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# PALEODIETARY PATTERNS OF THE CHEREPAKHA 13 SITE POPULATION (EARLY IRON AGE) IN PRIMORYE (MARITIME) PROVINCE, RUSSIAN FAR EAST, BASED ON STABLE ISOTOPE ANALYSIS

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**ABSTRACT.** New paleodietary data were obtained after the discovery and excavation in 2015–2017 of the Cherepakha 13 site in the southern part of Primorye (Maritime) Province in far eastern Russia. The site is located near the coast of Ussuri Bay (Sea of Japan) and belongs to the Yankovsky cultural complex of the Early Iron Age $^{14}$C-dated to ca. 3000 BP (ca. 1200 cal BC). The stable isotope composition of the bone collagen for 11 humans and 30 animals was determined. For humans, the following values (with ±1 sigma) were yielded: $\delta^{13}$C = –10.2 ± 0.8‰; and $\delta^{15}$N = +12.4 ± 0.3‰. The majority of terrestrial animals show the usual isotopic signals: $\delta^{13}$C = –19.4 ÷ –23.3‰; and $\delta^{15}$N = +4.6 ÷ +6.6‰ (for wolves, up to +10.1‰); dogs, however, have an isotopic composition similar to humans: $\delta^{13}$C = –11.7 ± 1.2‰; and $\delta^{15}$N = +12.4 ± 0.4‰. Marine mammals have common values for pinnipeds: $\delta^{13}$C = –13.7 ÷ –14.6‰; and $\delta^{15}$N = +17.4 ÷ +18.0‰. The main food resources for the population of Cherepakha 13 site were (1) marine mollusks, fish, and mammals; and (2) terrestrial mammals; and possibly $C_4$ plants (domesticated millets).

**KEYWORDS:** Cherepakha 13, Early Iron Age, paleodiet, Primorye (Maritime) Province, Russia, stable isotopes, Yankovsky Culture.

## INTRODUCTION

Paleodiet studies based on analysis of carbon and nitrogen stable isotopes in bone collagen are now one of the most important methods to investigate ancient human subsistence (e.g. Shoeninger 2014; Sealy 2017; see also Roberts et al. 2018). In the Russian Far East, this kind of bioarchaeological research is still at the very early stage, mainly due to the poor preservation of bones at the prehistoric sites; human remains are known mostly from shellmiddens and limestone caves (see review: Kuzmin 2015).

In the Russian Far East, encompassing the mainland Primorye Province and the Amur River basin, and insular regions of Sakhalin Island and the Kurile Islands, one of the most prominent cultural complexes studied since the late nineteenth century is the Yankovsky Culture (YC) of the Early Iron Age. The settlements and burial grounds of the YC are located in the southern part of Primorye (Maritime) Province (e.g. Okladnikov 1965; Andreeva et al. 1986), roughly between two points—one ca. 125 km SW of the city of Vladivostok, and another ca. 150 km E of the same city (Figure 1). Sites are situated mainly on the Sea of Japan shore, but sometimes more inland, up to ca. 80 km from the coastline, near the modern city of Ussuriysk. In the course of surveys and excavations of the YC, around 100 habitation sites and shellmiddens, and a few burial grounds were studied (Andreeva et al. 1986). Unfortunately, the human osteological materials from these burials did not survive. The numerous shellmiddens on the Sea of Japan coast are the "trademark" of this cultural complex, and it was assumed that marine

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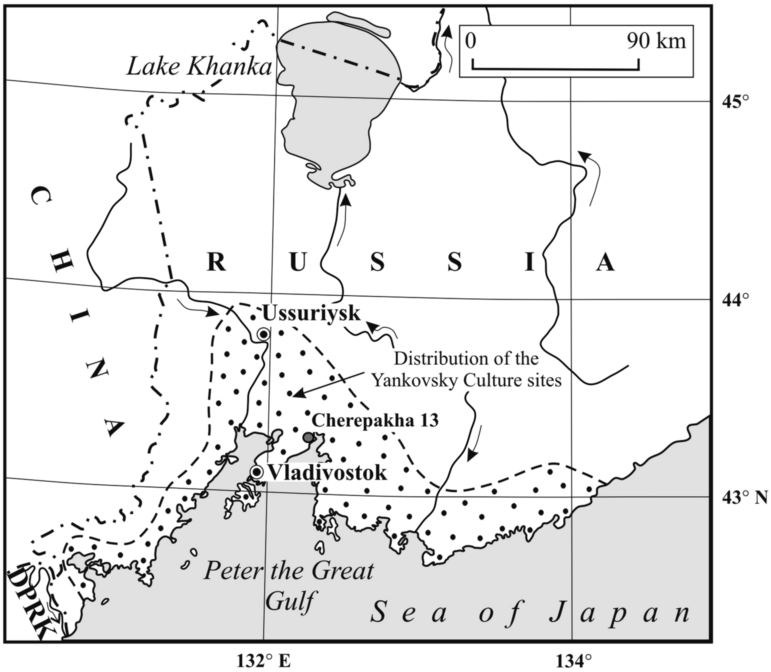


Figure 1 The position of the Cherepakha 13 site in southern Primorye Province of Russia (the dotted area is the territory with YC sites).

mollusks played an important role in human subsistence. The real proportion and importance of this food source for YC, however, was not established before this study. From the view of chronology, the YC is generally dated to the 12th–5th millennia BC based on charcoal radiocarbon ($^{14}$C) dates from habitation sites (Kuzmin et al. 2005).

New data were generated after the discovery and excavation in 2015–2017 of the Cherepakha 13 site in Primorye Province, with a plethora of animal bones and numerous human remains. Overall, in 26 graves the skeletons of 37 individuals were unearthed. This is the largest prehistoric burial ground excavated so far in the entire far eastern Russia. This provided us with an excellent opportunity to conduct paleodietary studies in this region, less studied compared to neighboring Japan, the Korean Peninsula, and North China. In this paper, we report the first data on the composition of carbon and nitrogen stable isotopes in human bone collagen of the Early Iron Age coastal populations in Primorye, and discuss the results obtained in a wider context.

## MATERIAL AND METHODS

The Cherepakha [*Turtle*] 13 site is located near the coast of Ussuri Bay, part of the larger Peter the Great Gulf, Sea of Japan (coordinates 43°17′N, 132°18′E; see Razjigaeva et al. 2017a) (Figure 1). Although several cultural components have been identified at this site (Malkov 2017), its main occupation phase and human burials belong to the YC. As for the site's chronology, the most securely YC-associated $^{14}$C date for the Cherepakha 13 site was obtained on charcoal from the Dwelling 26 where skeletons 7 and 9 (see Table 1) were found: 2960 ± 95 BP (SOAN-9602); this corresponds to 2880–3360 cal BP or 930–1410 cal BC (based on Calib Rev 7.0.2 software; http://calib.qub.ac.uk/calib/).

Table 1 Gender, age and stable isotope composition of collagen of the Cherepakha 13 humans.

| Individual | Gender | Age (years) | $\delta^{13}C$, ‰ | $\delta^{15}N$, ‰ | C:N |
|---|---|---|---|---|---|
| Skeleton 6 | Juvenile | 11 | –10.0 | +11.7 | 3.1 |
| Skeleton 7* | Sub-adult | 13 | –11.7 | +12.5 | 3.4 |
| Skeleton 9* | Juvenile | 7 | –11.3 | +12.5 | 3.3 |
| Skeleton 11 | Juvenile | 6 | –9.6 | +12.4 | 3.0 |
| Skeleton 16 | Male | 45–50 | –10.2 | +12.4 | 3.1 |
| Skeleton 17 | Female | 50+ | –11.2 | +12.7 | 3.3 |
| Skeleton 18 | Male | 35–40 | –10.1 | +12.9 | 3.1 |
| Skeleton 19 | Male | 16–18 | –9.2 | +12.5 | 3.1 |
| Skeleton 20 | Female | 15–19 | –9.5 | +12.5 | 3.1 |
| Skeleton 21 | Juvenile | 5 | –9.5 | +12.2 | 3.1 |
| Skeleton 22 | Male | 25–30 | –10.0 | +12.6 | 3.1 |

*A $^{14}C$ date of ca. 2960 BP was obtained for Dwelling 31 where these skeletons were found.

Zooarchaeological information for the Cherepakha 13 site was obtained by the determination of animal bones to species/genus level. Overall, around 17,300 bones were collected during the excavations, and 78% of them are identifiable. About 11,250 bones (71% of the total assemblage) belong to YC, and 80.9% of them are large mammals, 5.3% are birds, and 13.8% are fish; the two latter groups were not studied in detail. The large terrestrial mammals are represented by artiodactyls (Artiodactyla), carnivores (Carnivora) and lagomorphs (Lagomorpha); and marine mammals belong to carnivores and cetaceans (Cetacea). Domesticated animals are represented by dog (*Canis familiaris*) (8.5% of the total for YC) and pig (*Sus scrofa domestica*). Concerning the latter, there is a problem of separation from the wild boar (*Sus scrofa*), and the amount of suids' (pig/boar) bones is 7544 (82.9% of the total for YC). Major species of wild mammals (8.3% of the total for YC) are Siberian roe deer (*Capreolus pygargus*) and red deer (*Cervus elaphus*) (dominant species); and fox (*Vulpes vulpes*), sable (*Martes zibellina*), kolinsky (*Mustela sibirica*), and Asian badger (*Meles leucurus*). The amount of marine mammal bones—Steller's sea lion (*Eumetopias jubatus*) and largha seal (*Phoca largha*)—is very small (0.04% of the total for YC).

The paleoenvironmental study of the area around the Cherepakha 13 site (Razjigaeva et al. 2017a) allowed us to establish that during the site's existence the nearby territory was covered with forest consisting mainly of oak, with admixture of Korean pine and hornbeam. The climate was cooler than today; on the adjacent hills the main vegetation type was forest with a dominance of dark conifers (fir and Korean pine), with some broadleaved species (Razjigaeva et al. 2017b). Overall, during the existence of the YC sites in southern Primorye the climate fluctuated between warmer (at ca. 3380–3220 and 2950–2630 cal BP) and colder (at 3220–2950 cal BP) episodes (Razjigaeva et al. 2017b). It is suggested that when the Cherepakha 13 site was occupied by the YC population, the level of the Sea of Japan dropped, and this may have caused a decrease of marine resources (Razjigaeva et al. 2017a). Archaeobotanical research at the Cherepakha 13 site (Sergusheva and Moreva 2017) allowed us to identify the seeds of two species of millet: broomcorn millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*) in the YC layer. It is clear that the bearers of the YC practiced agriculture based on domesticated millets which are $C_4$ plants.

For this study, the bones of 11 humans and 30 animals were selected for stable isotope analysis. Samples were milled to the size of 200–300 µm, and were treated with chloroform to remove lipids and fats. After that, the material was rinsed with methanol 3–4 times. The resulting powder was dried, and treated with a 0.5 M solution of HCl overnight. This was followed by the removal of humic acids with a 0.1 M solution of NaOH (for 30 min), and then the powder was treated with 0.5 M HCl for 1 hr to eliminate the admixture of atmospheric $CO_2$. After each treatment, the powder was washed with mQ water 3–4 times. Gelatinization was performed at pH 3 (temperature of 70°C, 24 hr), and the gelatin obtained was freeze-dried. The C:N ratios were measured by a EuroEA 3000 HT elemental analyzer, and $\delta^{13}$C and $\delta^{15}$N values were determined with the help of a Finnigan Delta-V mass spectrometer.

As for comparative materials from the Primorye region and neighboring parts of the Russian Far East, there is a dearth of evidence currently available. Only 2 Neolithic sites in Primorye were analyzed, Boisman 2 and Chertovy Vorota (Kuzmin et al. 2002); in the Amur River basin, 11 individuals from the Early Iron Age and Medieval cultural complexes were investigated (Kuzmin 2015); and on Sakhalin Island, 13 skeletons from the Paleometal and ethnographic times were analyzed (see Kuzmin 2015). In order to generate a more comprehensive interpretation, we used the data available from the Japanese Islands, southern Siberia (Russia), southern Kazakhstan, and northern China (see references below).

## RESULTS AND DISCUSSION

The results of the stable isotope analyses for the Cherepakha 13 site (YC component) are presented in Tables 1–2 and in Figure 2. For humans, good quality collagen (C:N ratio of 3.0–3.4) yielded the following values (with ±1 sigma): $\delta^{13}$C = –10.2 ±0.8‰; and $\delta^{15}$N = +12.4 ±0.3‰. No significant difference based on gender or age of the individuals was observed.

Concerning the animals from the YC component, terrestrial wild mammals (elk, red deer, roe deer, and wild boar) show the usual isotopic signals in the following ranges: $\delta^{13}$C = –19.4 ÷ –23.3‰; and $\delta^{15}$N = +4.6 ÷ +6.6‰ (for wolves, up to 10.1‰). Marine mammals have common values for these kinds of animals: $\delta^{13}$C = –13.7 ÷ –14.6‰; and $\delta^{15}$N = +17.4 ÷ +18.0‰. Dogs have an isotopic composition similar to humans: $\delta^{13}$C = –11.7 ±1.2‰; and $\delta^{15}$N = +12.4 ±0.4%. Judging from the published data on soft tissues of marine fish and mollusks from coastal waters of Primorye (Kharlamenko et al. 2001, 2008, 2011; Kiyashko et al. 2011), the $\delta^{13}$C values are in the range of –16.8 ÷ –20.7‰, and $\delta^{15}$N are of +9.9 ÷ +12.6‰ for fish. As for mollusks, their stable isotope values are in the following ranges: from –9.1 ÷ –11.3‰ to –17.9 ÷ –18.8‰ (for $\delta^{13}$C); and + 7.7 ÷ +9.2‰ (for $\delta^{15}$N).

When the data for the Cherepakha 13 site are plotted on the background of the available information on the paleodiet in Primorye and other regions of Northeast Asia (Figure 3), it is clear that the YC individuals consumed less marine-based protein compared to the population of the Boisman 2 site (Kuzmin et al. 2002). The cut-off values for consumption of aquatic protein are $\delta^{13}$C = –20‰, and $\delta^{15}$N =+10–12‰ (e.g. Katzenberg 2008) (see Figure 2). This is also consistent with data on the marine-based diet of coastal prehistoric and Medieval people in Northeast Asia (Japan, Korea, and Sakhalin Island; see references in Kuzmin 2015); and the mainly terrestrial diets of the Tochibara and Boji sites belonging to the Jomon of Japan (Yoneda et al. 2002, 2004), and the Chertovy Vorota site in Primorye (Kuzmin et al. 2002); for the latter two sites, the consumption of a certain amount of anadromous fish (salmon) was also suggested (Kuzmin et al. 2002; Yoneda et al. 2004; Kuzmin 2009).

Based on $\delta^{15}$N values, the Cherepakha 13 individuals are close to those of the Chertovy Vorota site, with the diet of the latter based on a mixture of terrestrial animals and anadromous fish (Kuzmin et al. 2002, 2012); however, the former is much higher in terms of $\delta^{13}$C values than the

Table 2 Stable isotope composition of animal collagen from the Cherepakha 13 site.

| Species | $\delta^{13}C$ (‰) | $\delta^{15}N$(‰) |
|---|---|---|
| | *Terrestrial animals* | |
| Elk (*Alces alces*) | –21.4 | +4.0 |
| Elk | –21.0 | +4.0 |
| Siberian roe deer | –23.4 | +4.7 |
| Siberian roe deer | –23.1 | +4.3 |
| Siberian roe deer | –23.9 | +4.6 |
| Siberian roe deer | –22.6 | +4.9 |
| Red deer | –21.5 | +4.8 |
| Red deer | –22.0 | +5.1 |
| Red deer | –21.6 | +5.0 |
| Red deer | –21.3 | +5.2 |
| Wild boar | –22.1 | +5.1 |
| Wild boar | –22.0 | +5.1 |
| Wild boar | –24.0 | +5.4 |
| Wild boar | –23.4 | +5.9 |
| Wolf (*Canis lupus*) | –19.4 | +9.6 |
| Wolf | –20.0 | +10.6 |
| Pig | –18.4 | +6.8 |
| Pig | –19.7 | +6.4 |
| Pig | –20.1 | +6.8 |
| Pig | –19.5 | +6.3 |
| Dog | –10.8 | +11.9 |
| Dog | –12.6 | +13.0 |
| Dog | –12.2 | +12.5 |
| Dog | –11.0 | +12.5 |
| Dog | –10.3 | +12.3 |
| Dog | –13.6 | +12.0 |
| | *Marine animals* | |
| Pinniped (largha seal) | –13.3 | +17.9 |
| Pinniped (largha seal) | –13.4 | +18.0 |
| Pinniped (largha seal) | –14.3 | +18.2 |
| Pinniped (Steller's sea lion) | –14.6 | +17.4 |

latter (–10.2‰ vs. –17.6‰) (see Figure 3). The $\delta^{13}C$ signatures of the Cherepakha 13 humans are also higher compared to those for the Early Iron Age and Medieval populations in the Amur River basin, with the diet based on a mixture of terrestrial animals, $C_4$ plants (domesticated millets), and $C_3$ plants (mainly wheat) (see Kuzmin 2015). While the variation of $\delta^{13}C$ values for the Amur River sites is quite large (Figure 3), from –18.5‰ to –12.4‰, the mean value is toward the lower end: –15.8 ±2.0‰. The highest value of –12.4‰ was determined for the Alekseevsy Bugor site of the Early Iron Age (also called "Paleometal," according to Russian archaeological terminology) when millet agriculture was an important part of the economy.

Millet was the first cultivated plant introduced to the Russian Far East at ca. 4600 BP, most probably from China (Kuzmin et al. 1998; Kuzmin 2013; see also Pechenkina and Oxenham 2014; Stevens and Fuller 2017); unfortunately, no skeletons of this or a similar age have been recovered and analyzed, and we can only use the materials from the adjacent regions of

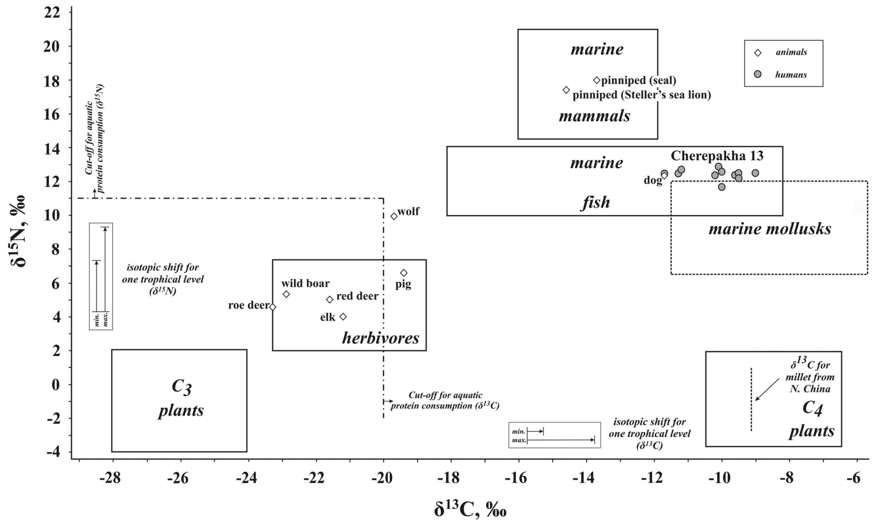


Figure 2 Composition of carbon and nitrogen stable isotopes in the bone collagen of the Cherepakha 13 site (humans and animals); boxes with ranges of the main dietary sources are from Choy and Richards (2010).

northern Asia (see Figure 3). In the Altai Mountains and the Minusinsk Depression of southern Siberia, the terrestrial-based diet gives us the $\delta^{13}C$ values of ca. –19‰ (Svyatko et al. 2013, 2017a, 2017b; Motuzaite Matuzeviciute et al. 2015, 2016). Populations of the Late Bronze Age, Late Iron Age, and the Middle Ages from the Minusinsk Basin and southern Kazakhstan, with a mixed diet consisting of terrestrial animals, $C_3$ plants, and millet, have higher $\delta^{13}C$ values of ca. –17 ÷ –15‰ (Motuzaite Matuzeviciute et al. 2015; Svyatko et al. 2017b; Ananyevskaya et al. 2018). Abundant information on the stable isotopes of a millet-based diet in mainland

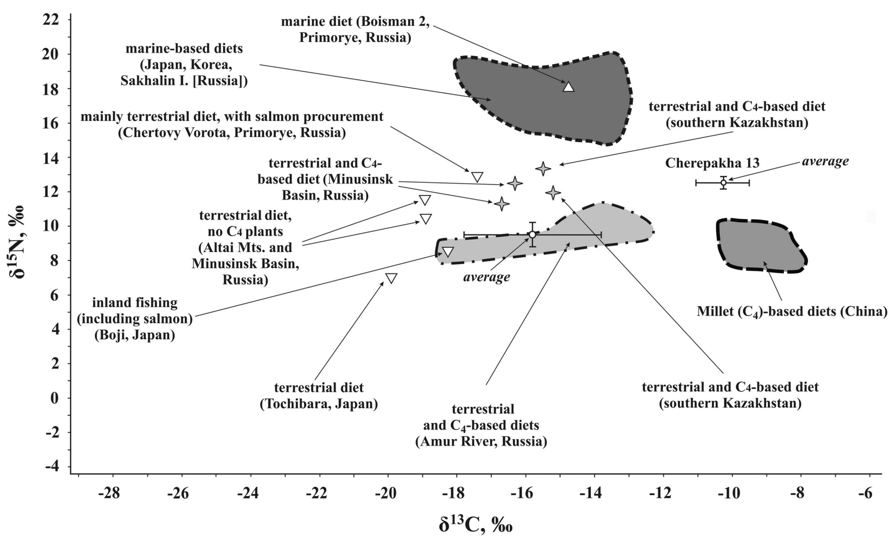


Figure 3 Comparison of carbon and nitrogen stable isotopes in the bone collagen of the Cherepakha 13 humans with isotope values for the prehistoric and Medieval populations of the Russian Far East and neighboring regions of Northeast Asia (see references in the text).

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China (e.g. Pechenkina et al. 2005; Barton et al. 2009; Liu et al. 2012; Hou et al. 2013; Lightfoot et al. 2013; Atahan et al. 2014; Ma et al. 2014; Chen et al. 2016; Ma et al. 2016; see also review: Hu 2018) shows that the $\delta^{13}C$ values for populations which relied heavily on $C_4$ plant protein are in the range of ca. –8 ÷ –10‰. The average $\delta^{13}C$ value for charred millet from Late Neolithic–Bronze Age sites in northern China is ca. –9.1‰ (Chen et al. 2017; see Figure 2). The Cherepakha 13 $\delta^{13}C$ values (average –10.2 ±0.8‰) are quite similar to those from China. When we compare the Cherepakha 13 data with information on Chinese $C_4$-dependent populations, it is quite possible that the former consumed a certain amount of millet as a source of $C_4$ protein.

The elevated $\delta^{15}N$ values for the Cherepakha 13 site inhabitants (Figure 3) can be explained by the consumption of marine-based protein (mainly from fish and mollusks); they are, however, lower than the $\delta^{15}N$ values for pure marine hunters and fishers from the coasts of Japan, Korea, and Sakhalin Island (see references in Kuzmin 2015). It can be assumed that the share of sea food resources of high trophic level (i.e., marine mammals) for the people buried at the Cherepakha 13 site was not large. If we compare it with the paleoenviromental situation at that time, ca. 3000 BP, the regression of the Sea of Japan level (e.g. Kuzmin 2002; see also Korotkii 1985) can indicate a deterioration of the maritime ecosystems and a decrease of their productivity, including the disappearance of oyster shellbeds which existed in estuaries and lagoons and were one of the main sources of food for coastal populations. This may explain why the role of marine-based protein in the subsistence of the YC population at the Cherepakha 13 site was smaller compared to the Boisman 2 site (Kuzmin et al. 2002). Nevertheless, the consumption of certain amount of marine food should be taken into account when direct $^{14}C$ dating of skeletons belonging to YC will be undertaken, as in case of other maritime-oriented prehistoric populations of the Russian Far East (see Kuzmin 2015: 577–8).

According to the data obtained and their interpretation, the main protein sources for the population of Cherepakha 13 site were the following: (1) marine mollusks, fish, and possibly mammals; (2) $C_4$ plants (domesticated millets); and (3) terrestrial animals. It is possible that consumption of a large amount of marine protein from low trophic level organisms (mollusks) alone can give humans isotopic signatures of ca. –10.2‰ ($\delta^{13}C$) and +12.4‰ ($\delta^{15}N$). More work is therefore needed to find out more precisely protein sources for the Cheerepakha 13 population, as it was done with the help of modeling using the FRUITS software (Fernandes et al. 2014). As it is known from general zooarchaeological and archaeobotanical data for YC, its economy was based on a combination of gathering marine shellfish, marine fishing, and hunting marine mammals; and terrestrial hunting and plant gathering, and animal husbandry (mainly dogs and pigs, and to some extent cattle and horses), supplemented by millet and wheat agriculture (e.g., Andreeva et al. 1986; Kuzmin 1995, 1997; Kuzmin and Rakov 2011; Gasilin 2013). Our results are in accord with these reconstructions.

## CONCLUSIONS

Using stable isotope data for the Early Iron Age individuals from the Cherepakha 13 site in southern Primorye Province, it is assumed based on direct evidence (i.e. human and animal bone collagen) that its diet consisted of at least two main sources: (1) marine mollusks, fish, and probably mammals; and (2) terrestrial animals (both wild and domestic species). The possible consumption of $C_4$ plants (domesticated millets) is also noteworthy. Marine organisms were one of the main food resources for the population of the YC, following the earlier maritime-oriented Boisman cultural complex of the Neolithic, dated to ca. 5800 BP (ca. 4700 cal BC). We have now for the first time in paleodiet studies of the Russian Far East the isotopic data for a population with a mixture of marine and terrestrial resources, and possibly $C_4$ plants. In order to find out the ratios of other food components (such as fats and carbohydrates), analysis of bioapatite in the human bones of the Cherepakha 13 site is now planned. Cherepakha 13 therefore has a high potential for in-depth studies of human subsistence in the Early Iron Age of Primorye.

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