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Mortality profiles of the large herbivores from the Lingjing Xuchang Man Site, Henan Province and the early emergence of the modern human behaviors in East Asia

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This paper presents the results of a detailed study of mortality profiles of the large herbivores from the Middle Palaeolithic (MP) bone assemblage of the Lingjing Xuchang Man Site, Henan Province. Based on the analysis of the crown heights of fossil teeth from this assemblage, we come to a conclusion that aurochs *(Bos primigenius*) and horse (*Equus caballus*) are the major prey species in this assemblage and the age structures of these animals can be best described as the "prime-dominated pattern". This study confirmed the well-established notions at many Middle and Upper Palaeolithic sites across Eurasia and Africa that MSA/MP foragers were fully effective in hunting aggressive prey species, particularly aurochs and horse. This find indicates that the hunting behaviors and subsistence strategies were not significantly different between MP and UP (the Upper Palaeolithic) humans in East Asia and hence suggests the early emergence of the modern human behaviors in this area.

modern human behaviors, Middle Palaeolithic, Lingjing Xuchang Man Site, taphonomy, zooarchaeology

The origin of modern human behaviors is a hot debate in Paleolithic archaeology. Klein and other scholars believed that modern human behaviors originated in Africa approximately between 50000 ― 40000 years ago and it is a relatively "revolutionary" process[1–3]; McBrearty and d'Errico argued that the emergence of modern human behaviors should be much earlier than this time[4,5]; it may not be limited to Africa, Near East and even Europe also have the potentials to be the alternatives[5].

Specialized hunting is an important mark of the emergence of modern human behaviors[4,6]. From the early eighties of the last century, hunting capacities of ancient humans have been a frequently discussed topic. Based on skeletal part representations, carnivore tooth marks and mortality profiles, Binford proposed that early humans of the Middle Paleolithic (MP) in Europe and Asia and its counterparts of the Middle Stone Age (MSA) in Africa were scavengers. Scavenging was the primary subsistence strategy of these people to acquire resources from the large and medium-sized animals; hunting was only occasionally employed by these people to catch some small and medium-sized herbivores[7–10]. Marean and other scholars strongly criticized this view[11,12]. Apart from the hunting-scavenging dichotomy of the MSA/MP humans, some scholars recently supplied this debate with some additional fuels and a new round of controversy was arising hereafter. To Klein and other scholars, ancient humans during MSA/MP had been able to catch

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a number of ungulates, but their hunting skills were obviously inferior to their counterparts of Late Stone Age (LSA)/the Upper Paleolithic (UP)[2,13]. Klein hypothesized that a significant cognitive change, the product of a genetic mutation occurred about 50000— 40000 years ago, could have caused the behavioral revolution by promoting a more effective way of hunting allowed these fully modern humans to spread throughout the world and replace the archaic people, including the contemporaneous non-modern MSA people[1,2,13]. However, many other scholars insisted that humans of this time were very skilled hunters; the emergence of modern hunting behaviors was just one of a series of modern human behaviors appearing in MSA/MP. The reason that modern humans spreaded to Europe and Asia can be attributed to the technological development, social activities and the population expansion[4,14].

Unfortunately, in these recent waves of controversy surrounding modern human behaviors, almost all the voices came from Africa, Europe and the Near East; in contrast, archaeological faunas from East Asia were always tacit in this regard and did not receive sufficient appreciation from the Western World[15]. The newly discovered Xuchang Man Site was an important finding of Chinese Palaeoanthropology research; it provided a good opportunity to the study of modern human behaviors in East Asia. So far, this site has yielded roughly 20 fragments of human skeletal materials, including parietals, occipitals, mastoids, etc. Along with these human fossils, a considerable number of Paleolithic artifacts and animal fossils were discovered. Based on the principles of biostratigraphy, Li Zhanyang and other scholars proposed that this fauna should be of about the same age with the Xujiayao fauna and its age should be around 100 ka before present[16]. The preliminary OSL dating results finished by Zhou Liping indicates that human fossils from this site should be of the age of about 80 —100 ka, and may even slightly older than 100000 year (detailed results will be published elsewhere). This period is crucial to the study of the origin of modern human behaviors in East Asia.

1 Material and methods

The Xuchang Man Site is located in the west part of Lingjing town, about 15 km to the northwest of the Xuchang City, Henan Province. From 2005 to 2009, Henan Provincial Institute of Cultural Relics and Archaeology reexcavated this site. Within the scope of about 300 m^2, the Xuchang Man Site yielded nearly 20 fragments of human fossils, 10 thousand stone artifacts and more than 10000 pieces of animal fossils. So far, 18 species of fossil mammal were identified from this fauna, including 2 species of Rodentia, 3 species of Carnivora, 1 species of Proboscidea, 4 species of Perissodactyla and 8 species of Artiodactyla[16]. The taphonomic analysis shows that the auroch (*Bos primigenius*) and horse (*Equus caballus*) are the predominant species of this fauna (Figure 1)[17].

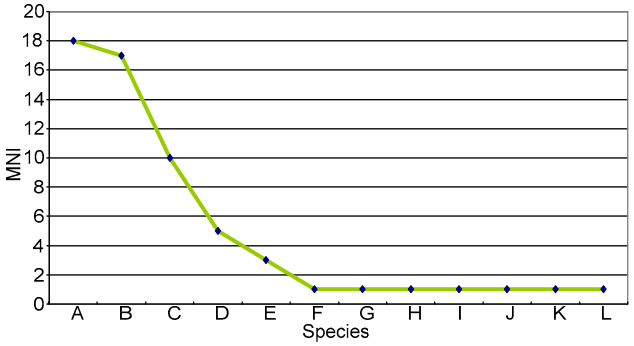

Figure 1 MNI distributions of the main fossil species in Lingjing assemblage. A, *Equus* sp.; B, *Bos primigenius*; C, *Megaloceros ordosianus* (*Cervus elaphus*); D, *Coelodonta antiquitatis*; E, *Procapra przewalskii*; F, *Dicerorhinus mercki*; G, *Pachycrocuta* cf. *sinensis*; H, *Palaeoloxodon* sp.; I, *Viverra* cf. *zibetha*; J, *Ursus* sp.; K, *Sus lydekkeri*; L, *Hydropotes pleistocenica*.

In zooarchaeological analysis, determining age or season of the death of a fossil animal is very important for taphonomic reconstructions[18,19]. Meanwhile, by studying the age and season of death, we may further collect some important informations regarding ancient human's behavioral capacities, social organizations and group sizes and even hunting methods and skills and subsistence patterns. Under normal circumstances, the three main methods of determining the age of animal and season of death are through analysis of epiphyseal fusion, teeth cementum annuli and teeth crown heights (tooth wear stages is also one of the commonly used system by the late period zooarchaeologists, but in terms of the early faunas, it seems not as popular as other methods). In general, there are many limitations to using epiphyseal fusion and teeth cementum annuli data to determine the age of large ungulates, analysis of teeth crown heights is hence the most reliable method of determining the age of fossil animals. In this study, following the tradition of taphonomic analysis, we measured the crown heights of various teeth of the two do-

minant species of Lingjing fauna and calculated the age of each animal in accordance with the corresponding regression equations[18–20]. Following Klein and other scholar's methods, once the approximate ages of fossil animals are determined we breakdowned them into successive age groups (here we adopted the six-age-class system) and plotted the results on a histogram to show the numerical differences between these classes.

In the study of the mortality profiles of aurochs and horse, we also adopted Stiner's scheme. In accordance with their physiological differences, Stiner divided fossil animals into three age stages, namely the juvenile, the prime and the old[9,10,21]; this system is currently a common practice in zooarchaeological analysis[22,23]. Stiner's age-division system is generally consistent with the life history of most fossil animals and may reasonably reflect potential changes of human's hunting tendency and ability; besides, it practically enhanced the comparability between different faunas and fossil species since most zooarchaeological analysis after 1990s have adopted this system.

According to Stiner's age-division-system, the transition between juvenile and prime adult age group corresponds to the time when a particular milk tooth is replaced by a new, permanent one (for example, dp4 and p4); The prime-old age boundary is roughly set at the 65% of the maximum potential life span of the animal concerned[10,21]. Here, we define the boundary between juvenile and prime age aurochs as 4 years of age; because maximum potential life span of the modern cattle is generally considered as 25 years[24], the boundary age between prime and old individuals of aurochs should be about 15 years old. As to horses, p2 is generally fully erupted and begin to receive abrasion before 4 years old; while the corresponding age for m3 is between 2.5 ─5 years[25]. Combined with the bone fusion data of modern horses[26], we define 4 years as the upper limit of the juvenile individuals of this species; at the same time, based on the studies of Levine, 17-year-old is set as the boundary age between the prime and the old groups[26].

We have to point out that whether in Klein's or Stiner's age-division-system, it is generally the Minimum Number of Individuals (MNI) that is used to construct the mortality profiles of the animal and the teeth based to calculate the ages are always dp4 and m3 (or dp4 and p4) from the hemi-mandibles. However, in the study of Lingjing fauna, we have taken some adjustments to this system. Take aurochs as an example, the Minimum Number of Individuals of this species is only 17 and it's not very conducive to the statistical analysis because of the slightly smaller sample size. Based on this consideration, we retained the traditional methods on the one hand and included more dental materials to account for the problems of sample size on the other hand. This adjustment significantly expanded the sample size of the teeth used to build mortality profiles, and thus is effectively minimized possible deviations. In fact, in the archaeological study of faunas, some scholars in Europe have taken the same means to circumvent the potential problems of sample size[18,19,27]; in age structure analysis of the spotted-deer from the Tianyuan cave, Li Qing and Tong Haowen adopted the same modification[28].

2 Results

2.1 Mortality profiles of aurochs (*Bos primigenius*)

The study of mortality profiles of aurochs from the Lingjing assemblage shows that the "prime-dominated pattern" is consistently typical of this species, regardless of whether we adopt Stiner's three-age-group scheme or the comparatively detailed six-age-group system and whether we tabulate the animals on the minimum number of individuals (MNI) or the number of identified specimens (NISP)[29] (Figure 2).

2.2 Mortality profiles of horses (*Equus caballus*)

Just as we have seen in the age patterns of aurochs, mortality profiles of horses of Lingjing assemblage displayed the similar tendency (in this case we only present the results of the three-age-group system based on the minimum number of individuals): prime adults of this animal are predominant in this assemblage, young individuals are relatively rare, and there is only one individual of old age, which accounts for only 5.6% of the minimum number of individuals of this species (Figure 3).

2.3 Comparison between mortality profiles of aurochs and bison from Lingjing and other related assemblages

A large number of Middle Paleolithic sites, including those of France, Italy and Germany from Europe and those of Israel from the Near East have yielded evidence of hunting and butchering aurochs or bison by ancient humans. Similar to Lingjing assemblage, many fossil species from these sites showed age structures of the typical "prime-dominant-pattern", including the well-known

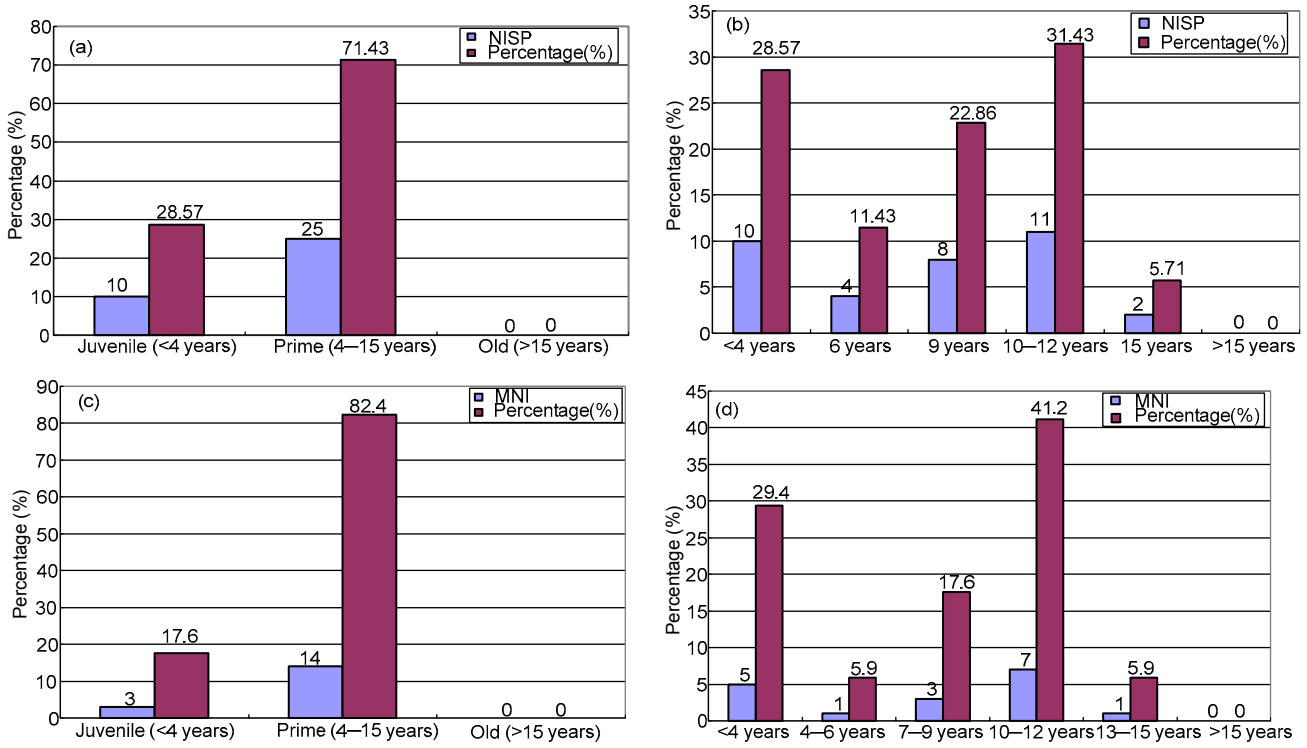

Figure 2 Mortality profiles of aurochs in Lingjing assemblage. (a) NISP, Three-age-group; (b) NISP, six-age-group; (c) MNI, three-age-group; (d) MNI, six-age-group.

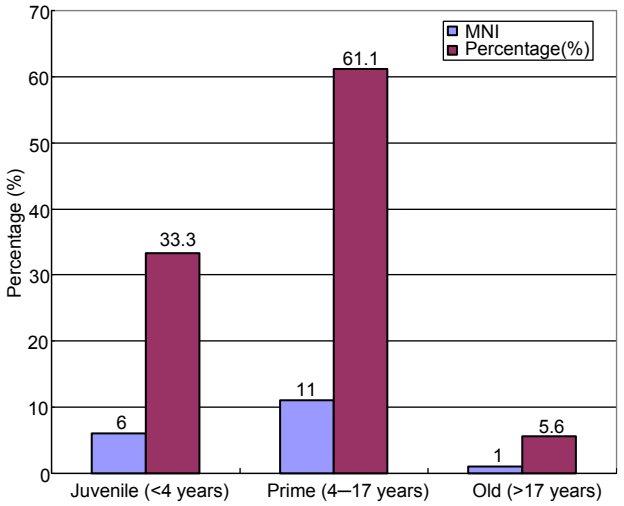

Figure 3 Mortality profiles of horses in Lingjing assemblage. MNI, Three-age-group.

La Borde site and Mauran site in France, the Il'skaya site in the former Soviet Union, Hayonim and Kebara sites in Israel and the Bruil site in Italy. In addition, the age patterns of aurochs or bison from some European Later Paleolithic sites, such as Palidoro and Polesini and several historic sites in the United States, such as Agate Basin, Casper, Lamb Spring Site and Garnsey are all typical of prime-dominated pattern[30,31].

Among them, particularly worth mentioning here is the La Borde site of France. Very similar to Xuchang Lingjing Man Site, La Borde is an open air site of Middle Paleolithic. This assemblage is persistently dominated by aurochs, regardless of whether we tabulate it by the minimum number of individuals (MNI) or the number of identified specimens (NISP). In addition, in the 27 individuals of aurochs from La Borde, prime adults accounted for 76.4%, juveniles accounted for 1.6% and old individuals were only about 2%[31]. Preservation state of the bones from this assemblage was fairly poor; cut and percussion marks and carnivores tooth marks hence could not be analyzed in this assemblage. However, a study of the age structures of the aurochs still laid a sound foundation for the archaeological interpretations of this site. Researchers eventually explained this site as an ancient human's hunting camp where aurochs of the "Nursery group" were specifically hunted and exploited, which finally resulted in the accumulations of the large number of bones of this species[31].

Based on the comparisons between different assemblages, we find that mortality profiles of aurochs or bison from Lingjing and other related sites basically fall within the prime-dominated area of the triangular plot. In other words, just as these widely recognized sites

mentioned-above, Lingjing assemblage reflected the relatively systematic subsistence activities and social organizations of ancient humans in the Middle Paleolithic (Figure 4).

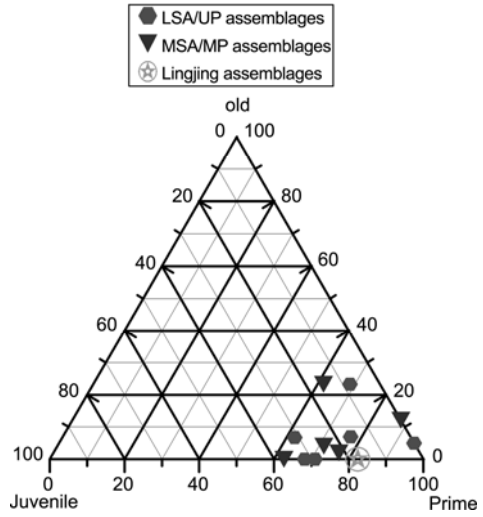

Figure 4 Comparison between mortality profiles of aurochs and bison from Lingjing and other related assemblages.

3 Discussion

3.1 Taphonomic factors influencing the mortality profiles of fossil animals

The mortality profiles of aurochs and horses of the Lingjing assemblage are patterns dominated by prime-age adults, with a certain proportion of juveniles. This type of age structure is of very special significance in the zooarchaeological analysis. According to Stiner, this pattern is specifically indicative of humans, and it can only be created by selective ambush hunting[10,21]. Many western scholars also related this pattern to the subsistence abilities and hunting techniques of ancient humans and even to the emergence of modern human behaviors[30–32].

However, from various perspectives of modern ecological observations, experimental studies and taphonomic analyses, some other scholars have frequently questioned the validity of this type of mortality profiles. In fact, taphonomic studies have persuasively shown that a relatively small number of young individuals in the archaeological assemblage may not necessarily be the result of ancient human's behavior, because many taphonomic agents including diagenesis may cause significant reduction and even disappearance of juvenile tooth specimens of some fossil species[33]. In addition, for many archaeological sites, because of the impact of carnivore ravaging, skeletal elements of juvenile animals, sometimes even their teeth will have a narrow chance to survive the damage. In other words, in many cases, we may finally find an assemblage of serious "biased" age distribution[34,35].

As to the Ling Xuchang Man Site, we currently can not completely rule out the roles of carnivores ravaging, water transportation and diagenesis played in the formation of this assemblage; but the well-preserved bone surface conditions and the very low proportion of water-abraded specimens and the homogeneous degrees of weak weathering of the bones were all indications that these bones only underwent limited taphonomic processes after their deposition at the site. At the same time, there was no evidence for the strong influence of the diagenesis processes, which attested the relatively weak role of the *in situ* destructions[17].

The milk teeth of small and medium-sized herbivores (such as goats, sheep, etc.) can be largely destroyed by the actions of large carnivores[36]; However, as cattle, giraffes and other large ungulates are concerned, even hyenas, the most powerful destroyer of animal bones, can not significantly reduce the number of teeth of these large ungulates[37]. At the same time, the distribution and the low percentage of 5.4% of tooth marks also strongly implied the relatively weak involvement of carnivores in this assemblage. The distribution and combination of human cut marks further validated the predominant role of ancient humans in the accumulation of this assemblage[17].

In summary, we believe that the age structures of aurochs and horses of Lingjing assemblage is rarely affected by the taphonomic agents; it thus a good illustration of its original composition. Therefore, archaeological analysis based on the mortality profiles of these two species should be more objective and realistic.

3.2 The archaeological significance of the "prime-dominated pattern"

The "prime-dominated pattern" is typical of Late Pleistocene and Holocene archaeological faunal assemblages[10,21,38]; among Eurasia MP faunas, there are also no lack of similar records[30,31]. Ethnoarchaeological and archaeological evidence associated this pattern with selective ambush hunting, regardless of the hunting party size[38].

For a long time, archaeologists have regarded aurochs and African buffaloes, especially its adult individuals, as

extremely dangerous prey and very difficult to hunt[2,39,40]. The emergence of the "prime-dominated pattern" of this animal and horses from the Lingjing assemblage shows that: ancient human of this period had acquired sufficient knowledge and skills of hunting; they had already had an in-depth understanding of and sufficient adaptation to the surrounding environments. Particularly, in relation to the large herbivores, these humans obviously had accumulated a good knowledge of the living habits and migration patterns of these "neighbors"; and they can accordingly adjust their hunting methods and subsistence patterns so as to ensure that they can regularly exploit the prime adults of these large animals.

4 Conclusions

At present, there is an increasing number of archaeological materials showing that ancient humans in Middle and Later Paleolithic Eurasia had been able to regularly hunting certain large and medium-sized herbivores, and scavenging was only an occasionally happened phenomenon accompanying the mainstream of ancient human's hunting activities[4,40]. Similarly, in the hunting skills of these people, they were equally skillful in catching ferocious herbivores such as aurochs and bison[14,22,30,31,38], and even more large-bodied animals of mammoth and rhinoceros[41,42]. In addition, as to the social organizations and specialized hunting behaviors, these humans had also shared the same characteristics: they can organize their hunting campaigns through some kinds of social activities; Moreover, if in needs, they may focus on a particular species of game or two or only target at some certain age groups or gender in order to achieve specialized hunting strategies. The age patterns of aurochs and horses from Ling Xuchang Man Site not only confirmed the proficient and systematic hunting abilities and social organizational behaviors of ancient humans of this period, but also provided a very important archaeological evidence for the early emergence of modern human behaviors in East Asia.

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