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Between Plain and Plateau: Micro-Transitions in Zooarchaeological Landscapes in the Guanzhong Region of Northwest China

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Abstract: Transitions in animal exploitation patterns are caused by topographical and climatic variations on both macro and micro scales. This paper presents temporally and spatially contextualized faunal profiles from 27 sites in the Guanzhong (关中) region of Shaanxi province (陕西省), PRC which date from the Early Neolithic to the Bronze Age (ca. 6000–1000 BCE). Climatic and environmental data was cross-referenced with archaeological, archaeobotanical and (where appropriate) historical sources to examine the reasons for the clear micro-transitions observed. Faunal profiles from sites in the Wei River plain (渭河盆地), loess plateau, and the transitional zone between them were analyzed. Animal utilization was found to vary substantially between different zones during the period under analysis. The transition in praxis between the Wei River valley and the loess plateau was not gradual. The hilly transition zone was found to have its own distinct animal exploitation pattern. These spatio-temporal differences in animal exploitation were caused by changes in both the local microclimates and the topography of the landscape in which the communities were living. Some regions apparently reverted to 'earlier' animal exploitation patterns in response to climatic changes. These environmental factors were also augmented by internal social developments and interactions with neighboring communities.

Keywords: Guanzhong; loess plateau; zooarchaeology; landscape; Neolithic; Bronze Age

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1. Introduction

The analysis of faunal remains within archaeological contexts usually focuses on the reconstruction of subsistence strategies, ancient economies, and past diets [1], but they can also provide useful insights into past environments and landscape use. In China, zooarchaeology has been applied on a site-by-site basis, with its main objectives being to understand: (1) faunal temporal and spatial distribution; (2) human-animal relationships; (3) past environments [2]. An increasing number of studies have enhanced our understanding of domestication [3,4], regional trajectories [5,6], secondary products [7–9], and craftsmanship [10–12]. Another application has been to reconstruct the impact of humans on past environments. Research in this direction has often focused on animal extinctions [13,14]. Paleoenvironmental reconstruction through the study of mollusks, small mammals, and parasites has also proved effective [15,16].

Most of the zooarchaeological and archaeobotanical research conducted to date is based in and around the Songshan (宋山) region of Henan Province (河南省) [12,17–22]. This is demonstrative of the tendency of research in China to coalesce around large and famous sites, which having been located according to historical texts, are considered to hold the greatest importance, for instance, Shimao (石峁) in North Shaanxi or Yangshao (仰韶) in Henan [23].

The Guanzhong plain and surrounding areas in Central Shaanxi are significantly less studied. The majority of the studies of ancient human occupation in this region from the Neolithic to the dynastic period to date have focused on archaeological evidence drawn from artifacts and ancient written sources [24]. Although there is some research that engages with the ancient climate through the use of zooarchaeology and archaeobotany, many of these studies are based on assumptions of a causal relationship between the environment and human actions, which remove human agency from the equation. The tendency for studies of human mobility and landscape exploitation to resort to environmental determinism and Euclidian approaches to the landscape has also previously been highlighted, but bears repeating [25].

This study takes 27 sites from the Guanzhong region which date from the Neolithic through to the Bronze Age (Figure 1, Table 1) to explore the exploitation of the landscape in different ecological regions through frequencies of the different taxa.

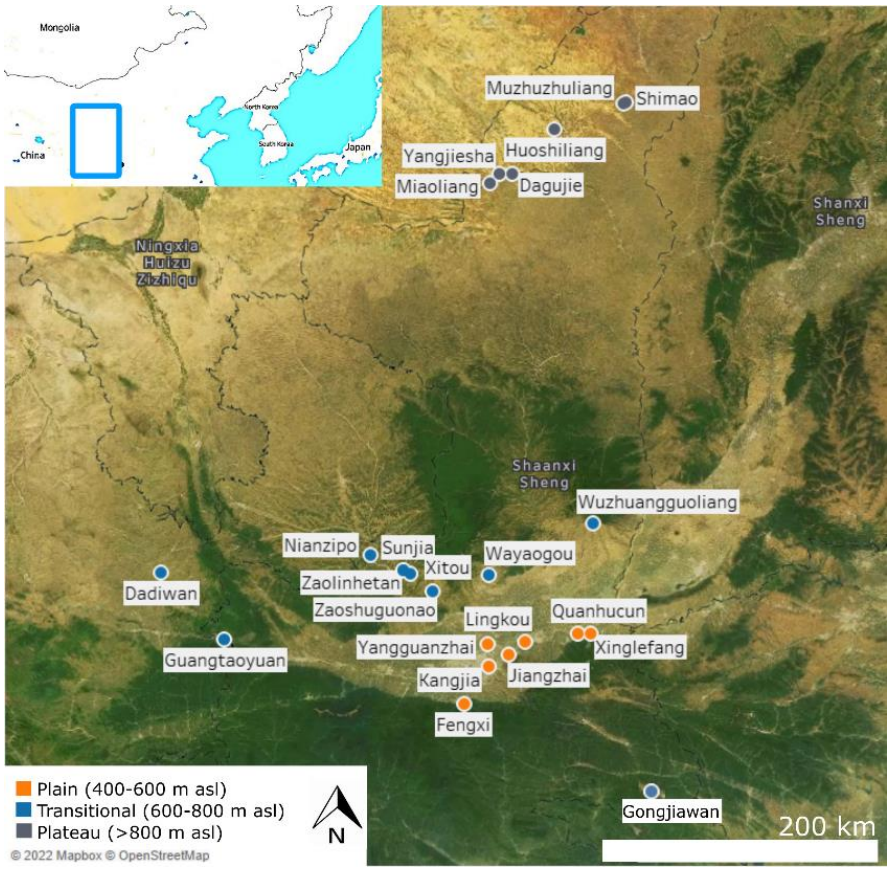

Figure 1. Map showing sites referenced in this paper.

For the purpose of this study, these sites have been divided into three topographically determined regions: plain, transitional, and plateau. The plain occupies the primary and secondary river terraces of large river valleys. These rivers are loess heavy and have a strong tendency to flood. The transitional zone consists of deep gullies carved into the soils of the loess plateau. These regions are formed of pockets of dense vegetation interspersed with scrubby bush. Small areas of flat land in the river valleys provide small areas of flat land for cultivation. The plateau sites are set in the broad plains of the loess plateau (黄土高原), which are relatively dry and can only be cultivated with irrigation.

Since many of the excavations from which our faunal profiles are taken were undertaken in the mid to late 20th century, zooarchaeological protocols were not followed to a modern standard. In particular, collection tended to be manual, with methods such as sieving and screening being the exception rather than the rule. This naturally has a significant

impact on the resulting zooarchaeological profiles, which are often biased against small animals and small elements [26]. Additionally, these profiles are taken from the excavation of settlements and can therefore be taken to represent the diet of the occupants, and to a certain extent the local ecology [27].

Table 1. Chronology of Northern China and coordinates of the sites included in this study. Chronologies for Chinese archaeological cultures are determined on the basis of a large number of calibrated radiocarbon dates obtained from archaeological sites, which are published in [35].

Period	Dates	Zone	Site	Latitude	Longitude
Early Neolithic (Laoguantai 老官台)	6000–5000 BCE	Transitional	Dadiwan I 大地湾 I	35.02024	105.92629
			Guangtaoyuan 光桃园	34.49701	106.53101
Mid-Neolithic (Yangshao 仰韶)	5000–3000 BCE	Plain	Jiangzhai 姜寨	34.38374	109.21308
			Lingkou 零口	34.4785	109.36208
			Quanhucun 泉护村	34.54805	109.86111
			Xinglefang 兴乐坊	35.0376556	108.216578
			Yangguanzhai 样官寨	34.46559	109.0113
		Transitional	Dadiwan II, III, IV 大地湾 II, III, IV [1]	34.49701	106.53101
			Gongjiawan 巩家湾 [1]	33.72038	11022784
			Wayaogou 瓦窑沟	35.00073	109.02031
			Wuzhuangguoluo 五庄果裸	35.39524	110.00372
		Plateau	Dagujie 大古界	38.03320	109.24746
			Yangjiesha 杨界沙	38.03961	109.12052
Late Neolithic (Longshan 龙山)	3000–1900 BCE	Plain	Kangjia 康家	34.29272	109.02815
		Transitional	Gongjiawan 巩家湾 [1]	33.72038	11022784
		Plateau	Huoshiliang 火石梁	38.36503	109.64894
			Miaoliang 庙梁	37.96861	109.0353
			Muzhuzhuliang 木柱柱了梁	38.55466	110.29661
			Shimao 石峁	38.56727	110.31886
Bronze Age (Pre-Shang 先商 * /Shang 商 /Proto-Zhou 先周)	1900–1600 BCE	Plain	Fengxi 沣西	33.99684	108.78804
		Transitional	Nianzipo 碾子破	35.14965	107.90275
			Sunjia 孙家	35.037656	108.216578
			Xitou 西头	35.037656	108.216578
			Zaolinhetan 枣林河滩	35.00568	108.27936
			Zaoshuguonao 枣树沟脑	34.872778	108.495833

* The regional transitional period between the Late Neolithic and the Bronze Age is culturally unclear, with a possible Erlitou (二里头)cultural phase between 1900–1600 BCE. Relevant archaeological (and zooarchaeological) evidence is, however, too little to make definitive claims. Therefore, this time period is referred to as "Pre-Shang" in this paper. [1] This site occurs across multiple phases and is therefore included in each.

The earliest sites included in this study show faunal profiles which are dominated by wild species, especially deer and other large or medium-sized mammals. Domestic species, such as pigs and bovids are notably scarce or absent. With the advent of animal domestication, humans have considerably extended the natural range of domesticated species through artificial feeding, landscape modification, and selective breeding [28–30]. The post-domestication assemblages are dominated by domestic species, this means that the potential for faunal data which might provide information on past ecologies is reduced.

Nevertheless, the distribution of domesticates is still limited to a certain degree by their basic physiology and dietary adaptations and has the potential to give indications, albeit generalized, of past environments and ancient landscape exploitation. For example, the mobility of the populations and their livestock within and across the landscape provides insights into the use of and impact on the landscape by humans and their animals. Certain animal types require a more sedentary existence (e.g., pigs and fowl), whilst others require and can tolerate greater mobility (e.g., bovids and equines). This leads to different faunal profiles:

(1) Profiles dominated by pigs supplemented by bovids are indicative of communities that relied mostly on agriculture and moved domestic herds of herbivores across short distances within a localized landscape, as part of a mixed agropastoral economy [31]. The presence of fowl is also presumed in such assemblages, however, their bones are often either not present or not recorded. This may be due to taphonomic processes or recovery bias against small elements.

(2) Profiles dominated by herd animals (caprines and cattle in this study) are usually indicative of seminomadic or specialized pastoralism [32]. Such seminomadic pastoralism can include transhumant communities in which the herds are moved seasonally between pastures (for example, summer pastures in the uplands and winter in the lowlands or vice versa) and can be evidenced by complementary sets of mortality profiles from upland and lowland sites [33]. Specialized pastoralism relies heavily on one (sometimes two) species of herd animals, which are extensively moved in the landscape. This degree of mobility precludes pig and fowl husbandry, the presence of such animals within the faunal profiles can be put down to trading or raiding [34].

As the distribution of species is to some degree limited by their physiology and foraging behavior, the result is that some animals are associated with certain environments [36,37]. In mapping the sites in terms of their topographic locations it is possible to trace the variations in animal exploitation on a much smaller scale. Faunal data from 27 sites in Guanzhong have been collected and mapped onto a satellite image with contour lines and considered alongside chronological and environmental data. This was done with the aim of understanding micro-transitions in animal exploitation patterns and, thus, exploring past human strategies of landscape exploitation. This study found that even within this limited region (<10,000 km^2) the animal utilization varied substantially between different zones during the period under analysis, each showing distinctive exploitation patterns, and with some regions apparently reverting to 'earlier' animal exploitation patterns in response to climatic influences.

Study Area

The study area includes three zones: the Wei River plain, transitional zone, and loess plateau. Twenty-one of the sites selected for this study are located in the Guanzhong plain and its surrounding transitional zones with six of the sites located 200 km to the north on the loess plateau. These sites have been included since they represent the only available zooarchaeological profiles for the loess plateau against which to contrast the animal exploitation present in the Guanzhong plain and its surrounding transitional zones.

The Guanzhong plain runs west to east across central northern China and occupies an area of 12,000 km. It is surrounded by the loess plateau to the north and the Qinling mountains (秦岭山脉) to the south. The Wei River flows through the region from west to east, from Baoji (宝鸡) where it enters the plain between the Liupan (六盘山) and Qinling mountains at an elevation of 600 m asl and continues 300 km to the confluence of the Wei and Yellow Rivers to the east of Huayin (华阴市) at 300 m asl [38]. Many small rivers feed into the Wei River from the Qinling Mountains, but its largest tributaries, the Jing 泾 and Luo 洛 Rivers, flow from the north. The Wei, Jing, and Luo all drain from the loess plateau and, therefore, have a high silt content and large seasonal variations in flow [39]. This high silt content means that the soil of the Guanzhong plain is mostly composed of loess which has been eroded and redeposited by water, before being modified by millennia of

farming. The rivers running from the Qinling run clear and have a more regular flow than those which run from the north due to the monsoon winds which deposit precipitation on the mountains [40,41].

The Guanzhong region has seen continual human occupation from the Neolithic period through to the modern day. The Neolithic period is generally divided into three phases: Laoguantai, Yangshao, and Longshan. The regional transitional period between the Late Neolithic and the Bronze Age is unclear, with a possible occupation of the Erlitou Culture between 1900 and 1600 BCE. This is then followed by the historical period which is divided according to dynasties. In this paper, sites dating from the Early Neolithic through to the Bronze Age are analyzed with the terms Early, Mid, and Late Neolithic being used to improve the accessibility of the paper to scholars outside of China (Table 1).

The distribution of sites in the region shifts significantly during the course of this time period [42,43]. In the Neolithic, the majority of sites are found in the Hanjiang Plain (汉江盆地) of the Qinling Mountains and eastern Gansu Province (甘肃省) in the region close to Tianshui (天水市). It has been suggested that deforestation in the Qinling during the Early and Mid Neolithic caused erosion, which raised the level of the river beds, meaning that the seasonal floods became a greater threat to the settlements on the secondary terraces within the mountain valleys and increased the potential for catastrophic landslides [44]. There is a sharp increase in sites in the Guanzhong plain region during the Mid Neolithic. It has previously been suggested that this increase in sites was made possible by the advent of irrigation which allowed for the cultivation of the fast-draining soils of the Guanzhong plain [45]. However, the fact that settlement in this area would have also been subject to even greater flooding risks than those of the mountain valleys makes these interpretations problematic.

It should be noted that many sites are attributed to different time periods on the basis of the different forms of pottery found therein. This, therefore, means that all sites at which Laoguantai style are found are dated to a single time period with only a few sites being dated using other methods. If the persons occupying the sites in the Hanjiang valley continued to use Yangshao-style pots after the adoption of Longshan potteries in the Guanzhong plain and loess regions, it is possible that these sites might have been misattributed. This could explain the relative absence of sites in this region recorded as belonging to the Longshan periods. This sort of residuality has been observed in European and West Asian contexts [46] but is rarely considered in terms of Chinese archaeology.

2. Materials and Methods

2.1. Zooarchaeological Approach

This study is based on zooarchaeological data from 27 Neolithic and Bronze Age sites (25 already published and 2 in publication) in the Guanzhong region dated to between 6000 and 1000 BCE, including 2 sites (Gongjiawan and Dadiwan) at which the zooarchaeological data spans more than one phase. These sites were re-examined individually. The locations of these sites are shown in Figure 1. The main faunal data analyzed in this paper is the NISP (Number of Identified Specimens) for each site. NISP is a straightforward system used to compare species representation across multiple contexts and datasets [47–49]. MNI (Minimum Number of Individuals) accepted standard practice zooarchaeology [2,50]. Where possible MNI data have been excluded from these analyses due to the inherent subjectivity of the analysis when it comes to combining bones, the variety of data aggregation methods, and the MNI positive correlation with NISP [47,50,51]. In some cases, it was necessary to use MNI data for comparison with other regions.

With the exception of two assemblages (Lingkou and Gongjiawan), the NISP exceeded 100, providing a reasonably sized data set for comparisons. The NISP was not reported for the faunal remains from Wuzhangguoluo, but only the percentage proportion of the taxonomic representation. However, this was a minor issue because the percentage of NISP of different fauna was calculated for each site, and then, the average value in different areas and periods were used. This prevented bias related to the potential differences in the NISP

from different sites. The %NISP distribution per site is included in Appendix A. In order to assure transparency, the standard deviation of each set of percentages was also calculated. Although it should be noted that in some cases the standard deviations were notably high this is to be expected with such a small dataset. The analysis herein presented focuses on those percentages which have relatively low standard deviations.

The total NISP analyzed was 48,545, 1106 from 2 Early Neolithic sites (Laoguantai Culture), 21,565 from 13 sites dated between 5000 and 3000 BCE (Yangshao Culture), 6071 from 6 sites dated to between 3000–1900 BCE (Longshan Culture), and 19,803 from 6 sites dated to between 1900–1050 BCE (Pre Shang/Shang/Proto Zhou Period). The distribution of data is biased by local researchers' tendency to focus on the intricacies of the Yangshao economy and the early phases of the domestication of pigs [52,53]. Chi-square test suggests that the difference in the distribution is statistically significant at $p < 0.05$ ($X^2 = 15{,}466.1$, df = 12, $p < 0.00001$).

This study divides the faunal remains into four main groups: one wild taxa, deer, and three main domesticates, cattle, pig, and caprine. Owing to the morphological similarity of sheep and goat and considering the uncertainties surrounding the standards to distinguish the two [54–57], these two animals ertr were combined into a single "caprine" category, which is used to refer to "sheep/goat". These taxa were selected because they were sufficiently evenly represented in the study area to be used for comparison across time and space. In addition, they are fairly common, and their bones have been well studied, making them relatively easy to identify in (and therefore more likely to have been reported for) each of the sites; these animals (and their bones) are also large enough to reduce the chance of recovery bias. They, however, may have been subjected to unavoidable fragmentation bias for the same reasons (i.e., larger bones produce more fragments) [49]. All the other taxa were included in the category "Others", and specific species are mentioned where relevant.

2.2. Mapping the Data

The faunal assemblages were mapped onto satellite and contoured maps using Tableau; this then permitted a clear understanding of the elevation and physical geography of the sites. The proximity to the nearest river, flat land within the vicinity of the site, elevation, and, where possible, the modern vegetation at the site were recorded. These factors were then combined to group the sites by type of site location according to overall topography: plain, transitional, and plateau.

The overall distribution sites in the region during each time period were plotted according to the data published in the *Zhongguo wenwu ditu ji: Shaanxi ce* [58]. As the result of the third round of the archaeological survey, these 'cultural heritage maps' are the most complete data available for the location of archaeological sites, despite being over twenty years old at this point.

3. Results

When the data from *Zhongguo wenwu ditu ji: Shaanxi ce* were mapped according to their time period, as expected, the resulting distribution was uneven, with the majority of the sites being dated to the Mid and Late Neolithic (Figure 2). This has been attributed to both recovery bias and apparent historical migrations of populations [42,59,60] (Figure 3).

It was, nevertheless, possible to identify clear temporal and spatial variations in the occurrence and abundance of animal species in the overall study area (Table 2). High standard deviation values were expected, given the small sample size and, in some cases, lack of reports of certain taxa (see Appendix A), while we acknowledge that it is problematic, we are constrained by the quality of the data available. There is also a significant reduction in the variety of taxa, which appears to be, at least partially, due to habitat loss [61,62], however, the impact of recording bias in favor of domesticated and well-known species is also a factor [2,52].

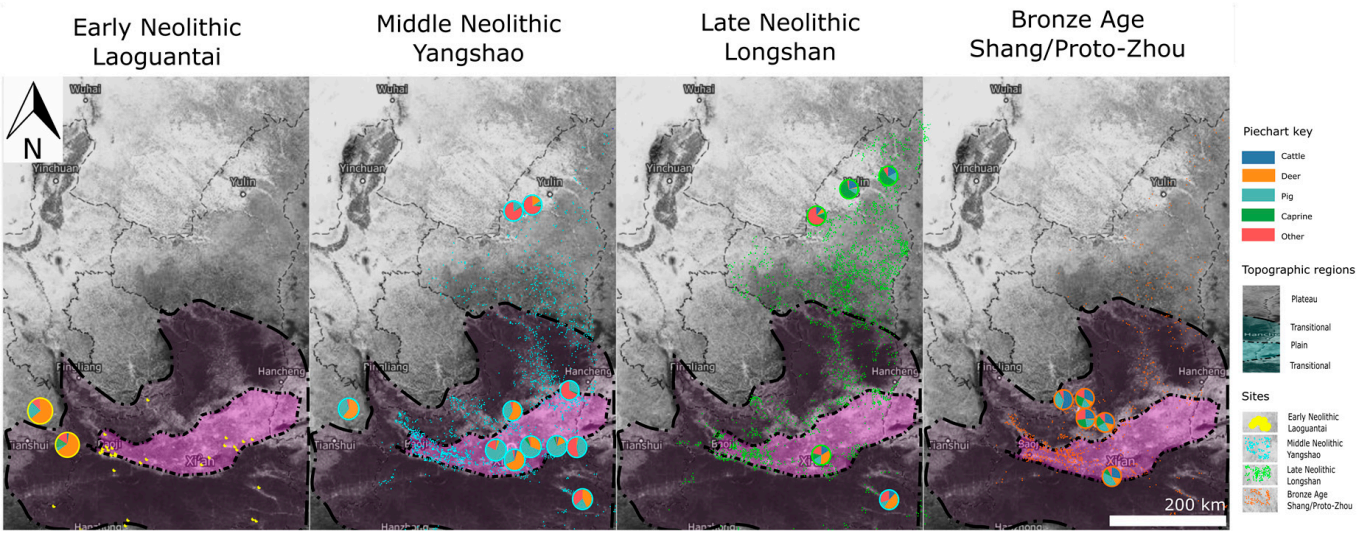

Figure 2. Maps showing the distribution of sites within the study region divided by time period with the three regions highlighted. The pie charts correspond to sites with zooarchaeological assemblages included in this study, while all other sites from each of the time periods are shown as small dots. (N.B. The dots for the Early Neolithic are by necessity larger than those of the periods due to the paucity of sites during this period). (Tableau, F. Monteith).

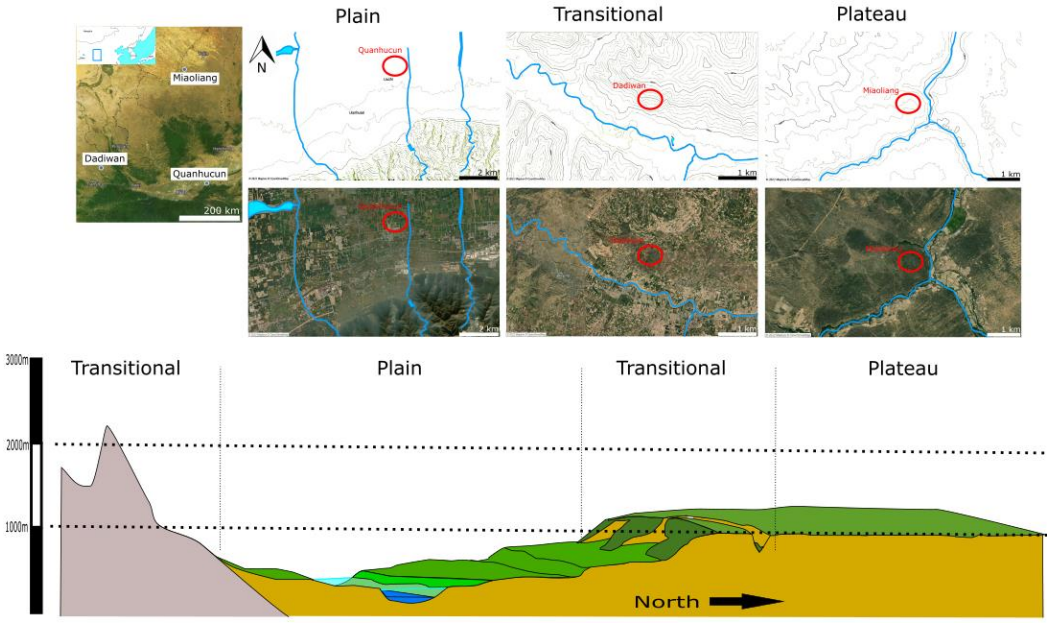

Figure 3. Landscape definitions, with the sites of Quanhucun, Dadiwan, and Miaoliang as examples. (Tableau and Inscape, F. Monteith).

The faunal profiles for the Early Neolithic sites in this study are dominated by wild fauna, with deer taxa making up to the 64% NISP on average. The Mid Neolithic shows a sharp increase in the prevalence of pigs (40% NISP on average), although the presence of deer remained significant (31% NISP on average). The assemblages from the following periods (Late Neolithic and dynastic periods) show a marked increase in the number of bovids, especially caprines (31% NISP on average in the Late Neolithic) and cattle (33% NISP in the Bronze Age).

Table 2. Average taxonomic abundance for Deer, Pig, Caprine, Cattle, and Others by NISP per time period. Data are presented in raw numbers (N) and percentages (%). Data sources are available in Appendix A. Differences between sites are highlighted using Standard Deviation (SD).

Period	Deer			Pig			Caprine			Cattle			Other			Tot		
	N	%	SD	N	%	SD	N	%	SD	N	%	SD	N	%	SD	N	%	No. of Sites
Early Neolithic	707	63.9	0.6	148	13.4	12.7	66	6.0	8.6	20	1.8	2.1	165	14.9	2.62	1106.0	100.0	2
Mid Neolithic	6706	31.1	26.5	8497	39.4	22	259	1.2	2	237	1.1	1.3	5866	27.2	31.79	21,565	100.0	13
Late Neolithic	941	15.5	22	899	14.8	9.2	1900	31.3	26.5	977	16.1	4.7	1354	22.3	24.3	6071	100.0	6
Bronze Age	1644	8.3	5.2	5069	25.6	10.5	3505	17.7	10.9	6515	32.9	10.9	3070	15.5	7.9	19,803	100.0	6

Further resolution is achieved when micro-variations in the physical geography of the region are considered. Three broad categories have been identified, plain, transitional zone, and the plateau (Figure 3).

In this study 'plain' is used to describe sites located on the Wei River plain. This region is at a relatively low elevation (c. 400–600 m asl). The land here is formed of almost flat terraces, which rise in steps from the river channel. The Wei River has a large seasonal variation in flow, historically it tended to flood and change course. This means that settlement on the plain usually occurred in areas of relatively increased elevation, with no sites being recovered from the primary terraces of the rivers. Set in the rain shadow of the Qinling Mountains, it is relatively dry with the majority of its water being supplied by the rivers. This means that prior to the advent of irrigation systems the potential for cultivation would have been restricted to the primary river terraces [38].

The transitional zone is formed by deep gullies which have eroded from the loess plateau. Aridification over the course of the 20th and 21st centuries has led to increased erosion in this region making an accurate reconstruction of the original form of the landscape here problematic. This region is characterized by small pockets of scrubby vegetation within the gullies. Although the hillsides are now terraced, this is a relatively recent innovation. Historically, this region would have only had limited land for cultivation. Although the Gongjiawan site is located in the Qinling mountains rather than the loess transitional zone, it is included in the latter category since the topography of the site is similar to that of the transitional zone.

The plateau is characterized by expanses of flat land cut across by rivers. These rivers run in relatively deep and narrow valleys, which only gradually change their courses. The climate here is presently semi-arid with sand dunes being evident on the satellite imagery. During the period of study, this region would have been less arid than it is in the modern day [63,64]. Although it would have been ideal to compare the sites in the plain and transitional zones with sites on the plateau closer to the Wei River Basin, those included in this study were the closest sites at which zooarchaeological studies had been undertaken for which the data had been published in a publicly accessible format. The concentration of sites in this region is likely due to its proximity to the Shimao site, which is a focal site for the Longshan Culture.

When these zooarchaeological profiles are divided into three broad categories in terms of the physical geography in their vicinity—plain, transitional, and plateau—the micro-regional differences in the taxonomic abundance and faunal exploitation in different time periods are highlighted (Table 3, Figures 2 and 4). Again, the presence of high standard deviation values while unfortunate was expected and may be attributed to the small sample size and the aforementioned research biases.

Table 3. Average taxonomic abundance for Deer, Pig, Caprine, Cattle, and Others by %NISP per time period and per zone. Those instances for which there are no data available are marked with the notation NR. Differences between sites are highlighted using Standard Deviation (SD). Given the small sample size, high standard deviation values are expected. Data sources are listed in Table Appendix A.

Zone	Age	N. Sites	Deer		Pig		Caprine		Cattle		Others		Total
Plain	Early Neolithic	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Mid Neolithic	5	23.2	25.5	57.06	20.6	2.12	2.9	1.76	1.8	15.86	21.6	100
	Late Neolithic	1	35.6	NA	15	NA	11.9	NA	15.9	NA	21.6	NA	100
	Bronze Age	1	14.6	NA	41.2	NA	8.1	NA	27.5	NA	8.6	NA	100
Transitional	Early Neolithic	2	63.9	0.6	13.35	12.7	6.05	8.6	1.75	2.1	14.95	2.6	100
	Mid Neolithic	6	45.4	24.8	34.03	12.3	0.22	0.4	0.92	0.9	19.43	27.5	100
	Late Neolithic	1	48.1	NA	11.1	NA	0	NA	11.1	NA	29.7	NA	100
	Bronze Age	5	7	4.8	22.56	8	19.68	11	33.92	11.76	16.84	8	100
Plateau	Early Neolithic	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Mid Neolithic	2	7.95	11.2	11.15	5.44	1.65	1.8	0	0	79.25	7.6	100
	Late Neolithic	4	3.1	3.5	15.6	11.7	43.8	22.5	17.4	5	20.1	31	100
	Bronze Age	0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

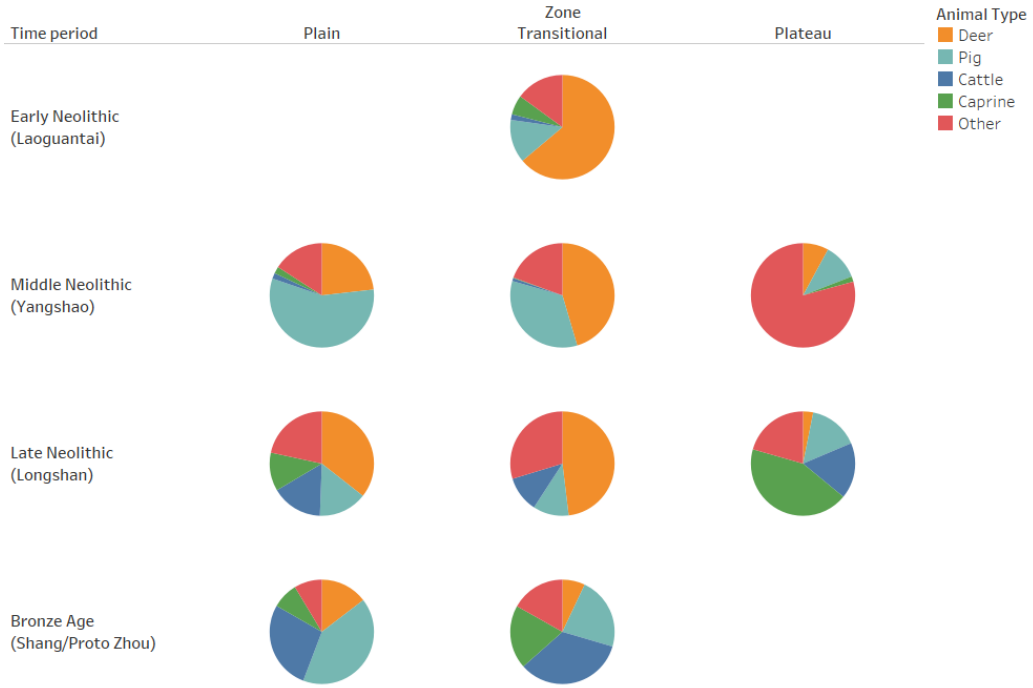

Figure 4. Pie charts showing the % NISP on average in each of the zones divided according to time period. (Drawn using tableau by F. Monteith).

3.1. Early Neolithic (Laoguantai Culture)

There are only 2 sites with faunal profiles in the transitional zone during this period. The faunal assemblages are dominated by wild species, among which cervids are the most common (64% NISP on average). Evidence of rhinoceroses (*Didermoceros sumatrensis*) and wild horses (*Equus caballus przewalskii*) have also been recorded along with golden snub-nosed monkeys (*Rhinopithecus roxellana*).

The proportion of pigs was relatively high (13% NISP on average). Given the fairly early domestication of pigs in the region at around 7000–7500 BP [65,66], some of these specimens may be domesticated, however, this is difficult to ascertain, since the process of pig domestication appears to have gradually arisen from commensal interactions. Additionally, there are methodological problems in the identification of domesticated versus wild suines during these early phases [66,67]. Bovids recovered in these assemblages are presumed to have been wild, on the basis of the identification of wild water buffalo (*Babulus* sp.) in the Guantaoyuan site and the relatively late introduction of domestic bovines and caprines into Central China [2].

3.2. Mid-Neolithic (Yangshao Culture)

There are faunal profiles for all three micro-regions during the Yangshao period with 5 sites on the plain, 6 sites in the transitional zone, and 2 sites on the plateau. The average site data for the faunal assemblages recovered in each of these three regions during this period is markedly different. These results show that during the Yangshao period, pigs were dominant in the plain (57% NISP on average) and that they were also an important taxon in the transitional zone (34% NISP on average). However, they only represent a minor percentage of the faunal assemblages in the plateau sites (11% NISP on average). During this period the majority of specimens are established as being domestic, with only a few individuals exhibiting the taxonomic characteristics associated with wild pigs [68].

The transitional zone was characterized by the highest proportion of deer remains (45% NISP on average), in contrast to the plain and plateau (23% NISP on average and 8% NISP on average, respectively).

The faunal profiles of the sites in the plateau are dominated by small mammals (79% NISP on average), especially hares (*lepus capensis*) (67% NISP on average), during this phase. This is in contrast to the plain and transitional zones, wherein the "Others" category only represents a relatively small proportion of the data (16% NISP on average and 19% NISP on average, respectively), but shows more taxonomic variety.

3.3. Late Neolithic (Longshan Culture)

There are faunal profiles available for all three regions during the Longshan Period with 1 site on the plain, 1 site in the transitional zone, and 4 sites on the plateau. There is a notable increase in domestic bovines in all three areas (plain 16% NISP up from 1% NISP on average in the Yangshao period, transitional zone 11% NISP on average up from 1% NISP on average, and plateau 18% NISP on average up from 0% NISP on average) during this period. In the plateau, a sharp increase in caprine (43.8% NISP on average up from 1.65% NISP on average in the Mid Neolithic) is recorded. The proportion of pigs is reduced compared to the Mid Neolithic, nevertheless, this taxon remains well represented in all the assemblages (plain 15% of NISP on average, transitional 11% of NISP on average, and plateau 16% NISP on average). The percentage of deer remains relatively high, particularly in the transitional zone (48% NISP) and the plain (36% NISP), while it is much lower in the plateau (3% NISP on average).

In one site on the plain, Kangjia, antler fragments make up 27% of the deer NISP [69], boosting the overall deer NISP. There has been much debate about whether to include antlers in the quantification of deer, since a single deer may shed multiple antlers during the course of its lifespan. Best practice does not include antlers that are not still attached to the cranium since they may have been collected individually from elsewhere and brought

to the site [70]. If such practice is to be followed, the % NISP for deer would be around one-third lower in the plain.

The faunal assemblage for the Kangjia site shows a significantly greater variety of species within the category herein described as 'Others'. This includes small quantities of canids, both domestic (*Canis sp*.) and wild (*Vulpes sp*.), as well birds (*Phasianus* sp. and *Gallus* sp.), small mammals (*Lepus* sp.), and aquatic species including mollusk shells and fish bones. The "Others" forms an important category in the Gongjiawan site which is located in the transitional zone, however, the taxonomic variety is reduced when compared to the Yangshao-phase faunal assemblage [71]. In Miaoliang which is located in the plateau region, a large number of wild horses have been found.

3.4. Bronze Age (Shang, Proto-Zhou)

There are only faunal profiles for the plain (1 site) and the transitional zone (5 sites) during the Bronze Age. In both regions the domestic assemblage was prevalent, the deer category only representing 15% NISP in the plain, and 7% NISP on average in the transitional zone. The domestic assemblage was fairly homogenous with only a few taxa represented.

In the Fengxi site which is located on the plain, pigs are prevalent (41% NISP), in contrast to the transitional zone, where they are less represented (23% NISP on average). In both cases, there is a further sharp increase in cattle (27% NISP in Fengxi up from 16% NISP on average, and 34% NISP on average in the transitional zone up from 11% NISP). These bovines have been identified as domesticated species. There is a slight decrease in caprines on the plain (8% NISP), but a sharp increase in the transitional zone (20% NISP on average up from 0% NISP on average). Other domestic species, such as dogs (*Canis familiaris*) and horses (*Equus caballus*), were also found in the plain and the transitional zone.

4. Discussion

From the Early Neolithic to the Bronze Age, the Guanzhong region underwent a shift in animal exploitation, from wild species to pigs between the Early to Mid Neolithic, to an increasing number of bovids from the Mid Neolithic through to the Bronze Age. Looking at the data from the perspective of subsistence strategies, they are in line with current research on the topic, which shows that hunting and fishing were practiced in the region in the Early Neolithic, but that their importance declined during the Mid and Late Neolithic (Yangshao and Longshan periods), possibly due to population growth and increased demand for meat for both consumption and ritual purposes. Husbandry, by contrast, developed along with agriculture [72–76].

The original environment of the Guanzhong region has been almost completely erased. Fossil pollen, which is often used to track changing vegetation over time, does not preserve well in the loess soil of the Guanzhong region, and those wetlands, which might have existed, and which would have preserved the pollen record, have been almost completely eliminated by anthropogenic activities [77]. A growing corpus of studies of paleoclimatic indicators, which are discussed more in detail in the following sections, have argued that prehistoric regional vegetation was highly spatially variable with different ecosystems characterizing the three locations, plain, transitional, and plateau, across time. Zooarchaeological finds have also shown important regional differences that are addressed below.

4.1. Early Neolithic (Laoguantai Culture)

Our Early Neolithic assemblages come from the transitional zone. While the fragmentary distribution of the published material (especially old reports) may have led to some data being overlooked, the paucity of information reflects the low number of Early Neolithic sites discovered in the Guanzhong region. There are only 20 or so small settlements, which have not all been reported archaeologically and zooarchaeologically [58,78]. This region may have originally been scarcely populated, or the continual migration of the

river channels might have erased the presence of such settlements from the archaeological record [77]. However, it is also possible that future research will recover further sites.

The faunal assemblages mostly include wild species, of which deer are the most prevalent. Palaeoecological studies undertaken in the region suggest that gullies and valleys were covered by forests and small grassland patches, therefore, the abundance of cervids is unsurprising [79–81]. The same habitat could have been shared by other wild hoofed animals, such as wild horses and Sumatran Rhinos, and carnivores, like bears and wild canids, which are also present in our Early Neolithic faunal assemblages. The discovery of golden snub-nosed monkeys in Guantaoyuan also suggests that the area was still forested during this period [82–84].

The pigs in these Early Neolithic sites would have been predominantly wild, with perhaps a few domestic or semi-domestic specimens. Although pigs seem to have been domesticated at around 7000 BP in Central Shaanxi [65,66], distinguishing wild and domestic specimens in these early stages of domestication has proven to be problematic. One problem is that the domestication of pigs probably progressed through a "commensal" pathway in three phases, "dependence", "initial exploitation" and "exploitation", with a high degree of interbreeding between domestic and wild individuals [66,67]. This makes a clear-cut taxonomic identification problematic. Methodologically, dental size and morphology have been the dominant technique to distinguish between wild and domestic pigs [85]. Reference, however, has usually been taken from larger western specimens of Eurasian boar [86], which, as noted by [87], may not be appropriate for comparison with inherently smaller Chinese pigs. C and N isotopes analysis increasingly used to assess domestication by examining the nutrition of individual specimens, has produced controversial results for pre-Yangshao pigs in Dadiwan [88–90].

Those few bovines and caprine specimens found in the Early Neolithic faunal assemblages were wild specimens. For bovines, more detailed information has been provided in the reports, where they were identified as wild water buffalos. Although many aspects of cattle domestication are still poorly understood, the sharp increase in specimens in the Late Neolithic would indicate that it occurred in this period or slightly earlier, thus supporting the wild status of our specimens [91–93]. The reports give little data on the caprines recovered. It is believed that domestic sheep and goats were introduced into China from Western Asia through the Hexi corridor ca. 3000–2500 BCE [2,6,94]. Early Neolithic caprines from our sites were, therefore, presumably wild. However, the recent discovery of domestic sheep's remains dating to 6000 BCE in Southern Kyrgyzstan [95], leaves room for further research on the timing and modes of introduction of this taxon into China.

The profile for our sites suggests the existence of hunters in the transitional zone, who mainly preyed on deer. Cervids mostly require woodlands and grasslands. Palaeoecological research indicates that, indeed, the gullies and valleys north of the plain were covered by forests in the Early Neolithic period [79–81]. Therefore, it is reasonable to argue that Early Neolithic communities likely exploited their immediate environs to some extent. This included wetlands, which were likely relatively extensive [96]. The exploitation of freshwater resources—mollusks and fish for food, and shells for making tools and ornaments—has been attested by recent studies on aquatic finds in Guantaoyuan [16,97].

There has only been limited research to date on the agriculture in this region during the Early Neolithic [98], however, the contribution of farming to local subsistence strategies was presumably small. There is significant data to affirm the presence of agricultural practice in the contemporaneous Peilingang (裴李岗) and Cishan (慈山) cultures, in present-day Henan Province [19,99]. Domestic pigs and dogs have been found to be relatively abundant [66,100]. Fowl were also recovered and they are usually presumed to be chickens or pheasants, although the early date of bird domestication in Central China is somewhat controversial [101,102].

In contrast to the faunal assemblages found in Henan, the faunal assemblages in the Guanzhong region are more consistent with low-investment or incipient farming profiles than cultavist or pastoralist profiles. There is also very limited evidence for anthropogenic

deforestation for agricultural or husbandry purposes during the Early Neolithic, with even deforestation through fire apparently being absent [103]. There is some evidence of incipient farming at the Dadiwan site. Isotope analysis of pig and human bones at this site provides some convincing (though not definitive) evidence for pig domestication [88]. Similarly, the retrieval of some broomcorn millet (*Panicum miliaceum*) at the site represents the earliest potential evidence to date of regional millet cultivation [98].

4.2. Mid-Neolithic (Yangshao Culture)

Our dataset for the Mid Neolithic is richer than that of the Early Neolithic, with data being available for all three zones, plain, transitional, and plateau. When compared to the Early Neolithic, the number of sites discovered in Guanzhong is two orders of magnitude larger (ca. N = 1500 compared to ca. N = 20 in the Early Neolithic) [78]. It is difficult to ascertain whether the area came to be more extensively occupied during the Mid Neolithic, if the sites are better preserved during this period due to changes in site selection criteria or environmental factors, or if research is biased by selective archaeological excavations. It is likely to be a mix of all three factors, Chinese archaeologists have to date shown greater interest in the large Neolithic sedentary centers, which formed the foundations of the Chinese Civilization [2,52,53]. Yangshao cultural sites have been well studied in terms of agricultural development and diversification, as well as the rise of intensive animal husbandry [88,104]. It is these factors, prompted by favorable climatic conditions of the Holocene Climatic Optimum, which appear to have been the prevailing forces behind the demographic growth and more extensive land occupation present in this region during this period [105–107].

In the plain, the faunal assemblages are dominated by domestic species including a large number of pigs, alongside fewer fowl and dogs. The domestication status of these animals has been assessed by zooarchaeological methods [85,108–112], isotopic, and DNA research [113–115]. Deer were exploited, as well as local freshwater sources, fish, turtles, and mollusks, for subsistence, tool making, and decorations [16,116]. This zooarchaeological profile is consistent with a relatively sedentary lifestyle, in which cultivation and pig husbandry were the main means of subsistence and were supplemented by hunting and fishing.

Early Yangshao sites in the plain, such as Banpo (半坡) or Jiangzhai, were small and likely occupied discontinuously (but repetitively) [117,118]. The presence of fences in these sites suggests, however, that livestock husbandry was already an established practice [119,120]. In time settlements became progressively larger, suggesting an increase in population, and were occupied more consistently for more prolonged periods of time [116]. Water management constructions, such as ditches for drainage may have been intended to mitigate the frequent flooding of the loess-heavy Luo, Jing, and Wei rivers [121,122]. Such water management constructions could also have assisted cultivation. Evidence of localized fires related to anthropogenic activities, such as vegetation clearance for land reclamation, further supports the presence of intensive agriculture during the Mid Neolithic [103]. Most importantly, archaeobotanical and isotopic research has indicated that substantial cultivation of dominantly dry crops—broomcorn millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*)—was established in the plain, in order to feed both humans and livestock [74,123,124]. As the yield of foxtail millet is higher than that of broomcorn millet, its introduction in the Wei River plain could be one of the factors behind the increase in population and the intensification of husbandry during the Mid-Neolithic [88]. It also suggests that the climate may have been more humid, as foxtail millet is less draught-tolerant than its broomcorn counterpart. Phytolith evidence for rice (*Oryza sativa*) recovered in at least two of our sites, Quanhucun and Yangguanzhai, indicates greater access to water at these sites [104].

The discovery of foxtail millet and rice in Guanzhong raises also the question of possible interactions between the Central Plain of Henan with the communities in the Guanzhong region during the Mid Neolithic. Foxtail millet is common in the eastern

regions of China throughout the Neolithic, however, it has not been frequently found in sites in Guanzhong until the Mid-Neolithic period [125]. Early evidence of mixed rice–millet farming has been discovered in Peiligang cultural sites in eastern and central China [53,126]. The westward spread of crops seems to have occurred along with certain types of pottery, by the gradual migration of small communities of farmers [126].

Faunal assemblages recovered from the transitional zone show some degree of continuity in animal exploitation with the Early Neolithic, with a high proportion of deer and a fairly high proportion of small mammals, and a lower, yet significant, presence of pigs. Deer are the most prevalent species, which indicates that intensive hunting on the hills and gullies remained a factor in the local subsistence. However, domestic pigs raised on fodder [88,127–129] would have provided a stable meat supply, making intensive hunting—which is high risk and does not provide a secure form of sustenance—unnecessary [130]. It is possible that deer were hunted for more than just their meat. Hunting was possibly a resource collection activity in the transitional zone [98] especially since deer bones, in particular metapodials and antlers, are good for tool making, since they are straight, dense, and easy to shape. At Wayaogou 4% NISP of deer elements were reported as being worked, and they make up 95% of the whole assemblage of worked bones at the site [131]. The acquirement of skin and leather could also have been other reasons for hunting aside from meat.

The presence of deer, and the great majority of sika and roe deer, suggests that the surrounding area, although not necessarily directly adjacent to the site, was formed of scrubby forest interspersed with meadowland. This habitat would also have been ideal for hares, which were similarly well represented in the assemblages. Hare bones were tested isotopically, revealing that their C3-based diet was different from the C4-based one of the humans, pigs, and dogs. This indicates that they were hunted at some distance from the site, possibly even in plateaus, where hares have been abundantly found in relation to settlements (see below). By contrast, isotopic results for rat bones indicated that they shared a similar diet with humans and domestic animals, suggesting that they live in, or very close to human settlements [127]. Insufficient bovine and caprine skeletal elements (0.92% and 0.22% NISP on average respectively) are present for the domestication status of these taxa to be established with any degree of certainty.

The plateau is characterized by a high proportion of small mammals, along with a significant presence of pigs. This suggests that, while the economy may have been dependent upon pig husbandry for meat, small game rodents were also exploited as a source of meat/marrow and fur. It is usually difficult to evaluate the presence of small mammals in sites, as they may have been deposited through accidental intrusion, by non-human predators, or as by-products of human habitat niches, which created favorable contexts for these taxa. However, given the relatively high quantity and concentration of specific *lepus* sp. in these settlements, it can be suggested that their deposition was probably related to subsistence, and may be taken as evidence of some hunting activity. Bone and stone hunting tools discovered in the sites support this conclusion [132]. Hunting may have occurred near, around, or in the site: results of isotope analysis on hare bones from Yangjiesha have revealed that these animals shared a C4-based diet similar to humans and pigs, suggesting some form of commensal relationship with humans [133].

Deer did not play a significant role in the regional economy. This can be understood in the context of different ecological conditions. Early studies, largely based upon written sources, claimed that the plateau was heavily forested in the mid-Holocene [40]. However, more recent research into climatic indicators has revealed that this was never the case: the plateau appears to have always been dominated by grasslands with no large areas of stable forest vegetation [80,81,134]. This is a niche environment, which would only have supported certain herbivores, including a few deer species, and small mammals, such as hares. Increasing human disturbance in the landscape by burning for land reclamation [103] would also have further reduced the habitat for deer. At the same time, the loess friability and porosity would have made the area appropriate for plowing, draining, and growing

roots for millet. There is evidence of millet consumption at the Yangjiesha site, where fairly abundant grains of broomcorn and foxtail taxa were recovered [135].

4.3. Late Neolithic (Longshan)

The dataset for the Longshan period is smaller than the one for Yangshao, and most of the data comes from the plateau, with only one site with a faunal profile available for the plain and the transitional zone, respectively. While the above-mentioned research bias likely affected the sites' distribution to some extent, this scenario may also reflect the decrease in density of human occupation in the Wei basin, and a relative increase in Northern Shaanxi during the Late Neolithic. This has largely been attributed to northward human migrations from the plain, and southward migration of communities from Inner Mongolia, which are believed to have occurred as a response to climatic deterioration [42,59,60].

Our evidence shows that the Late Neolithic was characterized by a general increase in caprines and bovines, at the expense of pigs, across the whole Guanzhong area. Diversified use of animal resources might have augmented human adaptability to the progressively cold and dry climate, which followed the Holocene Climatic Optimum [136–138]. Climatic deterioration had a significant impact on agriculture. Foxtail millet became the most important crop, although broomcorn millet and rice were also cultivated in some areas [126,139]. The reorganization of agricultural production may have led to an adjustment of subsistence strategies in different regions in response to various degrees of climatic deterioration [140,141].

There is only one faunal profile for the plain during this period, from the Kangjia site. The three main domestic taxa (pig, cattle, and caprine) are all fairly well represented as well as wild species. This profile suggests that pig husbandry was still central in the local economy, although it was increasingly supplemented by herding and hunting.

Deer are prevalent. Although the % NISP may have been boosted by antler fragments (which make up 22% of the deer NISP), this points to hunting as being a significant activity for the community. As discussed above, the presence of domestic species at the site would reduce the need to hunt for meat and suggests that deer were exploited for other purposes. In Kangjia, deer bones and antlers were important materials for producing utilitarian tools and oracle bones. Oracle bones were crucial tools for divination and their processing has been associated with the emergence of social complexity, with a gradual emergence of craft and ritual specialists taking control over ritual practices from the Late Neolithic onwards [142]. The relationship between hunting and social stratification has been suggested by ancient written sources and archaeological evidence, according to which hunting was a significant social activity carried out by the elites in the pre-Shang and early Shang periods [143]. It is apparent that Longshan cultural communities had already undertaken the process of social stratification [144]. It is therefore possible that in addition to complementing the community's diet, hunting deer was a symbol of emerging social power.

Domestic species, including pigs, cattle, and caprines are all well-represented. The presence of domestic cattle and caprine specimens at these sites aligns with previous research, which indicates that these species had been introduced into China by the Late Neolithic [2,6,93,145,146]. Although pigs would still have represented a significant source of meat, it appears that cattle and caprines would have also been raised for their meat and their secondary products. It is possible that cattle were also employed for draught or transportation, however, paleopathological data for the bones in this assemblage are insufficient for firm conclusions to be drawn.

Climatic deterioration, alongside the frequent floods, would have affected agriculture on the plain, reducing the viable arable land area, especially for millet, which requires dry cultivation. However, this land could still have been suitable for growing rice [59,104,116]. In order to cope with changing conditions, the local economy, previously based on dry agriculture and pig husbandry, may have been integrated with some form of bovid herding. This implies a wider and seasonal use of the surrounding environment, possibly transhumance into the valleys of the transitional zone [147].

The faunal profile of the transitional zone shows a prevalent presence of deer and a significant proportion of pigs and cattle. The report of the faunal remains from Gongjiawan suggests that deer were semi-domestic. While there is no sufficient zooarchaeological data to confirm this hypothesis, and no relevant research has been conducted on deer domestication, it is plausible that these animals would have orbited around the settlements for food and interacted with humans to some degree. Further zooarchaeological research and isotopic analysis would provide some clarification for this question.

The presence of fairly numerous domestic species, suggests that deer was exploited for purposes, other than meat acquirement. Deer skeletal elements were used for tool-making. Moreover, there is clear evidence for hunting being a significant activity in the transitional zone, rooted in the early communities of hunters-gatherers that inhabited the region in the Early Neolithic, and even prior to that [98], and it may have evolved in a symbolic social practice [143].

The dominant presence of sika deer in Gongjiawan suggests the existence of fairly extensive temperate, broad-leaf deciduous forests and woodlands, which would have been necessary for this species to proliferate [71]. Persisting relatively humid conditions are evidenced by discoveries of local freshwater mollusk shells, although their quantity and variety significantly reduced compared to the Mid Neolithic [16,71].

Dry agriculture, which had become increasingly difficult in the plain, may still have been practiced to some degree in the transitional zone [59,148,149], however, insufficient analyses have been undertaken to date in this section of the Guanzhong region. This lacuna could also be symptomatic of a relative decline of agriculture in the region in favor of other activities. Deterioration in climatic conditions would have led to cultivation being less productive [64], however, there is no notable change in demography [149]. In order to support the community, subsistence strategies would have shifted toward (or have been heavily supplemented by) herding of caprines and cattle. If agriculture was not fully productive, it would have provided a limited surplus to feed livestock. In this regard, bovid husbandry would be more efficient than raising pigs, since bovids do not compete with humans for food. They would also be used for secondary products such as milk, hides, and wool [7].

The climatic deterioration during the Longshan period affected the three zones outlined in this study to varying degrees, with the transition in climate being most intense in the plateau [64]. This is reflected in the faunal assemblages from the four relevant sites, which display the use of a diversified set of taxa, with a prevalence of caprines, and a fair proportion of other domestic and wild species. The profile is consistent with an incipient mixed agro-pastorist economy.

Wild fauna still played a significant role in the regional economy, but the deer was little represented. A large majority of deer were sika. According to C13 isotopic research for Shimao and Gaojiawan, they survived on a relatively rich C4 diet, suggesting that they interacted with humans, perhaps by living close to the sites [150]. This, in turn, may indicate that the ecological deterioration, brought about by the increasingly dry and cold climate (and farming-related anthropogenic activities), may have led deer to establish some form of commensal relationship with humans for survival. The high proportion of wild horses (*Equus ovodovi*) in Miaoliang (70% NISP) suggests that hunting was still a significant practice, either to acquire meat, material for making tools, or social status, as discussed above.

Agriculture was practiced [140,151] along with pig husbandry, which was still an important activity for meat provision. It was, however, supplemented with bovid herding, which appears to have become the staple form of subsistence. Research on paleoclimate by [64,152] has shown that climatic deterioration towards aridity in the Loess Plateau caused many agricultural economies to shift toward agro-pastoralism and mobile pastoralism from the beginning of the second millennium BCE. The diversified use of faunal resources in the plateau during the Late Neolithic can represent the early stages of this process. While bovids are fairly tolerant of arid conditions, pigs require a plentiful and dependable source

of water [153]. The increase in caprines, in particular, may also be related to the southern migration of pastoralist communities from Inner Mongolia, which has been mentioned in written sources [60] and supported archaeologically [113].

The diversification of the regional economy should also be considered from the perspective of an incipient regional social complexity during the Longshan period [144]. In Shimao, a large walled center, which survived intensive millet agriculture [140], the proportion of pigs is larger compared to other sites. By contrast, in Muzhuzhuliang, a great deal of the local economy was based on herding, with sheep being exploited for their secondary products—milk, skin, and wool—in addition to their meat [154]. Analyses in Miaoliang suggest that foxtail millet farming production was likely not sufficient to feed the community, which in turn would have to rely on sheep and cattle herding and horse hunting [151]. Notably, the horse species hunted by the resident of the Miaoliang site, *Equus ovodovi*, had long been believed to be extinct in the Pleistocene. Only recent genetic evidence on various groups of remains, including those from Mioaliang, has indicated that it survived until ~3500 BP [155].

4.4. Bronze Age (Shang, Proto Zhou)

Evidence for the Bronze Age period comes from the plain (1 site) and the transitional zone (5 sites). Coincidentally, these two zones cover what is historically known as the Bin region, which is presumed to be the ancestral land of the Zhou [156,157]. It has recently been intensively investigated by Northwest University and the Shaanxi Institute of Cultural Relics and Archaeology in the context of the project "The Archaeological Investigation of the Ancient Bin Area", with the main goal of understanding the dynamics of the rise of the Zhou dynasty, culminating in the defeat of the Shang. This can explain to a certain extent, the abundance of sites in the plain and the transitional zones, in comparison with the relative paucity of known sites in the plateau zone. Other than Fengxi, zooarchaeological reports used in this study were conducted under the umbrella of this project.

The Bronze Age in Central Shaanxi is characterized by further climatic deterioration, which promoted a further increase in bovid herding. This came to increasingly supplement pig husbandry, although to varying degrees in different zones.

The faunal assemblage from the site of Fengxi, located in the plain of the Wei River Valley, includes a relatively large proportion of pigs [76]. This, along with the discovery of significant quantities of millet [158], suggests that millet-based agriculture and pig husbandry remained the main subsistence pattern on the plain. A significant proportion of cattle and a small number of caprines indicate the existence of supplementary herding activity. Mortality profiles for these taxa suggest that sheep were killed in their early life, thus likely used for meat, while cattle usually survived into adulthood, which would have allowed for their exploitation for milk and, possibly, strength for agricultural purposes.

The faunal assemblages from the transitional zone are dominated by domestic species, wild animals being significantly scarcer. This suggests an economy based on animal husbandry, with a small contribution from other activities. Although the Bronze Age witnessed a general decline in hunting, this may have been practiced to different degrees: while in Zaoshuguonao deer finds were more numerous and hunting tools relatively common, paucity of bones and antlers and the dearth of arrowheads from Xitou and Sunjia indicates that hunting did not form a significant part of the local subsistence [75,159,160]. Ref. [161] argued that, from the Late Neolithic to the Bronze Age, the Guanzhong region underwent a shift from a meat-oriented toward an antler-oriented hunting practice. MNE (Minimum Number of Elements) analysis results for the assemblages in Zaoshuguonao, Sunjia, and Xitou support this conclusion and more specifically indicate that deer antlers and bones were largely exploited for tool-making [160,161]. Archaeological and textual evidence both indicate that during the Bronze Age, the importance of hunting became increasingly social rather than necessary for survival [74,143].

The exploitation of aquatic resources was also nominal. In spite of the increasing regional aridity, the paucity of mollusks and fish in these sites is unexpected, given the

large local water system. While this lack in our assemblages is likely due to poor sieving and taphonomic agents, it can also reflect a decline in fishing practices [16,74].

Bovids were prevalent in the transitional zone during this period. The growing importance of bovines and caprines in the region, as discussed above, could be due to the climate becoming colder and dryer during this period [64,152]. Under such climatic conditions, agricultural productivity would have declined, prompting a wider and more diversified use of the landscape, including expansion into marginal lands, in order to permit bovid herding. Research in Central Asia and Northern China has demonstrated that in the Bronze Age and in the Iron Age a flexible agro-pastoralist system was successfully established in arid and semi-arid regions to cope with this harsher environment [162–164].

Increasing caprine and cattle herding may have occurred under the influence of neighboring pastoral communities in the north, which had started their southward migration during the Late Neolithic. At the end of the second millennium BCE, small and large-scale movements of mobile and semi-mobile pastoralists dramatically increased and created a solid network of interaction across Central Asia, Northwest China, and Mongolia [162,165]. Interactions between residents of Central Shaanxi and northern agro-pastoralists and pastoralist societies are documented by archaeological evidence of steppe-type of artifacts in the former region [157,166] and are further suggested by written sources [156].

Mortality profiles available for four of the sites indicate that the three main domestic species (pigs, cattle, and caprines) were exploited for meat and secondary products to different extents at different sites [75,160,167]. This can be explained in terms of various degrees of reliance on agriculture and discussed from the perspective of emerging social complexity. Few archaeobotanical studies have been undertaken in the transitional zone [168], however different caprines/cattle-pigs ratios can be indicative of more intensive agricultural practices in some sites than in others [31,75]. Zooarchaeological research conducted in Zaoshuguonao and Zoalinhetan has revealed profiles consistent with the former being a larger agricultural center and the second being a smaller settlement [75,169]. Also, our zooarchaeological analysis of Xitou and Sunjia faunal assemblages has revealed a clear size difference in pigs and, especially, in cattle between the two sites. This may reflect diversity in economic structures, with a larger agricultural center requiring sizable animals (i.e., Xitou), and a smaller settlement (i.e., Sunjia), where smaller less-demanding specimens, would be preferred for their secondary products and light work [160].

Evidence of finished and unfished worked bones from all sites indicates that some taxa were exploited for the local production of tools and ritual objects. Not only deer, but also cattle bones, were used to make artifacts. In particular, by the Bronze Age, cattle had become the most important taxa for oracle bone production [142]. Indeed, cattle scapulae were fairly commonly recovered in all our sites, although at Nianzipo, specimens made of horse and other animals' scapulae were also found [167]. This further suggests a certain degree of regional variability in animal exploitation for ritual purposes, which can be related to a greater development of social complexity in the local Bronze Age [75,160,161].

5. Conclusions

This study has found that the Guanzhong region underwent a shift in animal exploitation, from wild species in the Early Neolithic to pig husbandry in the Mid Neolithic, when the area was experiencing the Climatic Optimum and a consequent substantial agricultural development. Climate deterioration from the Late Neolithic meant that localized communities had to adapt to new, less favorable conditions for cultivation. Generally, this appears to have been achieved through the resumption of hunting practices and, especially, the adoption of bovine and caprine herding.

Considering regional ecological variability, we found that even within the limited Guanzhong region (<10,000 km^2) animal utilization varied considerably between three different zones, the Wei River plain, the transitional region, and the Loess Plateau, during the period under analysis. Against expectations, it was found that there was not a gradual

transition in praxis between the Wei River valley and the loess plateau with the hilly transition zone having its own distinct animal exploitation pattern.

In the Mid Neolithic, the economy of the plain was dominated by dry agriculture and pig husbandry. Agriculture and husbandry remained central economic activities even during the climatic deterioration from the Late Neolithic onward: the former, however, would have switched into mixed dry and rice farming, and the latter was integrated with some bovid husbandry and deer hunting. Herded animals were used for their secondary products and aid in agriculture, in addition to their meat. Deer hunting would have provided supplementary meat and important material for tool-making. It also increasingly became a significant social activity, related to emergent social complexity in the Longshan Culture. In the Bronze Age, millet-based agriculture and pig husbandry were still the main subsistence strategies on the plain.

The exploitation of wild species underpinned the socio-economic foundation of the communities of the transitional zone until the Bronze Age. Throughout all the periods under study, deer hunting was particularly important, either for food, tool-making, or practiced for socio-ritual purposes. Pigs appear in significant numbers in the transitional zone, only in the Mid Neolithic, when an intensive agricultural system was developing in the whole Guanzhong region. Climatic deterioration following the Climatic Optimum prompted the need to diversify animal exploitation. In addition to hunted deer, herded bovids became increasingly important, for meat and their secondary products, including as draught animals. Diversification in animals' exploitation could also be favored by incipient social complexity and contacts with mobile and semi-mobile pastoralists from present-day North Shaanxi and Inner Mongolia.

The plateau presented a more complex scenario, partially because of the scarcity of zooarchaeological data, compared to other zones. Pig husbandry and dry-agriculture were practiced in the Mid Neolithic, supplemented by small game rodents, which were either orbiting around the site or were kept captives by the communities. The Late Neolithic witnessed an increase in caprines herding, which was integrated into the local subsistence strategies, perhaps as a consequence of the interactions with pastoral communities in the North. We did not have data for the Bronze Age, however, information collected by isotopic studies suggests that dry-agriculture and pig husbandry was practiced in the plateau during this period [170].

While this research is based on a limited number of sites, in their regional context, the results show the existence of micro-transitions in animal exploitation patterns and a variety of human landscape exploitation strategies on a smaller scale. Spatio-temporal differences in animal exploitation were caused by changes in both the local microclimates and the form of landscape in which the communities were living. In each case, the animals represent efficient exploitation of the immediate environment. These environmental factors were also augmented by internal social developments and interactions with neighboring communities. Further, more extensive and interdisciplinary research in North China would allow for a better understanding of different local zooarchaeological landscapes and, thus, effectively inform research on long-term, large-scale phenomena, such as pastoralism and ecological and climate change.

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Appendix A. Taxonomic Abundance by %NISP for Each of the Sites Considered in This Study

ID	Age	Site	Zone	NISP	% Deer	% Pig	% Sheep/Goat	% Cattle	% Others	Source
1	Early Neolithic	Guantaoyuan	Transitional	405	63.5	4.4	12.1	3.2	16.8	[84,97,171]
2	Early Neolithic	Dadiwan I	Transitional	701	64.3	22.3	0	0.3	13.1	[65]
3	Mid Neolithic	Dadiwan II	Transitional	3505	69.1	25.7	0	1.2	4	[65]
4	Mid Neolithic	Jiangzhai	Plain	1778	63.9	29.3	0	4	2.8	[120]
5	Mid Neolithic	Wayaogou	Transitional	6022	57.1	38.8	0.3	0.5	3.8	[131]
6	Mid Neolithic	Lingkou	Plain	81	30.9	58	6.2	0	4.9	[110]
7	Mid Neolithic	Dadiwan III	Transitional	2533	62.4	34	0	1.9	1.7	[65]
8	Mid Neolithic	Yangguanzhai	Plain	375	3.9	77.3	0	1.7	17.1	[109]
9	Mid Neolithic	Xinglefang	Plain	318	2.2	44.7	0.3	0	52.8 [1]	[108]
10	Mid Neolithic	Quanhucun	Plain	2646	15.1	76	4.1	3.1	1.7	[112]
11	Mid Neolithic	Gongjiawan	Transitional	51	43.1	19.6	0	0	37.3	[148]
12	Mid Neolithic	Dagujie	Plateau	138	15.9	7.3	2.9	0	73.9 [2]	[172]
13	Mid Neolithic	Yangjiesha	Plateau	493	0	15	0.4	0	84.6 [3]	[173]
14	Mid Neolithic	Wuzhuangguoluo	Transitional	NR	0	31	1	0	68	[174]
15	Mid Neolithic	Dadiwan IV	Transitional	3625	41.2	55.1	0	1.9	1.8	[65]
16	Late Neolithic	Kangjia	Plain	320	35.6	15	11.9	15.9	21.6	[69]
17	Late Neolithic	Miaoliang	Plateau	231	6.9	2.6	12.6	10.8	67.1 [4]	[175]
18	Late Neolithic	Gongjiawan	Transitional	27	48.1	11.1	0	11.1	29.7	[71]
19	Late Neolithic	Huoshiliang	Plateau	1111	2.5	12	63	19.5	3	[176]
20	Late Neolithic	Shimao	Plateau	1572	0.1	30.5	42.6	22.7	4.1	[145]
21	Late Neolithic	Muzhuzhuliang	Plateau	2810	NR	17.3	57.1	16.9	8.7	[154]
22	Bronze Age	Sunjia	Transitional	398	10	15.3	29.5	26.6	18.6	[160]
23	Bronze Age	Xitou	Transitional	247	5.2	18.2	20.3	36.8	19.5	[160]
24	Bronze Age	Zaoshuguonao	Transitional	8555	13.8	24.1	22.7	28.7	10.7	[75]
25	Bronze Age	Zaolinhetan	Transitional	1318	3.4	19.5	25	24.3	27.8	[75]
26	Bronze Age	Nianzipo	Transitional	9086	2.6	35.7	0.9	53.2	7.6	[167]
27	Bronze Age	Fengxi	Plain	199	14.6	41.2	8.1	27.5	8.6	[76]

[1] 49% shellfish, [2] 55.7% hare, [3] 67% hare, [4] 67% wild horse.

References

1. Charles, M.; Halstead, P. Biological resources exploitation: Problems of theory and method. In *Handbook of Archaeological Science*; Brothwell, D.R., Pollard, A.M., Eds.; Wiley: Chichester, UK, 2000; pp. 365–378.
2. Yuan, J. *Zhongguo Dongwu Kaoguxue* 中国动物考古学 *(Chinese Zooarchaeology)*; Wenwu Chubanshe: Beijing, China, 2015.
3. Huang, Y. Dongwu guge shuliang fenxi he jiachu xunhua fazhan chu shen 动物骨骼数量分析和家畜驯化发展初深 (Quantitative analysis of animal bones and the initial development of livestock domestication). In *Dongwu Kaogu (Di 1 ji)* 动物考古*(*第*1*辑*)*; Henan Sheng Wenwu Kaogu Yanjiusuo 河南省文物考古研究所, Ed.; Wenwu Chubanshe: Beijing, China, 2010; pp. 2–32.
4. Yuan, J. Lun Zhongguo xin shiqi shidai jumin huoqu roushi ziyuan de fangshi 论中国新石器时代居民获取肉食资源的方式 (Discussing the ways Chinese Neolithic people acquired meat). *Kaogu Xuebao* **1999**, *1*, 1–22.
5. Flad, R.; Yuan, J.; Li, S. Zooarchaeological evidence for animal domestication in Northwest China. In *Late Quaternary Climate Change and Human Adaptation in Arid China*; Madsen, D.B., Chen, F., Gao, X., Eds.; Elsevier: Amsterdam, The Netherlands, 2007; pp. 167–203. [CrossRef]

6. Yuan, J.; Huang, Y.; Yang, M.; Lu, P.; Tao, Y.; Yang, S. Gongyuan qian 2500 nian-gangyuan qian 1500 nian Zhongyuán diqu dongwu kaoguxue yanjiu 公元前2500年/公元前1500年中原地区动物考古学研究 (Zooarchaeological research in the Central Plain from 2500 BCE to 1500 BCE). In *Keji Kaogu (Di 2 ji)* 科技考古 (第2辑); Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo Kaogu Keji Zhongxin 中国社会科学院考古研究所考古科技中心, Ed.; Kexue Chubanshe: Beijing, China, 2007; pp. 12–34.
7. Brunson, K.; He, N.; Dai, X. Sheep, cattle, and specialization: New zooarchaeological perspectives on the Taosi Longshan. *Int. J. Osteoarchaeol.* **2016**, *26*, 460–475. [CrossRef]
8. Li, Z.; Brunson, K.; Dai, L. Zhongyuan diqu xin shiqi shidai dao qingtongqi shidai zaoqi yangmao kaifa de dongwu kaoguxue yanjiu 中原地区新石器时代到青铜器时代早期羊毛开发的动物考古学研究 (Zooarchaeological Research on Wool Explotation Development from the Neolithic to the Early Bronze Age in the Central Plain). *Di Siji Yanjiu* **2014**, *1*, 149–157.
9. Li, Z.; Campbell, R.; Brunson, K.; Yang, J.; Tao, Y. The exploitation of domestic animal products from the Late Neolithic Age to the Early Bronze Age in the heartland of Ancient China. In *Animal Secondary Products: Domestic Animal Exploitation in Prehistoric Europe, the Near East and the Far East*; Greenfield, H.J., Ed.; Oxbow Books: Oxford, UK, 2014; pp. 56–79.
10. Campbell, R.; Zhipeng, L.; Yuling, H.; Yuan, J. Consumption, exchange and production at the Great Settlement Shang: Bone-working at Tiesanlu, Anyang. *Antiquity* **2011**, *85*, 1279–1297. [CrossRef]
11. Hou, Y.; Campbell, R.; Li, Z.; Zhang, Y.; Li, S.; He, Y. The Guandimiao bone assemblage (and what it says about the Shang economy). *Asian Perspect.* **2018**, *57*, 281–310. [CrossRef]
12. Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo Anyang Gongzuo Dui 中国社会科学院考古研究所安阳工作队. Henan Anyang shi Tiesanlu Yinxu wenhua shiqi zhi gu zuofang yizhi 河南安阳市铁三路殷墟文化时期制骨作坊遗址 (Bone-working workshop of the Yinxu cultural period, in Tiesanlu, Anyang, Henan). *Kaogu* **2015**, *8*, 37–62.
13. Elvin, M. *The Retreat of the Elephants: An Environmental History of China*; Yale University Press: New Haven, CT, USA, 2004.
14. Tong, H. Occurrences of warm-adapted mammals in north China over the Quaternary Period and their paleo- environmental significance. *Sci. China Ser. D Earth Sci.* **2007**, *50*, 1327–1340. [CrossRef]
15. Lan, W.; Zhang, J.; Weng, Y.; Fan, W. Fu tu jisheng chong kaoguxue fangfa de tansuo yu shijian 腹土寄生虫考古学方法的探索与实践 (Exploration and practice of archaeolological methods to study parasites in soils). *Kaogu* **2011**, *11*, 87–93.
16. Li, F.; Wu, N.; Lu, H.; Zhang, J.; Wang, W.; Ma, M.; Zhang, X.; Yang, X. Mid-Neolithic exploitation of mollusks in the Guanzhong Basin of Northwestern China: Preliminary results. *PLoS ONE* **2013**, *8*, e58999. [CrossRef]
17. You, Y.; Chen, W. The uses of domesticated animals at the Early Bronze Age City of Wangjinglou, China. *Int. J. Osteoarchaeol.* **2021**, *31*, 789–800. [CrossRef]
18. Wang, C.; Lu, H.; Gu, W.; Zuo, X.; Zhang, J.; Liu, Y.; Hu, Y. Temporal changes of mixed millet and rice agriculture in Neolithic-Bronze Age Central Plain, China: Archaeobotanical evidence from the Zhuzhai site. *Holocene* **2017**, *28*, 738–754. [CrossRef]
19. Zhang, J.; Lu, H.; Gu, W.; Wu, N.; Zhou, K.; Hu, Y.; Xi, Y.; Wang, C. Early Mixed Farming of Millet and Rice 7800 Years Ago in the Middle Yellow River Region, China. *PLoS ONE* **2012**, *7*, e52146. [CrossRef] [PubMed]
20. Li, K.; Gao, W.; Wu, L.; Hu, H.; Gong, P.; Li, S.; Jin, R.; Si, Y. Spatial expansion of human settlement during the Longshan Period (~4.5–~3.9 ka BP) and its hydroclimatic contexts in the Lower Yellow River floodplain, Eastern China. *Land* **2021**, *10*, 712. [CrossRef]
21. Ma, X. Henan Lingbao Xipo yizhi dongwu qun ji xiangguan wenti 河南灵宝西坡遗址动物群及相关问题 (Fauna at Xipo site in Lingbao, Henan, and relevant issues). *Caoyuan Wenwu* **2007**, *4*, 48–61.
22. Zhang, Q.; Hou, Y.; Li, X.; Styring, A.; Lee-Thorp, J. Stable isotopes reveal intensive pig husbandry practices in the middle Yellow River region by the Yangshao period (7000–5000 BP). *PLoS ONE* **2021**, *16*, e0257524. [CrossRef]
23. von Falkenhausen, L. On the historiographical orientation of Chinese archaeology. *Antiquity* **1993**, *67*, 839–849. [CrossRef]
24. Liao, Y.; Lu, P.; Mo, D.; Wang, H.; Storozum, M.J.; Chen, P.; Xu, J. Landforms influence the development of ancient agriculture in the Songshan area, central China. *Quat. Int.* **2019**, *521*, 85–89. [CrossRef]
25. Jia, X.; Li, H.; Lee, H.F.; Liu, Z.; Lu, Y.; Hu, Z.; Sun, X.; Zhao, Z. Agricultural adaptations to the topography and climate changes in Central China during the mid- to late-Holocene. *Holocene* **2021**, *31*, 1705–1715. [CrossRef]
26. Lam, Y.H.; Brunson, K.; Meadow, R.; Jing, Y. Integrating taphonomy into the practice of zooarchaeology in China. *Quat. Int.* **2010**, *211*, 86–90. [CrossRef]
27. Mainland, I. The uses of archaeological faunal remains in Landscape Archaeology. In *Handbook of Landscape Archaeology*; David, B., Thomas, J., Eds.; Routledge: London, UK; New York, NY, USA, 2008; pp. 544–550.
28. Zohary, E.T.; Tchernov, E.; Horwitz, L.K. The role of unconscious selection in the domestication of sheep and goats. *J. Zool.* **1998**, *245*, 129–135. [CrossRef]
29. Crabtree, T.J. Zooarchaeology in Oceania. *Archaeol. Ocean.* **2016**, *51*, 1–6. [CrossRef]
30. Sabatini, S.; Bergerbrant, S.; Brandt, L.Ø.; Margaryan, A.; Allentoft, M.E. Approaching sheep herds origins and the emergence of the wool economy in continental Europe during the Bronze Age. *Archaeol. Anthropol. Sci.* **2019**, *11*, 4909–4925. [CrossRef]
31. Miller, N. Farming and herding along the Euphrates: Environmental constraint and cultural choice (fourth to second millennia B.C.). *MASCA Res. Pap. Sci. Archaeol.* **1997**, *14*, 123–132.
32. Marshall, F.; Capriles, J.M. Animal Domestication and Pastoralism: Socio-Environmental Contexts. In *Encyclopedia of Global Archaeology*; Smith, C., Ed.; Springer: New York, NY, USA; Heidelberg, Germany; Dordrecht, The Netherlands; London, UK, 2014; pp. 249–257.

33. Arnold, E.R.; Greenfield, H. An archaeological perspective on the origin of vertical transhumant pastoralism and the colonization of marginal habitats in temperate south-eastern Europe. In *Colonization, Migration and Marginal Areas: A Zooarchaeological Approach*; Mondini, M., Munoz, S., Winkler, S., Eds.; Oxbow Books: Oxford, UK, 2004; pp. 296–317.
34. Robinson, J. Ecological niche define the limits of pig agroecology: A comparative review of evidence from early centres of sedentary agriculture. *Agroecol. Sustain. Food Syst.* **2019**, *43*, 704–717. [CrossRef]
35. Zhongguo Shehui Xueyuan Kaogu Yanjiusuo 中国社会科学院考古研究所. *Zhongguo Kaoguxue Zhong Tan Shisi Niandai Shujuji* 中国考古学中碳十四年代数据及 *(C14 Data in Chinese Archaeology)*; Wenwu Chubanshe: Beijing, China, 1991.
36. Stuart, A.J. *Pleistocene Vertebrates in the British Isles*; Longman: London, UK, 1982.
37. Yalden, D.W. *The History of British Mammals (Poyser Natural History S.)*; T. and A. D. Poyser Ltd.: London, UK, 1999.
38. Lander, B. Birds and beasts were many: The ecology and climate of the Guanzhong Basin in the Pre-Imperial Period. *Early China* **2020**, *43*, 207–245. [CrossRef]
39. Li, X. *Shui Jing Zhu Xiao Jian Tu Shi. Weishui Liuyu Zhu Pian* 水经注校笺图释●渭水流域诸篇 *(Notes on the Jing River System: Various Articles Abouth the Wei River Basin)*; Fudan Daxue Chubanshe: Shanghai, China, 2017.
40. Shi, N. *Zhongguo Lishi Dili Gangyao* 中国历史地理纲要 *(An Outline of Chinese Historical Geography)*; Shanxi Renmin Chubanshe: Taiyuan, China, 1991.
41. Nylan, M. Supplying the Capital with water and food. In *Chang'an 26 BCE: An Augustan Age in China*; Nylan, M., Vankeerberghen, G., Eds.; University of Washington Press: Seattle, WA, USA, 2015; pp. 99–130.
42. Wang, L.; Cui, Y. The Spatiotemporal pattern of cultural evolution response to agricultural development and climate change from Yangshao Culture to Bronze Age in the Yellow River Basin and surrounding regions, North China. *Front. Earth Sci.* **2021**, *9*, 657179. [CrossRef]
43. Lander, B. Environmental Change and the Rise of the Qin Empire: A Political Ecology of Ancient North China. Ph.D. Thesis, Columbia University, New York, NY, USA, 2015.
44. Sang, G.; Chen, X. Ba he zhongxiayou hedao lishi bianqian jiqi huanjing yingxiang 灞河中下游河道历史变迁及其环境影响 (Historical changes in the course of the Ba River, at its middle and lower reaches, and its environmental impact). *Zhongguo Lishi Dili Luncong* **2007**, *2*, 24–29.
45. Wang, Z.; Tang, Z. *Atlas of Woody Plants in China: Distribution and Climate*; Springer: Heidelberg, Germany, 2011.
46. Van de Weghe, N.; Docter, R.; De Maeyer, P.; Bechtold, B.; Ryckbosch, K. The triangular model as an instrument for visualising and analysing residuality. *J. Archaeol. Sci.* **2007**, *34*, 649–655. [CrossRef]
47. Grayson, D.K. On the quantification of vertebrate archaeofaunas. In *Advances in Archaeological Method and Theory*; Schiffer, M.B., Ed.; Academic Press: New York, NY, USA, 1979; pp. 199–237.
48. Gilbert, A.S.; Singer, B.; Perkins, D. Quantification experiments in computer simulated faunal collections. *Ossa* **1982**, *8*, 79–94.
49. O'Connor, T.C. *The Archaeology of Animal Bones*; Sutton Publishing: Stroud, UK, 2000.
50. Lyman, R.L. *Vertebrate Taphonomy*; Cambridge University Press: Cambridge, UK, 1994.
51. Watson, J.P.N. The estimation of the relative frequencies of mammalian species: Khirokitia 1972. *J. Archaeol. Sci.* **1979**, *6*, 127–137. [CrossRef]
52. Lin, M. A statistical view for Chinese zooarchaeology: From the Neolithic to Pre-Han periods. *Archaeol. Anthropol. Sci.* **2016**, *8*, 89–95. [CrossRef]
53. Underhill, A.P. Current Issues in Chinese Neolithic Archaeology. *J. World Prehistory* **1997**, *11*, 103–160. [CrossRef]
54. Buitenhuis, H. A quantitative approach to species determination in Ovicapridae. In *Archaeology of the Near East II*; Buitenhuis, H., Uerpmann, H., Eds.; Backhuys: Leiden, The Netherlands, 1995; pp. 140–155.
55. Salvagno, L.; Albarella, U. A morphometric system to distinguish sheep and goat postcranial bones. *PLoS ONE* **2017**, *12*, e0178543. [CrossRef] [PubMed]
56. Zeder, M.A.; Lapham, H. Assessing the reliability of criteria used to identify postcranial bones in sheep, *Ovis*, and goats, Capra. *J. Archaeol. Sci.* **2010**, *37*, 2887–2905. [CrossRef]
57. Zeder, M.A.; Pilaar, S. Assessing the reliability of criteria used to identify mandibles and mandibular teeth in sheep, *Ovis*, and goats, Capra. *J. Archaeol. Sci.* **2010**, *37*, 225–242. [CrossRef]
58. Guojia Wenwu Ju 国家文物局. *Zhongguo Wenwu Dituji: Shaanxi Fence* 中国文物地图集:陕西分册 *(Atlas of Chinese Cultural Relics: Shaanxi Volume)*; Wenwu Chubanshe: Beijing, China, 1999.
59. Cui, J.; Sun, Z.; Burr, G.S.; Shao, J.; Chang, H. The great cultural divergence and environmental background of Northern Shaanxi and its adjacent regions during the late Neolithic. *Archaeol. Res. Asia* **2019**, *20*, 100164. [CrossRef]
60. Huang, C.; Zhao, S.; Pang, J.; Zhou, Q.; Qian, S.; Li, P.; Mao, L.; Ding, M. Climatic aridity and the relocations of the Zhou Culture in the Southern Loess Plateau of China. *Clim. Change* **2003**, *61*, 361–378. [CrossRef]
61. Li, B.; Pan, R.; Oxnard, C.E. Extinction of snub-nosed monkeys in China during the past 400 years. *Int. J. Primatol.* **2002**, *23*, 1227–1244. [CrossRef]
62. Lander, B.; Brunson, K. Wild mammals of ancient north China. *J. Chin. Hist.* **2018**, *2*, 291–312. [CrossRef]
63. Huang, C.; Zhou, J.; Pang, J.; Han, Y.; Hou, C. A regional aridity phase and its possible cultural impact during the Holocene Megathermal in the Guanzhong Basin, China. *Holocene* **2000**, *10*, 135–143. [CrossRef]
64. Huang, C.; Pang, J.; Zhou, Q.; Chen, S. Holocene pedogenic change and the emergence and decline of rain-fed cereal agriculture on the Chinese Loess Plateau. *Quat. Sci. Rev.* **2004**, *23*, 2525–2535. [CrossRef]

65. Qi, G.; Lin, Z.; An, J. Dadiwan Yizhi Dongwu Yicun Jianding Baogao 大地湾遗址动物遗存鉴定报告. In *Qin'an Dadiwan: Xinshiqi Shidai Yizh Fajue Baogao* 秦安大地湾：新石器时代遗址发掘报告 *(Qin'an Dadiwan: A Neolithic Site Excavation Report)*; Gansu Sheng Wenwu Kaogu Yanjiusuo, Ed.; Wenwu Chubanshe: Beijing, China, 2006; pp. 861–910.
66. Yuan, J.; Flad, R. Pig domestication in ancient China. *Antiquity* **2002**, *76*, 224–232.
67. Zeder, M.A. Pathways to animal domestication. In *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*; Gepts, P., Famula, T.R., Bettinger, R., Eds.; Cambridge University Press: Cambridge, MA, USA, 2012; pp. 227–259.
68. Rowley-Conwy, P.; Albarella, U.; Dobney, K. Wild. Distinguishing wild boar from domestic pigs in prehistory: A review of approaches and recent results. *J. World Prehistory* **2012**, *25*, 1–44. [CrossRef]
69. Liu, L.; Yan, Y.; Qin, X. Shaanxi Linyu Kangjia Longshan wenhua yizhi 1990 nian fajue dongwu yicun 陕西临渔康家龙山文化遗址 1990 年发掘动物遗存 (Animal remains excavated in 1990 at the Longshan cultural site of Kangjia, in Linyu, Shaanxi). *Huaxia Kaogu* **2001**, *1*, 3–24. [CrossRef]
70. Knight, B.; Milner, N.; O'Connor, T.; Elliott, B.; Robson, H.K.; Buckley, M.; Witkowski, P.; Charlton, S.; Craig, O.; Collins, M. Faunal remains: Results by species. In *Star Carr Volume 2: Studies in Technology, Subsistence and Environment*; Milner, N., Conneller, C., Taylor, B., Eds.; White Rose University Press: York, UK, 2018; pp. 195–254.
71. Hu, S. Shaanxi Danfeng Gongjiawan xin shiqi shidai dongwu guge fenxi 陕西丹凤巩家湾新石器时代动物骨骼分析 (Analysis of Neolithic animal bones in Gongjiawan, Danfeng, Shaanxi). *Kaogu Yu Wenwu* **2001**, *6*, 53–57.
72. Fu, Y. Shaanxi fufeng anban yizhi dongwu yicun de yanjiu 陕西扶风案板遗址动物遗存的研究. In *Fufeng Anban Yizhi* 扶风案板遗址 *(Remains at Anban, in Fufeng)*; Xibei Daxue Wenbo Xueyuan Kaogu Zhuanye 西北大学文博学院考古专业, Ed.; Kexue Chubanshe: Beijing, China, 2000; pp. 290–294.
73. Zhang, Y. Xunyi xiaweiluo yizhi dongwu yicun jianding baogao 旬邑下魏洛遗址动物遗存鉴定报告. (Report on the identification of animal remains at xiaweiluo site in xunyi). In *Xunyi Xiaweiluo Yizhi* 旬邑下魏洛遗址; Xibei Daxue Yichan Wenhua Xueyuan Shaanxi Kaogu Yanjiusuo 西北大学遗产文化学院 陕西考古研究所, Ed.; Kexue Chubanshe: Beijing, China, 2006; pp. 546–548.
74. Cheng, P.; Zhou, W.; Gong, W.; Zhu, Z.; Yang, Y.; Burr, G.S.; Du, H. Paleodietary analysis of humans in Guanzhong Basin, Shaanxi Province, since 8000 BP. *Radiocarbon* **2017**, *59*, 1435–1446. [CrossRef]
75. Li, Y.; Zhang, C.; Wang, Z.; Dou, H.; Liu, H.; Hou, F.; Ma, M.; Qian, Y.; Chen, H. Animal use in the late second millennium BCE in Northern China: Evidence from Zaoshugounao and Zaolinhetan in the Jing River valley. *Int. J. Osteoarchaeol.* **2020**, *30*, 318–329. [CrossRef]
76. Yuan, J. Fengxi chutu dongwu guge yanjiu baogao 沣西出土动物骨骼研究报告 (Report on the research on animal skeletal elements unearthed in Fengxi). *Kaogu Xuebao* **2000**, *2*, 246–256.
77. Zhang, W.; Lu, H.; Li, C.; Dodson, J.; Meng, X. Pollen preservation and its potential influence on paleoenvironmental reconstruction in Chinese loess deposits. *Rev. Paleobotany Palynol.* **2017**, *240*, 1–10. [CrossRef]
78. Liu, L. *The Chinese Neolithic: Trajectories to Early States*; Cambridge University Press: New York, NY, USA, 2004.
79. Liu, T.; Guo, Z.; Wu, N.; Lu, H. Prehistoric vegetation on the Loess Plateau: Steppe or forest? *J. Southeast Asian Earth Sci.* **1996**, *13*, 341–346.
80. Lu, H.; Liu, D.; Guo, Z. Natural vegetation of geological and historical periods in Loess Plateau. *Chin. Sci. Bull.* **2003**, *48*, 411–416. [CrossRef]
81. Shen, H.; Li, X.; Spengler, R.; Zhou, X.; Zhao, K. Forest cover and composition on the Loess Plateau during the Middle to Late-Holocene: Integrating wood charcoal analyses. *Holocene* **2021**, *31*, 38–49. [CrossRef]
82. Li, B.; Jia, Z.; Pan, R.; Ren, B. Changes in distribution of the snub-nosed monkey in China. In *Primates in Fragments*; Marsh, L.K., Ed.; Kluwer Academic/Plenum: New York, NY, USA; Boston, MA, USA; Dordrecht, The Netherlands; London, UK; Moscow, Russia, 2003; pp. 29–51.
83. Li, Y.; Huang, K.; Tang, S.; Feng, L.; Yang, J.; Li, Z.; Li, B. Genetic structure and evolutionary history of *Rhinopithecus roxellana* in Qinling Mountains, Central China. *Front. Genet.* **2021**, *11*, 611914. [CrossRef] [PubMed]
84. Hu, S. Shaanxi Baoji Guantaoyuan xin shiqi yizhi zhong shouci yu woguo beifang faxian jinsihou deng zhongyao dongwu yicun 陕西宝鸡关桃园新石器遗址中首次于我国北方发现金丝猴等重要动物遗存 (Important animal remains discovered for the first time in northern China, at the Guantaoyuan Neolithic site in Baoji, Shaanxi: The golden snub-nosed monkeys and other fauna). *Shoulei Xuebao* **2006**, *4*, 39–40.
85. Wang, H.; Wang, W.; Hu, S.; Lu, Y.; Ma, D. Weishui liuyu xin shiqi shidai jiazhu de xunhua yu siyang celüe 渭水流域新石器时代家猪的驯化与饲养策略 (Domestication and breeding strategies of domestic pigs in the Neolithic Age in the Wei River Basin). *Kaogu* **2013**, *9*, 87–98.
86. Mayer, J.J.; Novak, J.M.; Brisbin, I.L. Evaluation of molar size as a basis for distinguishing wild boar from domestic swine: Employing the present to decipher the past. In *Ancestors for the Pigs: Pigs in Prehistory*; Nelson, S.M., Ed.; MASCA: Philadelphia, PA, USA, 1998; pp. 39–53.
87. Yuan, J. Zhongguo xin shiqi shidai jiachu qiyuan de wenti 中国新石器时代家畜起源的问题 (The question of the origin of animal domestication in Neolithic China). *Kaogu* **2001**, *5*, 51–58.
88. Barton, L.; Newsome, S.D.; Chen, F.; Wang, H.; Guilderson, T.P.; Bettinger, R.L. Agricultural origins and the isotopic identity of domestication in Northern China. *Proc. Natl. Acad. Sci. USA* **2009**, *106*, 5523–5528. [CrossRef]
89. Wang, X.; Fuller, B.T.; Zhang, P.; Hu, S.; Hu, Y.; Shang, X. Millet manuring as a driving force for the Late Neolithic agricultural expansion of North China. *Sci. Rep.* **2018**, *8*, 5552. [CrossRef]

90. Price, M.; Hongo, H. The archaeology of pig domestication in Eurasia. *J. Archaeol. Res.* **2020**, *28*, 557–615. [CrossRef]
91. Zhang, H.; Paijmans, J.; Chang, F.; Wu, X.; Chen, G.; Lei, C.; Yang, X.; Wei, Z.; Bradley, D.G.; Orlando, L.; et al. Morphological and genetic evidence for early Holocene cattle management in Northeastern China. *Nat. Commun.* **2013**, *4*, 2755. [CrossRef]
92. Cai, D.; Sun, Y.; Tang, Z.; Hu, S.; Li, W.; Zhao, X.; Xiang, H.; Zhou, H. The origins of Chinese domestic cattle as revealed by Ancient DNA analysis. *J. Archaeol. Sci.* **2014**, *41*, 423–434. [CrossRef]
93. Chong, Y. *The Origin of Cattle in China from the Neolithic to the Early Bronze Age*; Bar International Series S2959: Oxford, UK, 2020.
94. Qi, G. Donghuishan mudi shougu jianding baogao 东灰山墓地兽骨坚定报告 (Report on animal bones found at the cemetery of Donghuishan). In *Minyue Donghuishan Kaogu- Siba Wenhua Mudi de Jieshi yu Yanjiu* 民乐东灰山考古- 四坝文化墓地的揭示与研究; Gansu Sheng Wenwu Kaogu Yanjiusuo 甘肃省文物考古研究所, Jilin Daxue Beifang Kaogu Yanjiushi 吉林大学北方考古研究室, Eds.; Kexue Chubanshe: Beijing, China, 1998; pp. 184–185.
95. Taylor, W.T.T.; Pruvost, M.; Posth, C.; Rendu, W.; Krajcarz, M.T.; Abdykanova, A.; Brancaleoni, G.; Spengler, R.; Hermes, T.; Schiavinato, S.; et al. Evidence for early dispersal of domestic sheep into Central Asia. *Nat. Hum. Behav.* **2021**, *5*, 1169–1179. [CrossRef]
96. Feng, Z.; An, C.; Tang, L.; Jull, T.A. Stratigraphic evidence of a Megahumid climate between 10,000 and 4000 years B.P. in the Western Part of the Chinese Loess Plateau. *Glob. Planet. Change* **2004**, *43*, 145–155. [CrossRef]
97. Hu, S.; Zhang, Y.; Zhang, T. Baoji Guantaoyuan yizhi dongwu yicun gu huanjing yiyi 宝鸡关桃园遗址动物遗存古环境意义 (The significance of the animal remains found at Guantaoyuan site in Baoji for palaeoevironmental studies). *Xibei Daxue Xuebao* **2007**, *37*, 115–118.
98. Bettinger, R.L.; Barton, L.; Richerson, P.J.; Boyd, R.; Hui, W.; Won, C. The Transition to agriculture in northwestern China. *Dev. Quat. Sci.* **2007**, *9*, 83–111. [CrossRef]
99. Lu, T. *The Transition from Foraging to Farming and the Origin of Agriculture in China*; John and Erica Hedges: Oxford, UK, 1999.
100. Xiang, H.; Gao, J.; Cai, D.; Luo, Y.; Yu, B.; Liu, L.; Liu, R.; Zhou, H.; Chen, X.; Dun, W.; et al. Origin and dispersal of early domestic pigs in northern China. *Sci. Rep.* **2017**, *7*, 5602. [CrossRef]
101. Xiang, H.; Gao, J.; Yu, B.; Zhou, H.; Cai, D.; Zhang, Y.; Chen, X.; Wang, X.; Hofreiter, M.; Zhao, X. Early Holocene chicken domestication in Northern China. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 17564–17569. [CrossRef]
102. Peters, J.; Lebrasseur, O.; Best, J.; Miller, H.; Fothergill, T.; Dobney, K.; Thomas, R.M.; Maltby, M.; Sykes, N.; Hanotte, O.; et al. Questioning new answers regarding Holocene chicken domestication in China. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, e2415. [CrossRef]
103. Huang, C.; Pang, J.; Chen, S.; Su, H.; Han, J.; Cao, Y.; Zhao, W.; Tan, Z. Charcoal records of fire history in the Holocene loess–soil sequences over the southern Loess Plateau of China. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2006**, *239*, 28–44. [CrossRef]
104. Zhang, J.; Lu, H.; Wu, N.; Li, F.; Yang, X.; Wang, W.; Ma, M.; Zhang, X. Phytolith evidence for rice cultivation and spread in Mid-Late Neolithic archaeological sites in central North China. *Boreas* **2010**, *39*, 592–602. [CrossRef]
105. Qiao, Y. Development of complex societies in the Yiluo region: A GIS based population and agricultural area analysis. *Indo-Pac. Prehistory Assoc. Bull.* **2007**, *27*, 61–75. [CrossRef]
106. Ma, X. *Emergent Social Complexity in the Yangshao Culture: Analyses of Settlement Patterns and Faunal Remains from Lingbao, Western Henan, China (c. 4900–3000 BC)*; Archeopress: Oxford, UK, 2005.
107. Liu, L.; Chen, X. *The Archaeology of China: From the Late Paleolithic to the Early Bronze Age*; Cambridge University Press: Cambridge, UK, 2012.
108. Hu, S.; Yang, Q.; Yang, M. Shaanxi Huayin Xinglefang yizhi dongwu yicun fenxi 陕西华阴兴乐坊遗址动物遗存分 (Animal remains at Xinglefang, in Huayin, Shaanxi). *Kaogu Yu Wenwu* **2011**, *6*, 117–125.
109. Hu, S.; Wang, W.; Guo, X.; Zhang, W.; Yang, M. Shaanxi Gaoling Yangguanzhai Huanhao Ximan zhi dongwu yicun fenxi 陕西高陵杨官寨环壕西门址动物遗存分析 (Analysis of faunal remains found at the west gate of Huanhao in Yangguanzhai, Gaoling, Shaanxi.). *Kaogu Yu Wenwu* **2011**, *6*, 97–107.
110. Zhang, Y.; Zhou, Q.; Yan, Y.; Yin, S. Shaanxi Lintong Lingkou cun wenhua yizhi jichui dongwu yihai 陕西临潼零口村文化遗址脊椎动物遗骸 (Vertebrate remains at the Lingkou cultural site in Lintong, Shaanxi Province.). In *Lintong Lingkou Cun* 临潼零口村; Sanqin Chubanshe: Xi'an, China, 2004; pp. 523–525.
111. Pechenkina, E.A.; Benfer, R.A., Jr.; Wang, Z. Diet and health changes at the end of the Chinese Neolithic: The Yangshao/Longshan transition in Shaanxi Province. *Am. J. Phys. Anthropol.* **2002**, *117*, 15–36. [CrossRef] [PubMed]
112. Hu, S. Hua xian Quanhucun yizhi chutu dongwu guge yicun yanjiu 华县泉护村遗址出土动物骨骼遗存研究 (Research on animal skeletal remains unearthed from the site in the Quanhu Village in Huaxian County). In *Hua Xian Quanhucun 1997 Nian Kaogu Fajue Baogao* 华县泉护村*1997*年考古发掘报告; Shaanxi Sheng Kaogu Yanjiuyuan 陕西省考古研究院, Ed.; Wenwu Chubanshe: Beijing, China, 2007.
113. Chen, L.; Xiong, J.; Jing, S.; Sun, Z. Shaanxi Shenmu Shimao chengzhi jisi keng chutu tougu yanjiu 陕西神木石峁城址祭祀坑出土头骨研究 (Research on the skulls unearthed from the sacrificial pit at Shimao City Site in Shenmu, Shaanxi Province). *Kaogu Yu Wenwu* **2016**, *4*, 134–142.
114. Wang, R. Fishing, Farming, and Animal Husbandry in the Early and Middle Neolithic of the Middle Yellow River Valley, China. Ph.D. Thesis, University of Illinois at Urbana-Champaign, Champaign, IL, USA, 2004.
115. Barton, L.; Bingham, B.; Sankaranarayanan, K.; Monroe, C.; Thomas, A.; Kemp, B.M. The earliest farmers of Northwest China exploited grain-fed pheasants not chickens. *Sci. Rep.* **2020**, *10*, 2556. [CrossRef]

116. Wa, Y.; Hein, A. A buried past: Five thousand years of (pre)history on the Jing-Wei floodplain. *Asian Archaeol.* **2020**, *4*, 1–15. [CrossRef]
117. Chang, K. *The Archaeology of Ancient China*, 4th ed.; Yale University Press: New Haven, CT, USA; London, UK, 1987.
118. Peterson, C.E.; Shelach, G. Jiangzhai: Social and economic organization of a Middle Neolithic Chinese village. *J. Anthropol. Archaeol.* **2012**, *31*, 265–301. [CrossRef]
119. Zhongguo Kexueyuan Kaogu Yanjiusuo 中国科学院考古研究所. *Xi'an Banpo* 西安半坡 *(Banpo in Xi'an)*; Wenwu Chubanshe: Beijing, China, 1963.
120. Xi'an Banpo Bowuguan 西安半坡博物; Shaanxi Sheng Kaogu Yanjiusuo 西省考古研究所; Lintong Xian Bowuguan 临潼县博物馆. *Jiangzhai: Xin Shiqi Shidai Yizhi Fajue Baogao* 姜寨:新石器时代遗址发掘报告 *(Jiangzhai: A Neolithic Site Excavation Report)*; Wenwu Chubanshe: Beijing, China, 1988.
121. Gu, H.; Huang, C.; Zhou, Y.; Pang, J.; Zha, X.; Zhang, Y. Guanzhong pendi Yangguanzhai yizhi Yanggaunzhai yizhi gu hongshui shijian shi guang ce nian 关中盆地杨官寨遗址古洪水事件释光测年 (OSL dating study on the palaeoflood events recorded in the Yangguanzhai Neolithic ruins in the Guanzhong Basin). *Dili Yanjiu* **2012**, *31*, 1837–1848.
122. Huang, C.; Pang, J.; Zha, X.; Zhou, Y.; Su, H.; Wan, H.; Ge, B. Sedimentary records of extraordinary floods at the ending of the mid-Holocene climatic optimum along the upper Weihe River, China. *Holocene* **2011**, *22*, 675–686. [CrossRef]
123. Shaanxi Sheng Kaogu Yanjiuyuan 陕西省考古研究院; Xibei Daxue Wenhua Yichan Xueyuan 西北大学文化遗产学院. Shaanxi Gaoling Yangguanzhai yizhi H85 fajue baogao 陕西高陵杨官寨遗址 H85发掘报告 (Excavation report of H85 at Yangguanzhai in Gaoling, Shaanxi). *Kaogu Yu Wenwu* **2018**, *6*, 3–19.
124. Tang, L.; Yang, L.; Ye, W.; Yin, Y.; Liu, X.; Zhao, Z.; Wang, W. Gudai zhiwu de yiyao gongneng chutan: Yi Shaanxi Gaoling Yangguanzhai yizhi H85 chutu zhiwu yicun wei li 古代植物的医药功能初探: 以陕西高陵杨官寨遗址H85出土植物遗存为例 (A preliminary study on the medical function of ancient plants: A case study of the remains of plants unearthed from Yangguanzhai site in Gaoling, Shaanxi Province, H85). *Di Siji Yanjiu* **2020**, *40*, 486–498.
125. Lee, G.; Crawford, G.; Liu, L. Plants and people from the early Neolithic to Shang periods in North China. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 1087–1092. [CrossRef] [PubMed]
126. He, K.; Lu, H.; Zhang, J.; Wang, C.; Huan, X. Prehistoric evolution of the dualistic structure mixed rice and millet farming in China. *Holocene* **2017**, *27*, 1885–1898. [CrossRef]
127. Guan, L.; Hu, Y.; Hu, S.; Sun, Z.; Qin, Y.; Wang, C. Shan bei Jingbian Wuzhuangguoluo dongwu gu de C he N wending tongweisu fenxi 陕北靖边五庄果裸动物骨的 C 和 N 稳定同位素分析 (C and N stable isotope analysis of animal bones from Wuzhuangguoluo, Jingbian, Northern Shaanxi). *Di Siji Yanjiu* **2008**, *28*, 1160–1165.
128. Chen, X.; Hu, S.; Hu, Y.; Wang, W.; Ma, Y.; Lu, P.; Wang, C. Raising practices of Neolithic livestock evidenced by stable isotope analysis in the Wei River Valley, North China. *Int. J. Osteoarchaeol.* **2014**, *26*, 42–52. [CrossRef]
129. Luo, Y. Guanzhong diqu shiqian dongwu kaoguxue yanjiu de ji ge wenti 关中地区史前动物考古学研究的几个问题 (Problems in prehistoric zooarchaeological research in the Guanzhong Area). *Kaogu Yu Wenwu* **2009**, *5*, 89–94.
130. Kent, S. Cross-cultural perceptions of farmers as hunters and the value of meat. In *Farmers as Hunters: The Implications of Sedentism*; Kent, S., Ed.; Cambridge University Press: Cambridge, UK, 1989; pp. 1–17.
131. Wang, H. Animal Subsistence of the Yangshao Period in the Wei River Valley: A Case-Study from the Site of Wayaogou in Shaanxi Province, China. Ph.D. Thesis, University College London, London, UK, 2011.
132. Shaanxi Sheng Kaogu Yanjiuyuan 陕西省考古研究院; Yulin Shi Wenwu Kaogu Kantan Gongzuodui 榆林市文物考古勘探工作队. Shaanxi Hengshan Yangjiesha yizhi fajue jianbao 陕西横山杨界沙遗址发掘简报 (Brief report on the excavation of Yangjiesha site in Hengshan, Shaanxi). *Kaogu Yu Wenwu* **2011**, *6*, 64–72.
133. Sheng, P.; Hu, Y.; Sun, Z.; Yang, L.; Hu, S.; Fuller, B.T.; Shang, X. Early commensal interaction between humans and hares in Neolithic northern China. *Antiquity* **2020**, *94*, 1–15. [CrossRef]
134. Xie, S.; Wang, Z.; Wang, H.; Chen, F.; An, C. Moci jian bingqi yilai huangtu gaoyuan de caoyuan zhibei jingguan laizi fenzi huashi de zhengju 末次间冰期以来黄土高原的草原植被景观来自分子化石的证据 (Molecule fossil evidence for paleovegetation changes in the Loess Plateau grassland since the last interglacial period). *Zhongguo Kexue D Ji Diqiu Kexue* **2002**, *32*, 28–35.
135. Sheng, P.; Shang, X.; Yang, L.; Zhang, P.; Hao, J.; Wang, W.; Wang, C. Shaanxi Hengshan Yangjiesha yizhi zhiwu yicun de chubu yanjiu 陕西横山杨界沙遗址植物遗存的初步研究 (Preliminary study on plant remains from Yangjiesha, in Hengshan, Shaanxi Province). *Kaogu Yu Wenwu* **2017**, *3*, 123–128.
136. Cai, Y.; Tan, L.; Cheng, H.; An, Z.; Edwards, R.L.; Kelly, M.J.; Kong, X.; Wang, X. The Variation of summer monsoon precipitation in Central China since the Last Deglaciation. *Earth Planet. Sci. Lett.* **2010**, *291*, 21–31. [CrossRef]
137. Zhou, A.; Sun, H.; Chen, F.; Zhao, Y.; An, C.; Dong, G.; Wang, Z.; Chen, J. High-resolution climate change in Mid-late Holocene on Tianchi lake, Liupan Mountain in the Loess Plateau in Central China and its significance. *Chin. Sci. Bull.* **2010**, *55*, 2118–2121. [CrossRef]
138. Marcott, S.A.; Shakun, J.D.; Clark, P.U.; Mix, A.C. A Reconstruction of regional and global temperature for the past 11,300 Years. *Science* **2013**, *339*, 1198–1201. [CrossRef]
139. Pechenkina, E.A.; Ambrose, S.H.; Ma, X.; Benfer, R.A., Jr. Reconstructing northern Chinese Neolithic subsistence practices by isotopic analysis. *J. Archaeol. Sci.* **2005**, *32*, 1176–1189. [CrossRef]

140. Sheng, P.; Shang, X.; Zhou, X.; Storozum, M.; Yang, L.; Guo, X.; Zhang, P.; Sun, Z.; Hu, S.; Sun, Z.; et al. Feeding Shimao: Archaeobotanical and Isotopic Investigation into Early Urbanism (4200–3000 BP) on the Northern Loess Plateau, China. *Environ. Archaeol.* **2021**, 1–15. [CrossRef]
141. Qu, Y.; Hu, K.; Yang, M.; Cui, J. Xin shiqi shidai Guanzhong diqu renlei shengye moshi yanbian de shengwu kaoguxue zhangju 新石器时代关中地区人类生业模式演变的生物考古学证据 (Bioarchaeological evidence for the evolution of human occupational patterns in Guanzhong during the Neolithic period). *Renleixue Xuebao* **2018**, *37*, 96–109. [CrossRef]
142. Flad, R.K. Divination and power: A multiregional view of the development of oracle bone divination in early China. *Curr. Anthropol.* **2008**, *49*, 403–437. [CrossRef]
143. Fiskesjö, M. Rising from blood-stained fields: Royal hunting and state formation in Shang China. *Bull. Mus. Far East. Antiq.* **2001**, *73*, 49–191.
144. Liu, L. Mortuary ritual and social hierarchy in the Longshan Culture. *Early China* **1996**, *21*, 1–46. [CrossRef]
145. Hu, S.; Yang, M.; Sun, Z.; Shao, J. 2012–2013 niandu Shaanxi Shenmu Shimao yizhi chutu dongwu yicun yanjiu 2012–2013 年度陕西神木石峁遗址出土动物遗存研究 (Research on animal remains unearthed in 2012-2013 from Shimao, in Shenmu, Shaanxi). *Kaogu Yu Wenwu* **2016**, *4*, 109–121.
146. Dongwu Kaogu Keti Zu 动物考古课题组. Zhonghua wenming xingcheng shiqi de dongwu kaoguxue yanjiu 中华文明形成时期的动物考古学研 (Zooarchaeological research during the formation of the Chinese civilization). In *Keji Kaogu Di San Ji* 科技考古第三季; Zhongguo Shehui Kexueyuan Kaogu Yanjiusuo 中国社会科学院考古研究所, Ed.; Kexue Chubanshe: Beijing, China, 2011; pp. 80–99.
147. Dai, L.; Balasse, M.; Yuan, J.; Zhao, C.; Hu, Y.; Vigne, J.D. Cattle and sheep raising and millet growing in the Longshan age in central China: Stable isotope investigation at the Xinzhai site. *Quat. Int.* **2016**, *426*, 145–157. [CrossRef]
148. Lu, H.; Zhang, J. Guanzhong diqu de xin shiqi gu wenhua fazhan yu gu huanjing bianhua de guanxi 关中地区的新石器古文化发展与古环境变化的关系 (Relationship between the development of ancient Neolithic cultures and changes in the ancient environment in Guanzhong). *Di Siji Yanjiu* **2008**, *28*, 1050–1060.
149. Li, X.; Shang, X.; Dodson, J.; Zhou, X. Holocene agriculture in the Guanzhong Basin, NW China indicated by pollen and charcol evidence. *Holocene* **2009**, *19*, 1213–1220. [CrossRef]
150. Sun, N.; Hu, S.; Sun, Z. Shan bei diqu dongwu guge de zhifangsuan dan ti tan tongweisu fenxi 陕北地区动物骨骼的脂肪酸单体碳同位素分析 (Compound specific carbon isotope analysis of individual fatty acids from animal bones in northern Shaanxi, China). *Di Siji Yanjiu* **2022**, *42*, 69–79.
151. Fu, W.; Din, A.; Shao, J. Shan bei jingbian Miaoliang yizhi fu xuan jieguo yu fenxi 陕北靖边庙梁遗址浮选结果与分析 (Flotation analysis and results at Miaoliang, in Jingbian, northern Shaanxi). *Di Siji Yanjiu* **2022**, *42*, 119–128.
152. An, C.; Tang, L.; Barton, L.; Chen, C. Climate change and cultural response around 4000Cal yr B.P. in the western part of Chinese Loess Plateau. *Quat. Res.* **2005**, *63*, 347–352. [CrossRef]
153. Burrin, D.G. Nutrient requirements and metabolism. In *Biology of the Domestic Pig*; Pond, W.G., Mersmann, H.L., Eds.; Cornell University Press: Ithaca, NY, USA, 2001; pp. 309–389.
154. Yang, M.; Hu, S.; Guo, X.; Wang, W. Shaanxi sheng Shenmu xian Muzhuzhuliang yizhi yang gu yanjiu 陕西省神木县木柱柱梁遗址羊骨研究 (Study on sheep bones from Muzhuzhuliang, in Shenmu County, Shaanxi Province). *Nongye Kaogu* **2017**, *3*, 13–18.
155. Cai, D.; Zhu, S.; Gong, M.; Zhang, N.; Wen, J.; Liang, Q.; Sun, W.; Shao, X.; Guo, Y.; Cai, Y.; et al. Radiocarbon and genomic evidence for the survival of *Equus Sussemionus* until the late Holocene. *eLife* **2022**, *11*, e73346. [CrossRef]
156. Khayutina, M. Western Zhou cultural and historic setting. In *The Oxford Handbook of Early China*; Childs-Johnson, E., Ed.; Oxford University Press: Oxford, UK, 2020; pp. 365–400.
157. Zhang, T. *Guanzhong Shang dai Wenhua Yanjiu* 关中商代文化研究 *(Research on the Shang Culture in Guanzhong)*; Wenwu Chubanshe: Beijing, China, 2004.
158. Xu, L. 1997 nian Fengxi fajue baogao 1997年沣西发掘报告 (Report on the excavations at Fenxi in 1997). *Kaogu Xuebao* **2000**, *2*, 199–256.
159. Xibei Daxue Wenhua Yichan Xueyuan 西北大学文化遗产学院; Shaanxi Sheng Kaogu Yanjiuyuan 陕西省考古研究院; Xunyi Xian Wenwu Luyou Ju 旬邑县文物旅游局. Shaanxi sheng Xunyi xian Xitou yizhi diaocha jianbao 陕西省旬邑县西头遗址调查简报 (Brief report on the investigations at Xitou, in Xunyi County, Shaanxi Province). *Caoyuan Wenwu* **2020**, *1*, 16–27.
160. Festa, M.; Monteith, F.; Dou, H.; Orton, D.; Wang, Q.; Zong, T.; Zhang, C.; Liu, B.; Li, Y. Forthcoming. Faunal exploitation during the Shang-Zhou transition: Evidence from the Jing River Valley in Central Shaanxi. *Int. J. Osteoarchaeol* **2022**, *in press*.
161. Li, Y.; Zhang, C.; Chen, H.; Wang, Z.; Qian, Y. Sika deer in Bronze Age Guanzhong: Sustainable wildlife exploitation in ancient China? *Antiquity* **2021**, *95*, 940–954. [CrossRef]
162. Frachetti, M.D.; Smith, C.E.; Traub, C.M.; Williams, T. Nomadic ecology shaped the highland geography of Asia's Silk Roads. *Nature* **2017**, *543*, 193–198. [CrossRef] [PubMed]
163. Ullah, I.; Chang, C.; Tourtellotte, P. Water, dust, and agro-pastoralism: Modeling socio-ecological co-evolution of landscapes, farming, and human society in southeast Kazakhstan during the mid to late-Holocene. *J. Anthropol. Archaeol.* **2019**, *55*, 101067. [CrossRef]
164. Wang, L.; Wang, Y.; Li, W.; Spate, M.; Reheman, K.; Sun, Q.; Wang, B.; Xu, H.; Zhang, Z.; Zhang, G.; et al. Inner Asian agro-pastoralism as optimal adaptation strategy of Wupu inhabitants (3000–2400 cal BP) in Xinjiang, China. *Holocene* **2021**, *31*, 203–216. [CrossRef]

165. Høisæter, T.L. Polities and nomads: The emergence of the Silk Road exchange in the Tarim Basin region during late prehistory (2000–400 BCE). *Bull. SOAS* **2017**, *80*, 339–363. [CrossRef]
166. Wang, Z.; Chen, H. Shaanxi Chunhua Zaoshugounao yizhi 2008 niandu fajue de zhuyao shouhuo 陕西淳化枣树沟脑遗址2008年度发觉的主要收获 (Main achievements of the 2008 excavations at Zaoshugounao in Chunhua, Shaanxi). *Xibei Daxue Xuebao* **2010**, *40*, 32–36. [CrossRef]
167. Zhongguo Shehui Kexue Xueyuan Kaogu Yanjiusuo 中国社会科学学院考古研究所. *Nanlinzhou Nianzipo* 南邻州●碾子破 *(South of Lingzhou, Nianzipo);* Shijie Tushuguan Chubanshe: Beijing, China, 2007.
168. Chen, S.; Fu, W.; Liu, J.; Tang, L.; Zhai, L.; Zhao, Z.; Wen, R. Shaanxi Xunyi Zaolinhetan Yizhi Tanhua Zhiwu Yicun Yanjiu 陕西旬邑枣林河滩遗址炭化植物遗存研究 (Study on the remains of carbonized plants at Zaolinhetan, in Xunyi, Shaanxi). *Nanfang Wenwu* **2019**, *1*, 103–112.
169. Lan, D. Shaanxi Chunhua Zaoshugounao Yizhi Chutu Ren he Dongwu Guge de Wending Tongweisu Fenxi 陕西淳化枣树沟脑遗址出土人和动物骨骼的同位素分析 (Isotopic Analysis of Human and Animal Skeletal Elements Unearthed at Zaoshugounao, in Chunhua, Shaanxi Province). Master's Thesis, Northwest University, Xi'an, China, 2017.
170. Li, X.; Zhang, S.; Lu, M.; Qiu, M.; Wen, S.; Ma, M. Dietary shift and social hierarchy from the Proto-Shang to Zhou Dynasty in the Central Plains of China. *Environ. Res. Lett.* **2020**, *15*, 035002. [CrossRef]
171. Hu, S.; Li, B. Zhongguo Baoji Guantaoyuan xin shiqi yizhi zhong faxian de jinsihou tougu ji qi yiyi 中国宝鸡关桃园新石器遗址中发现的金丝猴头骨及其意义 (Discovery and significance of the golden snub-nosed monkey skulls from the Neolithic site of Guantaoyuan, Baoji, China). *Shoulei Xuebao* **2006**, *26*, 417–420.
172. Hu, S.; Yang, L.; Kang, N.; Yang, M.; Li, X. Shaanxi Hengshan xian Dagujie yizhi dongwu yicun fenxi 陕西横山县大古界遗址动物遗存分析 (Analysis of the faunal remains from Dagujie, in Hengshan County, Shaanxi Province). *Kaogu Yu Wenwu* **2012**, *4*, 106–112.
173. Hu, S.; Sun, Z.; Yang, L.; Kang, N.; Yang, M.; Li, X. Shan bei Hengshan Yangjiesha yizhi dongwu yicun yanjiu 陕北横山杨界沙遗址动物遗存研究 (Faunal remains from Yangjiesha, in Hengshan, Northern Shaanxi). *Renleixue Xuebao* **2013**, *32*, 77–92. [CrossRef]
174. Hu, S.; Sun, Z. Shan bei Jingbian Wuzhuangguoluo dongwu yicun ji gu huanjing fanxi (Analysis of faunal remains and paleoenvironment at Wuzhuangguoluo, in Jingbian, northern Shaanxi. 陕北靖边五庄果裸动物遗存及古环境分析. *Kaogu Yu Wenwu* **2005**, *6*, 72–84.
175. Hu, S.; Yang, T.; Yang, M.; Shao, J.; Di, N. Shan bei jing bian Miaoliang yizhi dongwu yicun yanjiu jian lun Zhongguo mu ye de xingcheng 陕北靖边庙梁遗址动物遗存研究兼论中国牧业的形成 (Research on faunal remains from Miaoliang, in Jingbian, northern Shaanxi, and the formation of animal husbandry in China). *Di Siji Yanjiu* **2022**, *42*, 17–31.
176. Hu, S.; Zhang, P.; Yuan, M. Yulin Huoshiliang yizhi dongwu yicun yanjiu 榆林火石梁遗址动物遗存研究 (Research on animal remains at Huoshiliang). *Renleixue Xuebao* **2008**, *27*, 232–248.