A SYNTHETIC APPROACH TO THE STUDY OF DIET, HEALTH AND DISEASE IN AN OTTOMAN PERIOD POPULATION FROM PALESTINE

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Abstract

This paper applies a synthetic approach to the study of an Ottoman population from the coastal plain of Israel utilizing bioanthropological and archaeological data as well as historical records.

Bioanthropological analysis of skeletal remains from the 16th to 19th centuries that were discovered during the excavation of a Byzantine church at Dor revealed a high prevalence of paleopathology and low life expectancy. These results corroborate historical records for Ottoman Palestine, which describe poor living conditions and rampant poverty throughout the country. Although the archaeozoological record and botanical information indicates that a broad diversity of food staples were available in the area, the skeletal remains indicate that either they were not consumed in sufficient quantities to provide an adequate and healthy diet or that the population suffered from a heavy chronic disease load that was associated with metabolic disorders.

Introduction

Students of the Ottoman period in Palestine have at their disposal two valuable sources of information - historical records and archaeological remains. The Ottoman archive of government registers and court records provides historians with a documentary resource spanning four centuries (16th through 19th) with which to examine a wide range of issues (*e.g.* Cohen 1973; Coşgel 2006; Doumani 1995; Grossman 1994; Hütteroth and Abdullfatah 1977; Kark 1990). However, even these records, as well as other written sources such as those of early travelers' are frequently incomplete and/or biased by social, political, economic and cultural factors.

In contrast, the direct examination of remains of material culture may fill in gaps not covered by the historical record especially with respect to the documentation of daily life and activities of those who were excluded from the documentary record – termed by Baram and Carroll (2000) a 'history from below'. However, the archaeology of the Ottoman period in Palestine is still in its nascence, with few assemblages from this period having been studied in depth or published. Moreover, in many instances where Ottoman material remains were saved, mixing with modern surface material is common. In addition, although the Ottoman period covers four centuries, which were associated with far reaching changes in all aspects of the economy, political and social life, in most instances no division into smaller portions of time has been made so that there is little chronological resolution for this period. Finally, as with all archaeological investigations, post-depositional destruction and/or poor preservation are further limiting factors in archaeological reconstruction.

In this paper we advocate a synthetic approach that compares and contrasts historical and archaeological records. Such a methodology should result in a more comprehensive picture of past communities. Most importantly, it enables testing between these different data sets for consistency, and allows one, if not to arrive at more reliable conclusions, then at least to identify areas of discordance.

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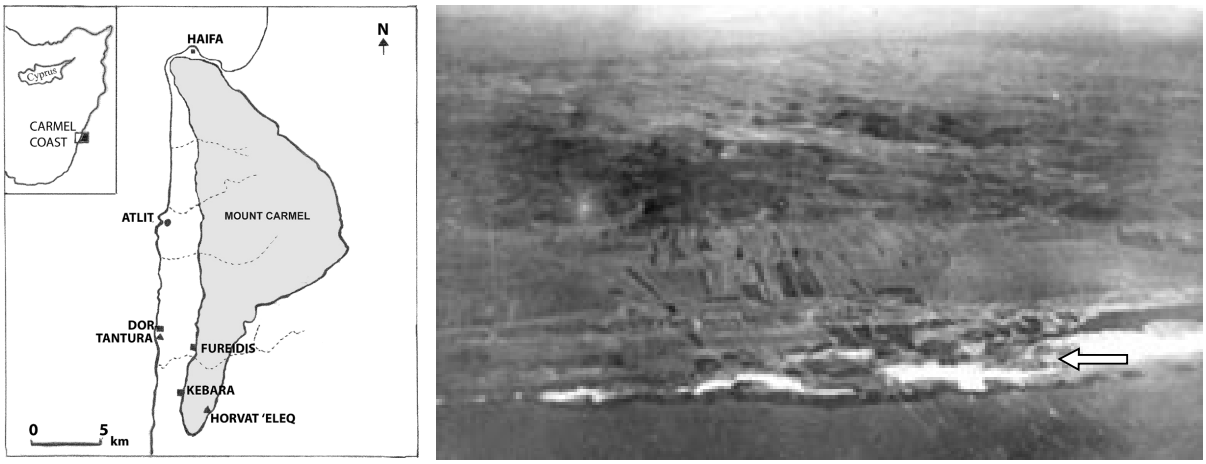


a b

Fig. 1: a. Map showing location of Dor-Tantura on the Carmel coast, Israel.
b. 1918 aerial photo from the sea of Dor-Tantura (arrow), in hinterland fields and Mount Carmel in distance (www.palestineremembered.com/Haifa/al-Tantura/Picture10318.html).

An excellent case study for the comparison of historical records with an archaeological data set is provided by sites in the Carmel region (Fig. 1), and especially Dor, one of the few Ottoman sites from which human skeletal remains have been recovered in well defined archaeological context. The site is located on the Carmel coastal plain, some 30 km south of the city of Haifa. Between the Middle Bronze Age and Roman periods, Dor was an important port and its rulers at various times included the Sikil (one of the Sea Peoples), Phoenicians, Assyrians, Greeks and Jews (Stern 1993, 1994). The site declined in importance after the construction of the neighbouring port of Caesarea in the Early Roman period and by the mid-3rd century AD was little more than a fishing village. At this point in time, occupation of the site shifted off the tell. From the 4th to 7th centuries it served as an important Christian center with a Church and associated structures (Dauphin and Gibson 1994). The village of Tantura was established to the south of the tell, probably after the Arab conquest in the 7th century AD when the ecclesiastical complex was abandoned (Dauphin and Gibson 1994; Stern 1994). During the 16th through mid-19th centuries the deposits overlying the Church were used for a cemetery (Dauphin 1979, 1981, 1984).

The human skeletal remains and animal bones recovered from this cemetery, enable us to assess the extent to which the anthropological data corroborate the historical records. Integration of these data with information on animal exploitation derived from faunal remains from the coeval site of Horvat 'Eleq in the surrounding Carmel region, as well as literary sources on food resources and diet in the region, provides a comprehensive picture of the economic status, nutrition and disease of populations along this portion of the Carmel coast.

Descriptions of Dor-Tantura in Historical Sources

Ashkenazi (1931) has provided a brief synthesis of the history of Dor-Tantura, based on the reports of early travellers that covers the period during which the cemetery was in use. In the memoirs of the Chevalier d'Arvieux, Tantura (or Tanturah) was described as a small fishing village with a single road leading down to the sea. This road led to the shore which served as a market place where local produce such as animals and fruits, were exchanged for rice and cloth that were brought to Tantura by Egyptian sailors in small boats.[1] The Chevalier d'Arvieux further states that the place was too small or too poor to have a mosque such that the local inhabitants prayed in the open.

Turning to the 18th century, Ashkenazi (1931) quotes Pococke who visited the Carmel coast

in 1737, to the effect that at this time Tantura was a small village. Two early 19th century visitors, Buckingham in 1816 and von Raumer in 1823 both wrote that Tantura comprised 40 or 50 houses with a population of some 500 inhabitants. Twenty years later, in May 1843, John Wilson noted that Tantura comprised only a few dilapidated houses next to a small bay, but in 1854 Guérin reported 1200 inhabitants. This sudden increase in population size at Tantura was part of a country-wide demographic increase associated with the wide-ranging economic and political reforms and increased trade with Europe following the Crimean War (Abdulfattah 2005, Ashkenazi 1931, Grossman 1994, Karl 1990, Scholch 1985). It was briefly interrupted by an outbreak of cholera in 1865–66 which decimated the population of Palestine. At this time, mortality rates attributed to cholera were high throughout the country with between 1500–2000 deaths registered in Jaffa and 1760 deaths in Nablus (Scholch 1985). Thus, at Tantura, Shumacher reported that by 1887 the population numbered only 770 people which may reflect the country-wide cholera outbreak. However, by 1897 the Tantura population had already increased to some 1200 to1500 inhabitants (Ashkenazi 1931: 31).

Grossman (1994:143) suggested that the absence of the name 'Dor' in Ottoman tax records of the 16–18th Centuries may indicate that the site was only used seasonally and that a permanent settlement was only established in the late 19th Century. He attributed the introduction of the name 'Tantura' to the 19th century, and reported that according to tradition the name was introduced by settlers claiming origin from a village in India, with a similar name. However, Grosman's statement is contradicted by the memoirs of d'Arvieux who notes that the name Tantura was already used in the 17th century (Ashkenazi 1931), while as early as the 16th century, the presence of a small and unimportant port at Tantura is noted in the tax registrar (Hütteroth and Abdulfattah 1977:93).

Stern (1994) notes that although the lagoon of Tantura is shallow, it is still one of the few natural harbours for small boats along the Mediterranean coast of Israel. Use of the Tantura harbour by trading vessels is attested to prior to the Ottoman period, as indicated by shipwrecks excavated in the lagoon dating to the early Islamic period - 8th–9th centuries AD. These provide indirect proof that Tantura was occupied at this time (Kahanov and Royal 2001, Barkai and Kahanov 2007). Much later, in 1806, when the explorer Ulrich Seetzen sailed from Jaffa to Acre and Tyre, his boat stopped on the way at Dor-Tantura (Ben-Arieh 1979), while in the late 1800's sailing ships regularly stopped at Tantura (Fig. 2). Indeed, several early 20th century sources note that many of the inhabitants of Tantura were sailors and that local agricultural produce (fruit and vegetables) was transported by sailing ship to Jaffa (Ashkenazi 1931: 31–32).

The data presented by Hütteroth and Abdulfattah (1977) in their publication dealing with tax registries, indicates that Dor-Tantura and its surroundings comprised one of the most poverty stricken areas of Palestine in the late 16th Century through 19th centuries. Geikie (1887: Chapter Four) describes the village of Tantura as follows:

> "The modern village is a little farther south, on the site of Dor (Josh 17:11), afterwards the Dora of the Romans, memorials of which, in the shape of pillars and sculptured capitals, slabs of marble, and hewn stones, strew the shore. A few mud huts, two or three better than the rest, make up the hamlet, which

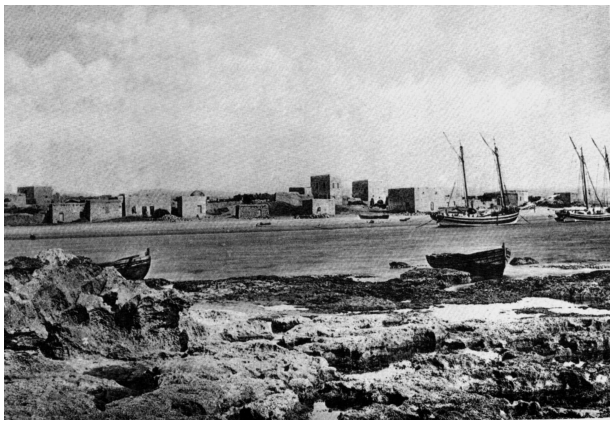


Fig. 2: Dor-Tantura harbour photographed in 1887 (from www. eretzyisroel.org/~dhershkowitz).

1 Chevalier d'Arvieux was the French consul in Sidon between 1660 to 1664.

looks miserable enough in its environment of sand and marshy flat. One of the principal houses consisted of a single square room, of good size, plastered with mud, and roofed with branches long since varnished black by the smoke. These hung down roughly over one half of the room; the other half was hidden by a canvas ceiling. The door had no hinges, but was lifted to its place, or from it, and the windows were only square holes in the mud walls. A clay bench, joined to the wall, ran along one side of the room, serving for chairs by day and sleeping-places by night. A rough cooking table of clay and stone, from the ruins, was at one corner, with a little charcoal glowing on the top of it—chiefly, as it seemed, to roast coffee-berries and boil water in which to infuse them, when they had been duly pounded in a stone or wooden mortar."

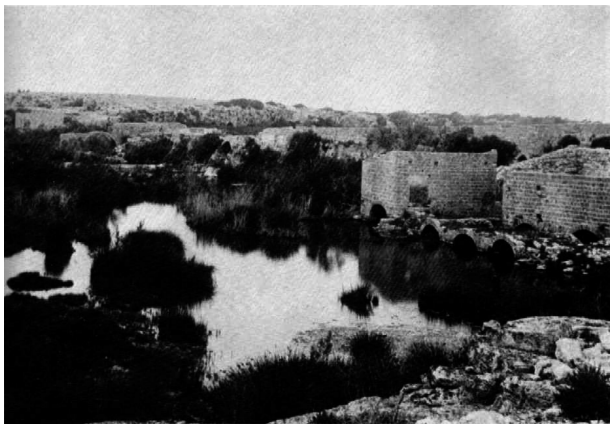


Fig. 3: Swamps in the vicinity of Kebara on the Carmel coastal plain photographed in 1925 (from www.eretzyisroel.org/~dhershkowitz).

According to other sources (Ashkenazi 1938; Dahl 1915; Hütteroth and Abdulfattah 1977), this part of the coastal plain comprised a few small villages whose occupants engaged in limited cultivation, herding and fishing. In addition, Kurdish and Turkmen nomads herded water buffalo in the nearby swamps and sheep and goats in the adjacent Carmel range. Grossman (1994) notes that during the Ottoman period, extensive swamps covered much of the coastal plain due to poor drainage (Fig. 3). Geikie (1887: Chapter Four) observed that:

> "A little south of Tanturah is another perennial stream, like the rest in the district in being only a few miles long, and fed by the marshes"

While in the 1890's George Adam Smith wrote:

> "The marshes on the Zerka [today the Crocodile River located some 8 km south of Dor] are intricate, and form the refuge of Arabs who keep themselves free from the requisitions of the Turkish Government." (Smith 1894:147)

The swamps, sand and the narrowness of the coastal plain undoubtedly limited the extent of arable land between the coast and the Mount Carmel range and determined the subsistence strategies of the inhabitants. These factors probably account for the fact that the Carmel coast was sparsely populated, settlements in this region were small and the socio-economic status of the inhabitants was low especially before the end of the 19th Century.

Subsistence and Diet

The Ottoman taxation lists offer some indication as to which animals were commonly raised and exploited. Hütteroth and Abdulfattah (1977: 82–83) list water buffalo, goats and bees, the latter two species always appearing on the tax lists together indicating that they were important sources of milk and sugar. Only adult buffalo, able to work or be milked, were taxed, while other beasts of burden, oxen, horses and camels do not seem to have been taxed at all. Mention of taxation of pastures is infrequent and it is unclear whether this applied to villagers (*fellahin*) or nomads. Shelters for flocks are also noted as being taxed as was off-shore, river and lake fishing. Writing specifically about the inhabitants of Dor, Dahl (1915) states that some were fishermen, others engaged in agriculture and animal husbandry herding sheep, goats and cattle.

In addition to literary sources, information on diet in the Ottoman period may be gleaned directly from the examination of botanical and faunal remains derived from archaeological excavations. These represent dietary residues of animals or plants either grown/raised or brought to the settlement for consumption or use.

(a) Faunal Remains

The following section describes the faunal assemblages recovered from the archaeological excavations at the Ottoman cemetery at Dor and at Horvat ʻEleq a late Ottoman village on the southern edge of Mount Carmel, (Fig. 1; Table 1a–b).

Dor: A small assemblage of animal remains deriving from Ottoman period fills from the cemetery at Dor was excavated by C. Dauphin and identified by Horwitz (unpublished data). The remains probably represent debris from Ottoman period activities coeval with the cemetery, but some mixing with the underlying Byzantine deposits cannot be totally discounted.

Domestic herd animals constituted the most common species; 31% sheep/goat and 25% cattle. Since the bones were associated with a Muslim cemetery, it was surprising to find that pig comprised a high 14% of the remains. It was not possible to assess whether they are solely associated with the underlying Byzantine deposits. Moreover, as all pig bones derive from young animals with unfused epiphyses, it was not possible to determine whether they represent domestic animals or immature wild boar that were hunted in the vicinity. Historically, wild boars inhabited the Carmel range and were sighted on the coastal plain as far south as Gedera (Mendelssohn and Yom-Tov 1999).

Remains of donkeys but not horses were common at the site (18% total), while chicken remains were also present (11%).

Based on tooth eruption and attrition (Silver 1969, Payne 1973), it was possible to establish that the majority of sheep/goat in this sample represent young animals aged 1–2 years, indicating preferential slaughter and/or consumption of young animals for meat. Likewise, most cattle are young animals aged less than 2 years, although one older animal is aged 3 years old or more. Donkeys were all young adults or adults aged ca. 4 years or older.

Site	**Dor**		**Horvat ʻEleq**	
Species	**NISP**	%	**NISP**	%
Sheep	2	3	2	2
Goats	2	3	1	1
Sheep/Goat	19	25	27	25
Pig	11	14		
Oxen + Cattle	19	25	47	44
Camels			8	7.5
Donkey	14	18	9	8
Horse			1	1
Equid			1	1
Dog/Cat	1	1		
Gazelle			1	1
Chicken	8	11	10	9.5
Total	76	100	107	100

Table 1a: Numbers of identified bones (NISP counts) and relative frequencies per species identified at Ottoman Dor and Horvat ʻEleq.

	Ottoman Dor	**1943* Tantura**	**Ottoman Horvat ʻEleq**	**1943* Fureidis**	**1943* Kebara**
	%	%	%	%	%
Sheep/Goat	55	75	39	79.5	40
Oxen + Cattle	45	25	61	20.5	60
Total NISP	42	1206	77	945	312

Table 1b: Frequencies of sheep/goat to cattle and oxen in the two Ottoman sites compared to three 20th century villages in the same region (Fig. 1).
(Frequencies for the Ottoman sites are based on the number of Identified bones while for the 1943 census they are based on the number of animals)
* taken from the 1943 British Livestock Enumeration Report

Horvat 'Eleq: The village of Horvat 'Eleq is located on the southern edge of Mount Carmel and was established in the 1840's. At the end of the 19th century, the villagers became tenants of the el-Khoury family, who owned a manor 70 km east of the village (Boas 2000). The Horvat 'Eleq Ottoman village and underlying archaeological site, was excavated by I. Hirschfeld (2000) and the fauna identified by Horwitz (2000). The Ottoman period finds are primarily agricultural implements such as axe heads, hoes, hooks, as well as items related to animal husbandry such as horseshoes – small, medium and large sizes, fetters and shears. The use of the latter is corroborated by the presence of a sheepfold. These finds testify to a primary involvement in agriculture and animal husbandry (Boas 2000).

Animal remains from Horvat 'Eleq are dominated by bones of domestic animals - cattle (44%) followed by sheep and goats (28% combined) and chicken (9.5%). Remains of donkeys (8%) and horses (1%) were also found which complement the horseshoes noted above. The width of a horse femur shaft measured 39.5 mm, which is comparable to that of modern Arab horses. Bones of a third beast of burden, the camel (7.5%), were as common as those of donkeys. The only wild taxon represented was gazelle.

An additional bone sample from this site comprising mixed Ottoman and recent bones, yielded a similar range of species to the Ottoman assemblage with the addition of duck and fallow deer. The latter species undoubtedly derives from the Ottoman levels since it became extinct at the end of the 19th century (Mendelssohn and Yom-Tov 1999).

Due to poor preservation, few bones and teeth in this sample could be aged. Despite this limitation, the majority of sheep/goat remains represent animals that were slaughtered young. A few animals aged older than 2 years were also found. Likewise most cattle bones belong to animals slaughtered by 2 years of age, with few remains from older animals. The presence of a fused cattle toe bone (phalanx) with extensive osteo-arthritic changes does however indicate the presence of an adult animal, since such exostoses take time to form. They are often found in animals used in labour such as draught.

When skeletal elements from the Horvat 'Eleq assemblage were pooled into three body part categories - skull, limb and trunk, it was evident that for both sheep/goat and cattle all body parts are almost equally represented. This would indicate on-site slaughter rather than the introduction of selected skeletal elements as would be expected if joints of meat were bought at a market. The presence of butchery marks on 9% of the remains, all associated with carcass dismemberment activities, would corroborate this claim.

Observations

Although the sample sizes are small, a clear similarity between the two Ottoman assemblages is evident. Firstly, domestic herd animals – sheep, goat and cattle were the most common taxa exploited with little evidence for hunting (gazelle, fallow deer and possibly wild boar). No remains of buffalo were identified despite the fact that Hütteroth and Abdulfattah (1977: 48) note that they were raised by late 16th century Kurdish and Turkmen inhabitants on the Carmel coast.

Secondly, in both assemblages, for sheep/goat as well as cattle, remains of immature animals predominated indicating the slaughter of surplus animals, probably excess males. Due to the presence of all body parts at the sites, their even distribution and presence of cut marks, it seems most likely that these remains originated from on-site slaughter of local animals rather than joints of meat bought at nearby markets. Grossman (1994: 50) points out that Ottoman towns like Acre and Caesarea were supplied by produce from rural areas including cereals, fruit, vegetables and animal foods - such that it is more likely that small sites such as Dor-Tantura or Horvat 'Eleq supplied fresh produce rather than purchased it. Moreover, the presence of bones of adult sheep/goat and cattle found at both sites, albeit few in number, indicate that some adult animals were kept in these villages, undoubtedly for their secondary products (milk, wool, hair) as well as breeding. Adult cattle were

probably used as draught animals in addition to milking.

The high proportion of remains of beasts of burden – donkeys, horses and camels – emphasizes the important role played by these animals in agriculture, trade and communication in these communities. That they may have played a role in the diet is attested to by butchery marks on some of their bones, although these may also have resulted from slaughtering or flaying an animal that died naturally.

Remains of chicken are found in both sites. Since the assemblages were hand collected and not sieved most of their small bones were probably not retrieved. This may also account for the absence of fish bones in the Dor sample despite its proximity to the sea and the historical evidence for fishing.

In the 19th century, in contrast to Dor-Tantura, the inhabitants of the neighbouring village Fureidis are identified as herders and/or woodsmen (Grossman 1994: 143). This probably reflects the proximity of Fureidis to the pastures and forests of the Carmel and its wadis since, as suggested by Hütteroth and Abdulfattah (1977: 48), the coastal plain would have offered limited seasonal grazing for sheep, goat and cattle. Consequently, the higher proportion of cattle found in the Horvat 'Eleq assemblage, a village located on the Carmel, compared to coastal Dor (44% compared to 25%), may be due to their different geographic locations and access to pasture. It is interesting to note that by 1943 (Table 1b) no marked differences are found in cattle to sheep/goat proportions between Tantura and Fureidis, while Kebara, which is located on the foothills of the Carmel, contained cattle frequencies as high as those found at Horvat 'Eleq.

These data indicate that a wide range of animals were raised and/or exploited in the Carmel coastal region. However, it should be borne in mind that the traditional Near Eastern subsistence economy was based on multiple resources with animal husbandry supplemented by cultivation of cereals, legumes, fruit and vegetables. Thus animal protein provided only part of the diet. Based on ethnographic accounts for Ottoman and British Mandate Palestine (*e.g.* Ashkenazi 1938), meat was a luxury and rarely eaten. From the archaeological record it is not possible to determine the relative proportions of animal protein to plants in the diet. However, it is clear from this study that meat of sheep, goat, cattle and several other minor domestic species (pig?, chicken, equids and camel) as well as wild taxa (gazelle, deer, wild boar?), was consumed. Given the presence of chicken, eggs were doubtless included in the diet as well. However, based on the age profiles of sheep/goat and cattle, there seems to be little evidence for intensive exploitation of milk products. Either this was small-scale, or else an item traded from other communities in the region. Similarly, although absent in the faunal assemblage from Dor, it is highly likely that fish were consumed.

(b) Botanical Information

Unfortunately, no archaeobotanical data is available for Ottoman sites in the Carmel. However, general information on crops grown in this region of Palestine and their relative importance may be gleaned from the 16th century registers and other records.

Hütteroth and Abdulfattah (1977: Ch IV) note that in the late 16th century, the main agricultural product in Palestine to be taxed was wheat followed by barley. Other taxable cultivars were: summer crops that included vegetables especially lentils, beans and sorghum. Other taxed cultivars were olives and olive oil, fruit trees (carob, vine, almond), sesame, cotton, rice and indigo. Cohen (1973: 262) notes that from 1697 tobacco was taxed but this was annulled by the second half of the 18th century since cotton became the major crop. In the 16th century, most of the local taxes levied in the rural areas of Palestine were paid in kind i.e. local produce but by the 18th century this was rare (Cohen 1973: 267–268).

A short description of the natural environs of Dor by Geikie (1887: Chapter Four) emphasizes the scarcity of cultivated fields in this region - "Old quarries, tombs, ruins, and bog, are, however, more

frequent than cultivated fields or gardens, reaching up to the ruins of Tanturah". He does however offer a description of the crops grown to the north of Dor, near the village of Sarafend: orchards including dates and figs, olives, sesame, corn, millet, tobacco, as well as vegetables were cultivated. He further observes that the Caesarea area, to the south of Dor, is noted for its melons.

Health Status

Archaeological excavations carried out at the Byzantine church at Dor uncovered a number of skeletal remains buried in and around the church. They included individuals from the Byzantine and Ottomon periods, the latter buried in cist tombs, dated to the 16th to 19th Centuries (Dauphin 1981, 1984, Dauphin and Gibson 1994).[2] Most of the tombs contained a single interment but occasionally two individuals were buried in the same tomb. Some of the tombs contained coins, as well as personal ornaments such as bracelets and beads that were used to date them. Similar burial patterns and grave goods were noted by Eakins (1993) at the larger Bedouin cemetery from Tel el-Hesi, northern Negev, dated to the 14th–18th Centuries. At Dor, the excavators identified seven distinct phases of burials, but because of the small sample size, these were pooled for analysis.

Age Distribution

Individuals were aged using dental development shown by radiographs for infants and children (Morrees *et al.* 1963), and dental attrition in adults as detailed in Miles (2001). Age estimates, using these procedures is accurate to within a few months in the case of children, to within 2–3 years in adolescents, and to within 10 years in adults because of individual differences in physiological aging rates (Krogman 1962).

An initial analysis was carried out dividing the sample into the two phases, in order to examine the extent of differences in the age or sex distribution of individuals over time (Table 2a). One group represented the earlier phase dating to the 16th to 18th centuries, and the other a later phase attributed to the late 18th through 19th centuries. Even in the combined sample, only 157 individuals were sufficiently preserved for age estimations. This obviously represents only a small proportion of the individuals recorded as living at Tantura and infants especially seem to be under-represented (Fig. 4). As can be seen from Table 2a, it seems that individuals of all age groups and both sexes were buried at the site, but that there were relatively more infants in the later phase and fewer children and juveniles. In both phases more females than males died as young adults and less than 20%

	Sex	0-1	2-5	7-10	11-17	18-24	25-39	40+	?	Total
Early Phase	F	–	–	2	4	2	6	7	–	21
	M	–	–	2	5	–	5	12	–	24
	U	11	7	5	1	1	2	–	10	37
		11	7	9	10	3	15	19	10	82
Late Phase	F	–	–	–	3	2	8	6	–	19
	M	–	–	1	2	-	5	9	–	17
	U	19	6	5	1	–	–	–	6	37
		19	6	6	6	2	13	15	6	75
Dor Total										
No.		30	13	15	16	5	28	34	16	157
%		19	8	10	10	3	18	22	10	100

Table 2a: Age and sex distribution in the Dor population by phase
(F = female; M = Male; U = Sex Unknown; ? = Adults, age unknown)

2 Originally the burials from this cemetery were erroneously dated to the 8th-11th centuries C.E. (Dauphin 1979, 1981).

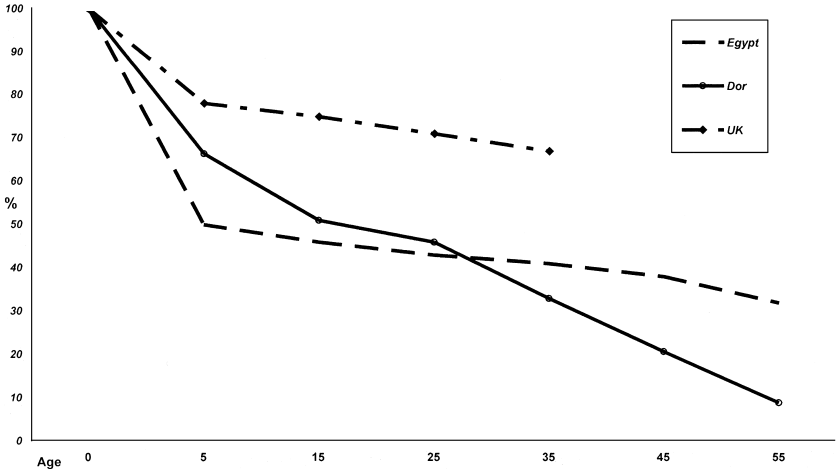


Fig. 4: Survivorship curve of individuals from Dor and those calculated from WHO census of deaths in 1950 for Egypt and the United Kingdom.
Note that Dor has a much lower frequency of older adults than that provided from WHO statistics for England and Egypt. This may be due to a consistent bias for underestimating the age at death from skeletal remains, but should be consistent within the archaeological samples. (EXCEL FILE)

survived beyond 40 years. Life expectancy at Dor was therefore low.

A similar low life expectancy to that found at Dor, was noted by Eakins (1993: 30) at the Bedouin cemetery of Tel el-Hesi dated to the 14th–18th Centuries. Here, more than 500 individuals were recovered with many more infants found than at Dor (Table 2b). These differences may reflect variation in burial practices for infants between the sites, but may also demonstrate the limited reliability of small samples compared to larger ones, which are more representative of a population.

Bocquet-Appel and Masset (1982) have shown that the age distribution in a cemetery, when several generations are represented, is influenced not only by sampling problems but also by expansion or contraction of the population. If the cemetery at Dor was in continuous use for some 300 years, then we are dealing with at least 15 generations so that the number of individuals excavated represents only a limited sample of the entire population, with some generations either not represented at all, or represented very unevenly. The increased number of adults combined with an augmented number of infant deaths in the later phase (Table 2a), may then simply be an artifact of sampling. Alternately, it may reflect a period of population increase, or permanent rather than intermittent settlement at Dor, since, as discussed above, the late 19th Century heralded a period of population growth for the entire region. As pointed out by Bocquet-Appel and Masset (1982), when a population is expanding, there will be relatively more infants born and so, even if the risk of infant mortality remains the same, there will be more infants dying. If the population is contracting there will be fewer infants born while the older individuals continue to die. This may account for the relative paucity of infant deaths

Age in years	**0-10**		**10-17**		**18+**	
Sites	N	%	N	%	N	%
Dor	58	37	16	10	83	53
Tel el-Hesi	285	63	14	3	154	34

Table 2b: Age distribution at Dor and Tel el-Hesi
Note higher frequency of infants and children at Tel el-Hesi aged 0–10 years and marked drop in juveniles aged 10-17 years. This pattern more closely approximates that expected for a stable population with poor life expectancy (see Fig. 4) than that found at Dor as discussed in the text.

found in the earlier phase at Dor, although other factors such as a more casual attitude to infant burial, poor preservation of infant bones, or low fecundity and so fewer births in the earlier phase may also have played a role. Whatever the explanation for the differences observed, the small number of adults aged more than 40 years, demonstrates that throughout the period that the cemetery was in use few adults survived to old age.

Morphometry

Adult body size and shape reflects the balance achieved between genes and environment during infancy and childhood. Adult stature and cortical thickness of bones are especially affected by disease and malnutrition, while craniofacial characteristics are more representative of the underlying genotype.

(a) Stature

Stature estimates for Dor were made based on measurements of femur and tibia length using both the formula of Trotter and Gleser (1958) for Caucasians and that developed by Feldesman and co-workers for different populations (Feldesman 1992). Since many skeletons were poorly preserved, the number of bones measured in any one analysis varies. In adults from Dor, male stature calculated according to the formula of Trotter and Gleser was 169±4 cm and female stature averaged 155.9±3.6 cm. The formula of Feldesman 1992) gave a similar range - 167±9.7 cm in males and 155±8 cm in females. These values are similar to those reported for a Hellenistic population (Hershkovitz 1988), and average some 5 cm taller than early 19th– 20th century Bedouin from Lahav (Goldstein *et al.* 1976) or those from Tel el-Hesi where stature was measured *in situ* for a small number of complete skeletons and ranged from 148–166 cm in males to 136–159 cm in females (Eakins 1993:38).

In order to examine the severity and duration of illness leading to death in infancy or childhood, we compared the diaphyseal length of tibias and femurs from our sample with that derived from radiographs of a modern American sample (Maresh 1970) of similar dental age. We assumed that prolonged ill health before death would be associated with progressive growth stunting. We found that children from Dor were consistently shorter than the American group of the same dental age. Stature estimates for twelve-year old children from Dor, calculated after Feldesman (1992), was 120 cm. This supports the hypothesis that those dying as children had suffered growth stunting from chronic illness throughout their lives.

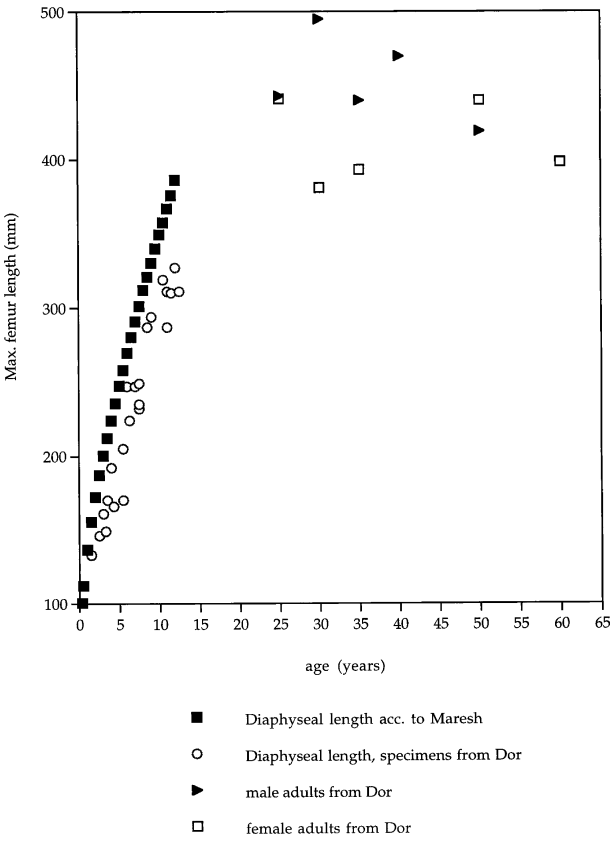


Fig. 5: Femur length in children from Dor aged according to dental development, compared with a North American sample of known chronological age.

(b) Craniometry

The Dor population was characterized by crania with moderate to large superciliary eminences, well developed mastoid processes, and prominent nuchal and supramastoid crests in males (Table 3, Fig. 6). Mandibles were robust with square chins with everted gonia and obtuse mandibular angles (Table 4, Fig. 7). The smaller female skulls show weaker

development of eminences, crests and mastoid processes and smaller mandibles with pointed or rounded chins. Significant differences (P>0.5), were found between the sexes in most of the measurements defining size, but shape ratios were similar (Table 3 and 4). Both sexes had mesocephalic skulls, with a cranial index of 77 in males and 76 in females. They had relatively broad and long faces that resemble the earlier Hellenistic-Byzantine population from Ein Gedi (Arensburg *et al.* 1980) (Table 5), and a combined Byzantine sample from different sites in Israel described by Hershkovitz (1988). All these populations differ from contemporaneous Bedouin samples from Tel el-Hesi (Eakins 1993) and recent Negev Bedouin (Arensburg 1973, 1988) who

Measurement	Males			Females		
	no.	x	S.D.	no.	x.	S.D.
* Max. cranial length (g-op)	20	182.5	7.4	14	175.9	7.4
* Max. cranial breadth (eu-eu)	19	140.2	5.5	12	133.3	4.9
* Basion-bregma height	19	136.6	5.8	12	128.3	4.0
* Basion-nasion length	19	104.2	4.8	12	98.6	4.0
* Porion-bregma height	19	118.2	4.9	14	111.5	2.2
* Biasterion width	19	109.6	4.2	14	104.9	2.7
* Min. frontal width (ft-ft)	19	97.6	4.1	14	92.1	3.3
Foramen magnum length (ba-o)	19	35.7	3.1	12	34.7	2.3
Foramen magnum width	19	29.2	2.4	11	28.1	2.4
* Frontal chord (na-b)	20	112.7	5.5	14	105.7	4.0
Parietal chord (b-1)	21	112.4	7.2	14	111.0	5.8
* Occipital chord (1-o)	19	97.0	6.5	12	90.3	6.9
* Frontal arc (na-b)	19	128.5	6.1	14	120.4	6.5
Parietal arc (b-1)	20	127.6	7.6	14	124.8	6.6
Occipital arc (1-o)	18	117.1	8.3	12	111.1	8.5
* Sagittal arc (na-o)	18	384.4	43.1	12	353.6	11.6
* Horizontal circumference	18	514.9	11.5	13	493.6	15.6
* Transverse arc (po-po)	18	315.8	13.1	14	297.5	7.9
Basion-prosthion length	16	97.5	6.4	8	95.1	6.1
* Biorbital breadth (ec-ec)	18	98.5	4.4	11	94.5	3.6
* Bizygomaxillae (zm-zm)	18	95.3	3.0	13	90.2	3.5
Interorbital breadth (d-d)	19	22.5	2.7	12	21.8	2.5
* Nasion-prosthion height	18	69.1	7.9	9	62.4	5.2
* Nasion-gnathion height	15	119.7	7.1	8	112.5	5.4
* Right Orbital breadth (mf-ec)	19	40.1	3.3	12	37.9	2.5
Left orbital breadth (mf-ec)	20	39.4	2.4	12	37.8	2.4
* Right orbital height	20	34.0	2.3	12	31.6	2.6
* Left orbital height	20	34.2	2.4	12	31.8	3.3
Nasal breadth (al-al)	20	24.0	2.3	13	24.5	2.2
* Nasal height (n-ns)	22	53.1	4.0	13	50.2	3.1
* Palate breadth (enm-enm)	17	36.1	2.1	7	33.7	2.6
* Palate length (ol-sta)	12	47.4	4.2	6	43.2	3.1
Palate depth M^1-M^2	15	13.2	2.1	6	12.2	2.7
Right Pm^1-M^3 length	9	41.2	1.9	3	39.0	2.0
Left Pm^1-M^3 length	14	40.7	2.0	7	39.1	1.8
* Mastoid length	22	28.4	3.6	14	24.4	3.0
* Mastoid width	22	24.1	3.4	14	22.2	2.5
* Bizygion (zy-zy)	15	131.4	5.5	10	119.7	3.4

Table 3: Dimensions of skulls from Dor
* Denotes significant difference between the sexes

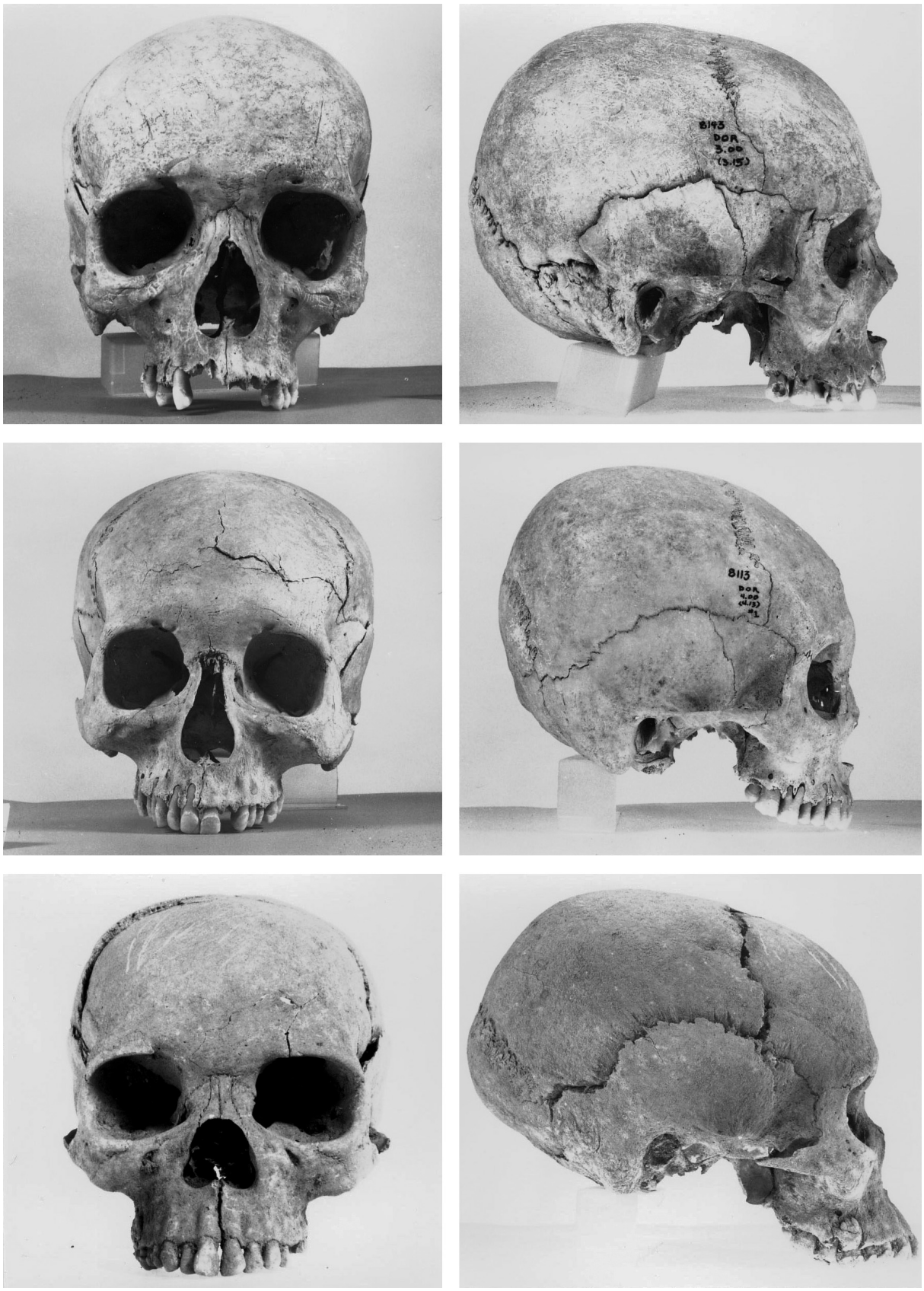


Fig. 6: Frontal and lateral views of adult skulls from Dor. Top two males, bottom female.

have smaller, narrower skulls and shorter faces.

Cephalometry

Brown and Smith (1988) carried out a cephalometric analysis of skulls of children and adults from Dor compared to Bedouin from the site of Tel Halif (Lahav) in the Northern Negev. The results showed that skulls of both these populations were smaller than those of a modern European sample. It was suggested that this might reflect growth stunting because of poor nutrition and/or chronic disease in childhood (Brown and Smith 1988). A later cephalometric study carried out on a sample from the Hellenistic period in Israel, that exhibited less nutritional stress than the Dor population, again emphasized the relatively small size of the skulls from Dor (Brin *et al.* 1992). The Hellenistic sample was closer in size to a modern European sample than Dor, despite their greater antiquity (Table 6). Of course genetic factors affecting shape as well as size may have played a role in determining the ranking shown here. However, Brown and Smith (1988) reported that the percentage difference in cranial measurements between Dor and a baseline European sample used for comparison, was 6.5% in males and 11.8% in females, that is almost the same percentage reduction as found for stature. These findings provide additional evidence of growth stunting in the Dor population and suggest that females were especially affected.

Growth of the cranial, facial and mandibular elements of the head occurs at different ages, so that the infant and adult profiles differ considerably. Growth of the neurocranium is completed at a relatively early age, while that of the mandible continues, at least in males, into the third decade of life. Accordingly, cephalometric analysis of 30 skulls and mandibles from Dor, of individuals aged between 2–14 years, was carried out in order to examine if these children had fallen behind the normal growth pattern for their age. Values were smaller than those of European children of the same dental age but fell within the expected values derived from the Dor adults (Brown and

Measurement	Males			Females		
	no.	x	S.D.	no.	x	S.D.
* Maximum length	18	107.5	5.7	13	100.8	5.0
* Body length	22	77.9	4.8	13	70.2	4.9
* Bicondylar breadth	20	118.3	5.0	10	107.5	3.9
* Bicoronid breadth	20	97.9	4.8	12	90.9	2.4
* Bigonial breadth	21	97.7	8.2	11	85.8	5.5
* Bimental breadth	22	45.2	2.3	13	41.3	2.5
* Ramus width	23	32.3	3.2	14	29.9	2.1
Ramus height	21	61.1	4.8	13	49.2	3.0
Symphyseal height	18	32.3	3.4	11	30.6	2.1
* Ht. at mental foramen	19	29.7	5.0	12	29.3	3.2
* Ht. at Pm2-M1	19	30.4	2.6	11	27.7	2.7
* Ht. at M1-M2	19	27.8	2.5	10	27.8	2.5
* Ht. at M2-M1	20	25.8	2.0	10	22.2	2.4
Width at mental foramen	22	11.3	1.9	14	10.3	1.3
Width at M1-M2	19	13.8	1.5	11	12.9	1.9
* Mandibular angle	22	124.1	5.0	13	132.9	4.0
* Symphyseal width	22	15.2	4.1	13	12.2	1.8
C-C width	9	24.4	3.4	5	27.0	2.9
M_1-M_1 width	12	46.6	3.1	7	44.3	3.2
I-M_1 length	8	36.0	2.7	6	34.7	3.2
* I-M_3 length	9	54.4	3.4	7	49.1	5.2

Table 4: Dimensions of mandibles from Dor
* Denotes significant difference between sexes

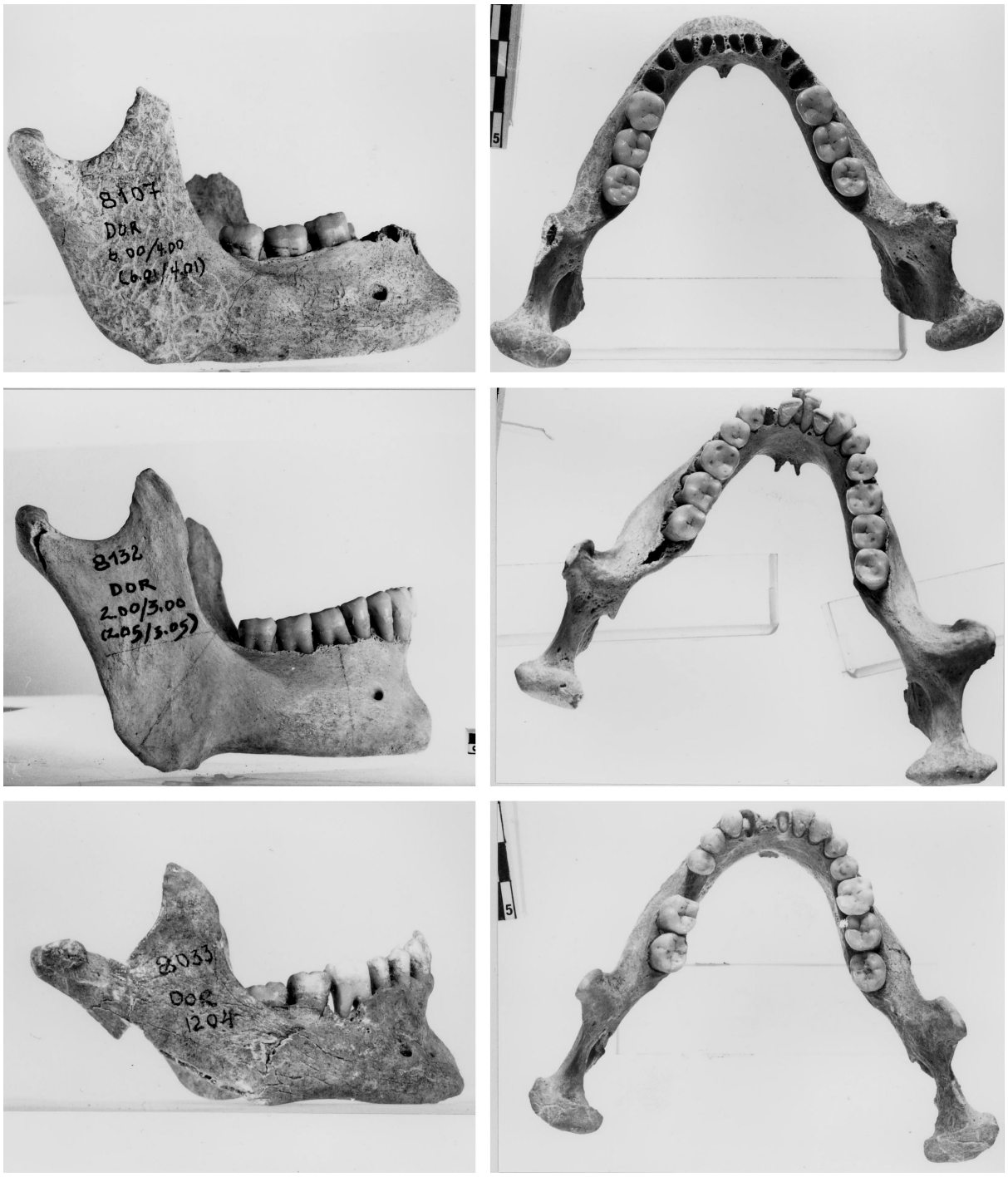


Fig. 7: Lateral and occlusal views of adult mandibles from Dor. Top two males, bottom female.

Smith 1988).

Discrete Traits

The frequency of discrete traits of the skull and mandible is listed in Table 7. Previous reports have emphasized the high frequency of wormian bones in populations from Israel and the West Bank; 60% at Bronze Age Jericho (Hughes 1965), 60% of the Hellenistic-Byzantine population from Ein Gedi (Goldstein *et al.* 1980), and 29% in the lambdoid suture in Bedouin from the Negev (Arensburg *et al.* 1977). They also show a relatively high frequency of patent metopic sutures, between 11%

Variable	Dor		Tel Halif		Hellenistic-Byzantine	
Measurements	no.	mean	no.	mean	no.	mean
Maximum length	20	182.0	61	184.2	99	181.4
Maximum breadth	19	142.0	61	134.4	95	142.9
Basion-bregma	19	136.0	44	129.6	50	131.3
Porion-bregma	19	118.0	57	111.6	61	113.2
Biasterion	19	109.0	54	106.5	83	110.2
Minimum frontal	19	77.0	61	94.3	79	96.4
Bizygomatic	15	131.4	37	127.7	22	131.5
Nasion-posthion	18	69.1	51	66.3	32.	67.3
Left orbital breadth	20	39.4	50	39.0	31	39.4
Left orbital height	20	34.4	51	32.4	33	33.7
Nasal breadth	20	24.0	54	25.1	36	24.0
Mandibular ramus breadth	23	32.3	29	33.1	29	33.1
Mandibular symphysis height	18	32.3	30	30.1	30	28.7

Table 5: Cranial measurements and indices of Dor compared to Tel Halif Bedouin and Hellenistic-Byzantine Jews (Ein Gedi and other sites)

		Ein-Gedi			Dor			Danes (N=120)	
Variable	Values	No.	Mean	S.D.	No.	Mean	S.D.	Mean	S.D.
n-s	(mm)	15	69.2	3.8	41	*65.6	3.7	71.2	2.9
s-ba	(mm)	9	44.4	4.3	41	*41.8	3.7	46.5	2.8
n-ba	(mm)	10	104.9	6.5	43	**98.6	5.8	106.7	4.2
n-s-ba	(deg)	9	132.8	4.5	41	134.6	5.5	129.2	5.0
s-n-sp	(deg)	6	90.1	4.2	35	*86.0	4.5	88.2	3.9
s-n-ss	(deg)	11	84.6	3.7	37	82.3	4.4	82.2	3.5
sp-pm	(mm)	6	56.2	4.0	35	**49.8	3.6	–	–
n-sp	(mm)	12	53.2	4.3	36	**50.2	3.5	–	–
NL/NSL	(deg)	9	9.3	5.6	40	10.1	3.6	–	–

Table 6: Cephalometric parameters from Dor (Ottoman) and Ein Gedi (Hellenistic-Byzantine) (males and females), and Modern Danes (only males)

Cranial Base

n-s	Anterior cranial base length
s-ba	Posterior medial cranial base length
n-s-ba	Medial cranial base angle
n-ba	Total cranial base length

Upper Face

sp-pm	Maxillary length
n-sp	Anterior upper face height
NL/NSL	Nasal line inclination

Profile

s-n-sp	Prognathism at spinal point
s-n-ss	Maxillary basal prognathism

* Dor significantly different from Ein Gedi $p \geq 0.01$

** Dor significantly different from Ein Gedi $p \geq 0.05$

mm = millimetres

deg = degree

and 8% at all sites. The Dor sample also has a high frequency of wormian bones in the sutures, especially in the lambdoid suture where large inca bones and/or multiple wormian bones were found in 81% of those examined (Fig. 8). However, in our sample no patent metopic bones were found in adults, although they were present in 11 out of 22 juveniles aged between 5 and 19 years (Fig. 9). The genetic and or functional basis for delayed metopic suture closure is still unclear. Normally it fuses by 3–5 years of age. Since the condition is not known to be associated with any known increased risk of death, its presence in juveniles from Dor may reflect delayed fusion of this suture in this population.

Trait	no. of individuals	% with trait
Bregmatic bone	71	3
Epipteric bone	71	11
Ossicle at asterion	72	26
Ossicle at lambda	72	22
Wormian bone in lamboid suture	73	81
Wormian bones at other sites	72	47
Highest nuchal line	74	3
Palatine torus	72	0
Maxillary torus	72	1
Auditory torus	73	1
Parietal foramen	75	71
Parietal notch bone	73	16
Foramen of Huschke	74	34
Mastoid foramen	72	81
Accessory infraorbital foramen	72	35
Interparietal groove	75	24
Pterion H	70	99
Pterion I	70	1
Posterior condylar canal patent	70	70
Condylar facet double	68	3
Precondylar tubercle	64	3
Anterior condylar canal double	67	21
Foramen ovale incomplete	70	9
Zygomatico-facial foramen	71	80
Supra-orbital foramen	72	19
Supra-orbital notch	72	79
Frontal notch or foramen	70	37
Mandibular torus	77	1
Mental foramen at Pm_2	42	74
Mental foramen at Pm_2-M_1	42	26
Multiple mental foramina	77	7

Table 7: Frequency distribution of discrete traits in skull and mandibles from Dor

Pathology

The pathological lesions identified at Dor fall into two categories. The first are developmental defects that result from acute infection or malnutrition during growth and development. The second category includes signs of infectious diseases, trauma, tumors, degenerative diseases and nutritional disorders identified in the bones. They provide an indication of the type and severity of environmental stress experienced by the inhabitants of Dor during their lifetime.

(a) Developmental Defects

The primary (deciduous) teeth start mineralizing at the age of three months *in utero*, and complete crown development at the age of two years. They start erupting between 6–12 months and are shed between 6–12 years. Children's primary teeth then provide information on health and nutrition *in utero* and in infancy. Mineralization of the permanent teeth starts at birth and continues until 12–15 years, when the third molar crown is formed. Even in old adults, as long as the teeth are retained, the presence and the location of hypoplastic defects that reflect areas of poorly mineralized enamel can be identified. These defects result from lowered serum calcium values at the time the enamel

Fig. 8: posterior view of skull from Dor showing two large wormian bones in the lamboid suture.

Fig. 9: Frontal, lateral and superior views of adolescent skull from Dor showing patent metopic suture.

was formed and so provide a record of the onset, severity and duration of stress in childhood (Nikiforuk and Fraser 1981). At Dor, enamel hypoplasia was present even in the primary teeth developing *in utero*. Hypoplastic defects were present in 17–26% of primary incisors, and in the later developing canines and second molars the incidence was 12–20% (Table 8). Such findings are uncommon in the offspring of healthy mothers and indicate either chronic ill health and/or acute infection of a high percentage of pregnant women. The high prevalence of enamel hypoplasia in the permanent teeth of older individuals shows that poor health characterized all infants and children independent of age at death. In permanent teeth, enamel hypoplasia was present in 90% of all lower canines and 80% of upper canines. The extremely high prevalence of enamel hypoplasia at Dor is almost double that recorded by Smith and Horwitz (1998) for the population from Hellenistic Ein Gedi, used in the cephalometric study by Brin *et al.* (1992), reinforcing the impression that growth stunting occurred in the Dor children.

The frequency of growth arrest lines in the long bones supports the dental evidence indicating chronic ill health throughout infancy and childhood. The location of these defects reflects the developmental stage at which the growth defect occurred. They appear as white lines representing

hypermineralization on radiographs (x-rays) and may disappear over time through remodeling of bone. Radiographs of the tibias of 44 sub-adults and 23 adults showed one or more growth arrest lines in all sub-adults, with an average of 3 growth arrest lines in the entire sample. Those dying in the 6–11 year age group, had twice as many growth arrest lines as those dying in the 0–5 year group, indicating that individuals who survived earlier episodes of growth arrest, succumbed in later periods after suffering repeated episodes of ill health. Adults had a significantly lower frequency of growth arrest lines - half that recorded in sub-adults - but this may be due to bone remodeling leading to replacement of the areas of growth arrest with new, normal bone. Certainly the findings for dental hypoplasia, where no tissue repair or replacement occurs, do not indicate that those surviving to adulthood enjoyed better health as children, than those dying earlier in life. This presumably contributed to some growth stunting reflected in adults both in stature and head size.

Permanent Teeth	Maxilla		Mandible	
	N teeth	%	N teeth	%
I1	55	78	36	61
I2	52	72	50	64
C	49	80	50	90
PM1	56	93	54	57
PM2	52	88	50	68
M1	62	87	67	67
M2	50	94	62	79
M3	29	91	37	81
Deciduous Teeth				
A	18	18	–	–
B	20	26	19	17
C	24	14	21	12
D	32	25	10	24
E	35	20	–	–

Table 8: Frequency of hypoplasia in permanent and deciduous teeth from Dor
- teeth not examined

(b) Congenital Defects

One infant was hydrocephalic, with an enlarged cranium and large patent fontanels, and had probably died from the effects of this condition (Fig. 10a). Another child had craniosynostosis, a condition resulting from premature fusion of the sagittal suture (Fig. 10b), which results in an elongated cranium. It is not in itself associated with other developmental anomalies or increased risk of death. No other congenital defects of the teeth or bones were identified in the sample.

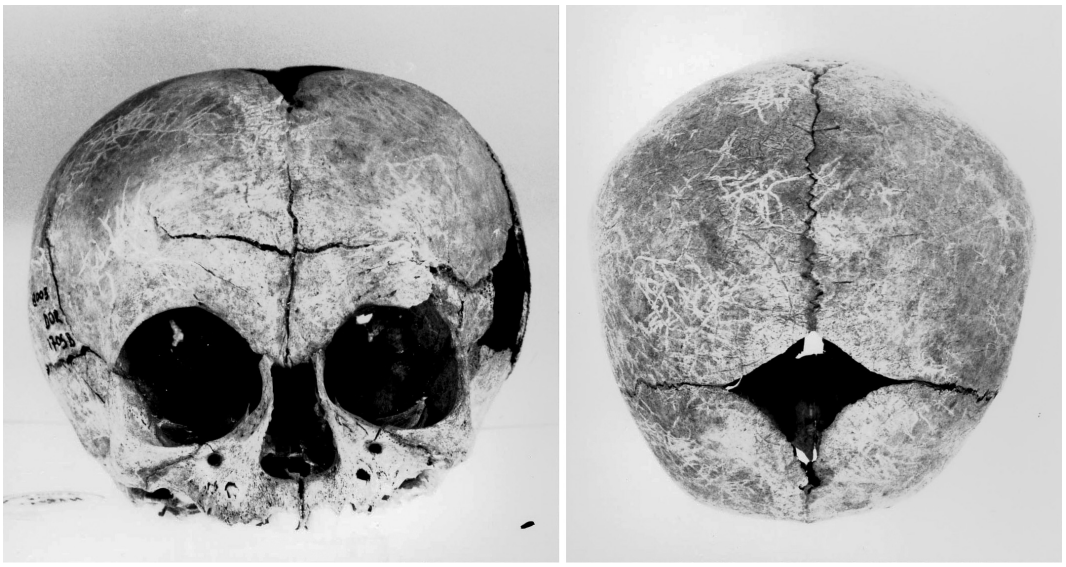
(c) Infectious Diseases

Osteomyelitis

The skeleton of an eight year old child showed massive irregular bone formation around a broken ulna, while radiographs showed that most of the other bones in the skeleton showed patchy areas of bone resorption and irregular new bone (Fig. 11). This picture is typical of that seen following a staphylococcal infection producing osteomyelitis. The distribution of the irregular bone formation and resorption in the skeleton indicates that the infection lasted for some eight months before death. During most of this time, the child must have been bedridden and carefully nursed to survive as long as he did (a fuller description appears in Lax *et al.* 1983).

Malaria, thalassemia and other conditions affecting red blood cell formation

Cribra orbitalia that results from irregular woven bone formation in the roof of the orbit was present in over 40% of adults and 84% of children at Dor while parietal pitting, attributed to the same cause, was observed in similar frequencies. The two were not invariably present together (Fig. 12a, b). Males and females were affected equally and radiographs of the skulls showed thickening of the internal spongy layer (diploe) of the frontal and parietal bones in many children and in eight adults. These changes in the skull are considered to reflect anemia resulting from various causes. These include chronic bleeding from intestinal infections, iron deficient diet, infections such as malaria, or genetic abnormalities such as sickle cell anemia and thalassemia (Nathan and Haas 1966, Stuart-Macadam and Kent 1992). Like growth arrest lines, but unlike enamel hypoplasia, the condition is reversible since, with improved health, new bone may replace the defective bone. Mittler and



a

b

Fig. 10: a. Frontal and superior views of hydrocephalic 18 month old child from Dor showing grossly expanded cranial bones and large patent frontal fontanel.
b. Lateral and superior views of a juvenile skull from Dor with completely fused sagittal suture (craniosynostosis) and patent coronal suture.

Van Gerven (1994) reported that in a series of Medieval Christian skeletal remains from Nubia, where the overall frequency of *cribra orbitalia* was similar to that found at Dor, unhealed lesions were primarily observed in infants and young children. In the Nubians surviving to adolescence or adulthood, most lesions showed signs of healing as new denser bone replaced the cribrotic bone. The Negev Bedouin studied by Goldstein *et al.* (1976), like those from Tel el-Hesi (Eakins 1993) had a much lower frequency of *cribra* than that found at Dor; 20% in children and 1.3 % in adults.

These differences in *cribra orbitalia* may reflect the higher prevalence of malaria in the coastal region of Palestine. Until the 1920s, endemic malaria was common and was especially prevalent in the swampy coastal region and Huleh Valley. Indeed, Hershkovitz *et al.* (1991) have proposed that thalassemia, an inherited condition affecting red blood cell formation, was present in the area

Fig. 11: Osteomyelitis of the armbones of an 8 year old child from Dor. Note irregular new bone.

some 9000 years ago at the Neolithic site of Atlit Yam. The mutations responsible for this condition are considered to have spread, since they afford some protection against malaria in heterozygotes, even though homozygotes die at an early age. Ancient DNA analysis has shown such mutations to be present in an Arab child from the Ottoman period excavated from the coastal site of Achziv, north of Haifa (Filon *et al.* 1995). Thus malaria, was probably a major contributing factor to the high levels of stress and growth stunting found at Dor.

Chronic ulceration

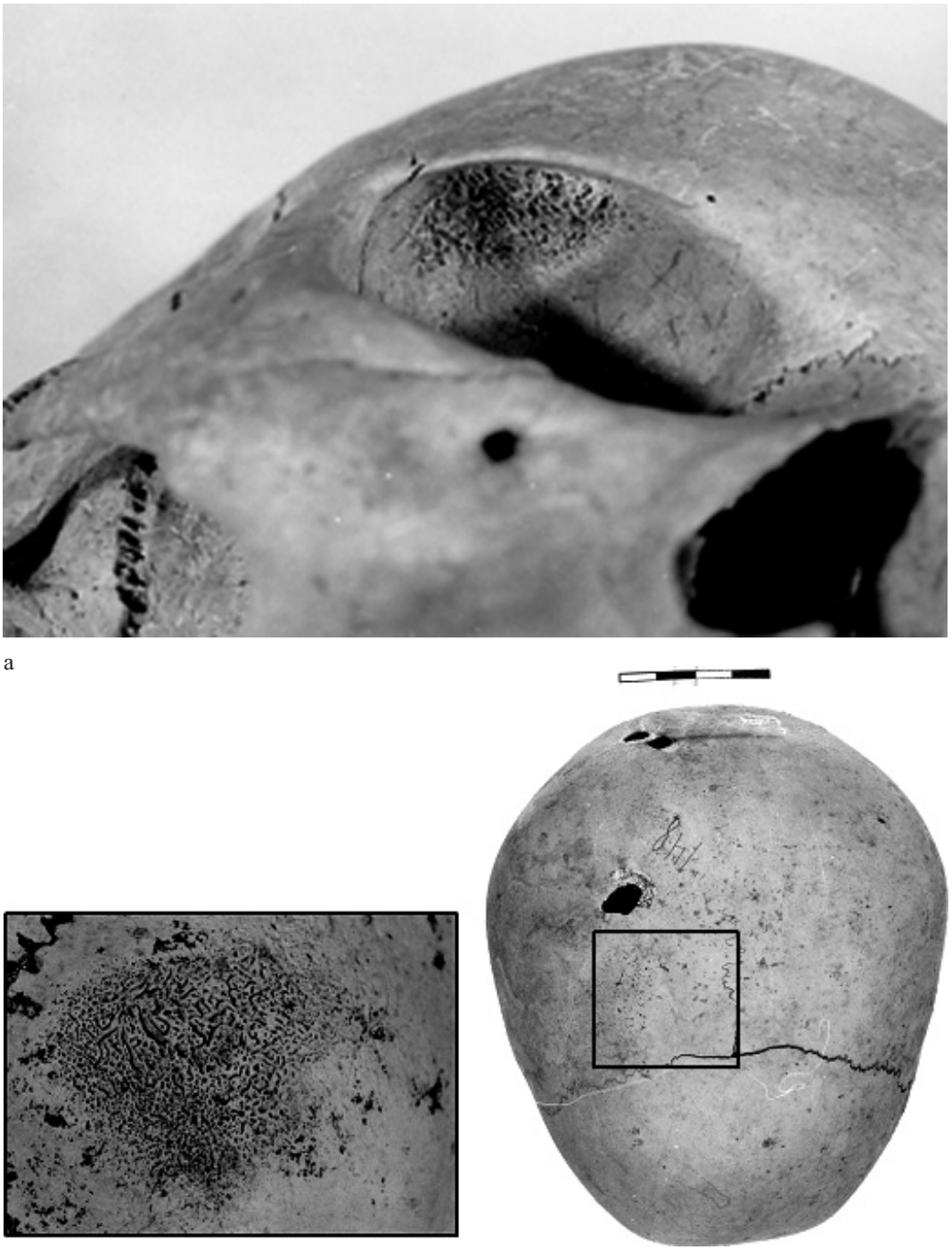
In six adults from Dor, circular lesions, some two centimeters in diameter, were present on the frontal bone. Radiographs showed sclerotic bone formation around an area of rarefaction, indicating that these were due to chronic infection rather than incomplete fractures from blows, as is often suggested. Similar lesions were also found in 8.5% of Negev Bedouin examined by Goldstein *et al.* (1976), but were attributed to trauma.

Arthrosis of the wrist

In one individual from Dor, the hand bones were fused, and the distal articulating surface of the radius showed severe osteoarthritic changes, with irregular bone formation around the joint margins (Fig. 13). While trauma cannot be excluded, chronic infection of the wrist appears a more likely explanation and tuberculosis is a possible cause. It has recently been positively identified at Dor by aDNA methods (Faerman 2008).

Bone mass

Estimates of bone mass at Dor were made from measurements of cortical thickness (CCT) on radiographs of left and right humeri of 37 adults. The radiographs were taken with the posterior surface of the bone placed flat on the intensifying cassettes as described in Smith *et al.* (1984) and measured according to the technique described by Bloom and Laws (1970). Mean values for CCT and CCT/Length ratios in the right humerus were extremely low. They were 9.4 mm in males and 7.0 mm in females, with 53% of the females identified as osteoporotic (Fig. 14). Moreover, as shown by Table 2a, most of the females from Dor died during their childbearing years, which is before the expected onset of post-menopausal osteoporosis. Vitamin D and nutrition are the two main factors affecting Calcium absorption in childhood and adult life. Pregnancy and childbirth make extra demands on the mother's supplies of calcium as well as other nutrients. Consumption of whole grain flour has been shown to affect serum calcium levels, since phytates in the husks of grains inhibits calcium absorption (Reinhold *et al.* 1973, 1981). It may lead to osteomalacia in women when the diet is poor in calcium and other nutrients (Berlyne *et al.* 1973). A number of recent studies on



a

b

Fig. 12: a. *Cribra orbitalia* in the right orbit of a child from Dor.
b. Parietal pitting in a child skull from Dor – inset shows close up of pitting. Note the porosity of the bone in both in both instances, attributed to increased vascularity.

Arab women suggest that the deleterious effects of such diets may be exacerbated by traditional dress that limits exposure to sunlight and so vitamin D production (Dawodu *et al.* 1998, 2003; Glerup *et al.* 2000).

Tuberculosis has also been associated with a reduction in bone mass. Bocquet and Bergot (1977) found that CCT values in tubercular women in their twenties were even lower than those present

Fig. 13: Fused hand bones of an adult from Dor with the distal articulating surface of the radius showing severe osteoarthritis.

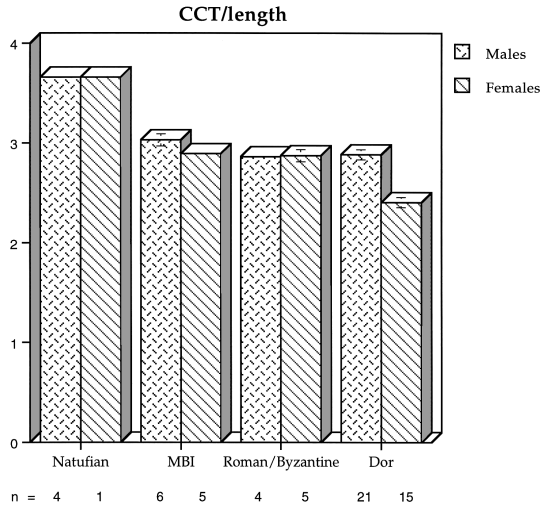


Fig. 14: A diachronic comparison of CCT/Length ratios in the humeri of males and females from different time periods in Israel compared to Dor.
(MBI = Middle Bronze Age I)

in tubercular women in their forties. aDNA studies have now identified a number of cases of tuberculosis and leprosy from Dor (Faerman 2008) and in general this population, as discussed above, showed a high frequency of growth insults (enamel hypoplasia and growth arrest lines on long bones) as well as *cribra orbitalia* and parietal pitting, indicating poor health in the period preceding death.

Since CCT also reflects function, CCT values of right and left humeri were compared. The relationship between skeletal mass and physical activity, and the extent to which activity using one arm more than the other produces asymmetry, is well documented (Garn 1970; Plato *et al.* 1980; Ruff and Jones 1981; Stevenson 1952). In males from Dor, all CCT values were greater in the right humerus than in the left, indicating the increased work load of the right arm. In females, CCT values for both humeri were similar, suggesting a more equal use of both arms. Taking this argument further, male/female differences in CCT/length ratios of right and left arms at Dor appear to be associated with sex-related differences in function. Similar male/female differences in degree of humeral asymmetry were recorded by Ruff and Jones (1981) for an archeological North American Woodland series, where gender-related differences in work patterns were pronounced. In contrast, in pre-contact San hunter-gatherers, women rather than men showed right-left differences in CCT values, possibly associated with use of digging sticks (Smith *et al.* 1992).

Spinal Column

The presence, severity and location of degenerative conditions of the spinal column were examined by visual inspection of individual vertebrae of adults from Dor by Langelbin (1989). Specific conditions examined were *Spondylosis deformans* (osteophytosis), Schmorl's Nodes in which localized pits are found on the inter-vertebral surface of the bodies of the vertebrae, as well as wedging and collapse of vertebral bodies. *Spondylosis deformans* was found in 45% of those under 40 years old and 100% of those aged over 40. The areas most severely affected were the lower thoracic

vertebrae (T9 and T10); the lower back (2nd to 4th lumbar vertebrae) and neck (cervical vertebrae C5 and C6). Similar findings have been reported for 20th century North Americans (Nathan 1959) as well as for a Medieval population from England (Kneel *et al.* 1997), despite marked differences in lifestyle of these three groups. The osteophytes occur in the regions of maximum spinal curvature and appear to relate to lordosis rather than particular activities producing strain in specific regions of the vertebral column.

At Dor, Schmorl's Nodes (SN) were found in 50% of young adults and 71% of older adults. The majority were between 2 mm and 5 mm in diameter. In contrast to *Spondylosis deformans*, Schmorl's Nodes were rare in the cervical region of young adults and most common in the lower back. Disagreement exists concerning the etiology of Schmorl's Nodes. They have been attributed either to a degenerative disease of the vertebral column, resulting from herniation of the inter-vertebral disc into the inter-vertebral joint, or to a developmental anomaly related to incomplete ossification of the vertebral body. A more pronounced age-related change was found in wedging of vertebral bodies, a condition resulting from osteoporosis. This was found in 9.8% of the younger age group and 42% of the older age group. *Spondylosis*, a condition in which separation of the body and neural arch of a vertebra occurs, was found in one young individual. The condition, according to Merbs (1989) is due to heavy strain in the lower back. It appears to cause little pain or disability and Merbs (1989) proposed that it may facilitate flexion of the lower back.

Discussion

Although the cemetery was not completely excavated, the data obtained from our sample indicate that only a small number of individuals were buried per generation. Either we are dealing with a small nuclear population or many were buried elsewhere. The chronological distribution of the skeletal remains show that half of the remains date to the last 100 years of use of the cemetery. The increased number of individuals dated to the later period may reflect an increase in the size of the population using the cemetery. Such a change accords well with the historic evidence for population growth in the 19th century.

The overall morphometric homogeneity expressed in craniofacial measurements and discrete traits suggests genetic continuity of the population, throughout the entire period in which the cemetery was used. The limited range of variation in biometric characteristics also indicates that foreigners were not buried in the cemetery. The Dor population was characterized by moderate stature with rounded heads, long faces, broad cheek bones and large jaws, and were slightly more robust than contemporaneous Bedouin from the Negev or Sinai. They also differed from them in disease patterns, notably in the high frequency of pathology attributed to malaria and absence of bejel.

Oliphant (1887) commented that the late 19th century was associated with massive immigration into Palestine. Even in the northern coastal area between Haifa and Caesaria he recorded the presence of Germans, Jews, Druze, Circassian refugees from Bosnia, Turkmen of 'Seljuk stock', Turkmen recently arrived from northern Mesopotamia, local Arab *Fellahin* and Bedouin. Many of these communities had been displaced in the upheavals following the Crimean war, while others were attracted by new economic opportunities in this part of the Ottoman empire. However, the main impact of such immigration post-dates the period of use of the Dor cemetery while the low coefficient of variation of the morphometric data suggests that we are dealing with a small insular community.

Health surveys carried out during the British Mandate, provide a fairly detailed picture of disease patterns in rural areas of Palestine before public health measures were implemented. While it is possible that some infectious conditions were introduced by the new immigrants, malaria, tuberculosis, and many parasitic infections have been documented in the region for several thousand years (Smith and Horwitz 1998) and as such contain information that is also relevant to the Ottoman period. The 1931 annual report of the Palestine Department of Health records a death rate of 18.7 of all infants

in the Muslim sector. Trachoma (eye disease) was present in some 90% of the population. Malaria and tuberculosis were common and a major cause of death, followed by measles and enteric fevers. Some 14.3 % of all deaths from infectious diseases, excluding malaria, were attributed to tuberculosis, but undulating fever was rare, despite the widespread use of non-pasteurized goat milk. In contrast to Egypt, bilharzia was uncommon. Syphilis, probably in its non-venereal form of bejel, was reported as widespread in the region of Hebron, and ankylostomiasis (hookworm) which causes gastro-intestinal bleeding and hence anemia, affected over 28% of children from Jaffa. Hygiene was poor especially in rural areas where there was no proper sanitation and animals and people shared the same space.

Examination of traditional Ottoman medical practices indicates that eye diseases, skin lesions, wounds, snake bites and trauma were some of the more common conditions treated, often with animal extracts (Lev 2003). Powders and pastes containing mercury were used from the Mamluk period onwards to cure a variety of skin diseases especially bejel and syphilitic lesions (Hudson 1958). The use of mercury and other heavy metals such as lead for medicinal purposes would have contributed to periodontal disease resulting in tooth loss as well as anemia, while cauterization, a common treatment for wounds and headaches would have caused much scarring of the tissue.

The archaeozoological and botanical data presented in the first part of this study, indicate that a rich and varied range of foods were potentially available to the Dor population. However, it is likely that the food supply varied seasonally and access differed between age classes and sexes. A study carried out on the diet of various sectors of the urban and rural population of Palestine in the 1930's, found the diet of rural Arabs to be relatively good, but showing marked seasonal variation, with winter the lean period-mainly because of the lack of fresh milk and seasonal fruits and vegetables (Kligler *et al.* 1931). The researchers found that cereals-mainly in the form of flat bread, provided over half the calories ingested. Fat was derived mainly from olive oil, but also from milk and milk products providing some 35% of the diet, and proteins only 10%. They found that the difference in subsistence basis between *Fellahin* and Bedouin was reflected in the greater intake of milk and milk products by the Bedouin. Indeed, little evidence was found for intensive dairying in either of the archaeozoological samples reported here. Kligler *et al.* (1931) further noted that despite the relatively high mineral intake, the calcium: phosphorus ratio was l: 3 and unbalanced-a factor which undoubtedly affected calcium metabolism. A more recent study of the Negev Bedouin (Gorodischer *et al.* 1995) found a correlation between sub-clinical Vitamin A deficiency and infant mortality and it is possible that the same factor contributed to infant mortality in the Ottoman period that was characterized by marked seasonality in food supplies.

The paleopathology found at Dor indicates chronic anemia and poor calcium intake, similar to that reported for the rural inhabitants of Palestine in the 1931 survey. Both the low life expectancy inferred from the age profile at death and the high prevalence of developmental insults inferred from the findings on enamel hypoplasia and growth arrest lines in long bones, indicate that health status at Dor was poor. In addition to possible seasonal shortages of food, both chronic and acute infections may have played an important role in limiting absorption of nutrients, or in causing anemia from bleeding (for example from hookworms, tapeworms and dysentery) or red blood cell destruction from malaria. While cholera appears to have spread to the Levant only in the 19th century (Scholch 1985), malaria, tuberculosis and possibly hepatitis have been endemic in the region for many thousands of years (Smith and Horwitz 1998), while bejel, a non-venereal disease has been reported in high frequencies from skeletal samples dating to the 19th–20th Centuries (Goldstein *et al.* 1976).

The high prevalence of dental hypoplasia, growth arrest lines and osteoporosis in young females from Dor reflects a cereal-based diet containing a high component of phytates and an unbalanced calcium-phosphate ratio as described by Kliger *et al.* (1931). More specifically, it may be related to additional demands on calcium and phosphorus reserves of women who are pregnant or breast

feeding since lactation doubles the daily calcium needs of women (Sowers *et al.* 1993). Indeed, these researchers found that even healthy, well-nourished women lost a significant amount of bone when breast feeding for 6 months. The low bone mass found in women from Dor is then not surprising. They had poor health to begin with, impaired calcium absorption because of the use of whole grain cereals as their dietary staple, and were probably deficient in vitamins. Moreover, their poor health was exacerbated by frequent childbirth, with breast feeding continuing into the second year of the infant's life.

The human assemblage recovered from Dor, is one of the largest and well-preserved skeletal samples recovered from a securely dated context in the Southern Levant and one for which it was possible to evaluate the bio-anthropological findings and faunal data described here against historical records for the period. It is evident that both historical and archaeological data sets concur in their assessment of the 16th through 19th century Ottoman period as one in which the health status of the rural population of Palestine was extremely poor.

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