DENTAL EVIDENCE FOR DIETARY PRACTICES IN THE CHALCOLITHIC PERIOD: THE FINDINGS FROM A BURIAL CAVE IN PEQI’IN (NORTHERN ISRAEL)

N. LEV-TOV, A. GOPHER AND P. SMITH

Abstract: Archaeological data mark the southern Levantine Chalcolithic as a period of great change at the economic and socio-political levels. At the economic level these include intensive cereal cultivation, the cultivation of fruit trees and the utilization of secondary animal products. At the socio-political level the changes include a higher level of socio-political complexity.

The analysis of the human dentition has long been used by anthropologists as a tool for reconstructing life ways of past populations. When analyzed by age and social group, pathological, and other conditions of the dentition, provide valuable clues to dietary practices, cultural habits and subsistence strategies.

This study examines the dentition from 100 mandibles found at the Chalcolithic burial cave in Peqi’in (northern Israel), in order to shed light on some dietary practices and the general health of this population in relation to the economic and socio-political changes that occurred during this time. The results showed a high frequency of hypoplasia (over 95% in canines) pointing to the prevalence of physiological stress during infancy and childhood. Molar wear rate was rapid and oblique in pattern indicating an abrasive diet. The caries frequency for the M2 and M3 was 19.3%, and with ante mortem tooth loss and abscissing points to a heavy reliance on cereals. The high frequency of hypoplasia in combination with other dental pathologies may be associated with a diet low in nutritional value and/or disease. The pattern of disease appeared to be similar in all individuals within the same age group, indicating that the population of Peqi’in shared a similar life experience in that no one group or individual was more socially buffered from disease or enjoyed differential access to nutritional resources.


L’analyse de la dentition humaine a été depuis longtemps utilisée par les anthropologues comme un outil permettant de reconstituer le mode de vie des populations du passé. Analyssées en fonction de l’âge et du groupe social, de leur pathologie et d’autres conditions sanitaires, elles livrent des informations sur les pratiques alimentaires, les habitudes culturelles ainsi que les stratégies de subsistance. Ici, la dentition de 100 mandibules provenant de sépultures chalcolithiques de la grotte de Peqi’in, au nord d’Israël, est examinée en vue de mettre en évidence les rapports pouvant exister entre certaines pratiques alimentaires, de montrer les changements économiques et socio-politiques et les conditions sanitaires de ce groupe de population.

Les résultats montrent une forte hypoplasie dentaire (95% sur les canines) découlant d’un haut niveau de stress physiologique pendant l’enfance. L’usure dentaire oblique est importante. Elle fut rapide et indique une diète abrasive. La fréquence (19.3%) des caries sur les M2 et M3 et la perte antemo mortem de dents ainsi que le nombre élevé d’abcès rendent compte d’une alimentation riche en céréales. La grande fréquence d’hypoplasie dentaire associée à d’autres pathologies peut être mise en relation avec une alimentation pauvre du point de vue nutritionnelle ou avec des maladies. Les types de maladies observées, semblables à l’intérieur des mêmes classes d’âge, indiqueraient que la population de Peqi’in partageait un mode de vie identique et qu’aucun groupe ou individu n’était avantagé face à la maladie et à l’accès aux ressources alimentaires.

Key-Words: Chalcolithic, Southern Levant, Peqi’in, Health status, Dental Pathology, Paleonutrition.

Mots Clefs: Chalcolithique, Levant Sud, Peqi’in, État sanitaire, Pathologie dentaire, Paléonutrition.
INTRODUCTION

Archaeological data collected regarding the Chalcolithic period in the southern Levant indicates that major changes occurred during this period at the socio-political and economic levels. At the demographic level evidence is mixed as to population size and density, nevertheless, the period is characterized by settlement in previously sparsely inhabited regions such as the northern Negev. Diet and subsistence in the Chalcolithic may be loosely defined as based upon a mixed farming regime similar to that of the modern day Fellaheen consuming a traditional diet. Significant changes at the economic level included the utilization of secondary animal products and the beginning of fruit tree cultivation. Technological innovations such as ivory and copper working are also a significant component of the changes noted in the Chalcolithic, as reflected in "treasure hoards" which have been found at several sites such as Nahal Mishmar and Nahal Qanah.

Developments at the socio-political level have been, for some time, at the focal point of a debate regarding the place of the Chalcolithic in the cultural sequence of the southern Levant. This debate is led primarily by two opposing points of view generally represented by Levy and Gilead. Levy suggests that demographic and economic changes, along with the emergence of public sanctuaries, burial grounds and settlement hierarchy reflect complex societies, which may be defined as separate, regionally oriented chiefdoms. Gilead, on the other hand, views the socio-political organization of the Chalcolithic as relatively simple, consisting of scattered farming communities, whose economic and social activities may have been influenced by household heads or seniors. While Levy believes that the developments that occurred during this period provided a foundation for the Early Bronze Age urban societies, Gilead views the urban societies as resulting from the impact of developments in Egypt and Mesopotamia rather than local evolution.

In their examination and reinterpretation of the symbolism associated with the "Gilat woman", Joffe et al. note that the difference between Chalcolithic symbols of power associated with the elite and the private domestic symbols as represented by the "Gilat Woman" point to a stratified society they cannot define as "chiefdom". The authors point out that these social systems should be defined on local terms and not compared to other systems in western Asia, much larger in scale and complexity. In this case it is understandable that the type of socio-political organization suggested by Levy is not as clearly identifiable in the material record as in the case of western Asia. Though radiocarbon dating as well as continuous accumulation of new archaeological data have not yet settled the longstanding debates, they do point to continuity of some Chalcolithic sites and elements into the Early Bronze Age.

Regardless of many unanswered questions, the Chalcolithic is marked as a crucial link between the farming communities, which developed during the Pottery Neolithic (PN), and the later urban societies of the Early Bronze Age.

Studies have indicated that profound changes, such as those that occurred in the Chalcolithic period, greatly affect the physical well being of the population. It has been suggested that the transition from hunter-gatherer to sedentary farming and later to urban societies, had many harmful as well as beneficial effects. As pointed out by Cohen, the adaptation for producing food for a growing number of individuals came at the expense of the nutritional quality of the food, also meaning a lowered ability to buffer disease. Furthermore, the rise in population density associated with sedentism meant an increased disease load for these populations. Nevertheless, these societies were ultimately successful in that they were able to sustain and provide for an increasing number of individuals.

Bioanthropological examinations provide a means for evaluating dietary patterns and health status through examination of skeletal remains. In this study, dental anthropology in general and the study of dental patholgy in particular have been used to obtain a window into dietary practices and health status of a Chalcolithic population in northern Israel.

The data presented were collected from mandibles and teeth of 100 individuals from the Chalcolithic burial cave in Peqi'in (northern Israel). The main questions addressed concern the dental evidence regarding diet, nutrition and the gen-

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6. LEVY, 1995 ; 227.
8. Ibid. ; 435.
eral health of the population in relation to the socio-economic developments that had occurred at the time. For this purpose the following types of data were obtained: dental enamel hypoplasia as an indicator of physiological stress occurring during tooth development; caries as a general indicator of carbohydrate consumption; periapical abscessing and antemortem tooth loss (AMTL) as end results of pulp exposure and/or periodontal disease; dental wear as an indicator of food consistency and abrasiveness.

BACKGROUND

The Peqi'in burial cave, located in the northern Galilee region of Israel was discovered in May 1995 during road construction works and excavated by the Israel Antiquity Authority (IAA). This large karstic cave, 17 m in length and 5-7 m in width, contained secondary burials dating to the main phase of the Chalcolithic period. A corridor, now blocked with debris, led to the uppermost of three man-made terraces lined with fieldstone walls. Stone platforms were found in the northern and southern corners of the cave. Ossuaries, jars and high-footed bowls, as well as stone, flint and copper objects were found scattered in the cave in disarray mixed with well-preserved, disarticulated human bones. The excavators have suggested that the cave was systematically robbed within the Chalcolithic period. Because of the disarray in the cave, it was impossible to relate any one bone to the other or any one individual to a specific artifact. Many of the artifacts and bones found in the cave were encrusted with speleothems attesting to the intensification of the karstic activity after the suggested robbery had taken place. Radiocarbon dates of the burial phase indicate that the cave was used for several centuries during the fifth millennium cal. BC. Further research revealed that the cave had been used for dwelling during the first stages of the Chalcolithic and perhaps even earlier. Though no Chalcolithic settlement has been found in the immediate vicinity of the cave, the recent discovery of Einot-Kochav, a large Chalcolithic site located to the southwest of Peqi'in, as well as a recently published survey listing 15 sites in the earlier part of the Chalcolithic and 22 sites in the latter part of the Chalcolithic indicate that the area was not devoid of permanent settlements, as previously thought.

A preliminary iconographic study of ossuaries and other artifacts excavated at Peqi'in revealed objects that have parallels in assemblages from the Negev in the south up to Byblos (Lebanon) in the north. The decorated ossuaries exhibiting a wide array of anthropomorphic imagery and the associated artifacts have led the excavators to believe that the finds are indicative of a ranked society.

The skeletal sample found in Peqi'in represents one of the largest and best-preserved skeletal samples from this period. The minimum number of individuals for the Peqi'in burial site as compiled thus far by IAA bio-anthropologist, Nagar, is 453. Since the cave has not been completely excavated, Nagar estimates that the final number will be greater than 600. The large number of individuals interred in the cave coupled with the amount of artifacts found and its long-term use may suggest that it served as a local or regional burial site.

MATERIALS AND METHODS

Mandibles for the study were selected on the basis of preservation alone, the 100 most complete mandibles found in Peqi'in, from which maximum information could be obtained, were thus chosen for the study sample. The study focused on the permanent dentition, primary teeth were not examined.

The sample was examined with the permission of the IAA and is stored at the bio-anthropology lab of the Tel-Aviv University Anatomy and Anthropology Department.

As mentioned above, the general disarray in the cave, attributed to secondary burial methods as well as robbery, prevented the relation of more than one bone to a specific individual. Each bone was thus collected separately. Many of the bones were covered by speleothems, and cleaning them included a long process of soaking in acid and in many cases the use of a burr. This removed most calculus from the teeth.

15. EL-NAJAR et al., 1978; GOODMAN and ROSE, 1990.
19. SEGAL et al., 1998.
22. NAGAR and ESHED, 2001: 27.
23. NAGAR, 2001- pers. comm.
24. GAL et al., 1997.
25. GAL et al., 1999.
making it impossible to score its accumulation. For complete mandibles, traits such as the shape of the chin, mandibular angle and overall size, were used to identify males. Nevertheless, an analysis of the material by sex could not be carried out since most mandibles were incomplete and could not be accurately sexed using morphometric criteria.

Subadults (aged 6-18) were assigned age on the basis of tooth development by using the developmental timetable suggested by Moorees et al.26. In order to obtain this information some of the mandibles were radiographed. The adults were assigned age categories by using the Miles method of aging by dental wear. This method allows for population specific wear rates, by determining these rates in a baseline group of subadult individuals of known age and using the different functional age of the permanent molars by extrapolation27.

Hypoplasia was examined by using a hand lens all out, and was scored using the FDI method (1982) to describe the type of the hypoplastic defect. Caries were examined using a hand lens and a dental probe. The severity was scored according to the method proposed by Metress and Conway28. The location of the lesion on the surface of the tooth affected was assigned when possible. The general caries rate was calculated using the traditional tooth count method-total number of carious teeth divided by the total number of scored teeth multiplied by 100. A specific caries rate was calculated for each tooth type.

Wear for the molars was recorded by using the method devised by Scott29. This ordinal method provides sensitive discrimination between different stages of enamel wear. The incisors, premolars and canines were scored using the 8-point scale suggested by Smith30.

Abscesses were visually investigated using a hand lens and a bright focused light. They were recorded as present or absent and their location was noted.

Ante mortem tooth loss was checked for the adults. Sockets were visually examined using a hand lens. Ante mortem tooth loss was defined by irregular margins of the bony socket and/or any indication of healing or resorption in the suspected site. Radiographs were used to rule out impacted teeth.

RESULTS

Table 1 shows the number of individuals examined and their distribution by age. Results are given as a frequency (%) of tooth type and/or socket examined. An analysis by tooth type was chosen for two main reasons a) the material was incomplete and thus could not be analyzed on the basis of individuals and b) the occurrence of different conditions varies by tooth type. Since not all mandibles were complete, comparisons between tooth classes do not necessarily apply to the same individuals.

AGE ASSESSMENT

Although older individuals with extensive AMTL were included in the sample, the age assessments reflect a young sample with 30 individuals between the age of 6 and 18 (30 %). Since the study was exclusively concerned with the permanent dentition, individuals under the age of 6 were not incorporated in the sample. Three mandibles were categorized as adults but were not assigned an age range due to bad preservation. These samples were used when calculating overall frequencies.

DENTAL ENAMEL HYPOPLASIA

Hypoplasia was examined in 99 individuals; one mandible was excluded since it did not retain any teeth. Hypoplasia was not examined where the crown surface was damaged. Of those individuals examined, 53 (53.5 %) had one or more hypoplastic teeth (fig. 1). Table 2 presents the frequency of hypoplastic lesions recorded for each tooth type. The difference between these tooth types was found to be statistically significant for the Chi Square Test (P < 0.05). Nearly every individual who retained the canine showed hypoplasia on this tooth (96.3 %). This was followed by the premolars with hypoplasia frequency of 88.9 % and 72.7 % respectively, and conforms to the pattern

<table>
<thead>
<tr>
<th>Age Range (years)</th>
<th>6-12</th>
<th>13-18</th>
<th>19-24</th>
<th>25-36</th>
<th>37-48</th>
<th>49-60</th>
<th>Above 60</th>
<th>Adults of unknown age</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>20</td>
<td>10</td>
<td>33</td>
<td>23</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Total number of individuals = 100

* Based on the Miles Method (1963, 2001).

26. MOOREES et al., 1963.
the age of 6-6.5 years. A relatively low frequency of hypoplasia was recorded in the incisors (47 %). This may be attributed to the small sample size or to their early development.

The pattern of hypoplasia recorded above may indicate a protected environment during infancy or more likely to the fact that those dying in infancy died on exposure or shortly after exposure to stress.

In 96 % of the hypoplastic teeth examined, hypoplasia was recorded mainly on the cervical third of the tooth. The frequency of enamel hypoplasia in M1 of those aged 6-18 was 10 % (N = 30) which when examined using Fisher’s Exact Test, was significantly lower than that of the adults (45.8 %; N = 59). It seems that some children died due to stress factors survived by others and that many of the adults in the population were in fact survivors of physiological stress in infancy. This might be depicted as follows: physiological stress in childhood or infancy may lead to death on exposure to the insult or shortly thereafter before hypoplastic enamel develops. Alternately this stress may have been overcome leaving a permanent imprint in the form of a hypoplastic lesion. Thus stress in early childhood results in a) death leaving little or no hypoplastic enamel or b) illness and survival leaving hypoplastic marks on teeth of those who survived to adulthood.

Table 2: Frequency of hypoplasia in permanent teeth.

<table>
<thead>
<tr>
<th>Tooth</th>
<th>M3</th>
<th>M2</th>
<th>M1</th>
<th>PM2</th>
<th>PM1</th>
<th>C</th>
<th>I2/I1</th>
</tr>
</thead>
<tbody>
<tr>
<td>N*</td>
<td>41</td>
<td>63</td>
<td>89</td>
<td>33</td>
<td>27</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>Hypoplastic</td>
<td>12</td>
<td>25</td>
<td>30</td>
<td>24</td>
<td>24</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>%</td>
<td>29.3</td>
<td>39.7</td>
<td>33.7</td>
<td>72.7</td>
<td>88.9</td>
<td>96.3</td>
<td>47.0</td>
</tr>
</tbody>
</table>

* Where both teeth were present, only one side counted. N = No. of teeth scored for each tooth type and the no. of individuals. Differences between tooth types were significant for Chi square Test (P ≥ 0.05).

noted in previous studies reporting these teeth as being the most susceptible to disruption. The canine and first premolar, have an overlapping crown growth period ranging approximately from the second year of life to the age of six years. The molars exhibited a lower frequency of hypoplasia. Among the molars the highest frequency was recorded for the M2 (39.7 %). The M2 is a late-developing tooth, whose crown development time overlaps with the premolars between the fourth year of life to

CARIES

One or more carious teeth were recorded in 24 out of 69 adult individuals (34.8 %). Forty three carious lesions were recorded on permanent teeth in the sample as a whole, making the total caries rate 9.24 % (N = 465). Caries rate for the adults aged 19-60 + (11.1 %, N = 388) was calculated separately, since caries frequency increases with age (table 3). The teeth with the highest caries frequency were the M2 and the M3 followed by the M1 (19.3 %, 19.3 % and 7 % respectively). The frequency calculated for the molars alone was 12.9 %. Except for one lesion on a first premolar all lesions were recorded on molars.

Taking into account the crown morphology of the molars it is not surprising that the majority of carious lesions were found on the occlusal surface of the teeth (59.5 %) (fig. 2). This trend is also noted for modern populations, since the occlusal surface of the molars is characterized by many grooves and pits that serve as ideal sites for caries formation. The high occurrence of carious lesions on the M2 and M3 compared with the M1 is characteristic of populations with a low caries frequency as

32. MOOREES et al., 1963.
33. WHEATCROFT and KLIMT, 1959.
Table 3: Caries frequency by age and tooth type (total number of examined teeth, excluding adult samples of unknown age).

<table>
<thead>
<tr>
<th>Age range</th>
<th>Total N</th>
<th>M3 N</th>
<th>M3 %</th>
<th>M2 N</th>
<th>M2 %</th>
<th>M1 N</th>
<th>M1 %</th>
<th>PM1 N</th>
<th>PM1 %</th>
<th>Total % for each age range</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-24</td>
<td>196</td>
<td>33</td>
<td>12.1</td>
<td>48</td>
<td>20.8</td>
<td>50</td>
<td>6</td>
<td>15</td>
<td>0</td>
<td>8.6</td>
</tr>
<tr>
<td>25-36</td>
<td>119</td>
<td>19</td>
<td>16.3</td>
<td>30</td>
<td>25.0</td>
<td>20</td>
<td>17</td>
<td>12</td>
<td>0</td>
<td>10.9</td>
</tr>
<tr>
<td>37+</td>
<td>61</td>
<td>4</td>
<td>6.6</td>
<td>75</td>
<td>12.2</td>
<td>16</td>
<td>26</td>
<td>25</td>
<td>40</td>
<td>16.4</td>
</tr>
</tbody>
</table>

Total of teeth examined = 376

* Grouped because small sample size.

Fig. 2: Occlusal view of mandible showing carious lesions on the occlusal surface of the molars and attrition pattern. Note that most wear is on the buccal cusps.

The positive correlation of caries with age is reflected in the caries frequency as recorded among the different age groups (fig. 3). No carious lesions were recorded for individuals aged less than 18. The frequency then increased from 8.6% in the 19-24 year olds to 10.9% in those aged 25-36, and 16.4% in those aged 37 and over.

![Fig. 3: Frequency of pathologies in different age groups.](image)

DENTAL WEAR

The first molars showed an earlier exposure of dentine than the other teeth. The highest mean wear score in the molars was calculated for the M1 (16.3) followed by the M2 (14.09) and the M3 (12.06). This pattern is attributed to the eruption schedule of the teeth: The M1 is first to erupt at the age of 6, followed by the M2 at the age of 12 and later the M3 at the age of 18-21. Wear scores for specimens identified as males were plotted against the general scores and do not seem to reflect a distinctive trend. Each score represents one individual (fig. 4).

Wear patterns for molars were as expected clearly oblique: the buccal portion of the molars was more worn than the lingual portion (fig. 2). The M1 showed the steepest slope, followed by the M2 and M3. Spearman’s Rank Correlation showed that M1 wear scores were significantly correlated with age (P > 0.0001). This was based on subadults aged by tooth development which provided the “baseline” data for aging the adult mandibles as proposed by Miles34 (fig. 5). Results show that by the age of 18 at least one of the buccal quadrants on the M1 had been worn to stage 4 of wear defined.

PERIAPICAL ABSCESSES

No abscesses were noted for the subadults. Abscesses were present in 19 of the adults (27.1%). Altogether 36 abscesses were recorded (table 4). As with dental wear and caries, the prevalence of abscesses increased with age and was most common in the molar region: M1: 9.3%; M2: 6.9%; M3: 5.6% (fig. 6). In the incisors the frequency was 4.4%, while in the canine region a lower frequency of 0.9% was recorded. No abscesses were found in the premolar region.

AMTL AND AGENESIS

The overall frequency of AMTL in adults was 4.6% and increased significantly with age (table 4; fig. 3; fig. 6; fig. 7). Tooth loss was greatest in the M1 followed by the M3 and then M2: 10.1%, 8.4% and 6.9% respectively, but the differences were not statistically significant. This is not surprising when taking into account that the M1 suffered from the highest wear rate followed by the M2 and M3, while the M2 and M3 exhibited the highest frequency of caries. The differential diagnosis between AMTL and unerupted third molars was made on the basis of age, signs of bone resorption and radiographs. No cases of agenesis were noted for other teeth.

DISCUSSION: THE ASSESSMENT OF HEALTH STATUS AND DIETARY PATTERNS

The extremely high frequency of enamel hypoplasia recorded for the Chalcolithic population of Peqi’in is similar to that found in other Chalcolithic populations in the southern Levant, indicating that these populations were exposed to a high level of physiological stress throughout infancy and childhood. This find is consistent with observations that record a gradually increasing frequency of enamel hypoplasia with the intensification of agriculture and sedentarization in the Levant and in other regions around the world. This continued into early urban Bronze Age populations of the south-

35. SCOTT, 1979.

Table 4: Overview of results.

<table>
<thead>
<tr>
<th></th>
<th>M3</th>
<th>M2</th>
<th>M1</th>
<th>PM2/PM1</th>
<th>C</th>
<th>I2/I1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>R</td>
<td>N</td>
<td>R</td>
<td>N</td>
<td>R</td>
</tr>
<tr>
<td>Hypoplasia (age 6 and above)</td>
<td>41</td>
<td>29.3%</td>
<td>63</td>
<td>39.7%</td>
<td>89</td>
<td>33.7%</td>
</tr>
<tr>
<td>Attrition score (age 6 and above)**</td>
<td>57</td>
<td>12.1%</td>
<td>109</td>
<td>14.1%</td>
<td>143</td>
<td>16.2%</td>
</tr>
<tr>
<td>Caries***</td>
<td>57</td>
<td>19.3%</td>
<td>109</td>
<td>19.35%</td>
<td>143</td>
<td>7%</td>
</tr>
<tr>
<td>Abscesses***</td>
<td>107</td>
<td>5.6%</td>
<td>115</td>
<td>6.9%</td>
<td>119</td>
<td>9.2%</td>
</tr>
<tr>
<td>AM loss***</td>
<td>107</td>
<td>8.4%</td>
<td>115</td>
<td>6.9%</td>
<td>119</td>
<td>10.1%</td>
</tr>
<tr>
<td>M3 Agenesis***</td>
<td>107</td>
<td>21.4%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* N: Number of teeth and/or sockets examined; R: Positive finding.
** Mean wear for molars (SCOTT, 1979) and for the other teeth (SMITH B.H., 1984).
*** Calculated frequency for the adults over number of teeth and sockets examined.
Note: No. of teeth scored for hypoplasia is smaller because of damage to the crown surface limiting its examination.

Fig. 6: Abscess in the second and third left molar sockets and ante mortem tooth loss.

Fig. 7: Extensive ante mortem tooth loss.

ern Levant. Nevertheless, since hypoplasia is a sensitive and non-specific indicator of stress, the causal factors of this find should be sought within a population-specific context.

Two main factors contribute to the occurrence of hypoplasia: poor nutrition and disease during infancy and childhood. Both factors seem to have operated during the Chalcolithic. The consumption of a diet based on a limited variety of food types, predominantly cereals low in essential nutrients, whose availability was subject to seasonal environ-

mental constraints and fluctuations, has been targeted as one of the major systematic causes of stress in the agricultural societies of the southern Levant.

The dental findings presented here for caries, abscesses and dental wear patterns support the notion of heavy reliance

38. SMITH, 1989.
39. EL-NAJAR et al., 1978; GOODMAN and ROSE, 1990.
40. SMITH et al., 1984; SMITH and HORBIN, 1998.
on cereal crops. Overall caries frequency for Peq’in was calculated at 9.2% and the frequency for the adult sample (aged 19-60+) reached 11.1% and 34.8% at the individual level. This is a higher frequency than recorded for Natufian and Pre-Pottery Neolithic populations and supports the notion that this population relied heavily on the consumption of cereals, but that no new dietary sugars (cariogenic foods) were introduced in a significant amount. The cariogenic potential of fructose is disputed, nevertheless, studies made during the last two decades have suggested that fructose is as cariogenic as sucrose. A study conducted at the University of Turku in Finland, aimed at measuring the long-term effects of fructose versus sucrose consumption concluded that “A fructose diet enhances the progression of carious lesions as much as a sucrose diet.” Studies have also revealed that carbohydrates in the form of lactose (as found in milk) are only slightly cariogenic. In view of this, the cultivation of fruit trees and the consumption of fructose-rich fruit during the Chalcolithic period may have contributed only a small and insignificant fraction to the diet. This is consistent with findings indicating that large scale horticulture was only practiced from the Early Bronze Age onward. Had fruit such as dates, figs and carob been consumed in greater quantities, a dramatic rise in caries frequency would have been expected, as observed in an Iron Age population in Oman, whose diet included the consumption of dates on a regular basis. Dates are not only rich in fermentable carbohydrates but are also sticky, adhering to the teeth and resisting the flushing activity of the saliva.

Assessing dental wear pattern and rate is yet another tool for the reconstruction of changing dietary patterns and food preparation methods. Previous bio-anthropological reports have noted a high rate of wear for many Chalcolithic sites in the southern Levant, indicating a high grit or husk content in the food. This is also true for the population of Peq’in, which exhibited a high rate of oblique wear whereby the lingual portion of the mandibular tooth was significantly less worn than the buccal portion, and the anterior teeth were less worn than the posterior teeth.

Studies of prehistoric populations generally record a different wear pattern and rate among hunter-gatherer versus agricultural populations. The diet of hunter-gatherer populations is generally tough and fibrous, requiring a long chewing time with a more pronounced lateral rotation of the mandible, accordingly the rate of dental wear of the posterior teeth was rapid and exhibiting a flat wear pattern. Agricultural populations relied mainly on cereals, needing extensive processing before they could be consumed. The outcome was soft food, decreasing the role of the oral cavity as a food processor. The abrasiveness of this food depended largely upon preparation methods, though the general result was a less rapid, oblique attrition of the posterior teeth.

Dental wear pattern and rate as recorded in the individuals from Peq’in may be clearly associated with the agricultural nature of this population and the consumption of soft foods, containing a great amount of abrasives. Since the evidence overwhelmingly points to the high consumption of cereals, it is safe to assume that these “soft foods” were mainly cereal gruels and/or bread processed by grinding on stone, and in most cases cooked in ceramic vessels. Popular use of basalt stone for grinding during the Chalcolithic, especially in the north, may have had a great affect on the rate of wear. Though there are many types of basalt stone, the preferred material, as may be seen in the case of the Golan sites, was tough olivine basalt that tends to create fewer but harder abrasives.

Archaeological, paleo-botanical and paleoclimatic evidence point to favorable climatic conditions during the Chalcolithic that lasted until the Early Bronze Age and to the utilization of a wide variety of nutritional resources. At the base of early agriculture in the Levant lay eight founder crops listed by Zohary and Hopf as: two-row barley, emmer wheat, einkorn wheat, lentil, pea, chickpea, bitter vetch, and flax. As Grigson points out, by the time of the Chalcolithic these crops had already been cultivated for thousands of years. Silos found in many Chalcolithic settlements indicate that at least some of these crops were stored.

The domesticated fruit trees of the Chalcolithic included olives, dates, figs and pomegranates. Carbonized olive stones were found at many sites such as Teleilat Ghassul (Jor-
dan valley), the “Cave of the Treasure” in the Judean desert and Nevalat on the Israeli coast. Zohary believes that the olives of Tell el-Ghassul were cultivated under irrigation similar to the way they are cultivated today in Jericho. Epstein has correlated large basalt basins found at Chalcolithic sites in the Golan Heights with olive oil production.

Domestication of fruit trees brought a significant increase in fruit size and an increase in the sugar content of fruit such as figs and dates. Much like today, figs may have been dried and used throughout the year. Besides cultivated fruit an abundance of wild fruit trees, vines and nuts (almonds, pistachio, walnuts and acorn) were utilized. Evidence for the cultivation and utilization of vegetables and herbs is rarely obtained in the archaeological record, but remains of garlic and onion found in the “Cave of the Treasure” provide evidence for their use.

Zooarchaeological evidence indicates that the Chalcolithic economy relied on four domesticated species of animals: goat, sheep, cattle, and pig. Cattle was used for meat and dairy products, providing fat and protein, but may have been used for traction as depicted in figurines. Hunted animals such as gazelle, deer and wild boar are present in low frequencies in the faunal assemblages, indicating that they were used infrequently to provide a dietary supplement. This notion is reinforced by the paucity of arrowheads or spearheads in the Chalcolithic flint assemblages.

Evidence for the secondary use of domesticated animals in the southern Levant during the Chalcolithic may be seen in the faunal assemblages and in the material culture, albeit, intensive milking is not recorded until the Early Bronze Age. Secondary products are those obtained without killing the animal, mainly milk and its products, wool/hair and energy. The faunal record of sites from southern Israel show that more rams and bucks were culled in the first year of life, while more female sheep and goats lived over the age of 2.5 years. This profile indicates that a greater number of males were slaughtered in their prime while females were kept alive longer for milk, wool/hair and breeding. The appearance of the “churn” in the pottery assemblages as well as its depiction in figurines may also serve as an indicator for milking.

The abundant grinding tools, cooking utensils (ceramics), and sickle blades, serve to support the contention of heavy reliance on cooked cereals suggested by the dental findings presented here. Isotopic analyses carried out on human bones from the Chalcolithic site of Ma’aravot (Central coastal plain-Israel), revealed that “The bulk of food was from C3 plants such as wheat and barley a small dietary component (< 10%) was derived from animal protein.”

Favorable climatic conditions and improvements in agrotechnology meant that components of a varied diet, providing all necessary nutritional requirements, were available during the Chalcolithic period. Nevertheless, bio-anthropological and archaeological evidence point to a heavy reliance on cereals. These are not only poor in nutrients such as vitamins, minerals and protein, but also contain phytates, limiting the absorption of minerals such as iron, calcium and zinc. Heavy reliance on cereals may increase the incidence of deficiencies such as anemia and contribute to osteopenia in young women. Furthermore, pots used for cooking and storage provide an ideal substrate for bacteria, causing diseases such as diarrhea and dysentery. The nutritional drawbacks of heavy reliance on cereals are seen in worldwide peasant populations as exemplified by Amerindian populations that shifted to intensive maze cultivation and consumption.

It seems that during the Chalcolithic the emphasis was upon a high caloric diet, whose nutritional value was low. When considering a rise in population size and density, this may be viewed in the context of the “tradeoffs” made in order to provide for a larger population. Nonetheless, other possible explanations, such as food culture and distribution should be considered.

Infectious diseases in infancy form another contributing factor to the occurrence of enamel hypoplasia. The role of animals as hosts and carriers of such infectious diseases is well documented. The change in human animal interaction, which began with animal domestication, called for increased handling of animals. This meant a close and prolonged contact with the animals, and in many cases required permanent dwelling near water sources, facilitating the transmission of

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57. GRIGSON, 1995.
63. AGELARAKIS et al., 1998: 438.
64. COHEN, 1989: 59.
67. EL-NAJAR et al., 1978; GOODMAN and ROSE, 1990.
68. COHEN, 1989; McGrath, 1992; HORWITZ and SMITH, 2000.
zoonotic disease. In Israel, an area where Malaria became established very early, permanent settlements adjacent to water may have contributed greatly to an increased disease load. During the Chalcolithic, the use of secondary animal products, especially wool, milk and milk products increased contact between man and animal and their consumption opened new pathways for infection. An interesting case in point is tuberculosis, a zoonotic disease contracted from cattle usually through the ingestion of milk and milk products. Recently skeletal evidence of tuberculosis was reported at the Pre-Pottery Neolithic site of ‘Ain Ghazal and disputed by Hershkovitz and Gopher who claimed that the evidence shows a tuberculosis-like pathology and not necessarily indicate tuberculosis. The latter conclude that tuberculosis did not emerge in the Levant until tolerance to bovine milk developed in the adult population, coinciding with the “secondary product revolution” of the Chalcolithic-Early Bronze Age.

Moreover, a rise in population size and density would have contributed to the spread of zoonotic, and other infectious diseases among these populations by maintaining a pool of susceptible hosts. Thus far, establishing demographic trends for the Chalcolithic has proved inconclusive. Archaeological surveys have suggested that the population density in the Galilee region may have declined after the early Chalcolithic, but since additional Chalcolithic sites have been recognized and excavated since the publication of the surveys, this picture is yet subject to change and should be regarded with caution. Other “infection enhancing factors” such as poor hygiene and the use of pack animals, as depicted in figurines, for travel and trade facilitated the transmittance of zoonotic and other infectious diseases to more individuals in a wider geographical range.

The high prevalence of hypoplasia as recorded for the population Peqi’in and other Chalcolithic populations in the southern Levant cannot, therefore, be attributed to a single factor, but may show that surviving stress episodes between birth and 4 years may have, to a limited extent, improved chances of survival in later life. This is the pattern expected if infectious diseases were endemic, with those surviving probably developing antibodies that protected them in later life to some degree.

The excavators of the Peqi’in burial cave have suggested that the rich, highly sophisticated artifacts found at Peqi’in indicate that individuals interred in the cave belonged to a ranked society. Whether this is defined in terms of a “chieftain” or the “weak social stratification” implied by Gilead, it did not apparently extend to food choices or greater freedom from disease. The life experience of the Peqi’in sample in terms of hypoplasia, caries and tooth wear appears to have been fairly homogeneous. Especially with regards to hypoplasia frequency the sample showed no differences from other Chalcolithic samples such as those of Gilat and Kissufim. This is particularly interesting when considering the simple nature of the burials in Gilat compared with the rich burials of Peqi’in. All those examined in Peqi’in seem to have suffered severe repeated physiological stress in infancy and childhood, no individual was more “socially buffered” from stress than others, or showed a different pattern of dental wear or caries. If high-ranking individuals were interred at Peqi’in as proposed by Gal et al., their status was not reflected in levels of stress or patterns of dental conditions.

CONCLUSIONS

The high incidence of hypoplasia recorded in this sample means that individuals interred at the burial cave in Peqi’in suffered from severe episodes of physiological stress during infancy and childhood.

Since hypoplasia is a non-specific indicator with a complex etiology, the possible causes for this find were sought within the context of the Chalcolithic Levant. It is argued that no one causal factor should be used to explain the high frequency of hypoplasia but a myriad of interwoven factors involving both nutrition and disease, playing within the interaction between humans and their environment as well as social interaction among individuals.

The frequency of dental disease in this population supports other archaeological findings indicating a great reliance on cereal crops, which have a high caloric value.

69. ANGEL, 1966.
70. EL-NAJAR ET AL., 1996.
73. EPSTEIN, 1985.
74. GAL ET AL., 1999.
75. LEVY, 1995.
76. GILEAD, 1988.
77. SMITH ET AL., in press; ZAGERSON AND SMITH, 2002.
78. GAL ET AL., 1999.
Results suggest that individuals interred at Peqi’in shared a common life experience regardless of their social status. This is shown by dental conditions such as hypoplasia, wear and dental pathologies and is significant in that hierarchy was not expressed in protection from disease or differential exploitation of dietary resources.

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