Chemical Analysis: A tool for differentiation between human and nonhuman bones

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Introduction

Forensic anthropologists play an important role in the identification or exclusion of human remains recovered amongst animal remains and environmental ruins[1]. Accurate separation techniques are needed as small animal bone fragments can easily be mistaken for human neonatal or infant remains[2]. Distinguishing between human and animal bones is easily done if the remains found contain distinctive gross morphological features related to the specific species[1,2]. In the absence of these anatomical characteristics, different methods have to be explored to enable the investigator to accurately determine the origin of the remains in question. A difference in the element distribution of carnivores and herbivores has previously been indicated. This is linked to the major differences found in the diets followed by the various groups[3]. Work done by Toots and Voorhies (1965) indicated significantly lower strontium (Sr) levels in carnivore bones as compared to herbivore bones. They suggested that these differences occur due to the animals' food prevalence, as high strontium levels exist in vegetation[4].

Aim

The aim of this study was to compare the chemical composition of herbivores, omnivores and carnivores to determine possible grounds for the separation of humans (omnivores) from that of other animal skeletal material (carnivores and herbivores). As part of a larger MSc, attention will also be given to the histomorphometrical analyses of human and animal bones.

The observed group consisted of dry bone samples removed from the anterior diaphysis of femora and tibiae collected from juvenile and adult humans as well as herbivorous, carnivorous and omnivorous animals (Table 1). The estimated ages of the juveniles included ranged between 3-14 years with an average of 7.33 years (SD±5.24). Bone samples were removed according to stipulations by Maat et. al.[5] The average elemental composition of each of the individual species was measured with a scanning electron microscope (SEM) fitted with an electron dispersive spectrometer (EDS) system, housed at the microanalysis laboratory at the University of Pretoria. An example of the results of such an analysis of a human femur is shown in Figure 1.

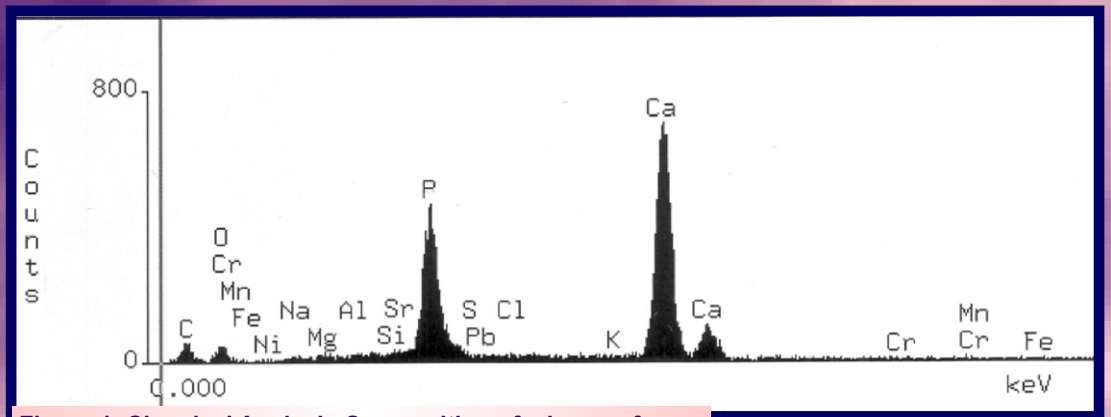

Figure 1. Chemical Analysis Composition of a human femur

Table 1. Samples used from the various groups

	Species	Femora (N)	Tibiae (N)	Total (N)
Omnivores	Humans	20	7	27
	Juveniles	3	3	6
	Pigs (*Sus scrofa domestica*)	6	6	12
Carnivores	Cats (*Felix catus*)	4	4	8
	Dogs (*Canis lupus familiaris*)	6	6	12
	Baboons (*Papio ursinus*)	3	4	7
Herbivores	Cows (*Bos taurus*)	5	5	10
	Sheep (*Ovis aries*)	5	5	10
	Donkeys (*Equus caballus*)	6	6	12
	Impala (*Aepyceros melampus*)	3	2	5
	Total	**61**	**48**	**109**

N = number of bones

Results

The results obtained from the SEM/EDS analysis is summarized in Table 2

Table 2. Average elemental composition (%) of carnivores, on

Elements	Carnivores Mean (%)	SD	Omnivores Mean (%)	SD	Herbivores Mean (%)	SD
Potassium (K)	0.10	0.06	0.11	0.08	0.05	0.04
Calcium (Ca)	70.88	0.56	72.17	0.70	71.95	0.51
Phosphate (P)	23.18	0.30	23.38	0.38	24.90	0.29
Silicon (Si)	0.04	0.03	0.05	0.04	0.03	0.02
Aluminum (Al)	0.03	0.01	0.05	0.02	0.02	0.01
Sodium (Na)	0.42	0.09	0.33	0.10	0.44	0.09
Magnesium (Mg)	0.32	0.06	0.29	0.06	0.42	0.06
Chloride (Cl)	0.21	0.06	0.14	0.08	0.10	0.05
Sulphur (S)	0.29	0.11	0.21	0.13	0.13	0.08
Zinc (Zn)	0.24	0.29	0.50	0.53	0.17	0.20
Lead (Pb)	4.25	4.19	2.75	3.77	1.76	2.66
Strontium (Sr)	0.04	0.06	0.04	0.06	0.04	0.04
Total	100.00		100.00		100.00	

SD = Standard deviation

Discussion

These results indicate no significant difference in the potassium, strontium and magnesium content of the combined groups of herbivores, carnivores and omnivores. Thus, these results do not confirm the findings of Toots and Voorhies. Statistically significant differences ($p<0.05$) are however present in the lead content of herbivores and omnivores, which may be used as starting point in separating herbivores from omnivores. Further analysis will be carried out to determine if any other statistically significant differences exist with regards to the remaining elements.

Conclusion

The results obtained from the elemental analysis indicated no significant differences amongst the various groups, except for the lead content in herbivores and omnivores, although subtle differences exist. Therefore this technique may not be sufficient on its own for the separation of human and animal remains; however positive results have been noted for the separation of bone and tooth remains found amongst environmental debris and other unknown materials. It seems possible that bone composition is too non-specific to yield significantly different values, and that the inter-individual variability is too high due to differences in the diet of individual animals. More research is needed.

Further investigation regarding the histomorphometrical features present in bones slides of the various groups will be carried out as this may be useful in the separation of human and nonhuman bones.

Acknowledgements

We could like to thank Mr. L de Villiers from Veterinary Sciences for the donation and maceration of animal bones as well as Dr A Oettlé from the Deparment of Anatomy for allowing the use of her animal bones. Our appreciation goes to Mr A Botha from the Microanalysis Laboratory and Mr. Erick from the Department of Anatomy for their technical assistance.

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