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CRANIAL VARIATION AND MICROEVOLUTION IN TWO EARLY MIDDLE AGE SITES FROM CROATIA: PRIVLAKA AND STARI JANKOVCI

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The analysis of 41 male skeletons recovered from two Early Middle Age sites in Eastern Slavonia, Privlaka and Stari Jankovci, provides data on population structure and the effects of ecological and cultural change on biological adaptation. A discriminanmt function analysis of 13 cranial measurements based on a sample of 150 skulls from the same temporal and spatial provenience was performed with the aim of determining the racial affinity of the individuals from the two analysed sites. The analysis correctly assigned race in 73.3 % of the sample (range from 64-80 %). In view of the large number of groups discriminated (n=6), this compares favourably to results achieved by other authors. Application of the discriminant functions to the analysed sample shows diferential racial presence and representation in the two sites. Paleodemographic data also indicates different mean ages at death, both between the two sites and between the various populations present in them. Skeletal markers of nutritional stress, dental pathology, trauma and occupational stress are evenly distributed. Different mean ages at death are related to disease selection in the presence of endemic tuberculosis. Cranial variation between the two sites is interpreted through thr effects of microevolutionary forces; natural selection and gene flow.

INTRODUCTION

In the past, physical anthropologists have traditionally ascribed changes in cranial metric values to migrations or intrusive populations. In recent years, however, much has been learned about microevolutionary processes in human groups and polygenic characteristics as, for instance, body size or head form have been shown to change under preassure of microevolutionary forces such as selective deaths or selective fertility. As a result of rigorous studies carried out on living populations, utilizing population genetic theory and integrating cultural and biological data, the processes of genetic change, particularly with reference to natural selection, gene flow and gene drift, have been fairly well defined and quantified for several gene loci (Neel 1970).

Living populations obviously possess striking advantages regarding this type of analyses, among them, a large and increasing quantity of biochemical and physiological polymorphisms with known modes of inheritance, knowledge of demographic variables and the availability of geneological and cultural data. On the other hand, while it is true that the best results for the problem of microevolutionary change have been obtained from living groups, it is also true that the only direct avenue for temporal studies of human groups lies in their skeletal remains. Unfortunately, few of the advantages taken for granted in studies of living populations apply to skeletal remains. There are few known variations in the skeletal system which obey simple mendelian laws of inheritance. Much of the time cultural and demographic data are inadequate, and geneological relationships among members of the population under study can seldom be obtained. The result of this is that we still know very little about the evolutionary or adaptive significance of craniometric variation. Despite the outlined disavantages, however, skeletal remains have not made the contributions to microevolutionary studies that they deserve. Three additional reasons which hamper efforts in this direction can be cited. First, there has been limited realisation of the importance of comparing groups contiguous in time and space. Second, until quite recently, there has been a reluctance on the part of many investigators to utilize precise statistical multivariate methods in the interpretation of their data. Third, as yet no clear and universally accepted research strategy for microevolutionary interpretation of human osteological archaeological data has been formulated. The latter results from the fact that microevolutionary mechanisms include natural selection, gene flow and gene drift, all of whose operations and interactions in human populations are conditioned largely by cultural factors (Coon 1950). As a consequence of this different categories and classes of data need to be collected, analysed and synthesised.

From the anthropological point of view skeletal maturation, bone response to acute and chronic developmental stress, and the form and distribution of pathological changes are important measures of the ability of a human group to deal with the problems of enviormental constraints. Demographic information, especially that definig longevity, also mesures adaptive efficiency, and is therefore crucial to the correct interpretation of the data.

Equally critical to the the proper interpretation of inherited and enviormentally influenced skeletal atributes is the archaeological context of the burial series. This includes determination of subsistence strategy and settlement patterning, the collection and analysis of grave goods, and the determination of interregional trade and possible migrations as an indirect measure of population interaction.

The successful microevolutionary interpretation of cranial morphological change through time, therefore, requires an inclusive "bio-archaeological" perspective.

Excavations carried out by prof. M. Šmalcelj from 1973 to 1988 in eastern Slavonia have yielded considerable quantities of skeletal material. This material is particularly amenable to microevolutionary analysis for several reasons. First, it is circumscribed in time and space, ranging from about A.D. 650 to 800, and spacially to a very small area; the skeletal material was located in two Avaro-slav cemeteries, Privlaka and Stari Jankovci who are separated from each other by about 8 kilometers. Second, the material is archaeologically defined as belonging to the same culture, the Late Avar period characterised archaeologically by griffin and tendril belt-mounts (Šmalcelj 1973: 118 and 1976: 127; Šmalcelj, pers. communication). Finally, the skeletal series in question represents a racially heterogenous mixure including memebers of various Caucasoid populations as well as members of Mongolian race. This heterogenity, combined with implied migration and enviormental changes, presents a situation conducive to biological change. In this paper I attempt to quantiffy the variability existing between the populations present in these two sites, and explore it's significance in terms of microevolutionary change.

MATERIAL

The osteological material selected for analysis originates from two archaeological sites, Privlaka and Stari Jankovci, located in south-eastern Slavonia, approximately 10 km. south-east of the town of Vinkovci.

The Privlaka site, situated south of Vinkovci and south-west of Stari Jankovci was excavated by prof. M. Šmalcelj in 1973 and from 1976 to 1980. The cemetery is characterised by graves aligned in (more or less) parallel rows. Alltogether, 230 graves were excavated which represents at least 75% of the complete cemetery (Šmalcelj, pers. communication). Based on archaeological material the site is dated to between A.D. 700 to 800 (Šmalcelj 1976: 127). Together with the site of Stari Jankovci, this site defines the southern border of the Avar state during the Late Avar period. Because of strong soil acidity and the effects of underground water the osteological material is in a poor to moderate state of preservation.

The Stari Jankovci site, located south-east of the town of Vinkovci and approximatelly 8 km. north-east of Privlaka, was excavated by prof. M. Šmalcelj from 1986 to 1988. The site was extensively devasted and only about 30% of the site was excavated. The 89 graves which were excavated yielded archaeological material which dated the site to between A.D. 650 to 750 (Šmalcelj, pers. communication).The osteological material found was in an excellent state of preservation.

One of the main goals of this investigation is to determine the specific populations present in these two archaeological sites. The period of Avar domination in the Carpathian basin, which lasted from 568 to 811 A.D., was characterised by an extreme heterogenity of various Caucasoid and Mongoloid populations. The ethnic conglomerate of the Avars consisted of various Central Asian tribes which, during the course of their migration from Central Asia to the Carpathian basin, assimilated various populations from the South Russian steppe belt. Following the destruction of the short-lived Gepid kingdom in 568 A.D. the Avars settled the Carpathian basin and absorbed the still remaining Germanic, Gepid and Langobard populations. If one adds to these the "Pannonian" Bulgars of the 5 th century whose existence was deduced by Simonyi (Simonyi 1959), and the still remaining romanised autochthonous populations, then, clearly, the term Avars must in fact be construed to imply an ethnically heterogenous Avar Period population. To further complicate the situation, the dresses, ornaments and arms brought by the politically dominant Central Asian tribes spread far and wide across the Carpathian basin so that all archaeological criteria by which the different populations could be distinguished disappeared within a few decades.

The preceeding short outline of Avar ethnogenesis and history amply illustrates why the only possible means of determining the specific populations present in the sites of Privlaka and Stari Jankovci lies in the analysis of skeletal attributes specific to the various populations present in these sites. Two basic approaches have been used by physical anthropologists to attribute race or population to unknown skeletal material. Nonmetric skull racing is based on the evaluation of specific cranial and dental morphological traits. This method is often prefered to metric analysis as it requires no expensive or delicate equipment. It can be accomplished rapidly, without elaborate laboratory equipment, and there are many features that can be assessed. Metric skull racing is based on the statistical analysis and comparison of craniometric data. The introduction of multivariate statistical methods, particularly discriminant function analysis, greatly contributed to the effectivnes of this method. Giles and Elliot, for instance, achieved a racial identification accuracy of 86.7% for males and 89.8% for females when discriminating between the three major races: Caucasoid, Mongoloid and Negroid (Giles and Elliot 1962).

One major drawback is, unfortunately, common to both of these methods. The accuracy of race determination depends, in both cases, on the presence of a previously constructed, relatively large, data base of "racially known" skulls belonging to the same populations. This fact was perhaps best illustrated by Birkby (Birkby 1966) and Snow (Snow et al. 1979), who applied the Giles and Elliot discriminant functions to populations other than those that they were calculated from. The accuracy of racial assesment that they achieved was significantly lower (66.1% and 14.3% respectively) than that reported by Giles and Elliot.

Returning now to the problem of racial assessment of Avar period skeletal series, it becomes obvious that a relatively large data base of previously racially determined skulls is a neccessary prerequisite. Anthropological analyses of Avar period populations were first begun in 1929 by Bartucz (Bartucz 1929) and were continued by such authors as Liptak, Wenger and Toth. These investigations confirmed the heterogenous composition of all Avar period sites and determined the presence of six major population groups: the Brachycephalic group (which includes numerous subpopulations such as the Armenoid, Alpine and Dinaric populations), the Cromagnoid-A population, the Cromagnoid-B population, the Gracile Medsiterranean population, the Nordic population and the Mongoloid population. Racial assessment was in all investigations detrmined by nonmetric, anthroposcopic evaluation of the skull. In this paper I will use these, racially previously determined skulls, as a data base for the computation of discriminant functions which will then be used to determine the racial affinity of the individuals intered in the cemetries of Privlaka and Stari Jankovci. A relatively high accuracy of racial assesssment by the discriminant functions will, as a by-product, also provide additional evidence for the correct or incorrect attribution of the previously racially determined skulls used in the data base. To minimise possible interobserver error all skulls used in this analysis have previuosly been racially determined by one author, Pal Liptak. Craniometric data for 25 skulls from all six major population groups, giving a grand total of 125 skulls, has been gathered. The skulls come from the sites of Kecel 1 (Liptak 1954), Ullo 1 (Liptak 1955), Ullo 2 (Liptak 1955), Alattyan (Liptak 1963), Feherto A (Liptak and Vamos 1969) and Kiskoros 1 (Liptak 1983), all of who are both temporally and culturally cognate with Privlaka and Stari Jankovci.

One unfortunate aspect of dealing with data derived from previously published sources is that any constaraint present in this data is, by neccessity, also present in the investigation based on it. In the published papers dealing with racial assessment of individuals present in Late Avar sites there was simply not enough craniometric data for females to include them in this analysis. For this reason this investigation will, perforce, be limited to the analysis of male individuals present in the sites of Privlaka and Stari Jankovci.

The first step, therefore, in selecting the osteological material to be used in this study was to sex the osteological remains of the individuals interded in the cemeteries of Privlaka and Stari Jankovci. As morphological diferences between the sexes are not apparent before puberty and as inclusion of subadult craniometic data would, in any case, both obscure existing morphological differences between the analysed populations and possibly bias the sample, the first limitation in selecting the sample was to exclude all subadults. The biological age of 15 years was taken as an arbitrary cut-off point between adults and subadults. Age estimation of the skeletal series was based on epiphyseal union and dental calcification and eruption. After excluding all individuals younger than 15 years, the sample was further reduced by eliminating female individuals from it. Sex determination was based on visual assessment of morphological differences between the male and female skeleton. Particular emphasis was placed on pelvic and cranial morphology. The scope of this article does not allow a detailed explanation of the numerous morphological differences present between the male and female skeleton. Quite logically, because of the child bearing function of women, most of these differences are located in the pelvic region. Other morphological differences are, however, also present, most noticeably in cranial morphology and in long bone lenghts and joint size. Interested readers are advised to consult any number of publications dealing with this subject among which Krogman and Iscan's "The Human Skeleton in Forensic Medicine" (Krogman and Iscan 1986) and Basses "Human Osteology" (Bass 1987) are probably the most comprehensive.

After all previously mentioned considerations have been taken into account, the final sample for analysis consisted of 31 individuals from the Privlaka site and 10 individuals from Stari Jankovci.

ANALYTICAL METHODS

Cranial Measurements

A total of 20 measurements was selected from Liptak's published craniometric data from the sites of Kecel 1, Ullo 1 , Ullo 2 , Alattyan, Feherto A and Kiskoros 1. A correlation and regression matrix was computed for each 2 x 2 combination. From these 20 dimensions, 13 were selected for analysis. The 13 were chosen rather arbitrarily, the main criterion being correlation with other dimensions. If two measurements were highly correlated, one or the other of them was excluded from the analysis. Another limiting factor was imposed by the requirement of choosing cranial variables for which a sufficient amount of data was available. The measurements used, their Martin-Saller number (Martin and Saller 1957), and anatomical landmarks are as follows:

1. Maximum length of the cranium; the distance between glabella and opisthocranion in the mid sagittal plane measured in a straight line. Martin-Saller number 1.
2. Cranial base lenght; the direct distance between nasion and basion. Martin-Saller number 5.
3. Maximum cranial breadth; the distance between the two euryons. Martin-Saller number 8.
4. Minimum frontal breadth; the direct distance between the two frontotemporale. Martin-Saller number 9.
5. Cranial height; the direct distance between the lowest point on the anterior margin of the foremen magnum, basion, to bregma. Martin-Saller number 17.
6. Porion-Bregma height; the direct distance between porion and bregma. Martin-Saller number 20.
7. Bizygomatic breadth; The direct distance between both zygia located at their most lateral points of the zygomatic arches. Martin-Saller number 45.

8. Upper facial height; the direct distance between nasion and prosthion. Martin-Saller number 48.
9. Orbital breadth; the laterally sloping distance from maxillofrontale to ectoconchion. Martin-Saller number 51.
10. Orbital height; the direct distance between the superior and inferior orbital margins. Martin-Saller number 52.
11. Nasal breadth; the maximum breadth of the nasal aperture. Martin-Saller number 54.
12. Nasal height; the direct distance from nasion to nasospinale. Martin-Saller number 55.
13. Palatal lenght; the direct distance between prosthion and alveolon. Martin-Saller 62.

Statistical methods

The statistical approach employed in this study is a multivariate one. Unlike more traditional univariate approaches, multivariate statistics allows comparisons of several groups or populations to be based on the simultaneous utilization of a number of variables while at the same time omitting redundant information resulting from covariance. This concept represents a significant departure from traditional univariate analysis, where individual measurements are considered separately, or at most combined to form indeces. Simultaneous consideration of a number of variables and their covariation permits populations or individuals to be delt with as units and prevents their conceptual dissection into a series of unrelated dimensions. This enables objective establishing of relationships between a set of populations, as well as interpretations guided by tests of significance. Furthermore, after relationships among a set of populations are worked out, undocumented populations or individual specimens can be evaluated within the established framework with a much higher degree of precision than would otherwise be possible.

The obvious advantage that this approach has over non-metric, anthroposcopic racing, is that racial classification is, in this case, based on simple, and in most cases, standard cranial measurements. Morphological cranial traits used to evaluate race are both numerous, and frequently hard to define. Despite some attempts, as yet, no comprehensive and generally accepted terminology for non-metric traits has been developed. This significantly increases the chance of interobserver error and, to a large degree, hampers both comparissons of results achieved by different authors, as well as the application of one author's method by other investigators.

The multivariate technique employed here is discriminant function analysis. A detailed explanation of the method is available in a number of sources (Fisher 1936; Howells 1972; Seal 1964). Put simply, the original variables are transformed to a set of axes which maximize the separation among the populations under analysis. The populations may be visualised as existing in a multivariate space with as many dimensions as there are variables. The first transformed axis is inclined in the direction of greatest variability, the second at right angles to the first in the direction of next greatest variability, and so on, until all variability is accounted for. This results in a reduction of the dimensionality of the multivariate space since the populations can be described by discriminant functions numbering one less than the number of populations. Thus, in the case of only two populations, all of the variability can be described with reference to a single linear function and, at the same time, provide a criterion for classifying unknown specimens into their correct population. This method has received a fair amount of attention by anthropologists, and it's value, especially in the sexing of skeletal material, has been amply demenostrated (Giles and Elliot 1963; Howells 1965). Simulataneous discrimination among three or more groups makes greater demands from a computational point of view, but the basic approach remains much the same.

The specific program used in this analysis is Statgraphics 4.0 (STSC Inc. 1989). Results include Eigenvalues, the relative percentage of each discriminant function, canonical corelations, Wilks Lambda and Chi-Square values, significance levels, standardised and unstandardised discriminant function coefficients, group centroids, actual and predicted classification results and classification coeficients for classifying new observations.

The results of the discriminant function analysis are shown in Table 1. Alltogether 5 discriminant functions were derived. The first 3 functions account for 92.14% of the total variability, and the first 4 functions are statistically significant ($p < 0.05$).

Standardised and unstandardised discriminant function coefficient values are given in Tables 2 and 3.

Drisciminant function analysis has two basic aims. The first, classification of unknown skeletal material into one of two or more defined populations, has allready been explained. The second aim is the analysis of the relative contribution that each individual variable gives to the differentiation between the analysed populations. These values represent correlations between the original measurements and each discriminant function. Table 2 shows the standardised discriminant function coefficients which are utilizable for evaluating the weight of each variable in the functions.

As can be seen, the first discriminant function is mainly characterised by a high negative loading for cranial length and an almost equally high positive loading for cranial breadth. Other variables contribute significantly less indicating that the first discriminant function differentiates primarily between long and narrow (dolichocranic) and short and broad (brachycranic) skulls.

The second discriminant function is characterised by negative values for all variables defining the facial area. Minimal frontal breadth has the highest positive loading while high negative loadings for bizygomatic breadth, upper facial height and nasal height also contribute appreciably to the second discriminant function. These values indicate that the second function differentiates primarily between skulls with wide foreheads and narrow, short faces, and skulls characterised by narrow foreheads and broad, high faces.

The third discriminant function is less easy to interpret and is mainly characterised by high negative values for cranial length and bizygomatic breadth and an almost equally high positive value for orbital height. A relatively high negative loading for cranial breadth also contributes to the third function.

Figure 1 shows the two-dimensional representation of all the analysed skulls, as well as population centroids for all six populations on the first two discriminant functions. Group centroids are surrounded with 90% confidence intervals. The first two discriminant functions account for 72.25% of the variation in the total sample. The first discriminant function clearly differentiates the dolichocranic populations (Cromagnoid-A, Gracile Mediterranean, Nordic, and Mongoloid) from the brachycranic populations (Brachycranic and Cromagnoid-B).

The second discriminant function differentiates mainly between the Mongoloid population, characterised by an extermely narrow forehead and a very broad and high face, and the other Caucasoid populations.

The accuracy of classification achieved by the discriminant functions (predicted / actual group) is given by both counts and percentages in Table 4.

Correct assignement by the discriminant functions was achieved in 110 cases which accounts for 73.33% of the complete sample. The percentage of correct classification is highest for the Brachycranic group (80%), and lowest for the Cromagnoin-B population (64%). With the exception of skulls from the Cromagnoid-B population, which were incorectly attributed to the Brachycranic population in 20% of the cases, there seems to be no visible pattern of misclassification in the incorectly attributed skulls from the other populations.

Classifiction coeficients, utilizable for classifing new observations, are shown in Table 5. A new case is classified by evaluating each function and assigning the case to the group corresponding to the highest function value.

Craniometric data was collected from the 41 analysed individuals from the sites of Privlaka and Stari Jankovci. All measurements were taken by the author, according to the techniques described by Martin and Saller (Martin and Saller 1957) with standard anthropometric instruments. In the interest of brevity, craniometric data used in the data base, as well as cranial measurements from the 41 analysed individuals from Privlaka and Stari Jankovci have been omitted from this report. However, this information is available on computer printout and can be obtained through correspondence with the author.

The distribution of population groups, as calculated from the discriminant functions, in the sites of Privlaka and Stari Jankovci are given in Tables 6 and 7. As can be seen from Table 6, the Privlaka site is characterised by the presence of three, well represented population groups. These three groups, the Cromagnoid-A, Gracile Mediterranean and Nordic population, together account for 87.1 % of the total sample. Two other populations, Cromagnoid-B and Mongoloid, are also present but their contribution is significantly smaller. Together they account for not more than 12.9 % of the analysed sample. Table 7 shows the distribution of populations present in the Stari Jankovci site. Once again, three populations account for a significant (80 %) part of the sample. Several features of the Stari Jankovci site point, however, to a significantly different pattern of population presence and representation than that seen in Privlaka. First, a relatively large percent (20 %) of the analysed sample consists of individuals belonging to the Brachycranic population group, a group which is not present in the Privlaka site. Second, the contribution of the Nordic population is significantly smaller in the Stari Jankovci site (10 %), than in Privlaka (25.8 %), and third, the ratio of the three best represented groups is considerably more even in Privlaka (1.0 : 0.9 : 0.8) than in Stari Jankovci (1.0 : 0.5 : 0.5). Taken as a whole, despite the appreciable contribution of one population (the Gracile Mediterranean population accounts for 40.0 % of the whole sample), the Stari Jankovci site seems to be more heterogenous than the Privlaka site.

Demography and pathology

Following multivariate craniometric analysis, paleodemographic and paleopathological data was collected from the 41 analysed individuals. The following categories of data were collected: age at death, skeletal evidence of nutritional stress, trauma, skeletal evidence for infectious disease, enthesopathic lesions related to occupational stress and dental pathology.

As previously mentioned, the biological age of 15 years was taken as an arbitrary cut-off point between juvenile and adult individuals. For this reason estimation of age at death could not, with the exception of third molars, be based on dental eruption patterns. The following criteria were used to estimate age at death: pubic symphysis morphology (Brooks and Suchey, 1990), strenal rib end morphology (Iscan et al., 1984), auricular surface morphology (Lovejoy et al., 1985), ectocranial suture closure (Meindl and Lovejoy, 1985), maxillary suture obliteration (Mann and Jantz, 1988) and epiphyseal union (McKern and Stewart, 1957). Mean ages at death for the populations present in the sites of Privlaka and Stari Jankovci are shown in Tables 8 and 9. As can be seen from these tables, significant differences in mean ages at death are present between populations from the same site, as well as between the same population but from different sites. While allowing for the possibilty of sampling error (especially regarding the sample from Stari Jankovci which is relatively small), some trends seem to be remarkably consistent. In the Privlaka site members of the Nordic population live on average 11 years longer than memebers of the Gracile Mediterranean group. Members of the same Gracile Mediterranean population live on average 10.5 years longer in Stari Jankovci than in Privlaka, while members of the Nordic group live longer for slightly more than 9 years in Privlaka when compared to Stari Jankovci. These trends are also confirmed when assesing mortality distribution by age category and racial affinity (Tables 10 and 11). The highest mortality in the Privlaka site for members of the Gracile Mediterranean population (7 out of 9 individuals, or 77.8 % of the whole sample), is between the ages of 30 to 39 years. The same population in Stari Jankovci has the greatest mortality (3 out of 4 individuals or 75 % of the sample) between the ages of 40 to 49 years. No memebers of the Gracile

Mediterranean population live over 40 years in Privlaka, while three members of the Nordic population (37.5 % of the sample) and four members of the Cromagnoid-A population (40.0 % of the sample) live over 50 years. While members of the Mongoloid population (which one would assume to be politically dominant) are too few for any meaningfull comparissons, it is interesting to note that the one Mongoloid individual from Stari Jankovci lived to between 40 to 44 years, while both members of the Mongoloid population in Privlaka died between 25 to 29 years.

Dental pathology data collected from the analysed individuals shows a 3.2 % incidence of carious lesions in maxillary teeth and a 7.3 % incidence of carious lesions in mandibular teeth for the complete sample from Privlaka. Anterior tooth involvement was relatively rare (for instance not one carious lesion was present in any incisor from Privlaka). Carious lesions in the Stari Jankovci site were present in 10.3 % of the maxillary teeth and in 14.73 % of the mandibular teeth. Once again anterior teeth were rarely involved and most of the carious lesion were located in the posterior teeth which are morphologically more complex and have broader occlusal surfaces therefore allowing a greater possibility for food and particle involvement. Population group differences for carious lesion incidence was evaluated using analysis of variance statistics. A two-factor analysis of variance was used to assess the effects of race and age on the incidence of carious lesions. Age was taken into consideration since, obviously, the longer an individual lives the longer is the duration of food and particle involvement which increases the chance for carious development. Two, relatively equal in tooth number, age categories were therefore constructed consisting of individuals younger than, and older than 35 years of age. Neither differences between population groups ($p = 0.635$), nor differences between age categories ($p = 0.285$) were, however, statistically significant.

Skeletal evidence for developmental stress collected from the analysed individuals included evidence for cribra orbitalia, enamel hypoplasia and porotic hyperostosis of the cranial vault. All of these skeletal changes have been linked with various etiologies including iron-deficiency anemia, nutrient losses associated with diarrheal disease, scurvy, chronic gastrointestinal bleeding, fever and malnutrition. While some of these etiologies are currently under debate, most researchers today agree that, taken as a whole, these changes allow a relatively precise evaluation of the amount of nutritional deficiency stress present in a population (Carlson et al., 1974; Steinbock, 1976; Goodman et al., 1984). One further skeletal change, ectocranial porosity without concomitant vault thickening, was later also added to the previously mentioned list of nutritional deficiency indicators. The reason for this is two-fold. First, cranial porotic hyperostosis was, on examination of the analysed sample, found to be completely absent, and second, ectocranial porosity without concomitant vault thickening has also been reported to be associated with acute and severe malnutrition. These changes were first documented by McKern and Stewart who found them in crania of American soldiers who have died in prison camps during the Korean conflict (Mckern and Stewart, 1957), and later by Owsley (Owsley et al., 1991) who found them in crania of soldiers who died during the War of 1812 where historical sources documented severe malnutrition.

The distribution of skeletal markers of nutritional stress for the Privlaka site is as follows: linear enamel hypoplasia was present in 23 individuals or in 74.2 % of the complete sample. The distribution of enamel hypoplasia among the members of the three best represented population groups is relatively uniform; enamel hypoplasia is present in 6 out of 10 members (60 %) of the Cromagnoid-A population, in 7 out of 9 members (77.7 %) of the Gracile Mediterranean population, and in 6 out of 8 members (75 %) of the Nordic population. All members of both the Cromagnoid-B and Mongoloid populations also show evidence of enamel hypoplastic defects. Cribra orbitalia was present in 5 individuals or in 16.13 % of the complete sample. It's presence was noted in both members of the Mongoloid population, in two members of the Gracile Mediterranean population and in one member of the Cromagnoid-B population. In all cases cribra orbitalia was healed and mild in severity without bone thickening. Ectocranial porosity without concomitant vault thickening was present in 6 individuals or in 19.35 % of the complete sample. It's presence was noted in both members of the Mongoloid population, in two members of the Cromagnoid-A population and in one individual from the Cromagnoid-B and one from the Gracile Mediterranean population. In all cases ectocranial porosity was active and moderate in severity. An interesting feature of both cribra orbitalia and ectocranial porosity is that all individuals who showed evidence of either of these markers of nutritional stress died before 35 years of age.

The presence of skeletal markers of nutritional stress in the Stari Jankovci site is the following: linear enamel hypoplasia was present in 9 individuals or in 90 % of the complete sample. The only individual not showing enamel hypoplastic defects belonged to the Nordic population. The presence of cribra orbitalia was noted in one individual or in 10 % of the complete sample. This individual belonged to the Gracile Mediterranean population. Ectocranial porosity without concomitant vault thickening was present in 4 individuals or in 40 % of the complete sample. Afflicted were three members of the Gracile Mediterranean population and one member of the Cromagnoid-A population.

Data on enthesopathic lesions present in the analysed individuals included the following markers of physical stress: hypertrophy of the deltoid tuberosities of the humeri, robusticity of the ulnar supinator crests and pectoral crests of the humeri, proximal elongation of the posterior olecranons (ulnae) owing to ossification of the triceps brachii tendons, ossification of the biceps brachii tendon insertions on the radial tuberosities of the radii, and hypertrophy of the adductor tubercle crests in the distal femurs. Enthesopathic lesions at loci of muscular insertions caused by hypertrophy of the relevant muscles are macroscopically seen as rough patches, irregularities, or osteophytes on bone. They can be defined as one expresion of bone plasticity under preassure of extracorporeal and internal forces that are not attributable to disorders of disease, metabolism, biochemistry, hormonal and enzymatic imbalances, or neuronal or vascular disorders (Kennedy, 1989, 156). These lesions can be induced by mechanical strain from forces external to the body, as for instance from carrying heavy burdens on the head which can result in fractures of the spinous processes of cervical vertebrae, or they may be induced from internal forces, as with hypertrophy of the supinator crest on the proximal ulna as a result of supination and hyperextension of the arm in spear throwing, slinging and wood-choping. Enthesopathic lesions analysed in this investigation are related to areas of major muscle attachments and concern the deltoid and pectoral muscles, which are involved in the lifting and lowering of heavy objects and use of an axe; the supinator muscle, involved in spear throwing, jack-hammering, slinging and wood-chopping; the triceps brachii muscle, involved in net casting, woodcutting, and blacksmithing; the biceps brachii muscle, involved in all hammering actions and archery; and the adductor magnus muscle, involved in horseback riding. As can be seen from the preceeding list, all enthesopathic lesions analysed in this report are related to activities which one could reasonably assume to have been a major concern of Late Avar period male individuals.

Enthesopathic lesions are a nonmetric observation The method used to evaluate them in this investigation is described by Angel (Angel, 1987, 218). Almost all of the analysed individuals from Privlaka and Stari Jankovci show some enthesopathic lesions. Only individuals from Burials 17 and 102 in Privlaka and from Burial 67 in Stari Jankovci show a complete absence of any enthesopathic lesions. Individuals with particularly marked enthesopathic lesions were found in Burials 36 (Figures 2 and 3), 66, 20-A (Figure 4) and 134 , all from Privlaka, and in Burials 21 and 17 from Stari Jankovci. Nine individuals from Privlaka (29 % of the complete sample) and three from Stari Jankovci (30 % of the complete sample) show marked hypertrophy of the adductor tubercle crest, suggesting horseback riding. All population groups present in both sites show a relatively equal distribution of enthesopathic lesions. No members of a particular group show any prefernce for a particular lesion and no group is completely devoid of enthesopathic lesions. When, however, all analysed individuals were, regardless of population group and site, pooled together and then separated into two age categories, under and over 35 years of age, it became apparent that older individuals showed a considerably larger amount of enthesopathic lesions. This suggests that the analysed enthesopasthic lesions were not population specific, but primarily age related, reflecting relatively uniform life histories involving high levels of physical labor and strain.

Skeletal evidence for trauma is present in three individuals from Privlaka (Burials 35, 18 and 16) and in one individual from Stari Jankovci (Burial 48). All of these injuries were likely the result of accidents and involve the distal humerus, clavicle and proximal femur. The absence of any trauma attributable to intentional violence, and the approximately 10 % proportion of injuries present in both sites, a proportion which could easily characterise a modern agricultural population, seems to belittle the fearsome reputation that the Avars acquired as warriors. While it is always possible that individuals killed during hunting or war expeditions were buried outside established cemeteries, the skeletal evidence from Privlaka and Stari Jankovci seems to indicate that the Late Avar period was considerably less violent than the Early period.

Skeletal evidence for infectious disease is present in two individuals, both belonging to the Nordic population, from Privlaka. Both pathological changes are located in the lumbar vertebrae. The first case is from Burial 17; age at death was estimated at between 15 and 20 years. The pathological change consists of a large central osteolytic lesion in the body of the first lumbar vertebra (L 1). The lesion is about 1.8 cm long, 0.9 cm wide and approximately 3 cm deep. The remaining trabecular bone is coarse and thickened, particularly at the bottom of the lesion. There is no compression of the vertebra. A carefull examination of the complete skeleton, particularly the ribs, remaining vertebrae and innominate, revealed no other lesions. The level and locus of the primary lesion, along with the lack of involvement in the neural arches are, at least, suggestive of infectious disease, specifically tuberculosis.

The second case is from Burial 67; age at death was estimated at between 35 and 40 years. The primary lesion involves the second and third lumbar vertebrae (L 2 and L 3), which are ankylosed without angular deformity, by large marginal osteophytes around the centra, at the laminae, and at the apophyseal joints (Figure 5). The lesion affects the contiguous halves of the two vetebral bodies. The centers of the bodies are eroded, particularly that of L 3, and the intervening disc space is perforated. The lesion emerges posteriorly into the spinal canal. The trabecula in the interior of the lesion are even more coarsened and sclerotic than in the first case. In addition, the lateral exterior surfaces of the two vertebral bodies show some periosteal inflammation. No other lesions were noted in the remains. Again, the level and locus of the lesion suggest the possibility of tuberculosis. While the lesions present in the individuals from Privlaka are suggestive of tuberculosis, other etiologies must also be considered. A considerable number of diseases produce lesions similar in appearance to those of tuberculosis. A survey of the literature shows that in differential diagnosis, particularly in the spine, the following pathological conditions must also be considered: pyogenic (suppurative) osteomyelitis, malignant neoplasmas (multiple myeloma, metastasic carcinoma, leukemia), fractures of the vertebrae, rheumatoid arthritis, fungal infections, histiocitis X, Pagets disease and typhoid spine. Several of these diseases rarely affect bone tissue (typhoid spine) and others are easily excluded on the basis of skeletal site predilection or multiple lesion patterns (rheumatoid arthritis, Pagets disease, multiple myeloma and leukemia). Before attempting, however, a definite diagnosis, a careful analysis of the complete skeletal material, (including children, females and all males excluded from this investigation) from both sites was undertaken. Since tuberculosis is an extremely infectious disease, it was felt that other individuals, not included in this study, could show skeletal evidence more unequivocally attributable to tuberculosis. This assumption was confirmed by the skeletal evidence found in Burial 37 from the Stari Jankovci site. The skeletal remains belonged to a female individual whose age at death was estimated to between 20 to 25 years of age. The primary lesion is centered in the thoracic spine. The area of involvement extends from the second to the twelfth thoracic vertebrae (T 2 to T 12). There is massive destruction and collapse in T 2 through T 8 and in T 10 and T 11, with severe kyphosis and scoliosis to the right (Figure 6). The surviving bodies of T 9 and T 12 are eroded posteriorly as is also the superiror surface of T 10. The disc space between T 9 and T 10 is preserved; all others are obliterated. The collapsed bone mass displays extensive fusion along both the bodies, spinous processes and articular processes; several drainage canals are also observable. The spinal canal, however, is intact and unobstructed. This massive vertebral destruction and collapse, as well as it's level, are typical of tuberculosis. Other possible etiologies include vertebral fracture, pyogenic osteomyelitis and fungal infections. The skeletal evidence from Burial 37 does not, however, support any of these. Wedge compression fractures are most common where the transition from stiff to mobile vertebrae occur, namely in the thoraco-lumbar and lumbosacral junctions. Fractures are usually confined to one vertebra and do not display osteolytic lesions. Intervertebral disc integrity is in the majority of cases retained. Pyogenic osteomyelitis typically results in considerable bony reactive proliferation. Gibbus formation is rare as is the destruction and collapse of several vertebrae. Fungal infections (actynomicosis, coccidioidomycosis, and blastomycosis) also do not seem probable. Osseous involvement in these diseases is frequent in the neural arches, and adjecent ribs. These diseases also tend to be rapidly terminal which is not compatible with the extensive fusion and buttressing present in the vertebrae from Burial 37.

The compelling skeletal evidence for tuberculosis found in Burial 37 lessens the uncertainty of diagnosis for the individuals from Privlaka. Based on the skeltal evidence, there can be no doubt that tuberculosis was present in both Privlaka and Stari Jankovci.

DISCUSSION

This investigation can, for all practical purposes, be divided into two parts. The first deals with the feasibilty of discriminant function classification of the various populations present during the Late Avar period in the Carpathian basin. The second is concerned with the interpretation of cranial variation between two specific Late Avar sites in Croatia from a microevolutionary perspective. The latter objective is impossible without the former which is the reason why these two topics are delt with simultaneously in this paper.

Regarding the first objective, because of the markedly heterogenous nature of Late Avar sites, discriminant function analysis was prefered to other multivariate statistical methods utilizing mean values of craniometric variables. The overall accuracy of classification achieved by the discriminant functions (73.3 %) is, taking into account the large number of groups (n = 6) involved in this analysis, an excellent result. It is worth pointing out that most of the groups differntiated in this analysis belong to the same, Caucasoid, group of populations and that corect classification between these, quite similar groups, was achieved in 73.6% cases. Correct classification between the Caucasoid and Mongoloid populations is also high and equals 72% with no Mongoloid individuals being incorectly classified in either the Cromagnoid-A or Cromagnoid-B populations, and only one incorectly attributed to the Gracile Mediterranean population.

The accuracy of classification achieved by the discriminant functions in this investigation indicates that definite, and measurable, cranial morphological differences exist between the various populations inhabiting the Carpathian Basin in the Late Avar period. Slightly better results, in the 80-90% range have been achieved by other authors discriminating, however, between a significantly smaller number of groups than is the case in this study. As previously mentioned Giles and Elliot (Giles and Elliot, 1962) achieved an 86.7% of accurate classification when differentiating between the three major racial groups; Caucasoid, Nergroid and Mongoloid. Gill (Gill et al., 1988) achieved an 85% accurate classification when differentiating between Caucasoid and American Indian populations. The only investigation discriminating between a comparable number of groups that I am aware of, is Rightmire's analysis of Iron Age skulls from South Africa (Rightmire, 1970). In this analysis the number of discriminated groups was seven and the total accuracy of classification achieved for the whole sample was 75.4%, a result very similar to that achieved in this study.

The relevance of Liptak's anthropometric classification system is, thus, confirmed by this investigation, and the new and exciting possibility of accurately racing unknown skeletal material from the Late Avar period, based, not on numerous and hard to define non-metric morphological traits, but on 13 simple and standard cranial measurements, is now open.

Cranial variation between the sites of Privlaka and Stari Jankovci, evident through the differential presence and representation of the six major population groups present in the Carpathian basin during the Early Middle ages, is best interpreted through the effects of microevolutionary processes. As previously mentioned, the operations and interactions of these processes in human populations are largely conditioned by cultural factors. While an important aspect of the study of Avar period populations has been the determination of the effects that these populations had, through the introduction of new cultural ways, religion, and technology, on neighboring and assimilated supstrate populations, as yet, little has been contributed to our knowledge of the effects that a changed ecological system, genetic interchange and disease transmission, had on the newly arrived Avar period populations. That these changes should have a profound impact on the gene pool of the newly arrived populations seems very logical. So far, however, the implications of these ecological and cultural changes for biological change have not been adequately recognized. It is necessary therefore, at this point, to review those aspects of Avar culture known through history and archaeology which are relevant to evolutionary processes.

The period of Avar dominance in the Carpathian basin from 650 to 800 AD is generally refered to by archaeologists as the Late Avar period or the Second Avar Kaganat. It is characterised by a significant military and political decline of the Avar state which resulted as a consequence of the unsuccessful siege and military defeat under the walls of Constantinople in 626 and the subsequent dinastic battles and civil war. Although historical sources are noticeably rare for the following period, archaeological evidence strongly supports the theory of a new migration of Central Asian populations and their subsequent political dominance (Laszlo, 1955). The huge losses in men, war equipment and politcal allies incured in 626, however, irreperably weakened the Avar state. While the early period of Avar dominance in the Carpathian basin (from 568 to 626 AD) is characterised by expansionist politics, warfare and the exaction of tribute to the amount of 27 tons of gold for the period from 575 to 626 AD (Kovačević, 1963, 125-127), the late period of Avar dominance is characterised by defensive politics, a complete lack of tribute as witnessed by the absence of Byzantine coins in the Carpathian basin from about 670 AD. (Czallany, 1956, 198-199), and a subsequently heavier reliance on agriculture.

Several observations collectively - the high frequency of skeletal markers of nutritional stress, dental pathology, enthesopathic lesions, and the incidence and type of trauma - may reflect this transition in the Privlaka and Stari Jankovci samples.

The skeletal markers of nutritional stress analysed in this investigation include both markers of nutritional stress developed during the growth phase (enamel hypoplasia), and those reflecting acute periods of malnutrition regardless of the time of their development (cribra orbitalia and ectocranial porosity without concomitant vault thickening). The high frequency of both of these types of markers, in virtually all of the individuals present in the samples from Privlaka and Stari Jankovci (90 % of the analysed individuals from Stari Jankovci and 74.2 % of the individuals from Privlaka show at least one indicator of nutritional stress), indicates frequent and repetative periods of severe malnutrition. While this hardly seems characteristic for a successful warlike population, it is consistent with life in a relatively primitive agricultural society. Comparable statistics for Early Middle Age European populations are not readily available, but the frequencies of enamel hypoplasia (74.2 % in Privlaka and 90 % in Stari Jankovci) and cribra orbitalia (16.1 % in Privlaka and 10 % in Stari Jankovci) in the two analysed sites are quite simillar to the frequencies of these skeletal pathologies in other agricultural populations. Smith, for instance, found a 53 % incidence of enamel hypoplasia in a Bronze Age sample from Jericho, an 80 % incidence in Chalcolitic Azor, and a 50 % incidence in Roman Jerusalem (Smith et al., 1984, 123.). Cribra orbitalia is, on average, present in 21 % of the Neolithic sample from Iran and Iraq, and in 23 % of the Metal Age groups from the Iranian plateau and the Mesopotamian valley (Rathbun, 1984, 149.). Further investigation in females, and particularly subadults from Privlaka and Stari Jankovci will show if the high frequencies present in the analysed sample are a consequence of sample bias, or a realistic reflection of inadequate nutrition in these two sites.

Economic and cultural change may also be reflected in the relatively high frequencies of carious lesions present in both sites. An extensive literature supporting the general observation of increased cariogenicity as a consequence of a stronger commitment to agriculture now exsists. The greater ferquency of caries among farming populations is typically attributed to differential food selection, specifically to greater levels of dietary carbohydrates. The relatively poor enamel formation suggested by the high frequency of enamel hypoplasia may also have predisposed Privlaka and Stari Jankovci teeth to caries. This is particularly relevant to the Stari Jankovci sample which shows a 90 % incidence of enamel hypoplasia and an accompanying, greater frequency of carious lesions in comparison with Privlaka.

The high incidence of enthesopathic lesions in both samples is also compatible with agriculturally induced heavy labor and chronic physical stress. Reconstruction of specific activity patterns and occupations from the distribution of enthesopathic lesions in a skeleton is never an easy undertaking and is, in light of the often badly fragmented and poorly preserved remains, in the present circumstances practically immpossible. There is no doubt, therefore, that some of the enthesopathic lesions present in the analysed sample could have been the result of non-peacefull, military activities. Partially preserved individuals with, for instance, extensive ossification of the biceps brachii tendon on the proximal radius could just as easily have hyperthrophied their biceps muscle from drawing a bow-string or wielding a battle axe, as from any number of peacefull activities such as blacksmithing or carrying heavy objects with the elbows bent. The frequency and type of traumatic injuries, as well as the previously mentioned high frequencies of markers of nutritional stress, make this hypothesis, however, improbable. A relatively low frequency (10 %) of traumatic injuries is present in both samples. Furthermore, all of the injuries were likely the result of accidents and not intentional violence. In the complete analysed sample not one case of cranial injury, or "parry" fracture in the lower arm was recorded. The injuries noted were, in fact, remarkably non-intentional in appearance and include an age related fracture of the femoral neck and three fractures (two in the clavicle and one in the distal humerus) which were most likely caused by accidental falls.

Apart from the military, and resulting economic decline which forced the transition to a heavier reliance on agriculture, the far more potent mechanism of disease selection was present in both sites in the form of tuberculosis. Tuberculosis is an acute or chronic communicable disease caused by Mycobacterium tuberculosis. The primary involvement is usually in the lungs but tuberculous bacilli are disseminated throughtout the body by the lymph and/or blood vessels and can invade any organ or tissue in the human body. Osseous involvement is relatively rare and is, according to different authors, present in from 1% (Daniel, 1981, 36.) to 5-7 % of the cases (Steinbock, 1976, 175.). As primary involvement is in most cases in the lungs, the most frequently affected bones are the ribs, vertebrae and, generally speaking, the axial skeleton.

Two factors have been cited as critical for the establishment and maintenance of tuberculosis. The first is achievement of a critical level of density neccessary for the maintenance of the disease. While the exact level of density is, at present, under debate, it should be noted that recent epidemiological data (Black, 1975, 517.) indicates that tuberculosis seems "quite able" to maintain itself in Amazon tribes of extremely small population size. Tuberculosis-like lesions have been reported in numerous, relatively small, sedentary, agricultural archaeological populations (Buikstra, 1977; Widmer and Perzigian, 1981; Allison et al., 1973), indeed, the transition from a nomadic, hunting and gathering, to a sedentary, agriculturally based subsistence economy seems to increase the frequency of tuberculosis lesions (Buikstar, 1977; Widmer and Perzigian, 1981). This may be related to the second critical factor for the maintenance od tuberculosis which can, in the most general terms, be defined as economic status, or more specifically as inadequate nutrition, poor living conditions and crowded housing. Malnutrition due to deficiencies of protein, calories, vitamins or trace elements can forestall immunological defense mechanisms; moreover, intrauterine growth retardation due to maternal malnutrition produces profound adverse effects on postnatal immunocompetence. Experiments carried out on animals show, for instance, that reduced immunocompetence persists for three generations after pregnant mice were fed a zinc-defficient diet (Beach et al., 1982). Resistance to tuberculosis might, therefore, be reduced because of dietary and consequent immunological changes that accompany the transition to agriculture.

Both of the factors critical to the establishment and maintenance of tuberculosis are present in the sites of Privlaka and Stari Jankovci. Together with the unequivocal skeletal evidence, there is no doubt that tuberculosis was endemic in these two sites. In view of the fact that population density was, in all probability, equal in both sites, and that skeletal markers of nutritional stress are evenly distributed, both between the two sites, as well as between the different population groups that inhabited them, the observed cranial variation between the sites may be the result of differential natural resistance to tuberculosis.

There is both clinical and experimental evidence that some genetic predisposition to tuberculosis does exist. Blacks, for instance, seem to be more suspectible than Whites (Lurie, 1950). To some degree, this may be related to socioeconomic conditions, but apart from this, there may still be a racial predisposition (Lurie, 1950). Tuberculosis in identical twins tends to follow exactly parallel courses and distributions, whereas in fraternal twins there is a lower incidence of parallel disease (Robbins, 1974). Animal experiments have also conclusively demonstrated that genetic factors can control suspectability to tuberculosis (Lurie, 1964). In addition, it has been suggested that the development of secondary infectious foci (such as skeletal lesions) indicates the presence of some immune response to the disease (Sanchis-Olmos, 1948, 45.). If genetic factors can be assumed to be responsible for any natural immunity, then survivors of an epidemic would tend to be related, distributed in family or population group lines rather than a random sample of the pre-tuberculosis sample. Several observations from the Privlaka and Stari Jankovci samples seem to confirm this assumption. The mean values of age at death for the various population groups present in these samples, shown in Tables 8 and 9, suggest several distinct trends. Bearing in mind that the Stari Jankovci site is approximately 50 years older than Privlaka, a sharp temporal decline in mean age at death is evident for the Gracile Mediterranean population. Members of this population live on average almost 11 years longer in Stari Jankovci than in Privlaka. There is a concomitant although somewhat less dramatic temporal decline in the mean age of death for the Cromagnoid-A population. At the same time members of the Nordic population show a significant increase in average life-span, from 32.5 years in Stari Jankovci to 41.9 years in Privlaka. Participation of the various population groups in the complete samples (Tables 6 and 7) reflect these temporal trends. The contribution of the Nordic population rises from 10 % in Stari Jankovci to 26 % in Privlaka while the contribution of the Gracile Mediterranean population drops from 40 % in Stari Jankovci to 29 % in Privlaka. Taking into account the fact that in the complete anaysed sample tuberculotic skeletal lesions were found only in memebers of the Nordic population, it seems reasonable to assume that members of this population possesed a higher degree of genetically inherited resistance to tuberculosis than members of the other populations.

If this hypothesis can be assumed, the implications for genetic change go far beyond whatever genes are involved in resistance to tuberculosis. The result would be very similar tro what Neel called the "lineal effect" (Neel, 1967, 5.). Neel's coinage of this term was ment to convey what happened when a group of related persons split from a village and founded a new one, as he observed among the Yanamama and Xavante tribes in South America. The result is a new biological group formed from a very nonrandom "draw" of the genes from the parent population.

By the same token, the survivors of a tuberculosis epidemic in Stari Jankovci, who have split off and founded a new settlement in Privlaka, represent a nonrandom draw from the Stari Jankovci population. The fusion of these individuals with other population groups (perhaps members of the Cromagnoid-B population who are not present in Stari Jankovci) can be expected to produce a biological picture very different from the original, pre-tuberculosis one. Preliminary results of multivariate, principle components analysis, utilyzing mean values of craniometric variables from 25 Early Middle age sites in the Carpathian basin, seem to confirm this. The analysis produces definite temporal and geographical vectors into which all of the analysed sites, with the exception of Privlaka, fit (Šlaus, unpublished data).

The present investigation acomplishes two objectives. On one hand, it demonstrates the opportunity for genetic change through time and space within and among Early Middle Age populations from the Carpathian basin. The processes of cultural and ecological change are seen to act in such a way as to foster biological change as well. At the same time this analysis also indicates what can be done when good samples of documented skeletal populations are analysed and the resulting anthropological data is interpreted in correlation with archaeological and historical information. For far to long potentially significant anthropological data has been neglected in archaeological reports and research designs, a fact perhaps best illustrated by the summing comments in an archaeological synthesis of the Middle East Neolithic :"It is only in the last few decades that scholars have learned to pay proper attention to plant and animal remains, but how many have realised the potential of anthropological studies, demography, and the pathology of human skeletal remains ?" (Mellaart 1974: 274).

Clearly, much more work needs to be done to develop this important data resource. Since a multidisciplinary approach seems most profitable, some consideration must be given to the use of comparable criteria and methods of data collection. Specific attention must also focus on the collection of sufficient skeletal material to allow valid statistical manipulation for demographic and comparative studies. Especially critical is the develpoment of a representative sample of subadult material, material which has traditionally not been collected. The collection of this data will enable further elucidation of the complex effects of cultural and ecological change on biological adaptation. This study is a modest step in that direction.

LIST OF ABBREVIATIONS

AJPA	American Journal of Physical Anthropology
Am. J. Med.	American Journal of Medicine
Anthropol. Kozl.	Anthropologiai Kozlemenyek
ARRD	American Revue of Respiratory Disease
Hum. Evol.	Human Evolution
JFS	Journal of Forensic Sciences

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Sažetak

Analiza 41 muškog kostura nađenog na dva avaro-slavenska lokaliteta, Privlaka i Stari Jankovci, u istočnoj Slavoniji, donosi nove podatke o populacijskom sastavu tih lokaliteta te o posljedicama ekoloških i kulturnih promjena na biološku adaptaciju. Od ukupnog broja analiziranih kostura 31 je otkopan na lokalitetu Privlaka (datiranom u razdoblje od 700. do 800. godine), a 10 ih je otkopano na lokalitetu Stari Jankovci (datiranom u razdoblje od 650. do 750. godine). Da bi se odredio populacijski sastav analiziranih lokaliteta, provedena je diskriminantno funkcijska analiza 13 kranijalnih varijabli na temelju uzorka od 150 lubanja poznate populacijske pripadnosti iz istog vremenskog razdoblja (7. do 9. stoljeće) i istog zemljopisnog prostora (šire područje Karpatske kotline). Ova metoda polučila je pet diskriminantnih funkcija od kojih su četiri statistički signifikantne ($p < 0,05$). Prve tri funkcije objašnjavaju 92,14 % ukupne varijabilnosti u uzorku. Kranijalne varijable koje najviše doprinose razlikovanju između analiziranih populacija su duljina i širina lubanje, najmanja širina čela, širina i visina lica te visina orbite. Uspješnost ispravnog određivanja populacijske pripadnosti postignuta je u 73,3 % slučajeva, odnosno u 110 od ukupno 150 analiziranih lubanja. S obzirom na veliki broj diskriminiranih grupa (n=6), ovaj postotak uspješnog određivanja populacijske pripadnosti dobro se sla'e s rezultatima koje su postigli drugi autori.

Diskriminantno funkcijska analiza lubanja s lokaliteta Privlaka i Stari Jankovci pokazuje da su oba lokaliteta imala heterogeni populacijski sastav. Na lokalitetu Privlaka ustanovljeni su pripadnici kromanjonske-A populacije (32,25 % od ukupnog uzorka), gracilno mediteranske (29,05 %), nordijske (25,8 %), kromanjonsko-B (6,45 %) i mongolske populacije (6,45 %), dok su na lokalitetu Stari Jankovci ustanovljeni pripadnici gracilno mediteranske (40 %), kromanjonske-A (20 %), brahikefalične (20 %), nordijske (10 %) i mongolske populacije (10 %). Na oba analizirana lokaliteta dominiraju tri populacijske skupine; u Privlaci pripadnici kromanjonske-A, gracilno mediteranske i nordijske populacije koji čine 87,1 % od ukupnog uzorka, a na lokalitetu Stari Jankovci pripadnici gracilno mediteranske, kromanjonske-A i brahikefalične populacije koji čine 80 % od ukupnog uzorka. Međusobni omjer tri najzastupljenije populacije iznosi za Privlaku: 1,0 : 0,9 : 0,8, a za Stare Jankovce: 1,0 : 0,5 : 0,5. Na temelju ovog, a i drugih pokazatelja, čini se da je uzorak iz Starih Jankovaca nešto heterogeniji u odnosu na onog iz Privlake.

Paleodemografski i paleopatološki podaci sakupljeni na analiziranom uzorku uključuju procjenu doživljene starosti, prisutnost pokazatelja nedovoljne prehrane, traume i zaraznih bolesti, te dentalne patologije i entezopatske lezije. Analiza i usporedba navedenih pokazatelja ukazuje na dvije bitne činjenice. Prva je da postoje znakovite razlike u prosječnim doživljenim starostima, prvenstveno između pojedinih populacija ali i na razini oba analizirana lokaliteta. Druga činjenica je sigurna prisutnost tuberkuloze na oba lokaliteta. Različita prisutnost i zastupljenost pojedinih populacijskih skupina na lokalitetima Privlaka i Stari Jankovci objašnjava se djelovanjem mikroevolucijskih procesa: prirodne selekcije i dotoka gena. U čitavom analiziranom uzorku pokazatelji tuberkuloze prisutni su samo kod pripadnika nordijske populacije. Ova populacija ujedno i jedina pokazuje znakoviti porast u prosječnoj doživljenoj starosti (pripadnici ove populacije žive u prosjeku gotovo 11 godina duže u Privlaci nego u Starim Jankovcima). Ovo povećanje prosječne doživljene starosti odražava se i na zastupljenosti pripadnika ove populacije u ukupnim uzorcima koja se povećava s 10 % u Starim Jankovcima, na 26 % u Privlaci. Tuberkuloza je bolest koja primarno napada pluća. Razvijanje sekundarnih žarišta infekcije u koštanom tkivu povezano je s nekom vrstom imunološkog odgovora. Ova žarišta javljaju se samo kod osoba koje su preživjele prvu akutnu fazu bolesti i kod kojih je tuberkuloza prešla u kronični oblik. Prisutnost koštanih manifestacija tuberkuloze kod pripadnika nordijske populacije upućuje na povećanu nasljednu prirodnu otpornost prema tuberkulozi koja im omogućuje nešto dulji životni vijek u odnosu na pripadnike drugih populacija. Ova prirodna selekcija uzrokuje povećanu homogenost uzorka iz Privlake i bitnu razliku u srednjim vrijednostima kranijalnih varijabli između Privlake i Starih Jankovaca.

Discriminant Function	Eigenvalue	Relative Percentage	Canonical Correlation
1	1.3458226	40.59	.75744
2	1.0498823	31.66	.71566
3	.6594169	19.89	.63038
4	.1877191	5.66	.39756
5	.0729060	2.20	.26068

Function Derived	Wilks Lambda	Chi-square	DF	Sig. Level
1	.0983433	323.54101	65	.00000
2	.2306960	204.59827	48	.00000
3	.4728997	104.46762	33	.00000
4	.7847378	33.81558	20	.02740
5	.9320481	9.81673	9	.36552

Table 1: Discriminant functions calculated from the data base consisting of 150 skulls from the Carpathian basin.

	1	2	3	4	5
martin 1	-0.84209	0.11672	-0.41854	-0.01951	0.26197
martin 5	-0.30038	-0.02860	-0.10579	-0.06622	-0.12585
martin 8	0.60861	-0.15227	-0.31271	0.45728	-0.17727
martin 9	0.12340	0.52416	-0.09187	0.71845	0.02344
martin 17	0.20244	0.20208	-0.11880	-0.24321	-0.42888
martin 20	-0.10100	0.19041	0.09461	0.11461	0.03152
martin 45	0.13624	-0.43624	-0.40462	-0.67055	0.05034
martin 48	-0.09521	-0.33336	0.17735	0.24245	0.44909
martin 51	0.11217	-0.06112	-0.07554	-0.10162	0.71143
martin 52	-0.21950	-0.11560	0.39203	0.36579	-0.30797
martin 54	0.30252	-0.02360	-0.26440	-0.06764	-0.21059
martin 55	0.05873	-0.28244	0.06317	0.09546	-0.39887
martin 62	-0.22340	-0.22856	0.00496	0.10819	-0.51162

Table 2: Standardized coefficients of the discriminant functions.

	1	2	3	4	5
martin 1	-0.17634	0.02444	-0.08765	-0.00409	0.05486
martin 5	-0.07419	-0.00706	-0.02613	-0.01635	-0.03108
martin 8	0.12956	-0.03241	-0.06657	0.09734	-0.03774
martin 9	0.02746	0.12066	-0.02045	0.15989	0.00522
martin 17	0.03297	0.03292	-0.01935	-0.03961	-0.06986
martin 20	-0.02016	0.03801	0.01889	0.02288	0.00629
martin 45	0.02836	-0.09082	-0.08424	-0.13960	0.01048
martin 48	-0.02061	-0.07217	0.03839	0.05248	0.09722
martin 51	0.05958	-0.03246	-0.04012	-0.05397	0.37786
martin 52	-0.10950	-0.05767	0.19557	0.18248	-0.15363
martin 54	0.14830	-0.01557	-0.12961	-0.03316	-0.10324
martin 55	0.01695	-0.08151	0.01823	0.02755	0.11511
martin 62	-0.08707	-0.08909	0.00193	0.04217	-0.19942
CONSTANT	14.8162	9.42115	36.6617	-15.8520	5.95763

Table 3: Unstandardized coefficients of the discriminant functions

Actual Group	Predicted Group (count, percentage)							
		Brachy.		Cr-B		Cr-A		Med.
1	20	80.00	3	12.00	1	4.00	0	.00
2	5	20.00	16	64.00	2	8.00	1	4.00
2	0	.00	4	16.00	18	72.00	0	.00
4	1	4.00	0	.00	3	12.00	19	76.00
5	0	.00	1	4.00	3	12.00	2	8.00
6	3	12.00	0	.00	0	.00	1	4.00

	p						
Actual	Group		Nord		Mong.		TOTAL
1		0	.00	1	4.00	25	100.00
2		1	4.00	0	.00	25	100.00
3		1	4.00	2	8.00	25	100.00
4		1	4.00	1	4.00	25	100.00
5		19	76.00	0	.00	25	100.00
6		3	12.00	18	72.00	25	100.00

Table 4: Accuracy of the discriminant function analysis; actual / predicted population by count and percentage

Row	CLCOEFF	CLCOEFF	CLCOEFF	CLCOEFF	CLCOEFF	CLCOEFF
1	4.86	5.06962	5.39	5.28	5.51	5.23
2	0.71	0.734627	0.91	0.86	0.94	0.87
3	3.43	3.40005	3.17	2.95	3.10	3.20
4	-0.20	-0.0886274	-0.23	-0.22	-0.15	-0.54
5	1.28	1.31118	1.31	1.24	1.17	1.18
6	1.39	1.41732	1.42	1.49	1.46	1.34
7	1.2	1.07846	1.13	0.87	0.93	1.27
8	-2.03	-2.11015	-2.16	-2.04	-1.97	-1.89
9	5.00	5.30260	4.95	4.98	4.97	5.20
10	4.33	3.86232	4.04	4.46	4.47	4.30
11	-1.40	-1.33388	-1.47	-1.88	-1.79	-1.59
12	1.40	1.18783	1.24	1.19	1.26	1.41
13	4.82	4.57530	4.89	4.80	5.00	5.00
14	-1165.06	-1192.99	-1235.44	-1148.61	-1245.90	-1217.25

Table 5: Classification coefficients for all six population groups

Population group	number of individuals	Percentage
Cromagnoid-A	10	35.25
Gracile mediterranean	9	29.05
Nordic	8	25.80
Cromagnoid-B	2	6.45
Mongoloid	2	6.45
Total:	**31**	**100.00**

Table 6: The presence of population groups in Privlaka

Population group	number of individuals	Pencentage
Gracile mediterranean	4	40
Cromagnoid - A	2	20
Brachycranic group	2	20
Nordic	1	10
Mongoloid	1	10
Total:	**10**	**100**

Table 7: The presence of population groups in Stari Jankovci

Population group	number of individuals	mean age at death	Standard deviation
Cromagnoid - A	10	37.50	14.31
Gracile mediterranean	9	30.83	7.45
Nordic	8	41.87	11.02
Cromagnoid - B	2	35.00	2.50
Mongoloid	2	27.50	0.00
Total:	**31**	**36.04**	**11.51**

Table 8: Mean ages at death for the varions population groups present in Privlaka

Population group	number of individuals	mean age at death	Standard deviation
Gracile mediterranean	4	41.25	8.19
Cromagnoid - A	2	42.50	0.00
Brachyranic	2	35.00	2.50
Nordic	1	32.50	0.00
Mongoloid	1	45.00	0.00
Total:	**10**	**40.00**	**6.70**

Table 9: Mean ages at death for the varions population groups present in Stari Jankovci

Age class	Nord.		Med.		Cr-A		Cr-B		Mong.		Total	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
15-19	1	12.5	2	22.3	1	10.0	0		0		4	12.9
20-24	0		0		2	20.0	0		0		2	6.4
25-29	0		0		1	10.0	0		2	100.0	3	9.6
30-34	0		4	44.4	1	10.0	1	50.0	0		6	19.4
35-39	2	25.0	3	33.3	1	10.0	1	50.0	0		7	22.7
40-44	2	25.0	0		0		0		0		2	6.4
45-49	0		0		0		0		0		0	
50-54	3	37.5	0		3	30.0	0		0		6	19.4
55-59	0		0		1	10.0	0		0		1	3.2
60 +	0		0		0		0		0		0	
Total	**8**	**100.0**	**9**	**100.0**	**10**	**100.0**	**2**	**100.0**	**2**	**100.0**	**31**	**100.0**

Table 10: Mortality distribution by age class and population group in Privlaka

Age class	Nord.		Med.		Cr-A		Brachy.		Mong.		Total	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
15-19	0		0		0		0		0		0	
20-24	0		0		0		0		0		0	
25-29	0		1	25.0							1	10.0
30-34	1	100.0	0		0		1	50.0	0		2	20.0
35-39	0		0		0		1	50.0	0		1	10.0
40-44	0		1	25.0	2	100.0	0		1	100.0	4	40.0
45-49	0		2	50.0	0		0		0		2	20.0
50-54	0		0		0		0		0		0	
55-59	0		0		0		0		0		0	
60 +	0		0		0		0		0		0	
Total	**1**	**100.0**	**4**	**100.0**	**2**	**100.0**	**2**	**100.0**	**1**	**100.0**	**10**	**100.0**

Table 11: Mortality distribution by age class and population group in Stari Jankovci

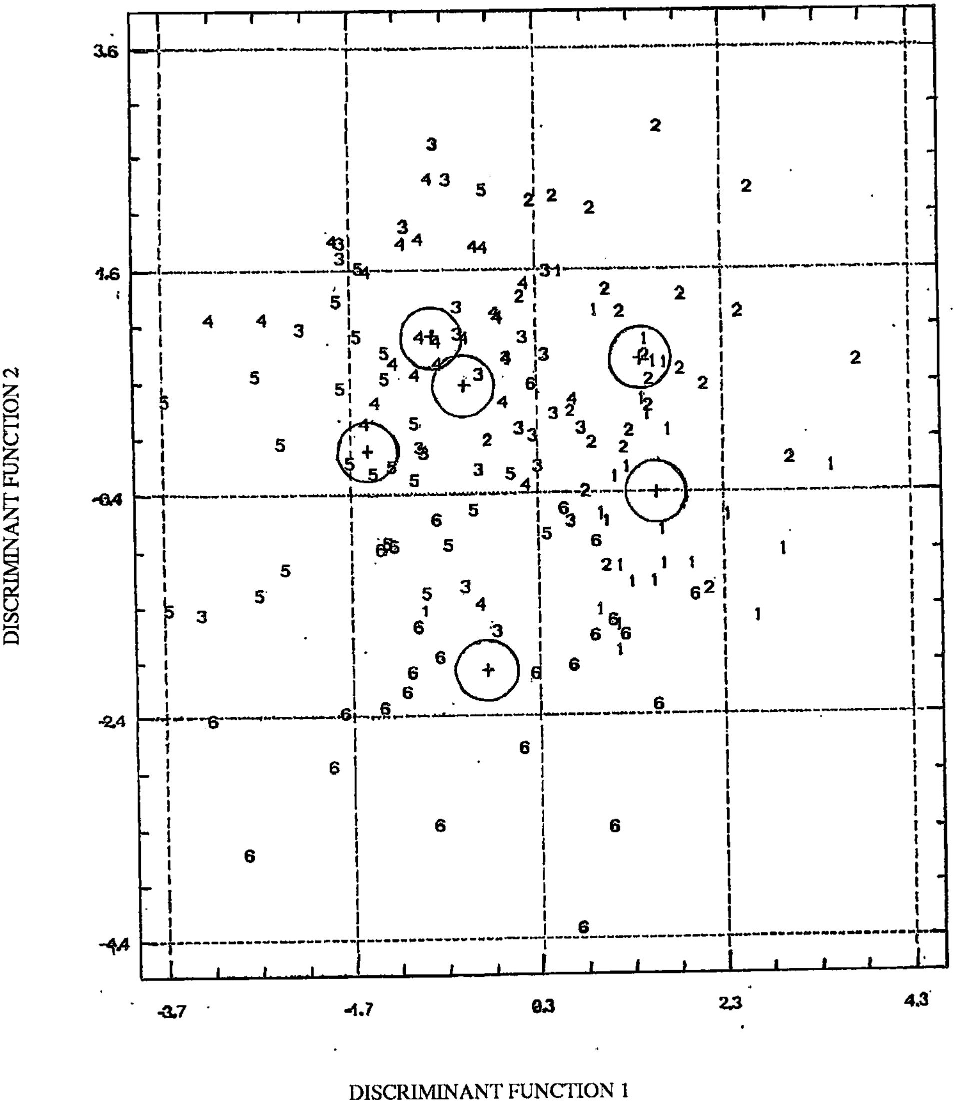

Figure 1. Two-dimensional representation of the analysed skulls from the data base and population group centroids. Group centroids are surrounded by 90% confidence intervals.
Skulls are coded with the following system:
1=Brachycranic, 2=Cromagnoid A, 4=Gracile Mediterran, 5=Nordic, 6=Mongoloid.

Figure 2

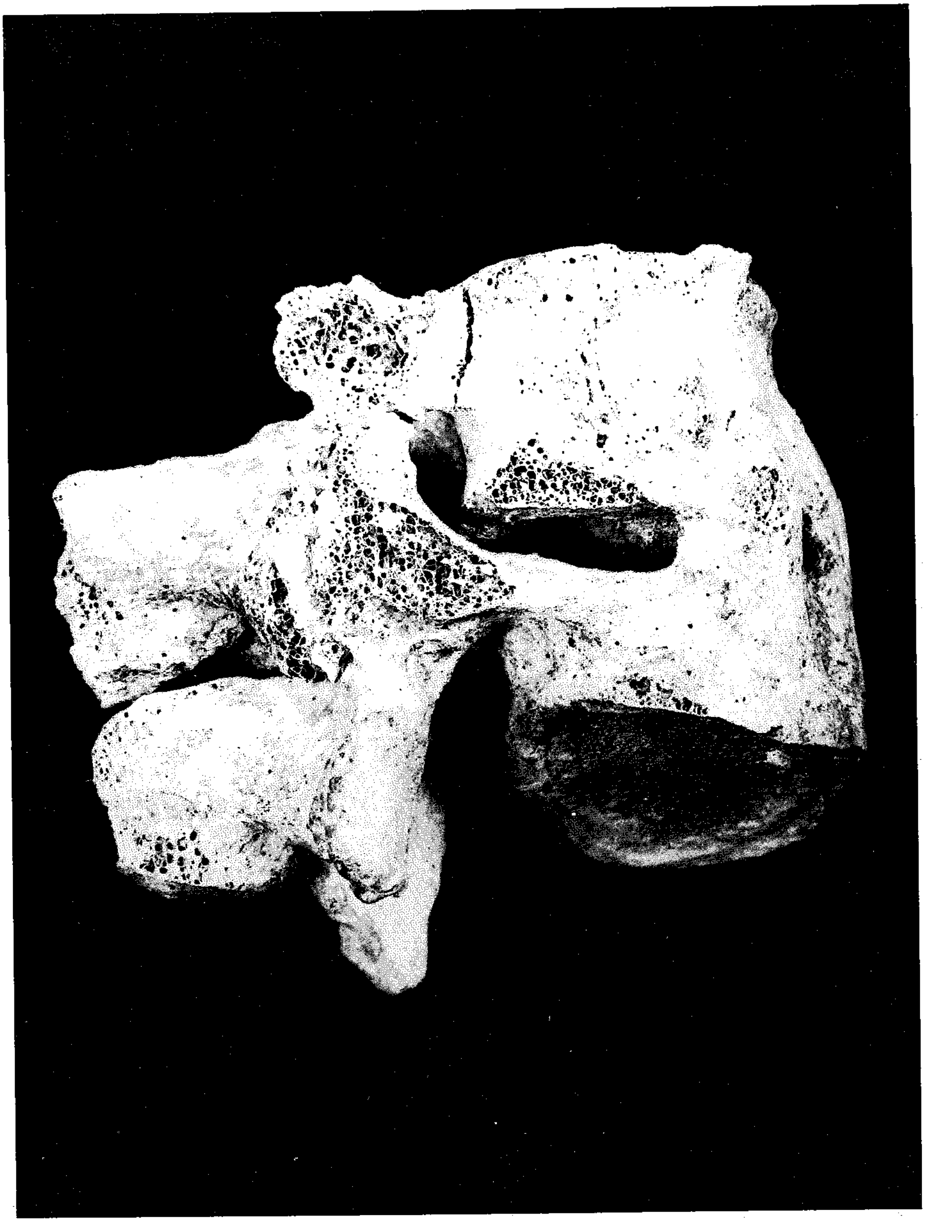

Figure 5

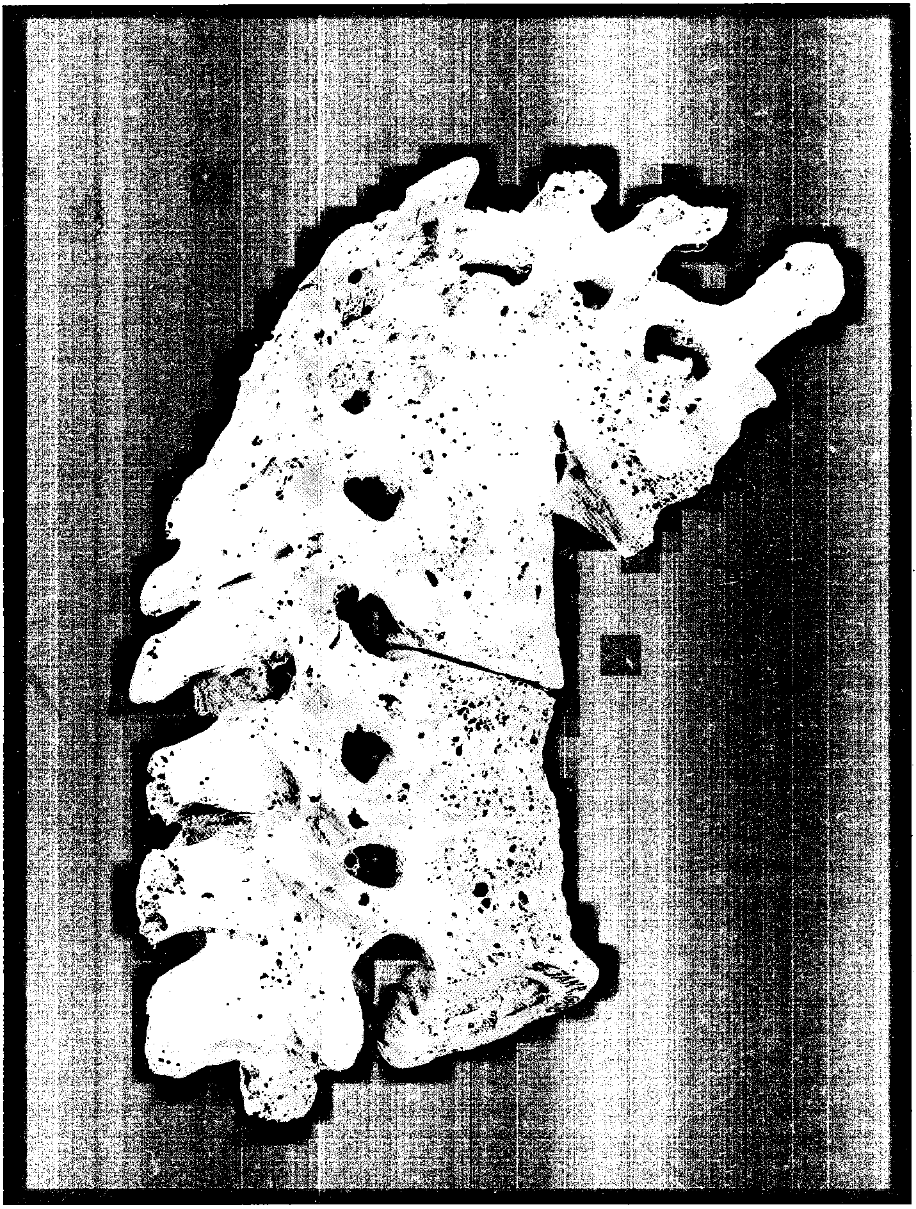

Figure 6