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DIET IN THE 1st—2nd CENTURIES ALONG THE NORTHERN BORDER OF THE ROMAN EMPIRE (A RECONSTRUCTION ON THE BASIS OF AN ANALYSIS OF CHEMICAL ELEMENTS FOUND IN SKELETAL REMAINS)

ABSTRACT — We reconstructed the diet of the people buried in the burial site of the Gerulata II military-civilian station on the Limes Romanus on the Danube River and of the people buried in two nearby Germanic burial sites in Abrahám and in Sládkovičovo.

All skeletal sets were dated to the 1st-2nd centuries A.D. 15 chemical elements were analysed and the Zn, Sr and Pb content of the skeletal materials has become the basis for the reconstruction. The population of the Sládkovičovo site used a diet based on sources with a high Zn content, probably in the form of meat and milk, while in Abrahám foodstuffs with a relatively high strontium content predominated, i.e. diet of prevailingly vegetable origin. Sr-sources used in Gerulata II were more similar to the Sládkovičovo than to those in Abrahám.

Lead content above the clinical standard of ugPb/g of dry bone weight was found in the skeleton of a child from Abrahám, and in that of an adult female and of a child in Gerulata II. In Gerulata II it has been established that the concentration of Zn, Sr and Pb in the proximal parts of the femur in the age groups up to 20 years was age-related. In the 0—2 year and 10—15 year age brackets the concentration was rising, while in the 2—10 year and 15—20 year groups the concentration of the followed elements was falling.

KEY WORDS: Diet — Roman Empire — Zinc — Strontium and lead.

The purpose of this paper has been to reconstruct the diet of prehistoric populations on the basis of chemical analyses of the elements found in human skeletal remains.

The foodstuffs forming part of funeral offerings in most cases have not been preserved under central European conditions, and if so their remains do not necessarily document the real composition of the diet in the given period.

One of the most important tasks is to determine the quantitative and qualitative changes caused by the environment following the burial.

The reconstruction of the diet is possible only with the help of elements showing minimum concentration changes due to environmental changes or changes that can be mathematically expressed. The diets of various populations can be compared under certain conditions even in cases when the representation of the individual elements of the diet is not determined: the elemental composition of the diet is possible, on the basis of the composition of the skeletal remains.

We have chosen the period of imperial Rome in view of the abundance of written information concerning the diet of the population in its territory, i.e. in view of the possible comparison of our results.

We have been especially attracted by the situation along the northern Limes Romanus, by the region of the so-called "Bratislava Gate" i.e. the gap formed by the valley of the Danube River between the Alps and the Carpathian Mountains and by the changes in the diet between the 1st—2nd centuries A. D. and 3rd—4th centuries A.D. respectively.

We studied materials in the burials from this period to be found on the territory of Czechoslovakia. In the first of them in what was Gerulata (now Rusovce, the southernmost suburb of Bratislava on the right bank of the Danube) including burial site Gerulata II (GII) dated to the period of the 1st—2nd centuries A.D.

Gerulata, a Roman military-civilian station, was situated at an important ford on the Amber Road.

On the Roman map Tabula Peutingeriana, drawn around the start of the Christian era, however, preserved in a copy made in the 4—5th century A.D., Gerulata appears as the first military camp east of Carnuntum, one of the centres of Pannonia Superior between the present Deutsch Altenburg and Petronell in Austria, east of Vienna. The GII burial ground has been archaeologically processed by Dr. Pichlerová (1977, 1981).

More to the north-east of Gerulata, in the region of the so-called Germanic Barbaricum, we studied the diet at two Germanic burial sites, one in Abrahám (AB), and the other in Sládkovičovo (SL), both dated to the 1th—2nd centuries A.D., similarly as Gerulata II (Figs. 1a, b). The latter two burial grounds were archaeologically processed by Dr. T. Kolník (1974, 1976). All the above-mentioned burial grounds were biritual; only samples from skeletal burials have been analysed.

MATERIAL

The skeletal material from the GII, AB and SL burial grounds, from which samples have been taken, is deposited at the National Museum in Prague. The anthropological description of the skeletons is by Dr. M. Stloukal, CSc., the pathological processing is by Doc. Dr. L. Vyhnánek CSc.

CHARACTERISTICS OF THE BURIALS AND OF THE SKELETAL ASSEMBLAGES

I. *Sládkovičovo*

The burial site was in use for about 100 years, namely from the twenties of the 1st century to the early 2nd century A.D. The excavated part of the burial ground yielded the remains of 88 people, six skeletal burials and 82 cremations.

The skeletal burials were situated in two groups, 25—30 m apart. They probably represent the burials of two families. In one group of graves dated to the later phase of Eggers' degree B2 there was pottery showing very close relations to the Przeworska cultural circle. It is supposed that in the course of the first-half of the 2nd century A.D. a new ethnic group appeared in the region. The cemetery originally included some 250—300 graves and the group burying its dead here was estimated at 75 members (Kolník, Stloukal 1976).

The frequency of Roman imports at the Sládkovičovo burial site is higher than that at the contemporary burial site in Abrahám.

The indicators of male burials were single- and double-edged swords, lance and spear points, spurs and the remains of a shield mounting. The female burial inventory is represented by a whorl, needles, hair pins, key and a metal mounting of Norico-Pannonian origin.

The finds of the above skeletal burials are deposited in the National Museum in Prague under inventory numbers 7,785—7,790. The classification of the skeletons according to their age and sex is shown in *Table 1*. The body height calculated in four skeletons according to the long bones in males amounts to 173 cm (grave No. 28) and to 172 (grave No. 31), while in the females it was 162 cm (grave No. 41) and 155 cm (grave No. 27). The attrition of the teeth is slight in 3 skeletons, medium in 2 skeletons and heavy in one skeleton. As regards pathological changes, degenerative diseases appear in two skeletons—spondylosis of the lumbar spine and arthritic changes in the great joints (gr. No. 27—a female of 50 to 60 years of age), spondylosis of 2nd degree of the nuchal and lumbar spine, bilateral arthritis in a male aged between 50—60 years (gr. No. 28). In grave No. 39 (a female aged 50—60) there are three carious teeth and 7 alveoli are healed following intravital loss of teeth (expert opinions by L. Vyhnánek in: Kolník, Stloukal 1976).

II. *Abrahám*

The burial site not far from Sládkovičovo, also in the Galanta District, yielded the remains of some 225 people. The site originally had some 500 graves and was used by a group of about 35 people. The burial site was used roughly for 350 years with cremation burials prevailing (94.8 per cent). The skeletal burials from which we took the samples all come from the 1st century A.D. and form a group at the centre of the eastern part of the burial site. The compass direction of the orientation of the bodies in the graves: W-E (6 x), N-S (4 x). The skeletons were in extended position, only some of them had slightly bent legs. Out of the set of 11 skeletal burials containing 12 skeletons (grave No. 135 contained the skeletons of two people, of a female and of a child) 8 skeletons were examined (see *Table 2*).

In Abrahám, too, the indicators of male graves were weapons—swords, lance and spear points, spurs and other outfits of warriors, shield mountings, flint and steel. The attributes of female graves were clay whorls, needles, a pin and needle case, ornamental pins, bracelets and combs.

No pathological changes have been described in the skeletons examined. The man found in grave No. 121 (aged 50—60) was 177.8 cm tall.

The skeletal anthropological material from Abrahám now forms part of the collections of the Anthropological Dept. of the National Museum in Prague under inventory numbers 6,122—6,249.

The Sládkovičovo and Abrahám sites are parts of important burial grounds, representing the Germanic tribe of Quades settled in the area between the Morava and Váh rivers in the 1st century A.D., and it is assumed that it is the central part of Regnum Vannia-

TABLE 1. *Age structure of the analysed skeletal material from Sládkovičovo*

Age	Infants I	Infants II	Juveniles	Adults	Matures	Seniles	Total
	0—6	7—14	15—20	20—40	40—60	over 60	
Males	0	0	0	1	1	0	2
Females	0	0	0	1	2	0	3
Unidentified	0	1	0	0	0	0	1
Total	0	1	0	2	3	0	6

TABLE 2. *Age structure of the analysed skeletal material from Abrahám*

Age	Infants I	Infants II	Juveniles	Adults	Matures	Seniles	Total
	0—6	7—14	15—20	20—40	40—60	over 60	
Males	0	0	0	0	2	0	2
Females	0	0	0	1	2	0	3
Unidentified	1	1	0	1	0	0	3
Total	1	1	0	2	4	0	8

TABLE 3. *Age distribution of the skeletal material processed in Gerulata II*

Age	Infants I	Infants II	Juveniles	Adults	Matures	Seniles	Total
	0—6	7—14	15—20	20—40	40—60	over 60	
Males	0	0	0	8	7	0	15
Females	0	0	1	4	2	0	7
Unidentified	4	9	3	2	0	2	20
Total	4	9	4	14	9	2	42

num—the Kingdom of Vannianus mentioned by Tacitus (Tejral 1969, Kolník 1971).

III. *Gerulata II*

The Gerulata II site (called "Pri cintorině") was used beginning with the second-half of the 1st century following the Markoman War. From the inventory of the graves we can conclude that it was a permanent burial site used during a period spanning 120—150 years, i.e. up to the end of the 2nd century A.D. In this period one can find here two basic rituals, the cremation of dead and burial of skeletons. In the skeletal burials skeletons lying in a prone position prevail, only some skeletons have their legs slightly bent (Pichlerová 1981). The skeletal burials used for our analysis do not represent a special chronological stratum, being contemporary with the cremation burials. The depth of the skeletal burials varied between 80 and 200 cm, but most skeletons were found at a depth of 100—150 cm, in sandy subsoil (Pichlerová, Stloukal 1977). The Gerulata II burial site was used mostly for the burial of males and children.

It is very difficult to determine the graves of soldiers in Gerulata. They were mercenaries, and thus they were not buried with their weapons. There is a principal difference between these burials and between the Germanic graves on the left bank of the Danube, where the warriors were buried with their weapons, which formed personal property (Pichlerová, personal communication). The skeletal material from which we took our samples is described in *Table 3*. The mean height of 11 males amounted to 167.7 cm the only female was 163 cm tall (Stloukal 1977—the applied method—Breitinger, Bach).

Among the diseases perceptible on the skeletons in Gerulata II, let us mention the inborn defects—spina bifida S1 and S2, open sacral canal (gr. No. XXXVII), bilateral spondylolysis L5 (gr. XXXII).

Traumata were caused by cuts (gr. L IV), healed impressions on the calva (LXIII) above the upper edge of the orbit (LXXXVI), healed fractures of ribs (LXXI), of the left clavicle (LXXVIII) and of the left radius (LXXXVIII). There was also ankylosis of a proximal interphalangeal joint (LXXI), Morbus Scheuermann (LXXXV, LXXXVI), cribra orbitalia (XXXVII) and the thinning of the right parietal bone (LXXIX [L. Vyhnánek in: Pichlerová M., Stloukal M. 1977].

METHODS

The process of reconstruction of the diet consists of four phases: 1. Taking the skeletal samples, 2. Chemical analysis of the elements contained in the samples, 3. Mathematical analysis, 4. Interpretation of the results.

1. The bone samples were taken from the greater trochanter of the femur and from the apex of the petrous bone. The samples were taken with the help of a pair of surgical forceps (Liston and Luer), taking at the same time both spongious and compact samples. As the forceps sometimes bruised and cracked, for later samples, to preserve the original structure of the bones, we took the samples with the help of a surgical saw.

TABLE 4. *The detection limits for the individual elements*

Element	Detection limit (ug/g dry weight)	Coefficient of variation (% within 95 % significance)
	Flame emission spectroscopy	
Ca	0.1	3.5
Sr	0.06	2.8
Na	0.05	2.6
K	0.08	2.1
Li	0.01	2.0
	Arc emission spectroscopy	
Co	0.5	9.5
Ti	0.04	12
Ag	0.006	8.0
Zn	9.4	14
Cu	0.035	7.3
V	0.03	7.7
Ni	0.08	6.8
Cr	0.05	9.0
Pb	0.2	8.4
Mn	1.0	9.6

2. The chemical analysis of the bone samples was by means of emission spectroscopy with flame excitation (for Ca, Sr, Na, K and Li) and spectral analysis with AC arc excitation (for Co, Ti, Ag, Zn, Cu, V, Ni, Cr, Pb and Mn). The detection limits for the individual elements are indicated in *Table 4.*

Besides bone samples analyses, of soil samples were also made, of soils from the surface and cavities of the analysed bones, of recently acquired samples of topsoil, of the interface between topsoil and loess and of the loess proper from the burial sites (*Table 12*). The samples from Gerulata II. were taken in the spring of the year 1985, from Abrahám and Sládkovičovo in June 1986.

3. For the concentration of each element in the proximal parts of the femur and in the pyramides in males, females, and children in the individual burial sites, the basic statistical characteristics were calculated. The significance of differences between means as regards sex were tested by dispersion analysis with the *t*-test.

The dependence of changes in the concentration of elements on age was evaluated graphically; in places of conspicuous depressions or steep curves we added also the statistical method of contingency tables, in comparison with the frequency of concentrations and with the critical values according to Fisher's exact test.

4. For interpretation it was necessary to determine the distribution of elements in the individual sections and layers of the long bones, to determine the occurrence and concentration of various elements in the same section in dependence on age, sex and diet. The comparison included skeletal materials from various epochs (from the 3—4th centuries and of recent cadaverous materials), material from various geographical conditions (including Egyptian Nubia). The comparisons will be subjected to a special study.

It was also necessary to compare the elemental composition of the skeletons on the one hand, with the spectrum of elements contained in the actual soil.

As basis for the evaluation of the diet we used the elements whose presence is more or less stable, both in the skeleton and also in the surrounding soil (zinc and strontium). The other elements were used for auxiliary purposes and will be assessed restrospectively with the growing number of sets. The presence of lead in the skeletons, in view of its specific character as an indicator of the contamination of foodstuffs will be described later in a special paper.

RESULTS

I. *Distribution of Elements in the Femur and in the Petrous Bone*

The mean values of the concentration of elements in the samples of the greater trochanter of the femur and of the apex of the pyramid of the petrous bone (apex partis petrosae ossis temporale) are indicated in *Tables 5—11.* The tables include indices (concentration of the given element in the sample with regards to the concentration of Ca), documenting the proportional relations among the elements.

In Gerulata II we found statistically important differences in the concentrations of Ca and Ag and in the petrous bones of males as compared with the pyramides of children.

As regards calcium, increased concentrations were registered in males compared with pyramides in children, while the skeletons of children showed significantly higher silver content (see *Table 10*), including Ag/Ca index).

TABLE 5. *Concentration of elements in the upper end of femora (greater trochanter)* (ug/g dry weight)

Elements	SLÁDKOVIČOVO			
	Male femora		Female femora	
	Mean ($n = 2$)	S	Mean ($n = 3$)	S
Ca	239,500	14,850	237,700	17,000
Sr	236	13	183	51
Na	4,650	1,900	5,770	610
K	150	42	148	68
Co	10	2.8	5.3	2.1
Ti	28.5	2.1	14.7	10.4
Ag	0.55	0.49	0.45	0.56
Zn	305	7	290	61
Cu	28	2.8	34.7	17.5
V	1.65	0.21	0.47	0.21
Ni	2.90	0.56	1.8	0.53
Cr	2.4	0.85	1.43	0,85
Pb	10	2.8	4	3
Mn	52	11,3	40.3	13.3
Indices				
Sr/Ca	0.989 . 10^{-3}	0.114 . 10^{-3}	0.774 . 10^{-3}	0,235 . 10^{-3}
Na/Ca	0.197 . 10^{-1}	0.919 . 10^{-2}	0.242 . 10^{-1}	0.986 . 10^{-3}
K/Ca	0.622 . 10^{-3}	0.138 . 10^{-3}	0.640 . 10^{-3}	0.334 . 10^{-3}
Co/Ca	0.414 . 10^{-4}	0.926 . 10^{-5}	0.229 . 10^{-4}	0.102 . 10^{-4}
Ti/Ca	0.120 . 10^{-3}	0.163 . 10^{-4}	0.639 . 10^{-4}	0.472 . 10^{-4}
Ag/Ca	0.236 . 10^{-5}	0.221 . 10^{-5}	0.200 . 10^{-5}	0.259 . 10^{-5}
Zn/Ca	0.128 . 10^{-2}	0.495 . 10^{-4}	0.123 . 10^{-2}	0.344 . 10^{-3}
Cu/Ca	0.118 . 10^{-3}	0.191 . 10^{-4}	0.149 . 10^{-3}	0.841 . 10^{-4}
V/Ca	0.693 . 10^{-5}	0.132 . 10^{-5}	0.198 . 10^{-5}	0.897 . 10^{-6}
Ni/Ca	0.120 . 10^{-4}	0.163 . 10^{-5}	0.769 . 10^{-5}	0.278 . 10^{-5}
Cr/Ca	0.102 . 10^{-4}	0.417 . 10^{-5}	0.607 . 10^{-5}	0.361 . 10^{-5}
Pb/Ca	0.422 . 10^{-4}	0.144 . 10^{-4}	0.172 . 10^{-4}	0.128 . 10^{-4}
Mn/Ca	0.219 . 10^{-3}	0.608 . 10^{-4}	0.173 . 10^{-3}	0.658 . 10^{-4}

S — *standard deviation.*

TABLE 6. *Concentration of elements in the upper end of femora (greater trochanter) and in petrous bones* (ug/g dry weight)

Elements	SLÁDKOVIČOVO			
	Femora		Petrous bones	
	Mean ($n = 6$)	S	Mean ($n = 4$)	S
Ca	234,600	15,600	281,700	52,700
Sr	203	42	149	65
Na	5,180	1,140	5,300	1,660
K	156	50	86	32
Co	8	3.5	4.5	2.4
Ti	23.0	11.9	22	9.4
Ag	0.49	0.42	0.38	0.17
Zn	312	55	305	24
Cu	33.8	12.4	40.2	12.9
V	1.07	0.68	0.48	0.25
Ni	2.32	0.71	1.70	0.75
Cr	1.88	0.83	1.08	0.66
Pb	6.17	3.76	3.25	1.5
Mn	47.2	12.5	32	14.6
Indices				
Sr/Ca	0.870 . 10^{-3}	0.191 . 10^{-3}	0.548 . 10^{-3}	0.275 . 10^{-3}
Na/Ca	0.222 . 10^{-1}	0.476 . 10^{-2}	0.2 . 10^{-1}	0.839 . 10^{-2}
K/Ca	0.674 . 10^{-3}	0.242 . 10^{-3}	0.310 . 10^{-3}	0.111 . 10^{-3}
Co/Ca	0.346 . 10^{-4}	0.157 . 10^{-4}	0.167 . 10^{-4}	0.102 . 10^{-4}
Ti/Ca	0.101 . 10^{-3}	0.551 . 10^{-4}	0.828 . 10^{-4}	0.406 . 10^{-4}
Ag/Ca	0.218 . 10^{-5}	0.192 . 10^{-5}	0.142 . 10^{-5}	0.780 . 10^{-6}
Zn/Ca	0.134 . 10^{-2}	0.317 . 10^{-3}	0.111 . 10^{-2}	0.207 . 10^{-3}
Cu/Ca	0.147 . 10^{-3}	0.616 . 10^{-4}	0.145 . 10^{-3}	0.504 . 10^{-4}
V/Ca	0.461 . 10^{-5}	0.302 . 10^{-5}	0.180 . 10^{-5}	0.106 . 10^{-5}
Ni/Ca	0.995 . 10^{-5}	0.312 . 10^{-5}	0.630 . 10^{-5}	0.334 . 10^{-5}
Cr/Ca	0.812 . 10^{-5}	0.370 . 10^{-5}	0.421 . 10^{-5}	0.304 . 10^{-5}
Pb/Ca	0.265 . 10^{-4}	0.161 . 10^{-4}	0.124 . 10^{-4}	0.740 . 10^{-5}
Mn/Ca	0.204 . 10^{-3}	0.632 . 10^{-4}	0.123 . 10^{-3}	0.668 . 10^{-4}

S — *standard deviation.*

TABLE 7. *Concentration of elements in the upper end of femora* (ug/g dry weight)

Elements	ABRAHÁM					
	Male femora		Female femora		Child femora	
	Mean ($n = 1$)	S	Mean ($n = 5$)	S	Mean ($n = 2$)	S
Ca	254,000	0	258,800	37,560	227,000	14,140
Sr	450	0	420	110	660	260
Na	6,100	0	5,640	450	6,050	70
K	790	0	206	126	96	20
Co	12	0	6	2.8	4.5	2.1
Ti	24	0	12	13	29	5.7
Ag	0.5	0	0.3	0.1	1.5	1.4
Zn	320	0	228	41	255	50
Cu	130	0	26	3.3	34	3.5
V	0.7	0	0.32	0.38	0.30	0.14
Ni	4.5	0	1.76	0.38	2.15	0.07
Cr	1.4	0	2.74	0.15	2.8	0.56
Pb	23	0	5	6.2	37.5	38.9
Mn	65	0	36.4	25.3	61	12.7
Indices						
Sr/Ca	$0.176 . 10^{-2}$	0	$0.162 . 10^{-2}$	$0.365 . 10^{-3}$	$0.296 . 10^{-2}$	$0.135 . 10^{-2}$
Na/Ca	$0.240 . 10^{-1}$	0	$0.223 . 10^{-1}$	$0.487 . 10^{-2}$	$0.266 . 10^{-1}$	$0.134 . 10^{-2}$
K/Ca	$0.311 . 10^{-2}$	0	$0.861 . 10^{-3}$	$0.623 . 10^{-3}$	$0.426 . 10^{-3}$	$0.114 . 10^{-3}$
Co/Ca	$0.472 . 10^{-4}$	0	$0.247 . 10^{-4}$	$0.158 . 10^{-4}$	$0.196 . 10^{-4}$	$0.813 . 10^{-5}$
Ti/Ca	$0.945 . 10^{-4}$	0	$0.527 . 10^{-4}$	$0.664 . 10^{-4}$	$0.128 . 10^{-3}$	$0.332 . 10^{-4}$
Ag/Ca	$0.197 . 10^{-5}$	0	$0.130 . 10^{-5}$	$0.643 . 10^{-6}$	$0.640 . 10^{-5}$	$0.580 . 10^{-5}$
Zn/Ca	$0.126 . 10^{-2}$	0	$0.909 . 10^{-3}$	$0.277 . 10^{-3}$	$0.113 . 10^{-2}$	$0.291 . 10^{-3}$
Cu/Ca	$0.512 . 10^{-3}$	0	$0.102 . 10^{-3}$	$0.263 . 10^{-4}$	$0.153 . 10^{-3}$	$0.254 . 10^{-4}$
V/Ca	$0.276 . 10^{-5}$	0	$0.140 . 10^{-5}$	$0.189 . 10^{-5}$	$0.134 . 10^{-5}$	$0.704 . 10^{-6}$
Ni/Ca	$0.177 . 10^{-4}$	0	$0.695 . 10^{-5}$	$0.196 . 10^{-5}$	$0.948 . 10^{-5}$	$0.283 . 10^{-6}$
Cr/Ca	$0.551 . 10^{-5}$	0	$0.108 . 10^{-4}$	$0.163 . 10^{-5}$	$0.124 . 10^{-4}$	$0.325 . 10^{-5}$
Pb/Ca	$0.906 . 10^{-4}$	0	$0.202 . 10^{-4}$	$0.305 . 10^{-4}$	$0.171 . 10^{-3}$	$0.182 . 10^{-3}$
Mn/Ca	$0.256 . 10^{-3}$	0	$0.153 . 10^{-3}$	$0.131 . 10^{-3}$	$0.268 . 10^{-3}$	$0.389 . 10^{-4}$

S — *standard deviation.*

TABLE 8. *Concentration of elements in the upper end of femora (greater trochanter) and in petrous bones* (ug/g dry weight)

Elements	ABRAHÁM			
	Femora		Petrous bones	
	Mean ($n = 10$)	S	Mean ($n = 5$)	S
Ca	240,100	35,650	266,200	42,200
Sr	520	170	182	28
Na	5,930	467	5,720	1,033
K	259	216	117	44
Co	7.8	5.8	4	2
Ti	21.7	14.7	19.6	10.7
Ag	0.62	0.68	0.62	0.49
Zn	255	49	290	19
Cu	55.7	46.3	65.8	50.4
V	0.6	0.79	0.3	0.24
Ni	2.31	0.94	3.1	1.8
Cr	2.75	0.62	1.12	0.53
Pb	19.7	21.7	5.6	3.5
Mn	44	21.6	27.4	15.9
	$n = 2$		$n = 2$	
Li	5.65	4.17	2.4	1.27
Indices				
Sr/Ca	$0.224 . 10^{-2}$	$0.942 . 10^{-3}$	$0.689 . 10^{-3}$	$0.984 . 10^{-4}$
Na/Ca	$0.254 . 10^{-1}$	$0.528 . 10^{-2}$	$0.217 . 10^{-1}$	$0.406 . 10^{-2}$
K/Ca	$0.112 . 10^{-2}$	$0.891 . 10^{-3}$	$0.454 . 10^{-3}$	$0.204 . 10^{-3}$
Co/Ca	$0.344 . 10^{-4}$	$0.294 . 10^{-4}$	$0.155 . 10^{-4}$	$0.821 . 10^{-5}$
Ti/Ca	$0.985 . 10^{-4}$	$0.743 . 10^{-4}$	$0.766 . 10^{-4}$	$0.452 . 10^{-4}$
Ag/Ca	$0.268 . 10^{-5}$	$0.287 . 10^{-5}$	$0.244 . 10^{-5}$	$0.211 . 10^{-5}$
Zn/Ca	$0.110 . 10^{-2}$	$0.313 . 10^{-3}$	$0.111 . 10^{-2}$	$0.193 . 10^{-3}$
Cu/Ca	$0.248 . 10^{-3}$	$0.221 . 10^{-3}$	$0.246 . 10^{-3}$	$0.186 . 10^{-3}$
V/Ca	$0.279 . 10^{-5}$	$0.397 . 10^{-5}$	$0.119 . 10^{-5}$	$0.104 . 10^{-5}$
Ni/Ca	$0.991 . 10^{-5}$	$0.433 . 10^{-5}$	$0.121 . 10^{-4}$	$0.758 . 10^{-5}$
Cr/Ca	$0.118 . 10^{-4}$	$0.376 . 10^{-5}$	$0.437 . 10^{-5}$	$0.238 . 10^{-5}$
Pb/Ca	$0.913 . 10^{-4}$	$0.104 . 10^{-3}$	$0.218 . 10^{-4}$	$0.141 . 10^{-4}$
Mn/Ca	$0.191 . 10^{-3}$	$0.102 . 10^{-3}$	$0.107 . 10^{-3}$	$0.656 . 10^{-4}$
Li/Ca	$0.215 . 10^{-4}$	$0.175 . 10^{-4}$	$0.760 . 10^{-5}$	$0.340 . 10^{-5}$

S — *standard deviation*

TABLE 9. *Concentration of elements in the upper ends of femora (greater trochanter area)* (ug/g dry weight)

Elements	GERULATA II					
	Male femora		Female femora		Child femora	
	Mean ($n = 14$)	S	Mean ($n = 6$)	S	Mean ($n = 8$)	S
Ca	263,700	34,370	286,170	27,130	246,120	43,060
Sr	178	41	214	44	199	75
Na	5,007	736	4,800	379	4,675	817
K	117	75	100	57	130	171
Co	4.6	2.6	6.2	4.9	5.8	6.8
Ti	6	4.2	3.9	2.7	8	15.2
Ag	1.01	1.06	1.19	0.94	1.2	0.89
Zn	221	75	220	67	229	68
Cu	26.7	12.1	25.8	6	33.9	9
V	0.29	0.19	0.24	0.66	0.7	1.15
Ni	1.46	0.71	1.13	0.16	1.72	1.16
Cr	0.82	0.58	0.42	0.28	1.46	2.15
Pb	19	13	18	20	26	18
Mn	28.1	13.2	29	10	33.1	14.4
	$n = 11$		$n = 7$		$n = 4$	
Li	4.9	1.6	5.4	1.2	7.5	3.9
Indices						
Sr/Ca	$0.676 . 10^{-3}$	$0.150 . 10^{-3}$	$0.748 . 10^{-3}$	$0.145 . 10^{-3}$	$0.800 . 10^{-3}$	$0.236 . 10^{-3}$
Na/Ca	$0.192 . 10^{-1}$	$0.344 . 10^{-2}$	$0.169 . 10^{-1}$	$0.225 . 10^{-2}$	$0.192 . 10^{-1}$	$0.348 . 10^{-2}$
K/Ca	$0.454 . 10^{-3}$	$0.294 . 10^{-3}$	$0.362 . 10^{-3}$	$0.217 . 10^{-3}$	$0.564 . 10^{-3}$	$0.793 . 10^{-3}$
Co/Ca	$0.178 . 10^{-4}$	$0.949 . 10^{-5}$	$0.206 . 10^{-4}$	$0.134 . 10^{-4}$	$0.259 . 10^{-4}$	$0.359 . 10^{-4}$
Ti/Ca	$0.237 . 10^{-4}$	$0.175 . 10^{-4}$	$0.138 . 10^{-4}$	$0.970 . 10^{-5}$	$0.387 . 10^{-4}$	$0.792 . 10^{-4}$
Ag/Ca	$0.389 . 10^{-5}$	$0.411 . 10^{-5}$	$0.420 . 10^{-5}$	$0.343 . 10^{-5}$	$0.499 . 10^{-5}$	$0.363 . 10^{-5}$
Zn/Ca	$0.851 . 10^{-3}$	$0.302 . 10^{-3}$	$0.778 . 10^{-3}$	$0.264 . 10^{-3}$	$0.952 . 10^{-3}$	$0.366 . 10^{-3}$
Cu/Ca	$0.103 . 10^{-3}$	$0.475 . 10^{-4}$	$0.909 . 10^{-4}$	$0.226 . 10^{-4}$	$0.142 . 10^{-3}$	$0.486 . 10^{-4}$
V/Ca	$0.112 . 10^{-5}$	$0.810 . 10^{-6}$	$0.856 . 10^{-6}$	$0.270 . 10^{-6}$	$0.328 . 10^{-5}$	$0.603 . 10^{-5}$
Ni/Ca	$0.563 . 10^{-5}$	$0.267 . 10^{-5}$	$0.402 . 10^{-5}$	$0.805 . 10^{-6}$	$0.733 . 10^{-5}$	$0.585 . 10^{-5}$
Cr/Ca	$0.316 . 10^{-5}$	$0.233 . 10^{-5}$	$0.151 . 10^{-5}$	$0.105 . 10^{-5}$	$0.654 . 10^{-5}$	$0.112 . 10^{-4}$
Pb/Ca	$0.725 . 10^{-4}$	$0.514 . 10^{-4}$	$0.656 . 10^{-4}$	$0.723 . 10^{-4}$	$0.101 . 10^{-3}$	$0.572 . 10^{-4}$
Mn/Ca	$0.108 . 10^{-3}$	$0.509 . 10^{-4}$	$0.102 . 10^{-3}$	$0.374 . 10^{-4}$	$0.140 . 10^{-3}$	$0.676 . 10^{-4}$
Li/Ca	$0.195 . 10^{-4}$	$0.720 . 10^{-5}$	$0.197 . 10^{-4}$	$0.439 . 10^{-5}$	$0.330 . 10^{-4}$	$0.225 . 10^{-4}$

S — *standard deviation.*

TABLE 10. *Concentration of elements in petrous bones* (ug/g dry weight)

Elements	GERULATA II					
	Male petrous bones		Female petrous bones		Child petrous bones	
	Mean ($n = 10$)	S	Mean ($n = 4$)	S	Mean ($n = 10$)	S
Ca	287,300	39,890	261,000	13,340	242,300	14,340
Sr	138	36	160	53	146	57
Na	5,940	850	4,410	2,840	5,470	1,270
K	66	30	81	23	174	177
Co	4	2.8	3.2	1.9	3.3	2.4
Ti	5.1	2.9	3	1.4	6.6	9.2
Ag	0.48	0.3	1.4	1.5	0.9	0.5
Zn	229	42	205	85	201	59
Cu	57	86	31	9.8	35	19
V	0.34	0.28	0.2	0.12	0.46	0.5
Ni	1.37	0.74	1.18	0.57	1.51	1.06
Cr	0.48	0.35	0.46	0.37	1.02	1.26
Pb	22.1	13.5	11.5	15.1	16.6	11.4
Mn	20.1	12.7	18	11.4	15.9	9.8
	$n = 8$		$n = 3$		$n = 9$	
Li	4	1.4	4.7	2.1	9.4	8.7
Indices						
Sr/Ca	$0.485 . 10^{-3}$	$0.126 . 10^{-3}$	$0.606 . 10^{-3}$	$0.172 . 10^{-3}$	$0.598 . 10^{-3}$	$0.215 . 10^{-3}$
Na/Ca	$0.211 . 10^{-1}$	$0.475 . 10^{-2}$	$0.172 . 10^{-1}$	$0.114 . 10^{-1}$	$0.225 . 10^{-1}$	$0.488 . 10^{-2}$
K/Ca	$0.236 . 10^{-3}$	$0.130 . 10^{-3}$	$0.312 . 10^{-3}$	$0.980 . 10^{-4}$	$0.746 . 10^{-3}$	$0.812 . 10^{-3}$
Co/Ca	$0.141 . 10^{-4}$	$0.917 . 10^{-5}$	$0.124 . 10^{-4}$	$0.703 . 10^{-5}$	$0.137 . 10^{-4}$	$0.101 . 10^{-4}$
Ti/Ca	$0.186 . 10^{-4}$	$0.114 . 10^{-4}$	$0.114 . 10^{-4}$	$0.507 . 10^{-5}$	$0.270 . 10^{-4}$	$0.366 . 10^{-4}$
Ag/Ca	$0.169 . 10^{-5}$	$0.113 . 10^{-5}$	$0.515 . 10^{-5}$	$0.551 . 10^{-4}$	$0.370 . 10^{-5}$	$0.198 . 10^{-5}$
Zn/Ca	$0.809 . 10^{-3}$	$0.181 . 10^{-3}$	$0.782 . 10^{-3}$	$0.308 . 10^{-3}$	$0.837 . 10^{-3}$	$0.268 . 10^{-3}$
Cu/Ca	$0.209 . 10^{-3}$	$0.326 . 10^{-3}$	$0.120 . 10^{-3}$	$0.409 . 10^{-4}$	$0.145 . 10^{-3}$	$0.790 . 10^{-4}$
V/Ca	$0.125 . 10^{-5}$	$0.108 . 10^{-5}$	$0.770 . 10^{-6}$	$0.452 . 10^{-6}$	$0.186 . 10^{-5}$	$0.197 . 10^{-5}$
Ni/Ca	$0.499 . 10^{-5}$	$0.279 . 10^{-5}$	$0.450 . 10^{-5}$	$0.213 . 10^{-5}$	$0.630 . 10^{-5}$	$0.438 . 10^{-5}$
Cr/Ca	$0.173 . 10^{-5}$	$0.132 . 10^{-5}$	$0.177 . 10^{-5}$	$0.139 . 10^{-5}$	$0.424 . 10^{-5}$	$0.524 . 10^{-5}$
Pb/Ca	$0.784 . 10^{-4}$	$0.509 . 10^{-4}$	$0.432 . 10^{-4}$	$0.562 . 10^{-4}$	$0.694 . 10^{-4}$	$0.480 . 10^{-4}$
Mn/Ca	$0.713 . 10^{-4}$	$0.446 . 10^{-4}$	$0.684 . 10^{-4}$	$0.418 . 10^{-4}$	$0.663 . 10^{-4}$	$0.417 . 10^{-4}$
Li/Ca	$0.141 . 10^{-4}$	$0.530 . 10^{-5}$	$0.179 . 10^{-4}$	$0.809 . 10^{-5}$	$0.405 . 10^{-4}$	$0.392 . 10^{-4}$

n = number of skeletons, S — *standard deviation*

TABLE 11. *Concentration of elements in the upper end of femora (greater trochanter) and in petrous bones* (ug/g dry weight)

Elements	GERULATA II			
	Femora		Petrous bones	
	Mean (n = 34)	S	Mean (n = 30)	S
Ca	263,000	42,000	265,000	36,000
Sr	186	53	144	44
Na	4,791	778	5,370	1,400
K	141	203	115	118
	n = 33		n = 29	
Co	5.27	4.2	3.9	2.7
Ti	5.62	7.9	5.69	6.6
Ag	1.09	0.96	0.78	0.71
Zn	220	68	214	58
Cu	28.1	9.7	40.9	51.6
V	0.37	0.59	0.38	0.36
Ni	1.4	0.76	1.38	0.79
Cr	0.84	1.15	0.71	0.84
Pb	19.1	15.5	17.6	13.4
Mn	29	12.3	19.4	12.8
	n = 27		n = 25	
Li	6.5	3.8	6.3	5.7
Indices				
Sr/Ca	$0.708 . 10^{-3}$	$0.174 . 10^{-3}$	$0.549 . 10^{-3}$	$0.166 . 10^{-3}$
Na/Ca	$0.184 . 10^{-1}$	$0.334 . 10^{-2}$	$0.206 . 10^{-1}$	$0.589 . 10^{-2}$
K/Ca	$0.601 . 10^{-3}$	$0.105 . 10^{-2}$	$0.466 . 10^{-3}$	$0.537 . 10^{-3}$
Co/Ca	$0.204 . 10^{-4}$	$0.191 . 10^{-4}$	$0.149 . 10^{-4}$	$0.102 . 10^{-4}$
Ti/Ca	$0.234 . 10^{-4}$	$0.403 . 10^{-4}$	$0.221 . 10^{-4}$	$0.263 . 10^{-4}$
Ag/Ca	$0.423 . 10^{-5}$	$0.377 . 10^{-5}$	$0.302 . 10^{-5}$	$0.266 . 10^{-5}$
Zn/Ca	$0.843 . 10^{-3}$	$0.296 . 10^{-3}$	$0.824 . 10^{-3}$	$0.241 . 10^{-3}$
Cu/Ca	$0.109 . 10^{-3}$	$0.446 . 10^{-4}$	$0.158 . 10^{-3}$	$0.195 . 10^{-3}$
V/Ca	$0.154 . 10^{-5}$	$0.304 . 10^{-5}$	$0.147 . 10^{-5}$	$0.144 . 10^{-5}$
Ni/Ca	$0.546 . 10^{-5}$	$0.351 . 10^{-5}$	$0.537 . 10^{-5}$	$0.319 . 10^{-5}$
Cr/Ca	$0.341 . 10^{-5}$	$0.580 . 10^{-5}$	$0.280 . 10^{-5}$	$0.348 . 10^{-5}$
Pb/Ca	$0.723 . 10^{-4}$	$0.555 . 10^{-4}$	$0.681 . 10^{-4}$	$0.523 . 10^{-4}$
Mn/Ca	$0.112 . 10^{-3}$	$0.518 . 10^{-4}$	$0.741 . 10^{-4}$	$0.495 . 10^{-4}$
Li/Ca	$0.274 . 10^{-4}$	$0.214 . 10^{-4}$	$0.256 . 10^{-4}$	$0.259 . 10^{-4}$

S — standard deviation

TABLE 12. *Elements in the soil of burial grounds* (ug element/g soil)

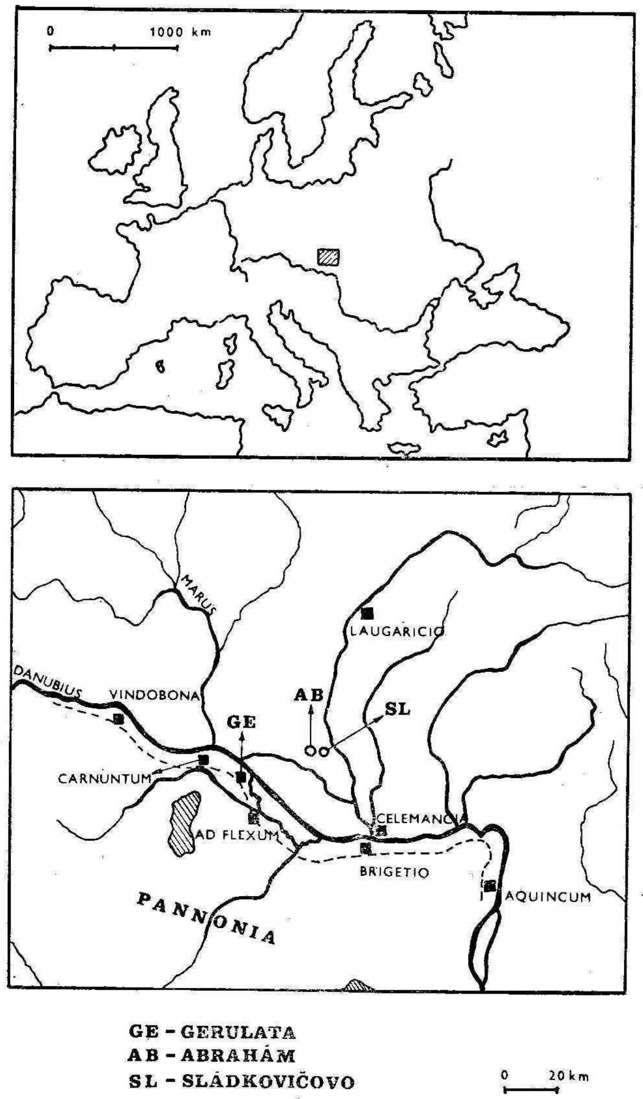
Elements	ABRAHÁM			SLÁDKOVIČOVO			GERULATA II	
	topsoil	topsoil and loess interface	loess	topsoil	topsoil and loess interface	loess	topsoil basis	intact sand
	0.2 m	0.3 m	0.4 m	0.3 m	0.4 m	0.6 m	0.6—0.8 m	1 m
Ca	93,000	86,000	116,000	28,000	55,000	54,000	97,000	104,000
Sr	109	120	145	28	42	40	82	101
Na	135	144	139	125	77	106	149	87
K	2,450	1,800	1,000	2,480	1,580	1,220	1,050	500
Li	1.68	1.59	1.41	1.50	1.89	1.98	1.61	0.98
Co	80	60	50	40	25	10	45	25
Ti	2	2	1	1	2	2	5	4
Ag	1.5	0.5	0.4	0.2	0.4	0.1	1.3	0.4
Zn	15	20	10	25	20	10	30	15
Cu	30	27	16	33	30	24	22	17
V	8	6	3	7	7	6	9	4
Ni	35	17	12	32	10	8	10	8
Cr	1	1	0.5	0.6	0.8	1.2	1	0.5
Pb	18	15	11	15	14	12	15	10
Mn	230	200	110	180	170	100	150	120

Note: It concerns soil leaches up to 1M HNO_3.

II. *Relations between Diet-related Elements*

Relations between Zn and Sr in the individual burial sites are expressed in graphs (*Figs. 1, 2, 3*). The graphs represent the sets of the concentration of zinc and strontium in femur and in the apex of the petrous bone.

According to the Zn/Sr graph with Sládkovičovo females diets containing zinc predominate, with Abrahám females there is more strontium.



FIGURES 1a, b. *The burial sites analysed with regard to the situation on the Limes Romanus in the 1st—2nd centuries A.D.*

Gerulata II occupies an intermediate position in the zinc-strontium graph. Zn supply is relatively high, although not as high as in Sládkovičovo.

Tables 5—11, indicating the mean concentration of elements, and *Graphs 2—4*, representing the set of absolute concentration values, are supplemented by bar charts (*Figs. 5, 6 and 7*), containing the minimum and maximum values of Zn, Sr and Pb concentrations in males, females and children in the burial sites studied.

The relations between the concentrations of Ca and Sr in femur and in the petrous bones of males, females and children in Gerulata II are in *Graph 8*, the relations between the concentrations of Na and Sr are in *Graph 9*.

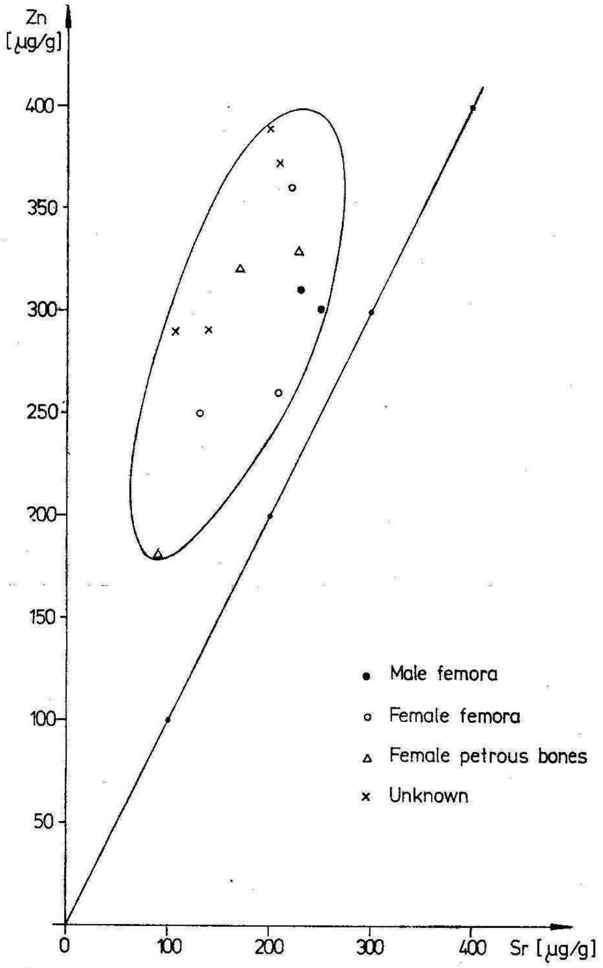


FIGURE 2. *The share of sources of Zn and Sr. in the diet as reflected by the content of the above elements in the femur and in the apex of the petrous bone in Sládkovičovo.*

III. *Age-related Concentration of Elements in the Proximal Parts of the Femur in Gerulata II*

As the skeletal material from Gerulata II comes from almost all age categories, we were able to compare the dependence of the concentration of elements on age and to describe the acceleration of growth for the proximal part of the femur in the 0—20 years age bracket.

For Zn and Sr the dependence of concentration on age is expressed in graphs (*Figs. 10, 11*). In these elements and in Pb we found a significant dependence of the increase of concentration in the 0—2 and 10—15 years groups, $\langle 0, 2) \wedge (10, 15\rangle$.

The concentration decreased in the age brackets $\langle 2, 10) \wedge (15, 20\rangle$.

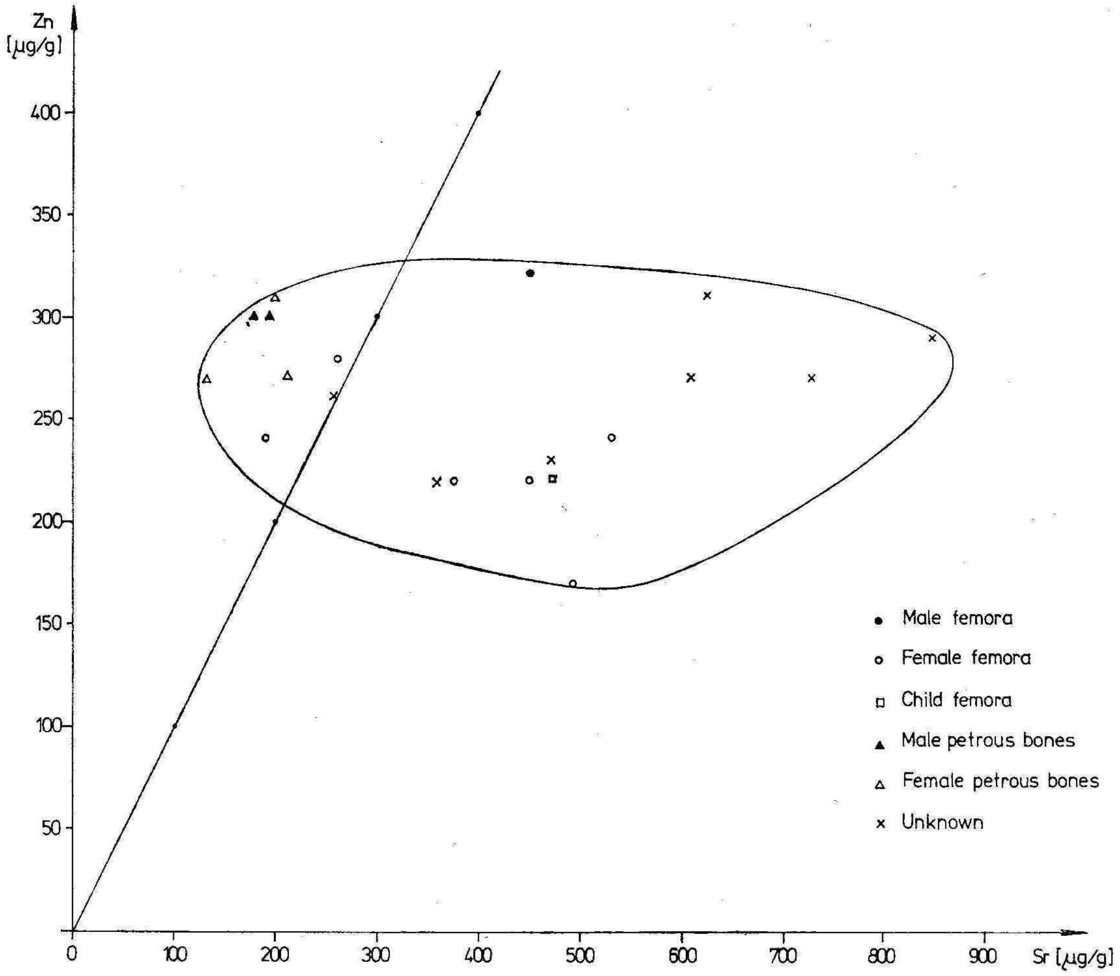


FIGURE 3. *The share of animal and vegetable sources of diet in Abrahám expressed with the help of a Zn—Sr graph in the sets of femora and apices of petrous bones.*

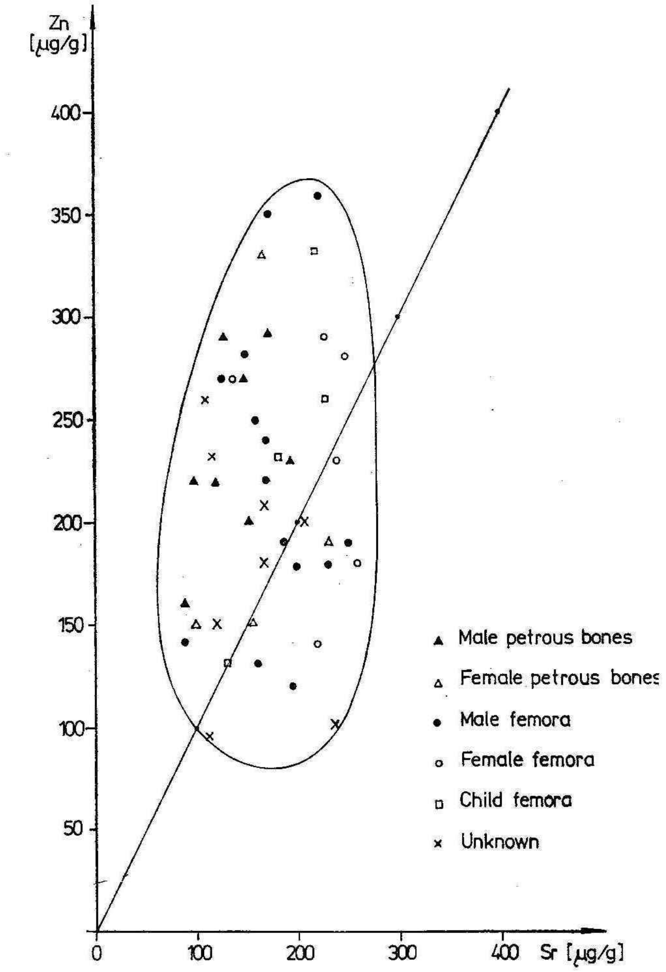


FIGURE 4. *The share of animal and vegetable sources of diet in Gerulata II as expressed with the help of a Zn—Sr graph in the sets of femora and apices of petrous bones (for clarity only the femora are pictured).*

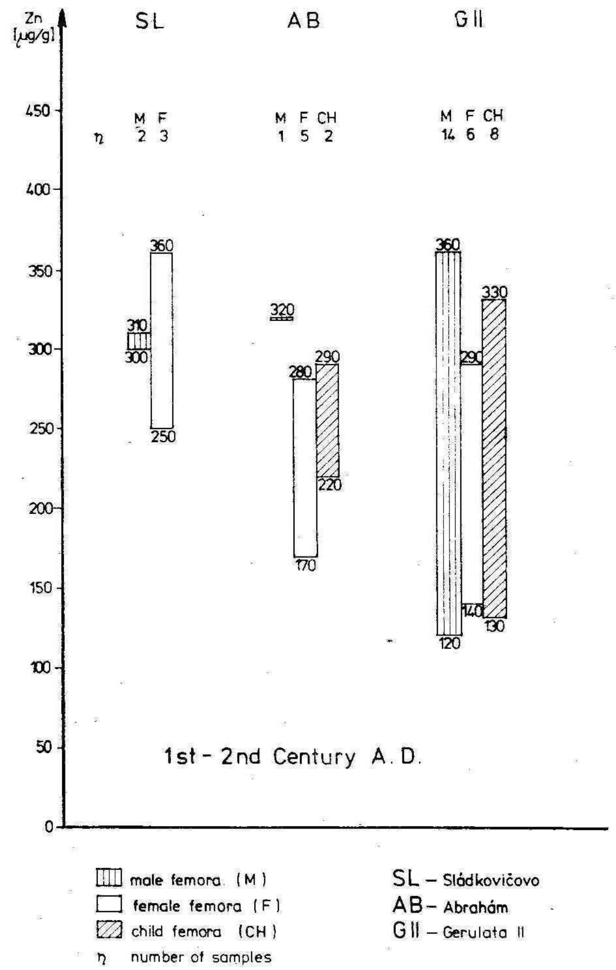


FIGURE 5. *Review of intervals of the minimum and maximum concentrations of zinc in adult males, females and in children.*

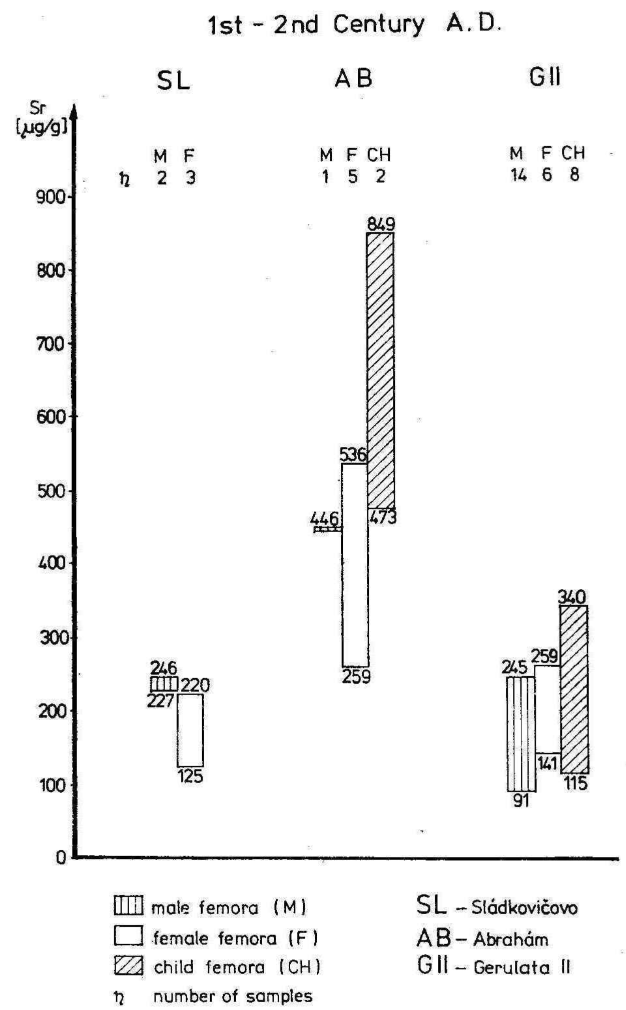


FIGURE 6. *Review of intervals of minimum and maximum concentrations of strontium in adult males, females and children.*

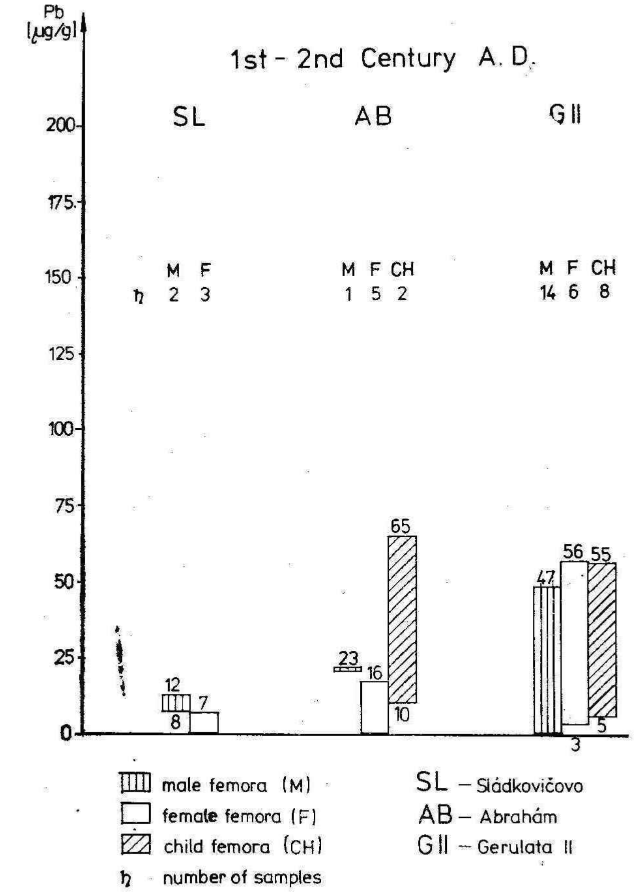


FIGURE 7. *Review of intervals of minimum and maximum concentrations of lead in adult males, females and in children.*

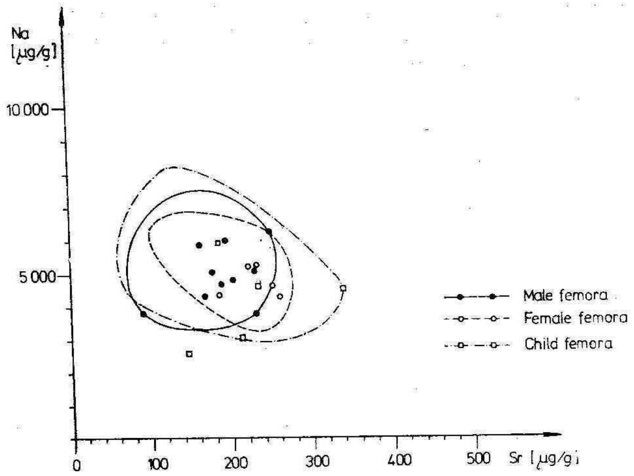


FIGURE 8. *Relations between the concentrations of Na and Sr in the femora of adult males, females and children in Gerulata II.*

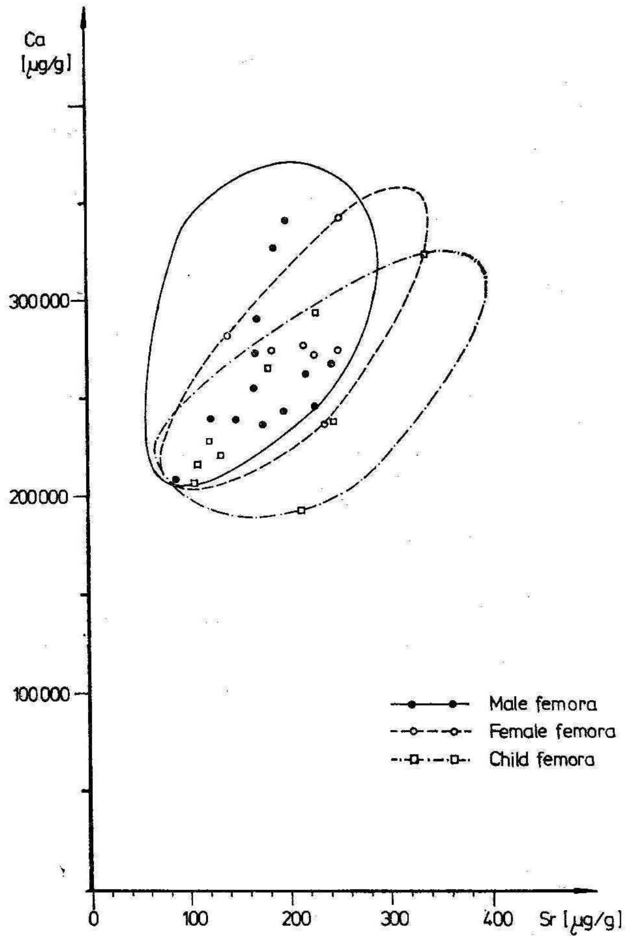


FIGURE 9. *Relations of the concentrations of Ca and Sr in the femora of adult males, females and children in Gerulata II.*

In other elements, i.e. in Ca, Cu and Na indicated in the graphs (*Figs. 12, 13* and *14*) no statistical dependence was proved.

IV. *The Spectrum of Elements Present in the Soil of the Burial Sites*

In *Table 12* we can see the concentration of elements in the soil of the individual burial sites. The samples have been taken from the topsoil, from the interface between topsoil and loess, and from the loess proper. The elements contained were analysed in extrakt in 1 M HNO_3. The elements in the soil of the burial sites in Abrahám, Sládkovičovo and Gerulata II did not appear in extraordinary concentrations as compared with similar types of soils.

DISCUSSION

1. *Inorganic Elements in Diet*

The results of our experiments agree with the conclusions of numerous authors, advocating the suitability of using Zn and Sr for the reconstruction of diet (e.g. by Gilbert 1985, Lambert 1984). In the survey of the contamination of bones by soil, Zn appears minimally (Jambor, 1988).

The level of zinc content is relatively high in meat, nuts and molluscs. Nuts contain large quantities of minerals and can conceal the role of other sources of minerals.

Strontium appears in larger amount in vegetable tissues, and once it was an important element used for the reconstruction of diet (Wing, Brown 1979). While Sr and Zn come from natural sources, i.e. from foodstuffs proper, Pb mostly comes from secondary sources, i.e. vessels, tubes, glaze used in the pottery and food ingredients. The study of Pb content provides important pathological information that can prove useful in an anthropological context (Lambert 1984).

2. *Results of the Chemical Analysis of Inorganic Elements Following from the Comparison of Old Germanic Diet (in SL and in AB) with the Roman Provincial Diet in GII*

It follows from a comparison of *Graphs 2 and 5* that in the diet of the people represented by the skeletal set of the Germanic burial site in Sládkovičovo there was a prevalence of foodstuffs containing a high proportion of zinc (including meat proteins), and, that it had relatively low strontium content (coming from vegetable tissues). This is very much in line with Caesar's comments on the eating habits of the Germanic tribes (Bell. Gall 6), that "they are not particularly interested in farming and that their diet consists mostly of milk, cheese and meat". According to Kolník (1977) these ethnic groups had arrived recently. Probably those groups were oriented mainly toward cattle breeding.

Cattle was the principal source of food, the most important domestic animal of the Germanic peoples.

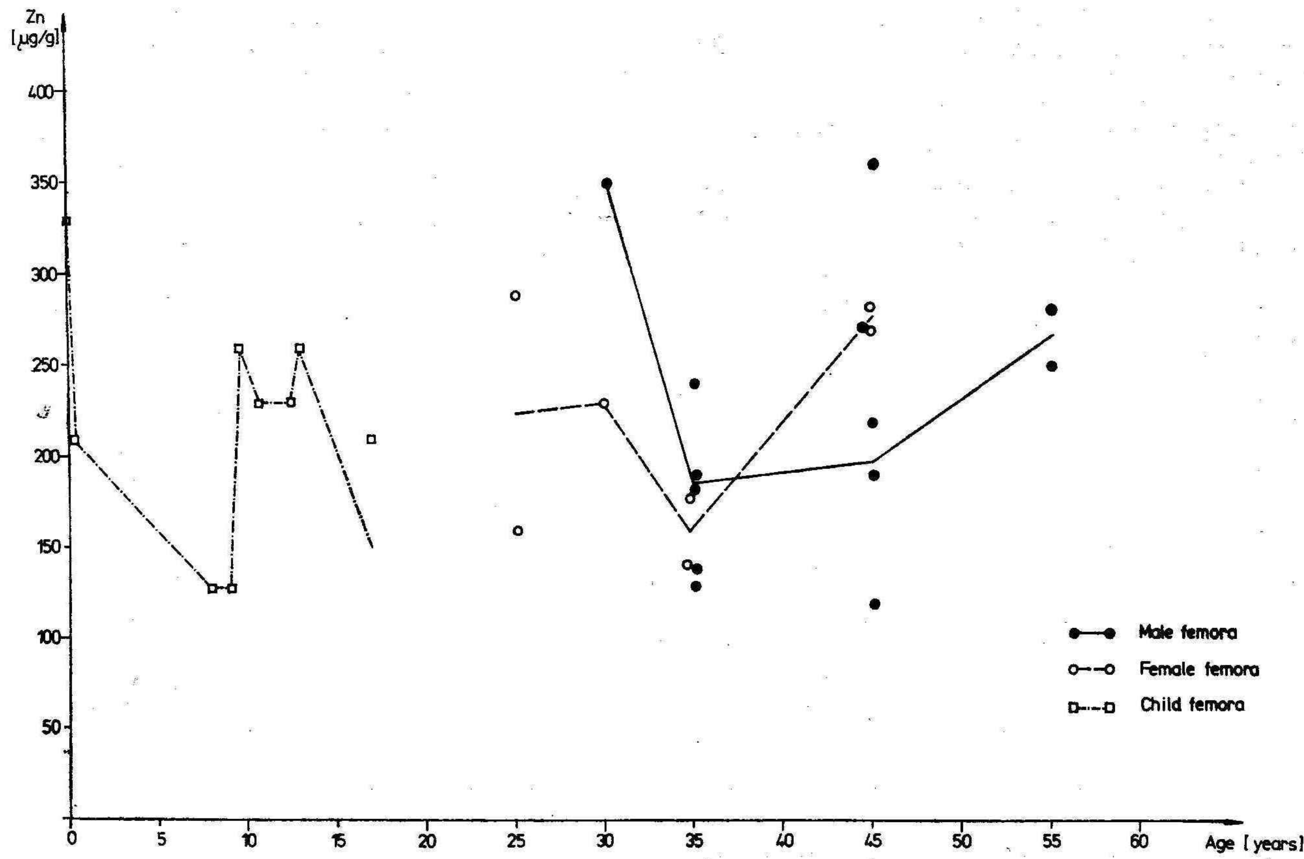


FIGURE 10. *Age-related concentration of Zn in the proximal part of the femur in Gerulata II.*

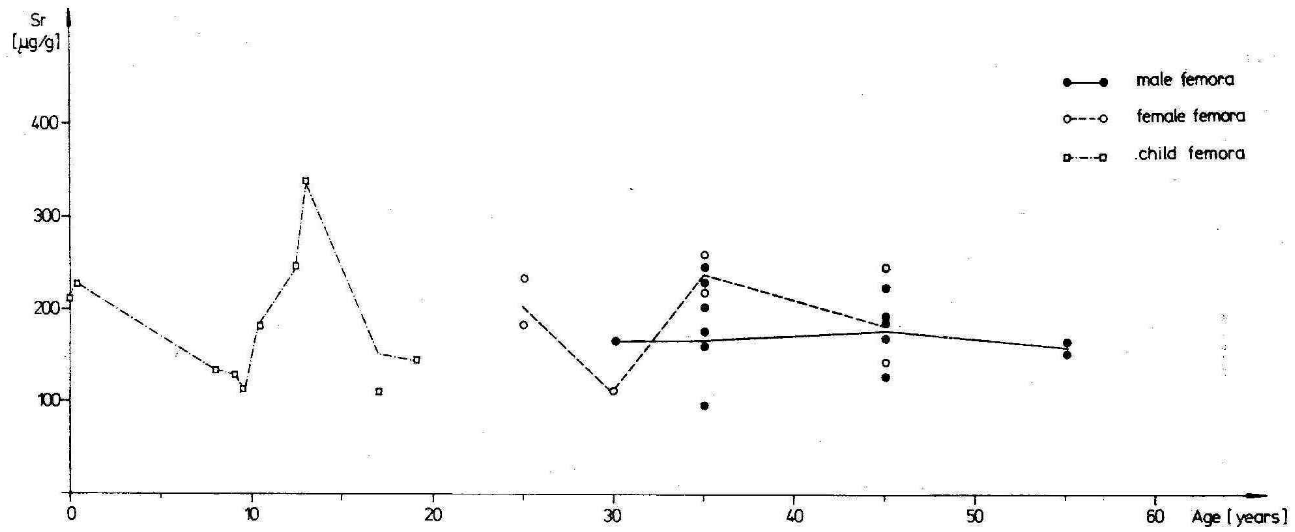


FIGURE 11. *Age-related concentration of Sr in the proximal part of the femur in Gerulata II.*

Cattle bones are strongly prevalent in the finds of refuse in the Germanic settlements. The Germanic peoples kept a short-horned type of cattle, in line with the report by Tacitus.

Cattle supplied the Germanic peoples with meat, but they also kept cows for milk, and also served as draught animals. Second to cattle were sheep and goats, especially in places with out a shortage of pasture land and with no deciduous forests. In wooded areas the second place following cattle was occupied by pigs, kept free and thriving on beech nuts, acorns, etc. (Beranová 1980). Nevertheless, farming formed in the given period an organic part of the food production, especially in the vicinity of the Roman provinces boasting advanced agriculture.

Not far from Sládkovičovo, at the Germanic burial site of Abrahám, of the same dating, we found large amounts of strontium in the skeletons, especially in those belonging to children. The zinc content with Abrahám females is lower than with those in Sládkovičovo and similar to the zinc content in Gerulata II. (*Tab. 5, 7, 9*)

We presume that the diet of the population in Abrahám contained more vegetables acquired through farming or just by gathering the vegetables.

Although our comparisons cover only a small fragment of Germanic burial sites, and we did not analyse the finds in the cremation burials, it seems that there could have been differences in the diet in two contemporary localities, not too far apart.

The diet in Gerulata II was characterized by a high zinc content, even if its mean value was lower than in Germanic settlements. The sources of strontium in the diet in Gerulata II had a similar strontium con-

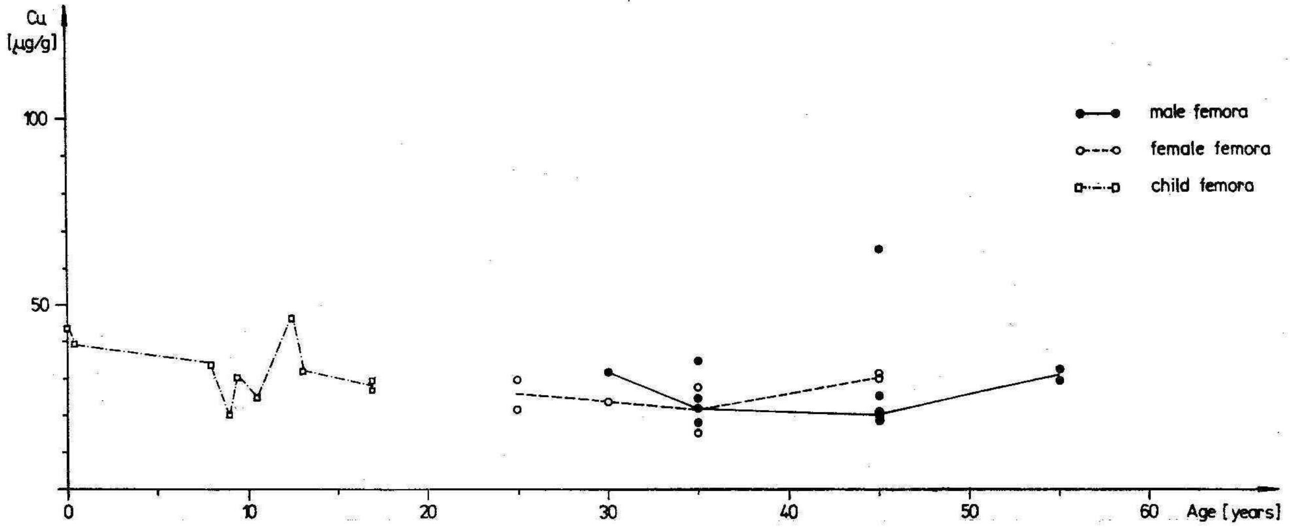


FIGURE 12. *Age-related concentration of Cu in the proximal part of the femur in Gerulata II.*

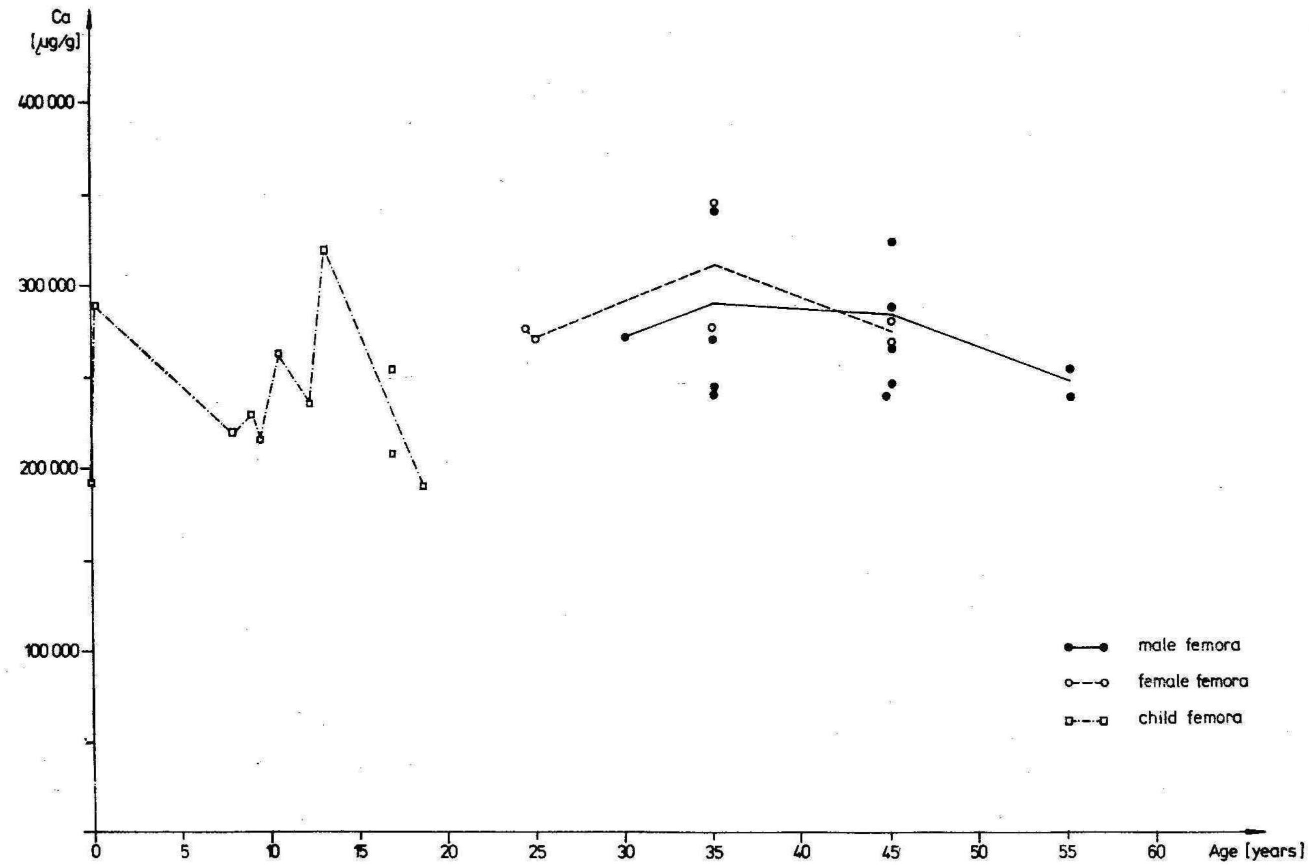


FIGURE 13. *Age-related concentration of Ca in the proximal part of the femur in Gerulata II.*

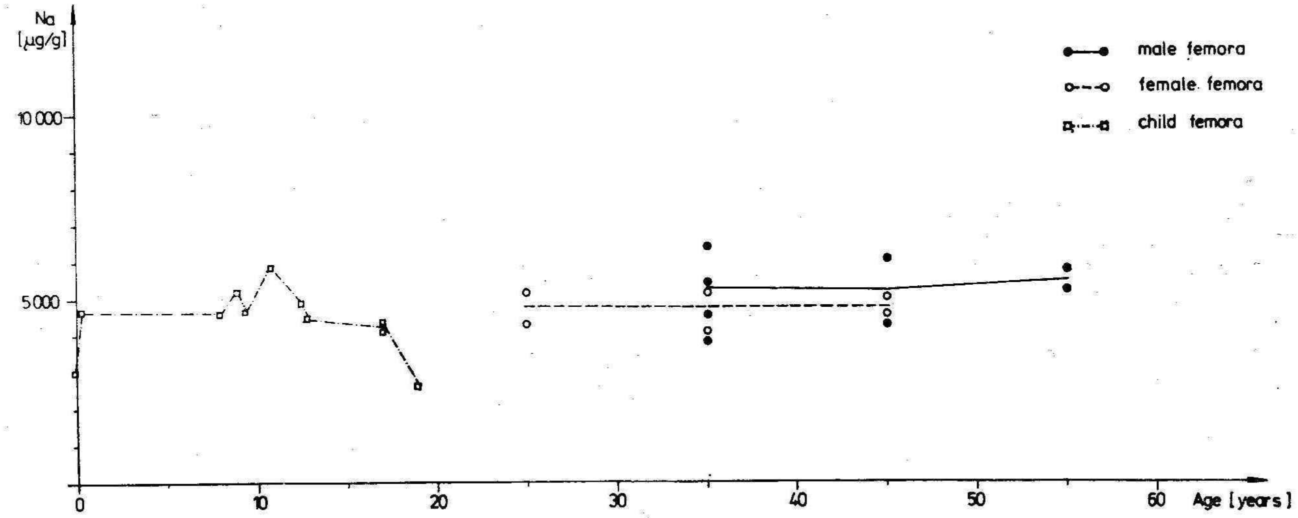


FIGURE 14. *Age-related concentration of Na in the proximal part of the femur in Gerulata II.*

centration to that in Sládkovičovo (*Tabs. 6, and 11*). In GII no cattle bones were found. Of course, a certain amount of foodstuffs was also acquired through trade and barter (Dobiáš 1964). *Tables 9 and 10* and *Graph 10* show that the diet of males in Gerulata II contained more calcium than that of the children; the finds of the apex of petrous bones show significantly higher Ca content in adult males than in children. On the other hand, in the diet of females and children in GII we find richer sources of Sr than in that of the males.

3. *The Exposition of the Inhabitants of Gerulata II and of the Surrounding Barbaricum to the Effects of Lead*

The concentration of lead in the soil of all burial sites studied is relatively stable (*Table 12*), varying between 10—18 ug Pb/g of soil. According to the information by Dr. Pichlerová and Dr. Kolník, directing the archaeological research in the above-mentioned localities (SL 1966—67, AB 1966—68, GII 1968—76), the area of the burial sites was not disturbed by any construction activities, either in the Middle Ages, or in modern times. The fields covering the burial sites were used for growing maize and potatoes. There are no mines in the vicinity. Chemical fertilization of the fields started as late as the year 1967 (information by Karol Godovič, Abrahám No. 6).

When one compares intervals of absolute values in *Graph 7*, the level of Pb content is conspicuously high in the children in Abrahám and in Gerulata II. In the age group up to 20 years we detected age-related concentration of Pb. It is quite possible that in the given age-bracket the lead was absorbed from the soil, but there were similar changes also in the Zn and Sr concentration, which is supposed to be stable with regards to the environment.

In the group of adults the highest Pb content was registered in Gerulata II, indicating that the provincial Roman population had more contact with lead than the Germanic peoples living on the other side of the border.

The level of 50 ug Pb/g in dry bone matter, deprived of fat, is accepted as standard. Above this value there appear symptoms of clinical poisoning (Patterson et al. 1987). This level is surpassed by the concentration of Pb in the skeletons of children in Abrahám (grave 135b), Gerulata II (grave LXIV), and in the skeleton of the female from Gerulata II (grave No. XX).

4. *Age-related Differences in the Deposition of Elements in the Bones*

The significant differences in the concentration of Ca in the apices of petrous bones between adult males and children are probably connected with a diet containing various amounts of calcium (see *Table 10*).

We do not have sufficient data for the interpretation of higher Ag concentrations in the apices of petrous bones of children compared with adult males.

The significant increase in the concentration of Zn, Sr and Pb in the proximal parts of femora in GII in dependence on age is reminiscent of the anthropometrically determined stages of growth acceleration (Nováková—Hloušková 1984).

It seems that these stages of the acceleration and stabilization of growth explain the increased content of the above elements in the proximal parts of femora. This situation is documented by the level of the inorganic elements:

1. growth spurt	0—2 year bracket
2. stabilization of growth	2—10 year age bracket
3. growth spurt	10—15 year age bracket
4. stabilization	15—20 year bracket

CONCLUSION

In the 1st—2nd centuries A.D. different sources of diet were used along the Roman Limes and in the Barbaricum beyond it.

Various types of diet were ascertained in two contemporary and close Germanic burial sites with foodstuffs with a prevalence of Zn content in Sládkovičovo, and with prevailing Sr content in Abrahám, being the differences more evident with Germanic females.

As zinc comes mainly from meat and strontium is of vegetable origin, we can conclude that in Sládkovičovo a meat diet predominated, while the diet in Abrahám contained mainly products of vegetable origin, obtained through farming or collection. Sr-sources in Gerulata II on the Limes Romanus was more similar to that of Sládkovičovo than to that of Abrahám. However, the foodstuffs in Gerulata II were more contaminated with lead than the foodstuffs used by the Germanic peoples.

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