Iron Age beehives at Tel Reḥov in the Jordan valley

Amihai Mazar[1], Dvory Namdar[2,3], Nava Panitz-Cohen[1], Ronny Neumann[4] & Steve Weiner[5]

Research

Beehives were discovered in a densley built area in the Iron Age city of Reḥov (tenth-ninth century BC). They consisted of hollow clay cylinders, each with a little hole at one end (for the bee) and a removable lid at the other (for the bee keeper). These beehives, the earliest found in the Near East, were identified by analogy with examples pictured on Egyptian tombs and in use by traditional peoples. The suggested identification was confirmed by chemical analysis.

Keywords: Israel, Jordan, Southern Levant, Iron Age, beehives, apiary, honey

This paper is dedicated to the memory of Eva Crane, one of the most prominent researchers of modern and ancient beekeeping.

Discovery and context

In a recent excavation at the site of Tel Reḥov in northern Israel (Figure 1), an intriguing installation was unearthed, consisting of eight unfired clay cylinders lying side by side (Figure 2). Tel Reḥov (Arabic: Tell es-Ṣarem) is a mound 10ha in extent located about 5km south of Beth-Shean and 7km west of Pella in the alluvial Beth-Shean valley, which is a segment of the Jordan valley. It is one of the largest Iron Age cities known in Israel. Eight excavation seasons since 1997 have revealed a prosperous and well-planned city of the tenth-ninth centuries BCE, with three consecutive main architectural phases or levels (Strata VI-IV; Mazar 1999; 2003; in press; Mazar *et al.* 2005). The background of the period under discussion (termed Iron Age IIA) includes what the traditional Biblical narrative relates as the monarchy of David and Solomon centred in Jerusalem, followed by the political division into the Northern Kingdom of Israel and the Southern Kingdom of Judah. The historical and archaeological interpretations of this period are currently subject to debate and the results of the excavations at Tel Reḥov figure prominently in the discussion (see introductory papers in Levy & Higham 2005: 15-42).

The material culture of Iron Age IIA is characterised by a revival of urbanisation in large parts of the Southern Levant, alongside the appearance of new glyptic styles and cultic

1 *The Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem, Israel*
2 *Kimmel Center for Archaeological Science, Weizmann Institute of Science, Rehovot 76100, Israel*
3 *Department of Archaeology and Ancient Near Eastern Cultures, Tel Aviv University, Ramat Aviv 69978, Israel*
4 *Department of Organic Chemistry, Weizmann Institute of Science, Rehovot 76100, Israel*
5 *Department of Structural Biology and Kimmel Center for Archaeological Science, Weizmann Institute of Science, Rehovot 76100, Israel*

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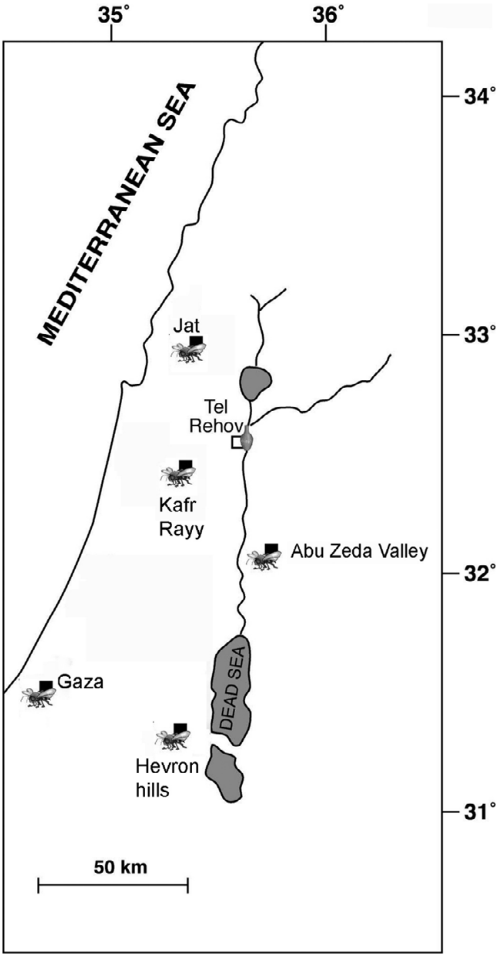

Figure 1. Schematic map of Israel and Jordan. Ethnographic hives are marked with a bee. Tel Reḥov is marked with a blank square.

objects, as well as a change in pottery traditions, epitomised by red-slipped, hand burnished pottery. This period also sees a development of trade relations with Cyprus and Phoenicia. The Iron Age IIA culminates in northern Israel in the last half of the ninth century BCE, with a rash of destructions that are attributed to the incursion of the Arameans led by King Hazael of Damascus.

The installation made of clay cylinders was discovered in Area C, located at the north-western corner of the city, where an area of 625m^2 of Iron IIA structures was excavated. The installation was found in Stratum V in the south-eastern part of the area, in an architectural complex dubbed 'Building H', which was part of a densely built area with well-planned mud-brick structures (Figure 3). This large complex has only been partly excavated. The intriguing installation included eight clay cylinders arranged along a north-south line. Each cylinder is about 0.8m long and about 0.44m in diameter and is made of unfired clay walls about 4cm thick. The cylinders were placed on a wooden beam that also ran on a north-south axis; burnt traces of this beam were revealed especially near the southern end of the installation (Figure 2A). The best preserved cylinders had a clay wall blocking their western end, in the centre of which was a small hole, with signs of burning along its perimeter. The opposite, eastern end of the cylinder remained open, but could be blocked by lumps of clay, some of which were found *in situ*. A few remnants of a second row of such cylinders above the bottom row were also found. The hives were set on a floor of light-coloured, compact earth.

The entire area was covered by a *c*. 1m-thick destruction layer, including many fallen bricks, burnt beams and a large amount of restorable pottery vessels. This destruction layer was tilted from the west to the east. Some of the intact and restorable pottery vessels from this layer appear to have fallen from a second floor (Mazar 1999; Mazar *et al.* 2005). It seems that the area was probably roofed and had a second floor above what seems to be a basement in which the cylinders were located. Locating unfired clay or mud-brick installations under a roof makes sense, as the winter rains would otherwise have damaged them.

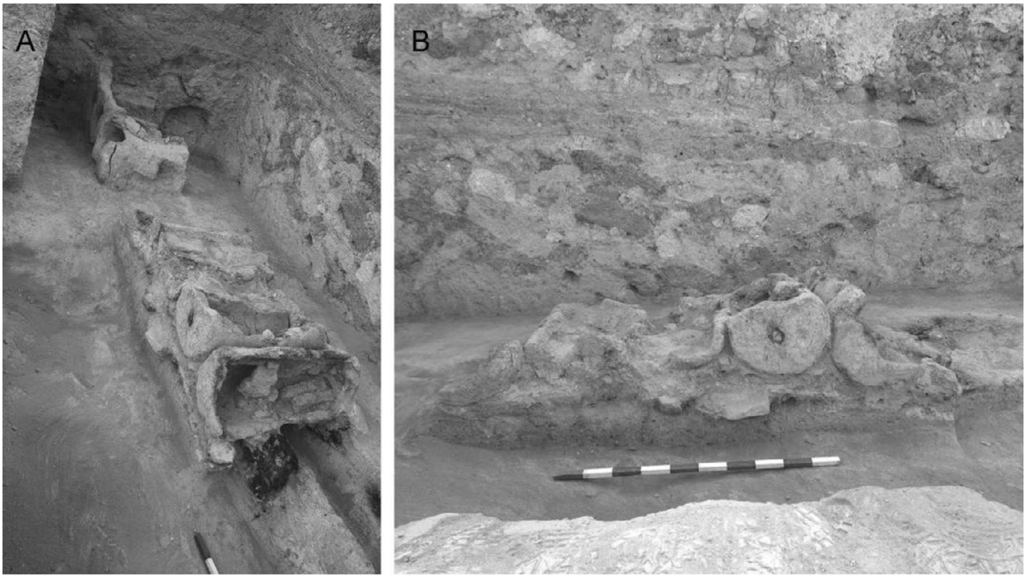

Figure 2. View of the beehives found at Tel Reḥov: A) looking north-east; B) frontal view, looking east.

Figure 3. Schematic plan of Tel Reḥov Area C Stratum V, showing the beehives in Building H.

Three ^{14}C dates of charred grain found on the floor below the thick destruction layer of Building H in Stratum V were measured with the Proportional Gas Counting method at the Centre of Isotope Research at the University of Groningen by J. Van der Plicht with the collaboration of H. Bruins from Ben-Gurion University, Israel (Bruins *et al.* 2003; 2005). The dates were 2764 ± 11; 2777 ± 13; 2785 ± 28 BP and the average calibrated age in 1σ is between 969 and 870 BCE (the 2σ range is 970 and 840 BCE; Mazar *et al.* 2005). A late tenth-century date for this destruction is consistent with other observations by the excavators (A.M. and N.P.C), including other archaeological considerations and the average of additional ^{14}C dates from this stratum.

Here we turn to several independent sources of information which have identified these structures as beehives: pictorial, literary and ethnographic parallels, as well as analyses of residues extracted from the walls of the structure.

Pictorial, literary and ethnographic parallels

The identification of the Tel Reḥov objects as beehives is based on pictorial depictions, literary evidence and ethnographic analogies. The only archaeological sources relating to beekeeping in the ancient Near East are four Egyptian pictures: one from the tomb of Niuserra of the fifth Dynasty, two from the eighteenth Dynasty and one from the seventh century BCE (Crane 1983: 34-9; Crane & Graham 1985: 24-7; Kritsky 2007; Kuény 1950; Serpico & White 2000: 410). They show cylindrical horizontal hives stacked in several layers. No other pictorial depictions of hives are known until medieval times, but there are literary references to beehives in Hittite documents, where they seem to have been a valuable commodity (Crane & Graham 1985: 31-4).

No such hives have been recorded from archaeological excavations from this or earlier ages. The main direct archaeological evidence for hives comes from Classical Greece where a good number of pottery hives were found; they are all shaped as cylindrical jars with a base, open on one side only, with extension rings and lids (Crane 1983: 45-7; Crane & Graham 1985: 149-53). Beekeeping is described by various Greek and Roman authors, who sometimes include a detailed description of the hives (for references see Crane & Graham 1985: 31-9). Columella's description is particularly comprehensive and is cited by later authors. Notably, he defines unfired clay as the most unsuitable material for constructing hives, since it would be too cold in the winter and too hot in the summer; tree bark and wood are considered by him to be the preferred materials for constructing hives.

Beehives shaped as cylinders made of unfired clay, fired pottery, bark, wood or basketry and placed in horizontal rows are well known in many traditional cultures throughout the Mediterranean, the Middle East, East Africa, India and the Far East (Crane 1983). In traditional Palestinian villages, hives made of unfired clay are common (Avitsur 1976). Some of these are similar to those at Tel Reḥov and are located in the courtyard of village houses and sometimes even inside a farm building (Figure 4). Unbaked clay hives were used by Palestinian cave dwellers in the southern Judean Hills; their front walls were decorated with clay mouldings (Havakook 1985, photograph between pages 144-5). A wall composed of such hives was recorded near Kefr Raay, north-east of Shechem (Zertal & Mirkam 2000). The rows of hives had front walls with small openings in the centre, similar to those in the Tel Reḥov Iron Age installation; these openings could be closed by a piece of wood. The ethnographic museum at Kibbutz Yif'at in Israel exhibits unbaked clay hives from the Druze village of Jat in western Galilee; they have a movable door composed of a clay disc with a protruding handle. Also exhibited are fired clay hives produced in the pottery workshops of Gaza, made as cylinders opened on both sides. Other traditional hives in that museum are made of wood and basketry. Unfired clay hives are well-known in modern Egypt, where 300-500 hives were recorded in single stacks (Crane 1983; Kritsky 2007; Mellor 1928).

In many of these hives, the cylinder's front was closed by either a permanent wall or a removable lid; in both cases, a small hole was left for the bees to enter and exit and yet prevent larger insects or animals from entering the hive. Such small round openings are found in the Tel Reḥov hives, as mentioned above (Figure 2B). The back was usually left open and sometimes blocked with removable materials in order for the beekeeper to be able to smoke the hive, forcing the bees to calm down, and thus enable the harvesting of the honeycombs. As Crane and Graham maintained (1985), this procedure is well-illustrated in an Egyptian pictorial depiction from the seventh century BCE (in Tomb TT279 at Thebes)

Figure 4. Photograph of an ethnographic modern parallel from Wadi Zeda, Jordan.

and is practised in all traditional beehives (though missing in Greek hives which are closed at one end).

Analytical identification of degraded beeswax residues

Two different cylinders from the Tel Reḥov installation were analysed, as well as the sediments associated with the installation. The organic residues extracted from the unfired clay walls were analysed using Gas Chromatography (GC) and GC/ Mass Spectrometry (GC/MS) (See supplementary material below).

Analysis of the lipids extracted from two of the eight Iron Age IIA beehives from Tel Reḥov detected assemblages that are dominated by long chain *n*-alkanes with 23 to 33 carbon atoms (nC_{21}–nC_{32}) and fatty acids (palmitic acid, $C_{16:0}$, stearic acid, $C_{18:0}$ and lignoceric acid, $C_{24:0}$) (Figure 5). Extracts from sediments sampled from the vicinity of the vessels showed completely different lipid assemblages (Figure 6), leading us to conclude that lipids extracted from the beehive walls indeed reflect the contents of the hives and have not been contaminated by the associated surroundings. The lipid extracts from the beehive show a clear predominance of n-C_{27} amongst the odd numbered alkanes (ONAs) and that the relative proportions between all ONAs normalised to the total peak area are similar. This is not the case for the even numbered n-alkanes (ENAs). The relative abundance of the ENAs is more varied (Figure 7).

Based on ethnographic similarities mentioned above, this installation is believed to have functioned as a beehive and is therefore expected to contain beeswax residues. It is well

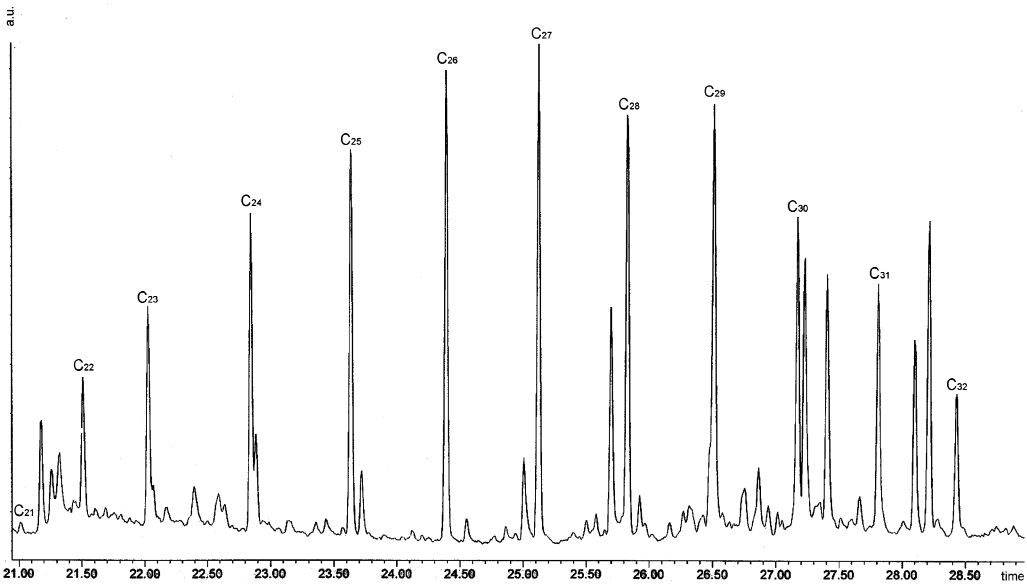

Figure 5. Gas chromatogram of the organic extracts from the installation walls found at Tel Reḥov. C_x refers to n-alkane with x carbons in its chain. x-axis represents the elution time (in minutes) of the compounds. y-axis represents intensity (in arbitrary units).

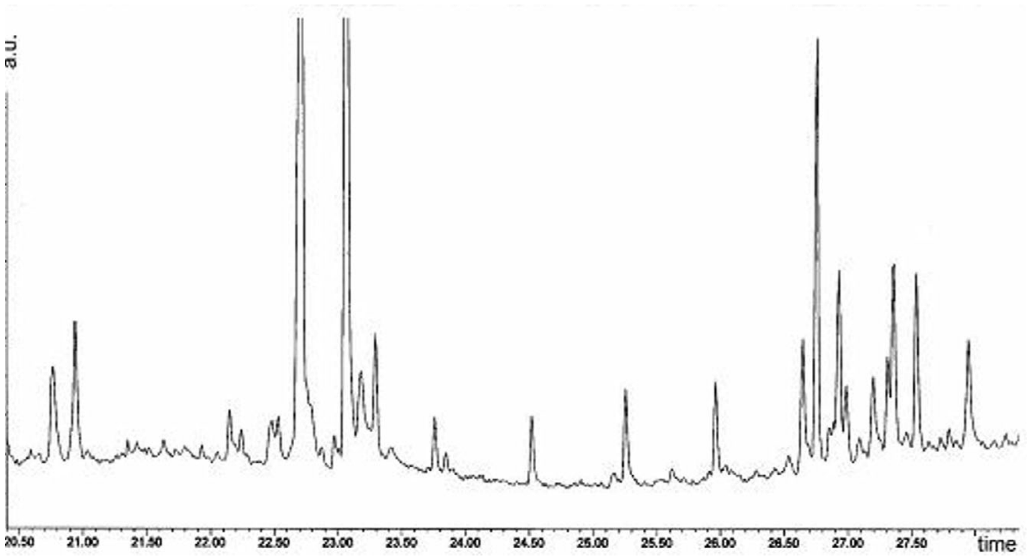

Figure 6. Gas chromatogram of the organic extracts from the sediments from the installation surroundings, reporting different organic assemblage from the one found in the installation analysed. x-axis represents the elution time (in minutes) of the compounds. y-axis represents intensity (in arbitrary units).

established that modern beeswax contains three major groups of compounds: (i) fatty acids, $C_{16:0}$, $C_{18:0}$ and $C_{24:0}$; the latter serves as a biomarker; (ii) ONA (C_{21}–C_{33}); and (iii) wax esters, mostly of palmitic acid in the range of C_{40} to C_{52} (Tulloch 1970). The presence

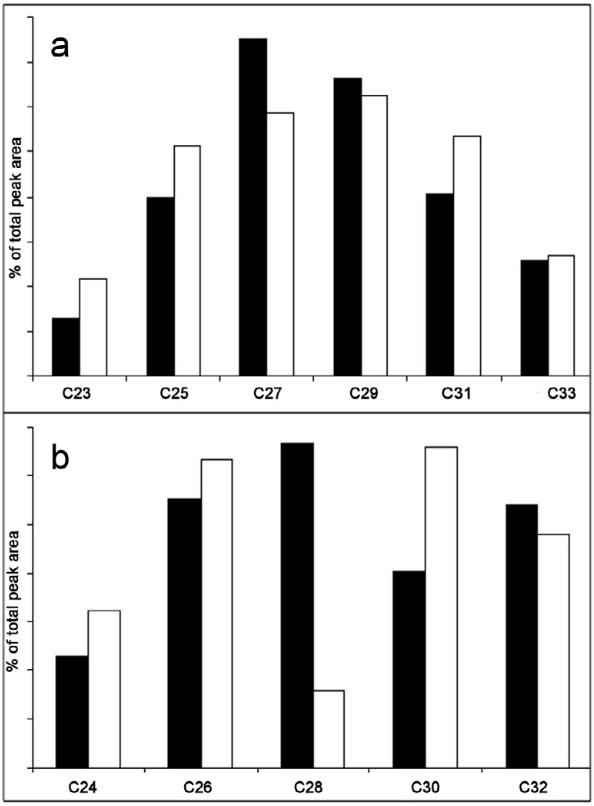

Figure 7. Histograms of the peak area of a) odd numbered; and b) even numbered n*-alkanes extracted from the walls of two cylinders of the installation found at Tel Reḥov. The relative peak areas are normalised to the total peak area of alkanes present in the extract.* C_x *refers to* n*-alkane with x carbons in its chain. %=of total peak area.*

of ONAs dominated by *n*-C_{27} and the significant presence of $C_{16:0}$, $C_{18:0}$ and $C_{24:0}$ fatty acids in the Tel Reḥov beehive extracts are all consistent with the identification of beeswax in the installation. The varied amounts of palmitic acid that are present may be due to the hydrolytic breakdown of wax esters known to be present in beeswax (Heron *et al.* 1994; Tulloch 1971). Although wax ester hydrolysis should have produced odd numbered *n*-alcohols in the range of 24 to 36 (Regert *et al.* 2001), no alcohols were detected in the beehive extracts. The hives at Tel Reḥov were covered by about 1m-thick debris of destruction layer that was severely burnt. Due to that, the hives could have been exposed to high temperatures which would cause both the breakdown of wax esters and the evaporation of long chain alcohols (Namdar *et al.* submitted).

The most stable components of beeswax, the ones that are predicted to survive through time, are the *n*-alkanes. The main difference between the ancient beehive extracts and modern beeswax regarding the alkane composition is that the latter is known to contain large amounts of ONAs and only negligible amounts of ENAs (Evershed *et al.* 2003; Kolattukudy 1969; Tulloch 1970). Since we found significant amounts of ENAs in the extracts of the cylinders, we investigated modern beeswax and found an enrichment of

ENAs compared to ONAs in dark coloured beeswax. This is attributed to the accumulation of bees' remains during the occupancy of the hive. The coatings of the bees' cuticles are rich in ONAs and ENAs (Salvy *et al.* 2001), and these could contribute *n*-alkanes to the beeswax (Namdar *et al.* 2007; submitted) also showed that another change in the *n*-alkane composition of beeswax occurs when modern beeswax from *Apis mellifera* is placed on a clean ceramic sherd and heated to 400°C. The relative proportions of ENAs compared to ONAs dramatically increases. In fact, the proportions of ENAs and ONAs are similar to those analysed in the cylindrical clay containers from Tel Reḥov.

Conclusions

Beehives are one of the lesser known subjects in the archaeological record. Perhaps due to their fragility and location outside settlements, no actual remains of beehives are known, to the best of our knowledge, in the entire ancient Near East prior to the Hellenistic period. Here we present the only beehives excavated so far in the ancient Near East. They were found at Tel Reḥov in a thriving urban centre of the tenth-ninth centuries BCE, in a context of a large building that was severely burnt most probably at the end of the tenth century BCE. Finds in the vicinity of the beehives point to cultic activity perhaps related to the honey and beeswax production. In Egypt, honey was used for various medical treatments, and thus beehives were considered important and were under state supervision. The function of honey in ancient Israel is less well known, since the Biblical references mentioning honey are unclear: many of them perhaps refer to honey made of fruits such as dates and figs, and the Bible does not mention beekeeping. Only two literary stories mention wild honeycombs (Judges 14:8; and possibly I Samuel 14: 25-9). The Tel Reḥov beehives are thus unique in their demonstration of the importance of honey and beeswax production in the local economy and perhaps in ritual and medicine as well.

The presence of beehives in Tel Reḥov raises the inevitable question: why and for what purpose were beehives located in a closed structure in the middle of a densely built city? The importance of the production of honey and beeswax in this complex is demonstrated by the discovery in the same space as the beehives of two outstanding cult objects: a decorated four-horned pottery altar and an elaborately painted large chalice. The latter was covered by a mottled rust-like coating, similar to the rust-like coating found on the inside of the hives. These were discovered just to the south-west of the hives, together with several pottery chalices to the west of the hives. These objects could have been used in cultic activities related to the manufacture of honey and beeswax. Such a relationship between cult and industry is known in various cases, such as the affinity between metal production and cult in the Late Bronze Age copper production centres at Timna' valley (Rothenberg 1988) and Cyprus (i.e. Artzy 2000; Dothan & Ben-Tor 1983; Karageorghis 1973), as well as the seventh-century BC olive oil industry at Tel Miqne-Ekron (Gitin 1989). In ancient Egypt, beeswax was considered to possess magical powers, and this could also have been the case in ancient Israel. Such attributes may explain the rather surprising location of the hives inside the city and so close to built structures. It might be that the beehives were part of a larger complex which had a specialised economic and perhaps religious function. Part of this complex was a granary structure (Building G) attached to Building H on the west (Figure 3).

The period to which these beehives relate, the second half of the tenth century and the beginning of the ninth century BCE, corresponds with what the traditional reconstruction of the history of Israel defines as the era of Solomon, the invasion of Shoshenq I and the split of Israel into two states: southern (Judah) and northern (Israel). Tel Reḥov was a flourishing city during that time and the beehives are just one aspect of the economic and religious practices in this city. The results of archaeological, pictorial, ethnographic and scientific analysis are integrated in this study to compose a lively picture that extends a new meaning to the Biblical definition of the Land of Israel as a 'Land of Milk and Honey'. Though the Bible does not mention apiaries, the example from Tel Reḥov shows that they were known at that time and functioned very much like those from Egypt that are dated much earlier, as well as like the much later beehives known from the ethnographic record.

Postscript

In the 2007 season of excavations at Tel Reḥov, additional beehives were discovered that clearly indicate the industrial nature of the Iron Age IIA apiary. Three rows containing more than 30 hives and at least three tiers suggest a reconstruction of some 100 hives that have the potential yield of several hundred kilograms of honey per year. At least two of the hives yielded remains of honeycomb, as well as other organic material. Scientific analysis currently being conducted includes pollen analysis by M. Evron of Haifa University, examination of the biological aspects of the finds by G. Bloch of the Hebrew University of Jerusalem, who has already discovered parts of bees' bodies in the remains of honeycomb. The new finds should be also dated and further analysed. For further details see www.rehov.org.

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Supplementary material – analytical methods

S1. Residues extraction method

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-treated with 1N HCl, fuming nitric acid then throughly washed with distilled water, and then washed with acetone, followed by chloroform and dried under a heating lamp. Pieces of ceramic were broken off the hives with pliers, cleaned under a stream of clean compressed air, and then ground to a powder in an agate mortar and pestle. About 2g of the powder was weighed and then split equally into clean glass centrifuge tubes. Duplicate blank samples composed of loess from the Negev heated to 600°C for 24 hours were analysed with each batch of samples. 10ml of chloroform and methanol (2:1 v:v) were added to each tube and the mixture was sonicated for 15 minutes. The tubes were centrifuged for 10 minutes at 3500 rpm. The supernatant was removed to another glass centrifuge tube and solvents were evaporated using a CS110 Speed-vac Plus (ThermoSavant). *N*, *O*-bis(trimethyl)silyltrifluoroacetamide, BSTFA, (150μl) containing 1% trimethylchlorosilane (TMC) were added to each tube and heated at 60°C for 30 minutes. After derivatisation, the samples were dried under a gentle stream of nitrogen and 100-150μl of cyclohexane was added to each tube. 5μl of each sample were injected into the gas chromatograph (GC) with either flame ionisation (FID) or mass selective (MSD) detectors. The amounts were calculated from the average peak area of a series of 7 $n-$alkane standards (nC_{26}-C_{32}) compared with the total peak area of compounds extracted from the unfired clay walls and analysed by the mass spectrometer.

S2. Gas Chromatography (GC)

The GC analysis was carried out using a HP6890 GC equipped with a flame ionisation detector (FID) and using a split injection mode with a 1:10 split ratio. A 15m, 0.32mm ID 5% cross-linked PhMe siloxane capillary column (HP-5) with a 0.25μm film thickness was used for separation. Helium was used as a carrier gas at a constant flow of 1.1ml/s. The initial oven temperature was 50°C and a heating gradient of 10°C/min was started after 2 minutes injection. Upon reaching 345°C, the run was continued for an additional 10 minutes. The injection temperature was 220°C and the FID detector temperature was 350°C. The identification of individual compounds was based on the elution order and comparison to reference standards.

S3. Gas Chromatography/Mass Spectrometry

GC/MS measurements were carried out on another gas chromatograph (HP6890) with a mass-selective detector (HP5973; electron multiplier potential 2kV, filament current 0.35mA, electron energy 70eV, and the spectra were recorded every 1s over the range m/z 50 to 800). The same capillary column noted above was used, 30m long. Peak assignments were based on comparisons with library spectra (NIST 1.6), spectra reported in the literature (Tulloch 1970; 1971; Tulloch & Hoffman 1972) and by comparison of retention times of reference standards.

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