Integrating taphonomy into the practice of zooarchaeology in China

Citation
Lam, Y.M., Katherine Brunson, Richard Meadow, and Jing Yuan. 2010. "Integrating Taphonomy into the Practice of Zooarchaeology in China." Quaternary International 211 (1-2) (January): 86–90. doi:10.1016/j.quaint.2009.01.014.

Published Version
doi:10.1016/j.quaint.2009.01.014

* Manuscript

REVISED SUBMISSION TO *QUATERNARY INTERNATIONAL*

INTEGRATING TAPHONOMY INTO THE PRACTICE OF ZOOARCHAEOLOGY IN CHINA

Y. M. LAM,[a] Katherine BRUNSON,[b] Richard MEADOW,[b] Jing YUAN[c]

[a] corresponding author
Department of Anthropology
University of Victoria
PO Box 3050 STN CSC
Victoria, BC V8W 3P5
CANADA
ymlam@uvic.ca
Telephone: (250) 721-7051
Fax: (250) 721-6215

[b]Department of Anthropology
Harvard University
11 Divinity Avenue
Cambridge, MA 02138
USA
krbrunson@gmail.com
meadow@fas.harvard.edu

[c]Institute of Archaeology
Chinese Academy of Social Sciences
27 Wangfujing Street
Beijing
CHINA
yuanjing@cass.org.cn

ABSTRACT:

With the study of faunal remains (zooarchaeology) emerging as an increasingly prominent component of archaeological studies in China, the importance of studying processes of assemblage formation and preservation (taphonomy) is becoming evident. Remains of animals recovered from an archaeological site are a biased sample of the assemblage that was originally deposited because certain animal parts preserve better than others. Important characteristics of faunal assemblages, such as skeletal element representation and age profiles, can be affected by differential preservation caused by taphonomic agents – cultural or natural. One primary goal of taphonomic studies is to provide an understanding of differential preservation of bone elements, allowing archaeologists to make more accurate assessments concerning the exploitation of different animal species by past peoples. Recent studies of the faunal assemblages from the Early Paleolithic site of Xujiayao and the Neolithic site of Taosi, both in Shanxi province, provide examples of the effects that differential preservation can have on archaeological interpretations of skeletal element representation and age profiles, respectively. These examples illustrate how an understanding of taphonomy is critical to the future practice of zooarchaeology in China.

Keywords: bone density, faunal analysis, Taosi, Xujiayao

1. **Introduction**

Over the past decade, the analysis of animal remains from archaeological sites (zooarchaeology) has become increasingly important to the study of prehistoric and early state societies of China, providing information concerning the subsistence and ritual behavior of early Chinese peoples (Yuan, 2002; Yuan and Flad, 2005). This development has recently been accompanied by recognition of the importance of taphonomy, the study of the processes that affect the preservation of an organism's remains after death (Norton and Gao, 2008a, 2008b; Zhang, 2008). Paleontologists and zooarchaeologists have long recognized that the faunal remains recovered from a site are typically a small, biased sample of what was originally deposited. A faunal assemblage may undergo significant modification through time as it becomes subject to many different biological, chemical, geological, and cultural processes before recovery by archaeologists. As investigators strive to reconstruct aspects of the behavior of past peoples, they have devoted greater effort to understanding how the differential preservation of different parts of the animal skeleton may affect their interpretations of the faunal record.

The importance of taphonomy can be illustrated from the perspective of the "life history" of a faunal assemblage. Table 1 shows the general similarity in how different researchers have defined the stages of this life history. The inverted triangle indicating sample size represents the loss of bones (i.e., data) from one stage to the next as an assemblage progresses from the animals that are potentially exploitable by the inhabitants of a site (Stage A) to the data eventually published from the study of that assemblage (Stage H). Zooarchaeologists are most interested in how ancient people selected and obtained the animals that they used (B) from all of the species available to them (A) and how the remains of these animals (C) reflect the manner in which they were used. Taphonomic studies have focused on determining how to reconstruct the death assemblage (B) from the preserved fossil assemblage (D). As it progresses through each stage, the assemblage, in its different manifestations, becomes smaller and smaller, and each stage of the assemblage may or may not be representative of the one that preceded it.

An important consideration, made explicit by researchers such as Meadow (1980) and Davis (1987), is that archaeologists play a role in shaping the life history of a faunal assemblage, making the decisions that determine the nature of each stage from E (bones in excavated volume) to H (published data). Archaeologists decide how a site is excavated (e.g., where to place excavation units), how bones are recovered from the excavated volume (e.g., the size of the mesh used for sieving), which of the recovered bones are recorded (e.g., how much time is spent in identifying a bone fragment), and what types of faunal data and what level of detail are presented in the eventual publication, if any. In the context of zooarchaeology, the role of taphonomy is to identify biases that affect the interpretation of the faunal record so that these can be discussed when presenting the results of an analysis. Taphonomic factors need to be taken into consideration in order to understand patterns documented in the faunal data and to assess how accurately these patterns represent the originally deposited faunal assemblage.

Archaeologists have long recognized that certain parts of the skeleton preserve better than others, and taphonomic studies have attempted to address this issue. In one of the most influential works in this field, *The Hunters or the Hunted: An Introduction to African Cave Taphonomy*, C. K. Brain reported on the collection and modification of bones by different species of prey animals (Brain, 1981). He also observed how pastoralists butchered animals and how their dogs consumed the discarded bones. They noted that the damage to and survival of different parts of the skeleton appeared to reflect their relative density. Some bone elements were denser, and therefore survived more frequently, than others. In addition, certain parts of a given element preserved better than other parts of the same element.

The remainder of this paper focuses on the effects of differential preservation on archaeological faunal assemblages by addressing the following questions:

1) Which bones are most likely to be lost in the archaeological record (specifically, between Stage B and Stage D)?
2) How does the differential preservation of bones affect our interpretation of the archaeological record?
3) How may zooarchaeologists adapt their analytical methodology, during the recovery (F) and recording (G) of bone specimens, to deal with differential preservation?

The Early Paleolithic site of Xujiayao and the Neolithic site of Taosi, both in Shanxi province (Figure 1), are used as examples to address these questions and to demonstrate the potential significance of taphonomic analyses in Chinese zooarchaeology.

2. Bone Density

In examining which bones are most likely to be lost in the archaeological record, the variable that has received the most attention has been bone density. Following initial studies by Binford and Bertram (1977) and Brain (1981), other researchers have measured the bone density of the entire skeleton of several different species of animals (e.g., Kreutzer, 1992; Lyman, 1994; Lam et al., 1999; Stahl, 1999) in different ways. Unfortunately, these sets of density data vary tremendously in accuracy, reflecting the different methods used to derive them (Lam & Pearson, 2005). In addition, because of the difficulty, expense, and effort involved in deriving density measurements, the sample sizes involved in all density studies have been small. As a result, we do not have enough data on how bone density varies within a species (e.g., between individuals of different sexes, ages, and/or diets) and between different species. Nevertheless, it remains evident that the density of a bone element (or parts thereof) plays an important role in determining the likelihood of that element (or parts thereof) preserving in the archaeological record.

Within an individual skeleton, bone density varies between and within different skeletal elements. Such variation appears similar not only among individuals of the same species but among animals with a similar skeletal structure. Comparisons of bone density data derived using computed tomography (CT) found that species of bovid, cervid, and equid all show similar patterns in bone density across the skeleton (Lam et al., 1999). In these species, the densest elements of the cranium are the teeth and the petrous bone; among the post-crania, the middle shaft portions of the long bones are the densest.

3. Interpreting Archaeological Faunal Assemblages

The differential preservation of faunal remains, whether due to differences in bone density or other factors, may have a significant effect on the interpretation of faunal assemblages. Here we examine the potential influence of biased preservation on two important lines of zooarchaeological evidence – skeletal element representation and age profiles – using examples from two archaeological sites in China.

3.1 Skeletal Element Representation

Skeletal element representation has been used to infer the hunting behavior of prehistoric peoples. In examining the relative abundance of different bone elements, zooarchaeologists rely heavily on the concept of bone “utility” developed by Binford (1978), in which he estimated the nutritional value represented by each skeletal part. High-utility elements are associated with a large amount of meat, marrow, and grease, while low-utility elements have little food value. In ungulates, the femur, which bears a high amount of meat and marrow, represents a high-utility element, while the metapodials (metacarpals and metatarsals), which contain some marrow but bear little meat, are considered to be of low-utility, as are cranial elements, carpals, tarsals, and phalanges.

Patterns of skeletal element representation at Palaeolithic residential sites have been examined by zooarchaeologists in order to determine how Palaeolithic peoples acquired and used animals. In these studies, interpretations have been based largely upon the utility index – the relative abundance of high-utility and low-utility skeletal elements. When many low-utility bones are found at such sites, researchers infer that the humans at the site engaged in scavenging – obtaining only the left-over parts of prey animals that had been killed and consumed by other predators. Conversely, the occurrence of high-utility bones at a Palaeolithic site is typically interpreted to represent the result of hunting activities, indicating that ancient people killed the animals and brought the most valuable parts of the carcass back to the site (e.g., Marean and Kim, 1998).

The quantification and subsequent interpretation of skeletal element abundance can be affected by differences in bone density within the skeleton. In particular, the most accurate bone density data have shown the middle shaft portions of long bones to be much denser and, therefore, more likely to preserve than their epiphyses (Lam et al., 1998, 1999). Most long bone epiphyses are composed largely of cancellous bone, which, when compared to cortical bone, is both less resistant to destruction and more likely to be consumed by humans or carnivores for the grease it holds. Long bone shafts may be broken for access to bone marrow, but the resulting fragments of cortical bone are extremely durable and thus likely to preserve in the archaeological record. Traditional methods of long bone quantification have focused on counting epiphyses because they are much more easily identified to element and to taxon than are shaft fragments. However, taphonomic research has demonstrated that if bone counts are based on epiphyses, the number of long bones present is underestimated. More importantly, counts based on epiphyses may not record the correct *proportion* of long bones. This is because the epiphyses of some long bones (e.g., the metapodials) are denser than the epiphyses of others (Lam et al., 1998, 1999). If bone quantification is based on epiphyses, then metapodials (the low-utility long bones) may be over-represented compared to the other long bones. Using the traditional method of basing long bone counts on epiphyses, studies of many archaeological faunal assemblages have found low numbers of high-utility long bones when compared to metapodials and cranial elements (i.e., a scavenging pattern). When long bone counts are based on shaft fragments, the relative proportion of high-utility long bones may increase dramatically.

The faunal assemblage from Xujiayao, a well-known Early Palaeolithic site in Yanggao county, Shanxi province, provides an example of this observation. Excavated in the late 1970s by the Institute of Vertebrate Paleontology and Palaeoanthropology under the direction of Professor Jia Lanpo (Jia and Wei, 1976; Jia et al., 1979; cited in Norton and Gao, 2008a), Xujiayao has produced a faunal assemblage dominated by bones attributed to horse (*Equus prezwlaskii*). While sieving was not conducted during the excavation, an effort was made to recover small bone fragments (Norton and Gao, 2008a). Norton and Gao (2008a) conducted a detailed taphonomic study of this assemblage and identified 889 specimens of equid long bone. They found that, for all long bones, the shaft portions were much more abundant than the epiphyses (Figure 2). The traditional method of counting epiphyses would have severely underestimated the numbers of long bones present and would also have found the low-utility metapodials to be the most abundant long bones. When shaft fragments are identified to element and counted, a much larger number of long bones are recorded, with the most abundant element being the tibia, a high-utility bone. The survival of these different long bone portions is highly correlated with their bone density (r_s=0.811, $p < 0.001$) (equid bone density values from Lam et al., 1999; see Lam and Pearson, 2005, for the assumptions required for such correlation analysis).

This example illustrates two points. First, variables such as bone density will determine how likely a bone specimen will survive in the fossil record (Table 1: Stages B to D). Second, the choices made by zooarchaeologists with regards to bones recovered (Stage F) and bones recorded (Stage G) can have a significant influence over the eventual interpretation of a faunal assemblage. The sieving of excavated sediments will recover diagnostic shaft fragments of macromammal long bones, and greater attention during laboratory analysis to such fragments will affect the quantification of skeletal element representation. While such efforts are likely to increase the accuracy of bone counts, this focus on shaft portions does have two practical shortcomings: identifying shaft fragments is extremely time-consuming and may not be practical for many studies, and it is often difficult to identify such fragments to species. As a result, such studies usually can draw conclusions based only on animal size classes.

In the case of Xujiayao, different methods of recording bones would have led to contrasting interpretations of how the assemblage of horse remains was accumulated. If only epiphyses were counted, metapodials would appear to dominate the assemblage. This predominance of low-utility elements could result in the interpretation that the ancient inhabitants of Xujiayao were primarily scavengers – that they had access to the remains of horses only after the original predators had consumed the more desirable parts of the carcasses. However, by identifying and counting shaft specimens, Norton and Gao (2008a) found a much higher relative abundance of other long bones, producing a pattern of skeletal element representation that is consistent with hunting. This distinction between scavenged and hunted faunal assemblages is relevant primarily to early Palaeolithic sites, but taphonomic processes also influence the preservation and interpretation of more recent faunal assemblages, as illustrated in the following example from the Late Neolithic site of Taosi.

3.2 Age Profiles

Archaeological age profiles for certain mammal species provide evidence for the herd management and hunting practices of prehistoric peoples. Age determinations are based typically on tooth eruption and wear, epiphyseal fusion, and incremental structures such as cementum bands in teeth. At Neolithic sites, the relative proportion of animals of different sexes and ages provide insight into whether a particular species was domesticated and if that species was exploited by humans for meat or for other products (e.g., Zeder and Hesse, 2000). At Palaeolithic sites, the predominance of very young and very old individuals representing large mammal species may indicate that the people living at these sites were not able to hunt healthy individuals in their prime (Klein and Cruz-Uribe, 1984). On the other hand, Palaeolithic faunal assemblages dominated by the remains of prime-aged large mammals have been interpreted to reflect effective hunting strategies on the part of the site occupants (Stiner, 1994; Gaudzinski and Roebroeks, 2000). For the Late Paleolithic site of Zhoukoudian Upper Cave, Norton and Gao (2008b) reconstructed the age profiles of the deer species based on tooth eruption and wear. They found mostly young and prime-aged deer, with very few old individuals, and concluded that this age profile was consistent with the activities of ambush hunters such as humans or large cats.

One important taphonomic issue is whether the bones and teeth of adult animals preserve better than those of juvenile animals. As the bones of juvenile animals are still developing, it seems reasonable to expect that they are less dense than those of adults, but the density studies that have addressed this issue are few and inconclusive (e.g., Symmons, 2005). Age profiles are often constructed on the basis of tooth eruption and wear, but it has been long been suspected that juvenile teeth do not preserve as well as adult teeth (Klein and Cruz-Uribe, 1984; Marean, 1995). This likely reflects not differences in density between juvenile and adult teeth but the fact that juvenile teeth are smaller and more likely to fall out of the mandible and maxilla. In addition, the mandibles of young deer (under 6 months of age) appear to be less dense than those of adult deer, providing less protection for juvenile teeth (Munson and Garniewicz, 2003). While it appears that juvenile bones and teeth are more vulnerable to destruction compared to those of adults, the degree to which juvenile bones are more likely to survive in the archaeological record than juvenile teeth remains to be determined (see also Pike-Tay et al., 2004).

Another taphonomic issue concerns the relative under-representation of teeth due to cultural behavior. In many depositional environments, teeth will preserve extremely well because of their enamel, which is primarily mineral and much denser than bone. However, teeth may be rare in certain contexts, such as Paleolithic residential sites, because the Paleolithic hunters may have chosen not to transport (low-utility) cranial elements, particularly those of large animals, back to the site (e.g., Assefa, 2006).

The faunal assemblage from the Late Neolithic site of Taosi in Xiangfen county, Shanxi province, illustrates the complexities involved in interpreting age profiles. The excavation of this assemblage was conducted in 2004 by the Shanxi Archaeology Team of the Institute of Archaeology, Chinese Academy of Social Sciences, under the direction of Dr. He Nu. As at Xujiayao, the excavation sediment was not screened, and bones were collected by hand. Brunson's (2008) analysis of the Taosi assemblage identified taphonomic biases in kill-off patterns for pig (*Sus* sp.). For sheep (*Ovis aries*) remains from Taosi, the age profile derived from tooth eruption and wear is consistent with the profile derived from the pattern of epiphyseal fusion of appendicular elements. These profiles both show that most sheep were killed when they were old, suggesting that the residents of the site had kept sheep for secondary (antemortem) products such as wool.

For pig, however, the data from tooth eruption and wear produced a different age profile than that based on epiphyseal fusion. The tooth data show that most pigs were killed when young, a pattern that is consistent with their being used for meat.[1] However, the epiphyseal fusion data show a different pattern, indicating that a large proportion of pigs had survived into adulthood (Figure 3). This discrepancy may reflect the fact that epiphyseal fusion is not an effective way of ageing pig bones (Bull and Payne, 1982). It may also reflect biased preservation or biased recovery against juvenile pig post-crania. Because shafts without epiphyses could not be aged, the destruction of juvenile long bone epiphyses (even if the shaft portions had survived) would result in a recording bias toward older individuals. For both pig and sheep, late-fusing epiphyseal portions, such as the proximal humerus and the distal radius, are poorly represented in the Taosi assemblage (Brunson, 2008: her Table 4.10). As late fusion corresponds with low bone density (e.g., Brain, 1981: his Table 7), the relative paucity of these long bone epiphyses suggests that they had been subjected to a higher degree of destruction by taphonomic processes. In addition, the proportions of small elements such as phalanges and metapodials are low in the overall Taosi faunal assemblage. This suggests that small bones, including the relatively smaller bones of juvenile individuals, may not have been systematically collected. It is possible that sieving of the excavation sediment might have resulted in the recovery of a larger number of post-cranial elements.

---

[1] In the Taosi collections analyzed by Brunson, the sex of most pig specimens could not be determined; therefore, sex was not included in the analysis of *Sus* age profiles. Consideration of sex may play a part in determining the culling strategies for pigs, and one might expect that males would be killed earlier than females. However, considering that female pigs can reproduce before one year of age and produce large litters, it is not necessary to keep even most female pigs alive much longer than 12 months or so (Redding and Rosenberg, 1998). Because it is particularly difficult to determine sex from the bones of infants and young juveniles, it may not be possible to ascertain the role of selection based on sex in cases of the extensive kill-off of young individuals.

4. Conclusion

In pursuing zooarchaeological studies in China, as elsewhere, it is critical to take into account the effects of taphonomic processes – in particular, the differential preservation of skeletal elements. Bone density is an important factor in bone survival, and accurate bone density values (such as those obtained using CT) have shown the importance of counting the shaft fragments of long bones. Shaft represent the densest portions of the post-cranial skeleton. If they are not collected and counted, the number of long bones in a faunal assemblage will likely be underestimated. Some research has suggested that, in certain conditions, the bones and teeth of young animals do not survive as well as those of adults and may be under-represented in faunal assemblages. In constructing age profiles, it is therefore important to compare data from teeth to those from post-crania. The examples from Xujiayao and Taosi illustrate how the choice of recovery methods, analytical techniques, and the lines of evidence that are examined may influence the interpretations of an archaeological faunal assemblage. Understanding the taphonomic biases shaping these lines of evidence represents an essential foundation to the practice of zooarchaeology.

Acknowledgements

We thank Christopher Norton and Jennie Jin, the guest editors of this issue of *Quaternary International*, for inviting us to submit this paper for publication. KRB, RHM, and YML wish to express their appreciation for the extensive assistance provided by YJ during the course of their research in China. We are grateful to He Nu and the researchers at the Center for Scientific Archaeology (Chinese Academy of Social Sciences), including Lu Peng, Li Zhipeng, Wang Linlin, Luo Yunbing, and Tao Yang. KRB thanks Rowan Flad, Pamela Richards, and Mathew Brunson. YML's research is funded by the Social Sciences and Humanities Research Council of Canada. He thanks Chen Xingcan, Yang Dongya, Christopher Norton, Fu Xianguo, Fu Yongxu, Yang Rui, and Zhang Yue. Figure 1 was produced with contributions from Wu Xiejie and Stacey Hrushowy.

References

Assefa, Z., 2006. Faunal remains from Porc-Epic: Paleoecological and zooarchaeological investigations from a Middle Stone Age site in southeastern Ethiopia. Journal of Human Evolution 51, 50-75.

Binford, L.R., Bertram J.B., 1977. Bone frequencies – and attritional processes. In: Binford, L.R. (Ed.) For Theory Building in Archaeology. Academic Press, New York, pp. 77-153.

Binford, L.R., 1978. Nunamiut Ethnoarchaeology. Academic Press, New York.

Binford, L.R., 1981. Bones: Ancient Men and Modern Myths. Academic Press, New York.

Brain, C.K., 1981. The Hunters or the Hunted? An Introduction to African Cave Taphonomy. University of Chicago Press, Chicago.

Brunson, K., 2008. Shifting Animal Exploitation Strategies in Late Neolithic China: A Zooarchaeological Analysis of the Longshan Culture Site of Taosi, Shanxi Province. BA thesis, Harvard University.

Bull, G., Payne, S., 1982. Tooth eruption and epiphyseal fusion in pigs and wild boar. In: Wilson, B., Grigson, C., Payne, S. (Eds.) Ageing and Sexing Animal bones from Archaeological Sites. BAR British Series 109, Oxford, pp. 55-75.

Clark, J., Kietzke, K.K., 1967. Paleoecology of the Lower Nodular Zone, Brule Formation, in the Big Badlands of South Dakota. Fieldiana Geology Memoir 5, pp. 111-137.

Davis, S.J.M., 1987. The Archaeology of Animals. Yale University Press, New Haven.

Ervynck, A., Dobney, K., Hongo, H., Meadow, R., 2001. Born free? New evidence for the status of *Sus scrofa* at Neolithic Çayönü Tepesi (southeastern Anatolia, Turkey). Paleorient 27, 47-73.

Gaudzinski, S., Roebroeks, W., 2000. Adults only. Reindeer hunting at the Middle Palaeolithic site Salzgitter Lebenstedt, Northern Germany. Journal of Human Evolution 38, 497-521.

Hongo, H., Meadow, R., 1998. Pig exploitation at Neolithic Çayönü Tepesi (southeastern Anatolia). MASCA Research Papers in Science and Archaeology 15.

Jia, L.P., Wei, Q., 1976. Xujiayao Paleolithic site, in Yanggao County, Shanxi Province, Archaeol. Bull. 2, 97-114.

Jia, L.P., Wei, Q., Li, C.R., 1979. Report on the excavation of Hsuchiayao Man Site in 1976. Vert. PalAsiatica 17, 277-293.

Klein, R.G., Cruz-Uribe, K., 1984. The Analysis of Animal Bones from Archeological Sites. University of Chicago Press, Chicago.

Kreutzer, L.A., 1992. Bison and deer bone mineral densities: comparisons and implications for the interpretation of archaeological faunas. Journal of Archaeological Science 19, 271-294.

Lam, Y.M., Chen, X., Marean, C.W., Frey, C., 1998. Bone density and long bone representation in archaeological faunas: comparing results from CT and photon densitometry. Journal of Archaeological Science 25, 559-570.

Lam, Y.M., Chen, X., Pearson, O.M., 1999. Intertaxonomic variability in patterns of bone density and the differential representation of bovid, cervid, and equid elements in the archaeological record. American Antiquity 64, 343-362.

Lam, Y.M., Pearson, O.M., 2005. Bone density studies and the interpretation of the faunal record. Evolutionary Anthropology 14, 99-108.

Lawrence, D.R., 1968. Taphonomy and information losses in fossil communities. Geological Society of America Bulletin 79, 1315-1330.

Liu, L., 2004. The Chinese Neolithic: Trajectories to Early States. Cambridge University Press, Cambridge.

Lyman, R.L., 1994. Vertebrate Taphonomy. Cambridge University Press, Cambridge.

Marean, C.W., 1995. Of taphonomy and zooarcheology. Evolutionary Anthropology 4, 64-72.

Marean, C.W., Kim, S.Y., 1998. Mousterian large mammal remains from Kobeh Cave (Zagros Mountains, Iran): Behavioral implications for Neanderthals and early modern humans. Current Anthropology 39, S79-S113.
Meadow, R.H., 1980. Animal bones: problems for the archaeologist together with some possible solutions. Paléorient 6, 65-77.
Munson, P.J., Garniewicz, R.C., 2003. Age-mediated survivorship of ungulate mandibles and teeth in canid-ravaged faunal assemblages. Journal of Archaeological Science 30, 405-416.
Norton, C.J., Gao, X., 2008a. Hominin-carnivore interactions during the Chinese Early Paleolithic: taphonomic perspectives from Xujiayao. Journal of Human Evolution 55, 164-178.
Norton, C.J., Gao, X., 2008b. Zhoukoudian Upper Cave revisited. Current Anthropology 49, 732-745.
Pike-Tay, A., Bartosiewicz, L., Gal, E., Whittle, A., 2004. Body-part representation and seasonality: sheep/goat, bird and fish remains from early Neolithic Ecsegfalva 23, SE Hungary. Journal of Taphonomy 2, 221-246
Redding, R. W., Rosenberg, M., 1998. Ancestral pigs: A New (Guinea) model for pig domestication in the Middle East. In: Nelson, S. M. (Ed.) Ancestors for the Pigs. Pigs in Prehistory (MASCA Research Papers in Science and Archaeology 15). University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, pp. 65-76.
Silver, I. A., 1969. The ageing of domestic animals. In: Brothwell, D., Higgs, E. (Eds.) Science in Archaeology: A Survey of Progress and Research. Thames and Hudson, London, pp. 283-302.
Stahl, P.W., 1999. Structural density of domesticated South American camelid skeletal elements and the archaeological investigation of prehistoric Andean ch'arki. Journal of Archaeological Science 26, 1347-1368.
Stiner, M.C., 1994. Honor Among Thieves: A Zooarchaeological Study of Neanderthal Ecology. Princeton University Press, Princeton.
Symmons, R., 2005. New density data for unfused and fused sheep bones, and a preliminary discussion on the modelling of taphonomic bias in archaeofaunal age profiles. Journal of Archaeological Science 32, 1691-1698.
Yuan, J., 2002. The formation and development of Chinese zooarchaeology: A preliminary review. Archaeofauna 11, 205-212
Yuan, J., Flad, R. 2002. Pig domestication in ancient China. Antiquity 76, 724-732.
Yuan, J., Flad, R. 2005. New zooarchaeological evidence for changes in Shang Dynasty animal sacrifice. Journal of Anthropological Archaeology 24, 252-270.
Zeder, M. A., Hesse, B., 2000. The initial domestication of goats (*Capra hircus*) in the Zagros Mountains 10,000 years ago. Science 287, 2254-2257.
Zhang, Y., 2008. A Zooarchaeological Study of Bone Assemblages from the Ma'anshan Site and the Interpretations of Hominid Behaviour. PhD dissertation, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing.

FIGURE CAPTIONS

Figure 1: Map showing the location of Xujiayao and Taosi, after Liu (2004: her Figure 1.1).

Figure 2: Equid long bone representation by portion at Xujiayao, based on data from Norton and Gao (2008: Table 10). When they are based on epiphyseal portions, the counts of long bones are low, with metapodials (low-utility elements) being most abundant. When they are based on shaft portions, the counts of long bones are much higher, with tibia (a high-utility element) being most abundant.

Figure 3: *Sus* (pig) survivorship curves at Taosi, based on data from Brunson (2008: her Tables 4.10 and 4.11). Epiphyseal fusion: 1 year: n=93; 2 years: n=43; 3 years: n=12. Tooth eruption and wear: 0-6 months: n=23; 6-12 months: n=25; 18-24 months: n=14; over 24 months: n=2. Tooth eruption and wear stages were defined according to Hongo and Meadow (1998) and Ervynck et al. (2001). Epiphyseal fusion stages were defined following Silver (1969) and Hongo and Meadow (1998).

Table

Table 1: The different stages in the life history of a faunal assemblage.

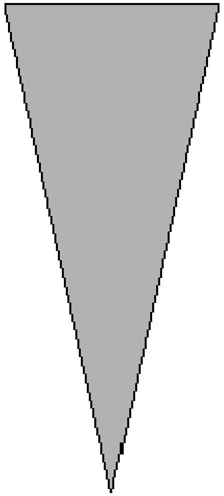
Sample Size	Stage	Clark and Kietzke (1967)	Lawrence (1968)	Meadow (1980)	Klein and Cruz-Uribe (1984)	Davis (1987)
LARGER 	**A**	life assemblage	birth		life assemblage	animals living around the site
	B	death assemblage	death	potential bone population	death assemblage	dead animals and parts brought to the site
	C		final burial	deposited fraction	deposited assemblage	buried bones
	D	total fossil assemblage		preserved fraction	fossil assemblage	preserved bones
	E		discovery	bones in excavated volume		bones in excavation area
	F	collection		bones recovered	sample assemblage	bones recovered
	G			bones recorded		bones recorded
SMALLER	**H**			published data		published data

Figure 1

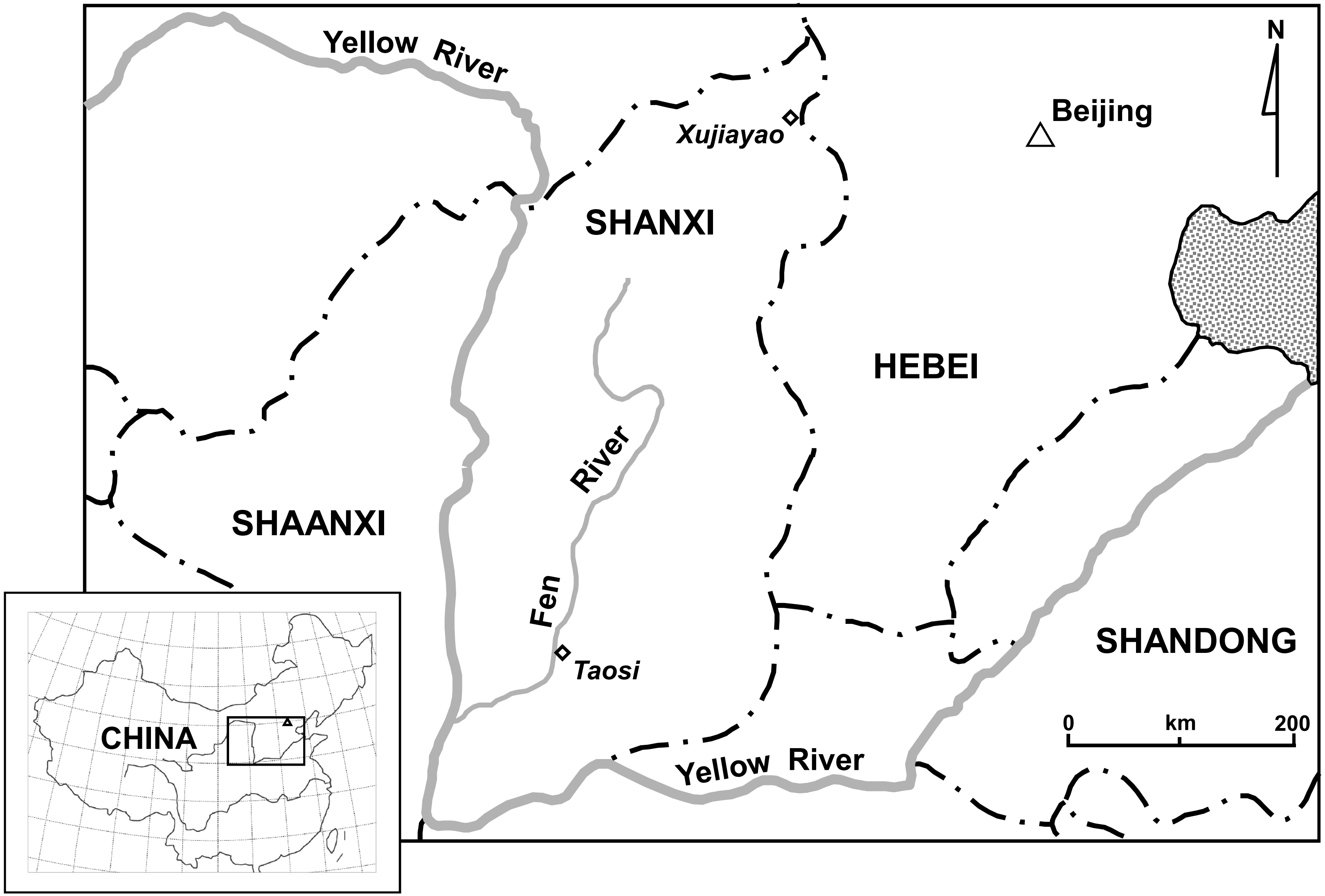
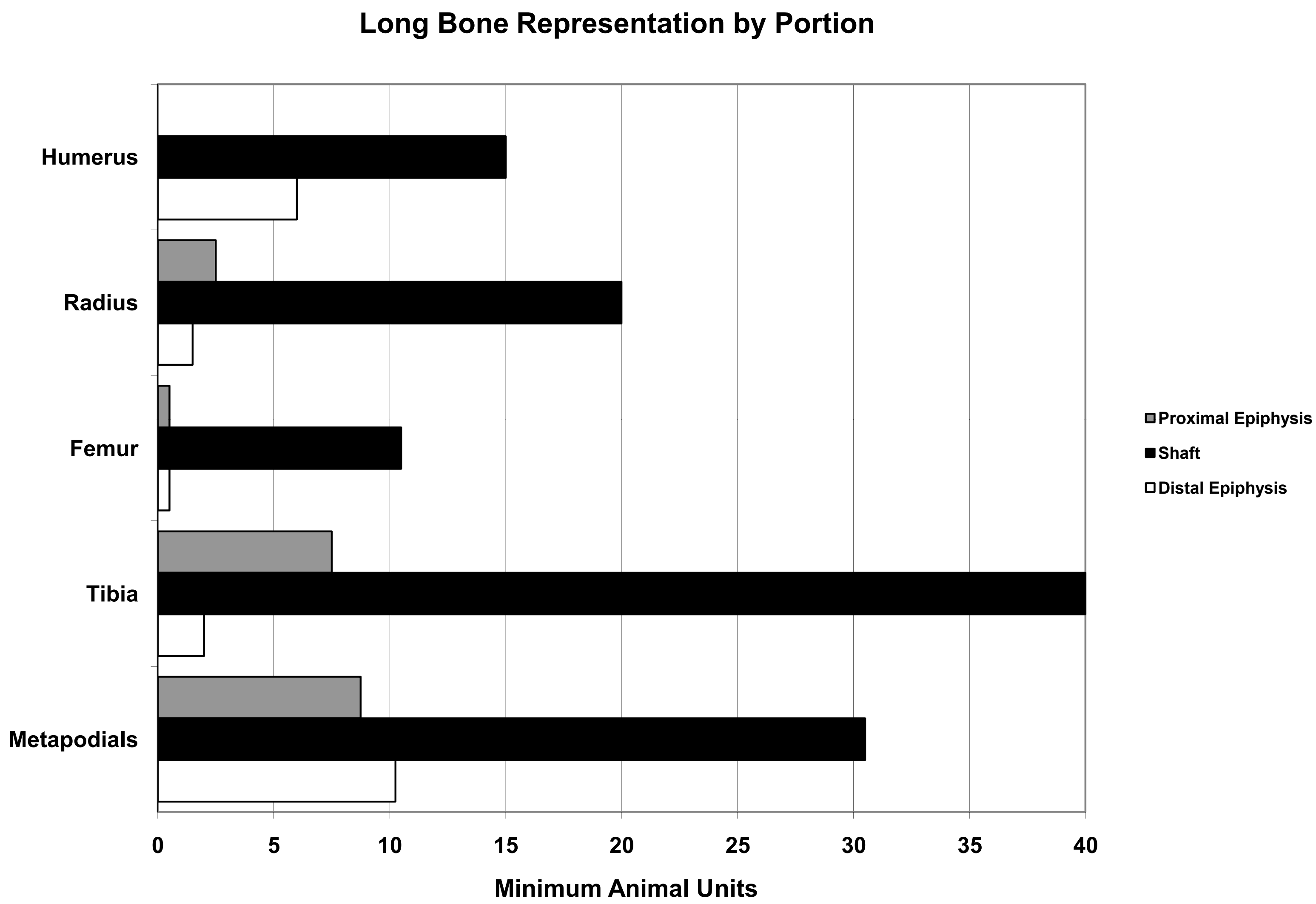
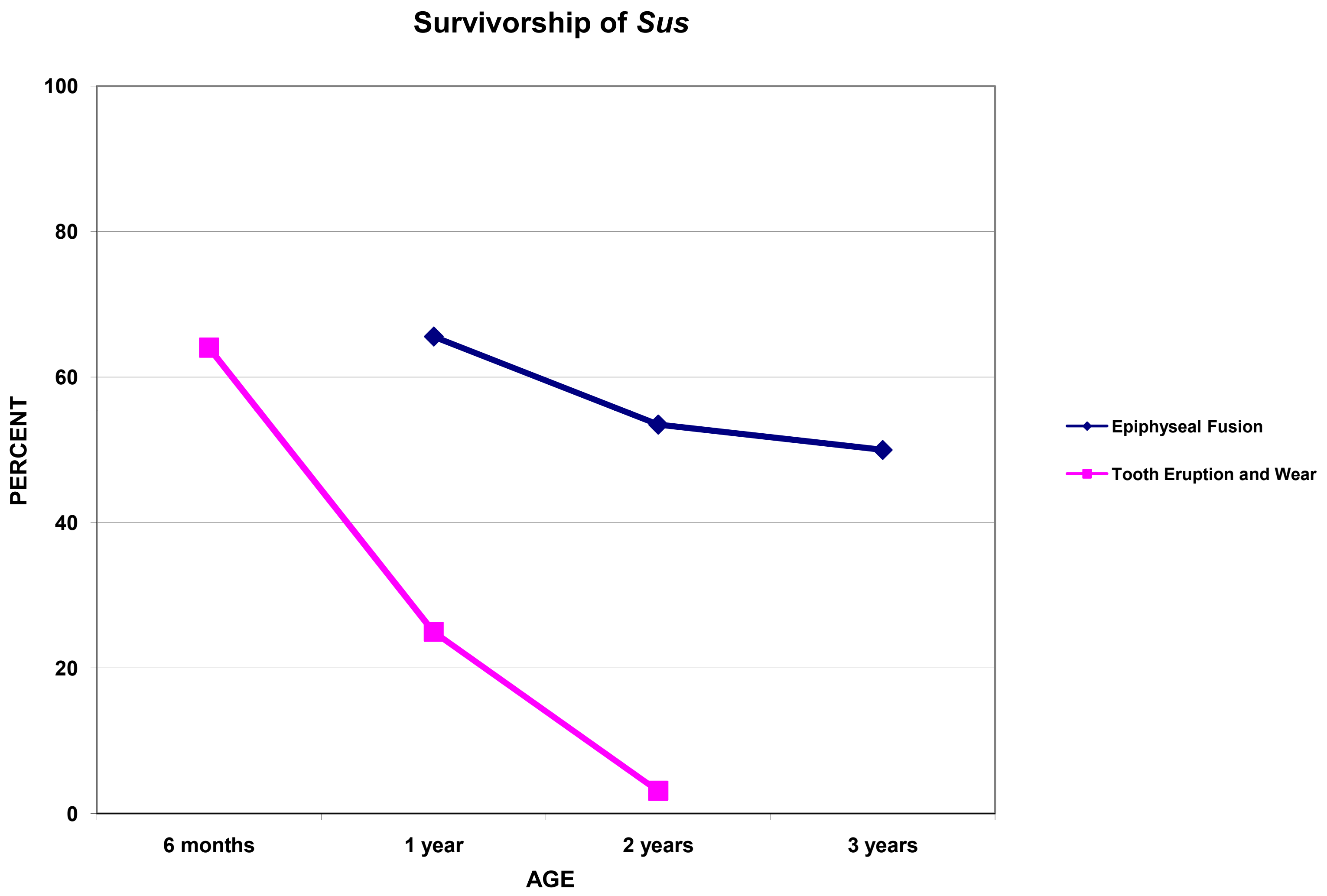

Yellow River
N
Xujiayao
Beijing
SHANXI
HEBEI
River
Fen
SHAANXI
Taosi
SHANDONG
0
km
200
Yellow River
CHINA

Figure 2



Long Bone Representation by Portion
Humerus
Radius
Femur
Tibia
Metapodials
0
5
10
15
20
25
30
35
40
Minimum Animal Units
Proximal Epiphysis
Shaft
Distal Epiphysis

Figure 3


Survivorship of *Sus*
100
80
60
40
20
0
PERCENT
6 months
1 year
2 years
3 years
AGE
Epiphyseal Fusion
Tooth Eruption and Wear