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Taphonomic analysis of the Lingjing fauna and the first report of a Middle Paleolithic kill-butchery site in North China

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More than ten thousand bone fragments were recovered from the Lingjing site, Henan Province, during 2005 and 2006. A taphonomic analysis of the faunal remains strongly indicates that hominids have a dominant role in the accumulation and modification of the assemblage. Based on the taphonomic and zooarcheological characteristics of the animal remains, including species richness, mortality patterns, skeletal element profiles, and bone surface-modifications, and on the local ecology, we suggest that the Lingjing site is a Middle Paleolithic kill-butchery site rather than a home base for early humans. The presence of large numbers of stone artifacts may therefore signify a strong sense of planning and farsightedness in the subsistence strategies of early human groups. The Lingjing site is presently the only taphonomically-identified, Middle Paleolithic kill-butchery site known in North China.

Lingjing site, Paleolithic, taphonomy, zooarcheology, kill-butchery site

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During most of the Paleolithic period, hunter-gathering was the main subsistence pattern of ancient humans. Usually, meat was not the major constitute of the human diet; however it influenced humans in many ways, including their physical evolution, behavioral adaptations, and social organization [1]. After successful taking of a prey animal, especially a middle or large-sized species, hominids needed to focus on disarticulation and processing of the prey to facilitate transport. Even in the earliest Paleolithic sites, there is strong evidence that hominids would choose to process large-sized animals, as these were difficult to carry whole, and would therefore select certain parts for transportation to their base camp [2]. Ethnic and ethnoarcheological evidence also testifies to the likelihood of such behavior [3,4]. Most archeologists argue that when making decisions, hominids would choose to transport the more nutritious animal parts, inevitably abandoning bones of limited use, such as crania, mandibles, and metatarsals [3,4]. Animal bones left at the kill site, and the stone artifacts used for disarticulation, are key evidence allowing us to identify site function and the existence of hunting and butchering activities.

In the early stages of Paleolithic study, co-occurrence of animal bones and stone artifacts was the main criterion used to identify kill-butchery sites [5]. However, it is now well known that hominid behavior is just one of the many natural forces that may contribute to the configuration of the archeological fauna. In addition to hominids, there are many other taphonomic agents, including fluvial action, carnivores, raptors, and rodents, able to accumulate bones at a site [6,7]. When animal bones are found along with stone artifacts, this influences the identification of the nature of the archeological site [8]. Since the 1990s, worldwide actualistic studies have confirmed the limitations of traditional methods in the study of animal bones from archeological sites [1,8]. Consequently, we should dismiss traditional influences and reconsider the associations between animal bones and stone

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artifacts at archeological sites, with taphonomic perspectives in mind. For archeo-faunas, the taphonomic method will be an important tool allowing us to distinguish natural and cultural agents in the site formation process, and to further discern hominid behavior and site function [4]. Actualistic studies have already indicated that hominids would kill and butcher animals and then crack the bones for marrow at kill-butchery sites. As a result, some hominid-introduced marks will be left on bone surfaces, such as cuts or percussion marks. It is not uncommon to find some evidence for hominid butchery in very early Paleolithic sites, such as at Gona, Ethiopia, dating from about 2.5 million years ago [9]. After disarticulation of the animal carcass, higher nutritional parts were generally transported by hominids to home bases. Parts with lower nutritional content were frequently left at kill sites; this is the most important criterion enabling us to identify the functional characteristics of an archeological site.

1 General introduction to the site

The Lingjing site is located in the west part of Lingjing town, about 15 km to the northwest of Xuchang, Henan Province, 34°04′N, 113°41′E, and at an elevation of 117 meters. Initially discovered in the mid-20th century, this site was re-excavated by researchers from the Henan Provincial Institute of Cultural Relics and Archaeology, between 2005 and 2006. Within an area of about 300 m^2, the site yielded nearly 20 fragments of human bone, 10000 stone artifacts, and more than 10000 pieces of animal bone [10]. So far, 18 species of mammal have been identified from this fauna, including two Rodentia, three Carnivora, one Proboscidea, four Perissodactyla, and eight Artiodactyla [11]. Based on biostratigraphy, Li and other scholars have proposed that this fauna is about the same age as the Xujiayao fauna; dating from around 100 ka before present [11]. Preliminary optically stimulated luminescence dating by Zhou has indicated that human fossils from this site are about 80–100 ka before present, and may even be slightly older than 100000 years (data not shown). This period is roughly equivalent to the Middle Paleolithic in Europe, and its counterpart the Middle Stone Age in Africa. In the Chinese Paleolithic cultural system, some scholars have even proposed that it lies within the transition between the Early and Later Paleolithic Age [12,13]. Taphonomic analysis shows that aurochs (*Bos primigenius*) and horses (*Equus caballus*) are the dominant species in the fauna [14].

2 Taphonomic characteristics of the Lingjing fauna

Hominids, carnivores, rodents, raptors, fluvial action, and natural depositional agents all aid the accumulation of animal bones at archeological sites [6,7]. From the percentage of rodent-gnawed bones in the Lingjing assemblage (0.06%) [14], we can easily exclude the role of rodents in its formation. In typical faunas accumulated by rodents, gnaw-marked bones usually account for around 20%–80% of the whole assemblage [15,16]; thus the low ratio in the Lingjing assemblage unequivocally rules out rodents as the agents of bone accumulation. In addition, rodents like porcupines prefer to carry bones of middle or large-sized animals into their caves [15]. Lingjing is an open site, and from ecological observations we know that rodents will not aggregate a large number of bones at such sites [16]. In addition, bones transported by rodents are usually heavily weathered [6]; this is not the case in the Lingjing assemblage.

Raptors, such as owls, also transport animal bones to their caves. However, corresponding to their ecological niches, raptors mainly hunted rodents, rabbits, birds and small primates; obviously a different assemblage from that at Lingjing [6,17]. Faunal remains of raptor origin are also distinguished by a large ratio of bones eroded by stomach acid [18,19]. Raptors can thus be easily excluded as primary agents in the accumulation of bones at Lingjing.

Fluvial action can lead to the aggregation of bones [6,7]. In archeological faunas, the main fluvial action usually manifested to modify the already-formed assemblage, rather than providing direct accumulation of bones [20,21]. Under certain hydrodynamic conditions, some bones carried by water will be deposited *en masse*, eventually sometimes leading to bone aggregations. About 15.75% of the bones in the Lingjing fauna are water abraded. And for the aurochs bones of the assemblage, the minimal number of animal units of the scapular, which is generally easy to be moved away by water, is relatively high (36.47%). The above evidence demonstrates that it is possible that the Lingjing fauna has been modified by fluvial action to some degree, but it could not have been formed by fluvial action [14].

The natural deposition of animal bones is always neglected by scholars. However, Potts [22] and Domínguez-Rodrigo [8] have validated the existence of such assemblages. The ecology of the Lingjing site indicates that it is possible that the bone assemblage could result from natural deposition (in a lake or pond); however the species abundance and mortality patterns strongly deny this possibility. The Lingjing fauna is dominated by middle and large-sized animals, while faunas resultant from natural deposition are usually dominated by small animals. In addition, the primary mortality patterns of the two major species, aurochs and horses, also differ from those expected from natural deposition; these animal assemblages are dominated by juvenile or old individuals [14]. It is known that large animals would sometimes plunge into swamps and be unable to escape, possibly leading to the natural deposition of animal bones around water sources such as lakes or ponds [23]. However, in Haynes's [24] many years of observation of African elephants, such accidents mostly happened to juvenile or old individuals, and rarely to those in their prime. This was true also for the horses and water buffalos observed by Berger [25] and Sinclair [26]. Thus, the mortality pattern of the two middle and large-sized herbivores at Lingjing eliminates natural deposition as the bone-accumulating agent.

Carnivores, such as hyenas and leopards also aggregate large numbers of animal bones in their lairs (this is the taphonomic field studied in the most detail) [15,27,28]. At the Lingjing site, aurochs and horses are the dominant animal species, of which the minimal number of individuals (MNI) are 18 and 17, respectively, and only 5.4% of the bones of these animals have tooth marks; suggesting that leopards can be excluded as the primary transport agent of these bones. From ecological observation and archeological study, we know that in hyena dens there were sometimes middle or large-sized bones, suggesting that hyenas are able to aggregate large numbers of animal bones (especially those of herbivores). However, from the abundant evidence in the Lingjing fauna, such as the percentage of tooth-marked bones (lower than 5.4%) and the scarcity of bones eroded by stomach acid, hyenas could not have been the primary accumulating agents of the large bones (Figure 1) [27]. Selvaggio [29] has even recorded hyenas temporarily caching their leftovers (bones and meat) in shallow ponds and then often forgetting to retrieve them. If this was case, some bones in the ponds would bear tooth marks; Selvaggio [29] even suggested that hyenas were one of the many bone-accumulating agents in early archeological faunas. However, these ecological records are still inconsistent with the fact that the Lingjing assemblage is dominated by middle and large-sized animals, such as aurochs and horses.

None of the recognized natural agents that could accumulate large numbers of bones at archeological sites correspond well with the Lingjing assemblage. Hominids are the only other agent able to accumulate bones at such sites [6,7]. The aurochs and horses, the two major animal species in the Lingjing assemblage, are both dominated by individuals in their prime (82.4% and 61.1%, respectively), with a smaller proportion of juvenile individuals (17.6% and 33.3%, respectively) [30]. Prime-dominated mortality patterns are of special value to archeological studies, and are, to some degree, specific signals of hominid behavior. Zooarcheological studies in recent years have repeatedly suggested that the hunter-gatherers of the Middle Paleolithic usually chose to hunt prime individuals within a prey species, to maximize nutritional returns during a single hunting episode [14,30]. This is significantly different from the old- or juvenile-dominated mortality patterns that distinguished hominids in archeological records of later periods [14,30]. In the Lingjing assemblage, about 17.2% of the bones from the site are cut-marked or percussion-marked, indicating that hominids were the primary bone-accumulating agents [14].

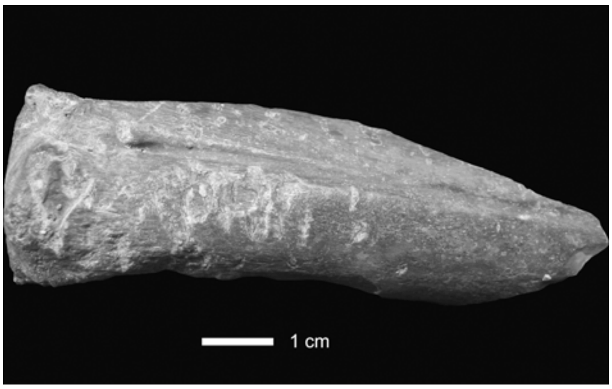

Figure 1 Carnivore tooth marks on a deer metacarpal.

3 Function and characteristics of the Lingjing site

Diversifications in function at an archeological site will lead to differences in the characteristics of the faunal remains, and will again affect our study of the subsistence patterns of early hominids [3]. Because of the complexities of open Paleolithic sites, it is generally not as easy as we might expect to identify the functions and the characteristics of archeological sites [31,32]. However, for the Lingjing site, we have enough evidence to confirm that it is a Middle Paleolithic kill-butchery site and not a base camp of early humans.

3.1 Characteristics of the animal species

Usually, after hunting a small herbivore, ancient hunters would transport the whole body to the base camp, or disarticulate it at the open site [4]. Consequently, they may leave more middle and large-sized animal bones at the kill-butchery site; bones of small animals have been found more frequently at base camps [33]. This argument is substantiated by the behavior of modern hunter-gatherers [4,34]. Thus, the Lingjing fauna, which is dominated by aurochs and horses, is more likely a kill-butchery site and not a base camp (Figure 2).

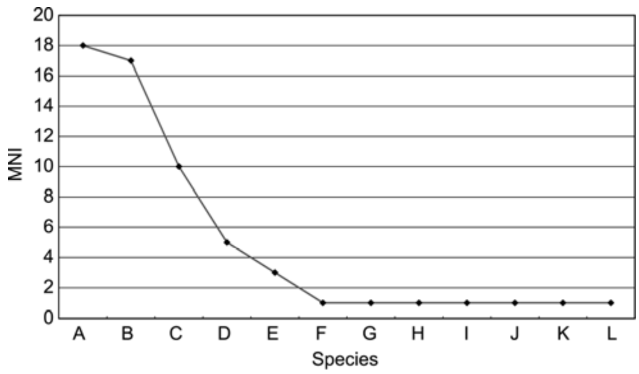

Figure 2 MNI distribution of the major animal species of the Lingjing fauna. A, *Equus* sp.; B, *Bos primigenius*; C, *Megaloceros ordosianus*; *Cervus elaphus*; D, *Coelodonta antiquitatis*; E, *Procapra przewalskii*; F, *Dicerorhinus mercki*; G, *Pachycrocuta* cf. *sinensis*; H, *Palaeoloxodon* sp.; I, *Viverra* cf. *zibetha*; J, *Ursus sp*.; K, *Sus lydekkeri*; L, *Hydropotes pleistocenica*.

3.2 Evidence of skeletal element profiles

When making decisions, ancient hunters always hoped to maximize nutritional returns. At base camps therefore we will generally find bones from body parts of higher nutritional value, and the bones from body parts with lower nutrition will be present more frequently at kill-butchery sites [3,4]. The long bones of ungulates, especially upper and middle limb bones, have more surrounding meat and are therefore more nutritious parts, than, for example, the vertebrae or ribs. Assemblages from kill-butchery sites are commonly dominated by crania, mandibles (due to taphonomic modifications, teeth are frequently the most common elements), and lower limb bones (metacarpals and metatarsals). Faunal remains at base camps will be dominated by bones such as the middle and upper limbs (femur, humerus, tibia, radius, and ulna) [3,4]. In the Lingjing assemblage, the dominance of bone elements from body parts with lower nutritional value, such as teeth and lower limb bones (% minimal number of animal units = 100 and 38.38) indicates that it was a kill-butchery site (Figure 3).

3.3 Evidence of bone surface modifications

Long bones of middle and large-sized herbivores give clearer indications of hominid behavior, and our study therefore focuses on these bones [8]. Around 34% of the upper limb bones, and 41% of the middle limb bones, of herbivores at the Lingjing site are cut-marked; for the lower limbs, the percentage is only 25%. Most cut-marked long bones, such as a femur, are from midshafts (185 pieces, 98.45%), while only two cut-marked bones are distal epiphyses (1.06%), and one is a proximal epiphysis (0.53%) (Figure 4). This profile is consistent with the findings of Domínguez's [36] experiments and Lupo's [37] ethnoarcheological observations, indicating that Lingjing hominids cut off most of the meat on the long bones of prey animals, were successful hunters and the primary consumers of the tissues of middle and large-sized animals. The presence and patterned distributions of cut marks on the bones imply that Lingjing hominids hunted and disarticulated animals at the site. Furthermore, there are no scraping marks on the Lingjing bones, indicating a non-intensive processing technique consistent with hominid behavior at kill-butchery sites.

3.4 Evidence of structural remains, artifacts, and local ecology

Hearths are one of the most representative structural remains at Paleolithic sites, especially at base camps where hominids lived somewhat permanently. In contrast, hearths and burned bones are usually rare at kill-butchery sites. No hearths have been found to date at Lingjing, again consistent with its hypothesized role as a kill-butchery site. The very few burned bones in the assemblage probably resulted from relatively heavy combustion in natural fires after deposition, rather than from nutritional extractions of hominids, which would usually induce only slightly heated bones [14]. We have not yet studied the functional attributes of stone artifacts from the site, but a use-wear analysis of the bones has tentatively suggested that hominids explored and processed the animals nearby [38].

In terms of ecology, tortoise bones and a large number of auroch bones are indicative of nearby water. The sediments

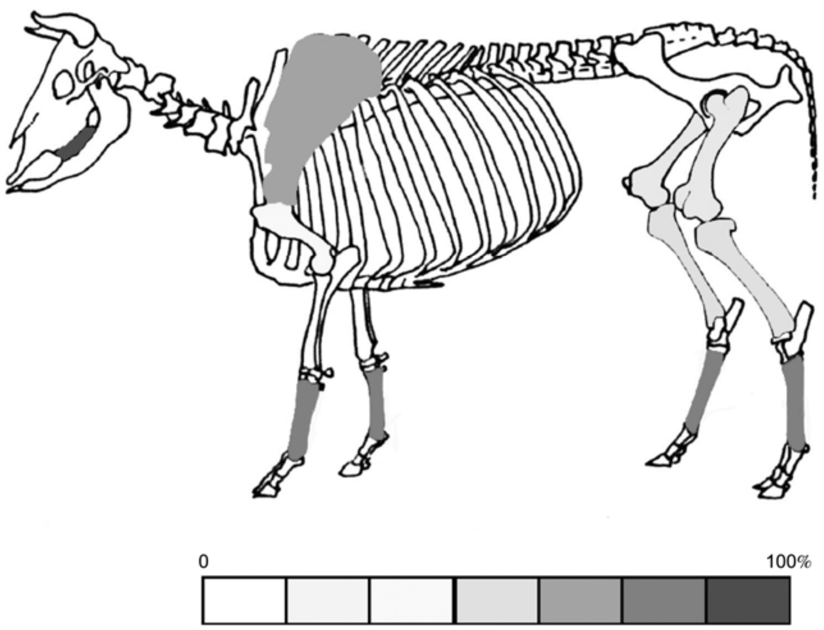

Figure 3 Skeletal element profiles (%MAU) of the aurochs from the Lingjing assemblage. MAU, minimal number of animal units [3,35].

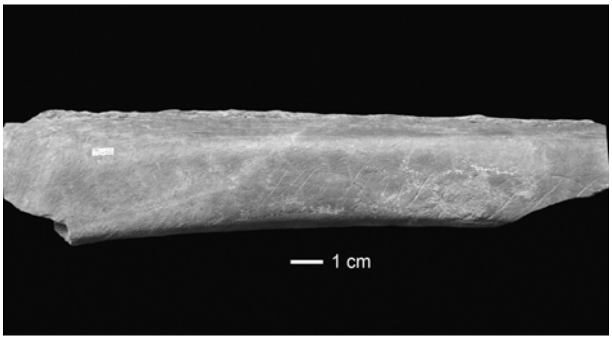

Figure 4 Cut marks on the rib of a large-sized animal (class III or IV).

and the biochemical erosion of the animal bones also indicate a relatively wet environment. Many scholars, such as Binford [39], have claimed that lake shores and riversides were not suitable places for hominids to live [40,41], and even modern hunter-gatherers will not place their base camps near water [39]. Potts [22] also believed that this kind of environment was not a suitable dwelling place for hominids, because the discarded bones would induce frequent harassment by carnivores at night. The ecology alone, therefore, suggests that Lingjing would not be a hominid home base. Many home bases or living floors in early Paleolithic sites in Africa were not far from lakes or rivers, however the sites and the water bodies were generally further away than would be the case at the Lingjing site. Koobi Fora, for example, was 15–20 km from the lake shore [42]; and Frida Leakey Korongo and Frida Leakey Korongo North were also about 1–2 km from a water source [22].

4 Discussion

Until recently, recognition of a Paleolithic kill-butchery site by zooarcheologists has been based on taphonomic analysis and ample evidence of hominids killing, disarticulating, and butchering animals [43]. The taphonomic characteristics of the Lingjing fauna suggest that hominids were the primary transport agent of the animal bones to the site; and this site demonstrably records hominid behavior and subsistence strategies in killing and butchering middle and large-sized animals. Following Isaac and Crader's [5] classic model, a *type B site* (i.e. a kill-butchery site), is characterized by the remains of an individual skeleton of one kind of big animal with a small number (commonly a few pieces to several hundred) of associated artifacts. Compared with a classic kill-butchery site, the Lingjing assemblage is distinguished by species abundance and the numbers of animal individuals. In addition, the abundant stone artifacts associated with the bones also differentiate it from a *type B site*. However, since Isaac published his work, scholars have unveiled some shortcomings with the traditional definition of *type B sites*. Potts [22] considered that a *type B site* was an over-simplification of the archeofauna. In most cases, archeologists substantially differentiate *type B sites* on species abundance, number of animal individuals [22], or scarcity of stone artifacts (even though there are sometimes cut marks on the bones) [41,44].

In terms of site function, Lingjing is undoubtedly a kill-butchery site. When population ecology is considered, the large numbers of individual animals reflect a palimpsest of many episodes of kill-butchering activities [14]. This is consistent with Chazan and Horwitz's [45] finds in Israel. Following protocols drafted by early scholars, Chazan and Horwitz considered a *type B site* to be a "Single Carcass Site", while sites with many skeletons were accordingly called "Multiple Carcass Sites". Based on the combination of animal bones and stone artifacts, the Multiple Carcass Sites of Chazan and Horwitz's definition seem more like the *type C sites* identified by Issac. However, compared with the traditional features of *type C sites*, Chazan and Horwitz's definition of Multiple Carcass Sites greatly weakens the behavioral significance of the site as a place for human habitation. We agree with Chazan and Horwitz that archeological sites such as Lingjing where the bones of many species and many individuals are preserved, along with large numbers of stone artifacts, are unnecessarily bearing characteristics and functions of a base camp or living floor. As we have argued above, we believe that the Lingjing fauna represents remains of the killing and butchering behaviors of hominids, and is clearly different from a home base or living floor.

Ethnic records may give clues to the comparatively large numbers of artifacts. O'Connell et al. [34] recorded that the Hadza, present day hunter-gatherers in Tanzania, would find a hiding structure or even build one near the locations that animals frequented, prior to ambush hunts, and would then conduct a variety of activities during waiting episodes. These kinds of hominid behavior would definitely increase artifact numbers at archeological sites. In addition, under certain ecological and geographic conditions, when hunters could predict hunting activities in the near future (at lake shores or riverside such as Lingjing), they would probably have stockpiled raw materials or stone artifacts there. This location could then be considered a cache site in some senses, and this use inevitably increased numbers of stone artifacts. In fact, in the widely accepted kill-butchery sites around the world, it is not uncommon to find thousands of stone artifacts. This view differs greatly from Issac's [45,46] classic model. We believe therefore, that based on its characteristics and function, the Lingjing site undoubtedly belongs as a t*ype B site*, but is also of significant archeological value.

Home bases are more common in the Paleolithic archeological records than kill-butchery sites; hominid activities at the latter are therefore comparatively poorly known. A kill-butchery site is thus an important source of information, supplementing our learning and interpretation of hominid subsistence patterns, social organization, and community behavior. At archeological sites centered around lakes or springs, such as at Lingjing, hunters were presumably already acquainted with the nearby environments and could therefore extract resources more efficiently. They may have successfully driven aurochs and horses into deep water [47,48]; this strategy would have very effectively slowed the speed of escape of the prey and consequently ensured the success of the human hunt.

5 Conclusion

Analyses of the taphonomic attributes of faunal remains from the Lingjing site, including species richness, mortality patterns, skeletal element profiles, and bone surface modifications of the animal species, signifies the hunting and butchering activities of hominids and further suggests that hominids are the causal factors for the accumulation and modification of bones of middle and large-sized herbivores. In addition, from the taphonomic and zooarcheological characteristics of the animal remains, and the local ecology, this is suggested to be a kill-butchery site rather than a home base. The large numbers of stone artifacts present may therefore signify planning ability and farsightedness in the subsistence strategies of human groups. Lingjing is presently the only taphonomically-identified Middle Paleolithic kill-butchery site known in North China.

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