

The Importance of Localized Hunting of Diverse Animals to Early Inhabitants of the Eastern Tibetan Plateau at the Neolithic site of Xiaoenda

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Abstract

Understanding of when and how human groups engaged with and settled different regions of the Tibetan Plateau has been greatly extended in the past decade. Research on the mid/late Holocene has focused on the roles of material cultural traditions and cropping systems in the process of long-term settlement. In this paper, we shift the focus to explore *animal*-based subsistence strategies used to adapt to life on the eastern Tibetan Plateau. Dated to between 5000 and 4000 cal. BP, Xiaoenda represents one of the oldest Neolithic sites known in this region. New zooarchaeological data from Xiaoenda reveals that the site's inhabitants relied on a diverse array of wild animal taxa. This contrasts with previous assertions regarding the role of domestic animals in this region. Xiaoenda's location between highland and multiple lower elevation catchment zones allowed access to a range of wild prey species. Zooarchaeological data indicate that the inhabitants of Xiaoenda took advantage of this, practicing a diverse localized hunting strategy. Our findings demonstrate that people at Xiaoenda depended on wild rather than domestic animals and indicate a role for wild game in facilitating continuous occupation in the eastern Tibetan Plateau during the fifth millennium BP.

Keywords: Xiaoenda; Zooarchaeology; Tibetan Plateau; Hunting

1. Introduction

Our understanding of human activities in high altitude (>3000 m.a.s.l.) regions of the Tibetan Plateau in the past has been greatly extended over the last decade. Recent work has contributed insights into the timing of early human settlement of the plateau in the Pleistocene and early Holocene (e.g. Brantingham and Xing, 2006; Aldenderfer, 2011; Lu, 2016; Madsen et al., 2017; Meyer et al., 2017; Zhang et al., 2018), and a suite of recent studies concentrating on subsequent mid-Holocene and later human occupations have also begun to reveal the diversity of regionally and likely environmentally and socially influenced patterns of plant and animal use on the Tibetan Plateau. However, scholarship to date has focused on material cultural traditions and cereal cultivation, and information on faunal remains is comparatively sparse. Further, the extent to which early year-round settlers of the plateau relied on wild, rather than domestic, animals is not well understood. Here, we shift this focus and examine animal-based subsistence strategies through the study of the recently excavated faunal assemblage from the site of Xiaomenda, one of the oldest known Neolithic sites in Eastern Tibet.

Regional and temporal subsistence patterns from different regions of the Tibetan Plateau have illustrated a broad range of variability. In the northeastern region of the Tibetan Plateau, millet farmers established settlements below 2500 m.a.s.l. between c. 5000 and 3600 cal. BP (Chen et al., 2015). After c. 3600 cal. BP, scholars argue that a novel agricultural economy that included both indigenous crops (Broomcorn, *Panicum miliaceum*, and foxtail, *Setaria italica*, millets) and exotic cereals newly introduced from the west (free threshing wheat, *Triticum aestivum/durum*, and barley, *Hordeum vulgare*) played a role in large scale settlement in the highlands of the northeastern Tibetan Plateau (i.e. above 2500 m.a.s.l.) (Dong et al., 2012; Chen et al., 2015; d'Alpoim Guedes, 2015; Dong et al., 2016; Liu et al., 2017; Ren et al., 2017). In the western and central regions of the plateau, such as Ngari and Shannan, there has also been growing interest in the strategies employed at high altitudes (above 3500 m.a.s.l.). Archaeological evidence in these regions for settlements begins slightly later. The oldest known sites, namely Dingdong and Changguogou, are dated to around 2700 BP and 3600 BP, respectively (Aldenderfer and Moyes, 2004; Lu, 2007; Liu et al., 2016). Here, a pastoralist economy—distinguished by mobile herds of domestic ungulates—in combination with an agricultural economy—seemingly played a key role in human subsistence (He, 1994; Fu, 2001; Huo, 2013; d'Alpoim Guedes et al., 2014; Tong et al.,

2014; Tong et al., 2015; Liu et al., 2016; Lu, 2016; Liu et al., 2017; Song et al., 2017; Zhang and Lu, 2017). As elsewhere on the plateau, however, detailed studies of large faunal assemblages are sparse.

Turning to the region of focus, previous research in the eastern part of the Tibetan Plateau has highlighted both the possibility of, as well as the environmental constraints to, millet cultivation (Region and University, 1985; d'Alpoim Guedes et al., 2014; d'Alpoim Guedes, 2015, 2018). Scholarly attention since the 1980s has also been drawn to the broad-spectrum nature of early subsistence on the eastern Tibetan Plateau, which included hunting a wide variety of wild animals (Huang and Leng, 1985; Region and University, 1985; Huo, 1993; Shi, 1994; Li, 2007; Zhang, 2013; d'Alpoim Guedes, 2015). However, only relatively small faunal assemblages from a few sites have been studied, and there is little published data on the diversity of species represented or the proportions of wild *versus* domestic fauna. Here, we build on and expand current research, to investigate the role of Neolithic animal-based subsistence strategies in the process of adapting to the challenging environments of the eastern Tibetan Plateau.

At the eastern edge of the plateau lying at 3100 m.a.s.l., the site of Karuo (5600 – 2900 cal. BP) represents one of the oldest known and best studied Neolithic sites in the eastern Tibetan Autonomous Region (Region and University, 1985; d'Alpoim Guedes et al., 2014; Liu et al., 2016). Archaeobotanical analyses have revealed the presence of cereal crops including broomcorn and foxtail millets at this site (Wu et al., 1985; Gao, 2013; d'Alpoim Guedes and Butler, 2014; d'Alpoim Guedes et al., 2014; d'Alpoim Guedes, 2015; d'Alpoim Guedes et al., 2016; Lu, 2016). Based on the material culture from Karuo, earlier studies proposed that these Karuo highlanders interacted with and were influenced by agriculturalist lowlanders from northwest China, and that they likely relied on cultivated cereal crops (Region and University, 1985; Wu et al., 1985) in addition to wild animals (Li, 2007; Zhang, 2013). However, it is worth noting that based on this faunal evidence an alternative and equally plausible hypothesis has been put forward, which suggests that inhabitants at Karuo were not farmers, but foragers who obtained cultivated grains through trade (d'Alpoim Guedes, 2015, 2018).

Initial analysis of the Karuo faunal remains was conducted in the 1980s, where the presence of domesticated pigs (*Sus scrofa domesticus*) along with various wild taxa, including species of Cervidae, Moschidae, Bovidae, Carnivora, Lagomorpha, and Rodentia were reported (Huang and Leng, 1985). Subsequent identification of faunal remains from the 2002 excavations at Karuo was conducted by two biologists—Qi Guo

and Shaoying Liu (Li, 2007)—and a third zooarchaeological investigation of faunal remains excavated in 2012 was conducted by the first author of this paper (Zhang, 2013). Both of the more recent studies confirmed the presence of wild taxa at Karuo but neither corroborated the evidence for domestic pigs proposed by the initial analysis. Limited quantitative data is available from the 1970s and 2002 excavations, and the sample size of the 2012 excavated faunal assemblage is small—number of identified specimens (NISP): <100—so our understanding of animal-based subsistence at Karuo remains incomplete, as has been rightly pointed out by a number of scholars (Huang and Leng, 1985; Huo, 1993; Shi, 1994; Li, 2007; Zhang, 2013; d’Alpoim Guedes, 2015, 2018). In order to achieve a more complete understanding of the diversity of subsistence strategies employed at Neolithic settlements of the eastern plateau, including the roles of domesticated and wild animals, it is clear that a great deal more zooarchaeological research is needed from additional sites beyond Karuo.

The recently excavated site of Xiaoenda—contemporary to, and geographically close to the Karuo site—provides a rare opportunity to evaluate animal acquisition strategies related to early year-round mid-Holocene settlement at higher altitudes in eastern Tibet. The faunal data presented in this paper from Xiaoenda also allows us to compare subsistence strategies among those living at higher and lower elevations across the plateau. Further, the results from the faunal analysis at Xiaoenda offer an interesting context for understanding the diversity of subsistence economies that existed in highland eastern Tibet, providing a base-line for understanding the various processes that may have enabled people to live year-round on the Tibetan Plateau during the mid-Holocene.

2. Materials and Methods

2.1 Environmental background

The location of Xiaoenda and its surrounding environment provide an ecological context within which zooarchaeological data can be interpreted. Located in the eastern Tibetan Plateau, Xiaoenda lies at an elevation of 3140 m.a.s.l. and sits on the eastern bank of the Ang-Qu River—a tributary to the Lancang River. Xiaoenda is located only 14 km to the northwest of the Karuo site, which is situated on the western side of the Lancang river (Figure 1). Located in one of the most mountainous and humid areas of

the plateau, the landscape of Xiaoenda exhibits contrasting vertical diversity in vegetation and available plant and animal resources (Figure 2). Beginning at approximately 3400 m.a.s.l. lower-lying montane, scrub, and meadow grasslands transition into alpine temperate coniferous forests at higher altitudes (Zhang et al., 1988). Facilitated by this vertical topography, more than 91 species of mammals and 240 species of birds inhabit the varied ecozones within the vicinity of the site (Feng et al., 1986; Zhang, 2011). During the period when Xiaoenda was occupied, paleoclimate data from this area suggest that the environment and surrounding vegetation was similar to that of the present, though conditions were probably slightly warmer and wetter (Wu et al., 1985; Tang et al., 2004).

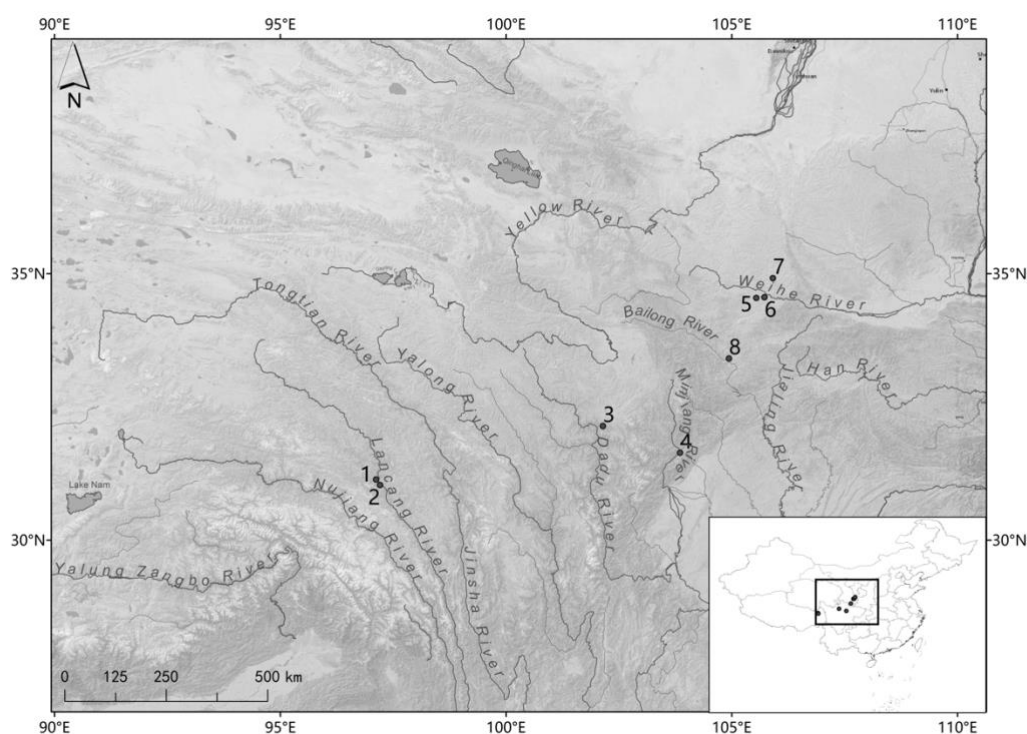


Figure 1. Locations of sites mentioned in this paper: 1) Xiaoenda, 2) Karuo, 3) Haxiu, 4) Yingpanshan, 5) Xishanping, 6) Shizhaocun, 7) Dadiwan, 8) Dalijiaping

2.2 Excavations and the faunal assemblage

Excavations were conducted at Xiaoenda over two different periods: first, in 1986 and again in 2012 by archaeologists from the Institute for Cultural Relics Conservation and Research of Tibetan Autonomous Region (Chen, 1990). During the most recent excavations, an area of 170m² was uncovered, led by three authors of this paper (ZC,

TW, and TD). Excavation districts or trench sampling areas were distributed on both the north (District I) and south (District III) sides of a local road. Uncovered archaeological features from the two districts revealed different stratigraphic sequences. There is no readily visible change in material culture style or architectural typology that would suggest the two districts belong to different periods (Z. Chen, pers. comm.). In light of this fact, as well as the relatively short occupation of the site (see discussion of dating below; Table 1), we have treated the faunal assemblages from both districts as one single component.

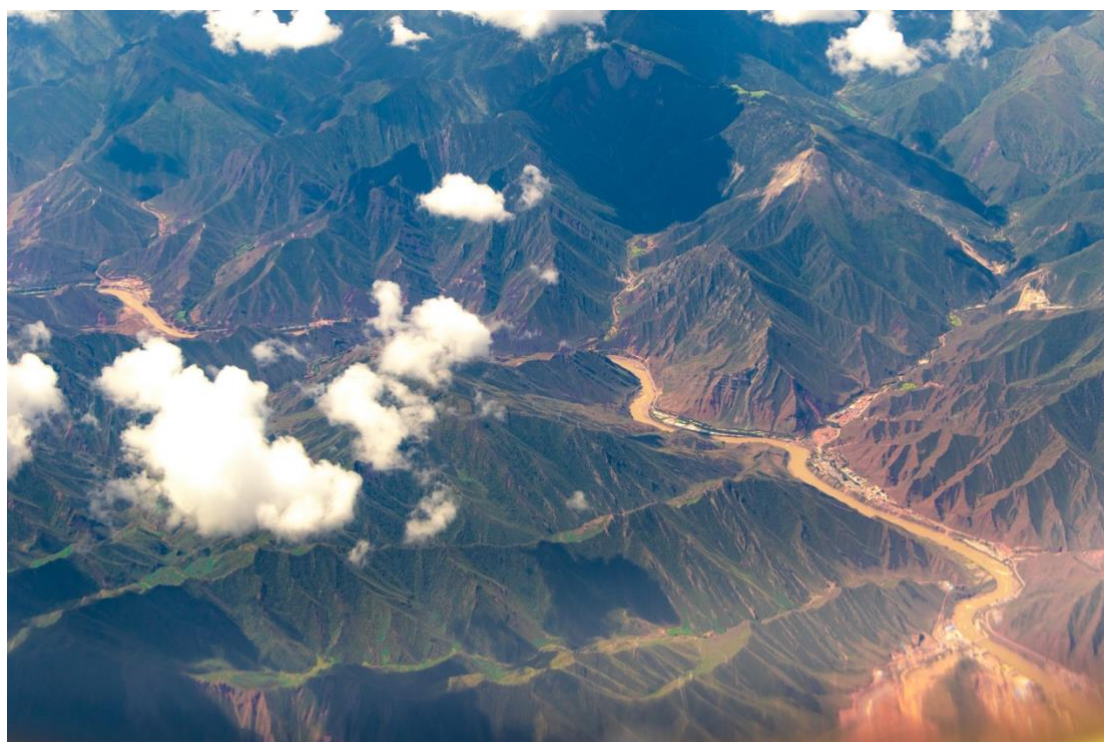


Figure 2. Typical Mountainous Terrain of the Eastern Tibetan Plateau (Photograph: Zhengwei Zhang).

Rectangular semi-subterranean household features, as well as ceramics, bone tools, and lithics retrieved within house-like structures from Xiaoenda resemble features and artifacts reported at Karuo. On the basis of this, excavators have proposed that Xiaoenda represents a Karuo-type site (Chen, 1990). Additionally, a small-scale flotation program conducted by co-authors of this article (Liu, Lü, and Chen, unpublished data) in 2012 also revealed charred grains of broomcorn (*S. italica*) and foxtail (*P. miliaceum*) millet from Xiaoenda—paralleling previous archaeobotanical results from Karuo (e.g. Wu et al., 1985; Gao, 2013; d’Alpoim Guedes et al., 2014; Liu et al., 2016; Lu, 2016).

To more precisely date the site and better establish its correspondence with Karuo, we submitted eight medium and medium-small sized mammalian long-bone fragments

to the Radiocarbon Accelerator Laboratory at Peking University for direct AMS radiocarbon measurements. These samples were obtained from diverse features and stratigraphic levels, including six samples from District I and two from District III. From these results—presented in Table 1 and Figure 3—we infer that Xiaoenda was occupied between 4900 and 4200 Cal. BP.

Table 1. Direct radiocarbon dates of mammal bones from Xiaoenda. The radiocarbon data have been calibrated using the IntCal13 calibration curve (Reimer et al., 2013).

Lab No.	Sample No.	Conventional ¹⁴ C age BP (±1σ)	Calibrated age (cal. BP)	
			1σ(68.2%)	2σ(95.4%)
BA171542	2012CXIT0101②c: 1	4025±40	4527 (68.2%) 4433	4783 (2.3%)
				4767
				4612 (1.6%)
				4595
				4586 (91.5%)
BA171543	2012CXIT0101③c: 1	3870±25	4402 (17.2%) 4368	4416
				4412 (93.1%)
				4233
				4197 (2.3%)
				4183
BA171544	2012CXIT0101④c: 1	4000±25	4515 (48.6%) 4473	4522 (95.4%)
				4446 (19.6%) 4428
				4420
				4815 (14.3%) 4786
				4780
BA171545	2012CXIT0101⑤c: 1	4150±25	4764 (5.2%) 4753	4770 (76.8%)
				4580
				4725 (48.7%) 4621
				4830 (17.3%) 4812
				4797
BA171546	2012CXIT0101⑥c: 1	4195±25	4756 (45.5%) 4708	4763 (70.7%)
				4628
				4666 (5.5%) 4659
				4825 (12.2%) 4807
				4831 (20.1%)
BA171547	2012CXIT0101⑥UD12c: 1	4175±25	4759 (41.5%) 4700	4785
				4765 (75.3%)
				4619
				4671 (14.4%) 4650
				4381 (0.8%)
BA171548	2012CXIII T0205②c: 1	3825±25	4246 (68.2%) 4155	4372
				4352 (2.9%)
				4329
				4298 (90.1%)
				4146
BA171549	2012CXIII T0206③c: 1	4245±35	4857 (56.3%) 4820	4115 (1.6%)
				4100
				4867 (65.8%)
				4807
				4760 (24.9%)
			4750 (11.9%) 4729	4700

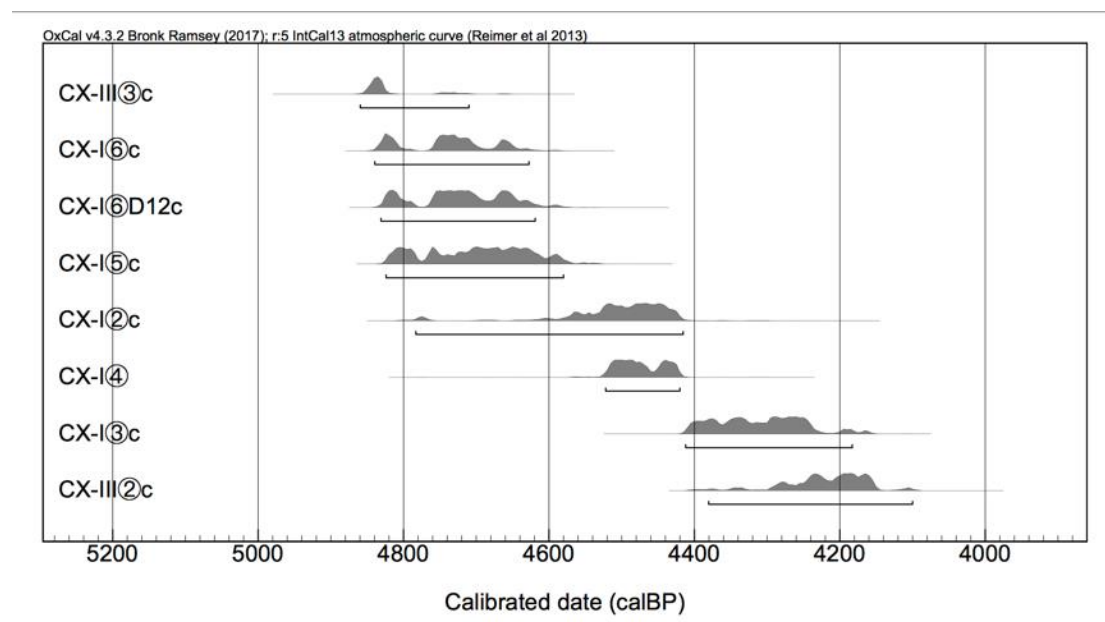


Figure 3. Radiocarbon dates from the Xiaoenda Site

A faunal assemblage totaling 7314 specimens was recovered during the most recent excavations in 2012. Mammal, bird, and fish bones were collected by hand and recovered from screens. All trenches excavated were screened using a double layered screen with 3mm and 5mm mesh. Specimens collected from features—designated as household floors (房址居住面) and storage pits (窖穴) by excavators (Chen, 1990)—comprise 41.3% (N=3019) of the assemblage. The other 58.7% (N=4295) of the assemblage came from identifiable cultural layers.

Between May and August 2017, the first author (ZZ) conducted field analyses of this faunal material and subsequently transported all identifiable specimens to the Zooarchaeology Laboratory at Sichuan University, where it is currently curated. Fauna was sorted into maximally, minimally and non-identifiable categories based on the presence of identifiable landmarks (Gifford-Gonzalez, 2018). Mammalian specimens that could not be attributed to finer taxonomic categories were assigned to size classes, which we defined by live weights as follows: (1) Large, for mammals larger than 200kg, such as red deer (*Cervus elaphus*); (2) Medium, for mammals weighing between 200 and 100kg, such as Sika deer (*Cervus nippon*); (3) Medium-small, for those between 20-100kg, including musk deer (*Moschus* sp.), and (4) Small, for those less than 20kgs such as marmots (*Marmota himalayana*) and hares (*Lepus* sp.). Modern mammal and

bird comparative reference materials at the Zooarchaeology Laboratory at Sichuan University were used in taxonomic identification and currently available reference works for the Himalayas and other regions were consulted (Boessneck, 1969; Li, 1981; Feng et al., 1986; Prummel and Frisch, 1986; Olsen, 1990; Sheng et al., 1992; von den Driesch, 1995; Wu and Wang, 2006; Hou, 2010; Zeder and Lapham, 2010; Zeder and Pilaar, 2010; Gillis et al., 2011; Luo, 2012; Lemoine et al., 2014).

Wild bovids from this region represent a diverse group of species including wild yak (*Bos mutus*), takin (*Budorcas taxicolor*), Tibetan gazelle (*Procapra picticaudata*), serow (*Capricornis sumatraensis*), goral (*Naemorhedus goral*), blue sheep (*Pseudois nayaur*), and argali (*Ovis ammon*) (Feng et al., 1986; Wang, 2003). Additionally, systematic assessment of landmarks for distinguishing these wild bovids has been conducted by only a few scholars (Gromova, 1960; Olsen, 1990; von den Driesch, 1995). Thus, identifying bovids from this region beyond the tribal level poses a significant challenge. As a result, two authors (ZZ and XL) worked with the mammalian osteological collections belonging to the National Museum of Natural History (NMNH), Smithsonian Institution, in Washington D.C., in order to expand on previous work and to establish landmarks and measurements useful for differentiating blue sheep, goral, tahr, and argali (Zhang et al., forthcoming). Once determined, comparative analyses of these landmarks and measurements provided an additional guide for identification of the archaeological specimens at Sichuan University. Using comparative collections at Sichuan University, bovids from Xiaoenda were also systematically compared to modern domestic sheep (*Ovis aries*) and goat (*Capra a. hircus*) specimens originating from eastern Tibet. Identification was conservative and confined to specimens with defined landmarks and clear comparative criteria, and we are confident that domestic sheep or goat specimens bearing key identifiable landmarks were not confused with those of wild taxa.

Regarding pigs (*S. scrofa* ssp.), larger samples and regional comparative wild boar specimens are necessary to successfully differentiate between wild and domestic specimens on the basis of traditional markers, such as size reduction (Luo, 2012) and culling patterns (Lemoine et al., 2014). Given the very small number of suid specimens recovered from Xiaoenda (NISP=5), sample size was not sufficient to be able to confirm domestic status using either technique at this site.

During zooarchaeological analysis, tooth rows, complete bones, and the distal and proximal ends of long bones were measured following von den Driesch (1976). Body

part representation was analyzed using broad categories (following: Stiner, 2002). Bone modification, including evidence of burning, carnivore or rodent gnawing, and butchery, was also recorded (Lyman, 1994; Gifford-Gonzalez, 2018).

3. Results

3.1 Taxonomic representation at Xiaoenda

Of the total 7314 faunal specimens recovered from Xiaoenda, the majority (N=5176) were non-identifiable (not identifiable to body part). A total of 730 mammalian remains were maximally identified specimens and identifiable to body part and to at least the Order level. Small numbers of bird and fish remains were recovered (N=58), but analysis of the non-mammalian fauna from this site is on-going and will not be discussed here.

Of the 730 maximally identifiable mammal remains, species from the families Suidae, Moschidae, Cervidae, and Bovidae are all present, with most specimens coming from the order Artiodactyla (92.47%, N= 688). Present in only very small numbers, species of Cercopithecidae, Canidae, Rodentia (*M. himalayana*), and Lagomorpha (Ochotonidae and Leporidae) are also represented in the assemblage (Table 2). Taxonomic representation was consistent throughout the lower and upper layers at Xiaoenda, indicating little change through time. Small Artiodactyla, including the small-bodied cervids (*Moschus* sp., *Capreolus capreolus*) and small Bovidae (*Ovis* sp., *P. nayaur*, *N. goral*, and *H. jemlahicus*) remain the most dominant taxa in all faunal samples, regardless of layer.

A total of 444 of the 688 Artiodactyl specimens were identified to at least the family level. Specimens of Moschidae and Cervidae make up 88.1% (N= 391), Bovidae make up 10.8% (N= 48), and only 1.1% (N= 5) were positively identified as Suidae (*Sus scrofa* ssp.). Of 391 deer specimens, musk deer (Moschidae) represent 47.3% (N= 185), 17.4% (N= 68) are attributable to large Cervidae, 11.5% (N= 45) to medium-sized Cervidae, and 21.0% (N= 82) to medium-small sized Cervidae (i.e. roe deer, *C. capreolus*).

Four species of the family Moschidae (*Moschus berezovskii*, *M. leucogaster*, *M. fuscus*, and *M. chrysogaster*), three species of large Cervid (*C. elaphus*, *C. albirostris*, and *C. unicolor*), and one species of medium-sized Cervid (*C. nippon*) all inhabit the

eastern Tibetan Plateau today (Feng et al., 1986; Sheng et al., 1992). In light of the fact that *C. nippon* is the only medium-sized deer in this region, it is likely that the less identifiable medium-sized Cervid specimens from Xiaoenda can be attributed to *C. nippon*. Additionally, when compared with published data (Li, 1981; Feng et al., 1986; Sheng et al., 1992), the lengths of mandibular cheek-teeth identified as Moschidae at Xiaoenda are closer to the measurements of *M. leucogaster* and larger (Xiaoenda specimens are longer) than the measurements of other Moschidae species, indicating that at least some Moschidae specimens derive from *M. leucogaster*.

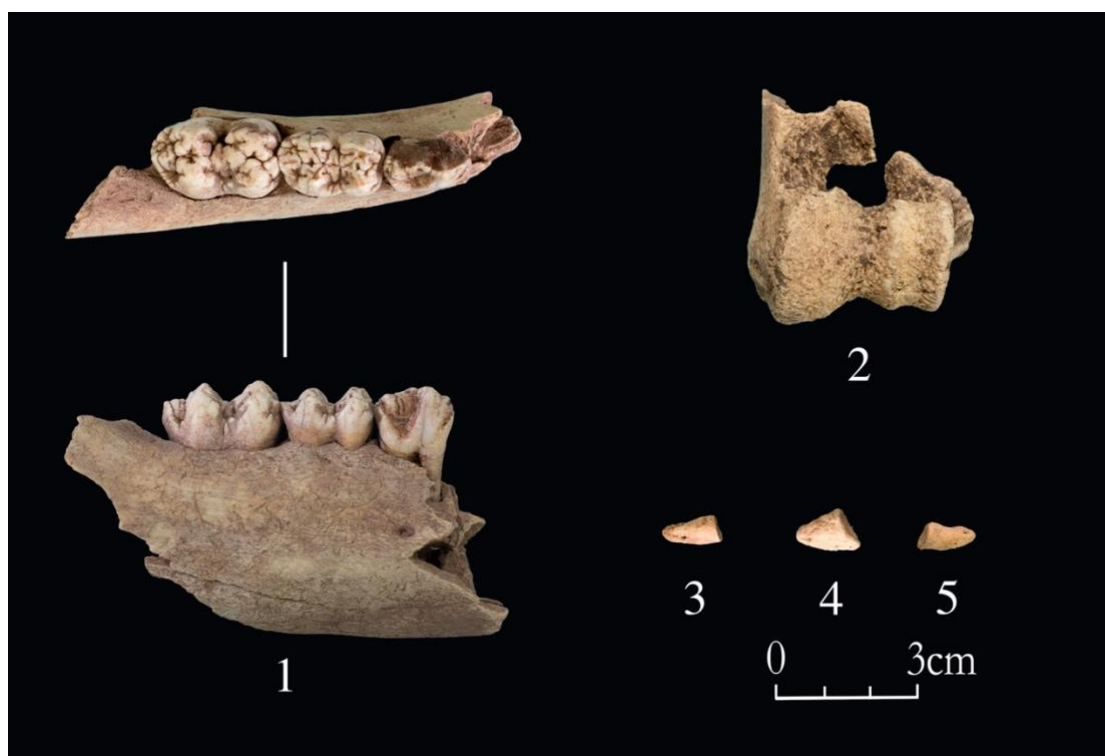


Figure 4: Suidae specimens from Xiaoenda

Wild members of the family Bovidae are also diverse in eastern Tibet, with at least seven wild bovid species inhabiting this region (Feng et al., 1986; Wang, 2003). According to morphological characteristics, we identified three specimens as *Ovis* sp. and attributed a further two specimens to blue sheep (*P. nayaur*), one to goral (*N. goral*), and one to tahr (*H. jemlahicus*). No specimens with identifiable landmarks were identified as domestic sheep or goat. Given the high diversity of wild bovid taxa in this region and relatively fragmentary nature of the assemblage, 36 specimens could only be identified to family Bovidae.

We identified only five specimens to the family Suidae (5/444 or 1.1% of the Artiodactyl specimens). One of them is a right mandible collected from the upper-most

stratigraphic layer, which was considered to be a modern disturbed layer during excavation and in subsequent stratigraphic interpretation. The other four specimens include one fragmentary distal humerus and three third phalanges (Table 3, Figure 4).

Table 2. Taxonomic Representation of Maximally Identifiable Specimens from the Xiaoenda.

	Taxon	Common Name	NISP	%	Total
Order Primates	Cercopithecidae	Monkey	1	0.14%	0.14%
	<i>Vulpes</i> sp.	Fox	8	1.10%	
Order Carnivora	Other Canidae		8	1.10%	3.97%
	Other Carnivora		13	1.78%	
	<i>Sus</i> sp.	Pig or wild boar	5	0.68%	
	Moschidae	Musk deer	185	25.34%	
	Large Cervidae	Large deer	68	9.32%	
	Medium Cervidae	Medium deer	45	6.16%	
	<i>Capreolus capreolus</i>	Roe deer	82	11.23%	
	Other Cervidae		11	1.51%	
	Large Bovidae		5	0.68%	
	<i>Pseudois nayaur</i>	Blue sheep	2	0.27%	92.47%
	<i>Naemorhedus goral</i>	Goral	1	0.14%	
	<i>Hemitragus jemlahicus</i>	Tahr	1	0.14%	
Order Artiodactyla	<i>Ovis</i> sp.		3	0.41%	
	Other small Bovidae		36	4.93%	
	Other large Artiodactyla		66	9.04%	
	Other medium Artiodactyla		30	4.11%	
	Other small Artiodactyla		135	18.49%	
	<i>Marmota himalayana</i>	Marmot	7	0.96%	
	Other Sciuridae		1	0.14%	2.05%
Order Rodentia	Other Rodentia		7	0.96%	
	Ochotonidae	Pika	6	0.82%	
Order Lagomorpha	<i>Lepus oiostolus</i>	Hare	4	0.55%	1.37%

Table 3. Information of Xiaoenda Suidae specimens

No.	Element	Portion	Side	Weight (g)
IT0202①:4	Mandible	P4-M2	R	44.7
IT0102②UF1F:7	Third Phalanx			0.2
IT0101⑥:26	Third Phalanx			0.3
IT0101⑥:59	Third Phalanx			0.2
IIIT0205②:1	Humerus	Distal	L	28.3

3.2 Body part representation & Bone Modification

In general, mammalian specimens from all size-classes at Xiaoenda indicated a high degree of skeletal completeness at the site (Figure 5). Specimens from both meaty and non-meaty elements are present for all taxa, although the composition of body parts varies (See Figure S1.). Traces of cultural modification (burning, cutting, chopping, polishing, carving, drilling, and sawing) are present on 775 mammal specimens (775/7314, 11%). Traces of non-cultural modification (carnivore and rodent gnawing) are present on 29 specimens (0.4%) (See Appendix: Table of frequency of different types of bone modification).

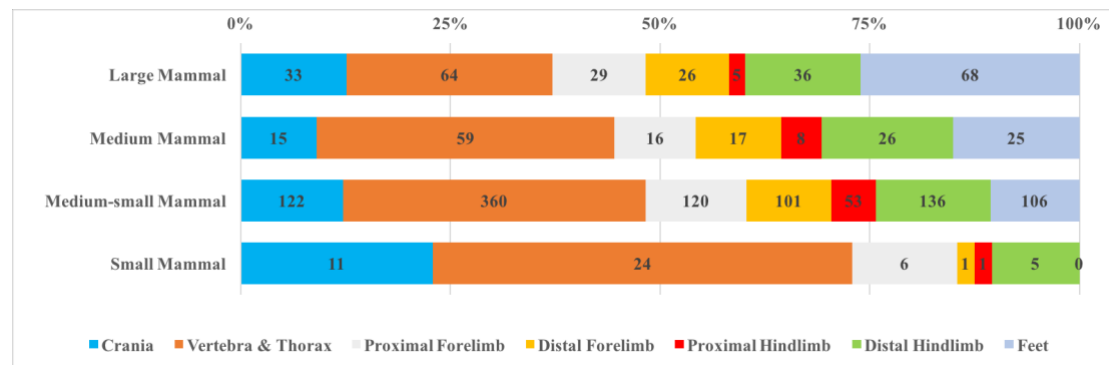


Figure 5: Body Part Representation in the Xiaoenda Faunal Assemblage. Note: Crania: antler/horn, skull, and mandible; Vertebra & Thorax: atlas, axis, vertebrae, rib, and pelvis; Proximal forelimb: scapula and humerus; Distal forelimb: ulna, radius, and metacarpal; Proximal hindlimb: femur; Distal hindlimb: tibia, astragalus, calcaneum, and metatarsal; Feet: phalange. Large mammal: large Cervidae and large Bovidae; Medium mammal: medium Cervidae and Suidae; Medium-small mammal: small Cervidae, Moschidae, and Canidae; Small mammal: Rodentia and Lagomorpha.

4. Discussion

4.1 Lack of domestic animals at Xiaoenda

All of the faunal specimens with clear landmarks from the site of Xiaoenda were derived from wild animals and there is no evidence that domesticated animals played a significant role in subsistence at this site. None of the maximally identifiable faunal specimens from Xiaoenda (N=730) were identified as domestic sheep, goat, cattle (*Bos taurus*), domestic yak (*Bos grunniens*) or domestic pig. Seven of the Bovid specimens (N=48) at Xiaoenda that could be identified to genus level or above were attributable

to wild bovids found in the vicinity of the site, including blue sheep, goral, and tahr. Further, Bovids in general account for only 6.6% (48/730) of the NISP from Xiaoenda, indicating that they did not play a major role in subsistence here.

Returning to the suids, the five specimens present make up an extremely small portion (1.1%, N=444) of the identifiable Artiodactyl assemblage—demonstrating that they did not constitute a substantial part of the assemblage, regardless of wild or domestic status. Wild boar and domestic pig are part of a continuum and difficult to differentiate from the fragmentary specimens and small samples available from Xiaoenda. As a result, we cannot rule out the possibility that domestic pigs were present, but there are no strong indications of this based on morphological criteria. Future investigation with expanded reference materials is necessary but will involve considerable efforts to document the morphological variation of local wild boar as well as contemporary domestic pig populations for comparison.

While we cannot give a definitive answer to the question of domestic pigs on the eastern plateau at this time, our findings do not support the argument that the management of domestic pigs played a significant role in the subsistence strategies of these Neolithic settlers in eastern Tibet. As we have discussed, the findings from Xiaoenda are consistent with more recent zooarchaeological research at Karuo, which similarly found no evidence for domestic pigs (Li, 2007; Zhang, 2013). The dominance of clearly identified wild taxa in the total faunal assemblage at Xiaoenda demonstrates that the inhabitants at this site relied overwhelmingly, and likely exclusively, on hunted wild animals. Whether this pattern holds for the region as a whole, and over what period, cannot be determined without additional faunal assemblages. This further underscores the importance of ongoing work in the southeastern Tibetan Plateau.

4.2 Subsistence at Xiaoenda: Localized Hunting Strategies

Our faunal data shows that hunting was the primary strategy for acquiring animal resources at Xiaoenda. People captured a variety of deer, including musk deer and roe deer, as well as wild bovids including goral and blue sheep. A wide range of taxa are present, but ungulates dominated the faunal assemblage. The behavior and habitat preferences of these and other taxa suggests that the site's location facilitated acquisition of a wide range of wild animals locally. At 3140 m.a.s.l., the site is situated in a resource diverse, transitional zone, within a vertical topography that provides access to the alpine meadows, shrubs, and broadleaf and mixed broadleaf-conifer

forests found between ~2500 to 5000 m.a.s.l. (Zhang et al., 1988). Today, shrubs are distributed widely around the site area and forests are found a short distance away on hills to the east side of Xiaoenda. All species identified, mainly inhabit shrub and forest habitats. Musk deer, for example, prefer alpine meadows, shrubs, and forest edges over 1900 m.a.s.l., while roe deer prefer broad leaved or mixed broadleaf-conifer forests lower than 4000 m.a.s.l. (Feng et al., 1986; Sheng et al., 1992). With a number of different micro-climates and habitats in close proximity of the site, settlers from Xiaoenda would have been able to easily and expediently hunt a diverse assortment of wild animals in the adjacent area.

Apart from habitat preferences of species found at Xiaoenda, body part frequency also provides evidence for a localized hunting strategy. As shown in Figure 5, (seen in more detail in Figure SI) mammals from all size classes, including very large deer, presented high degrees of skeletal completeness at Xiaoenda. This indicates that complete carcasses were likely carried back to the settlement, and that they were killed or captured nearby (Reitz and Wing, 2008: 213-216).

Large and small deer, blue sheep, and goral weighing between 20-200 kg would have provided a significant quantity of meat and bone nutrients, as well as pelts, sinew and bones for clothing and tools (cuisine and bone tools are the subject of ongoing research). Marmots and other rodents are uncommon at the site, and these small mammals were not a significant food resource. Carnivores known for their heavy pelts, such as red fox (*Vulpes vulpes*) were also uncommon, suggesting that meat, rather than fur for clothing or exchange, was the primary goal for hunting activities. The rarity of birds and exotic animals also suggests a greater focus on locally available subsistence resources than on exotic items. The monkey is an intriguing find at Xiaoenda, though represented by only one mandible. Traces of cut-marks on the buccal surface of the specimen (Appendix table) suggest that the monkey was skinned. Monkey remains in small numbers have been found at other archaeological sites in this region, including Karuo and Haxiu (Huang and Leng, 1985; He and Chen, 2006) and members of the family *Cercopithecidae* are still found in forests of the eastern Tibetan Plateau at slightly lower elevations (Feng et al., 1986: pp 114-124). Thus, the Xiaoenda specimen could have been hunted for skin or food, although a more exotic origin is also possible.

These data on taxonomic representation at Xiaoenda provide one of the most comprehensive descriptions to date of the contribution of wild fauna to human subsistence 5000-4000 years ago on the southeastern Tibetan Plateau. However, further

regional comparisons are needed to completely understand the significance of Xiaoenda's inhabitant's reliance on wild animals within a broader perspective.

4.3 Hunting as a key subsistence strategy in the eastern Tibetan Plateau

The faunal data from Xiaoenda presented here demonstrates that some of the people who inhabited the high-altitude eastern Tibetan Plateau (over 3000 m.a.s.l.) around 5000-4000 cal. BP relied primarily on wild animals for food and resources, rather than on domestic herds. Archaeological data from other regions of the Plateau have emphasized the importance of domestic herd animals to subsistence economies approximately 1000 years after the occupation at Xiaoenda (Zhou, 1999a; Huang, 2010; d'Alpoim Guedes et al., 2014; Tong et al., 2014; Tong et al., 2015; Zhang et al., 2015; Dong et al., 2016; Song et al., 2017; Zhang and Lu, 2017). In contrast, data from Xiaoenda highlights the significance of wild animals for long-term survival, at least during the fifth millennium BP in the eastern region of the Plateau. Thus, the likelihood of finding earlier sites in other regions where long-term and continuous occupation was facilitated by wild resources and *not* domestic species seems very likely, as has been suggested by other scholars for older time periods (Meyer et al., 2017).

The data presented here does not allow for empirical evaluation of discussions concerning population movements, local subsistence shifts, exchange and trade, or the nature of hunter-gatherer farmer interactions. However, our results from Xiaoenda, together with available faunal data from Karuo (Li, 2007) as well as from the site of Haxiu (He and Chen, 2006) do *not* support simple translocation models proposing the adoption of lowland cultivation and herding subsistence strategy packages by communities in eastern Tibetan Plateau (Hou, 2001; Shi, 2009; Han, 2012). Instead, animal exploitation strategies practiced on the eastern plateau were fundamentally different from those of Neolithic lowland farmers in regions such as Gansu and western Sichuan, who depended heavily on domesticated pigs during the same period (Flad, 2007; Yuan, 2008; Luo, 2012; He et al., 2014). Although there are differences among the taxonomic compositions of faunal assemblages from Xiaoenda, Karuo, and Haxiu, their taxonomic representations are broadly similar. All three sites are dominated by wild mammalian specimens with a notable abundance of deer and a near absence of suids, especially when compared to contemporary lowland sites (Figure 6). The fauna from these three sites provide intriguing information on the role of hunting during this

time period in the eastern Tibetan Plateau, which can be characterized as a shared focus on small sized cervids and bovids and diverse wild fauna.

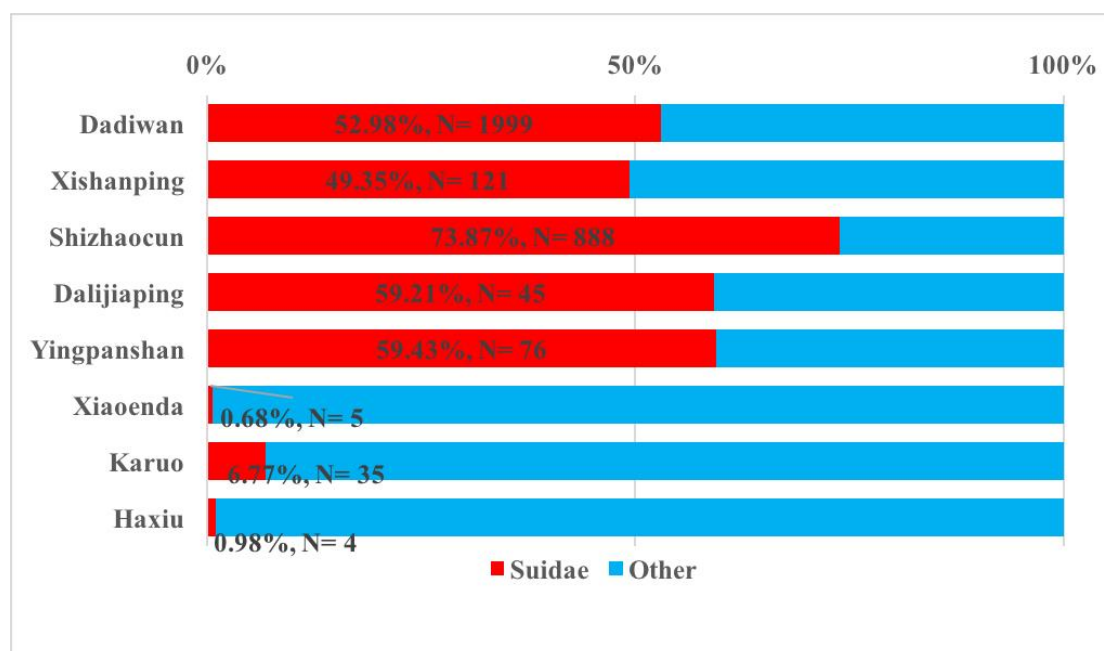


Figure 6: Taxonomic representation of Neolithic settlements from the eastern Tibetan plateau and contemporary sites in northwestern China (Data from: (The Institute of Archaeology, 1999; Zhou, 1999b; Zhang and Wang, 2000; He and Chen, 2006; Qi et al., 2006; Yanjiusuo, 2006; Li, 2007; Huang, 2010; He et al., 2014)) Note: data of Dalijiaping and Yingpanshan present MNI values, others present NISP values.

Available taxa, local subsistence practices, and relationships with wild and domestic animals may vary considerably, and the extent to which they do will provide interesting perspectives on local histories and strategies for survival on the southeastern Tibetan Plateau through time. Turning from the faunal data towards a more integrated view of subsistence at this site, if we consider the limited preliminary archaeobotanical analysis already conducted at Xiaoenda, it appears that the site's strategic location within a vertically transitional ecozone could have allowed for cereal cultivation as well as localized hunting. Within the broader context of early settlement on the Tibetan Plateau, the diversity of local strategies for acquiring animal resources exhibited by early Neolithic sites in this region of China, encourages us to reflect on assumptions about what being a "hunter" or "farmer" actually entails.

5. Conclusion

Our findings demonstrate that dependence on diverse wild animal resources was the primary animal-based subsistence strategy used by people living 5000 - 4000 years ago on the Eastern Tibetan Plateau. Animal species present at Xiaoenda such as musk deer, roe deer, goral, and blue sheep reveal that people living in this region focused mainly on hunting small-bodied cervids and bovids. Consideration of the ecological requirements and preferences of animal taxa at Xiaoenda suggests that they were able to hunt this diverse array of wild species within the vicinity of the site. This localized hunting strategy, which relied on a diversity of taxa, was enabled by the site's location within a transitional ecological zone.

When added to previously published zooarchaeological studies from this region, our study reveals that, when humans began their journeys toward more continuous or repeated settlement on different parts of the Tibetan Plateau during the middle Holocene, they experimented with various strategies for coping with the challenges of extreme ecological conditions distinct to different parts of the plateau. Systematic zooarchaeological studies of faunal assemblages from many important sites and burials from other parts of the plateau are still rather scarce, however. To further explore the question of how animal resources enabled survival in the northeastern, central, and western regions of the Tibetan Plateau, more systematic studies of faunal remains from these regions and all time periods are necessary.

Appendix

	BU	CU	CH	PL	CN	CG	RG	PL & DR	PL & CN	PL & SW	CU & CH	BU & CH	CU & CG	CH & CG	Amount
Rodentia		1													1
Primates		1													1
Large Cervidae		3		3											6
Medium Cervidae	1		1			1									3
Medium-small Cervidae	4	1	1	2		2						1			11
Moschidae	14	4	1	1	5	1									26
Large Bovidae			1												1
Small Bovidae	3	4				2									9

Carnivora	2															2			
Large																			
Artiodactyla	4	2	1											2				9	
Medium																			
Artiodactyla	1											2					3		
Small																			
Artiodactyla	14	5														19			
Artiodactyla	1	1														2			
Large Mammal	12	8	3											1				25	
Medium Mammal	4	3	1											1				10	
Medium-Small																			
Mammal	33	11	5	3											3				55
Small Mammal	2	1														3			
NID	520	15	41		15	10	2	6	4	1	2					616			
Amount	615	60	14	50	20	24	3	6	4	1	2	1	1	1					

Note: BU=burning, CU=cutting, CH=chopping, PL=polishing, CN=carving, SW=sawing, CG=carnivore gnawing, RG=rodent gnawing

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Supplementary Figure 1: Body Part Representation in the Xiaoenda Faunal Assemblage.



