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VÁCLAV SMRČKA, MARTIN MIHALJEVIČ, JAROSLAVA ZOCOVÁ, ONDŘEJ ŠEBEK, ALENA HUMPOLOVÁ, TOMÁŠ BERKOVEC, MARTA DOČKALOVÁ

# TRACE-ELEMENTAL ANALYSIS OF SKELETAL REMAINS OF HUMANS AND ANIMALS AT THE NEOLITHIC SETTLEMENT IN VEDROVICE (CZECH REPUBLIC)

*ABSTRACT: The chemical composition of bones in 32 animal and 10 human individuals was studied at the Neolithic settlement in Vedrovice. The contents of Ca, Mg, K, Fe, N, V, Cr, Co, Ni, As, Y, Cd, Ba, Pb, U, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu were determined by flame atomic absorption spectrometry and inductively coupled plasma mass spectrometry. The highest contents of trace elements, including the rare earth elements (REE) amongst human skeletons were detected in the group of newborns. The bone contents of the elements Zn, Pb, Mn, Fe, Cu, Mg, Cr, Co, Ni, As, Y, La, Ce, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and U follow an age growth curve. Differences in the inorganic bone content of trace elements were found amongst 32 animals (V, Ba) and the human population represented by 10 skeletons (Cu, Ni). The different composition of female skeletal remains could be associated with a different composition of females' food compared to the rest of the population.*

*The group of trace elements Pb, Cd, Yb and Lu indicates a possible impact of the external environment on the skeletons of children, newborns and wild animals related to the accumulation of these elements in forest fruits. Multi-elemental analysis of skeletal remains enables a comparison of relationships between the elements analysed that are not apparent in small groups.*

*KEY WORDS: Chemical composition – Bones – Humans and animals – Diet – Environment*

## INTRODUCTION

The Neolithic settlement and burial site at Vedrovice near Moravský Krumlov is one of the most important archaeological sites with linear pottery in Central Europe. In 1961 to 1975, V. Ondruš studied a total of 12 burials at this site (Ondruš 1961–1974), in the tract of land "Široká u lesa" in a settlement of the Linear Pottery culture (to LBK see Whittle 1996, Gronenborn 1999). For the time being, all of them can be assigned to the LBK IIa Phase (Tichý 1962). Radiocarbon dating has been used to determine the age of animal bones (pigs) at the settlement to 5990±133 BC.

Burials 1/1963 to 11/1974, and burial 2/1985 are present at the site which was located inside the area enclosed by a ditch ("Erdwerk") in the LBK IIa phase. There was a functionally regular burial site to the north of this densely populated area, where burials had been conducted continuously since the LBK period (Podborský 2002).

In addition to classical pious burials, either in a separate grave pit (Burials 4/1969 and 10/1974), in a settlement pit (Burial 1/1962) or in a construction pit (Burial 5/1971), cases have been recorded here of simple disposal by laying aside (Burial 9/1974), and of anthropophagy (Burial 11/1974). A ritual position was observed for the individuals in Burials 2/1963, 3/1966 and 6/1972. However, in these cases it was not possible to identify the grave pit because it was located at the loess subsoil level. Children predominate in these graves. Burials at settlements in separate grave pits, settlement pits, construction pits and in nonstandard positions are a relatively common phenomenon at the LBK settlements, for example at Mikulov (Unger 1974), Těšetice – Kyjovice (Dočkalová, Koštuřík 1996, Koštuřík, Lorencová 1989–1990), and Žádovice (Čižmář, Geislerová 1997).

It is highly probable that the children at Vedrovice in Burials 3/1966, 4/1969 and 5/1971 were not from the local population but from somewhere else (Smrčka *et al.* 2004, Smrčka *et al.* 2005). Both the child in Burial 5/1971 and the male in Burial 10/1974 were characterized by repeated migration. 37% of the individuals at the settlement in Vedrovice had migrated. The reconstruction of migration at Neolithic cemeteries indicates a 65% migration, e.g. in Dilligen (Bentley *et al.* 2002), especially for females. Mobility of children has been demonstrated in Grave 1 of the Bell Beaker culture at Straubing (Grupe *et al.* 1997).

The food of Mesolithic hunters and fishers can be clearly differentiated from the Neolithic population on the basis of C and N isotopes analysed in bone collagen (Tauber 1981, Richards *et al.* 2003). The skeletons at the Vedrovice settlement exhibit a range of stable $\delta^{15}$N isotopes between +8.8 and 12% and $\delta^{13}$C between –20.5 and –21.9% (Smrčka *et al.* 2004, Smrčka *et al.* 2005). This is a population that is dependent on inland plants of type C3 of the photosynthetic cycle (wheat), with various contents of proteins of vegetable and animal origin. A similar type of food had been found in Neolithic populations from the area of Denmark (Tauber 1981).

This research work was concerned with the use of multi-elemental chemical analysis to determine the contents of elements in the skeletons of human and animal populations for the purpose of reconstruction of Neolithic human and animal food at Vedrovice, and understanding the environment in which the humans and animals lived at the Vedrovice settlement and in its surroundings.

## MATERIALS AND METHODS

*Human skeletons:* From 10 human skeletons in Burials 1/1963 (child 6–8 months), 2/1963 (child 5–6 years), 2/1985 (male 20–25 years), 3/1966 (child 6–7 years), 4/1969 (child 7–8 years), 5/1971 (child 5–6 years), 6/1972 (child 3–4 years), 8/1974 (newborn), 9/1974 (female 50–60 years), 10/1974 (male 40–50 years) and 11/1974 (male 35–40 years) at the Neolithic settlement at Vedrovice, deposited in the Anthropos Institute in Brno, samples were taken from the proximal part of the femur opposite to the lesser trochanter, following the anthropological determination of age and sex.

*Animal bones:* 32 bone samples were taken (11 cattle, 8 pigs, 10 small herbivores – sheep/goats, a dog, an aurochs, a deer and an elk, following the determination of species) from the material of sites O11 (1963) and O55 (1966) of the Vedrovice settlement, deposited in the depository at Rebešovice. From animal bones samples were taken from the edge of the right side of the mandible, opposite to the second molar.

The bone fragments were cleaned from earth with a PVC brush, washed with deionised water and extracted with formic acid to remove diagenetically altered parts. After a thorough rinsing with deionised water and subsequent drying, the bone samples were ground to analytical fineness in an agate mill.

Soil samples were taken together with the bone material at the site. The samples were sieved through a sieve with mesh openings of 2 mm and dried to constant weight in the laboratory. After drying, the soil was homogenised to analytical fineness in an agate mill.

## CHEMICAL ANALYSIS

An exact weight of 0.2 g of each sample was transferred to a 50 ml volumetric flask, covered with 5 ml of concentrated $HNO_3$ and dissolved by careful heating on a heating plate at approx. 80°C. After cooling off, the volumetric flasks were filled up to the mark with deionised water. A blank was prepared with each series of 10 samples. Total mineralisation of the soil was performed as follows: An exact weight of 0.2 g of soil was annealed in a platinum bowl in a furnace (Linn, FRG) to a temperature of 450°C. After cooling off, the sample was covered with 10 ml conc. HF and 0.5 ml conc. $HClO_4$ and fumed to a damp residue in a fume cupboard. The residue was then dissolved in water in the bowl and transferred to a 100 ml volumetric flask with addition of 2 ml $HNO_3$. Merck brand acids and deionised water from the MilliQPlus (Millipore, USA) equipment were used to prepare the solutions.

The Ca, Mg, K, Fe and Na contents were determined in the mineral residues by flame atomic absorption spectrometry (SpectrAA 200HT, Varian, Australia) under the conditions recommended by the manufacturer.

The contents of V, Cr, Co, Ni, As, Y, Cd, Ba, Pb, U, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu were determined in the mineral residues by inductively coupled plasma mass spectrometry (PQ 3, VG Elemental, United Kingdom) under the following conditions: ICP power 1350 W, "peak jump" mod measurement, measuring time 3×50 s ionic optic parameters optimised by 115 In, gas flow rate 13.5 l/min cooling, 0.7 l/min auxiliary, 0.65 l/min nebuliser, internal standards In, Re, Sc. Astasol solutions (Analytika, CR) were used for calibration of both measurements.

## STATISTICAL ANALYSIS

Statistical analysis was based on 10 human skeleton samples and 32 domestic animal skeletons. Trace elements resulting from the analysis of samples from 10 human skeletons were tested statistically in groups of newborns (2 individuals), children (5 individuals), males (2 individuals), females (1) and for all the groups together. Trace elements from the samples of 32 animal skeletons were tested in groups of large herbivores (11 cattle), small herbivores (10 sheep/goats), omnivores (8 pigs) and carnivores (1 dog). The contents of the elements in the soil were not included in the statistical testing. In statistical testing, the two-sample t-test and its nonparametric form, the Mann-Whitney test, were used to compare the mean values in groups of humans and animals. The method of analysing the variance of simple classification was used to compare the mean values in each group and the nonparametric form of analysis of variance, the Kruskal-Wallis test, was used to determine the differences in the Scheff test.

The calculation was performed using the Statistica 7.0 program from the StatSoft Company.

## RESULTS

### 1. Differences in the bone contents of elements in human and animal skeletons

Higher contents of the elements Ca, Pb, Mg, Fe, K, Cu (*Figure 1A*), Ni (*Figure 2A*), La, Ce, Pr, and Nd were found in human skeletons (N=10) compared to animals, also in relation to calcium. On the other hand, higher contents of the elements Sr, V (*Figure 1B*), As, Y and Ba (*Figure 2B*) were found in animal skeletons (N=32) compared to humans, also in relation to calcium.

### 2. Bone contents of elements in the human population

The analysed human population at the settlements at Vedrovice included a group of two newborns, five children, two males and one female. We found out significant differences (p=0.044–0.002) in the bone contents of the elements Ca, Zn, Na, Cu and Ni in femurs examined in pairs by the Scheff test.

The **Ca** contents in the bones of five children (366 750 ±12 550 µg/g) differed (p=0.04) from the content in one female (305 900 µg/g), where the average for the children is higher. The average content in the whole population is 351 300±26 900 µg/g. The settlement's soil contains 41 600 µg/g Ca.

The **Sr** contents in the bones of the two newborns (337.2±114 µg/g) are higher than in the five children (279.8 ±31.51 µg/g). In these children, the Sr content is higher than in the two males (220.34±19.98 µg/g) and one female (240.61 µg/g), and the average content in the whole population is 275.5±60 µg/g. The differences between the groups are statistically significant approximately at the level

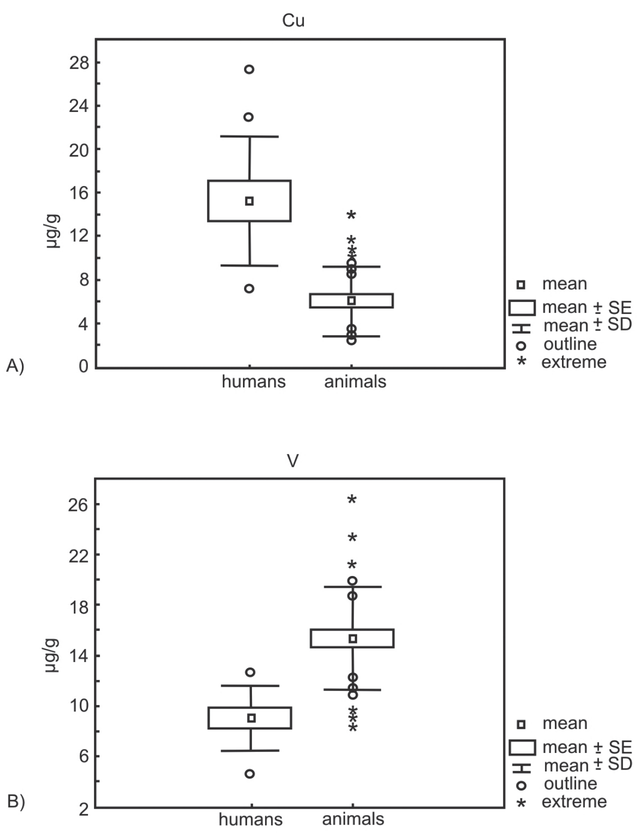


FIGURE 1 A, B. Comparison of the Cu and V contents in human and animal skeletal remains at the LBK Neolithic settlement in Vedrovice.

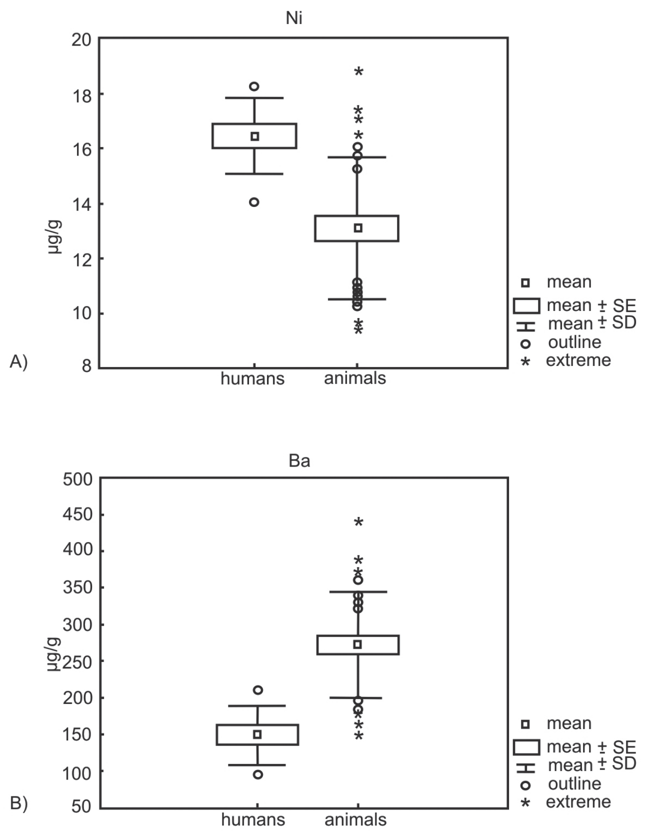


FIGURE 2 A, B. Comparison of the Ni and Ba contents in human and animal skeletal remains at the LBK Neolithic settlement in Vedrovice.

of p=0.1. The settlement's soil contains 105.5 µg/g Sr. The Sr/Ca ratio for the five children ($7.67\times10^{-4}\pm1.23\times10^{-4}$) was higher than for the two males ($6.10\times10^{-4}\pm1.59\times10^{-5}$). The ratio for the whole population equals $7.93\times10^{-4}\pm2.12\times10^{-4}$. The Sr/Ca ratio in the settlement's soil equals $25\times10^{-4}$.

The **Zn** contents in the bones of the two newborns (193.36±36.1 µg/g) are higher than in the five children (119.88 ±15.56 µg/g), two males (112.06±9.34 µg/g) and one female (101.96 µg/g). The average content in the whole population (N=10) is 131.2±37 µg/g. The differences between the groups are statistically significant at the level of p=0.01. The settlement soil contains 65.27 µg/g Zn. The Zn/Ca ratio is higher for the two newborns ($5.91\times10^{-4}$ $\pm8.8\times10^{-5}$) than for the female ($3.33\times10^{-4}$), five children ($3.27\times10^{-4}\pm4\times10^{-5}$) and two males ($3.11\times10^{-4}\pm6\times10^{-6}$). The differences between the groups are statistically significant at the level of p=0.003. The Zn/Ca ratio in the soil of the settlement equals $1.57\times10^{-6}$.

The **Na** content in the bones of the one female (3336 µg/g) is higher than in the two newborns (885.8±493.6 µg/g). The two males (2229±298 µg/g) have a higher Na content than the five children (1489±188 µg/g), the average content in the whole population is 1701.2±764.5 µg/g. The differences between the groups are statistically significant at the level of p=0.002. The settlement's soil contains 7100 µg/g Na. The Na/Ca ratio is higher for the one female ($109\times10^{-4}$) than for the five children ($40\times10^{-4}\pm4\times10^{-4}$) and two newborns ($26\times10^{-4}\pm14\times10^{-4}$ µg/g). This ratio is simultaneously higher for females than for males ($62\times10^{-4}\pm12\times10^{-4}$) and higher for males than for newborns ($26\times10^{-4}\pm14\times10^{-4}$). The differences between the groups are statistically significant at the level of p=0.001. The Na/Ca ratio equals $1708\times10^{-4}$ in the soil of the settlement.

The **K** contents in the bones of the two newborns (409.1±386.9 µg/g) are higher than in the five children (307.38±80.53 µg/g), two males (215.65±40.45 µg/g) and one female (75.12 µg/g). The average K content in the whole population is 286.1±171.4 µg/g. The K content in the settlement's soil equals 18 600 µg/g.

The **Cu** contents in the bones of the two newborns (22.06±7.5 µg/g) are higher than in the five children (15.45±4.27 µg/g), two males (11.73±1.63 µg/g) and one female (7.25 µg/g). The average Cu content in the whole population is 15.2±5.9 µg/g. The differences between the groups are statistically significant at the level of p=0.09. The settlement's soil contains 21.89 µg/g Cu. The Cu/Ca ratio for the two newborns ($67\times10^{-6}\pm20\times10^{-6}$) is higher than for the two males ($32\times10^{-6}\pm2\times10^{-6}$; $p<0.095$) and one female ($24\times10^{-6}$). The differences between the groups are statistically significant at the level of p=0.09. The Cu/Ca ratio equals $526\times10^{-6}$ in the soil of the settlement.

The **Ni** content in the bones of the two newborns (17.59±0.04 µg/g) is higher than in the five children (16.54±1.13 µg/g), two males (16.28±1.9 µg/g) and one female (14.03 µg/g), with the average Ni content in the Vedrovice settlement population of 16.4±1.4 µg/g. The Ni content in the settlement's soil equals 27.15 µg/g. The Ni/Ca ratio is higher for newborns ($54\times10^{-6}\pm2\times10^{-6}$) than for males ($45\times10^{-6}\pm4\times10^{-6}$). The differences between the groups are statistically significant at the level of p=0.07. The Ni/Ca ratio equals $653\times10^{-6}$ in the soil of the settlement.

The **Pb** content in the bones of the five children (4.91±5.20 µg/g) is higher than in the two newborns (3.78±1.91 µg/g), two males (1.09±0.87 µg/g) and one female (0.35 µg/g), with the average Pb content in the whole population of 3.5±4 µg/g. The Pb content in the settlement's soil equals 16.62 µg/g. The Pb/Ca ratio is higher for the five children than for the newborns, males and the female.

The **Cd** content in the bones of the five children (0.23±0.07 µg/g) is higher than in the two newborns (0.22±0.10 µg/g), two males (0.11±0.03 µg/g) and one female (0.06 µg/g), with the average Cd content in the whole population of 0.2 µg/g. The Cd content in the settlement's soil equals 0.35 µg/g.

The **Eu** content in the bones of the two newborns (0.194±0.062 µg/g) is higher than in the five children (127±0.044 µg/g), two males (0.098±0.009 µg/g) and one female (0.079 µg/g), with the average Eu content in the Neolithic population at Vedrovice of 0.1±0.1 µg/g. The Eu content in the settlement's soil equals 1.349 µg/g.

**3. Bone contents of trace elements in animals**

The analysed population of animals (32 individuals) included, amongst domestic animals, eleven large herbivores – cattle (Bos primigenius f. taurus), ten small herbivores – sheep/goats (Ovis ammon f. aries/Capra aegagrus f. hircus), eight omnivores – pigs (Sus scrofa f. domestica) and one carnivore – a dog (Canis lupus f. familiaris) and, from among wild animals, a deer and an elk (Cervus elaphus). Significant relationships were found amongst the contents of Zn, K, Na, Cr, Y, Cd, Ba, La, Ce, Pr, Nd , Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and U in the mandibles of these animals.

The **Ca** content in the bones of the carnivore (345 500 µg/g) is higher than in the eleven large herbivores – cattle (310 150±53 420 µg/g), in the deer and elk (301 960 ±84 160 µg/g), in the ten small herbivores – sheep/goats (301 250±53 030 µg/g) and in the eight omnivores – pigs (295 000±41 840 µg/g). The average Ca content in all examined animals is 304 170 µg/g.

The **Sr** content in the bones of the ten small herbivores (352.13±69.8 µg/g) is higher than in the eleven large herbivores (347.1±49.48 µg/g), two wild animals – deer and elk (301.6 ±126.7 µg/g), eight omnivores (292.9±24.59 µg/g) and the carnivore (285.07 µg/g). The average Sr content in the whole animal population is 330.3±59.9 µg/g.

The **Zn** content in the bones of the carnivore – dog (180.66 µg/g) is higher than in the eight omnivores (133.12±15.15 µg/g), the ten small herbivores (120.41±16.46 µg/g), the two wild animals – deer and elk (102.1±30.96 µg/g; $p< 0.009$) and in the eleven large herbivores – cattle (101.60±19.15 µg/g). The average Zn content in the whole animal population is 117.9±24.1 µg/g. The Zn/Ca ratio is significantly higher for omnivores ($463\times10^{-6}\pm40\times10^{-6}$) than for large herbivores ($332\times10^{-6}\pm3\times10^{-6}$). The differences between the groups are statistically significant at the level of p=0.035.

The **Na** content in the bones of the carnivore (2919 ±69.8 μg/g) is higher than in the ten small herbivores (2491.52±1015.38 μg/g), eight omnivores (2195±894 μg/g), the eleven large herbivores (1880±811 μg/g) and the wild deer and elk (790.6±149.30 μg/g). The average Na content in the whole population is 2114 ±149 μg/g.

The **K** content in the bones of the wild deer and elk (396.17±82.12 μg/g) is higher than in the eleven large herbivores (160.15±25.82 μg/g; p<0.007), ten small herbivores (140.8±51.50 μg/g), eight omnivores (120.59±25.82 μg/g) and one carnivore (84.27 μg/g). The average content in the entire population is 156.6±103.6 μg/g. The differences between the groups are statistically significant at the level of p=0.007. The settlement's soil contains 18 600 μg/g K.

The **Cr** content in the bones of the wild deer and elk (13.31±0.05 μg/g) is higher than in the ten small herbivores (8.31±2.58 μg/g), one carnivore (7.69 μg/g), eight omnivores (7.14±2.28 μg/g) and eleven large herbivores (6.85±1.47 μg/g). The average Cr content in the whole population is 7.8±2.5 μg/g. The differences between the groups are statistically significant at the level of p=0.007. The Cr content in the settlement's soil equals 47.19 μg/g.

The Pb content in the bones of the wild deer and elk (1.82±0.01 μg/g) is higher than in the ten small herbivores (1.02±0.6 μg/g), eight omnivores (0.9±1.0 μg/g), and eleven large herbivores (0.81±0.46 μg/g), and the average bone content in the whole population is 1.0±0.7 μg/g.

The **Cd** content in the bones of the wild deer and elk (0.46±0.27 μg/g) is higher than for the ten small herbivores (0.21±0.11 μg/g), eleven large herbivores (0.16±0.05 μg/g), eight omnivores (0.08±0.04 μg/g), and for the carnivore (0.08 μg/g), the average bone content of Cd in the whole animal population is 0.2±0.1 μg/g. The differences between the groups are statistically significant at the level of p=0.009.

The **Ba** content in the bones of the ten small herbivores (310.4±65.2 μg/g) is higher than in the eleven large herbivores (298.3±47.11 μg/g), the wild deer and elk (278.65 ±134.29 μg/g), eight omnivores (198.33±41.68 μg/g) and one carnivore (195.6 μg/g). The average bone Ba content in the entire animal population is 272.7±72.4 μg/g. The differences between the groups are statistically significant at the level of p=0.003. The K content in the settlement's soil equals 413.4 μg/g.

The **Y** content in the bones of the wild deer and elk (35.13±44.17 μg/g) is higher than in the ten small herbivores (16.67±13.48 μg/g), eleven large herbivores (9.15±8.76 μg/g), eight omnivores (3.23±5.43 μg/g) and one carnivore (0.42 μg/g). The average bone Y content in the entire animal population (N=32) is 11.4±14.7 μg/g. The differences between the groups are statistically significant at the level of p=0.031. The Y content in the Vedrovice soil equals 16.7 μg/g.

The **Eu** content in the bones of the wild deer and elk (0.267±0.129 μg/g) is higher than in the eleven large herbivores (0.147±0.058 μg/g), ten small herbivores (0.142±0.027 μg/g), one carnivore (0.120 μg/g) and eight omnivores (0.070±0.019 μg/g). The average Eu content in the entire animal population is 0.1±0.1 μg/g. The differences between the groups are statistically significant at the level of p=0.001.

The **La** content in the bones of the wild deer and elk (3.38±0.35 μg/g) is higher than in the ten small herbivores (0.698±0.39 μg/g), eleven large herbivores (0.67±0.62 μg/g), one carnivore (0.36 μg/g) and eight omnivores (0.31±0.13 μg/g). The average La content in the whole population is 0.7±0.8 μg/g. The differences between the groups are statistically significant at the level of p=0.001.

The **Ce** content in the bones of the wild deer and elk (3.57±0.85 μg/g) is higher than in the eleven large herbivores (0.88±0.996 μg/g), one carnivore (0.38 μg/g) and eight omnivores (0.37±0.06 μg/g). The average Ce content in the whole population is 0.9±1.0 μg/g. The differences between the groups are significant at the level of p=0.001. The Ce content in the settlement's soil equals 59.6 μg/g.

The **Pr** content in the bones of the wild deer and elk (0.744±0.120 μg/g) is higher than in the eleven large herbivores (0.158±0.155 μg/g), ten small herbivores (0.158±0.083 μg/g), one carnivore (0.077 μg/g) and eight omnivores (0. 064±0.027 μg/g). The average Pr content in the whole population is 0.2±0.2 μg/g. The differences between the groups are statistically significant at the level of p=0.001. The Pr content in the settlement's soil equals 8.278 μg/g.

The **Yb** content in the bones of the wild deer and elk (0.237±0.058 μg/g) is higher than in the ten small herbivores (0.076±0.040 μg/g), eleven large herbivores (0.069±0.038 μg/g), eight omnivores (0.028±0.015 μg/g) and one carnivore (0.027 μg/g). The average Yb content in the whole animal population is 0.1±0.1 μg/g. The differences between the groups are statistically significant at the level of p=0.005. The Yb content in the settlement's soil equals 1.699 μg/g.

The **Lu** content in the bones of the wild deer and elk (0.038±0.006 μg/g) is higher than in the eleven large herbivores (0.014±0.006 μg/g), eight small herbivores (0.014±0.007 μg/g), eight omnivores (0.0048±0.004 μg/g) and one carnivore (0.005 μg/g). The differences between the groups are significant at the level of p=0.005. The Lu content in the settlement's soil equals 0.249 μg/g.

## 4. Humans, animals and the Neolithic environment

Analysis of human bones from the Vedrovice settlement population for lead and cadmium (5 children, 2 newborns, 2 males and 1 female) indicated significantly elevated contents of Pb and Cd in children and newborns (*Figure 3A, B*). Similarly, amongst the animal population (2 deer, 11 large herbivores, 10 small herbivores, 8 omnivores and 1 carnivore), there were significantly elevated bone contents of Pb, Cd and of the rare earth elements (e.g. Yb and Lu on *Figure 4A, B*) in the wild animals (deer and elk).

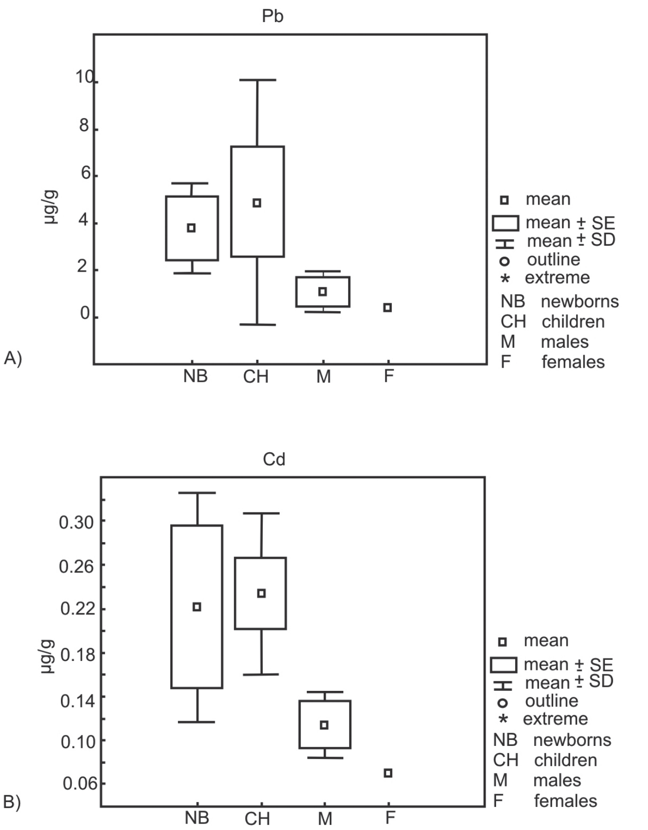


FIGURE 3 A, B. Comparison of the Pb and Cd contents in skeletal remains of population groups at the LBK Neolithic settlement in Vedrovice

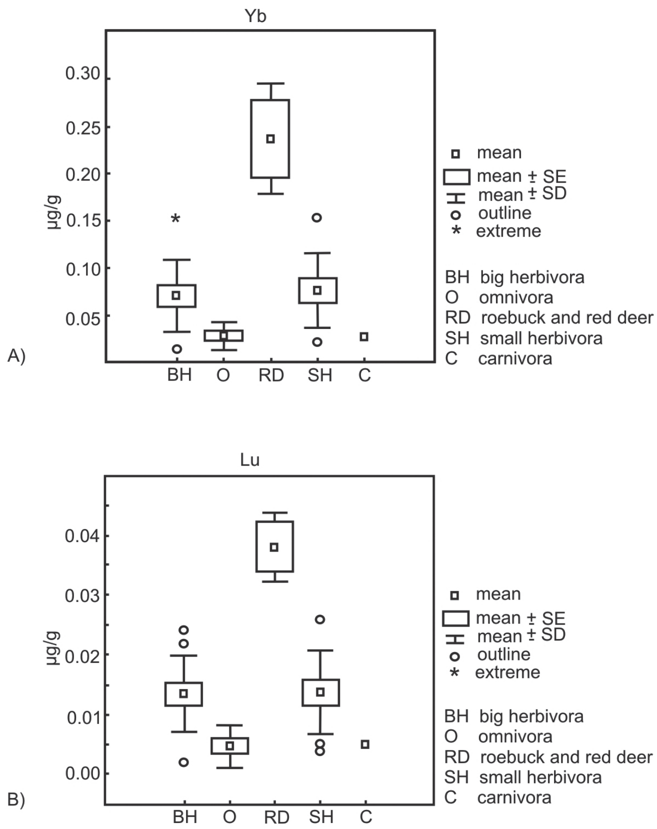


FIGURE 4 A, B. Comparison of the Yb and Lu contents in animal skeletal remains at the LBK Neolithic settlement in Vedrovice.

## DISCUSSION

The distribution of trace elements in particular groups of the human population according to age and sex, and in the animal population (large and small herbivores, omnivores and carnivores) at the Vedrovice Neolithic settlement enabled to follow up the relationships amongst these groups.

In the human population, the bone contents of the elements Zn, Pb, Mn, Fe, Cu, Mg, Cr, Co, Ni, As, Y, La, Ce, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and U follow an age growth curve with highest values for newborns, lower for children and lowest in the adult population of males and females. There are metal elements that predominate in the epiphyseal parts of bones and some of them are present as metallo-enzymes in the course of growth (Smrčka 2005). For example, the zinc concentration in the foetal plasma (umbilical vein) is significantly higher than in the mother. The placenta trophoblast is capable of concentrating zinc, leading to a higher concentration in the foetus (Simmer *et al.* 1985).

The highest values of sodium in the human population were detected in the female and in two males, and amongst animals in carnivores and omnivores (pigs). The elevated bone content of sodium in carnivores, pigs, males and the female could indicate an elevated proportion of food based on millet (Boardman 1975).

Compared to the other members of the Vedrovice population, children exhibited high concentrations of lead and cadmium. Newborns obtain part of the Cd and Pb content from their mothers through the placenta, where the degree depends on placental perfusion (Kelman, Walter 1977). The bone contents of lead and cadmium and the rare earth elements, which are elevated in children in the Vedrovice population, were similarly elevated in wild animals (deer and elk) compared to domestic animals. The most probable source of both these elements consists in the fall-out caught on forest fruits, which are subsequently eaten by children and wild animals. Concentration of heavy elements in the forest environment compared to open fields and meadows has also been demonstrated in the contemporary landscape (Ettler *et al.* 2005). It is assumed that children have a higher tendency to collect forest fruits. The food of the infants' mothers must have been supplemented with forest fruits during the pregnancy (Smrčka *et al.* 2005). The impact of the external environment, and of the fall-out, is characterised in children and wild animals (deer and elk) not only by Pb and Cd, but also by the rare earth elements, e.g. Yb and Lu (*Figure 4 A, B*).

In the animal population, V, Zn and Cu predominated in carnivores, while Sr and Ba predominated in herbivores. This confirms the detection gained from reconstruction of the food of prehistoric populations that zinc indicates food with higher amounts of proteins. In contrast, the Sr and Ba contents in the bone tissues indicate consumption of plant food. The advantage of these elements is that they are only minimally affected by diagenesis (Rheingold *et al.*, 1983).

## CONCLUSION

Multi-elemental analysis of Neolithic bone samples demonstrates relationships that are not apparent in a small range of analysed elements. Differences in the inorganic bone content of trace elements were found amongst 32 animals (V, Ba) and the human population (Cu, Ni) represented by 10 skeletons at the Vedrovice Neolithic settlement.

The highest contents of trace elements, including the rare earth elements, were found in the group of newborns amongst the human population of Vedrovice. The bone contents of the elements Zn, Pb, Mn, Fe, Cu, Mg, Cr, Co, Ni, As, Y, La, Ce, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and U are highest for newborns, lower for children and lowest in the adult population of males and females.

The group of trace elements Pb, Cd, Yb and Lu indicates a possible impact of the external environment on the skeletons of children, newborns and wild animals related to accumulation of these elements in forest fruits.

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Václav Smrčka
Institute for History of Medicine and Foreign Languages
1st Faculty of Medicine, Charles University
Kateřinská 32
120 00 Praha 2, Czech Republic
E-mail: vaclav.smrcka@lf1.cuni.cz

Martin Mihaljevič (corresponding author)
Institute of Geochemistry, Mineralogy and Mineral Resources
Faculty of Science, Charles University
Albertov 6
128 43 Praha 2, Czech Republic
E-mail: mihal@natur.cuni.cz

Jaroslava Zocová
Institute of Applied Mathematics and Information Technologies
Faculty of Science, Charles University
Albertov 6
128 43 Praha 2, Czech Republic

Ondřej Šebek
Laboratories of Geological Institutes, Charles University
Albertov 6
128 43 Praha 2, Czech Republic
E-mail: sebek@natur.cuni.cz

Alena Humpolová
Institute of Archaeology, Moravian Museum
Zelný trh 6
659 37 Brno, Czech Republic
E-mail: ahumpolova@mzm.cz

Tomáš Berkovec
Centrum of Archaeology
K. Světlé 2
771 11 Olomouc, Czech Republic

Marta Dočkalová
Anthropos Institute, Moravian Museum
Zelný trh 6
659 37 Brno, Czech Republic
E-mail: mdockalova@mzm.cz