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DIETARY RECONSTRUCTION OF THE EARLY BRONZE AGE MANIKA POPULATION (EUBOEA ISLAND, GREECE)

ABSTRACT: The Early Bronze Age (EBA) period in Greece is represented by the Manika and Aghios Kosmas cemeteries and some other sites with a few skeletal remains. Thus, the EBA Manika is a very important urban site, and though the skeletal material is not in a good state of preservation, a palaeodemographic analysis was carried out with important results (Neroutsos et al. *1994a, b). Next step of the study was the bone trace-element analysis for elucidation of the dietary habits of this early urban Hellenic city. This kind of analysis indicates a well-balanced food intake with the same contribution of vegetable and meat consumption. The analysis of the dental pathology showed a very low incidence of carious lesions and ante-mortem tooth loss, as well as a significant degree of tooth wear and a moderate incidence of DEH (indicative of a good teeth mineralization and a good status of general health). These data are in accordance with the results of the trace mineral analysis with regard to the kind of diet (well balanced) of this population supported by a mixed economy.*

KEY WORDS: Dietary reconstruction – Bone trace-element analysis – Strontium – Zinc – Dental pathology – Bronze Age – Greece

INTRODUCTION

Manika is a large Early Bronze Age (EBA) settlement with an estimated population size of about 6–7,000 residents according to the evaluation made by the excavator (Sampson 1985, 1988), located in central Euboea Island. It was relatively large (200 acres), surrounded by the sea in the west, today's national road of Chalkis-Psachna in the east and the cemetery in the south-west (*Figure 1*).

Manika reached the highest development during the EBA II period (2850–2350 BC). The residents at that time had undertaken the commercial trade supplying central Greece with obsidian, which they worked out in special laboratories and metals. Possibly they also supplied the Cyclades and other islands of the Aegean Sea with animals or wheat, since they controlled the agricultural production of the two major valleys of central Euboea, that are Psachna and Lelandion plains. They also had the control of the Euripos strait and consequently the north and south Evoikos Sea. We are sure that massive navigation was developed and thus high financial activities must had concentrated in the city, giving a leading role in the island of Euboea.

The palaeodemographic analysis raises the population at about 10,000 inhabitants for the EBA II period, and at 4,000 for the next cultural period (EBA III) (Neroutsos *et al.* 1994a, b). This is a fact which proved that the period of actual peak of development was the EBA II period. Later on its role is limited and during Middle Bronze Age and Late Bronze Age periods the biggest part of the settlement was deserted and confined in a small part at the peninsula. The EBA cemetery is located very close to the settlement and is almost adjoined to it. We assume that the cemetery is extended and occupies about 20 acres. Papavasiliou (1910) who excavated fifty tombs, gave no field plan and

FIGURE 1. Map of Greece: location of the Manika Cemetery.

as a result the rest of the cemetery was not excavated for many years. Thus, a large part of the cemetery was destroyed by construction works and other excavation activities. More recent excavations have revealed that the tombs are scattered all over the area, without excluding the possibility that there may be empty spaces in between. So, Papavasiliou's opinion that the cemetery contained small groups of tombs was revised (Sampson 1985, 1988).

Generally, the chamber tombs of Manika, measuring more than two meters in width and length, are dug in the rock, usually with a long and narrow corridor leading to the main chamber. They were constructed and used in two different periods, as we can assume by the burial findings. Most tombs are dated to the EBA II (2850–2350 BC), while others belong to the EBA III period. In some cases we found in one and the same tomb burials which belong to both phases (EBA II and EBA III). We discerned main burials and disturbed (earlier) dead. The reason that many tombs were used more than once must have been no other than the big population of Manika and the expensive construction of a chamber tomb to be used just once.

The ornaments of Manika tombs allow to draw conclusions for the socio-economic status of the dead. It seems that they should not be regarded as sufficiently rich in comparison to other burial sites of the same era. The discovery of few objects (pottery, lithic and bronze artefacts) of Cycladic and/or eastern origin, should be attributed to an "internationalistic" spirit of the period.

Nevertheless, the condition in which the skeletal material was found is still valuable, because there is little information about the EBA period. The excavation of Aghios Kosmas (Mylonas 1931, Koumaris 1932, Angel 1959) has been our basic source of information for the EBA people so far. Human skeletons have also been excavated in Corinth (Nemea, Cheliotomylos), but Angel did not publish this skeletal material.

Aim of the study

This study is part of an extensive physical anthropological study of the Manika cemetery which includes the description of the skeletal material (skeletal biology, palaeodemography, palaeopathology) and a research of the palaeodietary habits. The latter can be done in two ways. The former one is the dental study which includes the study of oral hygiene, attrition, ante-mortem or post-mortem loss of teeth and observations on the incidence of dental enamel hypoplasia (DEH). The second is the trace-mineral (Sr and Zn) and mineral (Ca) analysis of the bones, which permits a reconstruction of the palaeodiet. In this paper both ways of research and control of the palaeo-dietary analysis of the EBA people of Manika have been applied.

MATERIAL AND METHODS

Bone trace-element analysis

Out of the 39 samples that were taken 14 were not examined, belonging to children and some adults, because they were not reliable evidence (probably due to contamination from the burial ground). Thus, only 25 samples were examined. Seventeen of them were males and eight females. The age at death was not possible to determine because the skeletal material was in a really bad state of preservation (*Table 2*).

The bone samples were taken from femoral or tibial fragments in a cylindrical shape with the use of a special drilling instrument. The outer bone layer was removed, because it was more exposed to diagenetic phenomena (Waldron 1983). The quantity determination of the trace-elements through atomic absorption, was performed according to the theoretical methods of some recent papers on the subject (Bisel 1980, Schoeninger 1980, Sillen 1981a, b).

The aim of these analyses was to use the bone trace elements as a guide to reconstruct palaeodiet. The analysed elements were calcium (Ca), Strontium (Sr) and Zinc (Zn).

This limited choice (of only three elements) was necessary due to the fact that they, in contrast to others like Fe, Al, Mg, Mn etc., besides being crucial for researches of this type, and because they are little influenced by diagenesis (diagenetic procedures) (Bartoli 1995, 1996, Katzenberg 1984, Kile 1986).

Calcium is a basic ingredient of the bone itself, whereas the other two are present only in traces and characteristic of nutrition (dietary discriminants) (Peeters, Catoire 1966). The bony percentage of Sr is analogous to eating food of vegetarian origin and has a clear chemotaxis for the bony tissue (99% of the body Sr is contained in the bones) (Comar, Wasserman 1963). It is found in high concentrations in the bones of vegetarians, and low in those who eat meat (Toots, Voorhies 1965). The strontium

TABLE 1. Mean values and standard deviation of the trace minerals in the compact bone and in the soil of the burial ground.

Element	Bone	Soil	Observations
Ca(in mg/gr)	257 ± 11.2 (N = 25)	163 (N = 7)	There is not any contamination of the bones by the soil.
Sr (in ppm)	141 ± 47.1 (N = 25)	094 (N = 7)	
Zn (in ppm)	132 ± 51.4 (N = 25)	047 (N = 7)	

TABLE 2. Individual values of the skeletons of Manika analysed.

Grave	Sex	Type of bone	Ca (mg/g)	Sr (ppm)	Sr/Ca ratio	Sr/Ca ratio corrected	Zn (ppm)	Zn/Ca ratio
6A	Male	Femur	256	182	0.71	0.66	277	1.08
6B	Male	Femur	265	220	0.83	0.78	151	0.56
7B	Male	Femur	250	135	0.54	0.50	088	0.35
7D	Male	Tibia	254	083	0.32	0.30	079	0.31
8A	Male	Femur	296	173	0.58	0.54	078	0.26
8B	Male	Tibia	255	178	0.68	0.64	061	0.23
15B	Male	Tibia	254	116	0.45	0.42	157	0.61
16A	Male	Tibia	251	105	0.42	0.39	097	0.38
16B	Male	Femur	265	112	0.42	0.39	181	0.68
16D	Male	Femur	254	167	0.65	0.61	163	0.64
20A	Male	Femur	255	218	0.85	0.80	120	0.47
20B	Male	Femur	254	108	0.42	0.39	101	0.39
22A	Male	Tibia	252	102	0.40	0.37	083	0.32
26A	Male	Tibia	253	133	0.53	0.50	119	0.47
129	Male	Femur	243	093	0.38	0.35	135	0.55
146	Male	Femur	259	113	0.43	0.40	121	0.46
167B	Male	Femur	264	112	0.42	0.39	137	0.51
5	Female	Femur	259	235	0.90	0.84	068	0.26
7A	Female	Tibia	250	087	0.35	0.33	208	0.83
7C	Female	Femur	258	139	0.53	0.50	137	0.53
16C	Female	Femur	265	102	0.38	0.35	119	0.44
22B	Female	Tibia	240	115	0.47	0.44	161	0.67
24B	Female	Tibia	237	103	0.43	0.40	098	0.41
134	Female	Femur	259	190	0.73	0.68	224	0.86
167A	Female	Femur	270	219	0.81	0.76	144	0.53

TABLE 3. Comparison of the chemical bone synthesis between males and females.

Element	Males	t-test	Females
Sr (ppm)	138.00 ± 42.8	t = 0.536. p = 0.597	149.00 ± 57.8
Sr/Ca ratio (corrected)	0.49 ± 0.15	t = 0.715. p = 0.482	0.54 ± 0.19
Zn (ppm)	126.00 ± 51.5	t = 0.855. p = 0.401	145.00 ± 52.5
Zn/Ca ratio	0.49 ± 0.20	t = 0.933. p = 0.361	0.57 ± 0.20

TABLE 4. Mean value and standard deviation of the Sr/Ca and Zn/Ca ratios of Manika cemetery and several other Mediterranean populations.

Site	Era	No. of deads	Sr/Ca (1)	Zn/Ca	Inferred economy
MANIKA	EBA*	25	0.51±0.16	0.51±0.20	Mixed
KALINKAIA 2	EBA	32	0.80±0.36	0.72±0.59	Rich agricultural, pastoral(2)
MONTELETI	EBA	3	0.67±0.19	0.18±0.06	Indefinite
RIBERA CIAVOLARO	EBA	30	0.53±0.12	0.57±0.14	Rich Mixed
MONTE FULCINO	MBA**	29	0.31±0.03	0.67±0.20	Pastoral (2)
NICHORIA	LBA***	26	0.55±0.10	0.38±0.09	Mixed
GROTTA LIARDO	Bronze Age	3	0.42±0.11	0.47±0.07	Indefinite

(1) CORRECTED by site. (2) Rich in animal proteins

(*) EBA= Early Bronze Age. (**) MBA= Middle Bronze Age. (***) LBA= Late Bronze Age.

TABLE 5. Percentage (%) of the incidence of carious lesions and tooth loss in the anterior and posterior teeth, as the type of the carious lesions.

Carious lesion	Total No. of teeth	Posterior teeth	Anterior teeth
	14	**10** (71.43%)	**4** (28.57%)
Interdental stenoma	14	**8** (57.1%)	**6** (42.9%)
Occlusal surface			
Tooth loss	10	**9** (90.0%)	**1** (10.0%)

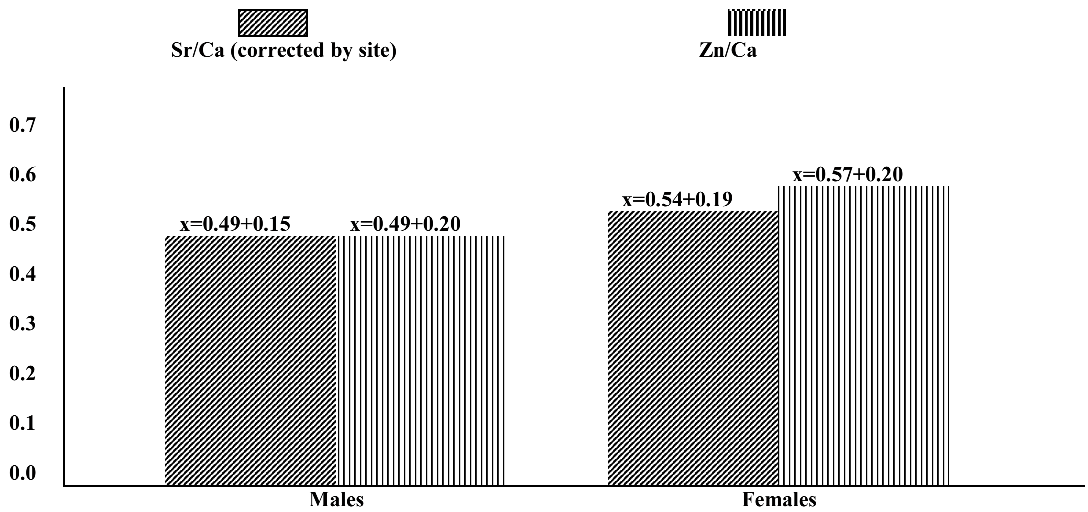
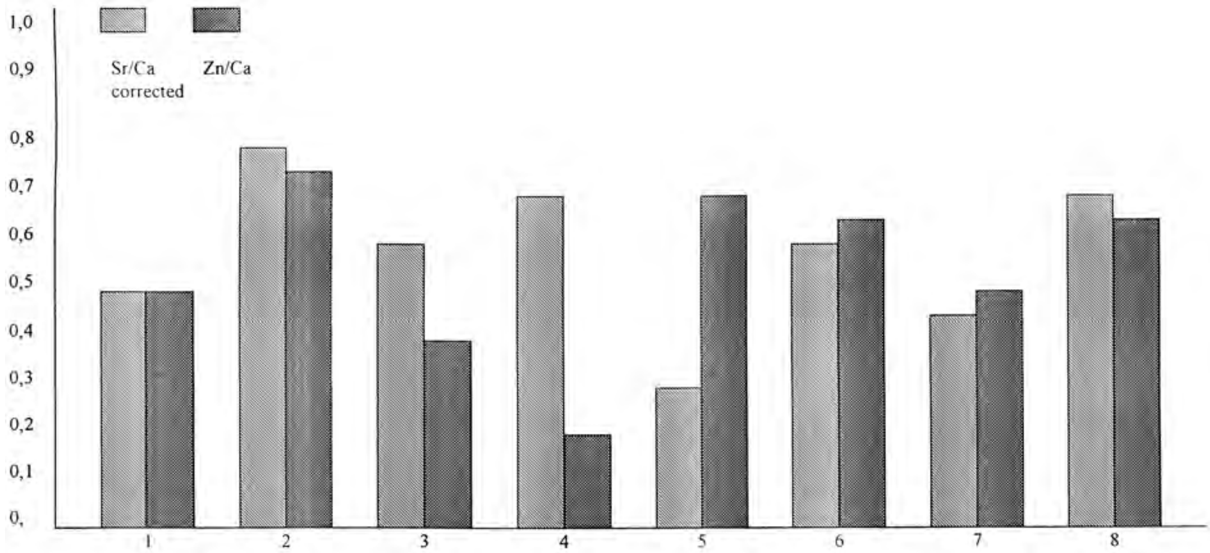


DIAGRAM 1. Comparison of the means of Sr/Ca (corrected by site) and Zn/Ca ratios for the male and female individuals respectively.



1 = Manika (Greece), 2 = Kalinkaia (Turkey), 3 = Nichoria (Greece), 4 = Monteleti (S. Italy), 5 = Monte Fucino (S. Italy),
6 = Ribera Ciavolaro (Sicily), 7 = Grotta Liardo (Sicily), 8 = Standard (modern human populations).

DIAGRAM 2. Comparison of the concentrations of Sr and Zn in the Manika cemetery to other Mediterranean populations of the Bronze Age Era.

TABLE 6. Distribution of dental enamel hypoplasia in deciduous teeth.

Age interval	No. of cases
Birth – 10 months	**1**
10 months – 2 years	**8**
2–3 years	**14**
3–4 years	**42**
4–5 years	**84**
5–6 years	**6**
6–7 years	**2**
7–8 years	**1**

quantity was measured through the Sr/Ca ratio (in ppm/mg/g), given the fact that it reflects the type of absorption and its metabolism in the bony tissue (Bisel 1980, Fornaciari, Mallegni 1986, Schoeninger 1981, 1982, Sillen, Kavanagh 1982, Sillen 1984).

For comparison to other populations, even those which are temporal and from different sites, we had to standardise the measurements. That is to correlate the human Sr/Ca ratio with the animal Sr/Ca ratio. This with regard to the animals which are definitely vegetarians and endemic (and also have lived in the same period and in the same environment). Thus we had to correct this ratio by site (Bisel 1980, Fornaciari 1984, 1986, 1987, Schoeninger 1981, 1982, Sillen 1981a, b, 1984).

The other trace element which was analysed is zinc (Zn), whose basic source is meat and especially red meat (Bisel 1980, Blakely, Beck 1981, Klepinger 1984), milk and dairy products (Guengen 1971, Montenera, Bonessa 1980). This element is found in abundance in seafood as well (Fidanza, Liquori 1988).

For this type of research it is necessary to perform several thorough analyses of the ground, near the burial, and never in contact with the bones of the dead, in order to avoid possible contamination of the type => ground (soil) –

FIGURE 2. MANIKA (Tomb No. 4). The mandible of a young individual. The third molar has not erupted yet. We observe the pits of dentine (high grade tooth wear) in comparison to the supposed young age of the individual.

FIGURE 3. The unique almost complete mandible (Tomb No 4). It belongs to a very young child (4–5 years old). The deciduous premolars and first permanent molar are shown.

human or animal bone and/or vice versa. Thus, we defined whether the bone was contaminated or not by diagenetic phenomena (Lambert *et al.* 1979, Klepinger 1984, Kile 1984).

Palaeoodontology

The dental material coming from the Manika cemetery is in poor state of preservation and fragmentary. Nevertheless, we made an effort to retrieve all possible information about the dietary habits of the population. The only intact lower jaws (mandibles) which were identified belonged to an adult (in which all the teeth were lost post mortem) (*Figure 2*), and to a child (*Figure 3*). It was impossible to identify other intact maxillary bones.

Generally, 15 fragments of mandible and 8 fragments of maxilla with identifiable alveoli were identified. The biggest part of the skeletal material consists of free teeth, which are also very fragmented, unfortunately. Almost all of them are broken at the roots and very often the only part of the tooth which is preserved is dental crown. This state

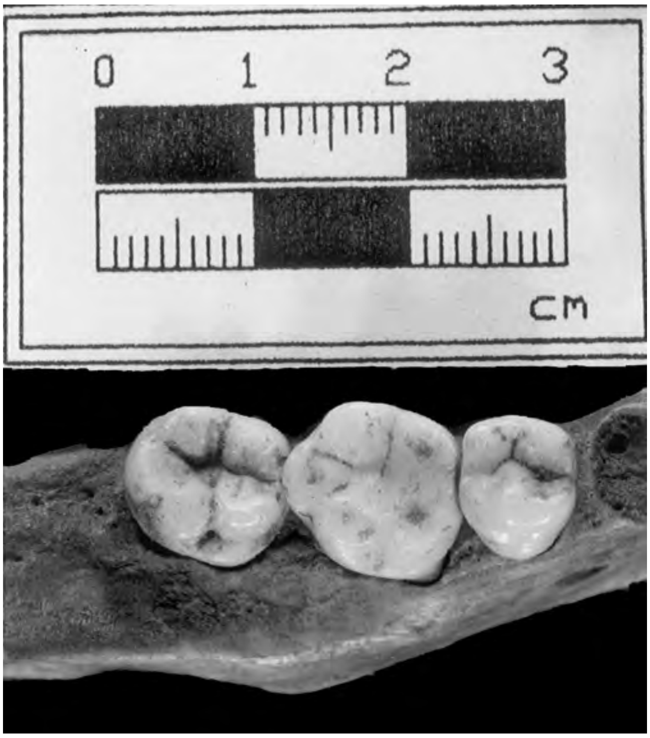


FIGURE 4. Details of the photograph in *Figure 2*. We can observe the severe tooth wear of the first molar.

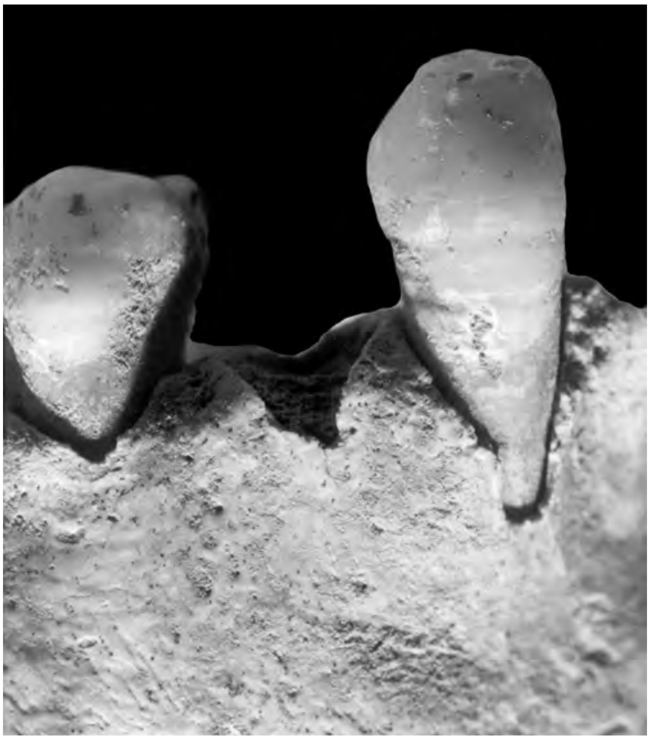


FIGURE 5. Dental enamel hypoplasia (DEH). We can observe two almost highly marked lines of DEH.

FIGURE 6. An example of DEH on a first lower molar, just under a pit of the 1st grade of a supernumerary cusp (hypocone), which can be scored.

of preservation makes the identification of the teeth problematic. Thus, our interest was focused on the dental crowns in order to increase the sample, knowing that in this way we could add even the crowns of the teeth that had not erupted yet (crown which is still within the vesicular bubble – capsule).

In total 394 crowns of permanent teeth and 158 of deciduous teeth were identified. Our sample, unfortunately, presents a distinctive dissimilarity, which makes it of doubtful use for any statistical research. Still, we can always make some speculations.

RESULTS AND DISCUSSION

A) Trace – elements data

From *Table 1* it is obvious that the concentrations of the three elements in the ground, are decisively low in comparison to the human bones. So, these are indications that there is not any contamination and the data must be representative of the original synthesis of the bone.

Table 2 presents the analytical values of the skeletons from the Manika cemetery. In *Diagram 1* we present a comparison between males and females, in relation to the diet. We can also observe that there are not statistically significant differences between both sexes, although the values in females are higher.

Table 3 shows the results of the comparison of the mean values and standard deviation using T-test. The analysis of the concentration of the two trace elements indicates a high probability that the different dietary substances are of the same amount for the quality and quantity of food intake.

In *Diagram 2* the concentrations of strontium and zinc in the Manika sample are compared to those in other Mediterranean populations which are dated in the Bronze Age Era. In the diagram also have been added the standard values of the two trace elements (Sr and Zn), which are attested in modern populations (Torekian, Kulp 1956, Fidanza, Liguori 1988). It can be observed that there is a very close similarity in diet between Manika, Nichoria (Messenia, Ellas) and Rivera Ciavolaro (Sicily, Italy). The population of Kalinkaia 2 (Turkey) seems to have adopted a rich agricultural way of life, while the Monte Fulcino (Lazio – Italy) has a pastoral way of life.

In conclusion, the analysis of the trace elements that determine the type of diet, gave the same values in the Sr/Ca and Zn/Ca ratios (*Table 4*). Finally, we can assert that the Manika population had a mixed diet, which did not reach the optimal values in carbohydrates and animal proteins, as revealed by the comparison to modern standards.

B) Palaeodoontological data

In order to clarify the oral hygiene of the population and indirectly the diet we focused on the effects of the pathological conditions and on the dental wear (Cran 1959, Powell 1985). The fragmentary nature of the maxillary and mandibular bones does not permit to judge the average effect of the periodontitis (carious lesions) and tooth loss during lifetime (intra-vitam). But the periodontitis seems to be generally low.

Indeed, we have found only 14 teeth (one of them is deciduous) infected by periodontitis. In the 8 maxillary bone fragments we have found traces of tooth loss ante mortem (totally 12 teeth). The cause of tooth loss were dental pathological conditions.

The dental wear shows a very heterogeneous distribution. Indeed, there are a lot of teeth with a high degree of dental wear (*Figure 4*) and also many teeth without dental wear or low. The incidence of a medium dental wear is rare. Additionally the anterior teeth are much more damaged (with severe dental wear) than the posterior.

The lack of clear demographic data does not permit to judge the actual effect of the food on the diet (nutrition). The high levels of wear in a large part of the sample which consists of many single teeth with low wear or without any at all could be indicative that the sample consists form young and old individuals (highly variable in age distribution).

The supposed not well balanced dental wear of the anterior teeth, could be connected either with a paramasticatory use of the teeth (Molnar 1971), or simply by reason of pathologic conditions of the masticatory system, which initially act in the posterior teeth, as our data indicate (*Table 5*).

The low effect of periodontitis could be connected with a high level of dental wear attrition (Powell 1985). The confirmed cases of periodontitis also could be of occlusal-fissural type with a slow development or interdental stenoma.

The analysis of dental enamel hypoplasia became interesting, and observed and recorded in 158 single teeth. Generally, DEH was identified in the form of horizontal lines, while there were only two cases in which DEH was illustrated in the form of pits (*Figures 5, 6*).

A detailed analysis (Massler *et al*. 1941, Goodman *et al*. 1980) which can recognise the period of abrupt incidence of DEH, revealed the following observations (*Table 6*). These data could be indicative of developmental disturbances caused by pathological conditions (El-Najjar *et al*. 1978, Giro 1947) or from malnutrition (Denell 1979, Goodman *et al*. 1980). Also we have to mention that these disturbances occurred in the age between 2 and 4 years of life, and this is confirmed in *Table 6* mentioned above, where most of the cases are recorded in this age interval. Should these phenomena be due to malnutrition – that could be the cause of this phenomenon, because it had occurred in the weaning period (even if this weaning period is prolonged).

The incidence of DEH and the mild effect of the dental pathologies on the stomatognathic system could favour to suppose a diet poor in carbohydrates, and surely in simple sugars (glucose). If we assume that the high level of dental attrition is not due to cultural activities, we can infer, in correlation to the special distribution of DEH, that this could be indicative of a distinguishing intake of food rich in fibres.

CONCLUSIONS

The dental data seem to be in agreement with those of the trace elements analysis [palaeodiet] and their values draw a diet in which the animal proteins, although limited, are present, while the vegetable proteins give an indication for a diet much richer in fibres.

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