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C AND N STABLE ISOTOPES IN A SET OF 17 SKELETONS FROM THE VEDROVICE CEMETERY

ABSTRACT: *The Neolithic population was dependent on terrestrial C3 photosynthetic plants (wheat). Plant food sources of the LBK period were evaluated with regard to representation of proteins in a plant-based diet by sex and age of the examined individuals. The analysis of collagen from human ribs revealed the ratios of N isotopes in 17 skeletons – 3 males, 8 females and 6 children.*

KEYWORDS: *Neolithic – Vedrovice – South Moravia – Skeletal material – Analysis of C and N isotopes – Reconstruction of diet*

INTRODUCTION

In order to reconstruct the diet based on the organic component of bone – collagen – an analysis of carbon and nitrogen stable isotopes was undertaken involving human skeletal remains from the Neolithic cemetery at Vedrovice, Czech Republic. Since collagen contains amino-acids produced within the body, as well as essential acids obtained from diet and derived predominantly from the consumption of meat, it is likely to reflect the diet of examined individuals.

METHOD

Human skeletons: Samples for diet reconstruction were taken from 17 skeletons recovered from the Vedrovice cemetery and stored at the Anthropos Institute in Brno. Samples were taken from ribs in order to reconstruct diet based on the analysis of stable isotopes ^{13}C , ^{12}C and ^{15}N , ^{14}N contained in the organic bone component – collagen (Smrčka *et al.* 2004, Smrčka 2005).

Sample processing

For reliable isotope analyses it is necessary to maintain the isotope composition of the source organic carbon and nitrogen, and to remove foreign and inorganic material. An established method, also employed for obtaining radiocarbon dating samples, was used in this study (Stafford *et al.* 1988). First, bone samples were ground into fragments smaller than 1 cm and washed in distilled water using ultrasound. These fragments were then dried at 50°C, resulting in material homogenised to the size <63 μm , extracted by methanol and water. The remainder was mineralised (in order to remove carbonate components) at 4°C by means of 0.5 HCl under constant pH, washed with distilled water and re-dried at 50°C. In order to minimise the loss of collagen, alkaline leaching of the samples was not used.

The elemental composition, i.e. the contents of carbon and nitrogen as well as the analyses of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of these samples was determined. This was conducted using established standard procedures for this type of material – following the combustion of collagen in an elemental analyser (Fisons 1108) the resulting gases were

chromatographically separated into nitrogen and carbon dioxide, and analysed on a Mat 251 isotope ratio mass spectrometer for the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values compared with reference gases of known isotopic composition. The entire procedure was verified by means of international reference materials NBS 22 (NIST USA, $\delta^{13}\text{C}$ -29.75‰) and NZ1, NZ2 (IAEA Vienna $\delta^{15}\text{N}$ 0 and 20‰). The size of the samples was optimised so that the metering error could not exceed 0.15‰ . The measurements are shown in *Table 1*.

RESULTS

Human skeleton remains (N=17) from the Vedrovice cemetery yielded a range of values for stable isotopes of nitrogen ($\delta^{15}\text{N}$ $+9.10$ up to $+10.9\text{‰}$ with an average of $+10.14\text{‰}$), and stable isotopes of carbon ($\delta^{13}\text{C}$ -19.94 up to -22.4‰ , with an average of -21.30‰).

The resulting statistical data are presented in *Tables 2a*, *2b* and *Figure 1*. It is noteworthy that the stable isotopes of nitrogen ($\delta^{15}\text{N}$) in three males ($10.87\pm 0.6\text{‰}$) are higher than in eight females ($9.90\pm 0.6\text{‰}$) and six children ($9.91\pm 0.38\text{‰}$) ($p=0.099$). In addition, the stable isotopes of carbon ($\delta^{13}\text{C}$) in three males ($-21.10\pm 0.30\text{‰}$) are also higher than in eight females ($-21.28\pm 0.79\text{‰}$).

DISCUSSION

Reconstruction of diet by means of C and N stable isotopes

The individuals buried at the Vedrovice cemetery were dependent on C3 photosynthetic plants (wheat). A similar type of diet was also determined for the Neolithic populations in Denmark (Tauber 1981).

The proportion of meat in the diet of males (N=3) at the Vedrovice cemetery is higher than in females. Can the source of meat be determined? By comparing *Figure 1* with

analysed isotopes of C and N in domestic and wild animals from Vedrovice (Smrčka *et al.* 2005; reference to *Figure 1* in the same) it is evident that the source of meat (and/or milk) in the diet of females and children were domestic animals, whereas the male in burial 36/76 apparently hunted wild animals.

A reference collection of animals from the Vedrovice settlement comprised numerous domestic animals including eleven big herbivores such as bovids (*Bos primigenius f. taurus*, found e.g. in Features A3, A7–10), ten small herbivores such as sheep, goats (*Ovis ammon f. aries/Capra aegagrus f. hircus*, found e.g. in Features A10–12), eight omnivores such as pigs (*Sus scrofa f. domestica*, found e.g. in Feature A1) and one carnivore – a dog (*Canis lupus f. familiaris*). Wild animals were represented by an elk and a deer (*Cervus elaphus*). In turn, the diet of the consumed animals also depended on the C3 photosynthetic cycle. The largest proportion of terrestrial or aquatic sources (streams) was identified with the aurochs ($\delta^{15}\text{N}=10.5\text{‰}$). According to the values of $\delta^{15}\text{N}$, a diet based on fish from water streams, so popular in the Mesolithic age, can be excluded (Smrčka 2005).

CONCLUSIONS

This study of 17 skeletons from the Vedrovice cemetery indicates a diet dependent on terrestrial C3 photosynthetic plants (wheat). Furthermore, males (N=3) indicate a higher proportion of meat in their diet than females (N=8) and children (N=6) ($p=0.099$).

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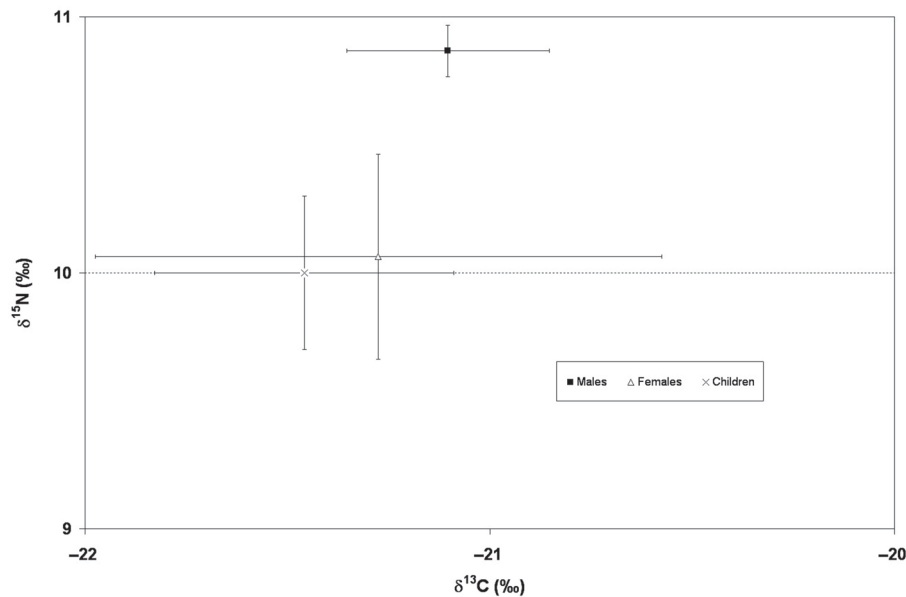


FIGURE 1. Graphic representation of sexual differences in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ contents in the Neolithic skeletons from the Vedrovice cemetery.

TABLE 1. Summary of C and N isotope analyses from collagen in 17 skeletons from the Vedrovice cemetery.

No. of laboratory sample	Burial No.	Sex/Age	Inv. No.	$\delta^{13}\text{C}$ (‰)	$\delta^{13}\text{C}$ (‰) converse	$\delta^{15}\text{N}$ (‰)	$\delta^{15}\text{N}$ (‰) converse	N (%)	C (%)	C/N	N% converse	C% converse	C/N converse
ribs – males													
0509-801/222/01	19/75	M/25–35	2283	-21.32		10.9		7.61	31.12	4.1			
0509-801/222/03	46/77	M/20–35	2306	-21.23		10.9		6.99	28.36	4.1	7.05	28.31	4.0
0509-801/222/04	69/78	M/20–30	3000	-20.76		10.8		5.32	19.39	3.6			
ribs – females													
0509-801/222/02	36/76	F/45–50	2297	-19.94		9.6		4.61	22.46	4.9			
0509-801/222/05	70/79	F/45–50	3001	-20.61		10.5		2.76	10.63	3.9	2.63	10.35	3.9
0509-801/222/06	80/79	F/35–45	3011	-21.29		10.4		3.38	13.13	3.9			
0509-801/222/07	21/75	F/30–40	2285	-21.24		10.6	10.4	8.16	28.83	3.5			
0509-801/222/09	45/77	F/35–45	2305	-21.46		9.7		3.23	12.65	3.9			
0509-801/222/10	64/78	F/18–25	2996	-22.15		10.1		4.54	17.06	3.8			
0509-801/222/11	67/78	F/35–45	2998	-22.40		9.1		2.92	14.31	4.9			
0509-801/222/12	81a/79	F/20–30	3012	-21.11		10.5		6.85	26.4	3.9			
ribs – children													
0509-801/222/08	27/76	Ch/>15	2291	-21.68		9.5		2.57	13.27	5.2			
0509-801/222/13	18/75	Ch/6–7	2282	-21.46		10.0		8.16	30.74	3.8			
0509-801/222/14	20/75	Ch/3–4	2284	-20.90	-20.46	10.4	10.1	12.01	38.38	3.2	12.35	39.04	3.2
0509-801/222/15	32/76	Ch/12–14	2295	-21.04		9.8	9.0	5.42	19.61	3.6			
0509-801/222/16	40/76	Ch/8–10	2300	-21.89		10.3		8.08	30.32	3.8			
0509-801/222/17	78/79	Ch/7–8	3009	-21.78		10.0		6.77	29.07	4.3			

TABLE 2a. Distribution of 17 Neolithic skeletons from the Vedrovice cemetery according to sex, and statistic differences within these groups.

Group	$\delta^{13}\text{C}$ (‰) Average	$\delta^{13}\text{C}$ (‰) N	$\delta^{13}\text{C}$ (‰) STD	$\delta^{13}\text{C}$ (‰) SE	$\delta^{13}\text{C}$ (‰) Minimum	$\delta^{13}\text{C}$ (‰) Maximum
Males	-21.103	3	0.301	0.174	-21.32	-20.76
Females	-21.275	8	0.785	0.278	-22.40	-19.94
Children	-21.422	6	0.472	0.192	-21.89	-20.68
All groups	-21.296	17	0.603	0.146	-22.40	-19.94
Males and females	-21.228	11	0.676	0.204	-22.40	-19.94

Group	$\delta^{15}\text{N}$ (‰) Average	$\delta^{15}\text{N}$ (‰) N	$\delta^{15}\text{N}$ (‰) STD	$\delta^{15}\text{N}$ (‰) SE	$\delta^{15}\text{N}$ (‰) Minimum	$\delta^{15}\text{N}$ (‰) Maximum
Males	10.867	3	0.058	0.033	10.80	10.90
Females	10.050	8	0.529	0.187	9.10	10.50
Children	9.908	6	0.377	0.154	9.40	10.30
All groups	10.144	17	0.539	0.131	9.10	10.90
Males and females	10.273	11	0.585	0.176	9.10	10.90

Group	N (%) Average	N (%) N	N (%) STD	N (%) SE	N (%) Minimum	N (%) Maximum
Males	6.650	3	1.189	0.686	5.32	7.61
Females	4.548	8	1.984	0.701	2.69	8.16
Children	7.197	6	3.203	1.307	2.57	12.18
All groups	5.854	17	2.599	0.630	2.57	12.18
Males and females	5.121	11	2.001	0.603	2.69	8.16

Group	C (%) Average	C (%) N	C (%) STD	C (%) SE	C (%) Minimum	C (%) Maximum
Males	26.283	3	6.129	3.539	19.39	31.12
Females	18.166	8	6.874	2.430	10.49	28.83
Children	26.953	6	9.050	3.695	13.27	38.71
All groups	22.700	17	8.392	2.035	10.49	38.71
Males and females	20.380	11	7.414	2.235	10.49	31.12

Group	C/N Average	C/N N	C/N STD	C/N SE	C/N Minimum	C/N Maximum
Males	3.923	3	0.247	0.142	3.64	4.09
Females	4.076	8	0.514	0.182	3.53	4.90
Children	3.963	6	0.690	0.281	3.18	5.17
All groups	4.009	17	0.526	0.127	3.18	5.17
Males and females	4.035	11	0.450	0.136	3.53	4.90

TABLE 2b. Summary statistics of C and N contents in 17 Neolithic skeletons from the Vedrovice cemetery.

	F	SV effect	SV error	p	Significance	Levene	K-W p	Difference
$\delta^{13}\text{C}$ (‰)	0.26	2	14	0.774			0.654	
$\delta^{15}\text{N}$ (‰)	5.15	2	14	0.021	5%	5%	0.020	M*F,M*Ch
N (%)	2.26	2	14	0.141			0.205	
C (%)	2.67	2	14	0.104			0.069	
C/N	0.11	2	14	0.893			0.781	

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