Tracing the locality of prisoners and workers at the Mausoleum of Qin Shi Huang: First Emperor of China (259-210 BC)

Ying Ma1, Benjamin T. Fuller2, Weigang Sun3, Songmei Hu3, Liang Chen4, Yaowu Hu2,5 & Michael P. Richards1,6

The mausoleum complex of the First Emperor of China, Qin Shi Huang (259-210 BC), is one of the most famous and important archaeological sites in China, yet questions remain as to how it was constructed and by whom. Here we present isotopic results of individuals from the Liyi (n = 146) and Shanren sites (n = 14), both associated with the mausoleum complex. Those buried at Liyi represent the local workers/inhabitants of the Qin population, and the δ13C (−8.7 ± 1.5%) and δ15N (10.3 ± 0.7%) values indicate that they consumed predominately millet and/or domestic animals fed millet. In contrast, the Shanren individuals were prisoners forced to construct the mausoleum (found buried haphazardly in a mass grave and some in iron leg shackles), and their δ13C (−15.4 ± 2.9%) and δ15N (8.0 ± 0.6%) results indicate a more mixed C3/C4 diet, with possibly less domestic animals and more wild game protein consumed. This pattern of decreased millet consumption is also characteristic of archaeological sites from southern China, and possible evidence the Shanren prisoners originated from this region (possibly the ancient Chu state located in modern day Hubei Province and parts of Hunan and Anhui Provinces). Further, this finding is in agreement with historical sources and is supported by previous ancient DNA evidence that the mausoleum workers had diverse origins, with many genetically related to southern Chinese groups.

As the First Emperor of China, Qin Shi Huang (259-210 BC), brought to conclusion the tumultuous Warring States Period (475-221 BC) and successfully established the first unified Empire of China: the Qin Dynasty1,2. The magnificent mausoleum complex of Qin Shi Huang (including the life sized Terracotta Warrior Army) is considered one of the most important archaeological sites of China, and has been described as the 8th of wonder of the world3. Chinese historical records indicate that as soon as Qin Shi Huang gained control of the Qin State (246 BC), he started building the mausoleum at the northern portion of Lishan Mountain4, near the present day city of Xi’an (Fig. 1). Massive amounts of planning, labor and capital were diverted to the construction of the mausoleum complex, and the entire project took thirty-nine years to complete5-7. In 231 BC, Qin Shi Huang commissioned the building of the city of Liyi (离邑) to serve as the base of operations for the construction efforts of the mausoleum8,9. Historians estimate it had a population of approximately a hundred thousand individuals, and it was divided into several neighborhoods such as Xi (西) and Jiao (交)8,9. Inscriptions on pottery were found at many sites around the mausoleum, verifying that the inhabitants of Liyi City produced a large quantity of domestic earthenware, brick, tile, and other goods used in both the construction of the tomb and the daily life of the town11,12. The Chinese historian, Sima Qian (ca. 145-90 BC), wrote that ~700,000 laborers were requisitioned from all over China to toil in the mausoleum over the course of its construction4, and that the workers consisted...
of skilled craftsmen as well as prisoners (captured warriors and/or criminals) and the indebted (people working to pay taxes)\(^{13,14}\). However, since the Qin Dynasty covered a vast area and included a diverse population of ~20 million people\(^{15,16}\), the origins of the individuals that comprised this massive labor force are not fully known. This topic has become an important focus of investigation with archaeologists studying writings on pottery tiles found with the burials of the workers as well as inscriptions on some of the Terracotta soldiers for clues about the people that made them\(^ {17–19}\). In addition, recent mtDNA evidence suggests the workers had diverse genetic backgrounds from different regions in China\(^ {20}\). Here we present the first research that isotopically examines the dietary habits of the workers/craftsmen from the public cemetery of Liyi, and the prisoners from the mass grave at Shanren that constructed the famous Qin Shi Huang Mausoleum (see supplementary information for more site details). In addition, these results are compared to other contemporary and earlier sites from across north and south China, and this isotopic information is used in combination with the archaeological evidence and previous mtDNA research\(^ {20}\) to better understand the diets and possible geographic origins of these individuals.

**Results**

The \(\delta^{13}C\) and \(\delta^{15}N\) results of the fauna and humans are presented in Tables S1 and S2 and plotted in Fig. 2. The preservation of bone collagen in human and faunal samples was variable. Of the bones prepared, 161 out of 223 humans and 8 out of 9 faunal samples yielded collagen. The %C, %N and atomic C:N together with collagen yields were used to determine the quality of collagen preservation and assess the effects of diagenesis\(^{21,22}\). The collagen yields obtained in the present study were low overall, due to the removal of small degraded collagen fragments during the ultrafiltration step\(^ {23}\), but all samples that produced collagen had C:N values that fell within the range of 2.9–3.6, considered acceptable for stable isotope analysis\(^ {24,25}\).

**Isotopic data for Liyi humans.** The Liyi humans (n = 146) show a large variation of isotopic values across the entire population, with the \(\delta^{13}C\) values ranging from −16.3% to −7.0% (mean = −8.7 ± 1.5%) and the \(\delta^{15}N\) values ranging from 6.1% to 12.3% (mean = 10.3 ± 0.7%) (Fig. 2). The majority of individuals have \(\delta^{13}C\) (> −12.0%) and \(\delta^{15}N\) (> 9.0%) results indicative of a predominately \(C_4\) diet that was derived from domestic...
animal proteins (likely pig, cattle, sheep, dog; Fig. 2). However, several individuals have relatively $^{13}$C-depleted values, evidence that they consumed a mixed $C_3/C_4$ protein diet. In addition, a single individual (M71) plots well away from the population with a $^{13}$C-depleted measurement (−16.3%) as well as the most $^{15}$N-depleted result (6.1%) of all the humans analyzed, suggesting a unique dietary pattern.

Isotopic data for Shanren humans. The Shanren humans ($n = 14$) have $\delta^{13}C$ values that range from $-18.2\%$ to $-8.5\%$, with a mean value of $-15.4 \pm 2.9\%$ and $\delta^{15}N$ results that range from $7.2\%$ to $10.8\%$, with a mean value of $8.0 \pm 0.6\%$ (Fig. 2). The isotopic results for 12 of the humans (except for M101, M111) cluster in a group (mean values, $\delta^{13}C = -16.4 \pm 1.1\%$; $\delta^{15}N = 8.0 \pm 0.6\%$). The range of $\delta^{13}C$ results fall within the expected values of a population consuming both $C_3$ and $C_4$ resources, but are closer to values expected for a purely terrestrial $C_4$ protein diet. In contrast, the individuals M101 and M111 have significantly $^{13}$C-enriched results reflecting that the protein portions of their diets were predominately $C_4$ either from plants ($M111$, low $\delta^{15}N = 7.6\%$) or from animals that were feeding on $C_4$ plants ($M101$, high $\delta^{15}N = 10.8\%)$.

Discussion

Substantial research on the agricultural practices of northern China, as well as archaeological evidence from pollen, phytolith and plant flotation studies found that millet agriculture was established in northern China and became the dominant grain for human food or for animal fodder in the late Neolithic\textsuperscript{26-27}. In this study, the isotopic evidence indicates that millet was the most important crop for the daily diet of the Liyi population during the Qin period. This finding is also supported by previously published isotopic data of contemporary sites from the Guanzhong Plain (an area central to the original Qin state)\textsuperscript{4,28} (Table 1). There are no large isotopic differences between these sites (Fig. 3), and nearly all of the north Chinese populations had diets that were predominately based on millets with varying amounts of domestic animal protein consumption (Fig. 3).

The human mean $\delta^{15}N$ value ($10.3 \pm 0.7\%$) indicates a significant consumption of domestic animal protein for the Liyi population as a whole, but individual differences exist (Fig. 2). In comparison with the fauna data, the offsets in the $\delta^{13}C$ values between the humans and the chicken/crane indicate that these species were not the main sources of protein for the population. In addition, the Liyi population is significantly elevated (one-way ANOVA; $p = 0.0000$) in mean $\delta^{15}N$ compared to the contemporary period Qin sites of Sunjianantou ($\delta^{15}N = 8.5 \pm 1.0\%$)\textsuperscript{29} and Jianhe ($\delta^{15}N = 8.7 \pm 0.5\%$)\textsuperscript{30} which might indicate that the Liyi people consumed more animal protein in their diet than other Qin sites (Fig. 3). However, due to the small number of faunal samples, we caution against more detailed interpretations.

Historical sources such as \textit{Shijing} (诗经)\textsuperscript{31}, \textit{Liji} (礼记)\textsuperscript{32}, and \textit{Zhouli} (周礼)\textsuperscript{33} provide important accounts concerning the diet during the pre-Qin period. Millet, soybean and wheat were discussed as the main crops in the central plains region of China before the Han dynasty. In particular, the \textit{Shuahuishi Qin bamboo texts} (睡虎地秦简), (written during the Qin Dynasty, recording Qin laws and public documents, and excavated from a Qin tomb in Yunneng County, Hubei Province in 1975)\textsuperscript{34} described that the Qin State stored a large amount of millet in the capital's granary. In \textit{Shiji} (史记), Sima mentioned that the Qin people avoided the consumption of soybean because they viewed it as a crop for the poor and were also uninterested in the planting of wheat\textsuperscript{4}. Thus, the
| Site                | Humans | δ\(^{13}\)C ± SD (%) | δ\(^{15}\)N ± SD (%) | Period            | Age       | Location | Modern Chinese Province | Reference |
|---------------------|--------|-----------------------|-----------------------|------------------|-----------|----------|--------------------------|-----------|
| Sunjianantou        | 25     | −10.8 ± 1.3%          | 8.5 ± 1.0%            | Eastern Zhou     | ca. 770–221 | North China | Shaanxi                  | 29        |
| Jianhe              | 14     | −9.2 ± 0.7%           | 8.7 ± 0.5%            | Late Eastern Zhou| ca. 476–221 | North China | Shaanxi                  | 30        |
| Zhounyu             | 10     | −9.3 ± 1.0%           | 9.1 ± 1.4%            | Western Zhou     | ca. 1046–771 | North China | Shaanxi                  | 45        |
| Liangdaicun         | 7      | −8.5 ± 0.6%           | 9.7 ± 0.7%            | Western Zhou     | ca. 1046–771 | North China | Shaanxi                  | 45        |
| Neiyangyuansu       | 22     | −8.3 ± 0.7%           | 9.5 ± 1.0%            | Late Eastern Zhou| ca. 476–221 | North China | Shaanxi                  | 46        |
| Tunluyuwen          | 6      | −9.7 ± 1.6%           | 8.8 ± 0.6%            | Late Eastern Zhou| ca. 476–221 | North China | Shaanxi                  | 47        |
| Qianjiangda         | 26     | −9.2 ± 1.4%           | 10.0 ± 1.3%           | Western Zhou     | ca. 1046–771 | North China | Shanong                  | 48        |
| Liangchengshen      | 15     | −9.8 ± 2.0%           | –                     | Neolithic        | ca. 2500–2000 | North China | Shanong                  | 27        |
| Beiqian             | 29     | −9.2 ± 0.7%           | 8.1 ± 0.1%            | Neolithic        | ca. 6100–5500 | North China | Shanong                  | 49        |
| Guzhendu            | 4      | −8.4 ± 0.7%           | 9.6%*                 | Neolithic        | ca. 4300–2500 | North China | Shanong                  | 50        |
| Xiqingqiao          | 8      | −15.0 ± 3.9%          | 8.4 ± 1.3%            | Neolithic        | ca. 5000–4500 | North China | Shanong                  | 51        |
| Qinglongquan        | 9      | −14.5 ± 1.1%          | 7.1 ± 1.0%            | Eastern Zhou     | ca. 770–221 | South China | Hubei                    | 54        |
| Sanxingcun          | 19     | −20.1 ± 0.2%          | 9.7 ± 0.3%            | Early Neolithic  | ca. 6500–5500 | South China | Jiangsu                  | 55        |
| Tianlaoshan          | 10     | −20.7 ± 0.5%          | 8.7 ± 0.9%            | Early Neolithic  | ca. 7000–5500 | South China | Zhejiang                 | 56        |
| Hemudu              | 4      | −18.2 ± 2.2%          | 11.4 ± 0.3%           | Early Neolithic  | ca. 6800–6000 | South China | Zhejiang                 | 50        |
| Songze              | 2      | −19.8 ± 0.4%          | 10.9 ± 1.6%           | Early Neolithic  | ca. 5800–4900 | South China | Shanghai                 | 50        |
| Tashan              | 3      | −18.4 ± 0.5%          | 10.7 ± 0.7%           | Early Neolithic  | ca. 5900–5600 | South China | Zhejiang                 | 56        |
| Liyudun             | 2      | −17.0 ± 1.3%          | 13.8 ± 1.4%           | Early Neolithic  | ca. 7000–6000 | South China | Guangdong                | 62        |
| Jinlianshan         | 9      | −18.8 ± 0.4%          | 9.8 ± 0.9%            | Late Eastern Zhou| ca. 476–221 | South China | Yunnan                   | 53        |
| Page                | 1      | −20.4%                | –                     | Late Eastern Zhou| ca. 476–221 | South China | Sichuan                  | 52        |

Table 1. Summary of isotopic results from the Liyi and Shanren sites as well as from the previous published pre-Qin and Qin populations from north and south China. *Only one sample measured for nitrogen.

Figure 3. Human \(\delta^{13}\)C and \(\delta^{15}\)N values (mean ± sd) from the Liyi and Shanren sites, and the previous published isotopic results from pre-Qin and Qin populations in north and south China.

isotopic results presented here, that the Qin diet was heavily reliant on millet, are in agreement with the Chinese historical texts. The typical Qin diet was also described as including a number of possible meat sources: cattle, sheep, goat, dog as well as wild boar. Sima wrote that there were special shops to sell dried and spiced meats in the city of Xianyang, the capital of the Qin. In addition, Shiji and Hanshu also mentioned that dog meat consumption was prevalent during the Qin and Han Dynasties, since many people made their living by the butchering dogs. In contrast to Liyi, the \(\delta^{13}\)C values for the Shanren humans were variable but show a diet reliant on mixed \(C_3/C_4\) protein sources, involving the consumption of millet or animals fed millet and possibly rice and/or wheat or wild
game over their lifetime (Fig. 2). However, two individuals (M101 and M111) ate predominately C₄-based foods, and one individual (M113) consumed predominately C₃-based foods. The δ¹⁵N values exhibit a narrow range (±1%) for all individuals (except M101), and were similar or only slightly elevated above the local animal species. This possibly suggests these people were consuming less animal protein compared to the population at Liyi which agrees with the fact that these mausoleum workers were of lower status (likely prisoners since buried with iron leg shackles in a mass grave without grave goods; see supplementary section) than the villagers.

Additional evidence to support this possibility comes from historical sources. The Shihuitu Qin bamboo texts (睡虎地秦简) recorded that prisoners were provided food according to their assignments, with workers that built walls or engaged in heavy manual labor receiving ~0.75 kg and ~0.5 kg of rough millet for lunch and dinner, respectively⁴¹. Since meat and wine were only given to soldiers as a reward, it is unlikely that domestic animal meat was part of a prisoner's daily diet⁴². However, it is possible that these prisoners could have supplemented their daily diet with wild game. It is interesting to note that only a single individual (M101) was observed to have isotopic values identical to the Liyi population. Thus, it is possible this person could have been a townsmerperson that was forced to labor in the mausoleum construction as a result of punishment or to pay back a debt. However, if many of the Shanren individuals were not locals and were from other regions of China, then these lower isotopic values would reflect the local environmental food web from where they originated, and this possibility is considered below.

While the archaeobotanical remains of rice and wheat have been discovered at many sites in northern China since at least the end of the Neolithic³⁹–⁴³, archaeological research indicates that distinct dietary differences existed between north (millet) and south (rice) China with the overlapping regions designated as rice-millet blended zones⁴⁴. Current isotopic findings focused on δ¹³C human values support that these general dietary differences existed at the population level between sites in north (C₄ = millet) and south (C₃ = rice) China (see Table 1; Figs 1a and 3). These isotopic dietary differences between north and south China can be used as markers to examine the general origins of the Shanren individuals, who died constructing the Mausoleum of Qin Shi Huang. Specifically, evidence from a number of previous isotopic studies in China are used for comparison to the Shanren results (Fig. 3).

All the Western and Eastern Zhou period sites from north China display evidence of significant millet consumption²⁹,³⁰,⁴⁴–⁴⁷ (Figs 1a and 3; Table 1). For instance, in Shanxi Province, Pei et al.⁴⁶ suggested that the Neiyangyuang people mainly relied on stockbreeding, and the high C₄ signatures in the δ¹³C values shows that the consumption of millet made a significant contribution to the diet by direct consumption and/or as fodder for their livestock. The isotopic results for people from the eastern Province of Shandong also show a reliance on millet²⁷,⁴⁸–⁵⁰, but the Neolithic Xigongqiao population had a mixed C₃/C₄ diet⁵¹. The hot and humid climate of south China is unfavorable for collagen preservation, and this has resulted in significantly less isotopic research in this region. Since only three relatively contemporary sites from south China exist²⁵–²⁸ (Fig. 1a; Table 1), additional south Chinese isotopic results from earlier periods were used²⁶,⁵⁵,⁵⁶, and we acknowledge and caution that this time difference between sites is not ideal for direct comparison. Still, by examining the south China δ¹³C results, it can be seen that nearly all populations were consuming C₃ diets (Figs 1a and 3).

Unfortunately, no grave goods or pottery tiles with identifying information were found in the Shanren mass grave and other research methods and historical sources are needed to determine their origins. When both the carbon and nitrogen results of the Shanren individuals are compared to the pre-Qin site of Qianzhangda in Shandong Province (Table 1; Fig. 3), we see there are no similarities, and that the sites are statistically distinct (one-way ANOVA; p = 0.000 for δ¹³C; p = 0.000 for δ¹⁵N). However, the carbon isotopic results are nearly indistinguishable from the much earlier Neolithic site of Xigongqiao (Fig. 3). Given the antiquity of Xigongqiao and that there is only a single pre-Qin site (Qianzhangda) from Shandong, it is difficult determine if the Shanren individuals were originally from the Shandong region, but this is a possibility since archaeobotanical studies have found evidence for populations with rice economies in this region⁹⁹–⁴¹. Thus, additional isotopic studies focused on Qin period archaeological sites from Shandong are necessary to provide more information.

Compared to the local Liyi population, the Shanren individuals had a mixed diet of millets or animals consuming millets and possibly rice and/or wheat and appear to have consumed less animal products. This decrease in millet consumption appears to correspond with the isotopic results of people from the southern areas China. Given that both the δ¹³C and δ¹⁵N values for the Shanren humans are similar to the contemporary Qinglongqan site in Hubei Province (Fig. 3) this could suggest that many of the Shanren individuals came from the same general region. However, there are outliers, with the individual M101, having nearly identical isotopic results as the Liyi population, strongly suggesting that he was from the local area. In addition, M111 had a similar δ¹³C value to the Liyi individuals but a significantly lower δ¹⁵N value. This could suggest two potential possibilities: he was from the Liyi area but consuming millet with little animal protein (a prisoner’s diet) or that he was from another area of northern China that was distinct from the Liyi community.

Excavations at the Zhaobeihu site (another contemporary cemetery consisting of mausoleum prisoners) discovered several fragments of pottery tile with epitaphs that recorded personal information (e.g. names, ranks, birthplaces) about these people and confirm that these prisoners were from distant regions of China²⁵–²⁸. In particular, these writings show that seventeen individuals were from the eastern region of the Qin State from today’s Shandong Province (n = 10), Jiangsu Province (n = 1), Henan Province (n = 3) and Hebei Province (n = 3)²⁷. This suggests that the prisoners were kept as a group and buried together by their rank and general regions of origin (similar language, customs, diet, etc.).

Additional evidence is provided by past ancient DNA analysis. Xu et al.²⁶ also studied the mtDNA from nineteen workers from the Shanren site, and concluded that many of these people were Hans or minorities from the south of China. Unfortunately, due to different individuals being selected, a direct comparison
between the ancient DNA and the isotopic results is only possible for a single individual (M91). M91 had a mixed C3/C4 δ13C signature (~17.1%) that is suggestive of southern China (Fig. 3), and this agrees with the ancient DNA findings that he was genetically related to the southern Han people.20 However, since the study of Xu et al.20 compared the Shanren remains to modern individuals, some skepticism and caution about the results is warranted. There is the possibility that later migrations and admixture between the populations of north and south China could complicate the understanding of the genetics from the archaeological individuals. However, bearing this possibility in mind, our isotopic results suggest that many of the Shanren prisoners had isotopic signatures for mixed C3/C4 diets found in southern China, and these results are in agreement with the genetic findings of Xu et al.20.

Finally, according to historical documents that describe the wars and battles of the Qin State6,7, a southern origin for these Shanren prisoners, forced to construct the Qin Shi Huang Mausoleum, is certainly plausible given the other lines of evidence presented here. Thus, we can further hypothesize that these Shanren individuals were possibly from the rival Chu state, located in modern-day Hubei Province, as well as northern Hunan and southern Anhui Provinces (Fig. 1). In conclusion, while limited and far from perfect, the isotopic results presented here are able to lend some support to the ancient DNA evidence and historical sources, highlighting the benefits of stable isotope studies to document migration in archaeological populations in China.

Methods

A total of 223 individuals consisting of rib and long-bone fragments were obtained from the Liyi cemetery, from both the “Xinfeng” (n = 166) and “Wanli” sites (n = 57). Fauna samples (pig, dog, cattle, sheep, chicken and crane; n = 9) found in the “Wanli” site during excavation were also collected and analyzed. In addition, human remains (n = 19) consisting of rib and long-bone fragments were sampled from the Shanren site19. Additional details about the fauna and humans can be found in Table S1 and S2, respectively.

Collagen samples were prepared following the protocol outlined in Richards and Hedges59 modified by using the ultrafiltration method60,61. Small bone chunks were cleaned by faunal abrasion and then demineralized at 4 °C in 0.5 M HCl for two weeks. Once demineralized, the samples were rinsed three times with deionized water, and then introduced to a pH = 3 solution and gelatinized at 70 °C for 48 hours. The samples were first filtered with a 5 μm EZEEM® filter to remove the insoluble residues; then ultrafiltered (Amicon® ultrafilters < 30 kDa), and finally the purified collagen was frozen and freeze dried for 2 days. About 0.5 mg of dried collagen was weighed into tin capsules for analysis and each sample was measured in duplicate using a Flash EA 2112 coupled to a Delta XP mass spectrometer (Thermo-Finnigan®, Bremen, Germany). Natural abundance of δ13C and δ15N is expressed as ‘per mil’ (%) with respect to international standards: δ13C or δ15N = (Rsample/Rstandard − 1) × 1000, where R in δ13C or δ15N is 13C/12C or 15N/14N, respectively. Vienna Pee Dee belemnite (VPDB) and atmospheric nitrogen (AIR) were used as the international standards for carbon and nitrogen, respectively. The analytical precision was ±0.2% for both δ13C and δ15N.

References

1. Chang, C. The Rise of the Chinese Empire: Nation, State, and Imperialism in Early China, CA. 1600BC–8AD (University of Michigan Press, Michigan 2007).
2. Lewis, M. E. The Early Chinese Empires: Qin and Han (Belknap Press of Harvard University Press, Cambridge, 2007).
3. Ministry of Culture, China. Eighth Wonder of the World: Terracotta Warriors. ChinaCulture.org. Available at: http://www.chinaculture.org/gb/en_artqa/2003-09/24/content_39719.htm. (Accessed: 18th September 2014).
4. Sima, Q. Shi ji: The Records of the Grand Historian, Qin Dynasty Volume (transl. Watson, B.) (Columbia University Press, New York, 1961).
5. Li, Y. The First Emperor of China (International Arts and Sciences Press, New York, 1975).
6. Cotterell, A. The first emperor of China: the greatest archeological find of our time (Holt, Rinehart and Winston, New York, 1981).
7. Yuan, Z. The Excavation and Research of Qin Shi Huang Mausoleum (Shaanxi People’s Press, Xi’an, 1986).
8. Liu, R. Textual distinguish on “Qin zhi Liyi” (Shaanxi people’s Publishing House, Xi’an, 2002).
9. Sun, W. “Xi”, “Liyi” and “Lishan Yuan”: the function of Liyi for the Qin Shi Huang Mausoleum. Archaeology and Cultural Relics 4, 67–71 (2009).
10. Yuan, Z. Archaeological finding and research of the Qin Shihuang Mausoleum (Shaanxi people’s Publishing House, Xi’an, 2002).
11. Archaeological Team of Terracotta Army. Brief report of Qin tomb in Shangjiao, Lintong. Archaeology and Cultural Relics 2, 42–50 (1980).
12. Chen, X. Inscription on pottery excavated from Qin Liuzhai site, Xinfeng, Lintong. Archaeology and Cultural Relics 4, 1–7 (1996).
13. Hu, L. & Feng, Z. Analysis on the Liyan offender. J. Humanities Researches of the Qin Shihuang Mausoleum (Shaanxi Traveling Press, Xi’an, 1992).
14. Zhang, Q. The management system of the solder and corvee in Qin state during Warring States. J. Puysang Vocational and Technical College. 2, 52–54 (2011).
15. Ge, J. The Population History of China (Fudan University Press, Shanghai, 2002).
16. Gao, K. Sex disproportion and depopulation in the Qin Dynasty, with reference to the discovery of offender tombs. J. Literature, History and Philosophy. 5, 123–127 (2007).
17. Shaanxi Provincial Institute of Archaeology & Archaeological Team of Lintong County. The tomb of Corvee and Prisoner for Qin Shi Huang Mausoleum (Shaanxi Traveling Press, Xi’an, 1992).
18. Zhang, Z. The archaeological data of offenders in Qin and Han dynasty. Historic Teaching 1, 5–8 (2001).
19. Shaanxi Provincial Institute of Archaeology & Emperor Qinis Terracotta Warriors and Horses Museum. Report on Archaeological Researches of the Qin Shihuang Mausoleum Precinct from 2001 to 2003 (Culture Relics Press, Beijing, 2007).
20. Xu, Z. et al. Mitochondrial DNA evidence for a diversified origin of workers building Mausoleum for first Emperor of China. PloS One. 1, 1–7 (2008).
21. Ambrose, S. H. Preparation and characterization of bone and tooth collagen for isotopic analysis. J. Archaeol. Sci. 17, 431–451 (1990).
22. Schwarz, H. P. & Schoeninger, M. J. Stable isotope analyses in human nutritional ecology. Yearbook of Physical Anthropology. 34, 283–321 (1991).
23. Jorkov, M. L. S. Evaluating bone collagen extraction methods for stable isotope analysis in dietary studies. J. Archaeol. Sci. 34, 1824–1829 (2007).
24. DeNiro, M. J. Post-mortem preservation of alteration of in vivo bone collagen isotope ratios in relation to paleodietary reconstruction. Nature. 317, 806–809 (1985).
25. van Klinken, G. J. Bone collagen quality indicators for paleodietary and radiocarbon measurements. J. Archaeol. Sci. 26, 687–695 (1999).
26. Zhao, Z. Palaeobotanical studies on the origin of agriculture and civilization. Management and Review of Social Sciences. 2, 82–91 (2005).
27. Lanehart, R. E. et al. Dietary adaptation during the Longshan period in China: Stable isotope analyses at Liangchengzheng (southeastern Shandong). J. Archaeol. Sci. 38, 2171–2181 (2011).
28. Liu, X. Zhan Guo Ce: Strategies of the Warring States (Shanghai Classics Publishing House, Shanghai, 1998).
29. Ling, X. et al. Carbon and nitrogen stable isotopic analysis on human bones from the Qin tomb of Sunjianantou Site, Fengxiang, Shaanxi Province. Acta Anthrop. Sinica. 1, 54–61 (2010).
30. Ling X. et al. Stable isotope analysis of Qin human remains from the Jianhe cemetery at Baoji, China. Archaeology and Cultural Relics. 1, 95–98 (2010).
31. Duke of Zhou. Shijing: The Classic of Poetry (Zhonghua Book Company, Beijing, 2006).
32. Dai S. Li: The Book of Rites (Huangshan Publishing House, Hefei, 2014).
33. Duke of Zhou. Zizhi (Zhonghua Book Company, Beijing, 2014).
34. Shi Huadu Qin Bamboo Slips Group. Shihudu Qinmu Zhihuan (Cultural Relics Press, Beijing, 2001).
35. Peng, W. Discussion on Qin People’s Diet. J. of Northwest University: Philos. and Social Sci. Ed. 4, 42–43 (1980).
36. Hua, K. Yantie Lun. The Discourses on Salt and Iron (Zhonghua Book Company, Beijing, 1992).
37. Liu, B. Laoshi Chenggu (Zhonghua Book Company, Beijing, 2011).
38. Ban, G. Hanzhu. History of the Former Han (Zhonghua Book Company, Beijing, 2007).
39. Crawford, G. et al. Late Neolithic Plant Remains from Northern China: Preliminary Results from Liangchengzheng, Shandong. Current Anthropol. 46, 309–317 (2005).
40. Fuller, D. Pathways to Asian Civilizations: Tracing the Origins and Spread of Rice and Rice Cultures. Rice. 4, 78–92 (2012).
41. d’Alpoim Guedes, J., Guijui, J. & Bocinsky, K. The Impact of Climate on the Spread of Rice Agriculture to North-Eastern China: An Example from Shandong. Philo. One. 10, 1–19 (2015).
42. Duddon, J. R. et al. Origin and spread of wheat in China. Quaternary Sci. Rev. 72, 108–111 (2013).
43. Barton, L. & An, C. An evaluation of competing hypotheses for the early adoption of wheat in East Asia. Word Archaeol. 46, 775–798 (2014).
44. Wang, X. G. & Xu, X. A discussion on the rice-millet blended zone in the Neolithic Age. Agriculture History of China. 22, 3–9 (2003).
45. Ling, X. PhD Thesis: The research on the diet of Qin human (Department of Archeology and museum, Northwest University, 2010).
46. Pei, D. et al. Paleodietary Analysis of Humans from the Neiyangyuan Site of Xianrung, Shansi Province. Acta Anthrop. Sinica. 4, 379–384 (2008).
47. Xue, J. P Master Thesis: Carbon and nitrogen stable isotope analysis on human remains from Tuntuliuywa during Warring State to Han Dynasty. (Department of Archeology, Shansi University, 2015).
48. Zhang, X. et al. Stable carbon and nitrogen analysis on the human remains from the Qianzhangda cemetery at Shandong, China. Kaogu. 9, 83–96 (2012).
49. Wang, F. et al. Stable isotopic analysis on human and animal remains of Beiqian site. Scientia Sinica Terrae. 12, 2029–2036 (2013).
50. Zhang, X. L. et al. A study of ancient human’s diet. Kaogu. 2, 62–75 (2003).
51. Hu, Y. W. et al. Stable isotope analysis on human bones from the Xiongqiao site, Tengzhou, Shandong. Quaternary Sci. 25, 604–611 (2005).
52. Cai, L. & Qiu, S. 13C analysis and paleodiet reconstruction. Kaogu. 10, 945–955 (1984).
53. Zhang, Q. Stable carbon and nitrogen analysis on the human remains from the Jilingzhan cemetery at Yunnan, China. Kaogu. 1, 30–33 (2012).
54. Zhang, Q., Zhou, M. & Zhu, J. Stable isotopic analysis on bones excavated from Eastern Zhou tombs in Qinglongquan Site of Hubei. Jianghan Archaeology. 123, 93–97 (2012).
55. Hu, Y. W. et al. The research on the diet of Sanxingjun Site, Jintan, Jiangsu. Chineses Sci. Bulletin. 52, 85–88 (2007).
56. Zhang, G. W. et al. Stable isotopic analysis on human and animal bones excavated from Tashan site, Zhejiang. 2, 138–146 (2015).
57. Archaeological Team of Terracotta Army. Report of Zhaoheibei site, workers building Qin Shi Huang Mausoleum. Cultural Relics. 3, 1–11 (1982).
58. Gao, F. & Xu, W. Review on the research of Emperor Mausoleum during Qin to Han Dynasties (1949–2012). Study on Qin and Han Dynasties. 7, 285–322 (2013).
59. Richards, M. P. & Hedges, R. E. M. Stable isotope evidence for similarities in the types of marine foods used by Late Mesolithic humans at sites along the Atlantic coast of Europe. J. Archaeol. Sci. 26, 717–722 (1999).
60. Brown, T. A. et al. Improved collagen extraction by modified longin method. Radiocarbon. 30, 171–177 (1988).
61. Brock, F. et al. Quality assurance of ultrafiltered bone dating. Radiocarbon. 49, 187–192 (2007).
62. Hu, Y. W. et al. Carbon and nitrogen stable isotope analysis of the human bones from the Liyudun site, Zhanjiang, Guangdong: A preliminary exploration of the Neolithic human lifestyle in South China. Acta Anthrop. Sinica. 29, 264–269 (2010).

Acknowledgements
We would like to thank the Archaeology Team of the Qin Shi Huang Mausoleum for the permission to work with the specimens and providing us with archaeological information. This research was funded with support from the Max Planck Society and CAS President’s International Fellowship for Postdoctoral Researchers 2013Y1J1A004. Grant Sponsorship: Max Planck Society CAS President’s International Fellowship for Postdoctoral Researchers 2013Y1J1A004.

Author Contributions
Y.M., B.T.F., Y.H. and M.P.R. designed the research and analyzed data. Y.M. performed experiments. W.S., S.H. and L.C. provided materials and resources. S.H. identified the fauna species. Y.M., B.T.F. and Y.H. wrote the paper.

Additional Information
Supplementary information accompanies this paper at http://www.nature.com/srep

Competing financial interests: The authors declare no competing financial interests.

How to cite this article: Ma, Y. et al. Tracing the locality of prisoners and workers at the Mausoleum of Qin Shi Huang: First Emperor of China (259–210 BC). Sci. Rep. 6, 26731; doi: 10.1038/srep26731 (2016).
