Available online at www.sciencedirect.com
ScienceDirect
Quaternary Research 68 (2007) 37–44
QUATERNARY RESEARCH
www.elsevier.com/locate/yqres

Excess in precipitation as a cause for settlement decline along the Israeli coastal plain during the third millennium BC

Avraham Faust [a,*], Yosef Ashkenazy [b,1]

[a] Institute of Archaeology, Martin (Szusz) Department of Land of Israel Studies and Archaeology, Bar-Ilan University, Ramat-Gan 52900, Israel
[b] Department of Solar Energy and Environmental Physics, The J. Blaustein Institute for Desert Research, Ben Gurion University of the Negev, Sede Boqer Campus, 84990, Israel

Received 3 September 2006
Available online 16 April 2007

Abstract

Although the relations between climate and settlement are not straightforward, there is a general agreement that arid conditions are less favorable for human settlement in the semiarid Near East than humid conditions. Here we show that humid conditions resulted in the abandonment of settlements along the Israeli coastal plain. We first present archaeological evidence for a drastic decline in settlement along the Israeli coast during most of the third millennium BC (Early Bronze Age II–III). Then, based on archaeological and climatic evidence, we link this decline to an environmental change occurring at that time. We propose that increased precipitation intensified the already existing drainage problems and resulted in flooding, which led to the transformation of arable land into marshes and to the spread of diseases, gradually causing settlement decline and abandonment.

Keywords: Early Bronze; Archaeology; Environment; Israel; Coast; Settlement; Precipitation

Introduction

Humankind can adapt to extreme climatic conditions, from the very cold weather of Greenland to the extremely arid conditions of the Sahara. Yet, it is clear that under extreme climate regimes, the ecological balance may be perturbed and may also influence human activity in general and human settlement in particular. Thus, the tendency to continue living in a familiar environment may be challenged by the difficulties imposed by environmental changes.

The impact of climatic changes on human settlement is widely discussed in the scientific literature. Some scientists adopt a deterministic approach (e.g., Huntington, 1911; Issar, 1995, 2003; Enzel et al., 2003; Migowski et al., 2006) that links climate variations to changes in human societies. Others stress the ability of human societies to adapt to changes in circumstances and to overcome the effect of climatic change (Rubin, 1989). While the consensus seems to be that climate change has a potential to influence human settlement, it is difficult (i) to provide a chronology to determine the climatic change and its parameters that affected human societies, (ii) to provide a direct link between the two phenomena, and (iii) to estimate the impact of climate change on settlement. In some cases the simultaneous occurrence of climate change and settlement shifts was presumed sufficient to suggest that the latter were the result of the former. Since much of the Near East is a semi-arid and arid region, many scientists were interested in the effect of drying conditions on settlement under the assumption that more humid conditions are generally more favorable for human settlement (e.g., Huntington, 1911; Issar, 1995, 2003; Weiss and Bradley, 2001; Enzel et al., 2003). Here we present evidence that intensive settlement abandonment occurred under increased precipitation in the coastal plain of Israel.

In the first part of the paper we present archaeological evidence for settlement decline along the Israeli coast during the third millennium BC. This is based on both data published from planned excavations and surveys, and a new database (see Faust

* Corresponding author. Fax: +972 3 6354941.
E-mail addresses: fausta@mail.biu.ac.il (A. Faust), ashkena@bgu.ac.il (Y. Ashkenazy).
[1] Fax: +972 8 659 6921.

0033-5894/$ - see front matter
doi:10.1016/j.yqres.2007.02.003

and Safrai, 2005) that encompasses all published salvage excavations in Israel—these data, although published, have not been previously used and analyzed in a systematic way. In the second part of the paper we present an array of known paleoclimate data from different regions and sources that indicate the occurrence of more humid conditions during the third millennium BC. Finally we suggest a scenario that links the decline of settlements with climatic change in this region.

Archaeological data

Background

From the late fourth millennium BC onward, the eastern Mediterranean (Fig. 1a) was generally characterized by intensive trade along its shores (e.g., Stieglitz, 1984; Marcus, 2002). Naturally, such trade is usually accompanied by ports and auxiliary agricultural settlements along the coast. Surprisingly, however, there is a time period for which there is evidence of maritime trade, as well as for general settlement growth, but during which settlement in Israel's coastal plain (Fig. 1b) was drastically reduced: the Early Bronze Age II–III (hereafter EBII–III; circa 3000–2300 BC). [For the purposes of the present paper, we defined the coastal plain as any area which is both on the plain and up to 12 km from the sea. The patterns reported here can be identified when defining the coastal plain using other distances from the sea.]

Based on excavations of mounds (*tels*) and surveys of large areas, archaeologists have estimated the total number of inhabitants of ancient Israel in the various periods (Table 1). The EBII–III, the period of the urban revolution in the Southern Levant, is a time of a major demographic peak in ancient Israel. [The data on the demography of ancient Israel is derived from various studies, e.g., Broshi and Gophna, 1984, 1986; Broshi and Finkelstein (1992) and references therein. Although the quoted numbers can be questioned, the demographic trends between the periods are quite secure, as the various studies used the same methods and density coefficients.] This peak was followed by a drastic decline and total collapse of the urban system in the following Intermediate Bronze Age, and a recovery and re-urbanization in the Middle Bronze Age II. Surprisingly, the EBII–III demographic peak is not represented in the coastal plain where settlement was significantly reduced.

The settlement and demographic decline in the coastal plain can be seen in two different databases. The first comprises excavations published in Stern (1993). These, mainly planned excavations, represent mostly major, usually urban sites. We will therefore refer to this as the "urban" database. The second

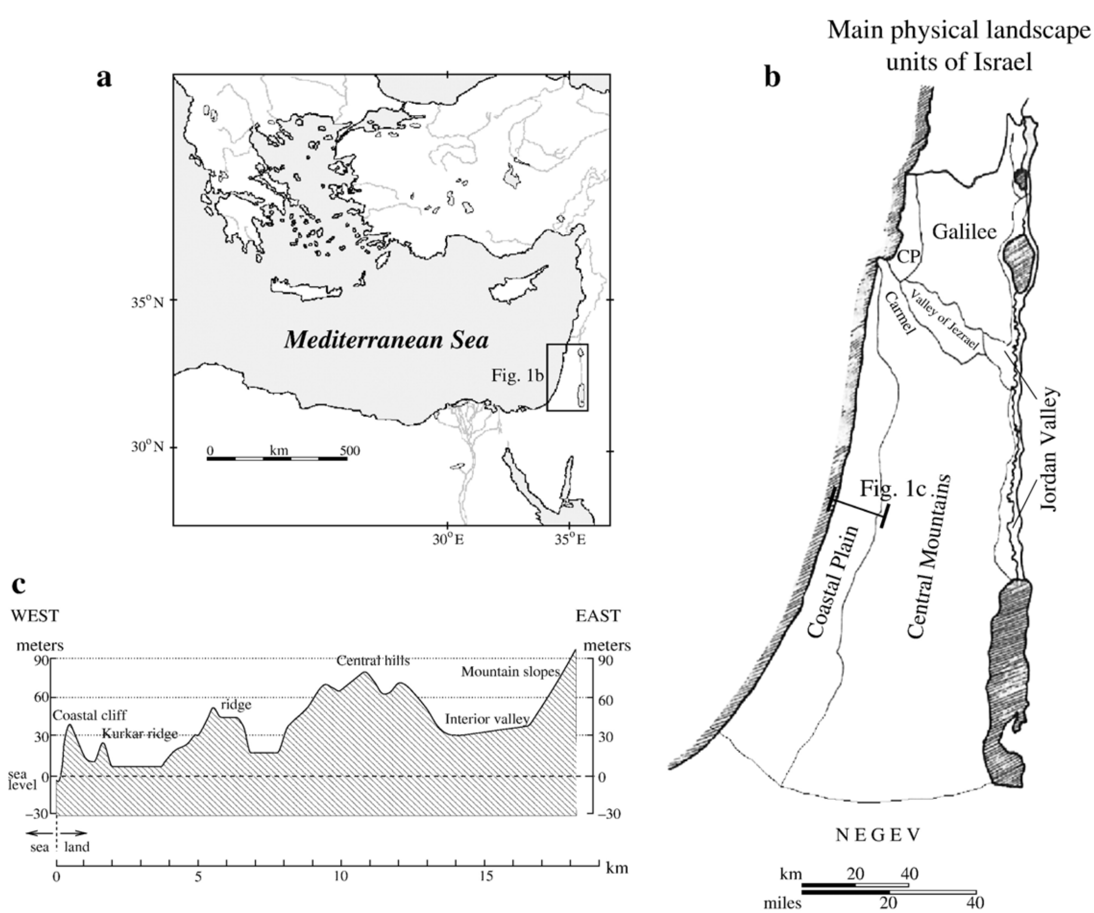

Figure 1. (a) A schematic map of the Near East. (b) A schematic map showing the main physical landscape units of Israel. (c) A schematic west–east section along the Sharon coastal plain (after Karmon, 1959). Note the several low valleys, which are one of the major reasons for the severe drainage problems in the ancient Israeli coastal plain.

https://doi.org/10.1016/j.yqres.2007.02.003 Published online by Cambridge University Press

Table 1
Summary of (i) demographical estimation for the entire country; (ii) number of 'major' sites in the coastal plain on the basis of data published in Stern (1993); (iii) number of 'minor' sites in the coastal plain on the basis of the salvage excavations database for the various archaeological periods

Time range (BC)	Period	Overall demography	No. of 'major' CP sites	No. of 'minor' CP sites	Source for demography
3500–3000	Early Bronze I	50,000 (?)	5	17	Ben-Tor (1990): 6
3000–2300	Early Bronze II–III	150,000	6	4	Broshi and Gophna (1984)
2300–2000	Intermediate Bronze	15,000	7	7	Gophna (1990): 155–156
2000–1600	Middle Bronze II	150,000	27	21	Broshi and Gophna (1986)
1600–1200	Late Bronze	60,000	25	18	Broshi (1993): 423

Note that while the estimated number of inhabitants during the EBII–III was 3–10 times larger than during the Early Bronze I and Intermediate Bronze Age (respectively), the number of 'major' coastal plain sites hardly changed, while the number of 'minor' coastal plain sites decreased drastically by factors of 4 and 2, respectively.

comprises salvage excavations published in the Israeli Journal Archaeological News over 42 years (1961–2003), consisting of 3592 'sites' throughout Israel (these 'sites' are from all periods, and so settlements that had more than one period of occupation are counted more than once). Salvage excavations are carried out to enable construction. Such sites are usually small and mainly represent the rural sector; hence, we refer to this as the "rural" database. The information from these excavations has never before been systematically studied.

The "urban" database

An examination of the coastal plain sites in the "urban" database reveals an anomaly during the EBII–III (Table 1). The EBII–III wave of urbanization and demographic growth hardly left any mark in the coastal plain, where settlement was extremely limited (Portugali and Gophna, 1993; Finkelstein, 1995; Yannai, 2002), similar to the preceding (Early Bronze I, 3500–3000 BC) and succeeding (Intermediate Bronze Age, 2300–2000 BC) periods. However, the Early Bronze I (EBI) was, for most part, a proto-urban period, and the Intermediate Bronze Age was a period in which the urban system collapsed and disappeared. That the number of sites excavated in planned excavations in the coastal plain during the EBII–III is similar to the following and preceding rural periods indicates that the large scale urban revolution of the EBII–III practically skipped the coastal plain. Full-scale urbanization reached the area only some 1000 years later, during the re-urbanization of the second millennium BC [Middle Bronze (MB) Age]. The rudimentary nature of the finds in most of the six EBII–III 'major' sites (Table 1) that were unearthed (mainly pottery) support this EBII–III settlement decline. Those sites were small and did not form urban settlements; it is possible that they served as minor road stations or small anchorages (which were necessary for the maritime trade).

The "rural" database

An examination of the second database of rural settlements reveals a greater contrast between inland and coastal plain settlements during the EBII–III. First, the number of sites in the coastal plain reaches a record low at this time (Table 1). Theoretically, this could be partially explained by a reduction in the number of small sites and concentration of the population in fewer larger sites. However, the relative importance of the region (i.e. the ratio of settlements in the coastal plain to the total number of sites in the entire country) is also minimal during the EBII–III (Fig. 2a) and is reduced to about one third of the preceding Early Bronze I period. Moreover, the finds at these 4 EBII–III sites are few and scattered, and they appears to represent ephemeral human habitation of the few settlers who managed to survive in the region.

We therefore suggest that the coastal plain was a fringe area during the EBII–III, with significantly reduced settlement, urban and rural alike. While this reduction in the number of settlements in the coastal plain has been noticed before (Portugali and Gophna, 1993; Finkelstein, 1995; Yannai, 2002), it was never really addressed; it is only now that we recognize the magnitude of this phenomenon. [Notably, while

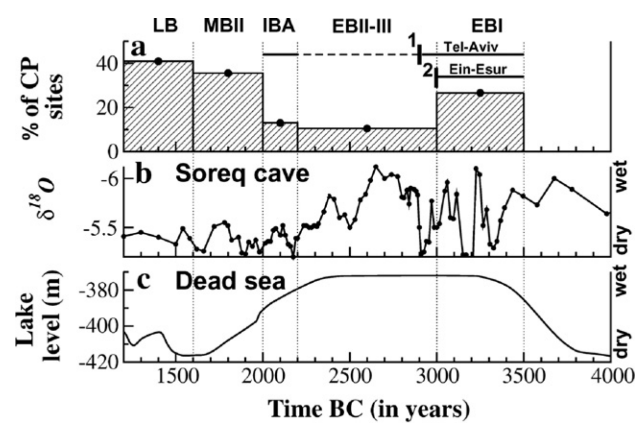

Figure 2. (a) Percentage of coastal plain sites (salvage excavations) out of the total number of sites (salvage excavations) for the different periods: EBI—Early Bronze Age I, EBII–III—Early Bronze Age II–III, IBA—Intermediate Bronze Age, MBII—Middle Bronze Age II, LB—Late Bronze Age. Note that the number of sites in the coastal plain is over-represented, as more salvage excavations were conducted in this region, but the trends (not the actual figures) are of greatest significance. The full circles represent the entire periods and are located in the median of each period. The horizontal solid line (1) indicates the periods of occupation at the Tel Aviv exhibition grounds (Ritter-Kaplan, 1984); note cessation of settlement during the EBII–III. The lower horizontal solid line (2) indicates the period of occupation accompanied with growing marshes until the final abandonment of Ein Esur (Yannai, 2002; Horowitz, in press). The vertical black bars indicate the abandonment of the sites due to growing marshes in the regions. (b) Isotope composition ($\delta^{18}O$) from the Soreq cave (Bar-Matthews et al., 1997, 1998). According to Bar-Matthews et al., lower values indicate higher annual precipitation amount. (c) Dead Sea water-level fluctuations (Enzel et al., 2003).

https://doi.org/10.1016/j.yqres.2007.02.003 Published online by Cambridge University Press

Egyptian sources indicate maritime trade along the Levantine coast during the EBII (Stieglitz, 1984), no port is identified along the Israeli Mediterranean shores and, surprisingly, settlement is greatly reduced (Ben-Tor, 1992).]

The statistics of the "rural" database

The database of rural settlement is one of the largest and most detailed archaeological databases in Israel. Although from a statistical perspective this database seems to be too small to conclusively estimate coastal plain settlement fluctuations, the Israeli coastal plain is a relatively small area (the study area as defined above is less than 2400 km^2) and the number of excavated sites per unit area is most probably one of the largest in the world. We therefore think that such a database is a very important tool in determining past settlement fluctuations.

To verify the statistical significance within the rural database (i.e. to what degree do the statistics of the sites within the database represent the overall statistics) we selected a period with a large number of sites, the Byzantine period (638 sites), and performed the following test. We randomly selected a subset from the 638 sites and asked two questions: (i) what is the number of cemeteries/burials in the subset, and (ii) what is the number of sites that are within the Judea region. The statistics for the entire period (120 cemeteries and 176 Judea sites) serve as the control for the statistics of the chosen subsets, and the deviations from the statistics of the entire period give us some indication about the significance of EBII–III results that are based on a relatively small number of sites. We performed 1000 such random selections of 25 sites and found that the standard deviation from the average is less than 9%. Obviously, for larger subsets the standard deviation becomes smaller (less than 4.5% for subsets of 100 sites). The number of sites (in all areas) for the different archaeological periods discussed here is more than 35 and thus the expected standard deviation is less than 8%, suggesting that the low coastal-plain ratio is significant with respect to the Early Bronze Age I, Middle Bronze Age, and Late Bronze Age periods.

We also estimated the significance of our results by assuming a null hypothesis, according to which the average coastal-plain ratio is 25.6%. This value is the ratio of the total number of coastal plain settlement sites for the periods discussed here (67 sites) to the overall number of sites (total of 262 sites; the relatively large number of sites in the coastal plain results not only from the importance of the region, but also from the higher rate of development in the region). Thus, using this null hypothesis, the probability of a site being in the coastal plain is $p=0.256$. Given this probability and using the binomial distribution it is possible to estimate the standard deviation from the average of 25.6% for each of the periods; it is the square root of $\sqrt{np(1-p)}/n$ where n is the total number sites for each period. We find that the standard deviation is less than 7.5%, thus indicating that the ratio during almost all periods is well outside the null hypothesis assumption.

These statistics therefore support the hypothesis that the coastal plain population was at a very significant low point during the EBII–III period. Here we offer an environmental explanation for the settlement decline during the EBII–III; other explanations would be needed to explain the significance of the other periods under this null hypothesis.

Discussion

What caused such a significant settlement decline in the coastal plain during the EBII–III—a period of flourishing settlements and urbanization in most other regions? Various cultural and historical reasons such as military campaigns, conditions of reduced security, or epidemics can account for the abandonment of settlements and even entire regions (Cameron and Tomka, 1993). Still, such explanations seem to fall short of explaining the pattern discussed above. Both the 800-year duration of sparse habitation in the coastal plain, and the fact that it covers a vast area encompassing several ancient polities (Finkelstein, 1995), make such explanations unsatisfactory. We therefore suggest another explanation, involving environmental changes, for the EBII–III phenomenon of coastal-plain settlement decline.

Paleoclimatic record

Did environmental change underlie the coastal plain settlement decline during the EBII–III (most of the third millennium BC)? Bar-Matthews et al. (1997, 1998) constructed an $\delta^{18}O$ record from speleothems from Soreq cave, west of Jerusalem, and interpreted it as a proxy for local precipitation. According to this interpretation (Fig. 2b) the EBII–III was a humid period. Enhanced precipitation around the beginning of the EBII–III is also suggested from another speleothem cave in the Jerusalem region (Frumkin et al., 1999). It should be noted, however, that there is an ongoing debate regarding the Bar-Matthews et al. (1997, 1998) interpretation of $\delta^{18}O$ of Soreq Cave as a proxy for precipitation (Kolodny et al., 2005). At the present state of knowledge, we elect to present with caution the data as interpreted by Bar-Matthews et al. (1997, 1998), and to show its relation to other types of data discussed here.

Frumkin et al. (1991, 2001) approximated the Dead Sea level fluctuations based on salt caves from mount Sedom (southern Dead Sea region). The relative passage width of the caves, their elevation, and the wood remains found in them were used for this approximation. It is apparent that precipitation in the Dead Sea region (affecting the Dead Sea level) was significantly higher during the Early Bronze I and the beginning of EBII. More recent studies showed high Dead Sea level also during most of the EBII–III (Fig. 2c; Enzel et al., 2003; Bookman et al., 2004; Migowski et al., 2006).

Lastly, Rosen (1986) studied the geomorphology of riverbeds in Israel's inner coastal plain. She concluded that the EBII–III was a more humid period than the present.

Environmental scenario

The Israeli coastal plain is a sensitive ecological region. Both on land and on the continental shelf, it is characterized by topography of longitudinal *kurkar* (aeolianite) ridges parallel to the coast, alternating with red soils (*hamra*). Along the much of the coast itself there are sand dunes (Fig. 3; Tsoar, 2000; Cohen-Seffer et al., 2005). The coastal plain is flat, close to sea level, and because it is intersected by *kurkar* ridges it suffers from severe drainage problems; for example, approximately 100 years ago some of the valley bottoms were below the water table and contained swamps (Karmon, 1959). Increased precipitation would flood the valleys by elevating the local water table and worsen the existing drainage problems. Percolation of water would be limited, and it is likely that more sediments, mainly clay, would be deposited on the sluggish riverbeds, leading to damming of rivers and reducing percolation. Drainage problems would be intensified if sand (originating in the Nile River) were deposited along the shores and dammed river outlets, as seems to have happened during the EBII–III (Horowitz, 1979; Sivan, 1982; see also Gvirtzman et al., 1998; Cohen-Seffer et al., 2005).

The majority of the agricultural soils and settlements in the ancient Israeli coastal plain were concentrated in the river valleys (Karmon, 1959). However, these rivers are known to have drainage problems (see, for example, Fig. 4; Cohen-Seffer

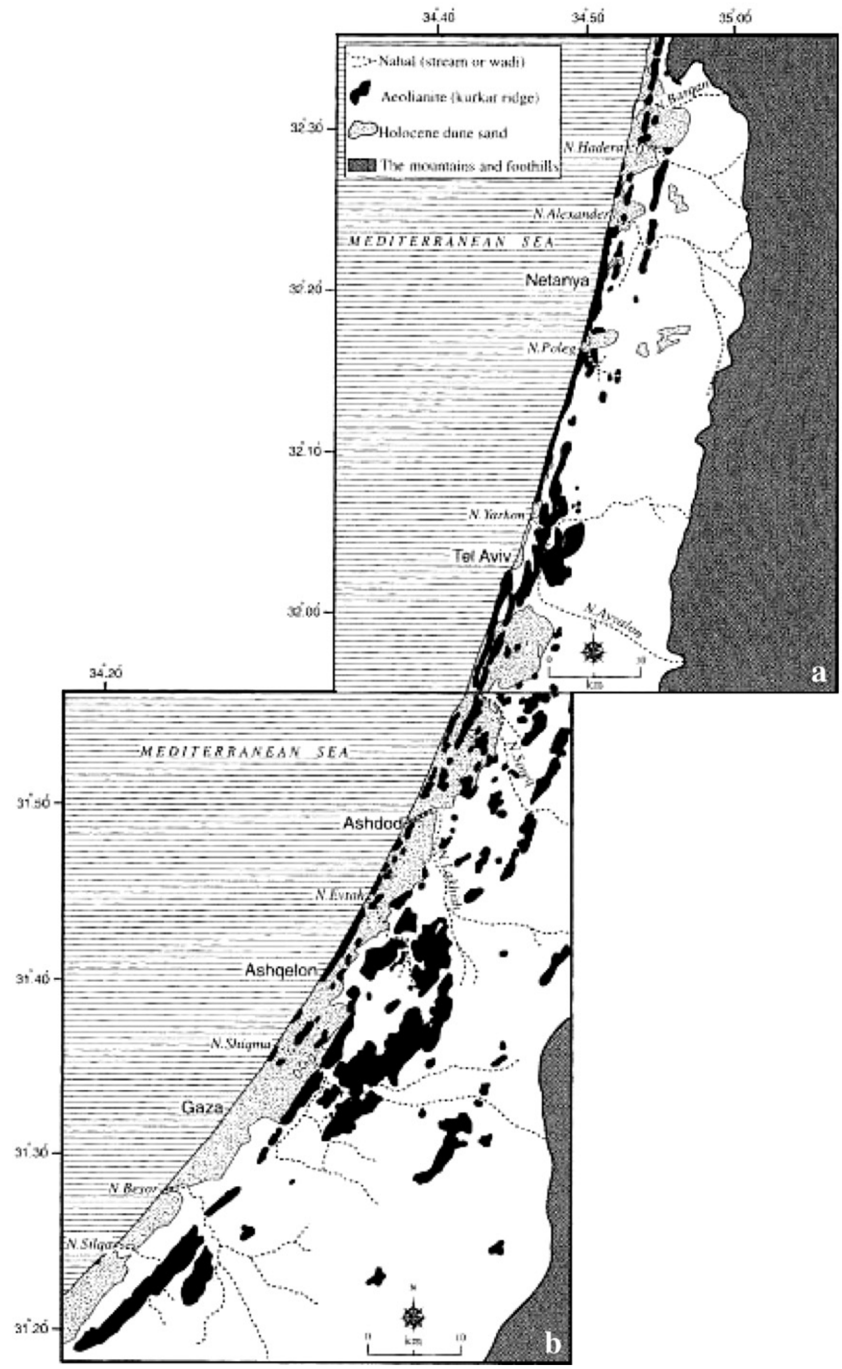

Figure 3. Map of the kurkar ridges, the Holocene sand dunes, and the drainage system along the central and southern coastal plain (from Tsoar, 2000, Fig. 1; used with permission of H. Tsoar and Israel Journal of Earth Sciences).

https://doi.org/10.1016/j.yqres.2007.02.003 Published online by Cambridge University Press

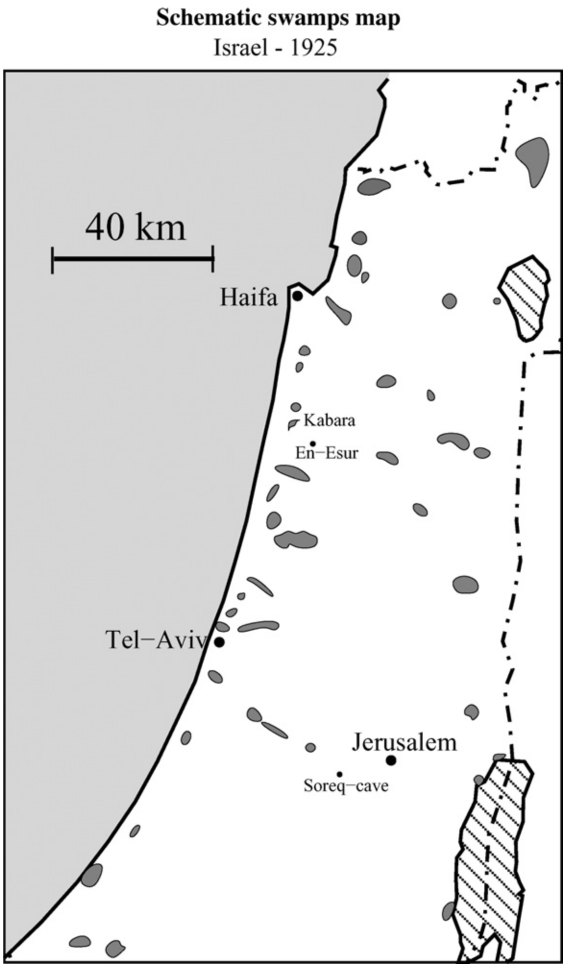

Figure 4. Schematic map showing the swamps areas in Israel during 1925 (redrawn after Grossman, 2004, Fig. 5.1).

et al., 2005 provides an example for the process in which swamps were created). Thus, deterioration of drainage conditions might have converted the fertile river valleys of the coastal plain into inhospitable swamps, leading to unbearable living conditions, limiting the economic basis, blocking roads, and isolating communities. Moreover, as marshes grow, diseases associated with them such as malaria and bilharzia spread, worsening living conditions and leading to a population decline. Notably, extreme and abrupt short-term wet climate events during the EBII–III may have worsened living conditions in the coastal plain even further.

The evidence for the abandonment of the coastal plain spans the entire EBII–III. The enhanced precipitation that may underlie this abandonment must therefore have started even before the EBII–III, as seems to be the case for the climatic evidence mentioned above.

The recovery of the coastal plain from the great settlement decline of EBII–III was a slow process. Full-scale urbanization was achieved in this region only in the early second millennium BC (Middle Bronze II). The late third millennium BC (the Intermediate Bronze Age) saw a great demographic decline throughout the country (Table 1), and the number of sites throughout the country is very low. Although the Intermediate Bronze Age was drier than the preceding EBII–III period, full recovery of the coastal plain was delayed due to the overall regional trend. The recovery and better environmental conditions in the coastal plain are reflected in the fact that the number of coastal plain sites, in both datasets, is higher than that of the EBII–III. This means that the relative importance of the coastal plain grew significantly already at that time.

Archaeological evidence in support of the environmental scenario

The temporal correspondence of environmental change and settlement decline is not the only evidence that links both. There are more direct archaeological and palynological indications for flooding of ancient sites during the EBII–III.

Paleontological data constructed from the excavations of the Early Bronze Age I site of En Esur in the coastal plain (some 12 km from the coast; Fig. 4) indicate that the percentage of marsh vegetation increased dramatically from the Chalcolithic period (4500–3500 BC) toward the end of the Early Bronze I (from 47.8% to 91.7%) indicating "that the site was abandoned resulting from rise in the water level in the rivers and the transformations of most of the site into a marsh" (Yannai, 2002; Horowitz, in press) (Fig. 2a).

Excavations at Tel Aviv's exhibition grounds (approximately 3 km from the coast; Fig. 4) have revealed strata, dating to the Early Bronze I and the beginning of the Early Bronze II, beneath a layer of black hard clay (Ritter-Kaplan, 1984). The pollen assemblages from this clay indicate a wetter climate and "swampy conditions" (Horowitz, 1979; Ritter-Kaplan, 1984). Later, during the Intermediate Bronze Age, a small encampment was established at the site, and it accompanied deposition of grey quartz sand on top of the hard clay, indicating the cessation of these swampy conditions (Fig. 2a).

The human factor

We note that it is not only the ecological factors that influence human settlement. Environmental changes initiate responses from human societies, and the outcome of environmental change results, to a large extent, from these responses (Rosen and Rosen, 2001). Regarding the EBII–III, it is likely that the urbanization process and the growing tendency of human societies to abandon their former way of life and to concentrate in larger and denser sites accelerated the rate of coastal-plain abandonment. The region was not only more difficult to settle than before but also completely unsuitable for hosting the large communities that had become the norm, and the entire systems that depended on them.

Conclusion

We present evidence that the Israeli coastal plain, a sensitive ecological niche, was almost abandoned during the third millennium BC (EBII–III), despite the overall population increase in other parts of the country. There is clear evidence for increased precipitation at that time, for the transformation of

https://doi.org/10.1016/j.yqres.2007.02.003 Published online by Cambridge University Press

settled land into marshland, and possibly for the transfer of sand to the Israeli coast. We propose that increased precipitation and blocking of river outlets intensified the existing drainage problems, leading to extensive flooding, transformation of arable land into marshes, and to the spread of diseases. We suggest that these factors gradually led to settlement decline and abandonment.

Acknowledgments

We would like to thank D. Adan-Bayewitz, A. Almogi, D.R. Baker, M. Bar-Matthews, H. Gildor, L.P. Horwitz, Y. Kolodny, H. Lavee, S. Lev-Yadun, A.M. Maeir, S. Pariente, Z. Safrai, E. Tziperman, E. Yannai, A. Zemel, and anonymous reviewers for their comments and help. YA is supported by the Yeshaya Horowitz Association through the Center for Complexity science.

We would like to note that the compilation of the salvage excavations database is currently being finished by Avraham Faust and Zeev Safrai, with the intention of making it available to the public in the future. In the interim, Avraham Faust (fausta@mail.biu.ac.il) will be happy to answer individual queries regarding the database.

References

Bar-Matthews, M., Ayalon, A., Kaufman, A., 1997. Late Quaternary paleoclimate in the Eastern Mediterranean region from stable isotope analysis of speleothems at Soreq Cave, Israel. Quaternary Research 47, 155–168.

Bar-Matthews, M., Ayalon, A., Kaufman, A., 1998. Middle to late Holocene paleoclimate in the eastern Mediterranean region from stable isotopic composition of speleothems from Soreq Cave, Israel. In: Issar, A.S., Brown, N. (Eds.), Water Environment and Society in Times of Climatic Change. Kluwer, Amsterdam, pp. 203–214.

Ben-Tor, A., 1990. The trade of the land of Israel during the early bronze age. In: Kedar, B.Z., Dothan, T., Safrai, S. (Eds.), Commerce in Palestine Throughout the Ages. Yad Ben Zvi, Jerusalem, pp. 3–20 (in Hebrew).

Ben-Tor, A., 1992. The early bronze age. In: Ben-Tor, A. (Ed.), The Archaeology of Ancient Israel. Yale University Press, New Haven, pp. 81–125.

Bookman, R., Enzel, Y., Agnon, A., Stein, M., 2004. Late Holocene lake levels of the Dead Sea. Geological Society of America 116 (5–6), 555–571.

Broshi, M., 1993. Methodology of population estimates: the Roman–Byzantine period as a case study. In: Biran, A. (Ed.), Biblical Archaeology Today 1990. Israel Exploration Society, Jerusalem, pp. 420–425.

Broshi, M., Finkelstein, I., 1992. The population of Palestine in Iron Age II. Bulletin of the American Schools of Oriental Research 287, 47–60.

Broshi, M., Gophna, R., 1984. The settlements and population of Palestine during the early bronze age II–III. Bulletin of the American Schools of Oriental Research 253, 41–53.

Broshi, M., Gophna, R., 1986. Middle bronze age II Palestine: its settlements and population. Bulletin of the American Schools of Oriental Research 261, 73–90.

Cameron, C.M., Tomka, S.A., 1993. Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. Cambridge University Press, Cambridge.

Cohen-Seffer, R., Greenbaum, N., Sivan, D., Jull, T., Barmeir, E., Croitoru, S., Inbar, M., 2005. Late Pleistocene–Holocene marsh episodes along the Carmel Coast, Israel. Quaternary International 140–141, 103–120.

Enzel, Y., Bookman (Ken-Tor), R., Sharon, D., Gvirtzman, H., Dayan, U., Ziv, B., Stein, M., 2003. Late Holocene climates of the Near East deduced from Dead Sea level variations and modern regional winter rainfall. Quaternary Research 60, 263–273.

Faust, A., Safrai, Z., 2005. Salvage excavations as a source for reconstructing settlement history in ancient Israel. Palestine Exploration Quarterly 137, 139–158.

Finkelstein, I., 1995. Two notes on the Early Bronze Age urbanization and urbanism. Tel-Aviv 22, 47–69.

Frumkin, A., Magaritz, M., Carmi, I., Zak, I., 1991. The Holocene climatic record of the salt caves of Mount Sedom, Israel. The Holocene 1 (3), 191–200.

Frumkin, A., Ford, D.C., Schwarcz, H.P., 1999. Continental oxygen isotopic record of the last 170,000 years in Jerusalem. Quaternary Research 51, 317–327.

Frumkin, A., Kadan, G., Enzel, Y., Eyal, Y., 2001. Radiocarbon chronology of the Holocene Dead Sea: attempting a regional correlation. Radiocarbon 43 (3), 1179–1189.

Gophna, R., 1992. The Intermediate Bronze Age. In: Ben Tor, A. (Ed.), The Archaeology of Ancient Israel. Yale University Press, New Haven, pp. 126–158.

Grossman, D., 2004. Arab Demography and Early Jewish Settlement in Palestine: Distribution and Population Density During the Late Ottoman and Early Mandate Periods. Magnes Press, Jerusalem.

Gvirtzman, G., Netser, M., Katsav, E., 1998. Last-glacial to Holocene kurkar ridges, hamra soils, and dune fields in the coastal belt of central Israel. Israel Journal of Earth Sciences 47, 29–46.

Horowitz, A., 1979. The Quaternary of Israel. Academic Press, New York.

Horowitz, A., in press. Palynology at Assawir: Advance of marshes as a possible cause for settlement desertion. In: Yannai, E. (Ed.), Ein Assawir: Excavations at a Protohistoric Site and Adjacent Cemetery in the Coastal Plain, Israel. Israel Antiquity Authority, Jerusalem.

Huntington, E., 1911. Palestine and Its Transformations. Houghton and Mifflin, Boston.

Issar, A.S., 1995. Climatic-change and the history of the Middle-East. American Scientist 83 (4), 350–355.

Issar, A.S., 2003. Climate Changes During the Holocene and Their Impact on Hydrological Systems. Cambridge University Press, Cambridge.

Karmon, Y., 1959. Geographical conditions in the Sharon plain and their impact on its settlement. Studies in the Geography of Israel 1, 111–133 (In Hebrew).

Kolodny, Y., Stein, M., Malchus, M., 2005. Sea-rain-lake relation in the Last Glacial East Mediterranean revealed by $\delta^{18}O$–$\delta^{13}C$ in Lake Lisan aragonites. Geochimica et Cosmochimica Acta 69, 4045–4060.

Marcus, E., 2002. Early seafaring and maritime activity in the southern levant from prehistory through the third millennium bce. In: van den Brink, E.C.M., Levy, T.E. (Eds.), Egypt and the Levant: Interrelations From the Fourth Through the Early Third Millennium BCE. Leicester University Press, London-New York, pp. 403–417.

Migowski, C., Stein, M., Prasad, S., Negendank, J.F.W., Agnon, A., 2006. Holocene climate variability and cultural evolution in the Near East from the Dead Sea sedimentary record. Quaternary Research 66, 421–431.

Portugali, J., Gophna, R., 1993. Crisis, progress and urbanization: the transition from Early Bronze I to Early Bronze II in Palestine. Tel-Aviv 20, 164–186.

Ritter-Kaplan, H., 1984. The impact of drought on third millennium B.C. cultures on the basis of excavations in the Tel-Aviv exhibition grounds. Zeitschrift des Deutschen Palastina-Vereins 100, 2–8.

Rosen, A., 1986. Environmental change and settlement at Tel Lachish, Israel. Bulletin of the American Schools of Oriental Research 263, 55–60.

Rosen, A.M., Rosen, S.A., 2001. Determinist or not determinist?: Climate, environment, and archaeological explanation in the Levant. In: Wolff, S.R. (Ed.), Studies in the Archaeology of Israel and Neighboring Lands, in Memory of Douglas L. Esse. The Oriental Institute and ASOR, Chicago, pp. 535–549.

Rubin, R., 1989. The debate over climatic changes in the Negev 4th–7th centuries B.C. Palestine Exploration Quarterly 121, 71–78.

Sivan, D., 1982. Paleoclimate of the Akko Area in Holocene period. Third Annual Coastal Conference, Haifa, pp. 51–63.

Stern, E. (Ed.), 1993. The New Encyclopedia of Archaeological Excavations in the Holy Land. Israel Exploration Society, Jerusalem.

Stieglitz, R.R., 1984. Long distance seafaring in the ancient Near East. Biblical Archeologist 47, 134–142.

Tsoar, H., 2000. Geomorphology and paleogeography of sand dunes that have formed the kurkar ridges in the coastal plain of Israel. Israel Journal of Earth Sciences 49, 189–196.

Weiss, H., Bradley, R.S., 2001. What drives societal collapse? Science 291, 609–610.

Yannai, E., 2002. The northern Sharon in the Chalcolithic period and the beginning of the Early Bronze Age in light of the excavations at 'Ein Assawir'. In: van den Brink, E.C.M., Yannai, E. (Eds.), In Quest of Ancient Settlements and Landscapes: Archaeological Studies in Honour of Ram Gophna. Ramot, Tel-Aviv, pp. 65–85.