A STUDY OF NEOLITHIC WATER BUFFALO REMAINS FROM ZHEJIANG, CHINA

Li LIU[1], Xingcan CHEN[2], Leping JIANG[3]

[1]Department of Archaeology, La Trobe University, Melbourne, Australia
[2]Institute of Archaeology, Chinese Academy of Social Sciences, Beijing, China
[3]Zhejiang Institute of Archaeology, China

ABSTRACT

Water buffaloes widely inhabited China during the Holocene and their bones have been found in many Neolithic and Bronze Age sites, especially concentrated around the lower Yangzi River region. Most have been identified as Bubalus mephistopheles, *and are regarded as a domesticated form, but this claim has not been systematically tested. We recently conducted a preliminary study of some of the earliest water buffalo remains unearthed from three Neolithic sites in Zhejiang dating from 6000 to 3400 cal. BC. In this study, we mainly focus on the newly excavated Kuahuqiao remains, but also examine partial buffalo assemblages from Hemudu and Luojiajiao, which have been published before (Wei* et al. *1990; Zhang 1981). The project aims to identify the Kuahuqiao buffalo population by species, to understand age profiles at the time the buffaloes were killed at these three sites, and to determine whether or not the Neolithic buffaloes in Zhejiang were domesticated.*

Kuahuqiao, in Xiaoshan county, is an early Neolithic site (*c.* 6000 - 5500 BC) in the lower Yangzi River region (Figure 1). The site appears to have been situated on the coastline and excavations have yielded abundant artefacts, domestic rice grains, and faunal remains, including many buffalo bones. The most impressive remains are wooden canoes, suggesting abundant water resources in the region. A total of 765 bones had been previously identified simply as *Bubalus* sp. (Yuan and Yang in press). Most buffalo bones were burnt and broken, but metacarpals and meta-tarsals were mostly complete because they were used as tools (Jiang in press).

About 100 km east of Kuahuqiao is the well-known site of Hemudu *(c.* 5000 - 3400 BC), in Yuyao county, located on the southern side of Hangzhou Bay. During the mid-Holocene this region was covered by marshes, swamps and rivers, and the coastline was situated more inland (Zhao 1993:167). The Hemudu faunal assemblage indicates that the area was a mosaic environment that included swamps, mountainous regions, forest land, and shrub-forest (Han 1988; Zhejiang Institute of Archaeology 2003:3). Hemudu yielded a large quantity of rice remains and many buffalo bones, identified as *B. mephistopheles* (Zhejiang Institute of Archaeology 2003), and a previous faunal report provided cranial data from 16 buffaloes (Wei *et al.* 1990).

The Luojiajiao site (*c.* 5000 BC) is located in Tongxiang county, north of Hangzhou Bay. Similar to Hemudu, well preserved wooden structures and rice remains were found, and about 1000 kg of animal bones were recovered from the site. There are more than 380 buffalo bones, including cranial and postcranial specimens. Most horncores are massive and sharply trihedral, but three are round in cross-section, perhaps from calves. Based on the morphological characteristics of the cranial remains, the Luojiajiao buffalo was assigned to *Bubalus* cf. *mephistopheles.* Cranial measurements from 17 individuals were previously published (Zhang 1981).

All three sites were located in ideal natural settings for wild buffaloes.

TAXONOMY OF THE KUAHUQIAO BUFFALO

We recorded and measured 172 relatively complete specimens from the Kuahuqiao buffalo assemblage, including 24 cranial bones and 148 postcranial bones. In order to understand the relationship between the Kuahuqiao animals and other buffalo remains in China, we compared the

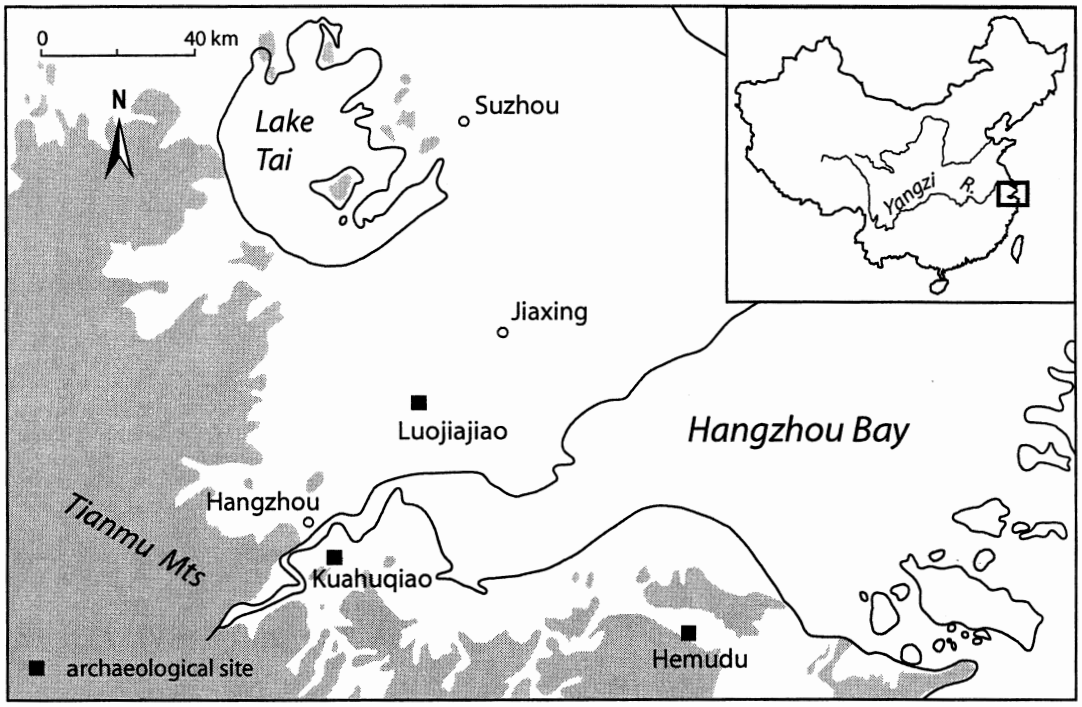

Figure 1: Location of sites in China where Neolithic buffalo remains have been found.

the measurements of Kuahuqiao samples with *B. mephistopheles* from Holocene Hemudu, Luojiajiao (Zhejiang), and Anyang (Henan); and *B. teilhardi* from Pleistocene Zhoukoudian (Beijing). In addition, we also compared these archaeological buffalo assemblages with a modern domestic buffalo skeleton (a 10-year old female) obtained from Xiawei in Zhuji county, Zhejiang (Table 1).The Kuahuqiao buffaloes are characterised by horncores that are short, massive, and trihedral in cross section. On the skull, the horns are directed backwards and gently curved inwards (Figure 2). Even by visual observation, such horncores are identical in shape to the type specimen from Chang-te-fu (Hopwood 1925) and to those from Hemudu, Luojiajiao and Anyang, all identified as *B. mephistopheles* (Teihard and Young 1936; Zhang 1981; Wei *et al.* 1990).

Our cranial data are derived from five Kuahuqiao buffalo skulls (Table 1), using four horncore measurements to examine relationships. As illustrated in Figure 3, the Kuahuqiao samples are closely clustered with those from Hemudu, Luojiajiao and Anyang. The Zhoukoudian specimen *(B. teilhardi* middle Pleistocene) appears to be much larger in all dimensions, while the Xiawei horncores (modern *B. bubalis,* the domestic buffalo) seem to be more slender and longer than those from Kuahuqiao. The horn cores of both the Zhoukoudian and modern Xiawei buffaloes are directed sideways, resulting in greater distances between the horn tips.

We also measured metacarpals and metatarsals from Kuahuqiao, Hemudu and Luojiajiao, using only complete adult bones for analysis. Measurements from these three assemblages were compared with those from Anyang, Zhoukoudian and Xiawei, as shown in Figure 4. Similar to the distribution of cranial measurements, the specimens from Kuahuqiao, Hemudu, Luojiajiao and Anyang cluster together and in most cases are separate from those of Zhoukoudian and Xiawei. The Zhoukoudian specimens appear to be much longer and thicker than the Kuohuqiao ones, and the modern specimens are more slender in shape.

Since the Kuohuqiao buffalo remains resemble those from Hemudu, Luojiajiao and Anyang, based on cranial and postcranial measurements, we can confidently identify them as *B. mephistopheles.*

KILL-OFF PATTERNS OF KUAHUQIAO BUFFALOES

Using Silver's (1969) tooth eruption and epiphyseal fusion criteria (for domestic *Bos),* we can approximately age the buffaloes at death, noting that we were unable to examine all the recovered bones. Among the 91 bones from Kuahuqiao that can be aged, 6 were from infants (less than 1 year old at death), 17 were from juveniles (1 to 2 years old), 63 were from sub-adults (*c.* 3 years old) and adult (*c.* 4 years and older), and 5 were from old adults. It is difficult to determine

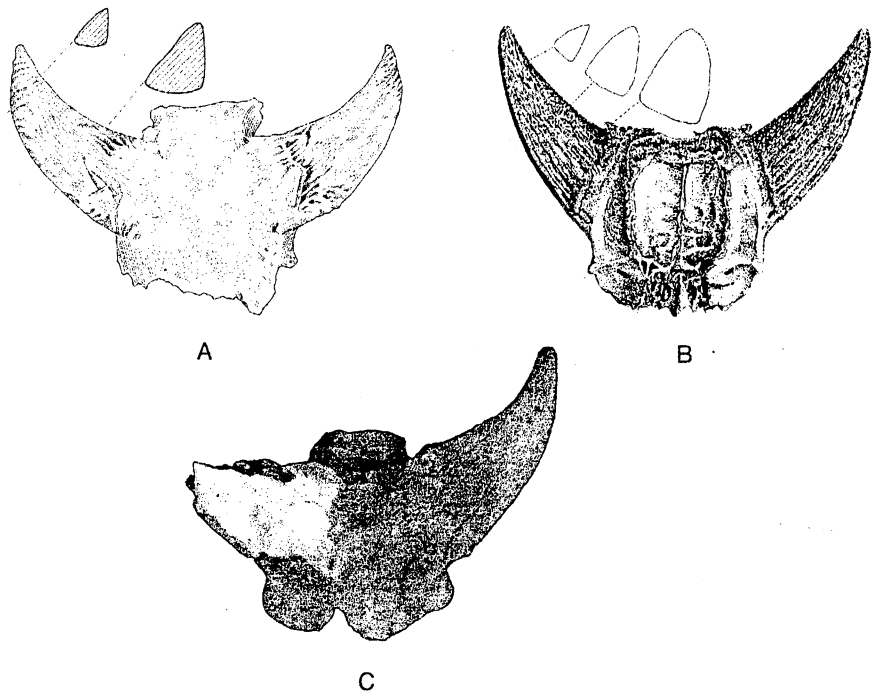

Figure 2: Buffalo cranial samples from Zhejiang;
A. Kuahuqiao (T0410[5]:50); B. Hemudu (after Wei et al. *1989: fig 47); C. Luojiajiao.*

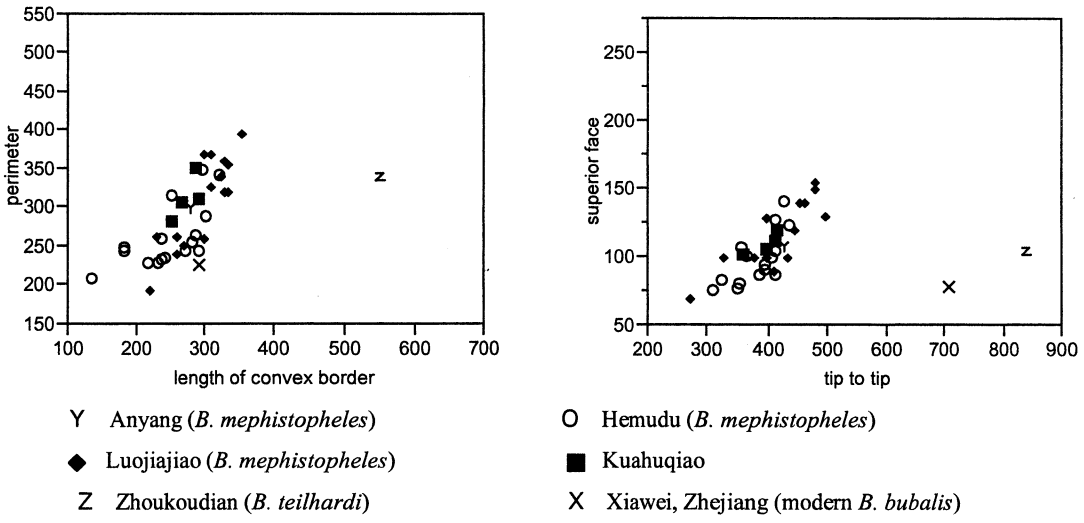

Figure 3: Comparison of buffalo horncore shapes in three Bubalus *species from Pleistocene and Holocene buffaloes in China (perimeter = perimeter at the base of the horncore; superior face = breadth of the superior face; length of convex border = length of the core along the convex border; tip to tip = distance from tip to tip; measured in mm).*

Table 1: Cranial measurements from archaeological and modern *Bubalus* specimens mentioned in the text (in mm)

Specimen number	Breadth of the anterior face of the horn core at the base	Breadth of the dorsal face	Breadth of the basal face	Circumference at the base	Length of the core along the convex border	Length along the concave border	Distance from tip to tip	Distance between core bases anterior	Distance between core bases posterior
Kuahuqiao									
T0410(5):50	68.9	100.9	82.9	280	250	160	360	165	124
T0411(8)A:51	82.5	118.5	99	350	285	195	415	180	132
T0411(8)A:52	67	110.3	100.2	305	265	180	410 tips slightly broken	170	130
T0410(5):53	65.4	101.4	90.2	285				163	136.8
T0411(8):54	82.3	104.9	96.6	310	290	200	397	230	155
Hemudu YH04									
1	72	123.2	104.6	315	252	160.2	435	149.5	133.8
2	53	83.3	72.2	245	180	127	325	195	118.3
3	71.5	126.4	99.7	343	320	230	410	149	99.2
4	64.5	107	94.7	290	300	202	355	169.7	137.8
5	56	101	83	260	237	170	365	148.5	122
6	57	77	69	230	230	106	350	184	108.9
7	51	76	67	210	134	103	310	172	125.5
8	54	94	78	265	285	230	395	173	115
9	68	141	101	350	295	180	425	147	128
10	58	104	86	255	280	195	410	140	92
11	52	99	80	245	290	230	405	153	86
12	57	91	74	245	270	185	395	166	122
13	52	87	77	250	180	115	385	170	155
14	64	81	69	233	235	200	352	169	109
15	54	87	97	235	240	192	410	187	111
16	55.8	93	95	230	215	70		162	110

... continued

Luojiajiao TN01									
1	74	155	138	395	355	250	480		
9	70	130	118	356	335				
21	62	125	114	320	335				
5	85	140	130	360	330	245	455	160	40(?)
14	65	120	105	320	330	220	445	160	140
4	80	140	130	340	325	250	460	150	40 (?)
7	75	130	120	370	310	245	500	170	75
6	70	125	116	326	310	230			
2	58	100	83	261	300	195	435	150	140
11	74	150	140	370	300	245	480	170	75
8	60	128	96	308	270		400	160	130
13	61	100	85	252	270	195	400		
10	64	90	80	240	260	170	410		
16	60	100	96	263	260	200	380		75
15	55	110	100	285	250				
12	52	100	89	263	230	140	330		
17	54	70	69	194	220	145	275		
Anyang	74	108	103	300	282	225	430	145	93
Type (Hopwood)	62	96	93	285	304	216	407	153	85
Zhoukoudian (*B. teilhardi*)	85	105	130	340	550	470	840	100	99
Xiawei, Zhejiang modern *bubalis*	39.03	76.51	80.9	225	290	265	705	270	225

the true ages of the old adults, which were characterized by extreme tooth wear and bones with pathologies such as exostoses. We estimate this age group as greater than 10 years old, based on the characteristics of the modern Xiawei skeleton, whose age was 10 years at death. The age profile of the Kuahuqiao specimens therefore suggests that 26% of buffaloes were killed before reaching three years of age, 69% were subadult and adult, and 5% were more than 10 years of age (Figure 5).

We also examined postcranial bones from the Hemudu and Luojiajiao assemblages, but the sample sizes were rather small (46 from Hemudu and 22 from Luojiajiao). The age profiles for these two assemblages appear to have been very similar to that for Kuahuqiao, with a considerable proportion of bones from infants and juveniles (19% for Hemudu and 32% for Luojiajiao), and 4-5% of very old individuals (Figure 5 and Table 2).

WILD OR DOMESTIC?

The age at death profiles of the buffaloes from Kuahuqiao, Hemudu and Luojiajiao are very different from that of a domestic buffalo/cattle assemblage from Dholavira, an urban site of the Harappan civilization in South Asia (*c.* 2600 - 1900 BC). At Dholavira, the ages of bovines have been categorized into six age-stages, ranging from infant (stage I) to adult (stage VI). Almost all the young bovines survived through stages I-III, but some were killed off before growth slowed down in stage IV and the rest mostly survived into full adulthood (stages V-VI) (Figure 6). This is a pattern consistent with the use of animals for traction, such as ploughing, hauling, and transport (Patel 1997). In contrast, the three Neolithic assemblages from Zhejiang all have rather large propor-tions of very young calves and some very old individuals, most likely representing a pattern of hunting wild populations.

It is often stated that the Hemudu buffalo was already domesticated (Chang 1986: 211; Han 1988; Chen and Li 1989; Wei *et al.* 1990:97), and the domestication was believed to have been associated with wet rice paddy technology (Chen and Li 1989). If this were the case, the Hemudu buffalo would be the earliest domesticated buffalo in the world. This claim, however, lacks supporting evidence from comparative morphological study of other wild and domestic buffalo remains from China, and has already been questioned by some experts (Patel and Meadow 1998).

The major difference between wild and domestic buffaloes lies in body size, since wild buffaloes are much larger than domesticated ones (Patel and Meadow 1998). If *B. mephistopheles* had gone through a Neolithic process of domestication in China, we might expect to

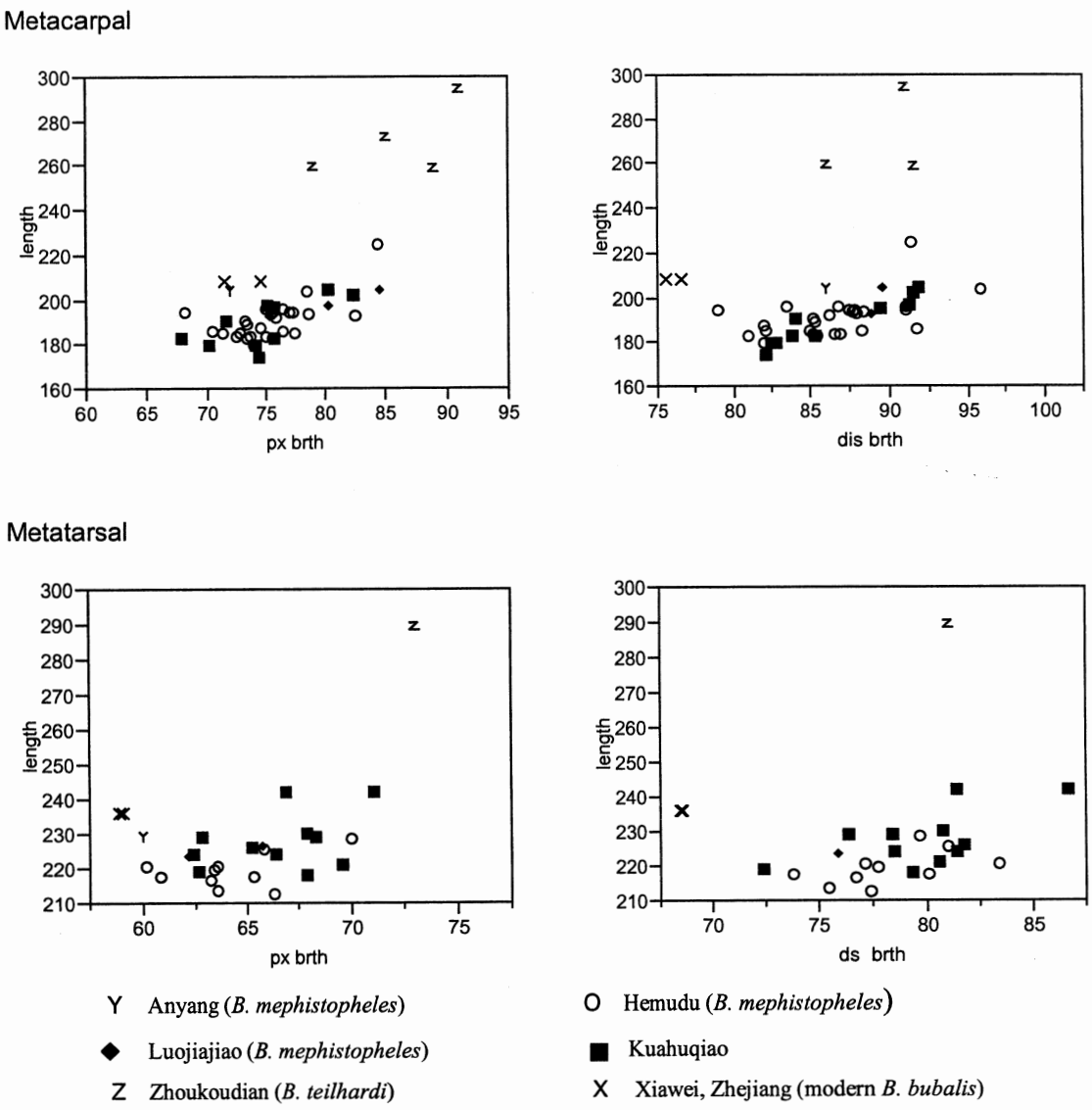

Figure 4: Comparison of metacarpal and metatarsals in three Bubalus *species from Pleistocene and Holocene, China (length = greatest length; px brth = greatest breadth of the proximal end; ds brth = greatest breadth of the distal end).*

Table 2: Comparison of buffalo kill patterns from Kuahuqiao, Hemudu and Luojiajiao

	Infant	Infant / juvenile	Sub-adult /adult	Old adult	Total # of samples
Kuahuqiao	6	17	63	5	91
Hemudu	7	2	35	2	46
Luojiajiao	4	3	14	1	22

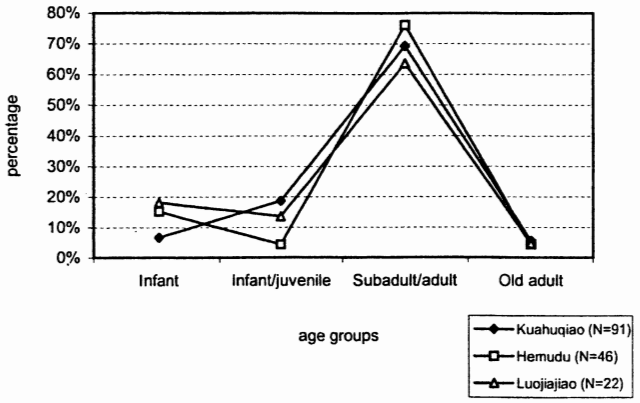

Figure 5: Comparison of kill-off patterns of buffaloes from Kuahuqiao, Hemudu and Luojiajiao.

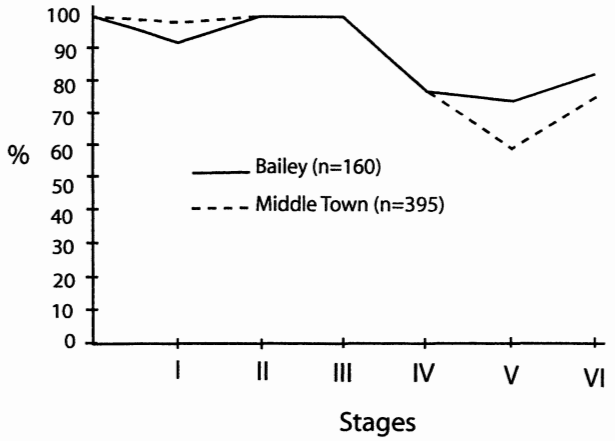

Figure 6: Survivorship curves for domestic cattle and water buffalo from the Bailey and Middle Town at Dholavira, western India (modified from Patel 1997: Figure 4).

see body size reduction through time. But our comparison of Kuahuqiao buffalo (*c.* 6000 - 5500 BC) with those from Hemudu *(c.* 5000 - 3400 BC), Luojiajiao *(c.* 5000 BC) and Anyang (*c.* 1200 BC), shows that no reduction of body size took place among these *B. mephistopheles* populations during a period of 5000 years or more. The age profiles from the Neolithic Zhejiang buffaloes are inconsistent with that of a Harappan domestic population documented in South Asia. These observations strongly suggest that *B. mephistopheles* in China was a wild species.

Since no wild buffalo exist today in China, it is possible that *B. mephistopheles* gradually disappeared from China's landscapes during the historic period, perhaps due to over-hunting. The modern domestic buffaloes of China belong to a different species, *B. bubalis* (Institute of Animal Science 1986), derived from wild swamp buffalo, *B. arnee,* which lives today in part of South Asia and mainland Southeast Asia (Mason 1974:3; Groves 1996: 335). The measurements of the buffalo assemblages discussed here also demonstrate morphological differences between *B. mephistopheles* and *B. bubalis,* confirming that they belong to separate species.

CONCLUSION

Although this investigation is preliminary, the results are fruitful. They call for a re-evaluation of the traditional view of buffalo domestication and its association with rice agriculture in ancient China, a topic that we will deal with in a separate article. Nevertheless, we need to point out that this is not a thorough study of all buffalo remains from Kuahuqiao, and more systematic analysis of this faunal assemblage is needed to test the hypothesis presented here. Animal remains provide invaluable information on ancient ecosystems as well as social behaviour, topics to which Chinese archaeologists should pay more attention. There are more questions than answers regarding the fate of Chinese indigenous buffaloes and the introduction of domestic buffaloes, and this study is only the first step in a long journey towards understanding the history of this extremely interesting animal.

REFERENCES

Chang, Kwang-chih. 1986. *The Archaeology of Ancient China,* 4th edition. New Haven: Yale University Press.

Chen, Y.S., and X.H. Li. 1989. New evidence of the origin and domestication of the Chinese swamp buffalo. *Buffalo Journal* 5:51-5.

Groves, C.P. 1996. The taxonomy of the Asian wild buffalo from the Asian mainland. *International Journal of Mammalian Biology* 61:327-38.

Han, Defen. 1988. The fauna from the Neolithic site of Hemudu, Zhejiang. In P. Whyte (ed.), *The Palaeoenvironment of East Asia from the Mid-Tertiary: Proceedings of the Second Conference,* pp. 868-72. Hong Kong: Centre of Asian Studies, University of Hong Kong.

Hopwood, A.T. 1925. A new species of buffalo from the Pleistocene of China. *Annals and Magazine of Natural History* Ser. 9, Vol. XVI (92):238-9.

Institute of Animal Science, Chinese Academy of Agricultural Sciences. 1986. *Zhongguo Niu Pinzhong Zhi.* Shanghai: Shanghai Kexue Jishu Press (in Chinese).

Jiang, Leping (ed.). In press (2004). *Kuahuqiao.* Beijing: Wenwu Press (in Chinese).

Mason, I.L. 1974. Species, types and breeds. In W. Ross Cockrill (ed.), *The Husbandry and Health of the Domestic Buffalo,* pp. 1-47. Rome: Food and Agriculture Organization of the United Nations.

Patel, A. 1997. The pastoral economy of Dholavira: a first look at animals and urban life in third millennium Kutch. In R. Allchin and B. Allchin (eds), *South Asian Archaeology 1995: Proceedings of the 13th Conference of the European Association of South Asian Archaeologists,* pp. 101-13. New Delhi: Science Publishers.

Patel, A., and R. Meadow. 1998. The exploitation of wild and domestic water buffalo in prehistoric northwestern South Asia. In H. Buitenhuis, L. Bartosiewicz and A.M. Choyke (eds), *Archaeozoology of the Near East III.* Groningen: ARC - Publicaties 18:180-99.

Silver, L.A. 1969. The ageing of domestic animals. In D.R. Brothwell and E. Higgs (eds), *Science in Archaeology: A Survey of Progress and Research,* pp. 283-302. Bristol: Thames and Hudson.

Teilhard de Chardin, P. and C.C. Young. 1936. On the mammalian remains from the archaeological site of Anyang. *Palaeontologia Sinica* Series C. Vol. XII, fasc.1:1-78.

Wei Feng, Weitang Wu, Minghua Zhang, and Defen Han. 1990. *Zhejiang Yuyao Hemudu Xinshiqi Shidai Yizhi Dongwuqun.* Beijing: Haiyang Press (in Chinese).

Yuan Jing and Mengfei Yang. In press (2004). Zhejiang Xiaoshan Kuahuqiao yizhi chutu dongwu guge yanjiu baogao. In Leping Jiang (ed.), *Kuahuqiao.* Beijing: Wenwu Press (in Chinese).

Zhang Minghua. 1981. Luojiajiao dongwuqun (Faunal assemblage from Luojiajiao). In Zhejiang Institute of Archaeology (ed.), *Zhejiangsheng Wenwu Kaogusuo Xuekan* pp. 43-53. Beijing: Wenwu Press (in Chinese).

Zhao Xitao. 1993. Progress in research on the Holocene coastal evolution and sea level changes in China: an overview. In Xitao Zhao (ed.), *Holocene Coastal Evolution and Sea-Level Changes in China,* pp. 155-87. Beijing: China Ocean Press.

Zhejiang Institute of Archaeology. 2003. *Hemudu.* Beijing: Wenwu Press (in Chinese).