The Integration of Farmers and Nomads: Archaeological Evidence for the Human Subsistence Strategy in Northwestern China during the Han Dynasty

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Abstract: The integration of farmers and nomads in northwestern China during the Han Dynasty (206 BCE ~ 220 CE) provides a crucial opportunity to reconstruct the material exchanges, formation and development of the Silk Road in antiquity. The subsistence strategy is arguably an effective proxy for the integration of various groups of people (e.g. farmers and nomads). In this paper, we have reported new stable isotope data from the Huangwan tombs dated to the Han dynasty in middle Gansu, which was the key juncture between the Han and Xiongnu empire, in order to fill the gap and further understand the substance strategies employed by the local people. According to the results of plant remains and stable isotopic data, millet farming, the typical agricultural activities for the Han Chinese in the Central Plains, was also the primary lifestyle for the Huangwan people in the mid Gansu. More importantly, this shows fundamentally remarkable difference from the agricultural practices in the Bronze Age Gansu Corridor, which were based on a variety of crops, including wheat, barley and millet. This major shift in the subsistence production at Huangwan can be correlated to a wider historical background in which the Han empire showed increasing political and military presence in the Gansu Corridor, indicating that local indigenous nomads followed the lifestyle of Han Chinese (e.g., millet farming), and/or the Han immigrates maintained millet farming.

Key words: carbon, nitrogen, nomads, Silk Road, Han Chinese

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1 Introduction

Integration of different social groups of people as a result of cultural and genetic exchanges has become an increasingly important perspective to capture the trajectory of human history across the world (Dong et al., 2017; Unterlander et al., 2017; Hermes et al., 2019; Li et al., 2019; Jeong et al., 2020; Wang et al., 2020; Wilkin et al., 2020). The concept concerning the Han Chinese, which was primarily developed during the Han Dynasty (206 BCE – 220 CE; Du and Yip, 1993), creates a critical lens to record the material exchanges, formation and development of the Silk Road societies mixed between farmers and nomads (Frachetti et al., 2017; Hermes et al., 2018). These two distinctive groups of people, nomads (e.g., Xiongnu) in the north and the Han farmers in the south, lived along the line of the Great Wall in northern China during the Han Dynasty. They were interacted with one another in a variety of forms, such as warfare, trade or marriage. As recorded in the well-known Chinese historical document *Record of History*, heqin, the political marriage was a common way of establishing connections between the Han Chinese and Xiongnu (Sima, 1959; Yü, 1967; Tian, 2005). One key research gap lies in the subsistence strategy the middle part of Gansu during the Han period. Since farmers and nomads are often assumed living in a completely different lifestyle, through what mechanism could they manage to merge together? Considerable research effort has been focused on the northern frontier zone in China, which was the key junction between the Han and Xiongnu empire. The Huangwan Han Dynasty tombs (104° 36′18″E, 36°47′21″N, Fig. 1) were located in the east end of the Silk Road. The tombs yielded a large number of human and animal skeletons, plant remains, pottery, bronze artifacts, iron artifacts, wood and bone tools, glass artifacts, coins and crystal ears (Du and Chen, 2013). The skeletal collections provide an excellent opportunity to study the local subsistence strategies carried out by the Han farmers and nomads through stable isotope analyses and create further basis to explore the mechanism of integration between the Han farmers and nomads.

The historical literature has recorded that the Han people in northern China was thought to be millet-based (foxtail millet and broomcorn millet) farmers (Han, 2012), although they also cultivated wheat, rice, soybean (Han, 2012). The number of published stable isotopic data of human bones, though admittedly very limited, indicated a

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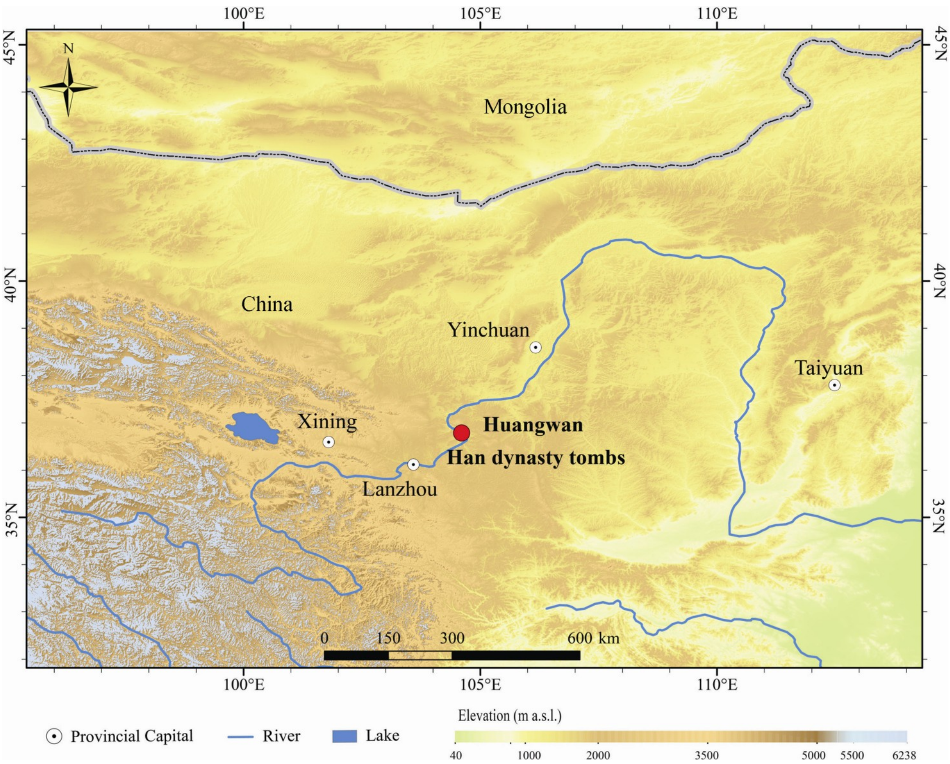

Fig. 1. The location of Huangwan Han Dynasty tombs.

great variety of dietary patterns of the Han people in different regions of northern China during the Han Dynasty (206 BCE – 220CE). The primary source of staple food is millet in Shanxi (Zhang et al., 2013), Shaanxi (Xue, 2015) and Inner Mongolia (Zhang et al., 2011; Zhang et al., 2012a, b) but it changed to a significant dietary intake of rice and wheat in Henan province (Hou et al., 2012; Zhou et al., 2017) and wheat and barley in the Hexi Corridor (Liu et al., 2014). Based on the historical literature (Sima, 1959) and archaeological materials (Ma, 2005; Joseph, 2016; Oleszczak et al., 2018), the major subsistence strategy for Xiongnu is thought to be nomadism and focus on herding animals, such as sheep, goats, cows and horse (Makarewicz, 2017) and millet made very little contribution to the Xiongnu diet (Ventresca Miller and Makarewicz, 2019). The most recent research has, however, revealed that subsistence strategy of both pastoralists in Bronze Age and nomads in later Iron Age were significantly more complex than previously thought (Spengler III, 2015; Hermes et al., 2019; Ventresca Miller and Makarewicz, 2019).

In this study, we report the results of stable isotope analysis on human and animal bones as well some tooth samples from the Huangwan Han Dynasty tombs. Our principal objective contains two folds: (1) to uncover the human diet and their subsistence strategy; (2) explore the integration of Han farmers and nomads in the northwestern China in Han Dynasty based on their subsistence strategies.

2 Geographical Settings

The Huangwan Han Dynasty tombs (104°36′18″E, 36° 47′21″N, Fig. 1) are located in the western Loess Plateau in the Gansu Province, China. The main landscape is covered by grasses and shrubs, including both C_3 and C_4 plants. However, the C_3 plants are the dominated vegetation, with C_4 plants accounting for no more than 30% (Wang et al., 2003; Wang et al., 2006; Yao et al., 2011; Jiang et al., 2019).

The Huangwan Han Dynasty tombs were first discovered and excavated in 1976. The second excavation was conducted in 2013, uncovering an area of approximately 200 m^2. It was located on a loess ridge and surrounded by houses and orchards, only 0.6 km from the bank of the Yellow River (Du and Chen, 2013). There have been found a total of twenty-six graves in the field investigation, so far, four of them were excavated. Three of them were exposed through human activities and human remains were collected. Human and animal bones (including teeth) were recovered from these seven graves. These animal bones were identified as sheep/goat and chicken. According to the field investigation and excavation, the Huangwan Han Dynasty tombs are much larger in terms of the physical area, with intensive burials. However, their burial features at Huangwan were primitive and changed little from the early Western Han to the middle Eastern Han, which marked the stable social relations and ethnic groups (Du and Chen, 2013).

3 Samples and Methods

3.1 Plant remains and chronology

A plant remain sample, provided by the Baiyin Museum, was identified at the Key Laboratory of Western China's Environmental Systems, Ministry of Education

(MOE), Lanzhou University. Some charred grains of the plant remain and two human collagen samples were selected for AMS radiocarbon dating (Table 1). The analysis was conducted in the Laboratory of Quaternary Geology and Archaeological Chronology at Peking University, Beijing. The radiocarbon dates were subsequently calibrated by OxCal v4.3 program (Bronk Ramsey, 2017), with IntCal13 curve (Reimer et al., 2013).

3.2 Isotope analysis

All samples in this study were from the Huangwan Han Dynasty tombs (listed in Tables 2 and 3). They included 9 humans and 4 animals (1 sheep/goat and 3 chickens). Permanent teeth and bone were analyzed for this study. The stable isotope values of human tissues can provide rich dietary information on different periods of an individual life, as these tissues form at different stages of one person, or have different turnover rates (Sealy et al., 1995; Malainey, 2011). For example, the dentine of permanent teeth is normally formed during childhood and adolescence (Table 4; Dupras and Tocheri, 2007). Once the root of the teeth is completely formed, the turnover for the teeth will be virtually stopped. The teeth therefore can provide the individual dietary habits during the childhood and adolescence. The bone collagen turnover rates are relatively longer (10–25 years) and can provide an average picture of the individual diet over the last 10 years of life (Manolagas, 2000; Malainey, 2011). Therefore, the stable isotope values of human teeth were chosen to examine the dietary habitats during adolescence in this study, while the isotope values of human bones were used to reflect the adult diets.

Table 1 ^{14}C date of the Huangwan Han dynasty tombs

Lab code	Material	Site	^{14}C date (BP)	Calibrated date 2σ (95.4%)
BA130859	millet	Huangwan Han Dynasty tombs	1970±30	50 BCE (95.4%) 90 CE

Conventional ^{14}C age was calibrated by OxCal v4.3 program (Bronk Ramsey 2017), with IntCal13 curve (Reimer et al., 2013).

Table 2 Isotopic composition and quality indicators of all human samples from Huangwan site

Code	Tombs	Sex	Skeletal element*	C/N	C (%)	N (%)	δ^{13}C (‰)	δ^{15}N (‰)
HW19	M2	Female	RM^2	3.1	42.9	16.3	−9.9	11.5
HW25	M2	Female	RM^1	3.2	46.8	17.3	−8.9	11.6
HW17	M2	Female	RI^1	3.2	44.3	16.3	−8.7	11.0
HW12	M2	Female	RPM^2	3.1	44.5	16.5	−9.5	10.7
HW5	**M2**	**Male**	**RM^3**	**3.8**	**54.3**	**16.9**	**−8.9**	**10.9**
HW6	M3	Male	RM^1	3.3	46.1	16.4	−9.8	10.6
HW21	M3	Male	RI^1	3.2	44.0	15.9	−9.6	10.6
HW28	M3	Male	RI^2	3.1	44.1	16.7	−8.9	10.6
HW8	M3	Male	RC	3.1	43.0	16.4	−9.2	10.8
HW1	M3	Male	RM^2	3.2	43.6	15.7	−9.2	10.7
HW31	M3	Male	RM_2	3.2	45.9	16.7	−8.7	11.1
HW29	M3	Male	RM^3	3.1	43.5	16.2	−9.8	10.9
HW18	M5	Male	LM^1	3.3	44.9	16.0	−8.4	11.1
HW26	M5	Male	LI^1	3.3	42.7	15.3	−8.6	10.8
HW23	M5	Male	LI^2	3.0	43.8	17.2	−8.5	11.3
HW2	M5	Male	LPM_2	3.1	43.0	16.0	−8.7	11.1
HW4	M6	Male	RM^3	3.2	43.7	15.8	−8.1	10.0
HW14	**M1R1**	−	**ulna**	**3.9**	**45.0**	**13.5**	**−9.3**	**9.8**
HW15	**M1R2**	−	**ulna**	**5.8**	**41.8**	**8.4**	**−10.0**	**11.0**
HW16	M2	Female	Humerus	3.2	45.6	16.4	−9.9	10.6
HW13	M3	Male	Femur	3.2	42.8	15.9	−9.2	10.6
HW27	M4R1	−	Humerus	3.2	42.5	15.3	−8.6	9.7
HW30	M4R2	Female	Maniphalanx	3.2	44.1	15.9	−11.5	12.9
HW11	M5	Male	Clavicle	3.1	44.9	16.7	−10.7	10.4
HW10	**M6**	**Male**	**ulna**	**2.7**	**37.8**	**16.4**	**−8.5**	**9.4**
HW20	M7	−	Radius	3.6	43.2	14.0	−15.1	7.7

Samples indicated in bold font are excluded from further analyses due to their rates of C: N are out of the range from 2.9 to 3.6.
R= right, L= left, C= canine, I= incisor, PM1= premolar1, M=molar

Table 3 Isotopic composition and quality indicators of faunal samples from Huangwan site

Code	Tombs	Species	Skeletal element	C/N	C (%)	N (%)	δ^{13}C (‰)	δ^{15}N (‰)
HW3	M1	Chicken	Rib	3.1	44.8	16.8	−11.0	7.7
HW7	**M1**	**Chicken**	**Tibiotarsus**	**2.6**	**43.6**	**19.6**	**−15.4**	**6.9**
HW22	M1	Chicken	Tibiotarsus	2.9	43.4	17.2	−13.6	6.7
HW9	M1	Ovicaprid	Tibiao	3.6	52.3	16.9	−8.0	8.3

Samples indicated in bold font are excluded from further analyses due to their rates of C: N are out of the range from 2.9 to 3.6

Table 4 Estimated age-spans of formation in tooth root dentine

Teeth	Approximate timing of root dentine development
Permanent C	4–12 years
Permanent I1	4.5–9.5 years
Permanent I2	4.5–10.5 years
Permanent PM1	5–12.8 years
Permanent M1	2–9 years
Permanent M2	6–13.8 years
Permanent M3	12–20 years

C= canine, I= incisor, PM1= premolar1, M=molar
Dental root formation timing for each tooth type (Dupras and Tocheri 2007).

A fragment of bone/teeth root was physically cleaned and then demineralized in 0.5 mol/L hydrochloric acid (HCl) at 4°C. The solution needs to be changed once in every 2 days for around 2 weeks. Samples were washed to neutral with distilled water and then soaked in 0.125 mol/L NaOH for another 20 h. Thereafter, they should be rinsed again to neutral with distilled water and then gelatinized in an acidic solution (pH = 3) at 75ºC for 48 h and filtered. Finally, the solution was freeze-dried in order to extract the collagen.

All the collagen samples were analyzed with a continuous-flow isotope ratio mass spectrometer combined with a Conflo interface device, Thermo Finnigan DeltaPlus at the MOE Key Laboratory of Western China's Environmental Systems, Lanzhou University. Atomic C/N ratios were measured on an Elemental Analyser (vario EL cube) at the State Key Laboratory of Applied Organic Chemistry, Lanzhou University. The carbon and nitrogen stable isotopes were measured relative to the V-PDB and AIR standards, respectively. The analytical precision of carbon and nitrogen stable isotopes was 0.1‰ and 0.2‰, respectively.

Statistical analyses were performed using SPSS 19.0 for Windows. The non-parametric tests employed were Mann-Whitney tests. The significance level was set at $p < 0.05$.

4 Results and Discussions

4.1 Plant remains and dates

Two sorts of cereal remain have been identified, common millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica;* Fig. 2). Millet grains and human collagen were used for radiocarbon dating, which suggest that the Huangwan Han Dynasty tombs were dated from 96 BCE to 125 CE at 1 sigma confidence (Table 1). The archaeological remains and historical literature indicate that the tombs formed from the early Western Han Dynasty to the middle Eastern Han Dynasty (114 BCE–111 CE) (Du and Chen, 2013, 2015), which is roughly consistent with the chronology defined by the radiocarbon dates.

4.2 Collagen preservation

The isotopic data, the collagen quality indicators and the basic information on the sampled individuals are recorded in Tables 2 and 3. The collagen of 25 samples are well preserved, with atomic C:N ratios of 2.9 to 3.6 (DeNiro, 1985; Ambrose, 1990). However, four human and one animal samples were excluded due to their poor collagen preservation, with atomic C:N ratios falling out of this range.

4.3 Animal analysis

The three faunal results are presented in Table 3 and plotted in Figs. 3 and 4. The faunal samples have a range of δ^{13}C values from −13.6‰ to −8.0‰ (mean = 10.9±2.3‰), indicative of a heavy consumption of C_4 foods (probably millets and millet byproducts). Although belong to the omnivorous taxa, the two chickens show slightly lower δ^{15}N values than those of the sheep/goat (8.3‰), with a mean of 7.2±0.5‰ and a range of 6.7‰ to 7.7‰, suggesting that both follow herbivorous diet.

4.4 Overall diet of the Huangwan population

The human results are presented in Table 2 and plotted in Figs. 3 and 4. The δ^{13}C values of human bones range from −11.5‰ to −8.6‰ (n=5, except the sample HW20), with an average of −9.98±1.0‰. The δ^{13}C values of human teeth range from −9.9‰ to −8.1‰ (n = 16), with an average of −9.0±0.5‰. No significant difference (p = 0.082) is spotted between the carbon stable isotopic values of bones and teeth. This is an intriguing result which means that people at Huangwan experience no major dietary shifts since their childhood and they were primarily dependent on the C_4-based diet. Since the millet grains dominate the macro fossils of plant remains at Huangwan (Fig. 2) and its cultivation millets were widely encouraged by the Han central court thus carried out across the entire state (Han, 2012), it might be reasonable to suggest that people at Huangwan lived primarily on millets, regardless of direct consumption or fodder to animals.

The mean δ^{15}N values of human bones and teeth are 10.8±1.1‰ (n = 5, except the sample HW20) and 10.9±0.4‰ (n = 16), respectively. Again, no significant nitrogen isotopic difference can be found between human bones and teeth (p = 0.134). The mean $\Delta^{15}N_{\text{human bone-ovicaprid}}$ (2.5‰) is less than the generally stated trophic level offset of 3–5‰ (Bocherens and Drucker, 2003), though the mean δ^{15}N values of ovicaprid was from only one individual. It might imply that faunal products contributed very little to the overall diet of the Huangwan population, with one exceptional case (HW30) who apparently consumed more faunal products than others.

4.5 Individual differences in dietary signatures

Two individuals of the tomb M1 were the highest social class based on the burial features (Du and Chen, 2013). Unfortunately, both bone collagen samples were not well preserved and cannot be used for dietary analysis (Table 2). The two individuals of interest are the sample HW20 from the tomb M7 and the sample HW30 from the tomb M4, respectively (marked on Fig. 3). The sample HW20 shows a δ^{13}C value of −15.1‰, which is more negative than those of the other individuals, indicating a more C3 input mixed with the C_4 foods. Considering the δ^{15}N value of 7.7‰, the δ^{13}C value of sample HW 20 could be explained by the consumption both wheat and millets but very little animal products. Given the fact that wheat was utilized as a staple food by the lowest social classes in China during the Han Dynasty (Zhou et al., 2017), the individual of the sample HW20 was likely from very low social class therefore had to consume more wheat than the other individuals of Huangwan and very small amount of animal products. The δ^{15}N value of the sample HW30 (12.9‰), which is enriched by 4.5‰ relative to the ovicaprid δ^{15}N value (8.4‰), is significantly higher that of the other individuals. This female individual appears very likely to have consumed more faunal protein (e.g., meat and/or milk). Moreover, her burial and dietary features (flexed burial and meat-eater) show some obvious difference with the other individuals and ancient DNA

Fig. 2. Plant remains of Huangwan Han Dynasty tombs.
(a) foxtail millet (*Setaria italica*); (b) common millet (*Panicum miliaceum*).

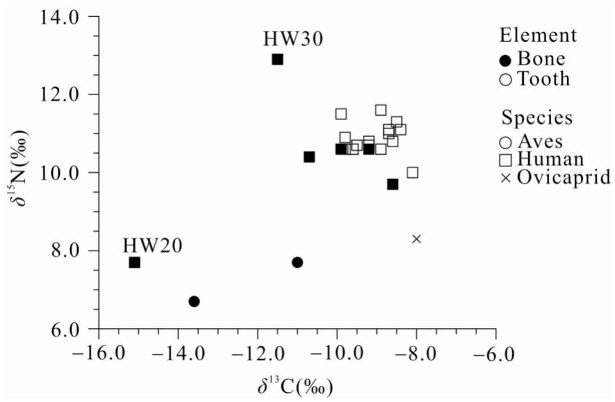

Fig. 3. Carbon and nitrogen isotopic results for humans and animals from the Huangwan Han dynasty tombs.

data of other two individuals (individuals from tomb M6 and M3) imply that both local pastoralists and Han farmers were mixed in the region, suggesting that the female might be at least influenced by the nomadic lifestyle (e.g., Xiongnu). A majority of the northern neighbors of the Han Dynasty were nomads, such as Xiongnu people, who frequently contacted and conflicted with the Han people in the northern frontier. Milk and meat were one of the routine diets for the Xiongnu people, supplemented by probably relatively a small amount of millet (Ma, 2005; Ventresca Miller and Makarewicz, 2019). As a result, their bone collagen is featured by elevated δ^{15}N values (Ventresca Miller and Makarewicz, 2019). The stable isotopic data provide critical data for pose this hypothesis but more ancient DNA analysis is needed to confirm the relationship between this female at Huangwan and the broadly defined pastoralists in the north, such as Xiongnu.

4.6 Adolescence diet vs. adult diet

The δ^{13}C and δ^{15}N results for the bones and permanent teeth from the same individuals are plotted in Fig. 4a–c. There appears little difference in δ^{13}C between permanent dentition and bone collagen from the same individuals (Table 2 and Fig.4a-b). Both of them are generally consistent with a C_4 terrestrial diet from adolescence to adult, such as millets and/or animals fed on millets. However, the comparison of δ^{13}C between permanent dentition and bone collagen from the sample of the tomb M5 (male) shows a remarkable difference. Permanent dentition δ^{13}C mean value is enriched by ~2.2‰ over bone (Table 2 and Fig. 4c; mean δ^{13}C permanent dentition = −8.6‰ vs. mean δ^{13}C bone = −10.7‰). Given the δ^{15}N value of bone collagen is lower (10.4‰), it suggests that this person may have consumed more C_3 foods when he became an adult (e.g., wheat and barley), but lived on a C_4 -based diet (probably millets and/or animals fed on millets) in his childhood. This contain further implications to understand the local/non-local groups.

4.7 The spatio-temporal variation of subsistence patterns and integration of Han farmers and mobile pastoralists in northwestern China

Undoubtedly, millet made substantial contribution to the traditional diets in the Central Plains since the rise of Bronze Age (Wang et al., 2019), while the poor and female might have eaten a supplementary amount of wheat between 770 BCE and 221 CE (Li et al., 2020). Subsequently, the communities of the Central Plains had varied dietary intake of millet based on the δ^{13}C values of human bones (Fig. 5). The poor of some communities ate a significant amount of wheat in the Central Plains between 141 BCE and 220 CE (Zhou et al., 2017), in response to the increased population and intensification of wheat cultivation in the Guanzhong Plain by the Han central government (Han, 2012). The Han elites, however, still consumed considerable amounts of millet in their daily life (Zhou et al., 2015). Some communities of the Central Plains, whose social classes were not identified, still had heavy dietary intake of millet (Fig. 5). The pastoralist communities in the neighboring areas of the

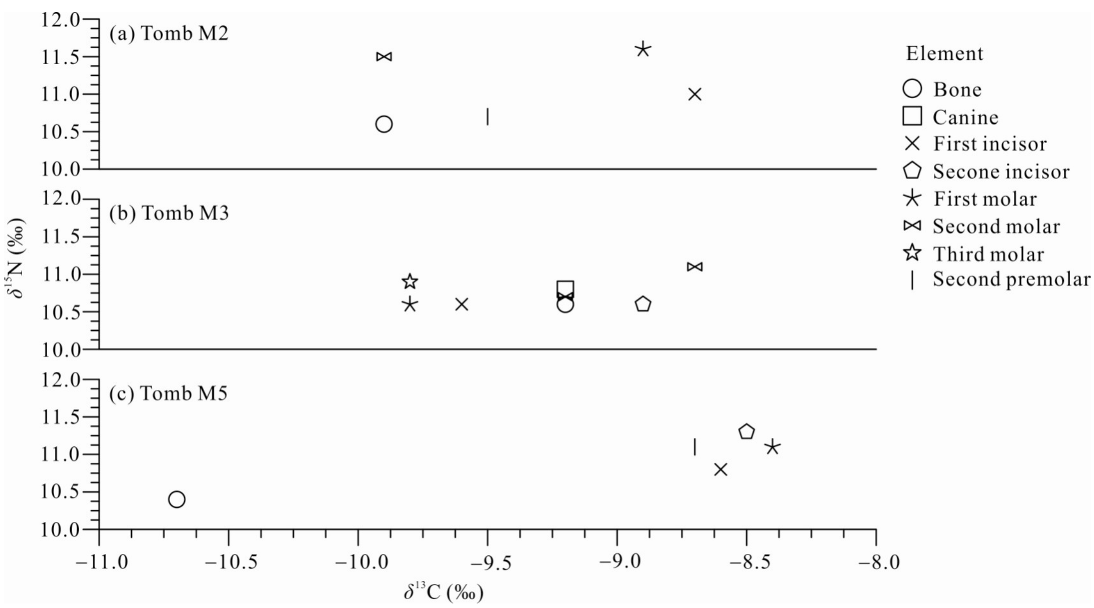

Fig. 4. Carbon and nitrogen isotopic results for human bone and permanent teeth from the same individuals.

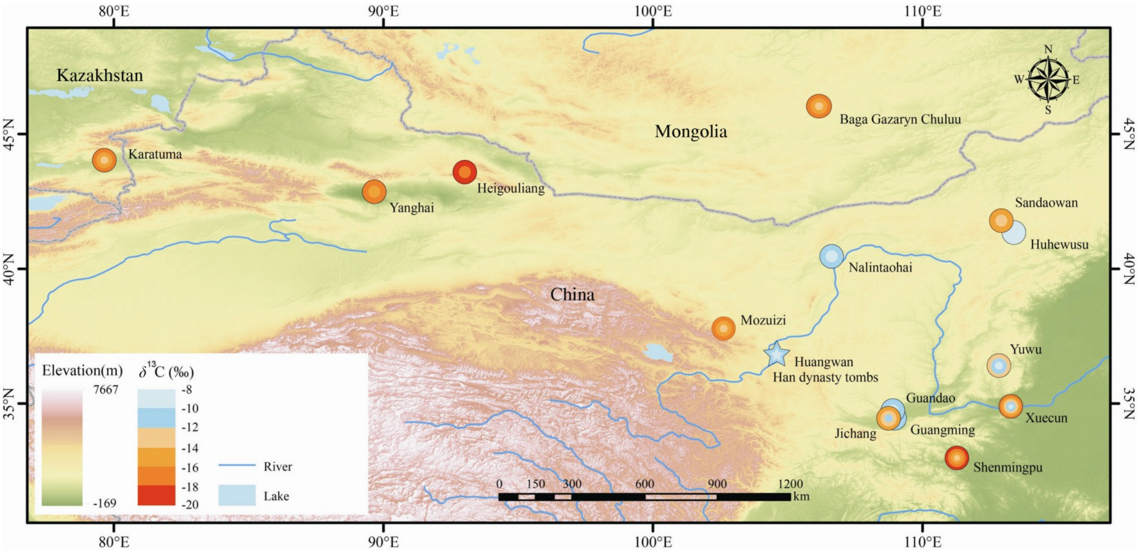

Fig. 5. Human carbon isotopic values in this study compared with other contemporary sites in northern China and neighboring regions (Zhang et al., 2009, 2012a, b; Machicek,2010 ; Zhang et al., 2011, 2013; Hou et al., 2012; Si et al., 2013; Liu et al., 2014; Motuzaite Matuzeviciute et al. 2015; Xue, 2015; Zhou et al., 2017; Ventresca Miller and Makarewicz, 2019)

Han Empire had evidently different dietary intake (Fig. 5). Relatively little contribution of millet can be seen from the dietary practice in Xinjiang (Zhang et al., 2009; Si et al., 2013). Instead, C_3 cultivars (wheat and barley) appear to be more significant. However, pastoralists of southeastern Kazakhstan, adjacent to Xinjiang, consumed moderate levels of millet from 400 to 50 BCE (Motuzaite Matuzeviciute et al., 2015; Ventresca Miller and Makarewicz, 2019). The northern neighboring nomads, who inhabited the Mongolian steppe, consumed an even relatively smaller amount of millet but more milk and meat of livestock between ~200 BCE and 200 CE (Ma, 2005; Machicek, 2010; Ventresca Miller and Makarewicz, 2019). The communities in the Inner Mongolian appear heavily relied on millet, which is probably affected by the lifestyle of the Han millet-based farmers (Zhang et al., 2011, 2012a, b). In summary, the high-level millet consumption appears strongly correlated with the communities of the Han farmers or communities who are closely related to the Han farmers during Han Dynasty.

Wheat and barley had been gradually incorporated into human diets and became a dietary focus in the Gansu and Qinghai province after 1500 BCE during the Bronze Age (Liu et al., 2014; Ma et al., 2016). Furthermore, the mobile pastoralist occurred and developed in the Gansu Corridor from ~1000 to ~150 BCE (Yang et al., 2019a, b). Subsequently, the Xiongnu people featured with nomadism conquered the Inner Mongolian, Gansu and Ningxia. Since the Han Dynasty defeated the Xiongnu in the Gansu Corridor in 121 BC, a great number of the Han farmers and soldiers were moved to the Inner Mongolian, Gansu and Ningxia, and mixed with local pastoralists in northwestern China (Sima, 1959). The agricultural technology and lifestyle were introduced in the northwestern China by these immigrates (Hui and Wang, 2005). Human diets in Gansu, therefore, could be potentially changed due to the demographic migration and ethnic integration during the Han period (Fig. 5). The relatively lower average values of human $\delta^{13}C$ and $\delta^{15}N$ (−15.7‰ and 10.5‰, respectively) indicate that high-level of C_3 and C_4 cereal consumption occurred in the Hexi Corridor (Liu et al., 2014). It suggests that their subsistence strategy was the mixed agriculture centered on millet, wheat and barley, which can be further supported by historic records and macro-plant remains (Wei, 2010). It seems that the subsistence lifestyle of the Hexi Corridor significantly changed from nomadism to agriculture around 121 BCE. But up to now, isotopic evidence for subsistence strategies of the Bronze Age pastoralists and Xiongnu in the Hexi Corridor is unavailable and the sample size of the Han Dynasty is rather unsatisfying (n = 6). Although the historic literature recorded many agricultural activities in the Hexi Corridor during the Han Dynasty, we cannot underestimate the degree of engaging in farming by pastoralists and nomads (Spengler III, 2015; Hermes et al., 2019; Ventresca Miller and Makarewicz, 2019). It means that farming strategies had been used as a crucial part of subsistence strategy in the Hexi Corridor from the Bronze Age to the Han Dynasty, although there were a series of differences in the intensity of crop cultivation in different periods (Yang et al., 2019b). Since the Han immigrates mixed with pastoralists in the Hexi Corridor, these millet-based farmers could incorporate cultivation of wheat and barley in their farming strategy to form the mixed agricultural system. Alternatively, these Han people were wheat and millet-based farmers before they were moved to the Hexi Corridor. Their farming strategy changed little when they moved to the Hexi region. Further studies on stable isotopes of the pastoralists and famers in the Hexi Corridor will help to determine which scenario was true or a combination of both. However, the community of Huangwan, adjacent to east end of the Hexi Corridor, shifted from mixed C_3 and C_4 diet in Bronze Age back to C_4 diet in the Han Dynasty, indicating that their subsistence food changed from wheat, barley and millet in Bronze Age to millet in the Han Dynasty. The dietary shift in isotopic signals (from mixed C_3 and C_4 in Bronze Age to C_4 in the Han Dynasty) in middle Gansu, indicates the integration of Han farmers and nomads in northwestern China in the Han Dynasty. The change in the subsistence production at Huangwan suggests that some individuals, who were local indigenous pastoralists, could adapt to the lifestyle of the Han Chinese at that time (e.g., millet farming). For instance, although individuals from Huangwan tombs M6 and M3 were millet eaters, about 20~30% of their DNA was from northern Eurasian pastoralists (Wen, 2017). By contrast, other individuals at Huangwan, who were most likely the Han immigrates, maintained millet farming strategy even they were moved to middle Gansu and received limited impact from local dietary habit such as the individuals (HW16, HW11 and HW27). Moreover, the individual (HW20) from tomb M7 might be influenced by the local lifestyle and consumed significant amount of C_3 crops. Although the overall diet of Huangwan implied a millet farming lifeway adopted by Han farmers, a significantly genetic contribution from pastoralists was observed though ancient DNA analysis of two individuals and genetic basis of both individuals accommodated easily to the nomadic lifestyle (Wen, 2017). The isotopic and ancient DNA data indicate an integration of Han farmers and nomads at Huangwan, likely by intermarriage, and so on. However, given only small samples for isotopic (n = 7) and ancient DNA (n = 2) analysis are available, more isotopic and ancient DNA data are needed to illustrate the integration of Han farmers and nomads in northwestern China in the Han Dynasty.

5 Conclusions

The $\delta^{13}C$ and $\delta^{15}N$ values of the bone collagen from the humans and animal samples from Huangwan, middle Gansu indicate that human diet was primarily focused on millet. Millet farming was the main lifestyle for the Huangwan people. The female individual featured with high-level domesticated animal protein is interesting and her relation to the Xiongnu nomads should be further explored. She might represent a group of people who might be deeply affected by the Han culture. Further studies will help to determine whether the female was genetically related to the Xiongnu nomads through ancient DNA analysis. Comparison with other sites indicates that the dietary shift reflected by the isotopic signals (from mixed C_3/C_4 in Bronze Age to C_4 in the Han Dynasty) in middle Gansu, which marked the change from millet, wheat and barley eaters to millet consumers, indicates the integration of Han farmers and nomads in northwestern China in the Han Dynasty.

The data presented in this paper illustrates new evidence for the integration of farmers and nomads in northwestern China from the perspective of the subsistence lifestyle. In addition to the implications for the ethnic integration of Han farmers and nomads, the data also shows individual dietary changes from adolescence to adult by comparing isotopic data between teeth and bones of the same person.

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