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SKELETAL TRACE ELEMENT CONTENT AS AN INDICATOR OF DIET AND SOCIAL STATUS IN THE LA TÈNE PERIOD

ABSTRACT: Samples of compact bone from the proximal femur were taken from 161 skeletons from 9 La Tène flat inhumation cemeteries across continental Europe. Concentrations of 15 trace elements were examined in order to reveal dietary differences within and between populations. Archaeological evidence suggests that wheat was the staple cereal during this period, with roughly similar ratios of cattle, pigs, sheep and goats. Two regions can be distinguished in terms of the concentration of strontium and zinc – the French Champagne region with zinc levels below 100 ppm in dry weight and the Czech region with zinc levels over 200 ppm. The concentrations of strontium in the Czech burial ground at Kutná Hora – Karlov were significantly higher in males compared to females. In the same burial ground, potassium concentrations were lowest in the group of male "warrior" burials. Lead concentrations appear to be directly proportional to social rank, with concentrations highest in the groups of male "warrior" burials and females buried with anklets. The "poorer" graves showed concentrations of lead below 1 ppm; these include the group of graves with no grave goods, possibly evidence of Caesar's description (Commentarii de bello Gallico) of the "common people who sometimes were not far removed from slavery".

KEY WORDS: Trace elements – Bone – Diet – Social rank

INTRODUCTION

The Celts could achieve an overproduction of foodstuffs thanks to newly introduced innovations in agriculture such as the iron component of the plough, the coulter, optimisation of sowing procedures and the employment of rotary grinders. According to Caesar [IV, 20] (1972) from the region of the British Isles "…military help was sent to all the enemies of Rome from there in all the Gaelic wars", corn was probably also exported, being cultivated mainly at the coast (Caesar [V, 12] 1972). According to archaeological evidence (Čižmář 1993) wheat was the staple cereal of the Czech Celts (95%) with some barley production (3.7%), while faunal analysis reveals similar quantities of cattle (20–40%), pigs (13–35%), and sheep/goat (25–48%) (Čižmář 1993, Meniel 1987). This model of diet is valid for both the Bohemian and Moravian Celtic burial grounds in the Czech Republic (Čižmář 1993). The diet of the Germanic populations differed in some components from the Celts. Cattle were present in much higher proportions (54–68%) compared to other domestic animals, while barley and millet were the main cereal crops. Barley contains less fibrous material in its grain than wheat. In the Czech Celts, who consumed wheat in a larger proportion, a lower concentration of trace elements might occur, even in those elements that influence growth, such as zinc. This difference in the elements important for growth could manifest itself in the difference in height of the Germanic and Celtic populations. From the classical writers it was Strabo who noticed the mighty body height of the

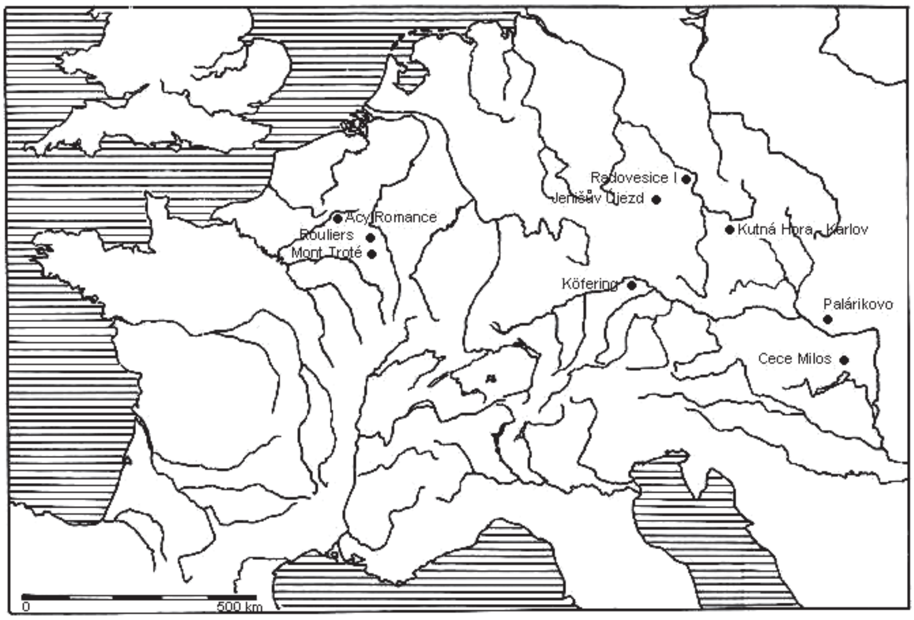

FIGURE 1. Map of observed La Tène burial grounds.

Germans (Geographica). Our own observations suggest a difference of 5 cm in adults in the burial grounds (Smrčka, Jambor 2000). Through reconstruction of diet by trace element analysis of archaeological bone tissue we can examine and compare the quality of the diet of the Celts during the La Tène period and attempt to identify social groups within La Tène society. Concentrations of strontium and zinc in archaeological bone samples were determined in a previous study (Smrčka, Jambor 2000) and were used successfully to update the model of La Tène diet.

METHOD

Bone samples were taken from 161 skeletons from 9 La Tène burial grounds (Roulier, Mont Trote and Acy Romance in France; Cece Milos in Hungary; Köfering in Germany, Palárikovo in Slovakia; Kutná Hora – Karlov, Radovesice I, and Jenišův Újezd in the Czech Republic) *(Figure 1)*. Samples of compact bone were taken from the proximal femur, against the lesser trochanter (Smrčka *et al.* 1989, Smrčka, Jambor 2000). After removal of surface layers and peri-cortical material, 200–300 mg of bone sample was digested in 5 ml nitric acid, prepared using sub-boiling distillation apparatus (BSB-939-IR, Berghof), and then diluted to 25 ml with Milli-Q™ deionised water (Millipore). Determination of trace element concentrations was carried out by emission spectroscopy: flame spectroscopy for alkaline elements, arc spectroscopy for heavy metals and inductively coupled plasma optical emission spectrometry. In addition, lead determinations were carried out by inductively coupled plasma mass spectrometry for which bone extracts were diluted 10-fold with Milli-Q™ deionised water and a terbium internal standard of 50 ppb added before analysis. Analytical precision in lead determinations was confirmed by the analysis of two international standard reference materials, NIST 1640 Water and Wageningen 2001.4 International Plant – Analytical Exchange IPE 885 – Maize. All results are expressed in ppm in dry weight of bone. Determination of mean trace element levels for individual burial grounds was carried out by statistical analysis.

RESULTS AND DISCUSSION

Reconstruction of Diet

Analysis of mean strontium and zinc values suggests two distinct Celtic regions, a French one and a Czech one (*Figure 2*). The concentration of strontium in the French region ranges between 70–250 ppm compared to 100–350 ppm in the Czech region. Zinc concentrations in the French region range between 50–140 ppm compared to 70–280 ppm in the Czech region, with Czech values rising from a geographical point of view towards the Germanic region. At Kutná Hora – Karlov in the Czech Republic, the mean strontium concentration was higher in males (211 ppm) than in females (185 ppm), statistically significant at the 95% level. A sexual division of diet can thus be suggested from the trace element data for this site, with less vegetal foodstuffs in the diet of the males.

Social differences observed in potassium concentrations

Differences in social rank during life can be related to differences in grave goods. When statistical analysis and differentiation by arrangement of the graves were applied to Kutná Hora – Karlov, the group of Celtic "warriors" had the lowest level of potassium concentrations at the 95% level of significance when compared with other grave groups and, hence, also with the social components of the

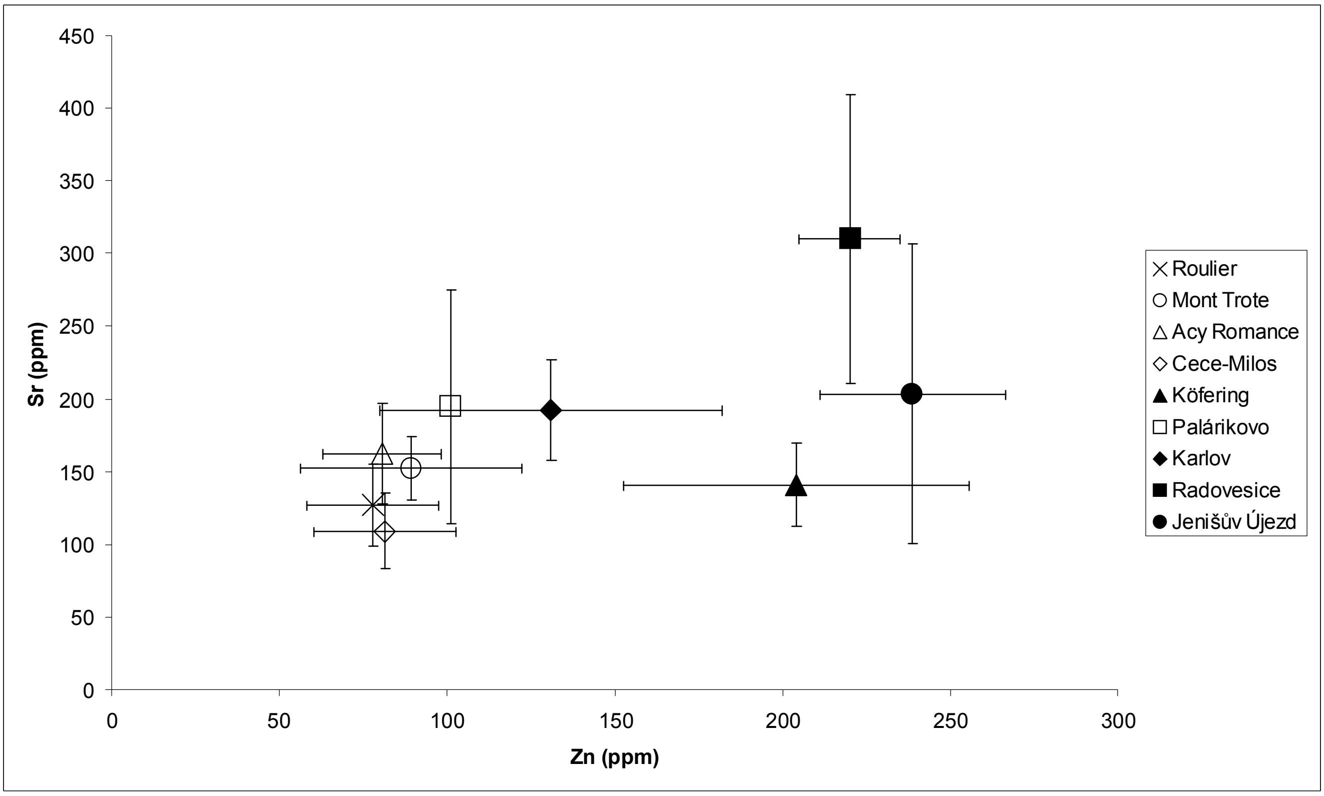

FIGURE 2. Zinc and strontium concentrations observed in human skeletal remains dating to the La Tène period. The mean and standard deviation for each site is reported in ppm in dry weight of bone.

population. Low potassium levels point to an excessive physical load, for example in Marathon runners (Wolf *et al.* 1997) and miners (Váňa, Z. *pers. comm.*), however the diuretic effects of items such as alcohol and from birch bark extracts cannot be excluded (Tobola, J. *pers. comm.*). The influence of diagenesis on potassium concentrations has not yet been adequately demonstrated.

Lead in skeletons of the La Tène period

The curve of lead concentration in European skeletons gradually rises from the Neolithic with a peak in the Roman period (Smrčka, Jambor 2000). Without taking absolute values into consideration, the course of this curve is similar to that which shows the occurrence of lead in the Greenland Ice (Rosman *et al.* 1997). Overall, concentrations of lead in bone can be seen as an indicator of this "civilisation" element in the environment (Smrčka *et al.* 1989, Jambor 1988). Differences in lead concentration can be tested to examine whether a pattern can be seen between graves with various grave goods and hence, between social groups.

Regional comparison of lead concentrations

On comparing the mean concentration in three French La Tène burial grounds, i.e. Roulier (0.68 ppm), Acy Romance (0.64 ppm), and Mont Trote (0.58 ppm), with three Czech ones, i.e. Jenišův Újezd (1.08 ppm), Radovesice I (2.165 ppm) and Kutná Hora – Karlov (1.86 ppm) there are differences between the group of French and Czech burial grounds, even though only in the overall concentration of lead. When the mean value from the Slovak site at Palárikovo (1.7 ppm) is included, an increase in concentrations towards the East is evident. The mean concentration of lead in the Hungarian site at Cece-Milos (0.9 ppm) can be compared to the French sites, while the mean concentration of lead at the German site of Köfering (1.2 ppm) can be compared to the Czech sites. Since unilaterally taken samples were included, the total averages in the La Tène burial grounds differ from the original comparative work (Smrčka, Jambor 2000).

Variation in lead concentrations within individual burial grounds

For the analysis of the variation of lead concentrations within individual burial grounds, four sites were included: the Czech burial grounds at Radovesice I (Waldhauser 1980) and Kutná Hora – Karlov (Valentová 1993), and the French burial grounds at Roulier and Mont Trote (Rozoy 1987). Concentrations of lead were calculated as the mean of the left and right femur samples, although unilateral sample values were included in the analysis.

At Radovesice I, samples were taken from a total of 18 graves (graves 1, 3, 3a, 5, 7, 8, 11, 12, 13, 14, 15, 16, 21, 22, 24, 33, 35 and 36). The highest concentrations of lead were observed in the females buried with anklets and also in the "warrior" burials. The samples taken from females buried with anklets showed concentrations of 14 ppm (grave 21), 3 ppm (grave 14) and 2.5 ppm (grave 12). A line can be drawn at the level of 1 ppm for lead concentrations which distinguishes the "rich" from the "poor" groups according to the inclusion of grave goods. Grave goods for the "poor" group include a single bracelet in grave 5 (0.45 ppm) and grave 7 (below the detection limit of 0.3 ppm); one or two brooches in grave 8 (0.3 ppm) and grave 11 (0.3 ppm); and no grave goods at all in grave 35 (0.3 ppm). Grave 24 of a female aged 30–40 at death, with several bracelets (2.5 ppm) and a male in grave 1, aged 40–50 at death, without grave goods (1.25 ppm) exceeded the distinguishing level of 1 ppm.

At Kutná Hora – Karlov the highest lead concentrations observed were in grave 45 (8.1 ppm) which contained a female buried with anklets, and grave 23 (5.82 ppm) which contained a male buried with a brooch. In six cases warrior burials had levels of lead above the level of 1 ppm (graves 10a, 14, 18, 25, 30 and 37) and in four cases a lower concentration (graves 10, 15, 17 and 19). Also, men without weapons had lead concentrations above 1 ppm in six cases (graves 1, 4, 11, 22, 23 and 41). An increased lead concentration was also found in an adolescent aged 13–17 at death, probably a male, in grave 9 (1.62 ppm). Of the graves determined as including "modest" grave goods (graves 1, 4, 5, 11, 21, 23, 40, 41, 42 and 44), only four were modest in lead concentrations, with concentrations below 1 ppm (graves 5, 21, 40 and 44).

At Roulier, grave 2 of an 18–19 year old "warrior" male (2 ppm Pb), and grave 75 of a "rich" female burial aged 18–30 at death (1.6 ppm) surpassed all other graves in terms of the concentration of lead in bone samples. Other "warrior" burials (graves 20, 28 and 68) with a lead concentration of 0.5 ppm, together with grave 2, had pork meat among the grave goods. In grave 85b, an older adult "warrior" male with only a spearhead, the concentration of lead was below the limit of detection. In terms of male burials without grave goods, grave 89a and grave 62 are below the limits of detection, while grave 85a (0.9 ppm) and grave 63 (0.62 ppm) had concentrations similar to those in warrior burials. A juvenile burial (8 years at death) from grave 8, without grave goods, showed one of the highest lead concentrations in this burial ground (1.05 ppm).

At Mont Trote, lead concentrations were all below 1 ppm. Grave 56 of a male aged 40–50 at death with a stature estimation of 167 cm, contained no grave goods and a lead concentration of 0.6 ppm; grave 87 of a juvenile aged 7–8 at death also contained no grave goods and a lead concentration of 0.57 ppm; grave 78a of a male aged 18–25 at death with only part of a sheep included in the grave had a lead concentration of 0.545 ppm. Lead concentrations in all other graves were below the limits of detection.

By extending the sample set to include unilaterally taken compact bone femur samples, it was possible to perform testing of skeletons with different grave goods in terms of concentrations of lead. Samples of cancellous bone are not included as it is most likely that these were affected by diagenetic changes.

From the lead concentration data, especially at the site of Radovesice, it appears as if social groups can be identified that include females buried with anklets and "warrior" burials with lead concentrations above 1 ppm, as well as individuals without grave goods with concentrations below this limit (with the exception of the two examples mentioned earlier: grave 1 at Radovesice and grave 23 at Kutná Hora – Karlov).

Lead in Celtic skeletons accumulated in the two richest groups within the burial grounds, peaks of the social hierarchy of the 4th to 3rd centuries BC, i.e. females buried with anklets and male "warrior" burials. Under the limit of 1 ppm were the "poor" groups including graves without grave goods. This group may include the "common people who sometimes were not far removed from slavery" as identified by Caesar [VI, 13] (1972).

Sources of lead in La Tène skeletons

There are rich veins of silver and lead in Central Europe, mainly in Bohemia; on the contrary there are none in the French Champagne region. The burial sites at Kutná Hora – Karlov, Radovesice and Jenišův Újezd are situated in areas of polymetallic ores. Exploitation activity on the central range of the Ore Mountains was documented from Radovesice I, from where polymetallic waste rock containing silver, lead, copper and tin were identified. In the area of Kutná Hora, silver, lead and especially copper are present in the waste rock (Waldhauser 1986). It was Spain, with the region of the Rio Tinto in the west and Cartagena in the east, which was the main producer of silver and lead in Classical times. The region was controlled by the Phoenicians (750–580 BC), the Carthaginians (535–205 BC), and the Romans (205 BC – 410 AD). The Phoenicians were producing 2 tons of silver per year in the period between 650 and 350 BC (Patterson 1972). The period 237–218 BC, between the first and second Punic Wars, was the time of the most intensive mining production of the Carthaginians in Spain. Isotopic analysis of the Greenland ice indicated that 70% of the lead from between the years 150 BC to 50 AD came from the region of the Rio Tinto (Rosman *et al.* 1997). Historic evidence shows that lead production from other regions was relatively small compared to Spain (Gaul 6%, Italy and Sardinia 8%, the Carpathian Mountains 10%, and the Balkans 23%) (Nriagu 1983). The curve of lead isotopes in the Greenland glacier (Rosman *et al.* 1997) is similar in form to the curve produced by analyses of lead carried out in 25 burial grounds from the Neolithic to the Early Middle Ages (Smrčka, Jambor 2000). Concentrations of lead in bone samples are thus an indicator of this "civilisation" element in the environment (Smrčka *et al.* 1989, Jambor 1988).

Greek wine can also be one of the supposed sources of lead in La Tène burial grounds, and was most likely the main source of lead in skeletons in the Roman world. Bisel

(1988) found a mean value of 125 ppm in 10 skeletons from Hellenistic Athens and a mean value of 82.7 ppm in 92 individuals from Roman Herculaneum. According to Filip (1976) there was variation in access to wine and related beverages in terms of an individual's social position. "Common" people drank beer known as "korma", brewed at home from barley, sometimes even with the addition of hops or cumin. Wine was the beverage of the "rich" in Gaul and surrounding regions, either pure or diluted with a little water. The drinking of wine was spreading in the upper social rank of the Celts in the 6th century BC and later on, during the military expeditions, this habit intensified. Ammianus Marcelinus [XV, 12] (1975) writes: "(the Gauls)…are a breed hankering after wine and drinking also various kinds of beverages rather resembling wine and among them some poor fellows benumb their senses by permanent drunkenness – which was defined by one Cato's statement as a voluntary type of madness – and without an aim they are madly dragging themselves to and fro, so that what Tullius Cicero said when defending Fonteus can become right, namely that the Gauls would drink diluted wine in the future which, so far, they considered poisonous". Sets of vessels for serving wine arrived in Bohemia in the 5th century BC (beaked pots and bowls from Hradiště at Písek). Wine amphorae dated to the 1st century BC are found in the oppida in Manching in Bavaria and Hradiště at Stradonice in Bohemia. Greek wine and wine from the south of France was imported through Massilia (Filip 1976), with Italian wine prevailing from the 2nd century BC. The wine trade with the south of France was taken over by Italian merchants. In the Bohemian barbaricon, trade contacts flourished in the 5th, 2nd and 1st centuries BC. During the 4th and 3rd centuries BC, this trade dwindled and was replaced by trade with areas from central Europe.

Differences in lead concentrations in the La Tène and Roman periods

During the Roman period from the 2nd to 4th centuries AD, mean concentrations of lead were observed in previous work ranging from 3.03 ppm in the Sarmatian Iazyges at the Hungarian site of Madarashi up to 23.8 ppm in the German burial ground of Abraham on the bank of the Danube (Smrčka *et al.* 1989). Mean concentrations of lead in 12 additional analysed sites from the Roman period, including two military camps and two towns, were rising towards the centres of civilisation and peaking in the towns of the Roman Pannonia. For example the mean concentration of 18.22 ppm at Gorsium (Smrčka *et al.* 2000) and the mean concentration of 82.7 ppm at Herculaneum (Bisel 1988). This difference in lead concentrations between town and country cannot be seen in burial grounds dated to the La Tène period with mean lead concentrations ranging from 0.6 ppm at Roulier in Champagne to 1.7 ppm at Kutná Hora – Karlov. A significant difference can thus be seen between lead exposure in the Roman and La Tène periods with greater exposure to lead in the Roman period evident from trace element analysis of archaeological bone samples.

CONCLUSION

The concentrations of strontium in the Czech burial ground at Kutná Hora – Karlov were significantly higher in males compared to females. In the same burial ground, potassium concentrations were lowest in the group of male "warrior" burials. Lead concentrations appear to be directly proportional to social rank, with concentrations highest in the groups of male "warrior" burials and females buried with anklets. The "poorer" graves showed concentrations of lead below 1 ppm: these include the group of graves with no grave goods, possibly evidence of Caesar's description of the "common people who sometimes were not far removed from slavery" (Caesar [VI, 13] 1972).

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