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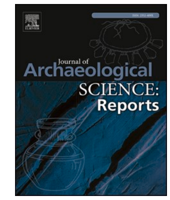

Heated beeswax usage in mortuary practices: The case of Ḥorvat Tevet (Jezreel Valley, Israel) ca. 1000 BCE

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ABSTRACT

The article presents and discusses the results of Residue Analysis performed on 27 pottery vessels, placed as offerings in burials dating to the Iron I period (ca. 1050–900 BCE) at the site Ḥorvat Tevet (Israel). The results show that heated beeswax was used during the burial ceremonies and placed in variety of vessels. These results shed new light on burial practices of South Levantine rural communities. They also contribute to the growing body of evidence regarding bee-product economy in the Southern Levant during the beginning of the Iron IIA.

1. Introduction

In this article we shed new light on burial practices in a South Levantine rural community in the late Iron I and the beginning of the Iron IIA, ca. 1050–900 BCE. More specifically we bring additional evidence for the use of heated beeswax during burial ceremonies based on residue analysis preformed on all 27 pottery vessels found in the site.[1] By "burial practices" we refer to activities such as funerary procession and rituals, ceremonial meal, treatment of the body and placing of burial offerings alongside the deceased (Parker Pearson, 1999). Residue analysis of vessels left as offerings inside graves allows researchers to identify the actual materials and the fashion in which they were used and discuss their significance (Evershed et al., 2011: 411–412).

The cemetery discussed here was found at Ḥorvat Tevet, located in the north-eastern margins of the Jezreel Valley (northern Israel; see details further below). Based on ceramic typology the burials were dated to the Iron I and early Iron IIA (ca. 1050–900 BCE[2]). This is a transitional period in the Levant during which political power shifted from the traditional city states of the Bronze Age that ruled over the region for centuries under Egyptian patronage to the territorial kingdoms of the Iron Age (Finkelstein, 2013; Gadot, 2019; Sergi, 2019). On one hand, archaeological data from excavations and surveys point to certain continuity in both settlement patterns and material culture. On the other hand, the new order, which emerged after the "Crisis Years" at the end of the Bronze Age, exhibit changing trade and economic systems (Yahalom-Mack et al., 2014; Gilboa et al., 2015; Gilboa and Namdar, 2015; Ben-Yosef and Sergi, 2018). The role of beekeeping for beeswax in the emerging new economy is especially intriguing as this product carried with it both economic and symbolic values (Mazar and Panitz-Cohen, 2007).

1.1. *The cemetery in Ḥorvat Tevet*

Ḥorvat Tevet is located in the Jezreel Valley, on the northern slopes of Hammoreh Hill, ca. 15 km east of Megiddo (map ref. NIG 231542/727111; Fig. 1). The site was first identified by the Survey of Western

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[1] This study is an outcome of the research project "The Archaeological Expression of Palace-Clan Relations in the Iron Age Levant: A Case Study from the Jezreel Valley, Israel", which is funded by the Gerda Henkel Stiftung (AZ 20/F/19) and directed by Omer Sergi (Tel Aviv University), Karen Covello-Paran (Israel Antiquities Authority) and Hannes Bezzel (University of Jena).

[2] Based on numerous radiocarbon measurements from nearby Megiddo (Toffollo et. al. 2014) and Tel Reḥov (Lee, Bronk-Ramsey and Mazar 2013).

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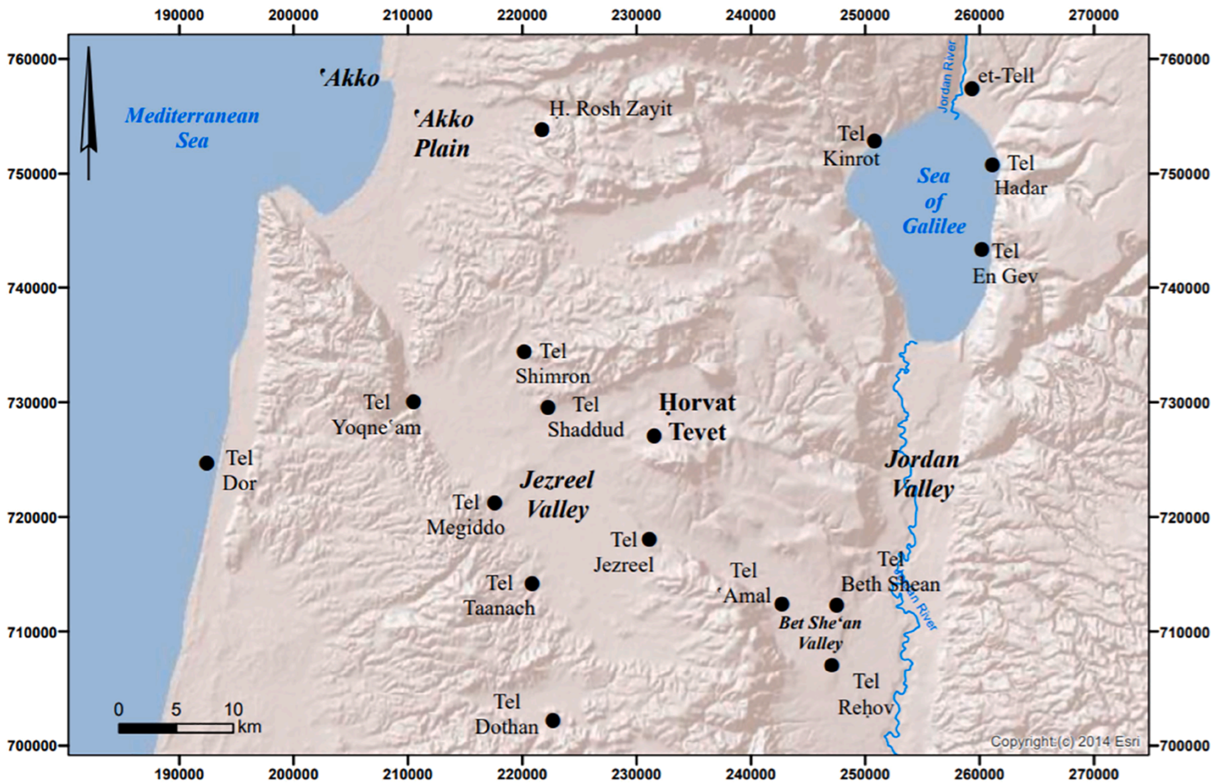


Fig 1. map of north Israel showing the location of Ḥorvat Tevet and other sites mentioned in the article (map by A. Shapiro, courtesy of the IAA).

Palestine and reported under the name Khirbet Bir Tibas (Conder and Kitchener, 1882: 121). Successive surveys suggested that it was intermittently settled from the third millennium BCE till the Medieval Periods (Zori:55, 1977; Gal: 54, 1998*; Dagan and Hanna, 2011; Finkelstein et al.: 758, 2006). Salvage excavations at the site began in 2007 and were carried on till 2019 by different expeditions.[3] The site stretches over three terraces; nine occupational levels, spanning from the Late Bronze I until the Roman period were identified. The earliest Iron Age level (Level 8, dating to the Iron I–early Iron IIA) included scanty architectural remains and burial pits; the latter were part of a cemetery located at the northern margins of the settled area (Areas A, D and E; Fig. 2).

Twenty-six burials were identified in the Iron I-early Iron IIA cemetery.[4] The burials are simple pits and cists that were hewn directly into the loose and crumbling basalt bedrock. Due to the acidity of the bedrock preservation of human skeletal remains was poor.[5] In the majority of cases, each pit was intended for the burial of a single individual, however, in four burial pits there was evidence for multiple interments in a single burial pit. In two burials infant storage jar burials were placed next to an adult interment. The burial offerings consisted of a limited range of locally-produced pottery vessels: bowls, chalices, juglets, flasks, storage jars and lamps (Fig. 3). Only a few more luxurious items, such as bronze jewelry and imported small pottery vessels, were present. Moreover, each burial was provided with only a small number of burial offerings. The storage jars, sometimes with a dipper juglet inside, were placed at the edges of the burial, while the other vessels were arranged around the head, feet and waist of the deceased. Traces of linen textile preserved on the outer surface of the bronze finds indicate that the deceased was wrapped in a linen shroud (Shamir, 2013). Most of the vessels have parallels in Stratum VIA at Megiddo (Arie, 2013b), the type-layer of the late Iron I in the northern part of Israel. However, two of the burials included a globular juglet with handle attached from mid-neck to shoulder. This juglet type is found in the northern valleys only in Iron IIA contexts (e.g. Arie, 2013a: 705, Type JT32). Therefore, the last interments in the cemetery must have taken place slightly after the end-days of Megiddo VIA.

Comparative pit or cist tombs are known from Tel Shaddud, located 9.5 km away from Ḥorvat Tevet, in the central Jezreel Valley (Arie: 261–272, 2011; van den Brink et al., 2017). Other nearby sites where such burials were found includes Tel ʻAfula, Hazore'a, Tel Kedesh, Tel Qishion, and Nahal Yifat (Sukenik, 1948; Dothan, 1955; Stern and Beit Arieh, 1979; Arnon and Amiran, 1981; Yannai, 2011). This tradition commenced in the Late Bronze Age (Gonen, 1992: 15–20, 70–97) and continued until the late Iron IIA in the Jezreel Valley, and beyond.

2. Materials and methods

2.1. Materials

Analyses were performed on vessels originating from nine pit burials. They include nine bowls, four chalices, five lamps, three juglets, three flasks, two jars (one of them containing human bones), and one unidentified base of a closed vessel (Table 1; Figs. 3, 4). For most types of

[3] Trial excavations on the upper terrace were conducted on behalf of the Israeli Antiquities Authority (directed by Abu-Zidan in 2008; by Covello Paran in 2012; and by Tsur in 2018–2019), and were followed by two seasons of salvage excavations (2018–2019) carried out by the Israeli Institute of Archaeology on behalf of the Sonia and Marco Nadler Institute of Archaeology, Tel Aviv University (directed by Omer Sergi in 2018 and by Omer Sergi and Rachel Lindemann in 2019).

[4] Some of these were described already by Abu Zidan (2013).

[5] Human remains were studied by Rachel Kalisher. The cemetery will be presented and discussed in detail in a MA study, conducted in Tel Aviv University by Jordan Weitzel under the supervision of Omer Sergi and Oded Lipschits.

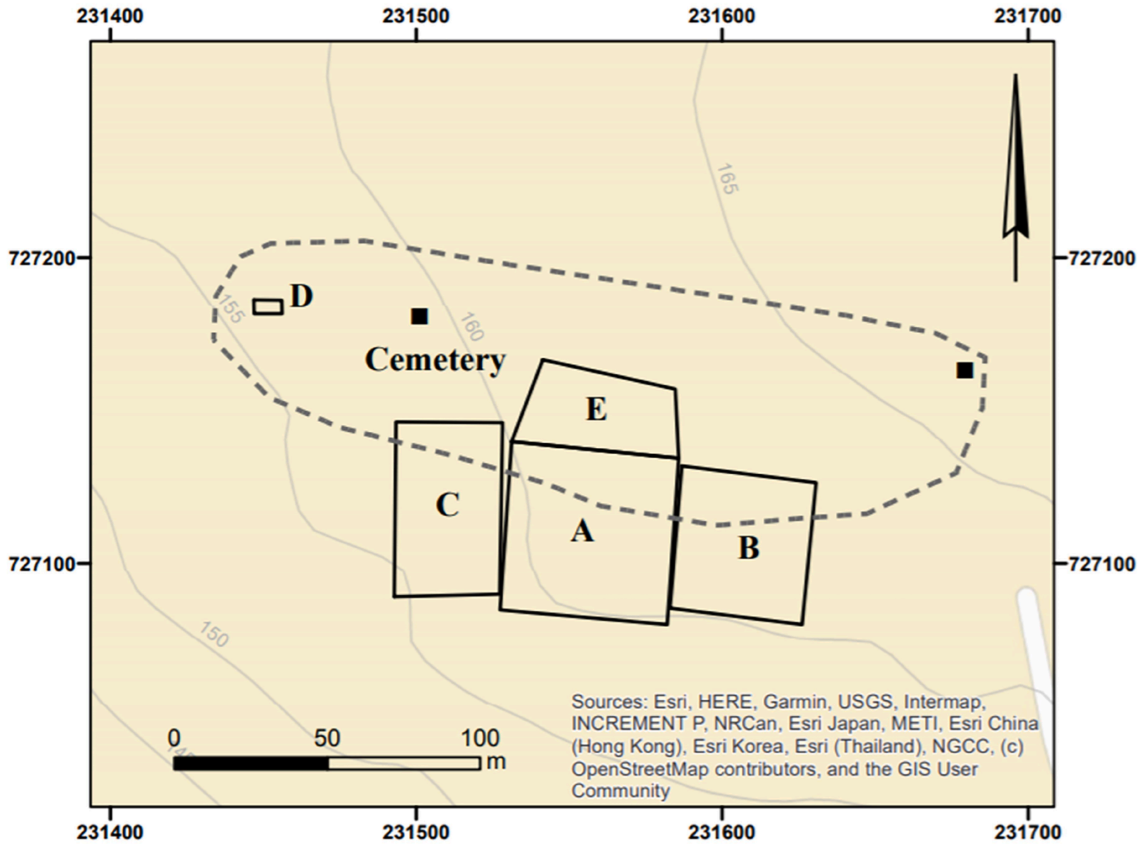


Fig. 2. topographical map of Ḥorvat Tevet marking the areas of excavations and the estimated extent of the Iron I–early Iron IIA cemetery, which was found in Areas D, E and in the northern section of Area A (map by A. Shapiro, courtesy of the IAA).

Fig. 3. The Iron I-early Iron IIA assemblage found in the burials. Note the two juglets in the front row to the right, which are the only imported vessels found in the cemetery. (Courtesy of the Institute of Archaeology, Tel Aviv University, Photograph by S. Flit).

vessels the samples were taken from the vessel's base. Each vessel was analyzed in triplicates. Control sediment was taken from inside the vessels or from their immediate vicinity (Namdar et al., 2009: 631). In order to avoid contamination, sampling of the vessels was performed by the first author in the field during the excavations.

2.2. Total lipid extraction

The extraction and analysis procedures of the lipids from the ceramic vessels followed Evershed et al. (1990) and Charters et al. (1993). All glassware was pre-heated in the oven to 100 °C. One g fragments were broken off the ceramic vessels using nitrile gloves and clean pliers, ground to a powder in an agate mortar and pestle and transferred into 8 mL vials. Five mL of dichloromethane and methanol (2:1, v:v) were added to each vial and the mixture was sonicated at 80 °C for 15 min. The vials were centrifuged for 10 min at 3500 rpm and the supernatant was transferred to another clean vial. The extraction steps were repeated three times. The solvents were then evaporated under a gentle stream of nitrogen gas and mild heating.

2.3. Derivatization by silylation

100 µl of N,O-bis(trimethyl)silyltrifluoroacetamide (BSTFA), containing 1% trimethylchlorosilane (TMC) was added to each vial and heated at 70 °C for 30 min. The samples were then evaporated to dryness under a gentle stream of nitrogen gas and re-dissolved with 50 µl of hexane and vortexed for 30 s to ensure a homogeneous solution. Eight µl of each sample were injected into the gas chromatograph (GC) coupled with a mass-selective detector (MSD). An analytical blank was also prepared by the same method with each batch of pottery samples.

2.4. Heat effect experiment on modern beeswax

Pieces of unused ceramic were cleaned from associated organic molecules by sonication at 80 °C in dichloromethane and methanol (2:1, v:v) for 5 h, and heating to 600 °C for 24 h. After cooling, the pieces were divided into pairs, with one piece used to examine the effect of heating on the beeswax composition while the other piece was used for control. On the pieces used for the experiment, 35 mg of modern dark *Apis mellifera* beeswax were placed, while the control piece was kept clean. Each pair of pieces was heated in the oven (Eurotherm 3116, PID temperature controller), under aerobic conditions, to different temperatures: 100, 200, 400, 600 °C for 3 h. Then the adsorbed compounds were extracted and analyzed by the same procedures described above for the Tevet vessels.

2.5. Gas chromatography/mass spectrometry (GC–MS)

GC/MS measurements were carried out using a HP6890 GC equipped with a mass-selective detector (HP5973; electron multiplier potential 2 kV, filament current 0.35 mA, electron energy 70 eV, and the spectra were recorded every 1 s over the range *m/z* 50–800). Splitless injection was performed. 30 m, 0.250 mm ID 5% cross-linked phenylmethyl siloxane capillary column (HP-5) with a 0.25 mm film thickness was used for the separation. Helium was used as a carrier gas at a constant flow of 1.0 mL/s. The injection temperature was 250 °C. The oven temperature was initially set at 70 °C (8 min. isothermic hold), ramped to 180 °C at 20 °C min − 1, and then to 280 °C at 5 °C min − 1 (8 min. isothermic hold). Peak assignments were based on comparisons with library spectra (NIST 17), spectra reported in the literature (Tulloch, 1970; 1971; 1972;; Tulloch and Hoffman, 1972; Mills and White, 1994; Charters et al., 1995; Evershed et al., 1997; Maia and Nunes, 2013), and by comparison of retention times of reference standards.

2.6. Quantification of hydrocarbons using gas chromatography-flame ionization detector (GC-FID)

Quantification of lipids was carried out using an Agilent HP6890 GC equipped with a flame ionization detector (FID). The samples were run as TMS derivatives, and were injected in splitless injection mode. Helium was used as a carrier gas at a constant flow of 1.0 mL min^{-1}. The same capillary column and method noted above were used. The FID detector temperature was 350 °C. The identification of individual compounds was based on the elution order and comparison to the GC–MS chromatograms and reference standards.

Quantification of the amounts of hydrocarbons per 1 g ceramic was conducted by adding a known amount of internal standard (IS), methyl-5-oxo-nonadecanoate, to each sample before the injection to the GC-FID and comparing the concentration of each alkane in the sample to the concentration of the IS by normalizing it to the number of carbons in the chains and the peak areas.

3. Results

The compounds identified in the vessels are presented in Table 1. These molecules were detected in the vessels, whereas the control samples had different chromatographic profiles (except for the common fatty acids: palmitic and stearic acids, and propylene glycol that appear in some of the sediment samples, see below). The control samples are characterized by more volatile compounds that immerge from the column at the retention time of up to 20 min (see Supplementary material). Burial A/F14 demonstrates poor preservation of organic molecules in the five vessels sampled. It was therefore excluded from further discussion. Nine types of molecules were found in a single vessel each and therefore cannot testify to its use as they may represent environmental contamination:

Propylene glycol, found predominantly in jar 3075/1, could be the reduction product of lactic acid, represented in this chromatogram by a small peak. Lactic acid is a product of meat fermentation process that could have occurred in this jar due to the fact that it contained human bones. Propylene glycol and lactic acid appear sporadically in other vessels and control samples. This could be due to the proximity of these vessels and sediments to the corpse laid in the grave, or rather a decomposition product of glycerides. Since the molecules do not appear consistently in the assemblage of vessels, their origin cannot be determined. Cholesterol, squalene and odd-numbered saturated fatty acids ($C_{15:0}$ and $C_{17:0}$), found in chalice 3087/1, may indicate that the contents of the vessel included ruminant milk or fat products (James and Martin:149-150, 1956; Hansen et al., 1957). Cholesterol was detected in chalice 3105/1 as well, and may testify to the animal product content of this vessel (Heron et al., 2013: 183-184). Campesterol and stigmasterol, which are plant analogs of cholesterol, found in bowl 3101/1, may indicate that this bowl contained vegetal products. The other compounds, 17α(H)21β(H)-hopane and trisaminol, found in vessels 3086/1, 3050/1 and 3101/1, may have originated from many sources such as bacterial activity (Zakaria et al., 2018: 347), or pre-burial contamination, and therefore cannot be traced back to their original contents. Future reoccurrence of these compounds in other vessels in other excavations may eventually suggest that they originate from primary content of the vessels, rather than from environmental contamination.

Biomarkers that appear consistently in most of the bowls, chalices and lamps are fatty acids (palmitic $C_{16:0}$, stearic $C_{18:0}$, and oleic $C_{18:1}$ acids, together with longer chain even-numbered fatty acids- $C_{20:0}$ to $C_{26:0}$), even-numbered n-alcohols comprising 18 to 28 carbon atoms, monoglycerides (MAGs) of palmitic and stearic acids, and a series of odd- and even-numbered n-alkanes (ONAs and ENAs respectively) comprising 22–32 carbon atoms (Fig. 5 and Supplementary material). The overall amount of these compounds varies in the range of 0.7–11 µg/g sherd. Bowl 3062/1 contains Methyl α-D-glucofuranoside as well. These results can be associated with beeswax, although there was no predominance of the ONAs over ENAs as one may expect in beeswax (Tulloch, 1970; 1971;; Tulloch and Hoffman, 1972; Mills and White, 1994; Charters et al., 1995; Evershed et al., 1997; Maia and Nunes, 2013). Wax esters were also not detected at high temperature (till 320 °C) GC–MS measurements.

Three other vessels thought to contain beeswax biomarkers are flask 4112/1 and juglets 3086/1 and 3050/1. They contained mostly the series of n-alkanes but no wax esters. Juglet 3086/1 contained monoglycerides of palmitic and stearic acid as well. Flask 4112/1 contained the same hydrocarbon profile as the vessels mentioned above, whereas juglets 3050/1 and 3086/1 contained a series of ONAs and ENAs comprising 17–30 carbon atoms. The appearance of fat and beeswax in these types of vessels may indicate that they were used to store this

Table 1
Compounds identified in the total lipid extracts of the vessels.

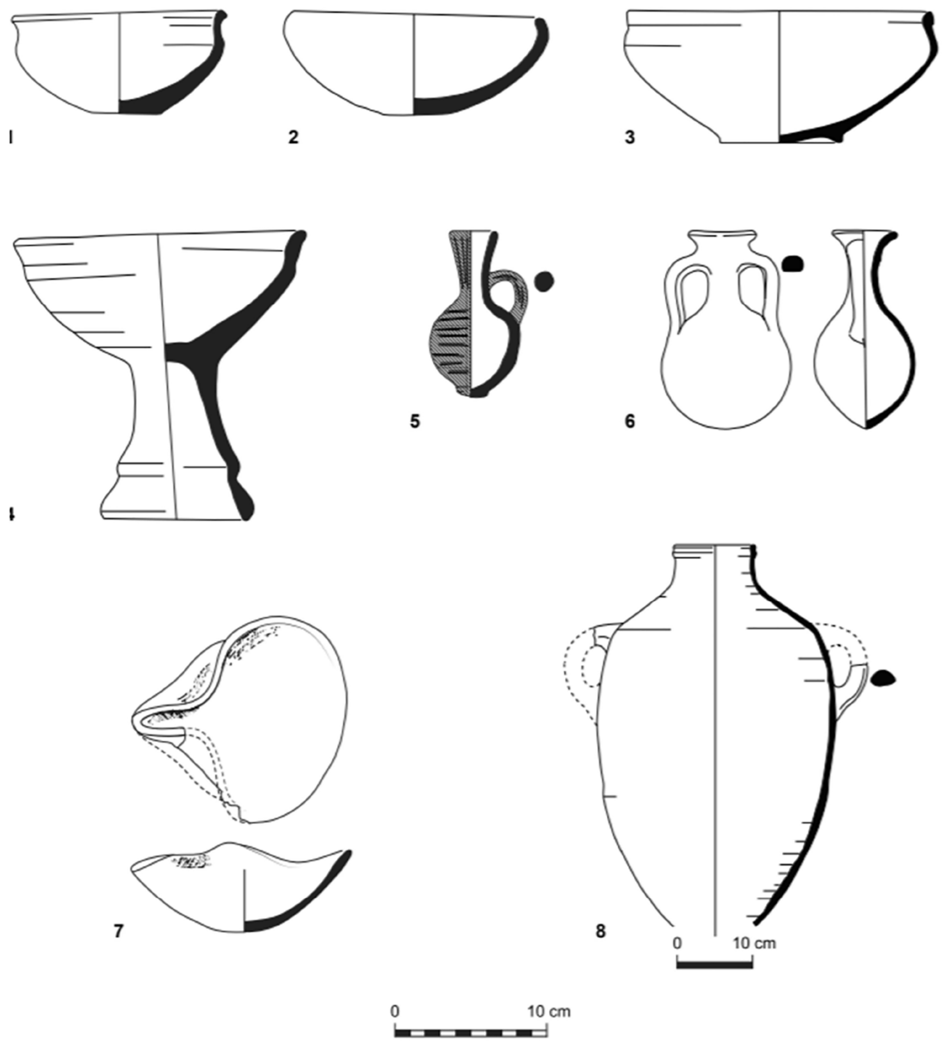
Vessel No.	Vessel Type	Burial No.	n-Alkanes	Fatty acids (TMS)	AGs	n-Alcohols (TMS)	Other
3062/1	Bowl	D/F2	C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$, dehydroabietic acid	$MAG_{16:0}$, $MAG_{18:0}$	C_{28ol} C_{26ol}, C_{24ol}, C_{22ol}, C_{20ol}, C_{18ol},	Methyl α-D-glucofuranoside
3063/1	Chalice		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$	$MAG_{16:0}$	C_{8ol}, C_{18ol}	Propylene glycol
3064/1	Lamp			$C_{18:1}$			
3066/1	Flask			$C_{16:0}$, $C_{18:0}$			
3075/1	Jar (bones)	D/F4		$C_{7:0}$, $C_{9:0}$, $C_{18:0}$			Lactic acid, propylene glycol, Glycerol
3080/1	Bowl		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{14:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$,	$MAG_{16:0}$, $MAG_{18:0}$		
3070/1	Bowl	D/F5	C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{16:0}$, $C_{18:0}$	$MAG_{18:0}$		
3067/1	Jar	D/F3			$MAG_{18:0}$		
3078/1	Juglet						
3086/1	Juglet		C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}	$C_{16:0}$, $C_{18:0}$	$MAG_{16:0}$, $MAG_{18:0}$, 2-Monostearoylglycerol	C_{8ol}, C_{14ol}, C_{16ol}, C_{18ol}	17α(H)21β(H)-Hopane
3087/1	Chalice			$C_{14:0}$, $C_{14:1}$, $C_{15:0}$, $C_{16:1}$, $C_{16:0}$, $C_{17:0}$			Cholesterol, squalene
3088/1	Lamp			$C_{6:0}$, $C_{9:0}$, $C_{12:0}$, $C_{14:0}$, $C_{16:0}$, $C_{18:0}$, $C_{20:0}$			Lactic acid, propylene glycol
3089/1	Unidentified base of a closed vessel						
3090/1	Bowl			$C_{16:0}$, $C_{18:0}$			
3050/1	Juglet	D/F1	C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}	$C_{16:0}$, $C_{18:0}$		C_{18ol}	17α(H)21β(H)-Hopane
3052/1	Lamp		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}	$C_{6:0}$, $C_{9:0}$, $C_{12:0}$, $C_{14:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$, $C_{22:0}$		C_{20ol}, C_{22ol}	
3100/1	Chalice	D/F7	C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{16:0}$, $C_{18:0}$	$MAG_{16:0}$, $MAG_{18:0}$,	C_{18ol}, C_{20ol}, C_{22ol},	Propylene glycol
3101/1	Bowl		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{14:0}$, $C_{16:0}$, $C_{18:1}$, $C_{18:0}$, $C_{20:0}$, $C_{22:0}$, $C_{23:0}$, $C_{24:0}$, $C_{26:0}$, dehydroabietic acid	$MAG_{16:0}$, $MAG_{18:0}$,	C_{22ol}, C_{24ol}, C_{25ol}, C_{26ol}, C_{28ol}	Trisaminol, campesterol, stigmasterol
3105/1	Chalice	D/F9	C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$	$MAG_{16:0}$, $MAG_{18:0}$,	C_{8ol}, C_{16ol}	Propylene glycol, cholesterol
3107/1	Bowl		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}		$MAG_{16:0}$,		
3111/1	Lamp		C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$, dehydroabietic acid	$MAG_{16:1}$, $MAG_{16:0}$, $MAG_{18:1}$, $MAG_{18:0}$	C_{24ol}	
4112/1	Flask	E/F11	C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}	$C_{16:0}$, $C_{18:1}$, $C_{18:0}$		C_{8ol}	
10511/1	Lamp	A/F14					
10512/1	Bowl						
10513/1	Bowl			$C_{6:0}$			Lactic acid
11152/1	Flask			$C_{16:0}$, $C_{18:0}$			
11153/1	Bowl						

C_x = n-alkane with x carbons in its chain; $C_{x:y}$ = fatty acid with x carbons in its chain and y is the number of double bonds; $MAG_{x:y}$ = monoglyceride with x carbons in its chain and y is the number of double bonds; C_{xol} = alcohol with x carbons in its chain.

mixture, or alternatively, this mixture was applied to the vessels as part of a post-firing treatment in order to seal them. In this case, either the beeswax was added as a sealant and the fat was added as part of the stored content during the use of the vessels, or vice versa; rather, the sealant was added as the mixture of both beeswax and fat (Charters et al., 1995: 123–124).

4. Discussion

Out of the 27 vessels tested, 16 provided positive results. This high preservation rate is significant and enables the identification of organic materials placed in burial offerings in nine of the excavated tombs. It seems that the most unique and common findings are the hydrocarbons that, together with the long chain even-numbered fatty acids and even-



No.	Type	Object no.	Burial	Comments	ORA
1	Bowl	3080/1	D/F4	Light reddish clay	Beeswax
2	Bowl	3070/1	D/F5	Orange clay	Beeswax
3	Bowl	3101/1	D/F7	Light reddish clay	Beeswax; vegetal products?
4	Chalice	3087/1	D/F3	Reddish-brown clay	Animal fat?
5	Juglet	3086/1	D/F3	Red-slip and hand-burnish	Beeswax
6	Flask	11152/1	A/F14	Pink clay	--
7	Lamp	3111/1	D/F9	Reddish clay	Beeswax
8	Storage Jar	3075/1	D/F4	Reddish clay	Lactic acid

Fig. 4. Vessels mentioned in the article (Courtesy of the Institute of Archaeology, Tel Aviv University, drawings by. Y. Gottlieb).

numbered n-alcohols, are characteristic of beeswax.

The unusual ratio of ENAs to ONAs raises the question of the origin of the ENAs in the samples. It was previously reported that the relative proportion of ENAs compared to ONAs adsorbed into the ceramic increases significantly when beeswax is heated on a ceramic surface (Namdar et al., 2009). As the current assemblage contains vessels that may have been related to the use of fire, we decided to examine the unusual proportions of ENAs and ONAs under heat conditions. We placed modern beeswax of *Apis mellifera* on clean ceramic fragments and heated them in an oven at 100, 200, 400 and 600 °C for 3 h. Subsequently we extracted and analyzed the compounds that were adsorbed into the ceramic, using the same procedures described above for the Ḥorvat Tevet vessels. The results show that the proportions of ENAs and ONAs did not change as a result of the heating. They were very similar to those observed in unheated beeswax, though their abundance was reduced due to their depletion, more significantly for the low carbon-

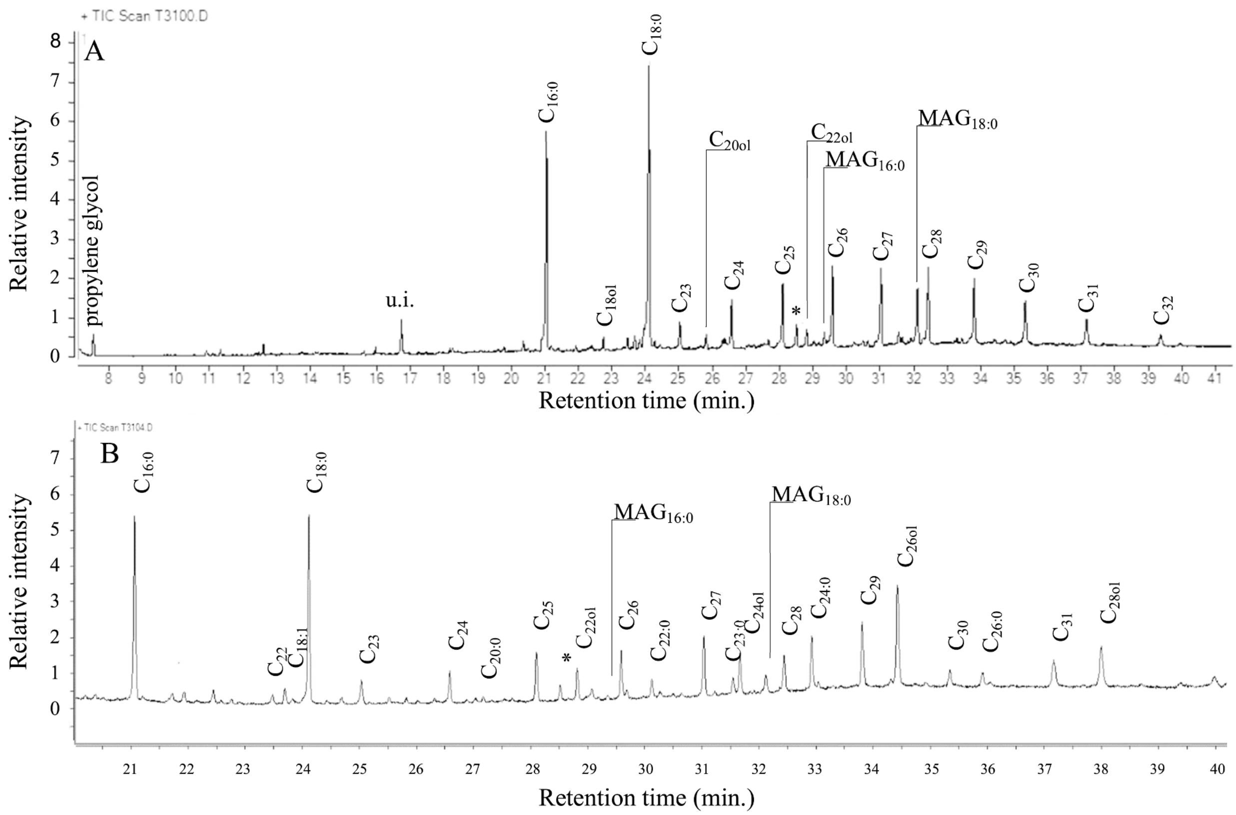


Fig. 5. Chromatograms of vessels from Ḥorvat Tevet: A) chromatogram of the trimethylsilylated total lipid extracts of chalice 3100/1. B) Partial chromatogram of the trimethylsilylated total lipid extracts of bowl 3101/1. C_x = n-alkane with x carbons in its chain; $C_{x:y}$ = fatty acid with x carbons in its chain and y is the number of double bonds; C_{xol} = alcohol with x carbons in its chain; * = plasticizer; u.i. = unidentified.

numbered alkanes, C21-C25. Depletion was proportional to the temperature in which the sherds were heated, with full depletion from the chromatogram as the temperature was raised (Fig. 6). These results are consistent with the chemical alteration of hydrocarbons in beeswax due to heat (Heron et al., 1994; Evershed et al., 1997, 2003; Regert et al., 2003). Our results require an alternative explanation for the ONA/ENA ratio to that offered by Namdar et al.

It is possible that the high frequencies of ENAs are the result of a contamination of the vessels by an ENA source during use or after burial. There are many sources for ENA contamination in beeswax, such as paraffins and triglycerides from palm, fat and hardened beef tallow (Bogdanov, 2016: 14). This explanation was strengthened by Waś et al. (Waś et al., 2015, 2016) who demonstrated that an almost identical content of ENAs and ONAs is a characteristic feature of paraffin (one of the most common modern adulterants of beeswax); the addition of paraffin to beeswax resulted in an increase in the total contents of n-alkanes and in particular, of the ENAs. On top of that, the sediment samples taken from the vicinity of the vessels did not contain beeswax biomarkers and the blank samples did not contain alkanes. Furthermore, the same hydrocarbon profile appears in all vessels containing beeswax, from different loci. We conclude that the beeswax had been adulterated while being used, rather than contaminated post-deposition or post-excavation. The appearance of monoacylglycerols of 16 and 18 carbon chains and the ratio of C_{18} to C_{16} acids in some of the vessels is consistent with the presence of an animal fat (Mills and White: 34–35, 1994; Charters et al.: 121, 1995), a further proof for the adulteration of beeswax with animal products. This finding is not surprising, as animal fat could have been added to the much more valuable beeswax (Mazar and Panitz-Cohen, 2007: 211). For example, cheap animal fats, such as tallow, were found to be added to beeswax in candle-making (Crane, 1983: 240–241).

It seems that the ONA/ENA ratio found at Ḥorvat Tevet demonstrates the addition of animal fat to the beeswax, rather than a heating process of the beeswax. A heating process is reflected in the presence of other molecules found in the chromatograms. First, vessels such as the bowls (3062/1, 3070/1, 3080/1, 3101/1, 3107/1) chalice (3105/1), juglets (3050/1, 3086/1), flask (4112/1) and lamps (3052/1, 3111/1), that contain beeswax biomarkers, presented peaks of palmitic and stearic acids with the ratio C18 < C16. The relative high abundance of palmitic acid in those vessels may be the result from hydrolysis of the wax esters (Charters et al.: 120, 1995; Evershed et al.: 984, 1997). Wax esters have low thermostability and therefore, undergo combustion in quite low temperature, and are not preserved in heating processes. Their decomposition products are fatty acids (especially palmitic acid) and even-numbered alcohols of increasing chain length (C24ol to C34ol) (Regert et al.: 551, 2003; Heron et al.: 267–268, 1994).

To summarize this part of the article, the absence of wax esters and appearance of palmitic acid and n-alcohols in the vessels, the ratios of ENAs to ONAs, and the fact that the beeswax biomarkers were identified in vessels that were mostly open and could be used for lighting fire, all testify to the use of the beeswax mixed with animal fat as a fuel material.

4.1. *The use of fire and beeswax in mortuary ceremonies*

Textual sources and pictorial depictions indicate the use of fire during the burial ceremonies in the Ancient Near East. Egyptian sources (murals and papyri) describe the burning of incense and libation during the procession to the tomb in all pharaonic periods (Hays, 2010). Two well-known examples are the murals in the tomb of Amenemhet son of Thutmose III (18th dynasty, 15th century BCE) and “The Greenfield Papyrus” – the funerary papyrus of princess Nesitanebtashru (21st Dynasty, 10th century BCE). Both describe scenes of the burial process in which the priest is “making (a burning of) incense and pouring libations” (Wallis Budge, 1912: 3, Pl. 2; Davies and Gardiner, 1915: 49, 52. Pls. XI,

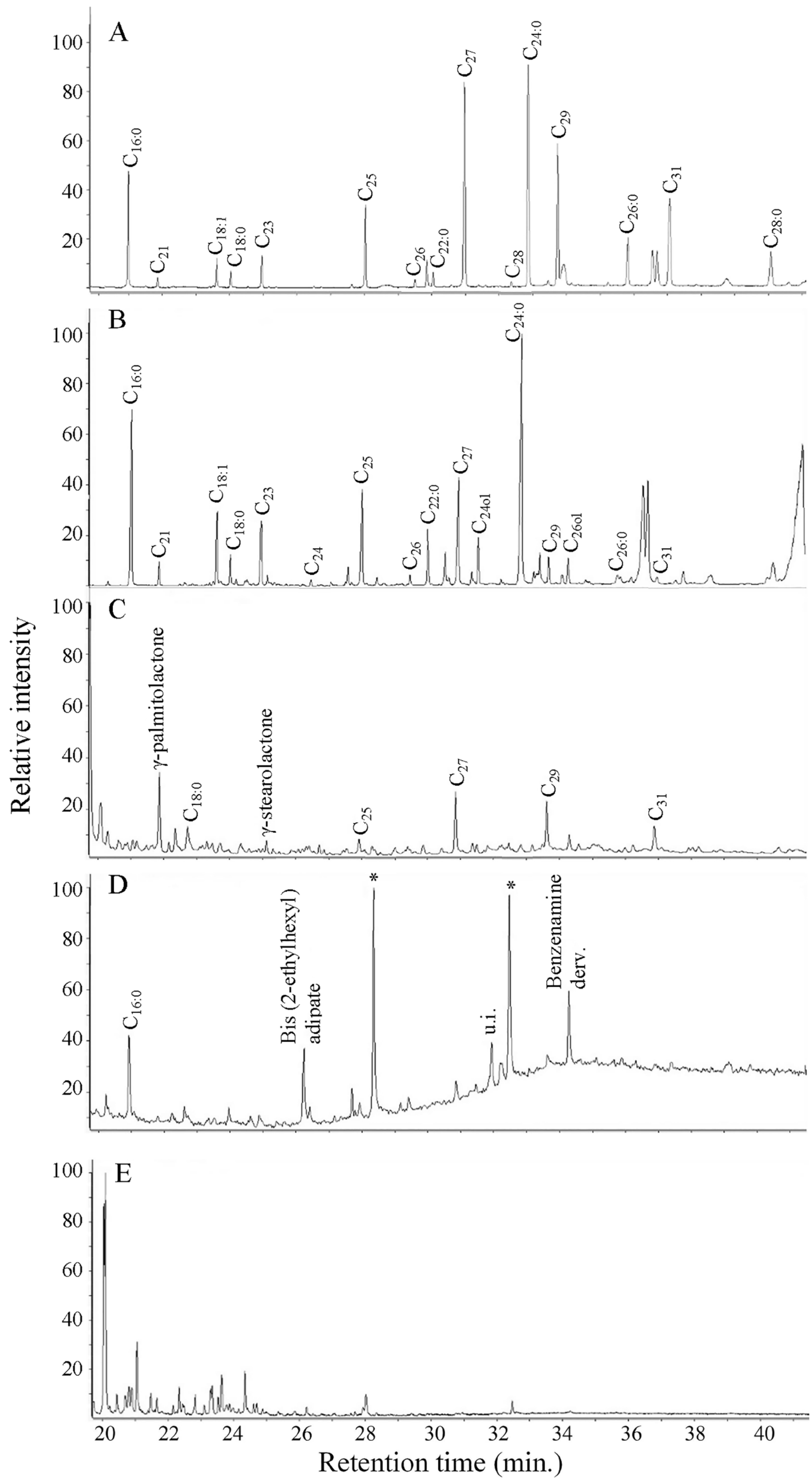


Fig. 6. Partial chromatograms of the trimethylsilylated total lipid extracts of modern beeswax samples: A) Unheated. B) Heated at 100 °C. C) Heated at 200 °C. D) Heated at 400 °C. E) Heated at 600 °C. C_x = n-alkane with x carbons in its chain; $C_{x:y}$ = fatty acid with x carbons in its chain and y is the number of double bonds; C_{xol} = alcohol with x carbons in its chain; * = plasticizer; u.i.= unidentified. Chromatogram E isn't labeled because all the peaks in it appear in the control sample as well

XII). The murals in the tomb of Amenemhet include a burning lamp standing on the skiff sailing towards the necropolis as well. These two examples, dating to different periods, demonstrate that the use of fire as part of the burial ceremony was a well-established practice.

Archaeologically the use of fire to burn mortuary offerings was recently attested at Tomb 10/K/100 at Megiddo, in use from the Middle Bronze III to the Late Bronze IB, in which one lamp was used to burn opium (Cradic, 2017: 238). Soot marks are fairly common in vessels in burial contexts, particularly lamps, at sites across the southern Levant from a long span of time, as was noted for example on oil lamps found at the ʻAra cemetery (Ilan et al., 2014: 271).[6] Soot and a "thin grey deposit" were found in the arcosolia of Tomb 1 at Tel ʻEton, dating to the 9th–8th century BCE along with blackened vessels indicative of a fire, although the skeletons showed no signs of burning (Ussishkin, 1974: 125). As for the use of beeswax, it was a known component of funerary practices in Egypt for other purposes; it was used in the mummification process as early as the Fourth Dynasty (Raven, 1983; Serpico and White, 2000; Buckley and Evershed, 2001; Abdel-Maksoud and El-Amin, 2011). At Tel Shaddud (9 km north-west of Ḥorvat Tevet), heated beeswax was used as a sealing agent in the manufacture of a Late Bronze III Egyptian-style anthropoid coffin (Namdar et al., 2017). Still, to the best of our knowledge, the Iron I—Early Iron IIA cemetery in Ḥorvat Tevet provides the first evidence for the use of beeswax as a fuel material as part of the burial ceremony. If the people using these vessels were only looking for lighting material one would expect them to use olive oil or other cheap combustion materials. Given these varying applications of beeswax and fire, it seems that the ritual burning of beeswax could have had multiple symbolic meanings.

4.2. Beeswax economy

The findings of Ḥorvat Tevet join a series of evidence for the use of bee-products in the region during the Bronze Age and the beginning of the Iron Age, for example as a sealing agent at the cemetery of nearby Tel Shaddud (Namdar et al., 2017; van den Brink et al., 2017). No less significant is the finding of the beehives at Tel Reḥov (Stratum V) (Mazar et al., 2008) which are dated to the very beginning of the late Iron IIA, meaning just slightly later than the Ḥorvat Tevet cemetery. So far, this is the only archaeological indication for beehives or apiaries of commercial scope in the southern Levant. There are many textual and pictorial sources for hive beekeeping (apiculture) and bee-product use in the Ancient Near East as early as old kingdom Egypt and in Hittite, Ugarit and Neo-Assyrian sources (Mazar and Panitz-Cohen: 214–216, 2007; Head, 2008). Mazar and Panitz-Cohen (2007) estimated that the annual yield of the Tel Reḥov apiary ranged between 300 and 500 kg of honey and 50–70 kg of beeswax, which indicates an industrial operation. The plan of the apiary, which was located in a densely populated urban context, as well as cultic practices related to it, point to a central authority that was able to conduct such a specialized industry, forcing the population to endure the huge amount of bees (Mazar, 2015; Mazar: 101–103, 2016). The bees in the Tel Reḥov apiary were an Anatolian species, which is more productive and less aggressive than local Levantine species (Bloch et al., 2010), further indicating the well-planned bee-keeping apparatus at Tel Reḥov. Although honey must have been the commodity produced in the largest quantity in this apiary, beeswax was perhaps even more precious. According to Mazar, beeswax was utilized in the production of bronze objects in the "lost wax" technique and could thus be related to the prosperous contemporary Arabah copper production and trade (Levy et al., 2014; Ben-Yosef, 2016; Mazar: 103, 2016).

The use of beeswax at Ḥorvat Tevet during the Iron I–early Iron IIA is slightly earlier than the apiculture industry at Tel Reḥov Stratum V (early years of the late Iron IIA or "middle Iron IIA according to Finkelstein and Kleiman, 2019). The hydrocarbon profile found in the bowls, chalices, lamps and flask from Ḥorvat Tevet however is very similar to the profile of the Tel Reḥov beehives. The short distance between the two sites and the direct link in their material culture (Mazar, 2020; Sergi et al., forthcoming) may suggest that the beeswax of Ḥorvat Tevet originated at Tel Rehov, meaning that the apiary industry was introduced there earlier than the days of Stratum V.

Juglets 3086/1 and 3050/1 are unique since alkanes with relatively short carbon chains with 17–21 carbon atoms were observed, that do not appear in the other vessels. These short hydrocarbons have been detected by others in *Apis mellifera* beeswax (Jiménez et al., 2004; Maia and Nunes, 2013; Waś et al., 2014). They are more volatile than the long chain alkanes, and therefore may have been hydrolyzed in high temperature of combustion. The closed form of the juglets (as opposed to open forms such as the open bowls, lamps and chalices) and/or their different use may have prevented the "disappearance" of the short chain alkanes. The unique hydrocarbon profile of juglets 3086/1 and 3050/1 may also indicate a different subspecies of bees. Note that these two juglets seem to be non-local and that one of them comes from a burial that was different from the others in several aspects, including a significantly higher number of burial offerings, suggesting an elevated status of the deceased.

5. Conclusions

The residue analysis study of ceramic burial goods from Ḥorvat Tevet has added considerable new information regarding the beginning of the Iron IIA burial practices in the Jezreel Valley and beyond. The open vessels, containing a heated solution made of beeswax and animal fat, could have served already in the funerary procession. The vessels were then placed next to the body as part of the burial kit.[7] The choice to use beeswax as a fuel for the burning can be related to a range of symbolic and functional reasons: first, heated beeswax had aromatic properties; second, beeswax may have been used for coating the body, a practice noted at Tel Shaddud and mainly known from embalming in Egypt (Namdar et al., 2017); and third, beyond the fact that bees and their products held a special symbolic value in ancient near eastern cultures, and must have considered prestigious, in the case of Ḥorvat Tevet they may also attest to the importance of apiculture in the economy.

Horvat Tevet, together with some other small sites in its vicinity, comprised the rural hinterland in the eastern Jezreel Valley. Textual and archaeological evidence from the Late Bronze Age to the Iron IIA indicate that this region was closely related to the Beth-shean Valley, where Tel Reḥov was the most dominant urban center (Na'aman, 1981; 1988;; van den Brink et al., 2017; Mazar, 2020). Thus, in spite of the fact that the provenance of the Ḥorvat Tevet beeswax remains uncertain, the use of this material among peasant communities cannot be disconnected from the apiary industry at Tel Reḥov. In other words, the Tel Reḥov industry may have been established earlier than the late Iron IIA, and was perhaps connected to the prospering copper industry in the Arabah and trade of copper to the north. The finds from Ḥorvat Tevet add to recent studies which exhibit the importance of beeswax for the symbolic realm and the economy of rural and urban communities in the Late Bronze and early phases of the Iron Age in the Jezreel-Beth-shean valleys.

CRediT authorship contribution statement

Ayala Amir: Investigation, Writing - original draft, Methodology. **Yuval Gadot:** Conceptualization, Supervision, Writing - review & editing. **Jordan Weitzel:** Resources, Writing - review & editing,

[6] However, only one vessel from Ḥorvat Tevet contained soot marks: a chalice that was not included in this study.

[7] For the expansion of our ability to identify the complete burial kit see Kisilevitz et al., 2017.

Investigation. **Israel Finkelstein:** Supervision, Writing - review & editing. **Ronny Neumann:** Supervision. **Hannes Bezzel:** Funding acquisition, Writing - review & editing. **Karen Covello-Paran:** Funding acquisition, Resources, Writing - review & editing. **Omer Sergi:** Conceptualization, Project administration, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Abdel-Maksoud, G., El-Amin, A., 2011. A review of the materials used in the mummification processes in ancient Egypt. Mediterranean Archaeol. Archaeometry 11 (2), 129–150.

Abu Zidan, F., 2013. Horbat Tavat. Hadashot Arkheologiyot: Excavations and Surveys in Israel 125. http://www.hadashot-esi.org.il/report_detail_eng.aspx?id=5435&mag_id=120.

Arie, E., 2011. "In the Land of the Valley": Settlement, Social and Cultural Processes in the Jezreel Valley from the End of the Late Bronze Age to the Formation of the Monarchy (Unpublished Ph. D. dissertation, Tel Aviv University). (Hebrew with English abstract).

Arie, E., 2013a. The Iron IIA Pottery. pp. 668–228. In: Finkelstein, I., Ussishkin, D. and Cline, E.H., eds. Megiddo V: The 2004–2008 Seasons, Vol. II (Monograph Series of the Institute of Archaeology of Tel Aviv University 31). Tel Aviv.

Arie, E., 2013b. The Late Bronze III and Iron I Pottery: Levels K-6, M-6, M-5, M-4 and H-9. pp. 475–667. In: Finkelstein, I., Ussishkin, D. and Cline, E.H., eds. Megiddo V: The 2004–2008 Seasons, Vol. II (Monograph Series of the Institute of Archaeology of Tel Aviv University 31). Tel Aviv.

Arnon, C., Amiran, R., 1981. Excavations at Tel Qishon – Preliminary Report on the 1977–1978 Seasons. Eretz Israel 15, 205–212.

Ben-Yosef, E., 2016. Back to Solomon's Era: Results of the First Excavations at Slaves' Hill (Site 34, Timna, Israel). Bull. Am. Schools Oriental Res. 376, 169–198. https://doi.org/10.5615/bullamerschoorie.376.0169.

Ben-Yosef, E. and Sergi, O., 2018. The Destruction of Gath by Hazael and the Arabah Copper Industry: A Reassessment. pp. 461–480. In: Hitchcock, L., Shai, I. Uziel, J., and Dagan, A. eds. Tel it in Gath: Studies in the History and Archaeology of Israel, Essays in Honor of Aren M. Maeir on the Occasion of his Sixtieth Birthday (Ägyptum und Altes Testament 90). Münster.

Bloch, G., Francoyb, T.M., Wachtel, I., Panitz-Cohen, N., Fuchs, A., Mazar, A., 2010. Industrial Apiculture in the Jordan Valley during Biblical Times with Anatolian Honeybees. PNAS 1–5. https://doi.org/10.1073/pnas.1003265107.

Buckley, S.A., Evershed, R.P., 2001. Organic chemistry of embalming agents in pharaonic and graeco-roman mummies. Nature 413, 837–841. https://doi.org/10.1038/35101588.

Bogdanov, S., 2016. Beeswax: Production, Properties, Composition, Control. Bee Product Science.

Charters, S., Evershed, R.P., Goad, L.J., Leyden, A., Blinkhorn, P.W., Denham, V., 1993. Quantification and distribution of lipid in archaeological ceramics: implications for sampling potsherds for organic residue analysis and the classification of vessel use. Archaeometry 35 (2), 211–223. https://doi.org/10.1111/j.1475-4754.1993.tb01036.x.

Charters, S., Evershed, R.P., Blinkhorn, P.W., Denham, V., 1995. Evidence for the mixing of fat and wax in archaeological ceramics. Archaeometry 37 (1), 13–28. https://doi.org/10.1111/j.1475-4754.1995.tb00730.x.

Conder, C.R., Kitchener H.H., 1882. The Survey of Western Palestine: Memoirs of the Topography, Orography, Hydrography, and Archaeology, Vol. II: Samaria. Palestine Exploration Fund. London.

Cradic, M.S., 2017. Embodiments of death: the funerary sequence and commemoration in the bronze age Levant. Bull. Am. Schools Oriental Res. 377, 219–248. https://doi.org/10.5615/bullamerschoorie.377.0219.

Crane, E., 1983. The Archaeology of Beekeeping. Duckworth, London.

Dagan, Y., Hanna, B., 2011. 'Afula, Survey of the Bypass Road. Hadashot Arkheologiyot – Excavations and Surveys in Israel 123. http://www.hadashotesi.org.il/report_detail_eng.aspx?id=1874&mag_id=118.

Davies, N.D.G., Gardiner, A.H., 1915. The tomb of Amenemhēt (No. 82). London.

Dothan, M., 1955. The Excavations at 'Afula. 'Atiqot 1, 18–63. (Hebrew).

Evershed, R.P., Heron, C., Goad, J.L., 1990. Analysis of organic residues of archaeological origin by high temperature gas chromatography and gas chromatography – mass spectrometry. Analyst 115, 1339–1342. https://doi.org/10.1039/AN9901501339.

Evershed, R.P., Vaughan, S.J., Dudd, S.N., Soles, J.S., 1997. Fuel for thought? Beeswax in lamps and conical cups from late Minoan Crete. Antiquity 71, 979–985. https://doi.org/10.1017/S0003598X00085860.

Evershed, R.P., James, M.A., Mukherjee, A.J., Musselle, C.J., Robertson, F., Pfälzner, P., 2011. Organic Residue Analysis of Ceramic and Stone Vessels, Resinous Artefacts and Anthropogenic Sediments from the Royal Tomb. pp. 411-447. In: Pfälzner, P. ed., Interdisziplinäre Studien zur Königsgruft von Qaṭna. Qatna Studien. Wiesbaden: Harrassowitz Verlag.

Evershed, R.P., Dudd, S.N., Anderson-Stojanovic, V.R., Gebhard, E.R., 2003. New Chemical Evidence for the Use of Combed Ware Pottery Vessels as Beehives in Ancient Greece. J. Archaeol. Sci. 30 (1), 1–12. https://doi.org/10.1006/jasc.2001.0827.

Finkelstein, I., 2013. The Forgotten Kingdom: The Archaeology and History of Northern Israel. Atlanta.

Finkelstein, I., Kleiman, A., 2019. The Archaeology of the Days of Baasha? Revue Biblique 126, 277–296. https://doi.org/10.2143/RBI.126.2.3286413.

Finkelstein, I., Halpern, B., Lehman, G., Niemann, H.M., 2006. The Megiddo Hinterland Project. pp. 705–76. In: Finkelstein, I., Ussishkin, D. and Halpern, B., eds. Megiddo IV: The 1998–2002 Seasons. Monograph Series 24. Tel Aviv.

Gadot, Y., 2019. The Iron I Settlement Wave in the Samaria Highlands and its Connection with the Urban Centers. Near Eastern Archaeol. 82, 32–41. https://doi.org/10.1086/703324.

Gal, Z., 1998. Archaeological Survey of Israel Map of Har Tavor (41) Map of 'En Dor (45). Jerusalem.

Gilboa, A., Namdar, D., 2015. On the beginnings of south Asian spice trade with the Mediterranean region: a review. Radiocarbon 57 (2), 265–283. https://doi.org/10.2458/azu_rc.57.18562.

Gilboa, A., Waiman–Barak, P., Sharon, I., 2015. Dor, the Carmel Coast and Early Iron Age Mediterranean Exchanges. pp. 85–109. In: Babbi, A., Bubenheimer-Erhart, F., Marin-Aguilera, B. and Muhl, S., eds. The Mediterranean Mirror: Cultural Contacts in the Mediterranean Sea between 1200 and 750 B.C. Mainz.

Gonen, R., 1992. Burial Patterns and Cultural Diversity in Late Bronze Age Canaan (American Schools of Oriental Research Dissertation Series 7). Eisenbrauns, Winona Lake.

Hansen, R.P., Shorland, F.B., June Cooke, N., 1957. Occurrence in butterfat of n-heptadecanoic acid (margaric acid). Nature 179, 98. https://doi.org/10.1038/179098a0.

Hays, H.M., 2010. Funerary Rituals (Pharaonic Period). pp. 1–14. In: Wendrich, W. and Dieleman, J., eds. UCLA Encyclopedia of Egyptology. Los Angeles. Retrieved from https://escholarship.org/uc/item/1r32g9zn.

Head, R.J., 2008. A brief survey of ancient near eastern beekeeping. The FARMS Review 20 (1), 57–66. https://scholarsarchive.byu.edu/msr/vol20/iss1/6.

Heron, C., Nemcek, N., Bonfield, K.M., Dixon, D., Ottaway, B.S., 1994. The chemistry of Neolithic beeswax. Naturwissenschaften 81, 266–269. https://doi.org/10.1007/BF01131579.

Heron, C., Andersen, S., Anders Fischer, A., Aikaterini Glykou, A., Sönke Hartz, S., Saul, H., 2013. Illuminating the Late Mesolithic: residue analysis of 'blubber' lamps from Northern Europe. Antiquity 87, 178–188. https://doi.org/10.1017/S0003598X00048705.

Ilan, D., Gadot, Y., Uziel, K., 2014. Conclusions. pp. 267–272. In: Gadot, Y., ed. The Bronze Age Cemetery at 'Ara (Salvage Excavations Reports No. 8). Tel-Aviv.

James, A.T., Martin, A.J., 1956. Gas–liquid chromatography: the separation and identification of the methyl esters of saturated and unsaturated acids from formic acid to n-octadecanoic acid. Biochem. J. 63, 144–152. https://doi.org/10.1042/bj0630144.

Jiménez, J.J., Bernal, J.L., Aumente, S., del Nozal, M.J., Martín, M.T., Bernal, J., 2004. Quality assurance of commercial beeswax: Part I. Gas chromatography–electron impact ionization mass spectrometry of hydrocarbons and monoesters. J. Chromatogr. A 1024 (1–2), 147–154. https://doi.org/10.1016/j.chroma.2003.10.063.

Kisilevitz, S., Turgeman-Yaffe, Z., Ben-Ari, N., Ilan, D., Marom, N., Weissbrod, L., Nagar, Y., Langgut, D., 2017. New Insights into Middle Bronze Age Burial Customs in Light of Recent Excavations at the Manaḥat Spur (Jerusalem). New Studies in the Archaeology of Jerusalem and its Region 11, 38–63.

Levy, T.E., Najjar, M., Ben-Yosef, E., 2014. Conclusions. pp. 977-1001. In: Levy, T. E., Najjar, M. and Ben-Yosef, E., eds. New Insights into the Iron Age Archaeology of Edom, Southern Jordan. Los Angeles.

Maia, M., Nunes, F.M., 2013. Authentication of beeswax (Apis mellifera) by high-temperature gas chromatography and chemometric analysis. Food Chem. 136 (2), 961–968. https://doi.org/10.1016/j.foodchem.2012.09.003.

Mazar, A., 2015. Religious practices and cult objects during the iron age IIA at Tel Reḥov and their implications regarding religion in Northern Israel. Hebrew Bible and Ancient Israel 4, 25–55. https://doi.org/10.1628/219222715X14343676549142.

Mazar, A., 2016. Culture, Identity and Politics Relating to Tel Reḥov in the 10th–9th Centuries B.C.E. pp. 89–119. In: Sergi, O., Oeming, M. and de-Hulster, I., eds. In Search of Aram and Israel: Politics, Culture and Identity. Oriental Religions in Antiquity 20. Tübingen. doi: 10.1628/978-3-16-155059-1.

Mazar, A., 2020. The Tel Reḥov Excavations: Overview and Synthesis. pp. 69–140. In: Mazar, A. and Panitz-Cohen, N., eds. Tel Reḥov: The Bronze and Iron Age City in the Beth-Shean Valley, Vol I, Introduction, Synthesis and Excavations on the Upper Mound. Qedem 59. Jerusalem.

Mazar, A., Panitz-Cohen, N., 2007. It is the land of honey: Beekeeping at Tel Rehov. Near Eastern Archaeol. 70, 202–219. https://doi.org/10.1086/nea20361335.

Mazar, A., Namdar, D., Panitz-Cohen, N., Neumann, R., Weiner, S., 2008. Iron age beehives at Tel Rehov in the Jordan valley. Antiquity 82 (317), 629–639. https://doi.org/10.1017/S0003598X00097271.

Mills, J.S., White, R., 1994. Organic Chemistry of Museum Objects. Butterworths, London.

Na'aman, N., 1981. Economic aspects of the Egyptian occupation of Canaan. Israel Exploration Journal 31, 172–185.

Na'aman, N. 1988. Pharaonic Lands in the Jezreel Valley in the Late Bronze Age. pp. 117–85. In: Heltzer, M. and Lipiński, E., eds. Society and Economy in the Eastern Mediterranean (C. 1500–1000 B.C.E.). Orientalia Lovaniensia Periodica 23. Leuven: Peeters.

Namdar, D., Neumann, R., Goren, Y., Weiner, S., 2009. The contents of unusual cone-shaped vessels (cornets) from the Chalcolithic of the southern Levant. J. Archaeol. Sci. 36 (3), 629–636. https://doi.org/10.1016/j.jas.2008.10.004.

Namdar, D., Shoval, S., Amroni, A., van den Brink, E.C.M., Kirzner, D., Beeri, R., 2017. Absorbed organic residues in a late bronze age II clay coffin from Tel Shadud, Israel. J. Archaeolog. Sci.: Rep. 12, 726–733. https://doi.org/10.1016/j.jasrep.2017.01.045.

Parker Pearson, M., 1999. The Archaeology of Death and Burial. Texas A&M University Anthropology Series: Texas A&M University Press. United States.

Raven, M.J. 1983. Wax in Egyptian Magic and Symbolism. Oudheidkundige Mededeelingen uit het Rijksmuseum van Oudheden te Leiden 64, 7 – 47.

Regert, M., Colinart, S., Degrand, L. and Decavallas, O., 2003. Chemical Alteration and Use of Beeswax through Time: Accelerated Ageing Tests and Analysis of Archaeological Samples from Various Environmental Contexts. Archaeometry 43, 549–569. doi: 10.1111/1475-4754.00036.

Sergi, O., 2019. (Re)Constructing Identities in the Bronze and Iron Age Levant. Die Welts des Orients 49, 146–150. https://doi.org/10.13109/wdor.2019.49.2.146.

Sergi, O., Covello-Paran, K., Bezzel, H., forthcoming. Ḥorvat Tevet in the Jezreel Valley: A Royal Israelite Estate and its Implications on Palace-Clan Relations in Early Monarchic Israel. BASOR.

Serpico, M., White, R., 2000. Oil, Fat and Wax. pp. 390–429. In: Nicholson, P.T. and Shaw, I., eds. Ancient Egyptian Materials and Technology. Cambridge University Press.

Shamir, O., 2013. Textile Remains on a Bronze Ingot. Excavations and Surveys in Israel 125. http://www.hadashot-esi.org.il/report_detail_eng.aspx?id=5435&mag_id=120.Sukenik, 1948.

Sukenik, E.L., 1948. Archaeological Investigations at 'Affula. J. Palestine Oriental Soc. 21, 1–79.

Stern, E., Beit Arieh, I., 1979. Excavations at Tel Kedesh (Tell Abu Qudeis). Tel Aviv 6 (1–2), 1–25. https://doi.org/10.1179/033443579788497531.

Tulloch, A.P., 1970. The composition of beeswax and other waxes secreted by insects. Lipids 5, 247–258. https://doi.org/10.1007/BF02532476.

Tulloch, A.P., 1971. Beeswax: structure of the esters and their component hydroxy acids and diols. Chem. Phys. Lipids 6, 235–265. https://doi.org/10.1016/0009-3084(71)90063-6.

Tulloch, A.P., 1972. Analysis of whole beeswax by gas liquid chromatography. J. Am. Oil Chem. Soc. 49 (10), 609–610. https://doi.org/10.1007/BF02609237.

Tulloch, A.P., Hoffman, L.L., 1972. Canadian beeswax: Analytical values and composition of hydrocarbons, free acids and long chain esters. J. Am. Oil Chem. Soc. 49 (12), 696–699. https://doi.org/10.1007/BF02609202.

Ussishkin, D., 1974. Tombs from the Israelite Period at Tel 'Eton. Tel Aviv 1 (3), 109–127. https://doi.org/10.1179/033443574788593520.

van den Brink, E.C.M., Beeri, R., Kirzner, D., Bron, E., Cohen-Weinberger, A., Kamaisky, E., Gonen, T., Gershuny, L., Nagar, Y., Ben-Tor, D., Sukenik, N., Shamir, O., Maher, E.F., Reich, D., 2017. A late bronze age II clay coffin from Tel Shaddud in the Jezreel Valley, Israel: context and historical implications. Levant 49 (2), 105–135. https://doi.org/10.1080/00758914.2017.1368204.

Wallis Budge, E.A., ed. 1912. The Greenfield Papyrus in the British Museum: The Funerary Papyrus of Princess Nesitanebtashru, Daughter of Painetchem II and Nesi-Khensu, and Priestess of Amen-Ra at Thebes, about B.C. 970. London.

Waś, E., Szczesna, T., Rybak-Chmielewska, H., 2014. Hydrocarbon composition of beeswax (Apis Mellifera) collected from light and dark coloured combs. J. Apicultural Sci. 58 (2), 99–106. https://doi.org/10.2478/jas-2014-0026.

Waś, E., Szczęsna, T., Rybak-Chmielewska, H., 2015. Application of gas chromatography with the mass detector (GC-MS) technique for detection of beeswax adulteration with paraffin. J. Apicultural Sci. 59 (1), 143–152. https://doi.org/10.1515/jas-2015-0015.

Waś, E., Szczęsna, T., Rybak-Chmielewska, H., 2016. Efficiency of GC-MS method in detection of beeswax adulterated with paraffin. J. Apicultural Sci. 60 (1), 145–162. https://doi.org/10.1515/jas-2016-0012.

Yahalom-Mack, N., Galili, E., Segal, I., Eliyahu-Behar, A., Boaretto, E., Shilstein, S., Finkelstein, I., 2014. New insights into Levantine copper trade: analysis of ingots from the Bronze and Iron Ages in Israel. J. Archaeol. Sci. 45, 159–177. https://doi.org/10.1016/j.jas.2014.02.004.

Yannai, E., 2011. An Early Iron Age Cist Grave at Kibbutz Ha-Zore'a. 'Atiqot 65, 47–51, 66*. (Hebrew with English abstract).

Zakaria, M.P., Bong, C.W., Vaezzadeh, V., 2018. Fingerprinting of Petroleum Hydrocarbons in Malaysia Using Environmental Forensic Techniques: A 20-Year Field Data Review. pp 345–372. In: Stout, S. A. and Wang, Z., eds. Oil Spill Environmental Forensics Case Studies. Butterworth-Heinemann. doi: 10.1016/B978-0-12-804434-6.00016-1.

Zori, N., 1977. The Land of Issachar: Archaeological Survey. Israel Exploration Society, Jerusalem. (Hebrew).