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Human diets of Yangshao Culture in the Central Plains

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Abstract

In this paper the isotope analysis of ^{13}C and ^{15}N is used for researching the diet of the past people on human bones from the Yangshao Culture sites in the Central Plains. The results showed that these people all took C_4 plant as staple food. The isotope analysis of ^{15}N showed that there has been some meat in their diet. Meanwhile, some animal bones from related regions are also analyzed, showing that the domesticated animals' diet might have been influenced by that of the people. These analyses with the situations of the burials reflected that the social hierarchies in the Yangshao period were also shown by the people's diets.

Keywords: diets-Neolithic Age; stable isotope analysis; Yangshao Culture.

Introduction

Traditional archaeology infers past human diet from artifacts and ecofacts. Yet, the ratios of stable isotopes of $\delta^{13}C$ and $\delta^{15}N$ extracted from human bones provide direct information of past diet in the molecular level. The $\delta^{13}C$ method may reveal the types of cereal staple intake; wherein the $\delta^{15}N$ method may indicate the trophic level. Used together, the traditional and isotopic methods complement each other and generate high resolution results of paleo-diet. The development and results of dietary study are closely monitored by the archaeological circle because it illuminates the natural environment, food production technology, and various social and cultural aspects of the past.

The use of stable isotope analysis in studying past human diet in Chinese archaeology has made substantial progress in recent years. The $\delta^{13}C$ and $\delta^{15}N$ methods were established in the 1960s and the 1970s respectively in the international community of science-based archaeology. In the 1980s, $\delta^{13}C$ method was introduced into China (Cai and Qiu 1984), breaking the ground of stable isotope analysis in Chinese archaeology. In the beginning of the 21st century, the Radiocarbon Dating Laboratory of the Institute of Archaeology, CASS installed the first set of instruments for $\delta^{15}N$ analysis in Chinese archaeology.

Over half a century of archaeological work in China laid the foundation for the study of past human diet. Floral remains of millet were recovered and identified from a number of prehistoric sites, such as Dadiwan, Cishan and Peiligang of the early Neolithic, Banpo and Dahecun of the middle Neolithic, and several sites of the Longshan Culture of the late Neolithic Ages. Floral remains of rice were recovered and identified from sites of Daxi Culture distributed in the middle reaches of the Yangtze River, Hemudu Culture distributed in the lower reaches of the Yangtze River, Majiabang and Liangzhu Cultures distributed in the Lake Tai region. Moreover, following the expansion of the field archaeology, remains of millet and rice of earlier dates were found. These findings inspired a new set of research questions, for instances, what were the domestication processes of these staple crops? What were the extents of utilization in different time periods? Stable isotope analysis is an indispensable tool for answering these questions.

A different line of questions are about the social fabric of diet. For instance, was there differential access to certain food classes in stratified societies? Investigation of paleo-diet, therefore, can greatly enhance our understanding of the processes of social evolution and the emergence of civilization.

This paper reports the results of stable isotope analysis of three sites of Yangshao Culture dated to 5000-7000 BP. They are Xishan in Zhengzhou, Yuhuazhai in Xi'an, and Xipo in Lingbao.

Method and samples

Several earlier publications (DeNiro 1985; Ambrose 1990; Zhang 2003a) had thoroughly discussed the theory, methods and approaches of stable isotope analysis. The operation stable isotope analysis includes the following steps: collecting human and animal bones in archaeological contexts, preparing collagen and gelatin, drying, combusting, isolating and purifying by devices for element analyzing, mass spectrum analyzing, and finally data processing and result interpreting. The mass spectrum instruments used in this study was the DELTA-plus manufactured by Thermo Finnigan Company. The standard materials for carbon and nitrogen were USGS-24 and IAEA-N1, respectively.

The materials analyzed included human specimens from Xishan, Yuhuazhai and Xipo Sites and animal specimens of comparable sites in the regions under study.

I-a. Xishan Site

The Xishan Site is located to the west of Sunzhuang Village, Guxing Township in the northern outskirt of Zhengzhou City. It was found in the winter of 1984. The Training Program for Archaeological Team Directors under the State Bureau of Cultural Relics (present-day State Administrative for Cultural Heritage) used the site for fieldwork training from 1993 to 1996, uncovering areas of 6385sq m in total. The cultural deposition was partitioned into three successive phases corresponding to the early, middle and late phases of Yangshao Culture.

Stable isotope analysis was employed on a series of human specimens recovered from Xishan. Table 1 shows

Table 1 Stable isotope analysis of human bone series of Xishan.

No.	Lab No.	Provenience	Phase	Sex (Age)	$\delta^{13}C$ (‰)	C_4 (%)	$\delta^{15}N$ (‰)
1	ZK8156	TG5M221	1	Female (Adult)	-11.293	66.98	8.472
2	ZK8162	T5133M225	1	Male (30–40)	-11.568	64.86	8.799
3	ZK8183	T3735M186	1	Male (25–30)	-11.598	64.63	9.847
4	ZK8152	T4539M88	2	Male (25–30)	-11.335	66.65	8.896
5	ZK8153	T3937M193	2	Female (Adult)	-8.993	84.67	8.606
6	ZK8157	T3837 M181	2	Male (25–30)	-7.553	95.75	8.892
7	ZK8159	T4539M130	2	Female (Adult)	-7.824	93.66	8.751
8	ZK8160	T3636M191	2	N/A (15–16)	-7.858	93.40	8.257
9	ZK8161	T3837M189	2	Female (18–19)	-7.816	93.72	8.478
10	ZK8163	T5533M209	2	Male (40–45)	-8.299	90.01	9.583
11	ZK8166	T4438M89	2	Female (20+/-)	-7.903	93.05	10.092
12	ZK8168	T5733M226	2	Male? (8)	-8.06	91.85	8.260
13	ZK8172	T3838M202	2	Female (Adult)	-6.66	100.00	9.444
14	ZK8173	T4539M98	2	Female (40–45)	-7.726	94.42	9.044
15	ZK8174	T5533 M222	2	Female (17–18)	-7.922	92.91	8.523
16	ZK8177	T3836M183	2	Male (30–35)	-7.339	97.39	8.112
17	ZK8178	T3534M180	2	N/A (10)	-8.743	86.59	8.038
18	ZK8179	T3738W120	2	N/A (1–2)	-6.427	100.00	10.164
19	ZK8180	T5233W148	2	N/A (Infant)	-6.091	100.00	11.642
20	ZK8181	T4338 W90	2	N/A (3–4)	-8.221	90.61	10.060
21	ZK8182	T5233W186	2	N/A (Infant)	-7.646	95.03	10.949
22	ZK8184	T3937 M192	2	N/A (Adult)	-7.844	93.51	8.233
23	ZK8167	T4439 M79	3	Male (25–30)	-7.975	92.50	9.199
24	ZK8147	T4639 M127	3	Male (35–40)	-7.6	95.38	9.239
25	ZK8148	T4739M94 ②	3	Male (40+/-)	-7.65	95.00	8.426
26	ZK8149	T4638M143	3	Female (Adult)	-7.976	92.49	8.263
27	ZK8154	T4739 M100	3	N/A (7–8)	-7.894	93.12	7.827
28	ZK8158	T4639M126	3	N/A (Adult)	-7.677	94.79	8.791
29	ZK8165	T3029M99	3	Male (45–50)	-6.984	100.00	8.693
30	ZK8169	T4338M75	3	Male (35–40)	-7.619	95.24	8.954
31	ZK8170	T3029 M80	3	Male (40–45)	-7.463	96.44	8.658
32	ZK8171	T4739M94 ③	3	Male (35–40)	-6.823	100.00	9.858
33	ZK8175	T3638M163	3	Male (35–40)	-7.614	95.28	8.614
34	ZK8176	T2432 M53	3	Male (30–35)	-8.646	87.34	9.569
35	ZK8185	T4738H657 ②	3	N/A (40–45)	-7.547	95.79	8.434
36	ZK8186	T3431H1051	3	N/A (Juvenile)	-11.336	66.65	8.963
37	ZK8187	T3931H1289	3	Male (Adult)	-6.739	100.00	9.336
38	ZK8188	T3434H1129	3	N/A	-10.921	69.84	9.172
39	ZK8189	T4738H657 ①	3	N/A (6–8)	-7.186	98.57	8.275

the analytic results.

I-b. Yuhuazhai Site

The Yuhuazhai Site is located on a mound 300m from Yuhuazhai Village in the western outskirts of Xi'an City. It is a rich and well-preserved Yangshao settlement site occupying over 4ha.

A series of human bone specimens were sampled from this site for stable isotope analysis. The results are tabulated in Table 2.

I-c. Xipo Site

Table 2 Stable isotope analysis of human bone series of Yuhuazhai.

No.	Lab No.	Provenience	$\delta^{13}C$ (‰)	C_4 (%)	$\delta^{15}N$ (‰)
1	ZK6605	G1 ⑤ (inner moat) in 02XYH T0205	-13.961	46.45	11.74
2	ZK6608	Flotation, H169, Underneath 040T0514 ⑧	-19.107	6.87	3.819
3	ZK6624	Flotation, H199, Underneath 084T1013 ⑤	-17.454	19.58	6.164
4	ZK6628	Flotation, H177, Underneath 038 T0414 ⑨	-21.689	12.99	4.157
5	ZK6630	Flotation, H160, Underneath 035 T0414 ⑥	-11.889	62.39	6.326
6	ZK6634	Flotation, H153, Underneath 013 T1014 ⑥	-16.987	23.18	5.392
7	ZK6635	Flotation, 017 T0709 Outer moat ④	-21.251	9.62	5.594
8	ZK6644	Flotation, 018 T0709 G ⑧ (outer moat)	-17.769	17.16	6.595
9	ZK6646	Flotation, H179, Underneath 061 T0614 ⑨	-18.472	11.75	4.461
10	ZK6620	Human Skeleton in M11, Underneath the Northern Balk of III T0713 ⑥	-10.008	76.86	8.77
11	ZK6621	Infant Skeleton to the South of M1, Underneath the Northern Extension of 2003 XYH III T0817/T0917 ②	-8.608	87.63	8.325
12	ZK6622	Human Skeleton in M1, Underneath the Northern Extension of 2003 XYH III T0817/T0917 ②	-8.002	92.29	8.435
13	ZK6623	Urn Burial W108, Underneath III T0520 ③ a	-10.505	73	8.829
14	ZK6623	N/A	-10.828	70.55	8.71
15	ZK6651	Human Skeleton in Urn Burial W45, Underneath 2003XYH III T0612 ③ C	-10.943	69.67	9.273
16	ZK6652	Human Skeleton in Urn Burial W89, Underneath 2004XYH III T0415 ⑥	-7.564	95.66	10.64
17	ZK6653	Infant Bone in Urn Burial W13, Underneath the Due Middle of the Northern Balk of 2003XYH III T0711 ③ D	-7.724	94.43	9.358
18	ZK6655	Human Skeleton below Urn Burial W73, Underneath 2003XYH III T0713 ④	-10.165	75.65	9.878
19	ZK6656	Human Skeleton in Urn Burial W1, Underneath 2002XYH II T1013 ③	-7.56	95.69	9.748
20	ZK6657	Human Skeleton in Urn Burial Underneath 2002XYH II T1013 ③ C	-7.553	95.75	8.53
21	ZK6658	Human Skeleton below Urn Burial W71, Underneath 2003XYH III T0712 ⑤	-7.494	96.2	10.215
22	ZK6660	Human Skeleton below Urn Burial W52, Underneath 2003XYH III T0612 ③ d	-7.539	95.85	9.112
23	ZK6661	Human Skeleton in M12, Underneath 2003XYH III T1014 ⑧	-8.449	88.85	9.726
24	ZK6662	Human Skeleton below Urn Burial W60, Underneath 2004XYH III T0713 ③ d	-8.989	84.7	9.206
25	ZK6663	Human Skeleton in M16, Underneath 2004XYH III T0619 ⑤	-8.456	88.8	8.762
26	ZK6664	Infant Bone in Urn Burial W37, Underneath ③ b	-9.576	80.18	9.074
27	ZK6664-2	N/A	-9.512	80.68	9.193
28	ZK6665	Infant Skeleton in Urn Burial W44, Underneath 2003XYH III T0612 ③	-8.169	91.01	10.378
29	ZK6666	Human Skeleton in Urn Burial W19, Underneath 2003XYH III T0913 ④	-8.19	90.85	9.569
30	ZK6667	Human Skeleton below Urn Burial W6, Underneath 2003XYH III T0713 ④	-6.536	100	9.154
31	ZK 6668	Human Skeleton below Urn Burial W9, Underneath 2003XYH III T0913 ⑤	-8.104	91.51	8.65
32	ZK6669	Human Skeleton in M3, Underneath 2004XYH T0913 ③	-11.631	64.38	8.773
33	ZK6670	Human Skeleton in Urn Burial W24, Underneath 2003XYH III T0712 ④	-7.445	96.58	9.751
34	ZK6671	Human Skeleton below Urn Burial W25, Underneath 2003XYH III T1312 ④	-6.685	100	10.803

The Xipo Site is located northwest of Xipo Village, Yangping Township, Lingbao City, Henan. It situates on a knoll locally known as Zhudingyuan and occupies an extensive area of about 40ha. To date, Xipo is the best preserved central settlement site of the Miaodigou Phase or Mid-Yangshao Culture ever discovered.

The results of stable isotope analysis of Xipo are summarized in Table 3.

I-d. Analyses of animal specimens

To supplement the human diet study, $\delta^{13}C$ analysis was conducted on animal series yielded from Xipo, Guchengzhai and Wadian. The results are listed in Table 4.

Guchengzhai is a late Longshan site occupation located on the east bank of Zhenshui River, Dafanzhuang Village, Quliang Township, Xinmi City, Henan Province.

Wadian, also a late Longshan occupation, is located on a terrace to the northwest and east of Wadian Village, Huolong Township, Yuzhou City, Henan Province.

Analyses and discussion

All the studied sites were excavated in recent years. What follows is a discussion on the results of stable isotope analyses.

II-a. Xishan Site

The results of Table 1 are further summarized by sex in Table 5.

Based on Tables 1 and 5, we reach the following tentative conclusions:

The mean $\delta^{13}C$ value of the Xishan group was

Table 3 Stable isotope analysis of human bone series of Xipo.

No.	Lab No.	Provenience	Sex (Age)	$\delta^{13}C$ (‰)	C_4 (%)	$\delta^{15}N$ (‰)
1	SP1701	M1	Male	-8.887	85.48	8.747
2	SP1702	M3	Male	-8.265	90.27	8.799
3	SP1703	M8	Male	-11.952	61.91	12.650
4	SP1704	M11	Female	-8.916	85.26	9.002
5	SP1705	M13	Male	-9.733	78.98	8.184
6	SP1706	M21	Male	-9.789	78.55	9.434
7	SP1707	M14	Female	-8.712	86.83	9.229
8	SP1708	M17	N/A	-7.950	92.69	9.851
9	SP1710	M20	Male	-9.541	80.45	10.206
10	SP1711	M22	Female	-12.442	58.14	8.928
11	SP1712	M16	Female	-8.343	89.67	9.652
12	SP1713	M18	Female	-10.858	70.32	11.449
13	SP1714	M4	Male	-11.314	66.82	9.608
14	SP1715	M5	Female	-9.765	78.73	9.235
15	SP1716	M6	Female	-10.115	76.04	9.142
16	SP1717	M12	Male	-9.630	79.77	9.287
17	SP1718	M7	Male	-9.866	77.95	9.367
18	SP1719	M9	Male	-9.608	79.94	6.854
19	SP1720	M10	Male	-7.907	93.02	8.777
20	SP1721	M15	Male	-8.263	90.28	9.470
21	SP1722	M24	Male	-8.201	90.76	8.585
22	SP1723	M23	Female	-9.149	83.47	8.740
23	SP1724	M30	Male	-9.568	80.25	9.826
24	SP1725	M29	Male	-10.224	75.20	10.780
25	SP1726	M26	Male	-10.153	75.75	9.052
26	SP1727	M25	Male	-8.674	87.12	9.232
27	SP1728	M28	Male	-11.266	67.18	9.445
28	SP1729	M27	Male	-9.956	77.26	10.832
29	SP1731	M33	Male	-10.868	70.25	9.509
30	SP1732	M32	Male	-9.843	78.135	8.729
31	SP1733	M31	Female	-9.451	81.15	9.570

Table 4 $\delta^{13}C$ isotope analysis of animal series from Guchengzhai, Wadian and Xipo sites.

No.	Lab No.	Site	Provenience	Taxonomy	$\delta^{13}C$ (‰)	C_4 (%)
1	SP2018	Guchengzhai	97XGT1 ⑨ Midden Deposition, Left Radius Shaft	Mid-sized *Cervidae*	-19.2	6.15
2	SP2019	Guchengzhai	99XG IV T103J4:7, Right Proximal Metacarpal	Mid-sized *Cervidae*	-20.2	0
3	SP2021	Guchengzhai	2000XG IV T71 ⑦ , Left Distal Humerus	*Sus* (Pig)	-7.4	94.3
4	SP2022	Guchengzhai	2000XG IV T71H113 ② , Right Proximal Humerus	*Sus* (Pig)	-8.7	86.9
5	SP2023	Guchengzhai	2000XG IV T87H106, Left Distal Humerus	*Sus* (Pig)	-7.3	97.7
6	SP2045	Wadian	YHW97 IV T4H24, Right Metatarsus	*Caprinae*	-8.6	87.7
7	SP2047	Wadian	YHW97 IV T1F2, Left Proximal Radius	*Sus* (Pig)	-7.1	99.2
8	SP2049	Wadian	YHW97 IV T3F4, Left Radius	*Sus* (Pig)	-8.2	90.8
9	SP2050	Wadian	YHW97 IV T6 ③ , Left Distal Tibia	*Sus* (Pig)	-14.9	39.2
10	SP2051	Wadian	YHW97 IV T3 ④ , Right Distal Humerus	*Sus* (Pig)	-11.1	68.5
11	SP2052	Wadian	YHW97 IV T3H45, Left Distal Femur	*Sus* (Pig)	-8.3	90
12	SP1734	Xipo	H104:011, Left Distal Femur	*Sus* (Pig)	-7.5	96.15
13	SP1735	Xipo	H116:117, Left Distal Tibia	N/A	-29.6	0
14	SP1736	Xipo	F102 ① :022, Left Humerus	Mid-sized Animal	-6.6	100
15	SP1737	Xipo	H22:323, Right Proximal Ulna	*Sus* (Pig)	-6.5	100
16	SP1738	Xipo	H107:025, Left Distal Humerus	*Sus* (Pig)	-7	100
17	SP1739	Xipo	H110:026, Left Ulna	*Sus* (Pig)	-7.1	99.23
18	SP1740	Xipo	H114 ④ :041, Left Proximal Tibia	Mid-sized Animal	-9.9	77.69

Table 5 Comparison of stable isotope results of Xishan site by phase.

Phase	General Comparison		Comparison of Male Specimens		Comparison of Female Specimens	
	Average $\delta^{13}C$ (‰)	Average $\delta^{15}N$ (‰)	Average $\delta^{13}C$ (‰)	Average $\delta^{15}N$ (‰)	Average $\delta^{13}C$ (‰)	Average $\delta^{15}N$ (‰)
I	-11.486 (3)	9.039 (3)	-11.583 (2)	9.323 (2)	-11.293 (1)	8.472 (1)
II	-8.125 (15)	8.747 (15)	-8.385 (6)	8.798 (6)	-7.853 (6)	8.982 (6)
III	-7.770 (16)	8.832 (16)	-7.511 (10)	9.055 (10)	-7.976 (1)	8.263 (1)

-8.215‰ , and the corresponding percentage of C_4 plant was 90.65%. These numbers suggest that the staple food of the group comprised mainly of C_4 plants. The local environment and archaeological data indicate that the C_4 plants were most likely derived from the millet family. The mean $\delta^{15}N$ value was 9.011‰ , suggesting that there was some meat in the diet of Xishan group (Table 1).

The sample size of Phase I of Xishan was too small for any meaningful conclusion. Nevertheless, the results of Phases II and III clearly indicate high percentages, over 90%, of C_4 plant in the diets of the studied samples. Evidently, plant domestication had become the main food source of the people. Xishan is located in the Central Plains with favorable environment for millet cultivation. Stable isotope analysis suggests that by the end of the sixth millennium BP, C_4 plants had become the staple food of the people living in the Central Plains. It further indicates that farming had developed from its incipient phase to a phase of intensified cultivation of C_4 crops.

The sequential development from Phase I to Phase III suggests a gradual increase in the proportion of C_4 plant in human diet over time. The difference between Phases I and II was more evident than that between Phases II and III. This is indicative that C_4 plant had become the major component of the human diet during Phase II and continued to develop during Phase III.

Another line of investigation is the sexual differentiation in diet. The 18 male specimens and eight female specimens of Xishan Site did not show significant difference in the composition of staple food and trophic level. When segmented longitudinally, Phase II had the largest sample size and therefore produced the highest resolution. It shows a small difference that the mean percentage of C_4 plant of the females was 4% higher than that of the males. Nevertheless, there was no evident change in the trophic level between the two sexes over time.

The urn-buried infants and children had relatively high trophic level. It might attribute to provisioning of higher nutritional food or they were breast-fed.

II-b. Yuhuanzhai Site

Table 6 stratifies the data of Table 2 by archaeological strata.

Table 6 Mean $\delta^{13}C$ and $\delta^{15}N$ of Yuhuazhai site by strata.

Stratum	Individuals	Average $\delta^{13}C$ (‰)	C_4 (%)	Average $\delta^{15}N$ (‰)
2	2	-8.305	89.96	8.380
3	10	-9.018	84.47	9.228
4	5	-7.804	93.80	9.831
5	3	-8.018	92.17	9.209
6	2	-8.786	86.26	9.705
8	1	-8.449	88.85	9.726

Due to the lack of contextual information on the human samples of Yuhuazhai, the following discussion is a brief one.

The archaeologists who excavated the site estimated that the entire occupation was short in absolute term. It is expected that the data lack longitudinal resolution. Yet, we can still extract some valuable information from the sample.

The following observations can be drawn from Table 2:

The mean $\delta^{13}C$ from the 25 human specimens was -8.65‰, suggesting that their diet comprised of 87.07% C_4 plant. Evidently, C_4 plant, most likely millet, was the staple food of the group. We can conclude that farming in Yuhuazhai, like Xishan, had been intensified.

The 34 human specimens of Table 2 can be partitioned into two groups: group A consists of the first nine specimens, and group B consists of the remaining specimens. The $\delta^{13}C$ values of group A were high in absolute terms, suggesting that they were derived from herbivores feeding on C_3 plants. These nine individuals might have foraged on C_3 plants abundant in the natural environment. At the same time, the $\delta^{15}N$ values of group A, with the exception of the first specimen, were lower than that of group B. The relatively high $\delta^{15}N$ value of specimen 1 might mean that it was an omnivorous individual.

The overall mean $\delta^{15}N$ of Yuhuazhai series was 9.310‰, which suggests that some meat was in the diet. It is known that the $\delta^{15}N$ value for herbivores distributes between 5‰ and 7‰. In contrast, the $\delta^{15}N$ value of Yuhuazhai series as a whole exceeded 9‰. In general, a difference of 3‰ in $\delta^{15}N$ equals the difference of one trophic level. Therefore, the human diet of Yuhuazhai was one tropic level higher than that of the animal diet. Let us return to the eight samples discussed above, their $\delta^{15}N$ values did range from 5‰ to 7‰. If the diet of the people at that time contained this kind of animals, the human diet would be higher on tropic level than that of the animals.

II-c. Xipo Site

Analysis of Table 3 generates the following observations:

1. The staple food. The mean $\delta^{13}C$ of the 31 human specimens was -9.654‰ , and C_4 plant comprised about 80% of their diet. It is evident that the Xipo group took C_4 plant, most likely millet, as staple food. This observation is comparable to the observations of the previous two sites that C_4 plants were the major cultigens during the Yangshao Culture in this region and farming had been intensified.

The Comparison between sexes shows that the 21 male specimens yielded a mean $\delta^{13}C$ of -9.691‰ and the nine female specimens yielded a mean of -9.751‰ , and C_4 plant comprised of 79.30% of the diet for the former and 78.85% for the latter. The insignificant differences suggest that males and females consumed the same staple food.

2. The trophic level. The general mean $\delta^{15}N$ for the Xipo group was 9.425‰ , meaning its diet constituted some meat. The mean $\delta^{15}N$ for the males was 9.400‰ ; wherein the mean $\delta^{15}N$ for the females was 9.439‰ . The difference is again insignificant.

3. Trophic level and mortuary difference. Human specimens of several larger than usual graves, such as M8, M18, M27 and M29, had higher $\delta^{15}N$ values. Figure 1 shows that M8 had the highest $\delta^{15}N$ value at 12.65‰ , followed by M18 at 11.449‰ , M27 at 10.832‰ , and finally M29 at 10.78‰ . Whilst the $\delta^{15}N$ values of human specimens of the remaining graves distributed between 8‰ and 9‰ , significantly lower than that of the big graves. This difference suggests that the occupants of the large tombs had trophic level higher than that of the other tombs, presumably attributable to more meat in their diet.

The material assemblage of Xipo Site suggests that it was a site of the mid-Yangshao Age. The significant differentiation in grave size and structure as seen in mid-Yangshao archaeology is generally taken as a signal

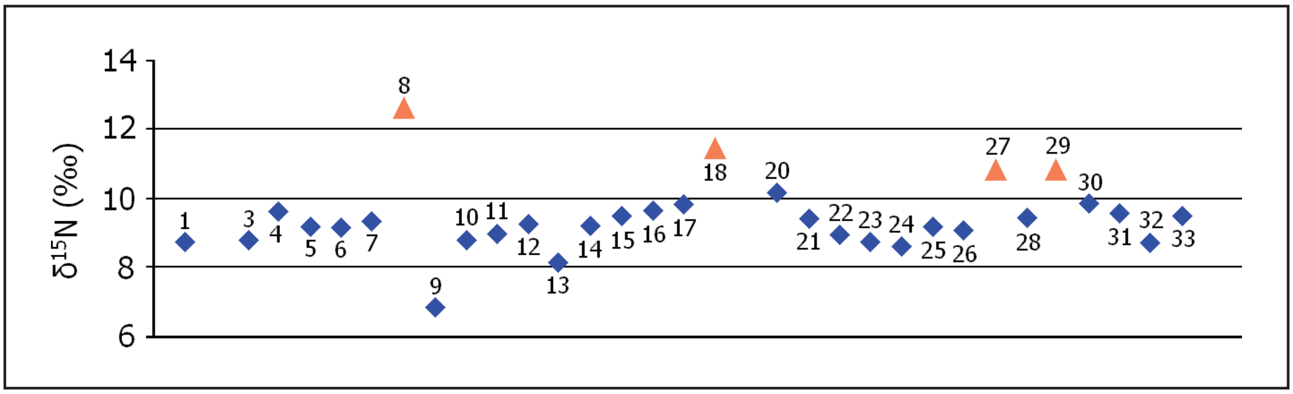

Figure 1 $\delta^{15}N$ isotope analysis of human bones from Xipo site.

of the emergence of social hierarchies. The more than 30 excavated burials at Xipo can be partitioned into three classes of large, medium and small ones. All the specimens yielding high $\delta^{15}N$ values were derived from the occupants of the large burials. Although the quantities of grave goods of these large burials were not particularly large, structures of them were different from that of the smaller ones. For example, M27 and M29 were not only large in size, wooden planks were used to cover the chambers and foot pits, and woven artifacts were placed on top of the planks. These features were not seen in the smaller tombs. In addition, the pit of M27 was filled and sealed with daub, which was a unique grave treatment during mid-Yangshao Age. Based on these findings, archaeologists argue that social delamination had emerged in Xipo.

In addition to the above observations, it is noteworthy that people with high trophic level had less C_4 plant in their diet in contrast to that of people with lower trophic level. This pattern should be viewed in the context of the Yellow River Valley and the Central Plains where prehistoric people took domesticated C_4 plants as staple. The four big tombs of Xipo had a diet lower in C_4 plant percentage than that of their counterparts. The C_4 plant percentage of M8 was 61.91%, that of M18 was 70.32%, that of M29 was 75.20%, and finally that of M27 was 77.26%. This pattern was similar to the patterns of other sites we previously studied, such as Erlitou and Qianzhangda. A probable explanation is that high-ranking individuals had varied staple food in addition to higher trophic level food like meat. Of course, the food chain effect from animals they consumed might have also reflected in these values.

II-d. Analysis of animal specimens

Table 4 lists the $\delta^{13}C$ results of animal specimens from Guchengzhai, Wadian and Xipo Sites. These results open a window to monitor the diet of prehistoric domesticated animals in the region. We argued in a previous study that there existed certain relationship between the dietary structures of humans and domesticated animals. The contention is further supported by the current study.

The animal series exhibits a contrasting pattern in stable carbon isotope ratios. On the one hand, the mean percentage of C_4 plant of the three *Sus* (pig) specimens of Guchengzhai was quite high, up to 93.85%, similar to that of humans in the same region. On the other hand, the mean percentage of C_4 plant of the two *Cervidae* was only 2.31%. It means that there were more C_3 plants, mostly likely comprised of wild plants, in their diet.

The five *Sus* and one *Caprinae* specimens of Wadian also yielded high mean percentage, up to 79.23%, of C_4 plant. Of the five *Sus* specimens, one had low percentage at 39.2%. This particular *Sus* individual might have been raised on grasses got from the natural vegetation or it was put out to pasture.

The seven animal specimens of Xipo comprised of four specimens firmly identified to *Sus*. All of their absolute $\delta^{13}C$ values were low with a mean at -7.025‰ and the mean percentage of C_4 plant was 99.81%. According to the archaeologists who excavated the site, two other unidentified mid-sized animals were also probably domestic pigs. Their $\delta^{13}C$ values were -6.6‰ and -9.9‰ and the percentages of C_4 plant were high, 77.69% and 100%. Finally the tibia of an unidentified animal yielded high absolute $\delta^{13}C$ value of -29.6‰ and no trace of C_4 plant was found, suggesting the animal survived only on natural vegetation. This was either a wild animal or a domesticated animal fed on the pasture.

Dr. Ma Xiaolin of Henan Provincial Institute of Archaeology and others had employed stable isotope analysis on human and animal specimens from Xipo and Kangjia, a site of Longshan Culture located in Lintong County, Shaanxi Province (Pechenkina 2005). Their results are tabulated in Table 7. The percentages of C_4 plant from the domestic pigs of Xipo were high, up to over 95%. It suggests that they were fed mainly on C_4 plants, and is consistent with our analysis on Xipo's pig specimens. The other animals, like wild sheep, had much lower C_4 percentage, no higher than 45%.

Conclusions

Yangshao Culture, dated from 5000 to 7000 BP, was an important archaeological culture of the Neolithic Age distributed in the middle reaches of Yellow River. Archaeological excavations yielded carbonized remains

Table 7 δ^{13}C isotope analysis of animal bones from Xipo and Kangjia sites.

Site	No.	Taxon	δ^{13}C (‰)	C_4 (%)
Xipo	26	*Sus*	-7.40	96.90
	27	*Sus*	-7.65	95.00
	28	*Canis Lupus Familiaris* (Dog)	-8.18	90.92
Kangjia	19	*Sus*	-11.53	65.15
	21	*Sus*	-11.76	63.38
	22	*Sus*	-7.53	95.92
	20	*Canis Lupus Familiaris* (Dog)	-8.97	84.85
	23	*Canis Lupus Familiaris* (Dog)	-14.53	42.08
	24	*Bubalus* (Hartebeest)	-14.20	44.62
	25	*Caprinae* (Domestic Sheep)	-18.76	9.54
	17	*Cervidae* (Deer)	-17.25	21.15
	18	*Bubalus* (Hartebeest)	-15.11	37.62

identified to foxtail and broomcorn millets from a number of sites, for examples, Banpo and Jiangzhai. The present study, nevertheless, follows a different route of investigation, and adds new information to the study of food resources of prehistoric groups.

The three sites under study are all distributed in the Yellow River Valley. The δ^{13}C analysis indicates that the mean percentages of C_4 plant from Xishan, Yuhuazhai, Xipo were 90.65%, 87.07% and 80%, respectively. These results suggest that the staple food of the people of these sites comprised mainly of C_4 plant, most likely millet, and farming was quite developed. Seen from the trophic level, their millet-based diet was supplemented with a stable supply of animal protein. The analytic results of animal specimens showed that C_4 plant comprised a high percentage in the diet of domestic animals and suggest that a significant proportion of their diet also came from farm products.

According to the theory on the origin of agriculture, increasing sedentary populations exacted increasing pressure on subsistence. Domesticated plants and animals would have become increasingly important in the subsistence of farming groups. The beginning and development of farming was an indication of the changing social needs and social development that laid the foundation for the emergence and development of civilization.

In addition, the emergence of social ranks as reflected in the mortuary practice of Xipo was supported by δ^{15}N analysis that showed differentiation of trophic level. It suggests that social hierarchy was also reflected in the diets of the people.

The analysis of trophic level between sex shows that there was no significant difference in the trophic levels of the two sexes. It might mean relative sexual equality at that time.

The above conclusions are based on the extant analytic results. We hope that more works in the future would enrich the database, test our arguments, and enable a fuller understanding of prehistoric diet and its relation with social evolution.

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Postscript

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