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Abstract

This article investigates, for the first time, the diet of the Yakut population between the 15th and 19th centuries AD. Analyses of the stable isotopes of carbon and nitrogen in human and animal bone collagen were used for the study. The stable isotope values were then compared through four historical periods, three geographical areas, sexes, and socio-economic groups determined by the presence or absence of artefacts in the excavated tombs. The results highlight the variety of dietary practices among the Yakuts. There are significant differences between the North, characterised mostly by the consumption of herbivores, the Viluy region, where fish had an important role, and Central Yakutia with a diversified diet. No differences were seen between the diets of men and women. The group of elites had a stable diet based on meat and milk consumption. Samples before 1700AD had δ15N values that were higher than samples from other periods, probably due to greater consumption of fish and foal meat. These data were compared with ethnographic, historical and archaeological information so as to better depict the diet of these past populations.

Keywords

Carbon isotopes, nitrogen isotopes, Yakutia, Eastern Siberia, diet, 15th-19th centuries AD

1. Introduction

Today, archaeology uses a wide array of biological analyses to investigate the lifestyles of ancient populations. Stable isotope analyses are routinely applied for the reconstruction of past population dietary habits. Paleodietary studies using carbon and nitrogen stable isotope analyses have been conducted on populations of Siberia, in the Cis- Baikal region including the Upper Lena river (Katzenberg and Weber, 1999; Katzenberg et al., 2009, 2012; Weber et al., 2011), Southern Siberia (Murphy et al., 2013), Western Siberia (Marchenko, 2015), the Baraba forest steppe (Privat et al., 2005; Molodin et al., 2015), the Minusinsk Basin (Svyatko et al., 2013; Svyatko, 2014), and the Altai Mountains (O'Connell et al., 2003). There is however a lack of studies focusing on East Siberia, where such analyses have a potentially large field of application, due to different ecological niches and a traditional way of life that has sometimes lasted until today.

Diet reconstruction with stable isotopes is implied in the sentence "We are what we eat". In other words, there is a direct relationship between the isotopic composition of the diet and consumer tissues. For carbon isotopes, a trophic level enrichment from diet to consumer is approximately 1‰, while for nitrogen isotopes it is 3 to 6‰ (De Niro and Epstein, 1981; Schoeninger and De Niro, 1984; Bocherens and Drucker, 2003; Hedges and Reynard, 2007; O'Connell et al., 2012). The carbon isotope value (δ13C) gives information about the distinction of diet based on C3 or C4 photosynthetic plant pathways as well as marine food resources. Freshwater sources however, have a significant variability in δ13C values (Katzenberg and Weber, 1999; Katzenberg et al., 2012; Katzenberg and Waters-Rist, 2018). In addition to δ13C values, nitrogen isotope values (δ15N) reveal information about the trophic position of an individual within a localised food resource. The advantage of the stable isotope method is the precise quantitative evaluation of the diet of humans and animals. It allows for the determination of the type of environment in which the subjects lived and their main food sources: plant, fish or terrestrial animal. It does not however allow us to distinguish different types of animal protein consumed by a subject, since meat and dairy products have the same isotopic value. Our research represents the first comprehensive study of the diet of the Yakut population which, to now, has been described through ethnographic studies only. The ancestors of the Yakuts (cow and horse breeders), populated the North East of Siberia, migrating from the South in the eleventh-thirteenth centuries AD (Okladnikov, 1955; Alexeev, 1996; Fedorova et al., 2013). People (Crubezy and Nikolaeva, 2017) and cattle (Librado et al., 2015) adapted to extreme climatic conditions with winter temperatures that could reach -60°C. When Russian expansion began in Yakutia in the 1620s, Yakuts settled in the lands between the Lena, Amga and Aldan rivers (a location currently referred to as "Central Yakutia"), as well as at the mouth of Viluy river in the west, and along Yana river in the North-East (Tokarev, 1940; Okladnikov, 1955; Gogolev, 1993). Their lifestyle was considerably transformed by Russian colonisation. After 1689, and the establishment of Yakut elites, inequalities increased (Crubezy and Nikolaeva, 2017). The number of bovines and horses owned by families determined their wealth. People without livestock were called "fishermen" suggesting that the poor had a diet based on fish. An important consumption of wild plants and larch bark has also been demonstrated in ethnographic studies (Lindenau, 1983; Middendorf, 1878; Shiman'skii, 1885; Seroshevskii, 1896). Agriculture, notably cereal crops, evolved from the 18th century. Following Christianisation, which spread from the 1750s and became dominant in the majority of the population by 1855, led to the appearance of new dietary specificities. These were due to a notable increase in the prescription of religious fasts and other dietary restrictions throughout the year. Furthermore, ethnographic texts indicate that the Yakuts from Viluy had a more fish- based diet (Maak,1887; Ivanov, 2015). At the same time, burials reveal a number of animal bones and vessels with dairy products deposited as funerary meal (Crubezy and Alexeev, 2007, 2012). Geographically, the closest isotopic studies were conducted in the Baikal region on Neolithic (5800-3000 BC) and Early Bronze (3400-1700 BC) Age (Katzenberg and Weber, 1999; Katzenberg et al., 2009, 2012; Weber et al., 2011). It has been noticed that humans from Upper Lena exhibited the lowest δ13C and δ15N values, indicating a diet based on local game and fish, when compared to the Baikal region and Angara valley where high values indicate mostly fish consumption (Katzenberg and Weber, 1999; Weber et al., 2011). In summary, these studies suggest that the diet of different archaeological cultures of Siberia was fluctuating through time and space due to their adaptation to the changing environment.

The main objective of this work is to better depict the diet of the Yakut population through by comparing an isotopic tool with ethnographic and archaeological studies. The study of ethnographic and historical texts enabled us to reveal several issues: (i) The relative importance of fish versus terrestrial resources in diet; (ii) The evolution of diet over time, especially under the Russian influence; (iii) The variation in diet depending on regions, and finally, (iv) The distinction in diet depending on economic status and sex. To test these hypotheses, we investigated the diet of ancient Yakuts using carbon (δ13C) and nitrogen (δ15N) isotope analysis in 61 subjects. In order to examine possible chronological and spatial differences, samples were selected from four regions of Yakutia dating from the 15th to the 19th century AD. Social and economic distinctions were determined by means of archaeological evidence.

2. Materials and methods

The French Archaeological Mission in Oriental Siberia (MAFSO) excavated more than 150 tombs dated from the 15th to the 19th century that were well preserved by permafrost. For this study, we sampled the femur from 61 individuals (37 men, 20 women and 4 children). These originated from three large regions of cattle breeders, that are otherwise ecologically and economically very different. Central Yakutia (n=36) is a large cattle breeding zone with numerous “alas” (thermokarstic lakes surrounded by pastures) (Crubezy and Alexeev, 2012). Viluy (n=10), is very humid and is known for its abundance of fish (Maak, 1887), and Verkhoyansk and Oymyakon (n=15) are regions of North Yakutia rich in wild game where hunting continues to provide a part of the diet of current populations (Figure 1).

Apart from geographic distribution and sex, we also divided the human remains into four major chronological eras (Crubezy and Alexeev 2007, 2012; Crubezy and Nikolaeva, 2017): before 1700 AD (n=12) when the Russian influence was not yet evident in the tombs; from 1700 to 1750 AD (n=35) during the Yakut Golden Age which witnessed a lineage taking power in Yakutia (Crubezy and Nikolaeva, 2017); from 1750 to 1800 AD (n=9) after the collapse of the Golden Age notably following smallpox (Biagini et al., 2012) and tuberculosis epidemics (Dabernat et al., 2014); and after 1800 AD (n=5) with a growing Russian influence on the economy and lifestyle (Burnasheva, 2015). We also identified four socio-economic groups according to the presence and type of artefacts in the graves: graves containing no artefacts (n=16), poor burials with one to five artefacts (n=14), middle class graves with six to ten artefacts (n=22), and a group of local elites with more than ten artefacts (n=9) (Table 1). We also collected animal samples from burial grounds and completed this list with modern samples (mostly fish) (Table 2).

Pieces of 1-2 cm of human femur bone were cleaned and abraded to remove surface contaminants and then crushed into particles smaller than 1 mm. Collagen was extracted according to Longin's protocol (Longin, 1971) with modifications by Brown (Brown et al., 1988). About 500 mg samples were put in a solution of equal 5ml volumes of methanol and chloroform and ultrasonically cleaned for 15 min to eliminate lipids and humic contaminants. The samples were then rinsed with distilled water and demineralised with hydrochloric acid (5 ml of 1M HCl) for one hour in a rocking tube mixer. Once cleaned (i.e. the solution was not cloudy) the samples were put in hydrochloric acid at a low concentration (10 ml of 0.01 M HCl) and solubilised in an oven at 90°C for 17 hours. The liquid was then filtered and frozen for more than 1 hour. The samples were finally freeze-dried for 48 hours. Five mg samples of the collagen extract were weighed in tin capsules which were combusted in a Flash EA 1112

(Thermo Scientific) elemental analyser coupled in continuous flow to a Isoprime 100 (Elementar) isotope ratio mass spectrometer. Carbon and nitrogen isotope measurements were calibrated using in house standards of casein and aspartic acid, calibrated against international standards from the International Atomic Energy Agency, Vienna, Austria (IAEA-CH3, IAEA-CH6, IAEA-N1, IAEA-N2). The δ13C and δ15N values were expressed relative to VPDB and AIR respectively, and are expressed in ‰ of the deviation from the international standard using: δX = (Rsample/ Rstandard – 1) × 1000, where X is 13C or 15N and R is the isotope ratio of the sample or the standard (i.e. 13C/ 12C or 15N/14N). Isotope analyses of "outliers" showing extremely low δ15N values have been repeated several times. The collagen extraction was carried out at the Ecole Nationale Supérieure (ENS), Lyon, Geology Laboratory and the carbon and nitrogen measurements were carried out at the "Isotope Ecology" platform of the Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés (LEHNA) Laboratory, Lyon.

3. Results

3.1 Faunal samples

The δ13C recorded in the collagen of domestic and wild terrestrial mammals showed that they all occupied the same ecosystem and did not consume marine plants or C4 photosynthesis terrestrial plants. The δ13C value varied from -20.3 to -22.7‰, with a mean value of -21.6 ± 0.8 (1SD, n = 12). The highest isotopic values (δ13C = -20.3‰ and δ15N = 9.5‰) were observed in the dog which is the only omnivore (Figure 2).

The δ15N value of terrestrial herbivores ranged from 1.6‰ to 8.0‰ with a mean value of 4.5 ± 1.7 (1SD, n = 11). The horse δ15N values ranged from 3.5 ‰ to 8.0‰ with a mean value of 4.9 ± 1.4 (1SD, n = 9). The samples of hare and bovine were lower, 3.4‰ and 1.6‰ respectively. The data on terrestrial animals are similar to previous studies on the region (Figure 3). The modern dog has similar values to the prehistoric dog from Upper Lena (δ13C = -19.1‰; δ15N = 9.7‰) (Weber, 2002); and exactly the same as a Neolithic wolf (δ13C = -20.2‰; δ15N = 9.7‰) from the Baikal region (Losey et al., 2011) which indicates that its diet was based on terrestrial animals. Ordinarily, the dog is considered to feed on human leftovers. In this way its stable isotopes values can be used as indicator of a human diet from the same environment. Isotopic values for fish were very heterogeneous (Figure 2). Carbon isotopic values varied from -27.2 to -24.3‰ with a mean value of -25.9 ± 1.3 (1SD, n = 4) for river fish (dace, pike) to lake fish (carp) which ranged from -16.1 to -11.5‰ with a mean value of -14.3 ± 2.5 (1SD, n = 3) except for the carp from the Nam region (Central Yakutia) with a δ13C of -29.8‰ and δ15N of 7.5‰ close to the value of pike from the same region (δ13C = -25.6‰, δ15N = 7.9‰). The δ15N of fish is higher than that of terrestrial herbivores (Katzenberg and Weber, 1999; O'Connell et al., 2003; Shishlina et al., 2009) and varies between 7.5 and 11.6‰. Carp have δ15N values between 7.5 and 11.6‰ with a mean value of 9.6 ± 1.7 (1SD, n = 4). River fish have δ15N values between 7.9 and 9.1‰ with a mean value of 8.2 ± 0.6 (1SD, n=4). The δ15N values of archaeological fish remains from Central Yakutia (site Jarama) is significantly higher (11.6‰) than modern fish samples with an average δ15N value of 8.5 ± 0.9 (1SD, n = 7). Carbon stable isotopes values for carp are broadly in accordance with values of Baikal lake fish, and those of dace and pike match with Angara and Lena river fish values (Figure 3). In general, they show a wide range of δ13C values which is explained by the fact that pelagic (open water) and benthic (deep water) fish have lower δ13C values (about -24.6‰) than species from littoral zones (-12.9‰) (Katzenberg and Weber, 1999; Katzenberg et al., 2012). Finally, δ15N values of fish from Yakutia are lower than those presented in former studies. This can be explained by low primary productivity in Yakutia water systems (Weber, 2011).

3.2 Human samples

The δ13C values for all human bones ranged between -22.0 to -18.7‰ (Figure 2). The average was -20.4‰ ± 0.6 (1SD, n = 61) and is slightly higher than values of herbivores. It is equal to a one step change in trophic level, the average δ13C value for herbivores being -21.7‰ ± 0.7 (1SD, n = 11). Occasional consumption of freshwater resources occurs. This is shown by the high δ15N values (>9.5‰) of some individuals together with their low δ13C values, indicative of consumption of freshwater fish. The lowest human δ13C values are observed in three exceptional cases with extremely low δ15N values (Ordiogone 2: δ13C = -21.1, δ15N = 5.3‰; At Daban 7: δ13C = -21.9, δ15N = 4.4‰; Sytygane Sihe2: δ13C = -22.0, δ15N = 4.9‰). Their low δ15N value is similar to those found for the herbivore specimens analysed and attests to the importance of plants in their diet to the detriment of animal proteins. Nevertheless, we do not completely exclude the possibility of wrong identification of faunal samples as human. One old man from the Viluy region (Tungus Keul 5: δ13C = -21.3‰; δ15N =11.6‰) also has one of the lowest δ13C values but, considering its high δ15N value, this suggests a mainly fish-based diet in this case. The δ15N values for all human bones ranged between 4.4‰ to 12.9‰ (Figure 2). The δ15N value of individuals consuming mainly the meat and dairy products of terrestrial animals is estimated to be in the range of 7.5 to 9.5‰ (n = 4), while values higher than 11.2‰ can indicate a diet rich in fish (n = 23). We presume that δ15N values between 9.5 and 11.2‰ indicate a mixed diet in which fish and meat have the same importance (n = 31). Three samples noted above with significantly low δ15N values: 4.4‰, 4.9‰, and 5.3‰, two from Central Yakutia and one from Viluy, respectively (all masculine) dating from the 18th century are considered as outliers and we did not include them in comparison studies presented below.

3.3 Dietary differences between phases and regions

The variability of δ13C values is higher in Central Yakutia with a range of 2.9‰ and Viluy (where the range is 2.6‰) than in North (where the range is 1‰). This suggests that varying proportions of plant and animal food may exist in the diet typical of Central Yakutia and the Viluy river, while a more uniform diet may have been practiced in the Northern regions. The variability of δ13C values is also higher before 1700 AD (δ13C = -20.1‰ ± 0.74, 1SD, n = 12) than during 1700-1750 AD (δ13C = -20.5‰ ± 0.50, 1SD, n = 28), during 1750-1800 AD (δ13C = -20.4‰ ± 0.56, 1SD, n = 16), and after 1800 AD (δ13C = -20.6‰ ± 0.25, 1SD, n = 5). Values of δ15N are the highest in the Viluy region with a mean δ15N value of 11.7‰ ± 0.9 (1SD, n = 9). Samples from Central Yakutia show the largest range of δ15N values which vary from 9.5 to 11.9‰ (δ15N = 11.0‰ ± 0.7, 1SD, n = 34). These values indicate an important role of fish in the diet of individuals from these two regions. Lower δ15N values are found in the North (Indiguirka and Verkhoyansk) with a mean δ15N value of 10.0‰ ± 0.5 (1SD, n = 15), which indicates a diet based on meat and dairy products of terrestrial herbivores in addition to plants (Figure 2).

The comparison of the C and N stable isotope evidence for ancient Yakut with Neolithic and Early Bronze Age humans of the Cis-Baikal area shows both regional and temporal variations in diet and subsistence (Figure 3). The Yakut horse-breeder δ13C and δ15N values (δ13C= -20.4±0.5, δ15N=10.8±0.9 (1SD, n=58) indicate a meat and fish-based diet due to the light isotopic values of fish in this geographical area. They appear lighter compared to foragers of the Baikal region. The difference is significant when it comes to the Little Sea (δ13C= -18.2±3.8, δ15N=14.0±1.6 (1SD, n=101), South-western Baikal (δ13C= -16.3±0.7, δ15N=14.6±1.0 (1SD, n=62) or Angara valley (δ13C= -16.7±1.4, δ15N=13.2±1.4 (1SD, n=119) where fish and sometimes seal meat from the Baikal seem important in the diet of hunters-gatherers. In the meantime, these values are close to the foragers of Upper Lena (δ13C= -19.8±0.5, δ15N=11.0±1.1 (1SD, n=28) characterised by consumption of local fish and meat.

3.4 Dietary differences between male and female and between socio-economic groups

When comparing the diet of males and females, we did not distinguish individuals by regions and periods but included all samples from 1700 to post 1800 where both women (n=21) and men (n=25) were represented. The average of both δ15N and δ13C values were found to be exactly the same for male (δ13C = -20.4‰ ± 0.4 and δ15N = 10.8‰ ± 0.8, 1SD, n = 25) and female (δ13C = -20.4‰ ± 0.3 and δ15N = 10.8‰ ± 0.8, 1SD, n = 21) samples, highlighting similar dietary habits among genders. Pairwise comparisons of socio-economic groups do not show isotopic variations depending on social status. However, the variability of both δ15N and δ13C values of local elite group's individuals is lower than for other social groups ("elites": δ13C = -20.4‰ ± 0.1 and δ15N = 11.2‰ ± 0.5, 1SD, n = 9, "middle group": δ13C = -20.5‰ ± 0.3 and δ15N = 10.5‰ ± 0.8, 1SD, n = 20; "poor": δ13C = -20.1‰ ± 0.5 and δ15N = 11.3‰ ± 1.1, 1SD, n = 13, and tombs without material: δ13C = -20.4‰ ± 0.6 and δ15N = 10.7‰ ± 0.7, 1SD, n = 16). This suggests that they had a more stable diet than other social groups.

4. Discussion

The differences between species of herbivore animals depend on variations in the isotopic composition of the plants consumed, digestive processes and ecological factors. Generally, the isotopic data of herbivores are higher in arid than in humid zones (Ambrose, 1991; Bocherens, 1999). This is the case in Yakutia. The high δ15N values in horse samples are characteristic for young animals and can be explained by the fact that they are suckled until being slaughtered (Bocherens, 1999). Yakuts are unique horse breeders who commonly slaughter young animals at the age of eight or nine months for climatic and economic reasons, (born in March, foals grow up and gain weight until November, a month with sufficiently stable cold temperatures to keep meat outside). The difference in isotopic values between the herbivores and the dog (δ15N=5.0‰ and δ13C=1.4‰) shows an enrichment in animal protein content with one trophic level leading the dog values to be comparable to human values, suggesting a diet based mostly on terrestrial animals. Regarding aquatic resources, we propose that the important variability of δ13C and δ15N values of fish samples is due to differences in trophic sources and vegetation in lakes and rivers in Yakutia. However, the C and N isotopic signatures of fish analysed in the present study show good similarities with those of the Baikal Lake and adjacent regions (Figure 3).

The distribution of δ13C and δ15N values illustrates the variety of dietary behaviours of Yakuts. We observed the existence of different trophic/dietary zones: that of consumers of terrestrial herbivores in the North, a group in Viluy with a diet rich in fish; and a group with a diverse diet in Central Yakutia. These results are in accordance with ethnological literature (Maak, 1887; Hudiakov, 1969) that shows a more varied diet in Central Yakutia than in the two other regions. We did not identify a clear difference between men and women, however a difference between social groups is evident with a regular consumption of meat and milk for subjects associated with rich tombs compared to those associated with modest tombs. This also confirms ethnological data (Seroshevskii, 1896; Maak, 1887). High δ15N values in the earlier phase can be due to a significant consumption of fish and herbivore protein, mainly, foal meat, before the 17th century, which slowly decreased during the 18th century.

Archaeological data attests to horse breeding and consumption, and to a lesser extent, cattle breeding and hunting, while there is occasional evidence for fishing and fish consumption. Among 61 analysed tombs, 16 did not have any archaeological artefacts, while 45 included some indications of diet such as vessels and/or meat and dairy products (Figure 4). The tombs did not contain any fish remains, probably for the reason that fish was not considered to be honorific as being a part funeral meal. The crucian carp bones investigated for this work come from the Jarama site where a few fish bones were discovered outside of the coffins of three child tombs. Funeral meals in analysed human tombs consists mostly of meat remains (38/45), and sometimes were associated with dairy products (12 cases). Milk product is rarely deposited by itself (3/45), nevertheless numerous vessels present in almost all tombs with artefacts (43/45) could initially have contained milk. Comparing our results tomb by tomb with archaeological data, we noted certain points: the Taralay subject, prior to 1700 AD, has one the highest δ15N value (12.7‰) which indicates a fish-based diet. This was the only tomb in which we found a fishing tool among funerary artefacts (a larch pick-axe used to break the ice for fishing during winter) (Figure 5).

Three subjects had an extremely low δ15N value, comparable to that of terrestrial herbivores. This defines that, at least during the last 8 years of their life (a timespan considered to affect the isotopic value), they had a dominantly vegetarian diet. In the tombs of these three subjects, however, the remains of funerary meals contained dairy and horse meat. Among these three subjects, two older men had lost almost all their teeth before death, which might indicate a soft vegetarian diet rather than a meat-based diet. Physiological effects such as starvation, and inversely overconsumption may also influence δ15N values (Hedges and Reynard, 2007; Balter et al., 2006). Multiple ethnographical and historical sources attest to the importance of plants and larch bark's flour in the diet of the Yakuts, in particular for poor people. There may have been a possibility of mis-identification of samples. New sampling of the specified burials will therefore have to be conducted.

5. Conclusions

The diet of Yakut population from 15th to 19th centuries appears relatively homogeneous according to ethnographic data. However, δ13C and δ15N values demonstrate a clear distinction between different geographical areas of Yakutia. We also documented variations in dietary habits related to social status. Men and women had the same type of diet. These results are correlated with ethnographical and historical evidences. We noticed considerable variation in δ15N values for terrestrial animals while δ13C turned out to be a less significant variable. We found that the N isotope composition of suckling horses was notably elevated. We also confirmed the existence of wide variation in δ13C and δ15N among fish from rivers and lakes. This indicates that the high δ15N values measured in humans could be explained not solely by an intake of freshwater fish, but also by the consumption of young animals, especially foals. In this context, it would be interesting to analyse the isotopes of sulphur and strontium/calcium and barium/calcium ratios (Balter et al., 2001; Balter and Simon, 2006) to distinguish the consumption of freshwater fish and terrestrial animals (Privat et al., 2007).

Captions for figures and tables

Figure 1. Localisation of the studied areas

Figure 2. Carbon and nitrogen isotopic results of the study. The close-up is given for humans.

Figure 3. Carbon and nitrogen isotopic results of the present study in the context of available isotopic data of the Baikal Lake and adjacent areas. Data are from Katzenberg and Weber, 1999; Katzenberg et al., 2009; Katzenberg et al., 2012; Weber et al., 2011.

Figure 4. The ribs of the horse and the ritual cup tchoron with the dairy product in the tomb Kerdugen, 1700-1750 AD

Figure 5. Fishing tool in the tomb Taralay, Central Yakutia, before 1700

Table 1. Carbon and nitrogen isotopic results for human samples. Isotope values are expressed in per mil. The social status is determined by number of artefacts: ○ – no material ● – poor (1 to 5 artefacts). ●● – middle (6 to 10 artefacts). ●●● – rich (more than 10 artefacts).

Table 2. Carbon and nitrogen isotopic results for animal samples. Isotope values are expressed in per mil

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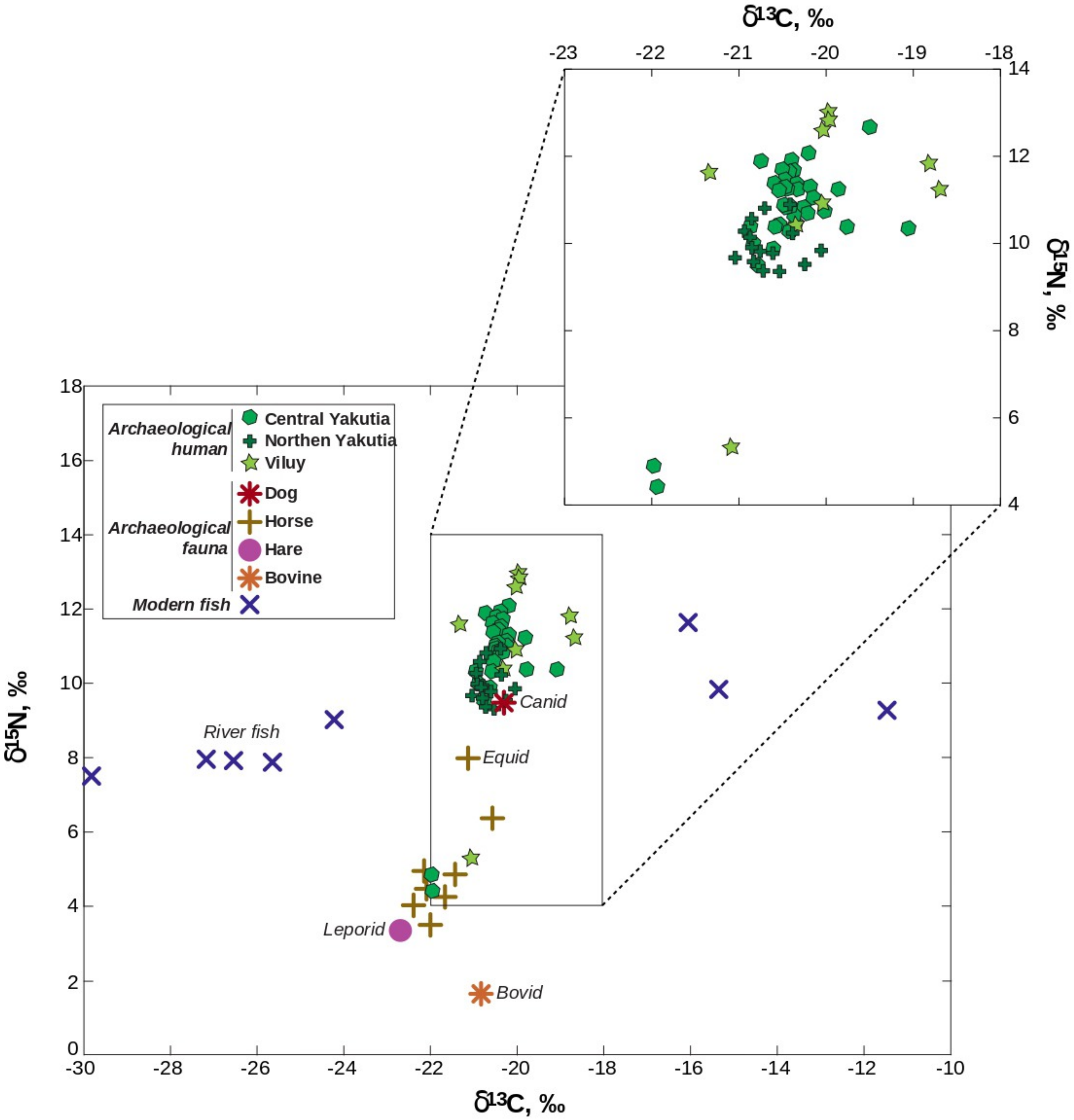
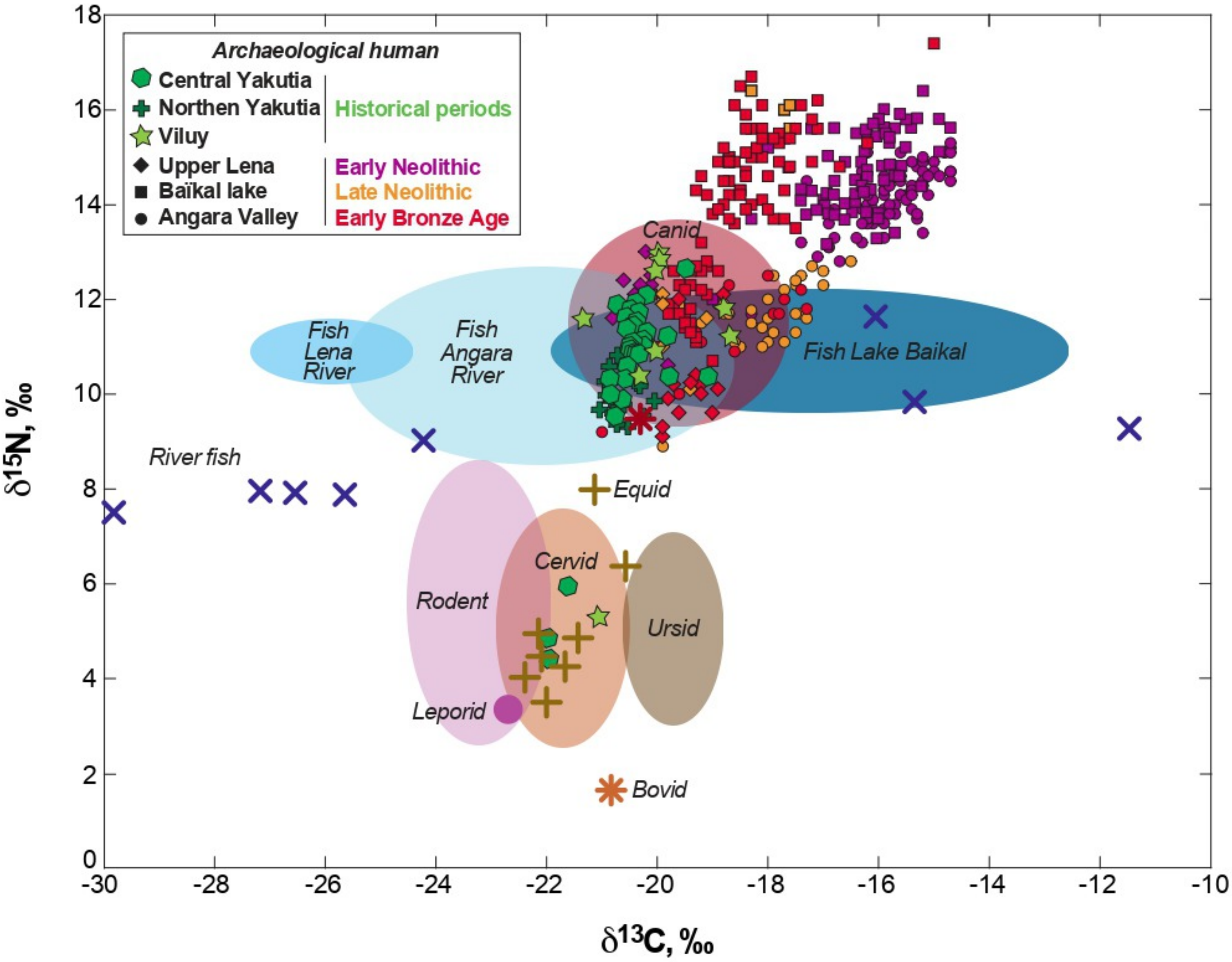
ARCTIC OCEAN
SWEDEN
FINLAND
Moscow
RUSSIAN FEDERATION
YAKUTIA
KAZAKHSTAN
MONGOLIA
CHINA
Olenyok
Yana
Indigirka
Verkoyansk
Oymyakon
Lena
Vilyuy
Yakutsk
Central Yakutia
Vilyuy
Aldan
Lena
100 km



δ13C, ‰
δ15N, ‰
Archaeological human
Central Yakutia
Northen Yakutia
Viluy
Archaeological fauna
Dog
Horse
Hare
Bovine
Modern fish
River fish
Canid
Equid
Leporid
Bovid



Archaeological human
Central Yakutia
Northen Yakutia
Viluy
Historical periods
Upper Lena
Baïkal lake
Angara Valley
Early Neolithic
Late Neolithic
Early Bronze Age
Canid
Fish Lena River
Fish Angara River
Fish Lake Baikal
River fish
Equid
Cervid
Rodent
Ursid
Leporid
Bovid
δ15N, ‰
δ13C, ‰


YAKOUTIE 2011
KERDUGEN 1


TARALAI 1


TARALAI 1
10 cm

Species	Site	Region	$\delta^{13}C$	$\delta^{15}N$	Elemental composition %C	Elemental composition %N	C/N
Archaeological							
Horse *(Equus ferus caballus)*	Ordiogone 2	Viluy	-21.4	4.9	42.3	15.1	2.8
Horse *(Equus ferus caballus)*	Ordiogone 1	Viluy	-22.0	3.5	40.1	15.0	2.7
Horse *(Equus ferus caballus)*	Tungus keul 4	Viluy	-22.1	4.5	42.6	15.5	2.7
Horse *(Equus ferus caballus)*	Oyogosse tumula	Viluy	-21.1	8.0	41.2	15.1	2.7
Horse *(Equus ferus caballus)*	Ordiogone 1	Viluy	-21.7	4.2	42.6	15.7	2.7
Horse *(Equus ferus caballus)*	Celyysse	Viluy	-22.4	4.0	42.5	15.5	2.7
Horse *(Equus ferus caballus)*	Okhtoubout 2	Central Yakutia	-20.6	6.4	39.3	14.4	2.7
Horse *(Equus ferus caballus)*	Bakhtakh 2	Verkhoyansk	-22.2	4.9	42.6	15.6	2.7
Bovine *(Bos taurus)*	Isting tumula	Viluy	-20.8	1.6	42.8	15.5	2.8
Hare *(Lepus timidus)*	Dakky kuola	Viluy	-22.7	3.4	39.6	14.5	2.7
Carp *(Carassius carassius)*	Jarama	Central Yakutia	-16.1	11.6	39.5	15.4	2.6
Modern							
Dog *(Canis familiaris)*	Ordiogone	Viluy	-20.3	9.5	38.1	14.0	2.7
Carp *(Carassius carassius)*	Nam	Central Yakutia	-29.8	7.5	38.3	14.1	2.7
Carp *(Carassius carassius)*	Kobiaï	Central Yakutia	-15.4	9.8	38.9	14.9	2.6
Carp *(Carassius carassius)*	Amga	Central Yakutia	-11.5	9.3	42.8	14.7	2.9
Dace *(Leuciscus leuciscus)*	Pokrovsk	Central Yakutia	-27.2	8.0	44.4	14.7	3.0
Dace *(Leuciscus leuciscus)*	Pokrovsk	Central Yakutia	-26.6	7.9	44.4	14.8	3.0
Dace *(Leuciscus leuciscus)*	Pokrovsk	Central Yakutia	-24.3	9.1	37.3	13.9	2.7
Pike *(Esox lucius)*	Nam	Central Yakutia	-25.6	7.9	42.9	14.1	3.0

Site	N of burial	Region	Sex	Social status	$\delta^{13}C$	$\delta^{15}N$	Elemental composition %C	Elemental composition %N	C/N
Phase 1 : Before 1700									
Boyola	1	Central Yakutia	♂	●●	-20.8	9.5	41.5	15.1	2.7
Djoussoulen	1	Central Yakutia	♂	●●	-20.6	9.9	39.5	14.3	2.8
At daban	4	Central Yakutia	♂	○	-19.1	10.4	42.3	15.6	2.7
Oulakh	2	Central Yakutia	♂	●	-20.0	10.7	40.9	15.1	2.7
Tyyt bappyt	1	Central Yakutia	♂	●●	-20.4	10.9	41.1	15.0	2.7
Bouogaryma	1	Central Yakutia	♂	○	-20.3	11.2	42.8	15.5	2.8
Lampa	1	Central Yakutia	♂	●	-20.2	12.1	40.5	14.6	2.8
Taralai	1	Central Yakutia	♂	●	-19.5	12.7	43.3	15.7	2.7
Kureleekh	1	North (Verkhoyansk)	♂	●●	-20.1	9.8	36.8	13.4	2.7
Tungus keul	5	Viluy	♂	○	-21.3	11.6	37.7	13.8	2.7
Oyogosse tumula	1	Viluy	♂	●	-18.8	11.8	40.1	14.7	2.7
Tympy	1	Viluy	♂	●	-20.0	12.9	43.2	15.8	2.7
Phase 2 : 1700-1750									
Istekh myran	2	Central Yakutia	♀	●	-20.8	10.0	40.8	14.9	2.7
At daban	8	Central Yakutia	♀	●	-19.8	10.4	41.7	15.4	2.7
Boyola	2	Central Yakutia	♀	○	-20.5	10.4	28.8	10.3	2.8
Odjulun	2	Central Yakutia	♀	●●	-20.4	10.7	41.9	15.4	2.7
At daban	6	Central Yakutia	♀	●●●	-20.2	10.8	40.7	15.1	2.7
Okhtoubout	2	Central Yakutia	♀	●	-20.5	11.2	34.1	12.4	2.7
Tchotchour	1	Central Yakutia	♀	●	-19.9	11.2	40.2	14.8	2.7
Eletchei	1	Central Yakutia	♀	●●●	-20.5	11.3	41.6	15.1	2.7
Bere	1	Central Yakutia	♀	●●	-20.5	11.3	44.6	16.1	2.8
Istekh myran	1	Central Yakutia	♀	○	-20.6	11.4	37.6	13.7	2.7
Arbre chamanique	1.2	Central Yakutia	♀	●●●	-20.4	11.6	30.1	10.9	2.8
Sordonokh	1	North (Verkhoyansk)	♀	●●	-20.6	9.8	40.2	14.6	2.7
Kureleekh	2	North (Verkhoyansk)	♀	●●	-20.9	10.1	35.1	12.2	2.9
Tysarastaakh	2	North (Verkhoyansk)	♀	●●	-20.4	10.2	35.6	12.9	2.7
Boulgounniakh	2	Viluy	♀	●●	-20.0	10.9	36.6	13.4	2.7
At daban	7	Central Yakutia	♂	●	-21.9	4.4	40.7	15.1	2.7
Sytygane sihe	2	Central Yakutia	♂	●●	-22.0	4.9	41.7	15.4	2.7
Sytygane sihe	1	Central Yakutia	♂	○	-20.4	10.3	42.5	15.5	2.7
Sytygane sihe	3	Central Yakutia	♂	○	-20.6	10.4	42.6	15.3	2.8
Oktiom	1.1	Central Yakutia	♂	●●	-20.3	10.4	41.1	15.1	2.7
Oulakh	5	Central Yakutia	♂	●●	-20.2	10.7	41.0	15.1	2.7
Kous tcharbyt	1	Central Yakutia	♂	●●●	-20.5	10.8	42.2	15.4	2.7
Oulakh	4	Central Yakutia	♂	●●	-20.1	11.0	40.1	14.7	2.7
Sette toumoul	1	Central Yakutia	♂	●●	-20.2	11.3	42.6	15.5	2.7
Urun myran	1	Central Yakutia	♂	●●	-20.4	11.7	42.6	15.5	2.7
Oulakhan alaas	1	Central Yakutia	♂	●●●	-20.5	11.7	58.4	21.4	2.7
Sola	2	Central Yakutia	♂	●●●	-20.4	11.9	35.5	13.1	2.7
Atyyr meite	1	North (Verkhoyansk)	♂	●●	-20.8	9.6	36.1	13.1	2.7
Kerdugen	1	North (Verkhoyansk)	♂	●●	-21.1	9.7	39.7	14.5	2.7
Bakhtakh	3	North (Verkhoyansk)	♂	●●	-20.8	9.8	42.9	15.8	2.7
Alyy	1	North (Verkhoyansk)	♂	●●	-20.9	10.6	43.9	15.9	2.8
Boulgounniakh	1	Viluy	♂	●●●	-20.3	10.4	39.0	14.2	2.7
Atakh	1	Viluy	♂	○	-18.7	11.2	41.8	15.2	2.7
Ordiogone	1	Viluy	♂	●●●	-20.5	11.2	43.9	15.5	2.8
Célyssé	1	Viluy	♂	●●	-20.0	12.6	32.8	11.9	2.7
Phase 3 : 1750-1800									
Us sergué	1	Central Yakutia	♀	●●●	-20.5	10.8	41.4	15.2	2.7
Lepsei	2	North (Verkhoyansk)	♀	○	-20.7	9.4	41.4	15.2	2.7
Lepsei	1	North (Verkhoyansk)	♀	○	-20.8	9.9	43.2	15.8	2.7
Isting tumula	1	Viluy	♀	●	-20.0	12.8	40.1	14.6	2.7
Bekh alaas	4	Central Yakutia	♂	○	-20.3	11.3	35.2	12.8	2.7
Tomtor	1	North (Oymiakon)	♂	○	-20.7	10.8	39.2	14.0	2.8
Kouranakh	1	North (Verkhoyansk)	♂	●	-20.5	9.3	40.4	14.8	2.7
Buguyekh	3	North (Verkhoyansk)	♂	●	-20.9	10.3	42.4	15.5	2.7
Ordiogone	2	Viluy	♂	●●	-21.1	5.3	43.5	16.0	2.7
Phase 4 : After 1800									
At daban	9	Central Yakutia	♀	●	-20.5	11.4	40.9	15.0	2.7
Tomtor	2	North (Oymiakon)	♂	○	-20.3	9.5	35.9	13.1	2.7
Balaganakh	3	North (Oymiakon)	♂	○	-20.4	10.9	40.3	14.7	2.7
Ken ebe	8	Central Yakutia	♀	○	-20.9	10.4	42.7	15.6	2.7
Toutekh	1	Central Yakutia	♂	○	-20.7	11.9	32.1	11.6	2.8

Carbon and nitrogen isotopic results for human samples. Isotope values are expressed in per mil. The social status is determined by number of artefacts: ○ – no material ● – poor (1 to 5 artefacts). ●● – middle (6 to 10 artefacts). ●●● – rich (more than 10 a rtefacts).