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BUILDERS AND USERS OF RITUAL CENTRES,
YAMPIL BARROW COMPLEX:
STUDIES OF DIET BASED ON STABLE CARBON
AND NITROGEN ISOTOPE COMPOSITION

ABSTRACT

The paper presents $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope content measurements in human bones from 16 graves, being part of the *Yampil Barrow Complex*. From the results, conclusions may be drawn about the diet of barrow builders and users. It was based on vegetable foodstuffs and characterised by a varied share of terrestrial animal meat, depending on the period. High $\delta^{13}\text{C}$ values suggest a share of C4-type plants in the diet, possibly millet.

Key words: paleodiet, stable carbon and nitrogen isotopes, barrows, Eneolithic, Early Bronze Age, Middle Dniester

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Nutrition strategies of populations identified with the ‘barrow cultures’ of the Northern Pontic Area of the 4th-2nd millennium BC have not been satisfactorily explored, as far as their adaptation picture is concerned, due to two major research limitations. First and foremost, this concerns the clear domination of archaeometric funeral sources in the body of research data, which is true, by the way, for the analytical studies all ‘grave cultures’. The first limitation is worsened by regionally recurrent limitations in the palynological examination of hypothetical economic penetration zones [for the *Yampil Barrow Complex* see Makohonienko, Hildebrandt-Radke 2014].

The selection of ‘terrestrial’ (vegetable or animal) foodstuffs and others procured by exploiting water reservoirs by ‘barrow communities’ both Late Eneolithic ones, for instance, the Tripolye culture – Gordinești group (TC-G), and Early Bronze ones – the Yamnaya culture (YC), Catacomb culture (CC), Babyno culture (BC) and Noua culture (NC), recorded in the course of the *Yampil Investigation Programme*, has already been reported on and appraised by presenting osteological data and discussed as part of preliminary consolidation treatments sketched against the broader research space of ‘Pontic Archaeology’ [Koško *et al.* (Ed.) 2014; Harat *et al.* 2014; Koško (Ed.) 2015].

The present article focuses on a relatively new – known since the 1980s – method of reconstructing the diet of the deceased by determining the composition of stable carbon and nitrogen isotopes in human bones. The analytical material for this article has come from the chronometric programme completed as part of the *Yampil Investigation Programme* in 2011-2016 [Goslar *et al.* 2014; 2015]. An important motive to take up this study was the necessity to confirm/exclude the reservoir effect that could distort the ^{14}C dating of bones. Possible distortions are produced by the share of foodstuffs coming from water reservoirs in the diet.

In the pursued research programme, the set of ‘isotope data’ is going to be discussed against broader identification contexts: (a) archaeological-anthropological ones on the *Yampil Barrow Complex* (YBC) scale (sections 2-4), and (b) archaeological, archaeozoological and historical-ethnographical ones viewed against the broad comparative background of the ‘nomadic societies’ of the Northern Pontic steppe/forest-steppe (sections 5-7).

a. Archaeologically speaking, the investigated burials can be divided into two groups: the *graves of builders* of ritual centres (= barrows and their clusters) and the *graves of users*, i.e. persons buried in or on the mounds of the barrows (= mounds encountered in the cultural landscape, being carriers of certain thanatological or rather mythological beliefs). The communities of builders, in the light of YBC identifications, comprise Eneolithic taxa (or, in more accurate versions, TC-G communities) and others from the transition period of the Eneolithic and Bronze Ages (Eneolithic-‘Pre-Yamnaya’ = EN/YC) and of the early YC. The communities of users, in turn, were found to include the populations of the developed YC, CC, BC and NC.

The archaeological contexts mentioned above were broadened by adding anthropological data on sex (including corrections using the DNA method) and age [Litvinova *et al.* 2015].

b. The interpretation of the results of isotope, botanical and archaeozoological studies, describing the potential subsistence means of the nomadic populations under discussion, is consistent with the living they could make out of the soils formed on 'the substratum of typical *chernozem*, exhibiting characteristics found in the transition zone of the subboreal belt and having a temperate climate with marked continental characteristics and steppe vegetation' [Bednarek, Jankowski 2014].

1. STABLE CARBON AND NITROGEN ISOTOPES IN LIVING ORGANISM TISSUES

Since the early 1980s, the measurements of ratios of stable isotopes of carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$) in bone collagen have been a useful source of information on the diet of examined individuals, in particular with respect to its protein component [Ambrose 1993; Richards, Hedges 1999; Olsen *et al.* 2010]. The ratio of stable carbon isotopes (expressed as $\delta^{13}\text{C}$) is particularly useful in determining the proportion of sea-origin to land-origin diet. This is a result of a very different carbon isotope composition of atmospheric CO_2 ($\delta^{13}\text{C}$ – approx. 7‰) and marine carbon HCO_3 ($\delta^{13}\text{C}$ – approx. 0‰). However, $\delta^{13}\text{C}$ is not very helpful in differentiating between a diet originating on land and that coming from freshwater, because the isotopic composition is often similar in both environments. In the group of foodstuffs originating on land, it is relatively easy to distinguish between plants photosynthesizing according to the so-called C_3 cycle and a smaller group of plants of the C_4 type (such as millet, maize, sugar cane or sorghum), because the $\delta^{13}\text{C}$ value ranges of these plant groups (from -20‰ to -35‰ for C_3 plants and from -9‰ to -14‰ for C_4 plants) are completely disjoint [Katzenberg 2000].

The nitrogen isotopic composition, in turn, mainly reflects the place of a consumer in the food (trophic) chain, because $\delta^{15}\text{N}$ of the tissues of a higher-order consumer is markedly higher than that of eaten foodstuffs (producer or lower-order consumer). The difference between the values of $\delta^{15}\text{N}$ of a consumer and foodstuff, amounting to 3-5‰ [Drucker, Bocherens 2004], usually about 3.5‰ [Richards, Hedges 1999], follows mainly from the preferential degradation (and excretion with urine) of compounds containing a lighter nitrogen isotope ^{14}N [Schoeninger, DeNiro 1984]. For this reason, $\delta^{15}\text{N}$ of predators is as a rule higher than that of herbivores. Moreover, since the food chains in an aquatic environment are longer than those in a terrestrial environment, aquatic organisms (marine or freshwater) usually

have $\delta^{15}\text{N}$ markedly higher than that of terrestrial organisms. Whereas, the length of a food chain is poorly reflected in $\delta^{13}\text{C}$ values, because $\delta^{13}\text{C}$ of a consumer is, admittedly, sometimes 5‰ higher than that of eaten plants, but only 1‰ higher than $\delta^{13}\text{C}$ of eaten animals [DeNiro, Epstein 1978; Van der Merwe, Vogel 1978].

The measurements of the composition of stable carbon and nitrogen isotopes have been often used in relation to the radiocarbon dating of human and animal remains, the ^{14}C ages of which could be distorted by the reservoir effect [Cook *et al.* 2001; Eriksson 2004; Olsen *et al.* 2010; Shishlina *et al.* 2009; 2014], provided that the share of aquatic-origin foodstuffs (fish, molluscs) in their diet was considerable. Even more often, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements are used in the studies of the diet of our ancestors, independently of its impact on ^{14}C dating. For instance, in Poland, such studies were conducted, regarding human and animal bones from the medieval cemetery in Giecz [Reitsema *et al.* 2010] or the Przeworsk culture cemetery in Karczyn [Pospieszny, Bełka 2015]. In both cases, it was concluded that the individuals in question subsisted mainly (or exclusively) on terrestrial-origin foodstuffs ($\delta^{15}\text{N}$ of 8-10‰), while the diet of men was richer in meat than that of women ($\delta^{15}\text{N}$ of the collagen of men's bones was on average 1‰ higher than $\delta^{15}\text{N}$ of women's bones).

The carbon and nitrogen isotopic composition in examined bones is usually hard to interpret due to its high variability caused by many additional factors, even when there were no aquatic organisms in the food chain. For instance, $\delta^{13}\text{C}$ of plants growing in open spaces is usually higher than $\delta^{13}\text{C}$ of those growing in a forest environment, where CO_2 produced by breathing plants locally influences the carbon isotopic composition of CO_2 available for photosynthesis [Drucker *et al.* 2008; Reitsema *et al.* 2013] and where there is less light available [Farquhar *et al.* 1982]. Furthermore, the composition of carbon and nitrogen isotopes (in plants, and the tissues of people and animals eating them) depends on the intensity of fertilization of fields and pastures [Bogaard *et al.* 2007]. The complexity of factors determining the isotopic composition of nitrogen and carbon in human and animal tissues makes the values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ differ greatly between individuals. For this reason, any conclusions about the dietary customs of a given community usually require examining a large number of individuals and taking a statistical approach.

The isotopic composition of carbon and nitrogen depends also on the climate. The mechanisms of this interdependence are known rather well in the case of carbon so much so that the studies of $\delta^{13}\text{C}$ of plant remains serve the purpose of quantitative palaeoclimatic reconstructions [McCarroll, Loader 2004; Loader *et al.* 2013]. In contrast, a clear regional differentiation of the isotopic composition of nitrogen seems to be related to the correlation between $\delta^{15}\text{N}$ and the precipitation total, but the mechanism of this correlation is not completely clear.

The studies of isotopic composition of nitrogen in animal tissues from South Africa [Heaton *et al.* 1986] and Kenya [Ambrose, DeNiro 1986] show that the

values of $\delta^{15}\text{N}$ have a very broad range (from 2‰ with the annual precipitation of about 1,000 mm to 12‰ with the annual precipitation of about 100 mm). Schwarcz *et al.* [1999] showed that under extremely dry climatic conditions, $\delta^{15}\text{N}$ of plants, animals and people (whose diet comprised foodstuffs of exclusively terrestrial origin) might reach 14, 16 and 18‰, respectively, and observed that the value of $\delta^{15}\text{N}$ was not directly dependent on the availability of drinking water (thus, it is not dependent on mainly physiological factors). As the mechanism of observed relationships, he suggested the precipitation-dependent volatilization of ammonia enriched by a lighter nitrogen isotope (^{14}N) and its production by bacteria in soil. Whatever the mechanism is, the difference in the value of $\delta^{15}\text{N}$ of animals feeding on the same food may be many times higher than the difference between $\delta^{15}\text{N}$ of a consumer and food as well as the difference between $\delta^{15}\text{N}$ of aquatic and terrestrial organisms from the same region. This makes it highly desirable, when drawing conclusions on the diet of humans in the remains of which the isotopic composition of nitrogen is studied, to determine $\delta^{15}\text{N}$ of the animals that at the same time and in the same region fed on food of terrestrial origin (herbivores and carnivores) as well as of aquatic animals.

2. MEASUREMENTS OF $\delta^{13}\text{C}$ AND $\delta^{15}\text{N}$ IN HUMAN BONES FROM THE YBC

The study comprised 16 results (Tab. 1) of analyses of human bones from ritual centres in Pidlisivka, site 1, Porohy, site 3A, Klembivka, site 1, and Prydnistryanske, site 1, situated in Yampil Region, Vinnytsia *Oblast*, on the left bank of the Middle Dniester [Klochko *et al.* 2015; 2015a; 2015b; 2015c].

The composition of the stable isotopes of carbon and nitrogen was studied in collagen extracted from certain bones ^{14}C dated in the Poznań Radiocarbon Laboratory [Goslar *et al.* 2014; 2015]. Collagen extracted from the bones [Longin 1971; Piotrowska, Goslar 2002] was subjected to ultrafiltration on the Vivaspin 15 MWCO 30 kD filters [Bronk Ramsey *et al.* 2004]. The measure of the quality of collagen obtained in this manner was the extraction yield (determined as the ratio of obtained collagen to original bone mass) and the ratio of C/N in the collagen measured with a Thermo Flash EA 1112 analyzer. The measurements of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were made in the Laboratory of Isotope Dating and Environmental Research, PAN Institute of Geological Sciences, Warsaw, Poland, using a Thermo Flash 1112 HT analyzer coupled with a Thermo Delta V Advantage mass spectrometer. To calibrate the instrument, USGS 40, USGS 41 and IAEA 600 standards were used. The standard uncertainty of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ was 0.33‰ and 0.43‰, respectively.

Table 1

Results of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ analyses of human bones from the Yampil Barrow Complex. Archaeological dates are based on source publication [Klochko *et al.* 2015; 2015a; 2015b; 2015c] allowing for sex determination corrections relying on DNA analyses [Chyleński *et al.* 2017]

Taxon – Feature Sex – Age	Sample no.	^{14}C Age	% coll	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
<i>Pidlisivka 1</i> builders: late 4th – 3rd millennia BC (EN – EN/YC)					
No data					
<i>Pidlisivka 1</i> users: 2800-2700 BC (YC); 2850-2600 BC (CC?); 1850-1700 BC (BC)					
YC – 1A ?/Male – 7-8 years/30-40 years	Poz-38529 Poz-39214	4195±35 4080±40	??	-19.3	10.6
CC? – 7 Male – 25-30 years	Poz-38531	4120±35	??	-18.9	11.3
BC – 5 Male – 30-35 years	Poz-38530	3430±35	??	-19.5	11.2
<i>Porohy 3A</i> builders: late 4th –early 3rd millennia BC (Eneolithic/YC?)					
No data					
<i>Porohy 3A</i> users: 2760-2515 BC(YC); 1713-1464 BC (NC)					
YC – 11 Male – 25-30 years	Poz-47741	4075±35	1.1	-19.1	10.3
YC – 17 Male – 30-35 years	Poz-47743	4050±35	1.0	-19.4	11.4
YC – 20 Male – 50-55 skeleton 1	Poz-47744	4190±35	1.4	-19.2	10.9
<i>Klembivka 1</i> builders: 3005-2720 BC(EN – EN/YC)					
EN/YC – 14 Male – 25-30 years	Poz-52605	4135±35	1.9	-18.8	8.9
<i>Klembivka 1</i> users: 19th–18th BC (BC);15th–14th BC (NC)					
No data					
<i>Prydnistryanske 1</i> builders: 3350-3150 BC (KT-H); 3100/3000-2550 BC (YC)					
TC-G – III/1 ? – 20+ years	Poz- 66224	4540±35	11.8	-18.4	9.0
TC-G – III/2 20+ years	Poz-66225	4530±35	14.0	-18.6	9.3
TC-G – IV/10 ? – 20 years (adultus)	Poz- 66234	4520±40	7.4	-18.8	8.9
YC – V/4 Male – 35-50 years (adultus' matusus)	Poz-66230	4455±35	1.5	-18.0	10.3
YC – IV/3 ? – 40+ years (matusus'senilis)	Poz-66228	4090±35	4.6	-18.7	9.2
YC – IV/8 Male – 35-50 (matusus)	Poz-66232	4090±35	9,0	-17.9	9.4
YC – IV/9 Male – 25-35 (adultus)	Poz-66233	4120±35	8,0	-18.1	8.2
<i>Prydnistryanske 1</i> users: CC 2700–2400 BC; EŽ = AD					
CC – I/4 skeleton W = 2 [BPS 20: 192=1] Male – 35-50 years	Poz-66219	4070±35	13.6	-18.3	8.4
CC- I/4 skeleton E – 1 [BPS 20: 192=2] Female – 15 years	Poz-66220 Poz-66732	3940±40 3940±35	11.0	-18.2	10.9



Fig. 1. Regions of origin of individuals whose isotopic composition of carbon and nitrogen is discussed in the text

3. INTERPRETATION OF RESULTS

The interpretation of the isotopic composition of carbon and nitrogen in human bones could concentrate on the general determination of the share of foodstuffs of aquatic origin in the diet of the deceased individuals, the aspect of diet differentiation depending on sex and age, the role of diet in the development of ritual centres (builders→users), and diet changes in time. In most of these aspects, a serious hindrance to interpretation is the unavailability of comparative material, if only herbivorous animal bones from the region and period under investigation.

How important it is to study suitable comparative material is shown in Fig. 2, giving the isotopic composition of human and animal bones. The data come from European regions lying to the west, east and south of the Yampil Region (Fig. 1). What can be clearly seen in Fig. 2 is the geographical differentiation of the $\delta^{15}\text{N}$ values of herbivores, with the lowest values (2-7‰) occurring in Denmark and the highest (4-13‰) on the Caspian Steppes. In between lie the values of $\delta^{15}\text{N}$ from Gotland (2-8‰), Schwerin (4-7‰), Kaldus (4-8‰), Giecz (6-7‰), Iron Gates (5-10‰) and the Northern Pontic Area (4-10‰). The mean value of $\delta^{15}\text{N}$ tends to grow, moving from the west to the east. If there is any relationship between $\delta^{15}\text{N}$ and the amount of precipitation (decreasing as one moves from the areas of mari-

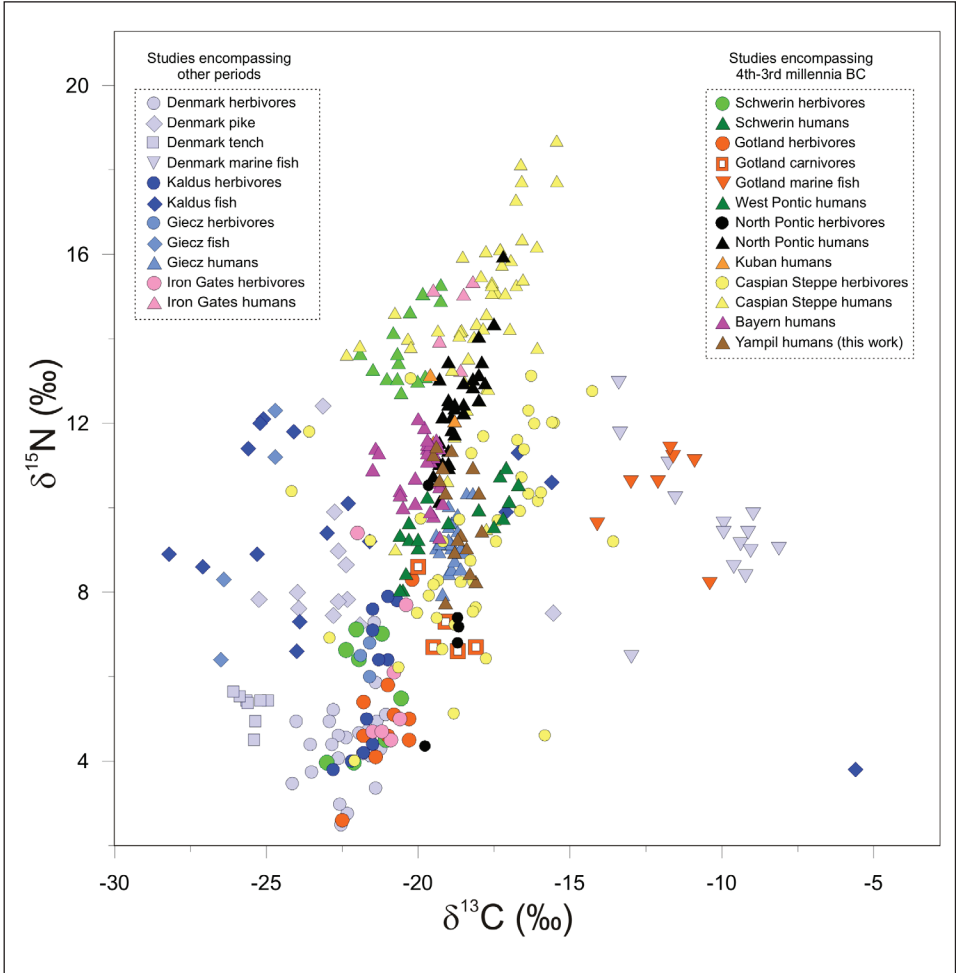


Fig. 2. Composition of stable carbon and nitrogen isotopes in bone collagen from the Yampil Barrow Complex against the background of bone analysis results from selected regions of Europe (Fig. 1). Data from various regions and source publications are colour coded: Denmark – Mesolithic/Eneolithic [Fischer *et al.* 2007], Kaldus – 1200-1300 AD [Reitsema *et al.* 2013], Giecz – 1000-1200 AD [Reitsema *et al.* 2010], Iron Gates – 6200-5500 BC [Cook *et al.* 2001], Schwerin/Ostorf – 3800-2800 BC [Olsen *et al.* 2010], Gotland – 2900-2600 BC [Eriksson 2004], West Pontic, North Pontic, Kuban – ca. 4000-2000 BC [Gerling 2015], Caspian Steppes – 4300-2000 BC [Shishlina *et al.* 2009; 2014], Bayern – 2700-2400 BC [Sjögren *et al.* 2015]. Symbols distinguish data for the bones of terrestrial herbivores, carnivores, freshwater fish, sea fish, and humans. In the group of freshwater fish, tench is distinguished

time to continental climate), similar to that exposed in the study of African organisms [Heaton *et al.* 1986; Schwarcz *et al.* 1999], cannot be said beyond doubt, but such a relationship cannot be ruled out either.

3.1. DIET SHARE OF FOODSTUFFS ORIGINATING FROM AN AQUATIC ENVIRONMENT

Fig. 2 illustrates differences between $\delta^{15}\text{N}$ - $\delta^{13}\text{C}$ of terrestrial herbivores and freshwater fish (on the example of Denmark, Kałdus and Giecz), $\delta^{15}\text{N}$ - $\delta^{13}\text{C}$ of terrestrial herbivores and sea fish (on the example of Denmark and Gotland) or, finally $\delta^{15}\text{N}$ - $\delta^{13}\text{C}$ of herbivores, predators and humans (Schwerin, Gotland, Giecz, Iron Gates, Caspian Steppes). In the last-named aspect, the shift in the $\delta^{15}\text{N}$ range for humans from Giecz in respect of such a range for herbivores is consistent with the expected growth in the value of $\delta^{15}\text{N}$ along the foodstuff-consumer line. A similar interpretation may also be put on the herbivore-predator differences on Gotland. In turn, markedly higher (than $\delta^{15}\text{N}$ of herbivores) values of $\delta^{15}\text{N}$ in human bones from Schwerin and Iron Gates undoubtedly reflect a very significant share of fish in the diet of humans from those locations. A high share of fish in the diet was also concluded from the study of $\delta^{15}\text{N}$ in humans from the Caspian Steppes. As far as stable carbon isotopes are concerned, $\delta^{13}\text{C}$ in the bones of humans from Giecz (without a share of fish in the diet) differs from $\delta^{13}\text{C}$ of herbivores too much to permit an interpretation based solely on the foodstuff-consumer isotope shift. The result for the bones from Giecz shows rather that the staple food of local people included C4-type plants (in this case: millet).

When compared with the data from various regions of Europe (Fig. 2), the values of $\delta^{15}\text{N}$ for human bones from the YBC are only slightly higher than those for humans from Giecz (eating only foodstuffs of terrestrial origin), markedly lower than those for humans from Schwerin, Iron Gates and the Caspian Steppes, and comparable to those for herbivores from the last-mentioned region. Expecting the values of $\delta^{15}\text{N}$ for herbivores from the YBC to be intermediate between those for Giecz and the Caspian Steppes, a claim can be made that $\delta^{15}\text{N}$ values for humans buried in the YBC fit into the range expected for individuals eating exclusively (or almost exclusively) foodstuffs of terrestrial origin. This interpretation seems to be consistent with the conclusions from the study of $\delta^{15}\text{N}$ in human bones from Early Bronze sites in the Northern Pontic Area and Kuban' (Figs. 1, 2). In the study [Gerling 2015], the values of $\delta^{15}\text{N}$ in bones from western Pontic sites, covering a similar range as $\delta^{15}\text{N}$ in bones from the YBC, were interpreted as an indicator of a diet based on vegetable foodstuffs with a share of meat of terrestrial animals. Whereas the values of $\delta^{15}\text{N}$ in the bones of humans from the Northern Pontic Area and

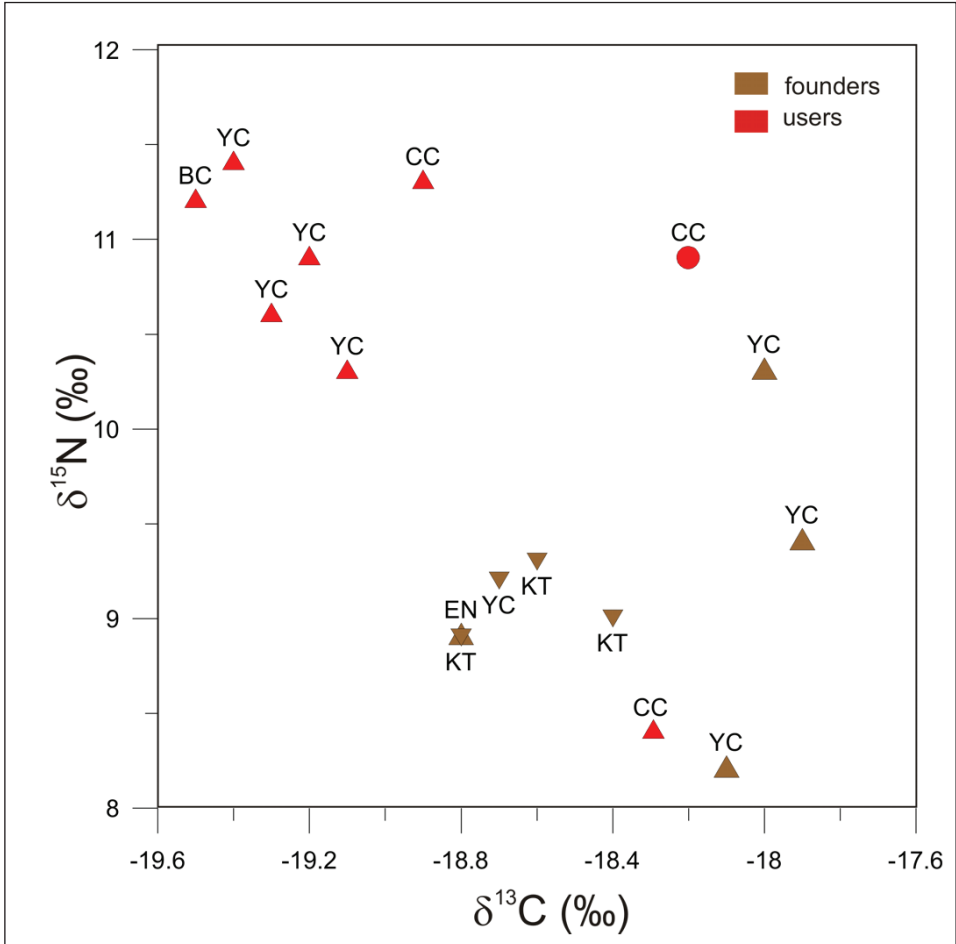


Fig. 3. Composition of stable carbon and nitrogen isotopes in bone collagen from the Yampil Barrow Complex. Isotope data for bones from the graves of builders and users of studied cultural centres are colour coded. Symbols represent data for males (\triangle), females (\circ) and those whose sex could not be determined (∇). Abbreviations (TC, EN, YC, CC, BC) refer to the cultural attribution of particular graves

Kuban' (Fig. 2), which Gerling [2015] interpreted as an indicator of the significant share of freshwater fish in the diet, are markedly higher than $\delta^{15}\text{N}$ in bones from the YBC. The conclusion about the terrestrial character of the diet, showing that no reservoir effect influenced the ^{14}C dating of the bones, is consistent with an earlier suggestion [Goslar *et al.* 2015], following also from the clustering of ^{14}C dates in the plateau sections of the radiocarbon calibration curve. The same conclusion follows from comparing $\delta^{15}\text{N}$ values in human bones from the YBC and the bones of people living elsewhere in Europe approximately at the same time (Fig. 2).

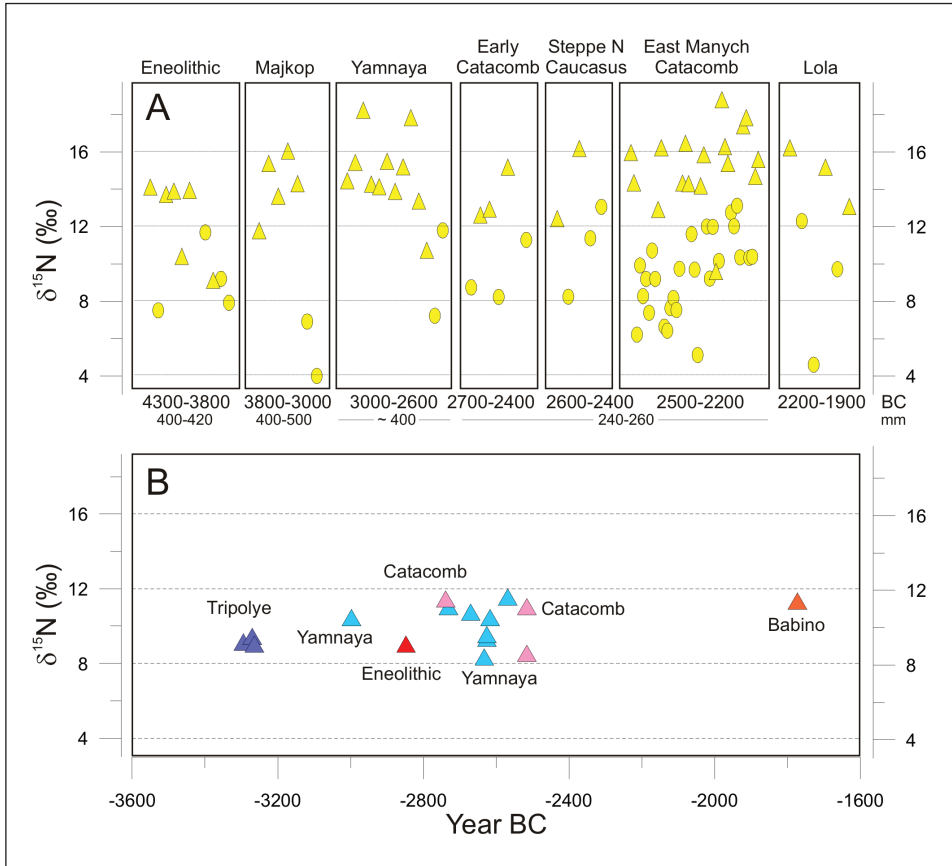


Fig. 4. A – $\delta^{15}\text{N}$ values in the bones of herbivores (O) and humans (Δ) of particular cultures from the 2nd and 3rd millennia BC on the Caspian Steppes [Shishlina *et al.* 2009; 2014]. Since the ^{14}C ages of all individual burials are not known, the points in the drawing are marked along the horizontal axis at random and only grouped in separate boxes, corresponding to particular cultures. The lifetimes of particular cultures and average precipitation totals in these periods are given *after* Shishlina *et al.* 2009; 2014. B – $\delta^{15}\text{N}$ values in the bones of people from the Yampil Barrow Complex

The high ($> -20\%$) values of $\delta^{13}\text{C}$ for human bones from the YBC, as for those from Giecz, suggest a share of C4-type plants (most likely millet) in food. Evidence for the cultivation of millet and other cereals in the Northern Pontic Area as early as the Eneolithic includes grain impressions on pottery [Motuzaitė-Matuzėviciute *et al.* 2009]. Furthermore, the chief crops on the steppes in the Bronze Age were wheat varieties: emmer, einkorn, bread wheat, as well as rye and millet [Pashkevich 2003]. The isotope studies of human bones from Northern Pontic Early Bronze sites show a relationship between $\delta^{13}\text{C}$ and latitude [Gerling 2015] and a positive correlation between the values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$. According to the cited author,

this is a result of the fact that the share of C4-type plants falls in higher latitudes. Gerling [2015], however, does not specify which C4-type plants were supposedly part of the diet of the populations she studied.

The current state of exploration of millet cultivation on the Middle Dniester is discussed in some detail in section 5. It must be stressed that the question of millet in the YC has not been studied in any greater detail [for a synthesis *see* Milisauskas, Kruk 2002]. This is particularly true for the YBC for which archaeobotanical data is generally scarce [Makohonienko, Hildebrand-Radke 2014].

3.2. DIFFERENCES IN THE DIET OF BUILDERS AND USERS, AND OF MEN AND WOMEN

A comparison of the isotopic composition of bones of the builders and users of investigated cultural centres (Fig. 3) shows the values of $\delta^{15}\text{N}$ to be regularly (by 1.5‰ on average) higher in the latter. This regularity could reflect a change in the eating customs of successive generations or, entirely independently of them, follow from climate changes in time. However, in the temporal perspective, no systematic $\delta^{15}\text{N}$ trends can be seen (Fig. 4). This may mean that higher $\delta^{15}\text{N}$ values for users (in relation to builders) reflect a rise in animal protein consumption, which took place in different centres at different times. Thus, the rise in animal protein consumption resulted rather from the economic stabilization of a particular centre than from regional developments triggered by climatic or cultural changes. Remembering that $\delta^{15}\text{N}$ of a consumer is on average 3.5‰ higher than that of a foodstuff, the fact that the value of $\delta^{15}\text{N}$ in users' bones is 1.5‰ higher than in builders' could be attributed to the inclusion of animal proteins in the diet up to about 40 per cent.

In the light of this regularity, as an exception – for a user – comes the value of $\delta^{15}\text{N}$ (=8.4‰) for a person (skeleton W-2) from grave I/4 of the CC, Prydnistryanske site, which is by 2-3‰ lower than $\delta^{15}\text{N}$ in the bones of other users and by 2.5‰ lower than $\delta^{15}\text{N}$ for the other person (skeleton E-1) buried in the same grave. Curiously enough, out of all 16 skeletons examined for the composition of carbon and nitrogen isotopes, only skeleton E-1 was positively identified as female. This would show that in this pair of individuals, the diets of an older man (died at the age of 35-50 years, skeleton W-2) and a young woman (died at the age of about 15 years, skeleton E-1) were completely different, while in the group of users, the eating habits of the man buried in grave I/4 were absolutely exceptional.

Among the 16 skeletons whose isotopic composition was determined, only one was identified as female, 11 as male and four (including three from TC graves) were left without sex identification. It needs to be emphasized, however, that if the

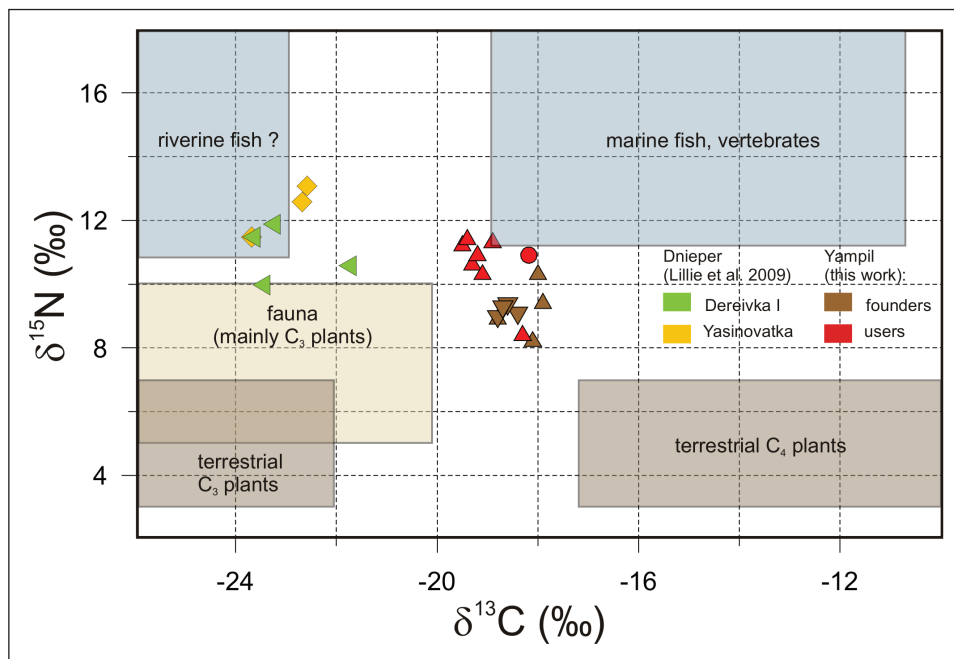


Fig. 5. Composition of stable carbon and nitrogen isotopes in bone collagen from the Yampil Barrow Complex against the ranges of isotopic composition expected for various diet components [after Gerling 2015: Fig. 6.16]. The meaning of colours and symbols concerning the Yampil Barrow Complex is the same as in Fig. 3. For the sake of comparison, the isotopic composition in human bones from two sites on the Dnieper (ca. 5200-5000 BC) is given, in which the share of freshwater fish in the diet was confirmed by the measurements of the reservoir effect [Lillie *et al.* 2009]

sex of these four individuals is identified, it will not alter the finding that the values of $\delta^{15}\text{N}$ in the bones of users are generally higher than in those of builders.

In the studied skeletons, a negative correlation is observed between the values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ (Fig. 3). The correlation coefficient ($r = -0.575$), significant at $p = 0.02$, makes one believe that the correlation is not merely accidental. The relationship between the isotopic composition of carbon and nitrogen may be related to the share of millet in the diet mentioned already earlier. The consumption of millet, whose $\delta^{13}\text{C}$ (between -14‰ and -9‰) is much higher than that of most other plants ($\delta^{13}\text{C} < -20\text{‰}$) may explain the generally high values of $\delta^{13}\text{C}$ in the bones of humans buried in the YBC. If, however, animals (whose meat and milk had an ever-greater share in the diet of users) did not feed on millet, the consumption of animal proteins by humans brought down the average value of $\delta^{13}\text{C}$ of the whole diet. In other words, a growth in the consumption of foodstuffs of animal origin entailed a lowering of the share of millet in the diet of humans. Interestingly enough, the correlation between the values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ was also observed in the as-

semblage of male skeletons from the medieval cemetery in Giecz [Reitsema *et al.* 2010]. Unlike in the YBC, however, in the medieval society of Giecz, a growth in $\delta^{15}\text{N}$ was accompanied by a growth in $\delta^{13}\text{C}$ (positive correlation), which was explained by the greater consumption of meat being accompanied by the greater consumption of blood sausage (*farcimina*), with grits made from millet, or alcohol produced by fermenting millet. In the light of the Giecz situation, the cause of the relationship between $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ in the YBC seems to be much simpler.

3.3. POSSIBLE SHARE OF FRESHWATER FISH IN THE DIET

An alternative cause of correlation between the values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$, and differences between the isotopic composition in the bones of the builders and users of the YBC could be the inclusion of freshwater fish in the diet, with their share being higher in the diet of users. The share of fish in the diet seems to be attested by the comparison of the absolute values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ with the ranges expected of various diet components (Fig. 5). It follows from Fig. 5 that fish could represent as much as 20-30 per cent of the diet of YBC builders, with the share going up by another 20-30 percent in the diet of users. It must be noted, however, that the values of $\delta^{15}\text{N}$ for terrestrial plants and herbivores in some regions and periods may be higher than shown in Fig. 5. By the way, Gerling [2015] herself, from whose publication the ranges of expected isotopic compositions were taken (Fig. 5), interpreted $\delta^{15}\text{N}$ values from the Western Pontic Area similar to Yampil ones as the reflection of a diet of terrestrial origin. Undoubtedly, any final settlement of the question of diet composition of individuals buried in the YBC would first require to determine the isotopic composition of plants or herbivores from the same period and region.

A considerable share of freshwater fish in the diet affects the ^{14}C age of consumer remains (in this case: human) with the reservoir effect. The distortions it causes depend on the reservoir effect in a given body of water (which differs from one water body to another) and the percentage share of foodstuffs of aquatic origin in the diet. To measure the impact of the reservoir effect, it is necessary to compare the results of ^{14}C dating of human remains with that of the remains of organisms that died at the same time and had fed on foodstuffs of terrestrial origin. Such a comparison is only very rarely possible. In East-Central Europe, such studies were made while investigating Eneolithic sites around the Iron Gates on the Danube [Cook *et al.* 2001] and Mesolithic, Neolithic and Eneolithic sites located close to the Dniester Rapids [Lillie *et al.* 2009]. These publications claim that the average reservoir age of people from the area of the Iron Gates is 425 ^{14}C years and the reservoir ages of people from two Eneolithic sites on the Dnieper (Dereivka and Yasinovatka) are 250 and 450 ^{14}C years, respectively. Judging by the value of $\delta^{15}\text{N}$ in human and animal bones, the share of freshwater fish in the diet of the Iron

Gates communities was estimated at 80 per cent. This indirectly allowed setting the reservoir age of Danube waters at ca. 550 ^{14}C years [Cook *et al.* 2001]. A more accurate determination of the reservoir age of waters (at ca. 750 ^{14}C years) was possible in the investigation of the Dnieper sites, owing to the radiocarbon dating of fish remains contemporaneous with human and herbivore remains [Lillie *et al.* 2009]. By comparing the reservoir age in water and human bones, the share of fish in the diet of people from Dereivka and Yasinovatka may be estimated at about 30 and 60 per cent, respectively. In this context, taking into account rather broad ranges of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values characteristic of various environments (Fig. 5), the stable isotopic assessment of fish share in the diet appears less certain and accurate. This is best seen in the investigation results of the Dereivka and Yasinovatka sites [Lillie *et al.* 2009], where, relying on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values (Fig. 5), the authors could only claim that the share of fish in the diet was significant (Dereivka) or dominant (Yasinovatka).

As far as we can tell, the radiocarbon reservoir effect in the waters of the Dniester (whence fish being a possible diet component of individuals buried in the YBC could come) has never been measured, but it can hardly be expected to be significantly lower than in the Danube or the Dnieper. For this reason, already a 20%-share of fish in the diet of YBC populations would make ^{14}C dating results of human bones older by 100 years. Such an effect is contradicted by the difference in ^{14}C ages of the bones of a woman (Poz-66220 and Poz-66732, ca. 3940 BP) and a man (Poz-66219, ca. 4070 BP), identified in grave I/4, Prydnistryanske site, as a set of coherent funerary behaviour. The difference, being too large to be a probable effect of only a statistical dispersion of measurement results, could be explained by a considerable age difference between the two individuals at the time of death (the woman was much younger than the man) and the effect of carbon accumulation in the bones of the man over several decades prior to his death [Goslar *et al.* 2015: Fig. 4]. If, however, a significant element in the diet of YBC users were fish, of the two individuals buried in grave I/4, a greater (or the sole) consumer of fish would be the woman (her bones had a much higher value of $\delta^{15}\text{N}$). Allowing for the reservoir effect (about 100 years) in her radiocarbon age would prevent the dating results from being reconciled with the coherence of both burials. In addition, making the ^{14}C dates of a considerable number of examined individuals older by 100 years or more due to the reservoir effect would greatly weaken the effect of their clustering in the plateaux of the calibration curve [observed by Goslar *et al.* 2015]. To the insignificant share of fish (in relation to the share of milk and meat of terrestrial animals) in the diet of YBC users, a very small shift of $\delta^{13}\text{C}$ values with respect to those in the bones of builders seems to testify, whereas the inclusion of fish (whose $\delta^{13}\text{C}$ values are usually very low – Fig. 5) in the diet should considerably lower the value of $\delta^{13}\text{C}$ in a consumer's organism.

3.4. VARIATION OF NITROGEN ISOTOPIC COMPOSITION IN TIME

Keeping in mind the considerable interregional differentiation of nitrogen isotopic composition (probably having climate differences as its reason, Fig. 2) and the relationship between the value of $\delta^{15}\text{N}$ and precipitation total, found to exist in some regions, one may wonder whether the differences in $\delta^{15}\text{N}$ in the bones of people buried in the YBC over a period exceeding a millennium are not a result of general climate changes in the region in question.

Detailed information on climate changes in the Yampil Region in the period in question, unfortunately, is not known to the present authors. Data on precipitation total changes in the 3rd and 2nd millennia BC and a rich set of isotope examination results for this period were presented for the Caspian Steppes [Shishlina *et al.* 2009; 2014]. There, precipitation was the greatest in the lifetime of the Maikop culture (3800-3000 BC) only to fall gradually, making the climate increasingly drier. Annual precipitation totals in the period of 2700-2200 BC were lower by as much as 150 mm than in the time of the Maikop culture. These climate changes are in a way reflected in the nitrogen isotopic composition in the bones of herbivores, because the lowest values of $\delta^{15}\text{N}$ were recorded in the lifetime of the Maikop culture. It must be noted, however, that the set of isotope data in this case is very meagre (only two samples). Obviously, no clear reflection of climate changes in isotopic composition in human bones can be expected if only because far greater differences in $\delta^{15}\text{N}$ are in this case related to differences in the share of foodstuffs of aquatic origin in the diet.

The values of $\delta^{15}\text{N}$ in YBC bones (Fig. 4) seem to show a slight increase between 3300 and 2800-2400 BC, but if one takes into account considerable dispersion of $\delta^{15}\text{N}$ ca. 2600 BC, undoubtedly connected with changes in eating habits along the builders-users line, and the fact that all isotope data for 3300 BC concern builders, attributing this increase to the impact of climate appears to be risky.

4. ISOTOPIC PICTURE OF YBC POPULATION DIET: SUMMARY

The composition of stable carbon and nitrogen isotopes in the bones of 16 individuals buried in the YBC show that they ate foodstuffs of terrestrial origin, with the share of foodstuffs of aquatic origin being insignificant. Furthermore, the isotopic data show that in relation to the builders of particular centres, the diet of centre users was several dozen per cent richer in animal proteins and that eating

habits changed in various centres at various times. The relatively high values of $\delta^{13}\text{C}$ and the negative correlation between the isotopic composition of carbon and nitrogen suggest that millet was a major component of vegetable food eaten by people in the region under discussion and the rise in the consumption of animal food entailed a drop in the share of millet in the diet. Chronologically speaking, the average values of $\delta^{15}\text{N}$ in the oldest studied period (ca. 3300 BC) appear to be slightly lower than in later periods, possibly due to climate changes or – which is far more probable – a change in the diet of examined individuals.

5. MILLET: A BRIEF ARCHAEOBOTANICAL CLASSIFICATION COMPLEMENTING ISOTOPIC IDENTIFICATION

As already mentioned, a plant eaten by YBC populations – having a strong impact on the local diet – could have been millet. To avoid any terminological confusion, it must be explained that under the popular name millet, a number of genera are understood, belonging to the family Poaceae (syn. Gramineae) [Madella *et al.* 2016]. Relevant for the discussion at hand are two species: (a) broomcorn millet, *Panicum miliaceum* L. and (b) foxtail millet, *Setaria italica* (L) P. Beauv. The first is a tetraploid plant ($2n=36$) and one of the earliest domesticated and most important cereals [Zohary *et al.* 2012: 69]. Its origin is not entirely clear, because ‘neither a wild ancestor nor the place of domestication is known’ [Lityńska-Zajac, Wasylkowa 2005: 107]. One of the species that was until recently considered its wild progenitor is *P. miliaceum* subsp. *ruderales* (Kitag.) Tzvelev (syn. *P. ruderales* (Kitag.) Lysov). It grows, however, ‘in secondary habitats, which justifies a presumption that it is a mutant that has developed from cultivated millet’ [Lityńska-Zajac, Wasylkowa 2005: 107; Zohary *et al.* 2012: 69]. More recent phylogenetic studies of tetraploid and diploid species from the genus *Panicum* show, to put it simply, the origin of *P. miliaceum* to be allotetraploid, with its maternal ancestor possibly being *P. capillare* (or its close relative) and the other genome being shared with *P. repens*. It is also suggested that further search for parent forms be continued in Asia [Hunt *et al.* 2014]. The oldest archaeological finds of broomcorn millet come from northern China, which may suggest the location where the species was domesticated. Most likely, it is from there that it migrated west as is shown by the successive finds of *Panicum miliceum* remains in Georgia (ca. 8000-7150 cal BP) and Moldova (ca. 7600-7400 cal BP) [Zohary *et al.* 2012: 70]. However, millet caryopses extracted from the Bronze Age cemetery in Xinjiang, China, having different genetic characteristics from early cultivated forms, shed a new light on the questions of domestication and migration routes of this species [Li *et al.* 2016].

Archaeobotanical finds of this species have only relatively recently been reviewed [Hunt *et al.* 2008; Conolly *et al.* 2008; Colledge, Conolly 2007 (Eds)]. As already mentioned, the oldest finds come from China and are dated to 7600-7610 cal BP and 8060-7750 cal BP. It was not recorded in the Balkans in the Early Eneolithic, while in the materials of the Linear Pottery culture, it was found at over a dozen sites [Conolly *et al.* 2008]. Some of these finds, in the light of ^{14}C AMS determinations, do not necessarily have to reflect the connection between the plant material and archaeological context [Motuzaitė-Matuzevičiūtė *et al.* 2013]. Nevertheless – generally speaking – it can be assumed that broomcorn millet appeared in Europe in Eneolithic subfossil materials, but always in small amounts, indicating that it was not an important cereal at that time. Its importance markedly grew, beginning with the Late Bronze Age [Lityńska-Zajac, Wasylkowa 2005; Hajnalová 2012; Stika, Heiss 2013; Moskal-del Hoyo *et al.* 2015].

The other species – foxtail millet (*Setaria italica*) – is a diploid plant ($2n = 8$) [Zohary *et al.* 2012: 71]. Its wild ancestor is green millet *Setaria viridis* (L.) P. Beauv., a species very similar to foxtail millet and producing with it fertile hybrids. *S. viridis* grows wild in Eurasia and northern Africa, often as a common weed of spring cereal and root crops [Zohary *et al.* 2012: 71; Lityńska-Zajac, Wasylkowa 2005: 109; Lityńska-Zajac 2005: 70, 71]. Most likely it was domesticated in China [Zohary *et al.* 2012: 71; Le Thierry d’Ennequin *et al.* 2000], but this ‘could have happened anywhere within the entire range of *Setaria viridis*, possibly in several places independently of one another’ [Lityńska-Zajac, Wasylkowa 2005: 109]. The oldest archaeological finds of *Setaria italica* come from China. In Europe, burnt foxtail millet caryopses are recorded beginning from the Bronze Age [Zohary *et al.* 2012: 71, 72].

Foxtail millet (*Setaria italica*) has two varieties (or subspecies): convar. *mocharia* (Alef.) Körn. with loose panicles and smaller caryopses and convar. *italica* (syn. convar. *maxima* (Alef.) Körn.) with compact panicles and larger grains. The varieties differ in the relief of glumes. *Setaria italica*, similar to millet, has a short vegetation season, is resistant to drought and adapted to the climate of the temperate zone of Eurasia. To grow, it calls for similar cultivation as is required in the case of broomcorn millet [Lityńska-Zajac, Wasylkowa 2005: 108, 109]. These properties allow farmers to grow both species together, i.e. broomcorn millet and foxtail millet, which is done for instance in Afghanistan [Sakamoto 1987]. Both species are grown together with other millet grasses, e.g. barnyard grass *Echinochloa* in China, sorghum in Africa and India, and pearl millet (*Pennisetum glaucum*) in Africa [Körber-Grohne 1988].

6. PICTURE OF DNIESTER NORTHERN PONTIC AREA
COMMUNITY DIET, 4TH/3RD-2ND MILLENNIUM BC:
COMPARISON OF ISOTOPIC, ARCHAEOBOTANIC
AND ARCHEOZOOLOGICAL DATA

Among currently used identification methods of prehistoric eating habits, the study of stable carbon and nitrogen isotopes preserved in bones has a special place as it provides a synthesis on adaptation strategies: proportion of nutrition ecotypes (aquatic vs. terrestrial) and plant or animals species found in each. In the case under discussion, the strategy involved the domination of millet consumption combined with increasing consumption of herbivore meat (*see* section 1). The latter indication calls for a comparison of the isotope findings with (a) archaeobotanical and (b) archaeozoological evidence available until now for the Dniester area and the times when the YBC developed. Taxonomically, the above covered three stages:

(1) transition period between the Eneolithic and Bronze Age = TC Gordinești group/YC prologue

(2) early, classic period of the Bronze Age = ‘classic’ YC, CC

(3) late period of the Bronze Age = BC, NC

From the north-western Pontic forest-steppe, a fragment of which the YBC is, we have only meagre evidence of the economic use of millet (*Panicum miliaceum*) already from the Atlantic Climatic Phase. This is when the oldest early-agrarian colonizers of the Boh-Dniester culture were settling the area (Sokolec phase III, Balkan trend = Starčevo-Körös/Cris) and especially the Linear Pottery culture (early phase, central European trend), i.e. the second half of the 7th and the 6th millennium BC [Pashkevich 2000: Tab. 2, 3; Pashkevich, Videiko 2006: 33]. A similar tendency seems to have prevailed during the ‘Eneolithic prologue’ – in the first half of the 5th millennium BC – which is shown by archaeobotanical records for period A (‘pre-ploshchadka’ one) of the TC. Then, millet was shown to represent 13 per cent of sources from Ukraine and 1 per cent of those from Moldova [Pashkevich, Videiko 2006: 74].

Communities settling the Pontic forest-steppe grew more interested in millet in the second half of the 5th millennium BC. This is true of both steppe Eneolithic cultures, corresponding to eastern Eurasian – ‘nomadic’ – civilization experience (Dereivka and Lower Mikhailovka I cultures), and – being a border case between the mentioned ones – the Tripolye culture of stage B (‘ploshchadka’ one). In the latter case, millet was found to represent 7 per cent of ‘Tripolye’ archaeobotanical sources from Ukraine and 19 per cent of those from Moldova [Pashkevich 2000:

410-411, Tab. 5; Pashkevich, Videiko 2006: 77]¹. Interestingly enough, concerning the archaeobotanical identifications of this cereal – taking into account the conventional range of central Europe – it was maintained that: ‘particularly large amounts of millet were recorded in TC “ploshchadkas”’ [Wiślański 1969: 194]. It is not known, however, if this was true for all the development stages of these structures, in particular those associated with TC stage CI. What catches the eye here is the difference between the incidence of millet remains in stage ‘TC C’ from Ukraine: 0% and Moldova: 21% [Pashkevich, Videiko 2006: 78].

The first mention of millet domination among cereals concerns the second half of the 4th millennium BC and the Lower Dnieper, ‘early barrow’, Usatovo group/culture – a steppe offshoot of the TC (stage CII). With regard to Usatovo and Mayaki, it was said that: ‘on pottery, millet impressions clearly dominate. It is no accident either that on ritual objects, such as statuettes, on more than 100 occasions, if any plant impressions are recorded, these are exclusively millet impressions. The cultivation of millet must have laid the foundation of Usatovo agriculture, but this claim cannot be proven beyond doubt’ [Patokova *et al.* 1989: 118; Patokova 1979; Videiko, Peterenko 2003; Klochko *et al.* 2003]. As a staple crop, millet was known in the Northern Pontic Area beginning from the 2nd millennium BC, for instance in the Timber Grave and Sabatinovka cultures [Pashkevich 2000: Tab. 6].

Broomcorn millet (*Panicum miliaceum*) is not very demanding in terms of edaphic conditions and grows well on various soils including poor ones. Exceptions include very dry sands and waterlogged soils [Dzieżyc 1967: 92-93]. The highest millet yields are obtained on virgin soil, humic soils if additionally fertilized, and on fertile *chernozem* soils [Strzelczyk 2003: 15]. Millet is a short-day, light- and warmth-loving plant, resistant to drought and shortages of soil water, with a short growing season of 60-90 days [Herse 1980]. It ripens unevenly in a field and because its grains easily fall, it needs to be reaped in a specific way. This could have been done by cutting the stalk under the ear, cutting the plant right above the ground or by pulling up entire plants [Strzelczyk 2003: 17]. This crop is hard to cultivate, because its rows need to be earthed up, as many as several times in one growing season, and it has to be weeded and thinned if it grows too dense. This manner of cultivation permits weeds, typical today of root crops communities, to spread across millet fields.

In the YBC area, on the hilltop of a loess plateau, *chernozem* soils, typical of a steppe landscape, dominate. When analyzed by pedological methods, barrow

¹ See the historical-ethnographic description of millet origin and growing area from the early 20th century by Moszyński [1967: 224-225]: ‘The chief cultivation range of millet proper covers Japan, Korea and northern China, central and southern Asia as far as the Caucasus and countries lying on the Black Sea’. ‘Millet is actually grown today or rather has been grown until recently in all Slavic countries, with the exception of the north-western frontier’, ‘judging by ancient sources, millet used to be one of the most important or the most important cereal across the vast expanses of Slavic countries’. Against this background, see also palaeobotanical ‘topogenetic doubts’ – as formulated by G.A. Pashkevich – concerning the assessment of millet reception by researchers studying the Northern Pontic Area [Pashkevich, Videiko 2006: 33].

mounds and original soils preserved underneath them suggest that a steppe landscape prevailed there when the barrows were being built. Steppe *chernozem* soils, by their nature associated with the continental climate, characterized by high insolation and relatively low climate humidity [Bednarek, Prusinkiewicz 1980], are fully consistent with millet habitat conditions. Furthermore, the habitat conditions are relatively consistent with the several-thousand-year-old nomadic traditions of Eurasian steppes, from northern China and central Asia, believed to be the places of origin of *Panicum miliaceum*, to the Hungarian Plain [Gyulai 2014, Hunt *et al.* 2008, Jones *et al.* 2016]. The transit location of Dniester steppes seems to point to the natural necessity of millet cultivation appearing in this region.

Harvested millet crop should be stored in spikelets as in this form it can last even up to 20 years [Lundstrom-Baudais, Bailly 1995: 190]. This spikelet durability could not only save people from famine in time of war and crop failure [Muel-ler-Bieniek 2012: 76], but also allow the crop to be transported over long distances. Whereas, a naked caryopsis decays soon, even in two days only. That is why, millet was roasted or thrashed in small portions immediately prior to consumption [Strzelczyk 2003: 18; Lityńska-Zajac, Wasylkowa 2005: 106].

It seems, thus, right to believe that from the transition from the Pontic Eneolithic to the prologue of the Bronze Age, ca. 3300-2800 BC, millet was a permanent part of the economic-subsistence strategy on the Middle Dniester, of the oldest *Yampil barrow communities* – the TC Gordinești group or early YC – which corresponds well with the isotope data. This hypothesis is supported by millet impressions recorded on YC pottery on the Lower Dnieper steppe [Kuzminova 1990: 261]. They dominate among the impressions of crop plants, albeit the source base is rather small. More evidence of millet presence is related to the CC horizon [Bunyatyan 2003: 274], while a major quantitative increase is recorded in the Late Bronze Age.

It remains an open question, however, how nomadic peoples procured grain. Possibly, broomcorn millet was permanently present in agriculture and, therefore, played a dominant (significant) role in the crop structure (?). Such situations were observed in some pastoral peoples on the Eurasian steppe [Zhang *et al.* 2017]. It cannot be ruled out, however, because of spikelet durability (*see above*), that it was procured in other ways: by exchange or trade with farmers [Spengler *et al.* 2014].

The continuous record of millet presence (*Panicum* and *Setaria*) – beginning with the second half of the 4th millennium BC – underscored the role of steppe communities in spreading the cultivation of these plants across Eurasia [Pashkevich 2003: 292]. In Sherratt's model [2003: 235], millet cultivation was part of a cultural behaviour characteristic of steppe peoples and had an impact on neighbouring areas.

The fact that evidence for 'Yampil' taxa comes only from funerary sources rules out practical – direct – documentation of plant remains such as caryopses or their impressions in available YBC archaeometric sources. For reasons of the

poor production and meagre dispersion as an autogamous (self-pollinated) plant of very fine and difficult to identify pollen grains of broomcorn millet [Milecka *et al.* 2004: 263], as well as ‘post-deposition distortions’, we do not have any palynological data, either [Makohonienko, Hildebrandt-Radke 2014]. Perhaps, some positive results could be produced by analyzing phytoliths or starch grains. This has been done for various grass species of the millet group [Madella *et al.* 2016; Lu *et al.* 2009]. Taking the palaeopaedological and palaeoenvironmental perspective quoted earlier, one may assume that around Yampil, on the Middle Dniester, millet could have been grown on ‘the substratum of typical *chernozem*, exhibiting characteristics found in the transition zone of the subboreal belt and having a temperate climate with marked continental characteristics and steppe vegetation’ [Bednarek, Jankowski 2014: 279]. Specifically, it is expected that millet could have been cultivated on the Dniester – in areas that had been exploited earlier by TC communities².

From the *Yampil Barrow Complex*, 13 grave features are known in which ‘animal deposits’ were recorded in the course of excavations in 2010–2014 [Marciniak *et al.* 2017: Tab. 1]. All the deposits were found in the context of Eneolithic taxa: YC, CC, BC and NC. This list is complemented by the finds of animal bones, being remains of funeral feasts; it is not possible, however, to date them more or less accurately [Klochko *et al.* 2015; 2015a; 2015b; 2015c]. In terms of species, the deposits represent five wild animals (red deer – 4, fox – 1), three sheep/goats–goats, two instances of cattle and two of the horse. The domination of the former category in animal deposits can be explained by primarily ritual reasons. Interestingly enough, the image of a golden deer appears on a ‘Usatovo’ symbolic ‘tombstone’ or a stela from Usatovo, barrow I-3 [Patokova 1979: 46–49, Fig. 19: 7]. The meaning of the other deposits combines a ritual message (related to occasional life) with a pragmatic one: arguments in favour of the position of a given species in everyday life, including the diet. The high position of sheep/goat on the list is borne out by the herding profile of ‘early barrow’ communities on the Lower Dniester and on the steppe recorded on Usatovo group/culture settlements [Patokova *et al.* 1989: 119, Tab. 4]. On the eponymous site, in Usatovo, the position of sheep/goat was documented by 70.0% of bone fragments and 58.7% of individuals, against 20.2% of cattle bones and 22.2% of individuals, and 9.8% of horse bones and 19.1% of individuals. Similarly organized data for Mayaki are: sheep/goat: 78.4% of bones and 70.0% of individuals, cattle: 12.0% of bones and 16.6% of individuals and horse: 9.6% of bones and 13.4% of individuals. These quantitative data, in herds, when converted into meat production adjust the above percentages for Usatovo as follows: cattle: 49.1%, sheep/goat: 17.5%, horse: 33.4% and for Mayaki: cattle: 54.2%, sheep/goat: 25.8%, horse: 29.0%.

Bringing together both bodies of information on the nutritive use – by ‘Usatovo’ and *Yampil populations* – of millet, cattle, sheep/goat and horse does not allow us to redraw them as a dynamic picture of the diet before *ca.* 2800 BC

² For experience from later times see Wyczański [1969: 28].

(= stage 1) and after that time (= stages 2 and 3). The perspective of the ‘Usatovo point of view’ applies to the first of the named development stages: ‘early barrow diet’ (=Gordinești group TC/prologue of YC). The data is insufficient to make the picture of stage 2 more specific: growth in meat consumption in relation to the consumption of processed millet. As far as ‘Yampil’ data is concerned, evidence for the consumption of horse meat (?) should be noted but only in archaeometric records relating to the 2nd millennium BC and the NC. This may be another argument for treating this period separately: as a hypothetical third stage.

7. AN ATTEMPT TO CONCRETIZE THE DIET PICTURE – SUBSISTENCE STRATEGY – OF DNIESTER COMMUNITIES IN THE 4TH/3RD-2ND MILLENNIUM BC

Millet caryopses were used in various ways. In Europe, they were usually eaten as groats (millet groats), but Columella and Pliny write that [quoted after Körber-Grohne 1988] in the past both millet groats and millet bread were eaten. ‘In Asia, besides groats, broomcorn millet and foxtail millet flour are used to make a special dish with milk or fat, while gluten-rich varieties are used to bake bread’ [Lityńska-Zajęc, Wasylikowa 2005: 106]. In addition, millet grains were fed to fowl and poultry, and used to make beer (*braga* in Romania, *bosa* in some Asian countries) and vodka [Hanelt 2001 (Ed.); Podbielkowski 1985: 298]. Various examples of millet (groats) dishes in Slavic countries are discussed by Maurizio [1926] and H. Lis and P. Lis [2009].

Foxtail millet caryopses are used to make primarily flour, groats and pancakes [Lityńska-Zajęc, Wasylikowa 2005: 109]. Grains and flour are easily digestible and as such, they are recommended to infants and the elderly. Grains are also fed to fowl and poultry. In Asia, foxtail millet is used to make beer and wine, while in China it is also used for medicinal purposes [Hanelt 2001 (Ed.)]. Various dishes and beverages made from broomcorn and foxtail millet caryopses in Eurasia are listed by Sakamoto [1987a]. Detailed ethnobotanical studies of the cultivation, crop processing and food preparation in the Iberian Peninsula were presented by Moreno-Larrazabal *et al.* [2015].

The geographical area under discussion can be related to historical and ethnographic data indicating the use of grits and groats in the diet. They had been known in the menus of European societies since the ‘pre-agrarian’ times. The isotope finding of millet domination in the diet of Middle Dniester *Yampil Barrow Complex*, complemented by bioarchaeological data from the upper steppe Dniester area

(from the similarly ‘early-barrow’ Usatovo group/culture with strongly marked ‘eastern’ civilization influences), makes it reasonable to consider the possibility that already in the prologue of Late Eneolithic-Early Bronze barrow culture (3300-2800 BC) development there was a clear dividing line of millet groats use – or millet presence – that is, so-called *yagla* groats (*yagla*, *yagly* = millet in Old Slavic languages).

An ‘attempt to concretize’ may be based – preliminarily – on historical and ethnographic data, i.e. by referring to the everyday practices of Iron Age Northern Pontic ‘nomadic’ communities. In this context it should be observed that the oldest – potentially of great significance – record by Herodotus [1959], concerning the Scythians, does not bring any information of note that may further the discussion of staple diets on the part of Pontic prehistoric communities.

The first more detailed information on the diet of ‘Pontic nomads’ – 17th-century Crimean Tatars – we owe to Wilhelm Beauplan [1972]. He writes: ‘their staple food is millet, and barley and buckwheat groats; their common beverage is *braha* made of cooked millet’. *Braha* is thicker than milk but does not intoxicate’. ‘They eat mutton and goat meat: when they roast meat, they put a whole sheep on the spit’ [Beauplan 1972: 130]. These observations apply also, as it seems, to the steppe between the estuaries of the Dniester and Danube, known as *Budzhak*: ‘where rebels hide, who recognize neither the Khan nor the Turks (*see Orda Budziacka*)’ [Beauplan 1972: 92, 123].

In Feliks Berdau’s 1865 ‘encyclopaedic’ description of the decline stage of the Sarmatian culture, millet is referred to as a cereal plant ‘differing greatly from all other cereals’, ‘it grows best on virgin soils after clearing a pine forest,’ ‘it is usually sowed in mid-May. The harvest is frequently unusually bountiful’. ‘Millet grains thrashed in mill crushers to remove outer glumes produce so-called *yagly* or millet groats, which is very nourishing but less easily digestible’ [Berdau 1865: 608].

* * *

The effects of the studies raised in this article set new – of major importance for the *Yampil Programme* – trends in the study of the culture-formation role of the YBC in relation to the settlement environments of the 4th/3rd and the first half of the 3rd millennium BC in the Baltic drainage basin, chiefly the ‘Vistula-Oder’ groups of the Corded Ware culture. The ‘Yampil diet’ record poses questions about the scale of its ‘Corded’ reception. The reception marker could be evidence for

the share of millet in ‘Corded diet’³. This is especially true for the CWC eastern segment – ‘Central European Corded Ware culture’, and within it, the Małopolska and Kujawy-Wielkopolska groups. In the areas occupied by these communities, in funerary assemblages from the first half of the 3rd millennium BC, YC or YC/CC components have already been identified in rituals and the topogenesis of object sources identified as exogenous [Włodarczak 2014; Koško 2014; Koško *et al.* 2017]. The determination of the isotopic composition of such selected exogenous objects should initiate conceptually an extensive study, taking advantage of the research vistas opened up by the *Yampil Programme* [Ivanova *et al.* 2015].

Translated by Piotr T. Żebrowski

³ See a parallel trend of bioarchaeological, isotope and aDNA studies focusing on the bio-cultural borderland between the West and East on the taxonomic scale of the Corded Ware and Yamnaya cultures (diets, settlement mobility, social structure ...), pursued as part of programmes developed in West-Central Europe: Sjögren *et al.* 2016;

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