous intensification of animal husbandry. Inferring from isotope results, the average $\delta^{13}\text{C}$ value of pigs from central urban settlements is $-8.6\text{‰} \pm 1.3\text{‰}$ at Xinglefang, and $-8.9\text{‰} \pm 1.3\text{‰}$ at Quanhucun respectively (Hu et al., 2014; Hu et al., 2020), which are significantly higher than that of pigs from the ordinary settlement Kangjia, which is $-10.3\text{‰} \pm 2.4\text{‰}$ (Pechenkina et al., 2005). The domesticated pigs at urban settlements apparently consumed more C₄ plants, which in the Guanzhong region were mainly millet and its by-products. Provisioned by fodder from millet cultivation, pigs could have been managed in a more enclosed and intensive way. This intensified husbandry, capable to feed more people, adapted well to the growing urbanism in Guanzhong.

The urbanization process could have brought in the shrinkage of the wildlife habitat, resulting in the decline of wildlife resources. At the same time, intensified agricultural practices left farmers less time for hunting. Residents in smaller sites, on contrary, still could have relied on hunting wild animals in the surrounding environment due to a low population density, as seen in examples of Kangjia and Jiangzhai where a variety of wild animals were utilized (Qi, 1988; Liu et al., 2001).

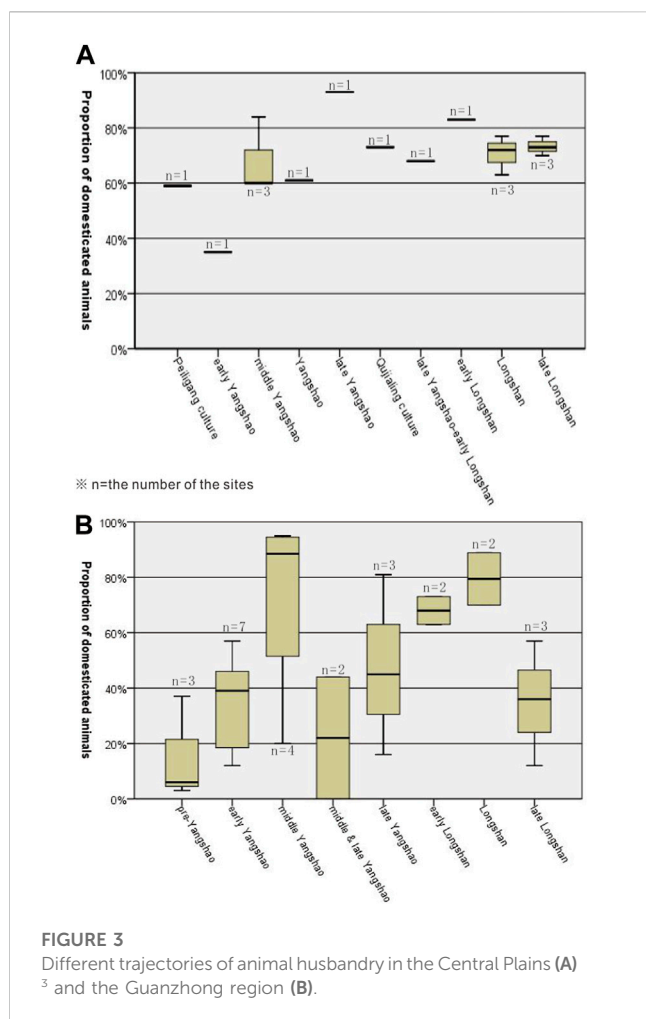
In the pre-Zhou and Western Zhou periods, the overall subsistence shifting to husbandry may be also attributed to some social factors. In many historical documents such as *Shi Ji Zhou Ben Ji*, *Shi Da Ya Sheng Min*, and *Shi Da Ya Gong Liu*, it is recorded that ancestors of the Zhou community specialized in husbandry, and rulers attached great importance to husbandry, encouraged people to develop husbandry (Liu, 1985). This may be an important reason for the increase in the proportion of domesticated animals in the pre-Zhou period. The husbandry intensification in the Western Zhou period may also be related to the change of social organization. The Guanzhong region was marginal to the great polities in the Central Plains during the Xia and Shang periods while in the Western Zhou period, it became

the capital of the state where agriculture production was under unified planning and strict organization by the rulers. Inferring from several historical texts, officers were assigned in charge of husbandry (Liu, 1985; Si, 2008; Geng, 2012; Lu, 2013; Zhao, 2018), decrees to plan specialized grazing land and restrict the pastoralists from changing their professions at will were issued to ensure that there were sufficient labor for animal husbandry (Liu, 1985). The inscriptions on the unearthed bronzes also record that Zhou elites controlled both the land and the labour for animal husbandry (Chen, 2022).

Changes in the livestock composition

Another issue worthy of attention is the time lag between the introduction and the intensive utilization of the domesticated bovids in Guanzhong. Unlike the rapid replacement by the bovids for the pigs in the Gansu-Qinghai region and northern Shaanxi after their introduction (Zhang, 2017), the domesticated bovids remained under-exploited until the Zhou dynasty. Apart from the fact that the mild condition at Guanzhong rendered rich wild resources and residents there experienced lower population pressure during the Longshan periods, it is also plausible that the innovative technologies (milking, processing wool) and husbandry skills (killing cycle, breeding, etc.) tailored for the utilization of the bovids' secondary products in West and Central Asia were not readily accepted by local people, and failed to be integrated into the existing local subsistence system in the Guanzhong region. As a result, the meat procurement strategy maintained the long tradition of the combination of pig husbandry and wildlife hunting.

During the pre-Zhou and Western Zhou periods, domesticated bovids replaced pig as the main livestock species. Festa and her colleagues suggest that it may be related to the increasingly cold and dry climate and the contact with northern pastoral community (Festa et al., 2023). We believe that in addition to these factors, the adjustment of livestock structure during this period may also be related to their biological natures. As the dramatic increase in the population likely led to increasing demand for meat, it is necessary to improve the utilization efficiency of land within a limited area. The biological natures of domesticated bovids make them a better choice than pigs. The first advantage is their fodder. Since cattle mainly fed on millet straw, sheep and goat mainly fed on wild plants (Chen, 2021), they could transform shrubs and grasses that were not directly edible to humans into meat. Isotopic studies on animals from the Zaoshugou and Zhougongmiao sites during the pre-Zhou and Western Zhou periods indicate a combination of penned feeding and grazing (Lan, 2017; Li N. et al., 2021). In this sense, the husbandry of the domesticated bovids developed a new way of land use out of the farmlands, significantly improving the efficiency of land use. Secondly, because of its gregarious nature, the state-organized and institutionalized ranch management formed in the Western Zhou dynasty (Okamura, 2020; Chen, 2022) made it more efficient to raise domesticated bovids than to raise pigs. In addition, the amount of meat provided by cattle is about three times that of pigs (Luo, 2012), feeding cattle is an effective way to increase the amount of meat. Besides, the age structure of the herds indicates that the acquisition of meat resources was the main aim of husbandry while secondary products were utilized though to a limited extent (Li, 2015; Li et al., 2019). The diverse utilization of domesticated



bovids elevated their importance in the animal economy. Meanwhile, there was a rising importance of the bovids in ritual contexts during the Shang and Zhou periods (Liu et al., 2020), which could have also intensified husbandry. All of those factors have contributed to the improvement of the status of domesticated bovids in livestock during this period.

Subsistence and societies

It is noted that the Guanzhong region has the potential for the development of civilization, as evidenced by the prosperity of the Miaodigou culture and the establishment of the Western Zhou dynasty. However, the earliest civilization and complex polity did not occur there. There was a general decline of archaeological cultures in China during 1900 BCE-1500 BCE, except for the Central Plains where the Erlitou culture emerged around 1800 BCE and bred the earliest state in China (Yuan, 2016). The zooarchaeological data there shows that the proportion of livestock in the Central Plains increased from the middle Neolithic (about 7000 BCE-5000 BCE) to the terminal Neolithic (namely, the Longshan period, about 3000 BCE-2000 BCE), at a steady and continuous pace (Bai, 2020; Figure 3A). The characteristics of subsistence economy in the Central Plains may be related to the favorable natural environment for agriculture (Yuan,

2019b) and a constantly growing population size (Chen et al., 2003; Erlitou Archaeological Team, Institute of Archaeology, Chinese Academy of Social Sciences, 2005). Besides, a diversified livestock regime including pigs, dogs, sheep, and cattle had been formed rapidly during the Longshan period, securing stable meat provision for the rapid growth of the population (Yuan, 2016). This progressive development of the subsistence economy would have laid a solid economic foundation for the emergence of China's first dynasties.

On contrary, although new productivity elements such as sheep, goat and cattle were introduced in the Guanzhong region during the Longshan period, they were not widely utilized. The subsistence economy in the Guanzhong region maintained unstable and imbalanced and had not been well developed for thousands of years (Figure 3B), making it unsuitable for the formation of early civilization. During the pre-Zhou period, the meat procurement strategy changed dramatically with husbandry intensified and the livestock diversified. Consequently this development of the subsistence economy, contributing to the population growth and growing social complexity, laid a solid economic foundation for the Zhou polity to defeat the Shang and establish a new political authority.

Subsistence economy, determining food availability, and shaping the pattern of land use and labor organization, plays an imperative role in social development (Weiskopf, 2010; Barton and An, 2014). It is very likely that agricultural productivity and the invention/adoption of military technologies could have played two strong causal roles in increasing the scale and complexity of human societies (Turchin et al., 2022). In China, the establishment and expansion of agricultural complexity seemed a key force driving economic, cultural and social changes including the formation of state-level societies (Chen et al., 2016b), which has been archaeologically verified in the cases of the Central Plains and the lower Yangtze valley (Yuan, 2016; Jing et al., 2020; Yuan et al., 2020). In this study, faunal remains from the Guanzhong region support the close association between subsistence and societal development.

Conclusion

In this paper, we summarize the characteristics of the meat procurement strategy from the Neolithic to the Bronze Age in the Guanzhong region. Firstly, the development of husbandry was discontinuous and unstable, following a winding trajectory involving acceleration and regression. Secondly, there was a mosaic meat procurement pattern where heavy reliance on husbandry was more frequently found in central urban settlements and exploitation of wild animals in settlements of lower ranking throughout the Yangshao to Shang periods.

Environmental, demographic and societal factors would have shaped the meat procurement pattern. The subsistence, in turn, could have influenced the development of society. The Guanzhong region failed to evolve into a more complex great polity earlier partly due to the unstable and imbalanced subsistence during the Longshan and Shang periods. The formation of the intensified and diversified meat procurement strategy during the pre-Zhou and Western Zhou periods, would have supported the rise of the Zhou authority originating from Guanzhong.

We hope that future research can be expanded into untapped regions, such as the Sichuan Basin and Northeast China, with the

aids of isotope and ancient DNA analyses. A closer look into a particular region would certainly help contextualize our comprehension of the complex interplay of subsistence economy, culinary tradition and societal development.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

Author contributions

The study was designed by QH and JY. The data was collected by QH and analyzed by QH. QH and ND wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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