Vegetation History and Archaeobotany (2018) 27:717–736
https://doi.org/10.1007/s00334-018-0667-x

ORIGINAL ARTICLE

Agricultural resources on the coastal plain of Sidon during the Late Iron Age: archaeobotanical investigations at Phoenician Tell el-Burak, Lebanon

Andrea Orendi[1] · **Katleen Deckers**[2]

Received: 9 January 2017 / Accepted: 10 January 2018 / Published online: 20 January 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract
With regard to Near Eastern archaeobotanical investigations, Lebanon is still underrepresented. Archaeobotanical data have been obtained from only a few excavation sites, mostly from the Phoenician settlement of Tell el-Burak. The site is situated on the southern coastal plain of Sidon, between Sidon and Tyre. Continuous sampling throughout six seasons of excavations have enabled the detailed investigation of the archaeobotanical material from the site. Due to the fine stratigraphic resolution there, it is possible to examine the development of agricultural resources through the 400 years of Phoenician occupation. Additionally, systematic sampling has allowed investigation of the spatial distribution of botanical remains within certain building structures. The combination of the archaeological results with the data from the charcoal and seeds reinforces the assumption that Tell el-Burak was established by the city of Sidon or the nearby city of Sarepta as a production and trade centre for wine and possibly olive oil. The agricultural resources of grapes and olives were most probably cultivated in the immediate vicinity of the settlement and probably along the western slopes of the hill country further inland.

Keywords *Vitis vinifera* · Phoenicia · Lebanon · Late Iron Age · Wine production · Levant · Charcoal · *Olea europaea*

Introduction

Archaeobotanical studies on Lebanon are rare. Only a few sites situated along the Lebanese Mediterranean coast have been investigated archaeologically and have also provided archaeobotanical material. The publication levels of the archaeobotanical remains from these sites vary. Several archaeobotanical publications have accompanied the recent excavations at Sidon (de Moulins 2009, 2015; de Moulins and Marsh 2011) and Tell Fadous-Kfarabida (Riehl and Deckers 2007, 2010; Riehl in press), which have provided significant data. Preliminary reports have been published for the archaeobotanical assemblages from Tyre al-Bass (Rovira 2015) and Kamid el-Loz (Behre 1970) and a Late Bronze Age (LBA) storage find of *Echium* sp. from Kamid el-Loz was published as a special study (Baas 1980).

The archaeobotanical assemblage from Tell el-Burak presented here complements the existing Lebanese archaeobotanical data. The analysis of its seed and charcoal material contributes to a longstanding need for additional environmental studies in this region. Tell el-Burak provides data from the Middle Bronze Age (MBA) and the Late Iron Age, the Phoenician period. This paper focuses on the archaeobotanical data from the Phoenician period of the settlement between the 8th and the 4th century BC. Due to the high stratigraphic resolution of the tell (Kamlah et al. 2016a, b) it was possible to investigate the development of the preferred useful plants there throughout 400 years of Phoenician occupation. Furthermore, this paper contributes to the basic research on Phoenician agriculture within its core country, the central Levant (Fig. 1).

Communicated by A. Fairbairn.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00334-018-0667-x) contains supplementary material, which is available to authorized users.

✉ Andrea Orendi
a.orendi@uni-tuebingen.de

[1] SFB 1070 "ResourceCultures", University of Tübingen, Gartenstraße 29, 72074 Tübingen, Germany

[2] Institute for Archaeological Sciences, Archaeobotany Workgroup, University of Tübingen, Rümelinstraße 23, 72072 Tübingen, Germany

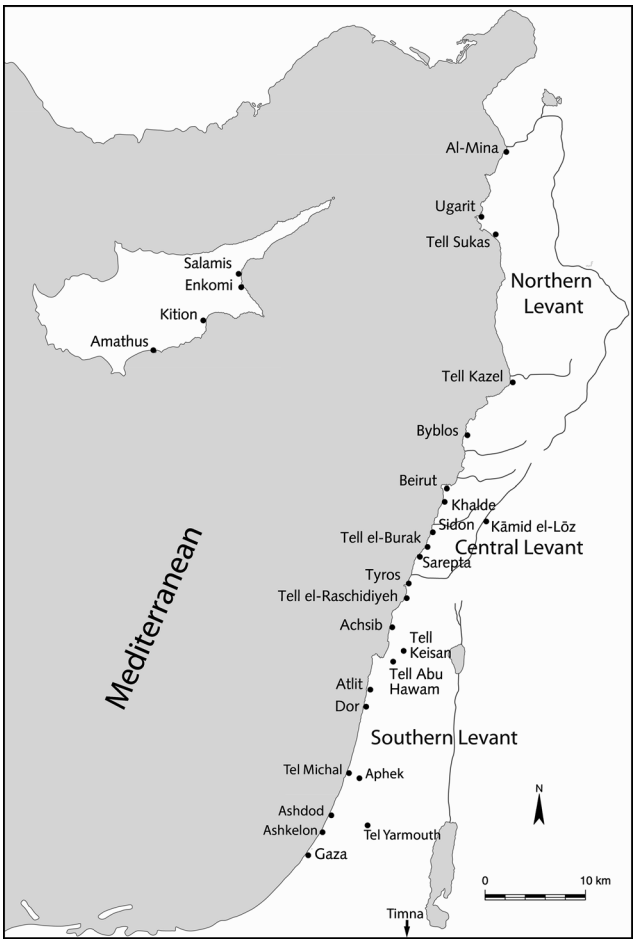

Fig. 1 The Levant with the sites mentioned in the text (adapted from Kamlah 2006)

It is well known that the major coastal cities in Phoenicia were primarily seaports, which served as centres of the Phoenician trade networks which extended throughout the Mediterranean (Aubet 2014). It is believed that the Phoenicians relied on these extensive networks as their primary source of supply for their settlements (Bondì 1995; Markoe 2000). However, this assumption does not take into account the favourable conditions for agriculture on the Lebanese coastal plain and its surroundings. This paper aims to demonstrate that, based on the investigations at Tell el-Burak, it is imperative to consider the existence of agricultural settlements and the use of cultivated plants as resources on the coastal plains and in the adjacent inland regions. The analysis of the archaeobotanical data from Tell el-Burak shows how the preferred useful plants developed throughout the period of settlement at the site. Therefore, this contribution aims to investigate the use of natural resources, including agricultural practices along the Phoenician coastline and in inland regions, which is still under-studied with regard to archaeobotanical as well as archaeological research.

The complementary studies of the charcoal and the seed records from Tell el-Burak enable an exhaustive understanding of the use of local plant resources by its inhabitants and prove that it is crucial for our understanding of the supply of the Phoenician societies in the central Levant to consider both the use of local resources and those from long-distance trade.

Ancient agriculture in the central Levant

The central Levant, which covers the territory of present-day Lebanon (Fig. 1), provided good conditions for agriculture during antiquity. Sufficient water supply was made available by high winter precipitation rates as well as various springs and perennial streams, which were used for irrigation during the rainless months of summer (Isserlin 1983). Due to the relief of the landscape, cultivation areas were restricted to the coastal plain, the Beqa valley and the slopes of the Mount Lebanon range where terraces allowed the cultivation of crops (Spanò Giammellaro 1999; van Gucht 1992). Nowadays, these regions are mostly covered with red Mediterranean soils (terra rossa) and rendzinas which are suitable for growing various crops (Wolfart 1967). In accordance with these favourable conditions, a report of the 5th campaign of the Egyptian pharaoh Thutmose III into Phoenicia refers to a fertile land filled with fruits and cereals (van Gucht 1992).

Studies dealing with Phoenician agriculture and archaeological excavations of rural Phoenician settlements are, however, very rare (Isserlin 1983; van Gucht 1992). Whereas recent studies cover the rural landscapes of the later Punic or Carthaginian world (van Dommelen and Bellard 2008), the Phoenician core country has not been taken into account.

Geographical and environmental setting of Tell el-Burak

The coastal plain of Sidon is part of Lebanon's coastal strip on the shores of the Mediterranean. It stretches from the city of Sidon southwards to Sarepta. Near Sidon, the Mount Lebanon range is very close to the sea, which leaves only a very narrow coastal plain. In the area surrounding Tell el-Burak, however, the mountains are further inland and therefore make way for an arable strip of land. Tell el-Burak is located directly on the shore of the Mediterranean about 9 km south of Sidon (Fig. 2).

The coast of Sidon is situated within the Mediterranean coastal climate zone with a modern mean annual precipitation of about 700 mm and a mean annual temperature of 20 °C (http://de.climate-data.org). The winters are mild and rainy, while the summers are hot with less than 10 mm of rainfall during the months of June, July, and August. Typical Mediterranean vegetation grows there now, but it was formerly dominated by Mediterranean macchia

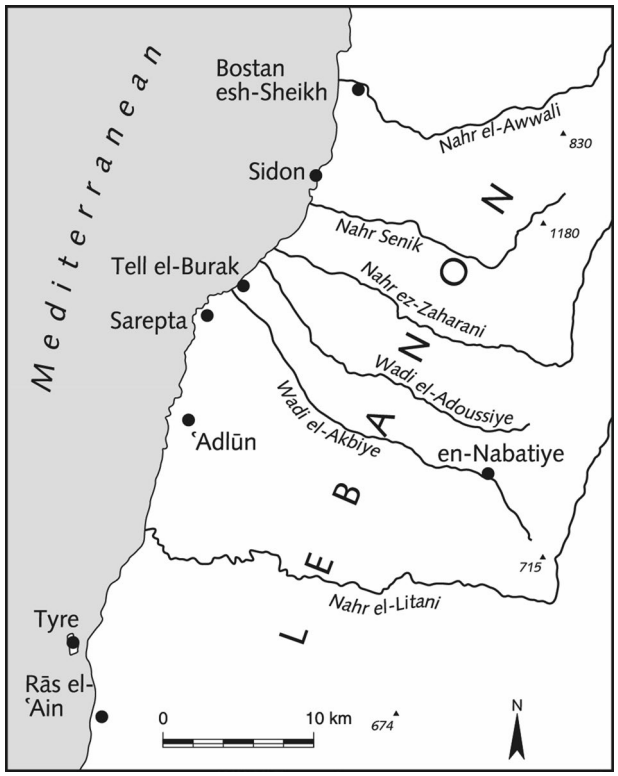

Fig. 2 Location of Tell el-Burak

(maquis) scrub, including evergreens and partly deciduous trees and bushes. As much of the southern Lebanese coastal zone has been transformed into agricultural land, only degraded remnants of this scrub remain (Wolfart 1967; Marriner et al. 2004). Typical Lebanese coastal vegetation is now herbaceous, with *Astragalus berythus, Trifolium billardieri, Matthiola crassifolia, Rumex occultans, Campanula pilosa* as well as *Glaucium flavum, Cakile maritima* and *Medicago maritima* (Mouterde 1966). During the 1960s, olives and citrus fruits were cultivated on the plain of Sidon, and the western hillsides of the Mount Lebanon range were planted with vineyards (Wolfart 1967). Currently, the site of Tell el-Burak is surrounded by plantations of *Persea americana* (avocado).

The soils of the plain around Tell el-Burak are characterized by shallow rendzinas such as lithosols and regosols, which do not have a high water capacity (Wolfart 1967). However, high precipitation rates as well as streams and springs near Tell el-Burak provide sufficient water for extensive agriculture. According to isotope analyses from Jeita cave (Verheyden et al. 2008), climatic conditions in the late Iron Age did not significantly differ from those of today, indicating that the area would certainly have been appropriate for intensive agricultural use during the Late Iron Age.

Archaeological and chronological results of the excavations at Tell el-Burak

From 2001 onwards, excavations at Tell-el Burak were carried out by a joint team from the Eberhard Karls University of Tübingen and the American University of Beirut in cooperation with the Orient Department of the German Archaeological Institute. Since 2013, the Johannes Gutenberg University of Mainz has joined the project.

Tell el-Burak was already inhabited during the Middle Bronze Age I (MBA I, 1900–1700 BC). During this period, an isolated monumental building, which was constructed on top of an artificially raised hill or tell, served as a central building complex for the surrounding coastal plain (Fig. 3). Since no other remains of a settlement have been found, it is assumed that the monumental building at Tell el-Burak was established by the MBA city kingdom of Sidon, the principal town along the Sidonian coast and its surroundings (Sader and Kamlah 2010). After the abandonment of the monumental building, the site was not resettled for approximately 1000 years. Near the end of the 8th century BC, Phoenician settlers returned to the tell. As in the case of the MBA monumental building, the Phoenician settlement of Tell el-Burak was a satellite town, most probably established by Sidon, or possibly Sarepta.

Four major areas have been excavated (Area 1–4). Excavations on the southern slope of the tell in Areas 3 and 4 (Fig. 3) have revealed a multi-phase Iron Age settlement with three major occupation periods (Early, Middle and Late; Fig. 4; Table 1). Detailed stratigraphic analysis has enabled further separation of these occupation periods into five phases (E to A). The chronology of the phases E-A is established on the basis of comprehensive statistical and comparative studies of all diagnostic potsherds (Schmitt 2016). However, to understand the development of agriculture at Tell el-Burak it is necessary to analyse the archaeobotanical data from the three major occupation periods mentioned above (Kamlah et al. 2016a, b).

The earliest Phoenician settlement was surrounded by an enclosure wall, Structure I (Fig. 4). House 1 consisted of three rooms inside the building, and two additional rooms outside it. According to the stratigraphy, it was built during the early occupation period, according to the dating of the pottery assemblage, towards the end of the 8th century BC directly on top of the MBA rampart. After a period of rebuilding during the middle occupation period, it finally went out of use in the 4th century BC, the late occupation period. House 3 was partially contemporary with House 1, sharing one wall with it. House 3 contained two rooms (3.1 and 3.2) which collapsed at the end of the early occupation period. The destruction debris consisted of an accumulation of 2,629 sherds from at least 105 Phoenician amphorae on the floors of Room 3.1 and Room 3.2 indicating that

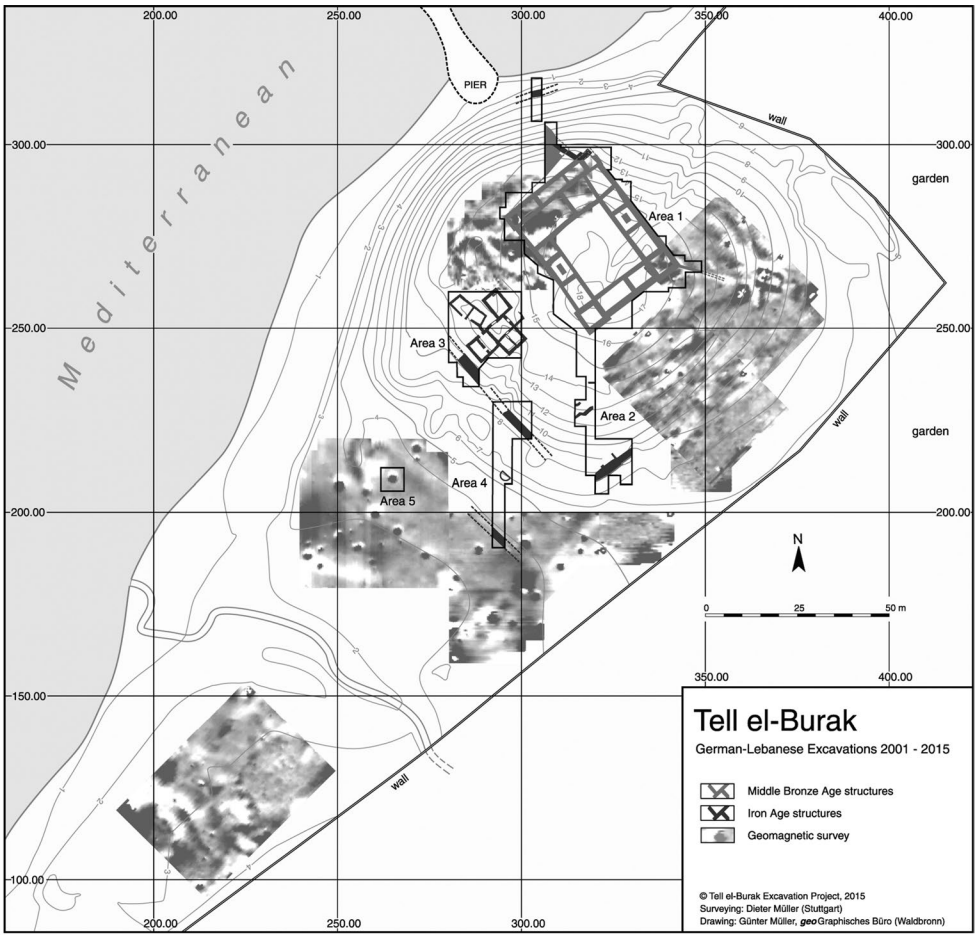

Fig. 3 Topographical plan of Tell el-Burak, with archaeological remains. Light grey: monumental building of the Middle Bronze Age; dark grey: remains of the Late Iron Age (Phoenician) settlement

both rooms had a storage function (Kamlah et al. 2016a; Schmitt 2016). The amphorae as well as fragments of a wine amphora from Chios date the material to the 2nd half of the 7th or the early 6th century BC. Room 3.3 appeared to be a courtyard in front of the storage rooms 3.1 and 3.2. However, it has not been fully excavated yet.

There is no direct stratigraphic connection between Structure I and Houses 1 and 3. The pottery assemblage consisting of local Phoenician pottery and imports from Cyprus found on top of Structure I, indicating that it went out of use in the 1st half of the 7th century BC (Kamlah et al. 2016a, b; Schmitt 2016).

Structure II was erected at the beginning of the middle occupation period, at the beginning of the 6th century BC (Fig. 4). It is tentatively interpreted as a casemate wall (Neumann 2016; Kamlah et al. 2016a) and contained at least two rectangular rooms numbered II.1 and II.2. The first room had various layers of ash which were signs of burning processes inside it or in its vicinity. A large storage jar, remains of cooking pots and sherds of amphorae in addition to the ash layers might suggest that this room had a food processing function (Kamlah et al. 2016a). However, no remains of an oven have been found and therefore it is assumed that the ashy remains from fireplaces and ovens in the vicinity had been discarded in there. Contemporary with Structure II, House 1 was still in use and House 2 was newly built. The latter was a two-room building partially covering the remains of House 3, which went out of use at the end of the early occupation period. The pottery assemblages from Houses 1 and 2 date the beginning of the middle occupation period to approximately 600 BC. The end of the middle occupation period is less clear to determine, although between approximately 550 and 500 BC.

The late occupation period (Fig. 4) is characterized by a gradual decline of the settlement (Kamlah et al. 2016a, b). Structure II went out of use at the end of the middle occupation period and during the following period the remaining buildings were not surrounded by a wall anymore. House 1 was still in use at the beginning of the late occupation period, but was abandoned some time in this period. House 2 was the only structure which continued in use until the site was finally abandoned. According to the comprehensive pottery analysis, the final abandonment of the site took place in approximately 350 BC (Kamlah et al. 2016a, b).

During the 2015 season, excavations in Area 4 revealed one context connected to agricultural activities, a large

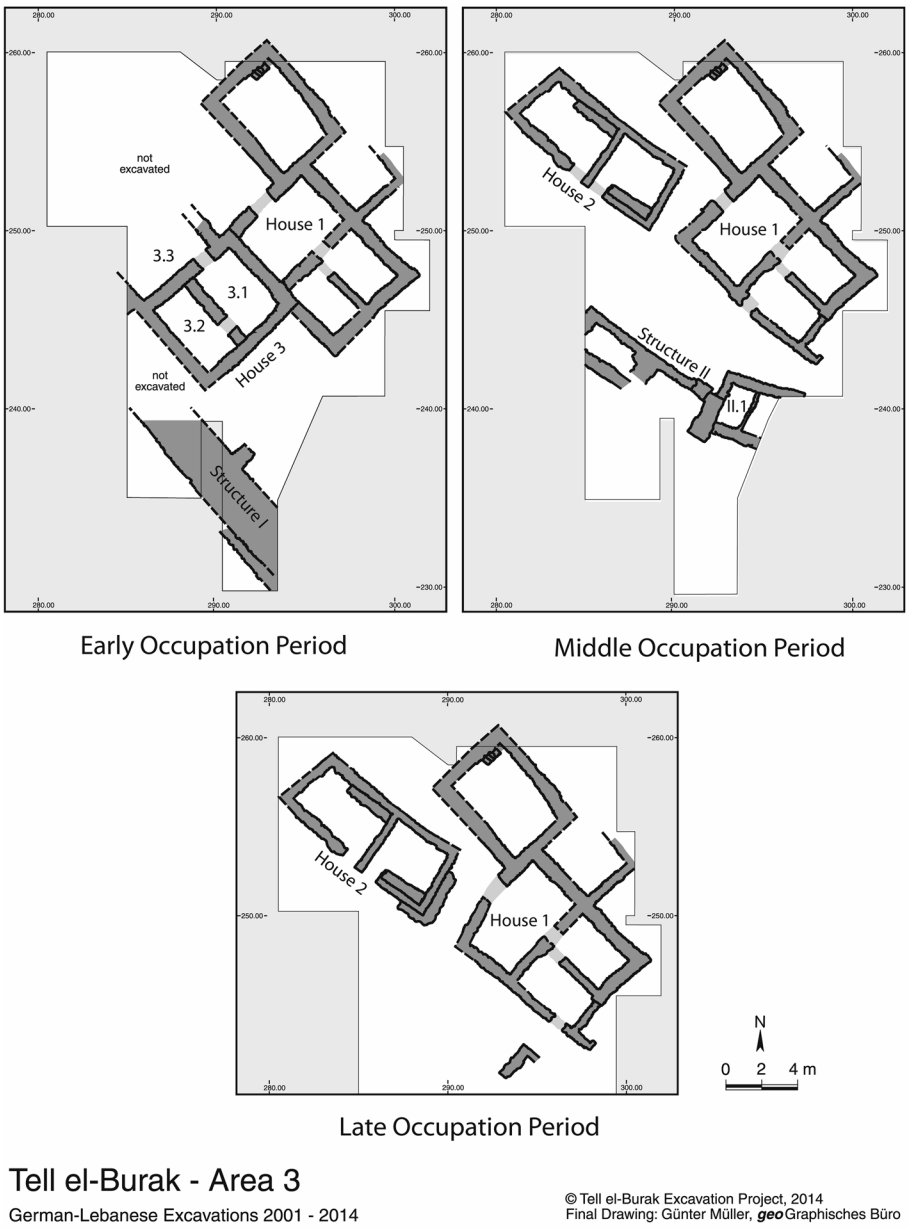

Fig. 4 Site plan showing architectural remains from the early, middle, and late occupation periods in Area 3 at Tell el-Burak

Table 1 Late Iron Age (Phoenician) settlement history of Tell el-Burak according to archaeological remains

Occupation period	Settlement development	Area 3 (intramural)	Area 4 (extramural)	Sub-phases[a]	Date
Early	Foundation and early period of occupation	Structure I (surrounding wall); House 1; House 3	Structure I; fire pit for lime production	E-D	ca. 725–600 BC
Middle	Continuous occupation	Structure II (surrounding wall); House 1; House 2		C	ca. 600–550/500 BC
Late	Late period of occupation with gradual decline	House 1 went out of use during the late occupation period; House 2 in use until the end of the late occupation period	large basin	B-A	ca. 550/500–350 BC

[a]According to detailed stratigraphic analysis

basin, as well as one context associated with the preparation of building material, a fire pit used for the preparation of lime (Fig. 3). The fire pit was situated directly outside and adjacent to the first surrounding wall (Structure I). Crushed limestone within the ash layers of the pit show that the function of this area can be related to the production of lime. The large basin was situated outside the settlement on the southern slope of the tell, but its function is not yet definitely determined. No direct stratigraphic connection between the building structures within and outside Structure I could be established. However, detailed analyses of the pottery finds enable correlation of the stratigraphy of Area 3 with Area 4. Therefore, the fire pit can be dated to the early occupation period, while the basin has to be dated to the late occupation period (Kamlah 2016).

Materials and methods

Archaeobotanical sampling and flotation were conducted continuously during all six excavation seasons at Tell el-Burak between 2005 and 2015 (2005, 2009, 2011, 2013–2015). A total of 262 samples from MBA and Iron Age layers were collected, with all Iron Age samples belonging to the Phoenician occupation. In general, all contexts were sampled. The sediment volumes of the samples varied between 1 and 100 l, depending on the context, but most of them were 30 l. The samples were floated on site using a Siraf type flotation device with water recycling, and the light fraction was collected in a 0.2 mm sieve and dried on site in cotton cloth bags. The floated material was sent to the archaeobotanical laboratory of the University of Tübingen for further examination. The heavy residues were collected from a 1 mm mesh, and after drying these were sorted for botanical macroremains, faunal remains such as small mammal and fish bones, and for archaeological finds. The archaeobotanical macroremains were sorted and identified using a binocular microscope with 10× magnification. The seeds and the charcoal were sorted into separate groups.

Seeds and fruits

Identification of the charred seeds was done using the seed reference collection of the archaeobotanical laboratory at the University of Tübingen and various identification literature such as Nesbitt (2008), Jacomet (2006) and Neef et al. (2011). Each complete seed was counted as one, as were two halves or four quarters of fragmented cereals. As the olive stones were commonly broken and some samples contained many fragments, weighing was the main method used for quantifying these remains (samples are marked in ESM 1). However, some samples contained a single fragment of olive which in turn was counted as one olive stone. The proportions (percentage of a particular taxon out of total seeds) and ubiquities (percentages of samples containing a particular taxon) of the identified seeds were calculated for the interpretation of the archaeobotanical material.

Charcoal

Charcoal fragments larger than 2 mm were identified using standard methodology by studying the transversal, tangential and radial sections with a microscope with incident light at magnifications varying from 60× to 500×, depending on the diagnostic features that needed to be investigated. The identification was based on a charcoal reference collection for Mediterranean woody taxa and identification literature, such as Fahn et al. (1986), Gale and Cutler (2000), Schweingruber (1990), and Crivellaro and Schweingruber (2013). The charcoal fragments were counted and then fragment percentages were calculated. According to the "principle of least effort", the percentages of a charcoal taxon should approximately reflect the abundance of that taxon in the former vegetation, although it needs to be kept in mind that factors other than availability in the landscape, especially human preferences for example, may also have influenced wood collection in the past (Smart and Hoffman 1988; Shackleton and Prins 1992; Asouti and Austin 2005; Marston 2009; Théry-Parisot et al. 2010). Ubiquity values for each taxon help to understand the representativeness of the fragment percentage results (Smart and Hoffman 1988; Asouti and Austin 2005; Théry-Parisot et al. 2010).

Results

In total, the six excavation seasons at Tell el-Burak provided 169 archaeobotanical samples dating to the Iron Age. Eight samples were not studied, because they were from unstratified Iron Age contexts, leaving 161 samples suitable for analysis (ESM 1). Overall, 5,662 l of sediment were floated, resulting in 6,543 charred seed and fruit remains. The find density of seeds and fruits was very low, with about one find per litre sediment.

The seed and fruit assemblage contains 2,785 cultivated and 3,758 wild plants. Wild plants accounted for 94 taxa, thus forming the clear majority of the 141 identified taxa from the site. Unfortunately, the seed material from Tell el-Burak was not well preserved. Most of the seed remains were eroded and fragmented and also had calcium carbonate coating the charred material. Therefore, identification of the seeds, especially the smaller ones, was in many cases only possible to genus level. The proportions and ubiquities of the cultivated plants were then calculated from the seed identifications. The proportions and ubiquities of the wild taxa were calculated separately. For a

clearer presentation of the wild taxa, the dataset of the wild plants was condensed, so that taxa belonging to the same species or even genus with a ubiquity less than 5% (ESM 1) were combined, resulting in 36 taxa. Then wild taxa were deleted if they still had a ubiquity of less than 5%. This finally resulted in 14 taxa of wild plants and a total sum of 3,638 seeds.

From the 161 Iron Age samples, 49 have been investigated for their charcoal. In total, 2,758 charcoal fragments were identified: 1,052 fragments dating to the early occupation period, 1,577 from the middle occupation period, and only 128 from the late period (ESM 2 shows fragment counts). The Tell el-Burak charcoal fragments were often rather small and had a calcium carbonate coating, making identification difficult. Due to the presence of the coating and the fact that Mediterranean vegetation contains many small shrubby plants that are often difficult to determine, about 8% of the fragments could not be identified.

Proportion and ubiquity values for the whole settlement

Crops

Regarding the seeds and fruits, the proportions of the cultivated plants are dominated by the remains of *Vitis vinifera* (41.7%; the following values are percentages of all crop seeds) and cereals (33.8%), followed by various large-seeded legumes (14.1%) and *Olea europaea* (8.3%) (Table 2; ESM 1). About 88% ubiquity for grape pips shows their considerably high use by the inhabitants of the site. Although olive stones are represented in smaller numbers than the cereals, a ubiquity of nearly 83% points to a wide distribution of *Olea* throughout the excavation area. The proportions of the main cereals are *Hordeum vulgare* (barley, 4.9%), *Triticum durum/aestivum* (free threshing wheat, 7.7%) and *T. monococcum/dicoccum* (hulled wheat, 2.3%), but the majority of the cereal finds (17.2%) could not be identified to the genus level. The cereal grains in general outnumbered the chaff remains. The legumes, which are represented in roughly half of the samples, occur with a great variety of taxa though in small amounts (*Lathyrus clymenum, Vicia faba, V. sativa*, and *Pisum* sp.), with *Lens culinaris* (proportion 3%) and *Vicia ervilia* (2.3%) comprising the major portion of legumes. Other crops are *Punica granatum* (0.3%) and *Ficus carica* (1.4%), with single finds of *Cucumis* sp. (0.1%) and *Coriandrum sativum* (0.1%). Moreover, three seeds and one capsule of *Linum usitatissimum* (0.1%) were found. The seeds of *Pistacia lentiscus* (0.2%) might be the remains of cultivated mastic bushes or from wild growing plants.

Weeds

The proportions of the wild plant taxa are dominated by *Chenopodium* spp. (60.9% of all weed seeds) and other segetal plants such as *Lolium* sp. (13.8%), *Trifolium* sp. (13.4%) and other wild grasses, as well as small-seeded legumes (Table 3; ESM 1). In ubiquity, *Lolium* and *Trifolium* were identified in more than half of the samples, while *Chenopodium* seeds were only recorded in nearly 17% of the samples. Most of the wild plants, like *Trifolium*, are indicators of open vegetation, and especially disturbed habitats, such as *Phalaris* sp. and *Hyoscyamus* cf. *niger*. Typical weeds of cultivated fields were found in the samples from Tell el-Burak such as *Lolium* sp. and *Anagallis* sp. In addition, a few seeds were from plants of damp habitats such as Cyperaceae, *Epilobium* sp., *Phalaris* sp. and *Alopecurus* sp.

Charcoal

Twenty-six woody taxa were positively identified (Table 4; ESM 2; SEM images of charcoal are shown in ESM 3). More than 40% of the wood charcoal fragments identified were *Olea* sp., making the proportion of this taxon particularly dominating. The second most represented woody taxon was *Quercus* sp., which amounted to about 32% of the fragments. Although only a small portion of the *Quercus* sp. charcoal could be differentiated between deciduous or evergreen types, deciduous *Quercus* sp. appears to dominate. The third most represented taxon was *Pistacia* sp., with about 6% of the fragments, which were mostly of the type *lentiscus*. Furthermore, *Vitis* sp. charcoal was the fourth most represented taxon, with about 4%. Interestingly, the taxa with high fragment percentages also have the highest ubiquities. All other taxa occur in smaller proportions. Of these taxa, *Cedrus* sp. and *Pinus brutia/halepensis* are most numerous and most ubiquitous (with respectively 1.4 and 1.2%). The following taxa were present in proportions less than 1%: *Taxus* sp., *Juniperus* sp., *Cupressus* sp., *Larix* sp./*Picea* sp., *Phoenix* sp., *Ficus* sp., *Punica* sp., *Acer* sp., *Amygdalus* sp., Maloideae, *Arbutus* sp., *Calycotome* sp./*Genista* sp., Leguminosae, *Rhamnus* sp./*Phillyrea* sp., Chenopodiaceae, *Fraxinus* sp., *Tamarix* sp., and some monocotyledons.

Analysis by period

The seeds and fruits have been summarized according to their representation in the early, middle or late occupation period (Table 5). We focus on cultivated plants, and summarize wild plant data. A high intermixture of seed material between periods can be ruled out, as the pottery of the individual periods is not mixed. For the early occupation period, samples from the fire pit are not included in this analysis due to sample heterogeneity. Particularly, one rich sample from

Table 2 Seed list of the cultivated plants found at Tell el-Burak with total counts, percentages (%) and percent ubiquities (U)

Species	Common English name	No.	%	U
Pulses				
Cicer arietinum	Chickpea	2	0.1	1.2
Lathyrus clymenum	Crimson pea	2	0.1	1.2
Lathyrus sp.	Vetchling	7	0.3	1.2
Lens culinaris	Lentil	84	3.0	24.8
cf. *Pisum* sp.	Pea	1	0.04	0.6
Vicia ervilia	Bitter vetch	63	2.3	19.9
Vicia faba	Broad bean	8	0.3	3.7
cf. *Vicia faba*		3	0.1	1.9
cf. *Vicia sativa*	Common vetch	3	0.1	1.9
Vicia sp.	Vetch	1	0.04	0.6
Vicia sp./*Lathyrus* sp.	Vetch/vetchling	17	0.6	4.3
Leguminosae indet., cultivated	Edible legumes	201	7.2	54.0
Cereals				
Hordeum vulgare	Barley	128	4.6	18.6
cf. *H. vulgare*		5	0.2	2.5
H. vulgare ssp. *distichon*, rachis	Two-row barley	1	0.04	0.6
H. vulgare, rachis	Barley	2	0.1	1.2
Triticum sp.	Wheat	46	1.7	19.3
T. dicoccum	Emmer wheat	10	0.4	3.1
T. cf. *dicoccum*		7	0.3	1.9
T. dicoccum, spikelet		3	0.1	1.9
T. cf. *dicoccum*, glume base		3	0.1	1.2
T. di./monococcum	Hulled wheat	21	0.8	3.7
T. di./monococcum, spikelet		3	0.1	1.9
T. di./monococcum, glume base		5	0.2	3.1
T. di./monococcum, glume base fragm		7	0.3	2.5
T. aestivum, rachis	Bread wheat	2	0.1	1.2
T. durum/aestivum	Free-threshing wheat	212	7.6	28.6
T. durum/aestivum, rachis		1	0.04	0.6
Cerealia	Cereals	480	17.2	63.4
Cerealia, culm		6	0.2	3.1
Fruits				
Pistacia lentiscus	Pistachio	6	0.2	3.7
Punica granatum	Pomegranate	8	0.3	2.5
Ficus carica	Fig	27	1.0	14.3
Ficus carica, mineralised		2	0.1	0.6
cf. *Ficus* sp.		8	0.3	3.7
Olea europaea	Olive	230	8.3	59.6
Vitis vinifera	Grape	988	35.5	88.2
Vitis vinifera, mineralised		13	0.5	5.6
Vitis vinifera, undeveloped pip		30	1.1	15.5
cf. *Vitis vinifera*		2	0.1	1.2
Vitis vinifera, undeveloped fruit		84	3.0	10.6
Vitis vinifera, pip with fruit remains		7	0.3	3.1
Vitis vinifera, pedicel		36	1.3	15.5
Others				
Coriandrum sativum	Coriander	2	0.1	1.2
Cucumis sp.	Cucumber species	4	0.1	1.9
Linum usitatissimum	Flax	3	0.1	1.9
Linum usitatissimum, capsule		1	0.04	0.6
Total sum		2,785		

this context contained more than 1,000 seeds of carbonized *Chenopodium murale* (Fig. 5). Numerically, these samples increase the sum of macroremains considerably and bias the average composition of the remaining samples from the early occupation period.

Table 3 Seed list of the wild plants found at Tell el-Burak with total counts, percentages (%) and percent ubiquities (U), condensed

Taxon	Common English name	No.	%	U
Asteraceae	Daisy family	19	0.5	8.1
Chenopodium spp.	Goosefoot	2,215	60.9	16.8
Chenopodiaceae/ Caryophyllaceae	Goosefoot/Pink family	50	1.4	11.8
Cyperaceae	Sedges	23	0.6	6.2
Fabaceae	Legumes	49	1.3	19.9
Trifolium sp.	Clovers	486	13.4	68.9
Scorpiurus sp.	Scorpion's tails	97	2.7	34.8
Poaceae	Grasses	107	2.9	40.4
cf. *Alopecurus* sp.	Foxtail grass	36	1.0	15.5
Lolium sp.	Darnel grass	502	13.8	59.6
Phalaris sp.	Canary grass	16	0.4	7.5
Anagallis sp.	Pimpernel	9	0.2	5.6
Ranunculaceae	Buttercup family	17	0.5	5.6
Rubiaceae	Bedstraw family	12	0.3	6.8
Total		3,638	100	

In the early occupation period, the proportion of cereals (29.8% the following are percentages of all seeds from the particular period; Table 5) outnumbers the remains of *Vitis* (grape 13.1%), which are represented by pips, undeveloped pips, pedicels, undeveloped fruits and fragmented fruit remains. Nevertheless, the ubiquities of both crops are very high (cereals: 73%, grape remains: 87%). The main proportion of cereals consists of unidentifiable cereal grains (15.1%). Grains of *Hordeum* (barley; 3.8%) and *Triticum* (free threshing wheat; 7.3%) are found in almost equal proportions. Remains of hulled wheat are rare (0.8%). *Olea* (olive) and edible legumes are each about 5%. The ubiquity of olive is quite high (85.9%) compared to its proportion. *Lens* (lentil; 1.7%) and *Vicia ervilia* (bitter vetch; 1.9%) show the highest proportions of legumes. Wild plants comprise 40.9% of all seeds from the early occupation period.

The middle occupation period is dominated by the proportions of the remains of *Vitis vinifera* (66.9%; Table 5) increasing drastically from the early to the middle occupation period. The remains of *Vitis vinifera* also show a great variety of different parts, although in slightly higher amounts than in the early period. With proportions of 3–4% each, cereals, legumes and olive are almost equally represented. The cereals were mostly not identifiable to species level (2.4%); in addition, remains of barley grains (0.7%), free threshing wheat grains (0.8%) and glume base fragments of hulled wheat (0.9%) were equally distributed. As in the early period, the legumes are mostly represented by unidentifiable legumes (2.5%), lentil (1.3%) and bitter vetch (0.7%). In contrast to the early period, the wild taxa are only about 25% in proportion.

The late occupation period is also characterized by a large amount of grape remains (29.3%; Table 5), but due to the greater number of wild taxa (38.8%), the proportion is less distinct than in the middle period. The cereals decrease drastically with grains of free threshing wheat (1.4%) and glume parts of hulled wheat (1.4%) occurring in larger amounts. In contrast, the proportion of olive stones increases from the middle to the late period. Following this trend, the legumes also increase in proportion, whereas the finds of lentil (1.4%) and bitter vetch (0.7%) stay almost the same, but the number of unidentifiable legumes (6.2%) increases drastically.

The charcoal fragment percentages are summarized in Table 6. *Olea* sp. charcoal proportions increase somewhat from the early to the middle occupation period, while those of *Vitis* sp. charcoal decrease simultaneously. This trend reverses from the middle to the late occupation period, when there is a strong reduction in *Olea* sp. charcoal percentages, from ca. 47 to 6%, while *Vitis* sp. increases strongly in the late period from ca. 0.5 to ca. 37%. It needs to be mentioned that the few investigated charcoal samples from the late occupation period all derive from the basin fill, so those samples are unlikely to be representative of the entire late occupation period. *Quercus* sp. and *Pistacia* sp. percentages are at their highest in the middle occupation period, while conifer percentages are highest in the early occupation period.

Spatial analysis

In the following sections, the archaeobotanical seed assemblages from the three rooms of House 3 (Rooms 3.1, 3.2 and 3.3), Room II.1 from Structure II, the fire pit and the basin are presented (Table 7; Figs. 3, 4). As our focus is on cultivated plants, the wild plant data has been summarized.

Rooms 3.1, 3.2 and 3.3 of House 3

The ratio between cultivated plants and wild taxa is almost equal in all three rooms, although the distribution of crops differs slightly between the three rooms. In Room 3.1, legumes (16.6%; the following are percentages of all seeds from the particular room), cereals (19.7%) and grape (18.1%) are almost equally distributed. In Room 3.2, the legumes are less represented (10.8%), whereas *Olea europaea* (8.5%) is more numerous. As for Room 3.3, the finds of olive (3.2%) are less numerous again, but the greatest value is of *Vitis vinifera* (32.3%). The major charcoal taxa found at the site are also the major taxa found within all three rooms. *Olea* sp. is dominant. However, olive charcoal is more numerous in Rooms 3.1 (42%) and 3.2 (30%) than in Room 3.3 (14%).

Table 4 Charcoal results from Tell-el Burak for the different occupation periods, with total counts, fragment percentages (%), and percent ubiquities (U)

Occupation Period	Early			Middle	Late	No.	%	U
Phase	E	D	E-D	C	B-A			
Location	Intramural	Intram.	Extram.	Intram.	Extram.			
Dicotyledons								
Acer sp.				5		5	0.2	1
Amygdalus sp.	1	1				2	0.1	2
Arbutus sp.	3	12		2	3	20	0.7	7
Calycotome sp./*Genista* sp.				1		1	0.0	1
Chenopodiaceae	1		2		3	6	0.2	5
Dicotyledon	26	131	16	54	12	239	8.7	41
Ficus carica		4	1			5	0.2	5
Fraxinus sp.		1			3	4	0.1	3
Leguminosae	7	5		3	2	17	0.6	7
Maloideae		1			2	3	0.1	2
Olea europaea	147	203	13	743	8	1,114	40.4	45
Pistacia lentiscus		6		141	6	153	5.5	9
Pistacia sp.	2	2	3	6		13	0.5	6
Punica sp.	1			1	2	4	0.1	3
Quercus sp., deciduous	2	8	1	149		160	5.8	14
Quercus sp.	49	171	29	416	32	697	25.3	44
Quercus sp., evergreen	3	19		3	1	26	0.9	12
Rhamnus sp./*Phillyrea* sp.			5		1	6	0.2	2
Tamarix sp.		2				2	0.1	2
Vitis vinifera	13	29	4	8	47	101	3.7	22
Monocotyledons								
Monocotyledon				14		14	0.5	3
Phoenix sp.		1				1	0.0	1
Gymnosperms								
Cedrus sp.	22	17				39	1.4	7
Conifer	1	15		25	5	46	1.7	9
Conifer without resin ducts	19	4				23	0.8	2
Cupressus sp.	12					12	0.4	1
Juniperus sp.	1	4		5		10	0.4	7
Larix sp./*Picea* sp					1	1	0.0	1
Pinus halepensis/brutia	3	14	14	1		32	1.2	11
Taxus baccata		1				1	0.0	1
	313	651	88	1,577	128	2,729	100.0	49

Furthermore, large amounts of *Quercus* sp. also occurred in all three rooms of House 3, 24% in Room 3.1, 27% in Room 3.2 and 33% in Room 3.3. Additionally, *Vitis* sp. is present in the three rooms in a small but consistent proportion with a slightly greater amount of *Vitis* charcoal in Room 3.3 than in Rooms 3.1 and 3.2. Besides a very small proportion of *Pistacia* sp. found in all three rooms, the remains of *Cedrus* sp., *Pinus halepensis/brutia, Taxus* sp. and *Juniperus* sp. were found. In general, the variety of taxa in Room 3.3 is higher than in Room 3.1 and 3.2. Moreover, *Phoenix* sp., *Ficus sp*. and a Maloideae taxon found in Room 3.3 probably represent cultivated plants.

Room II.1 of Structure II

The samples taken from Room II.1 make up the largest part of the seed and fruit samples from the middle occupation period. The archaeobotanical assemblage revealed some interesting results corresponding to the middle occupation period (Table 5). *Vitis vinifera* (86.9% of all seeds from this room; Table 7) dominates the archaeobotanical assemblage. As well as pips, other grape parts were found, including undeveloped pips, undeveloped fruits and pedicels (Fig. 6).

The remaining cultivated taxa are represented by seeds of *Lens* (lentil), *Vicia faba* (broad bean), *Ficus* (fig), *Punica*

Table 5 Seeds and fruits from Tell el-Burak as percentages (%) and percent ubiquities (U) for each occupation period. For the early occupation period, the samples from the fire pit have not been taken into account

Occupation period	Early		Middle		Late	
No. of samples/volume (litres)	78/3,021		29/916		34/850	
No. of remains	2,465		843		564	
	%	U	%	U	%	U
Pulses						
Cicer arietinum					0.2	2.9
Lathyrus clymenum		1.3	0.1	3.4		
Lathyrus sp.	0.2	1.3	0.2	3.4		
Lens culinaris	1.7	20.5	1.3	27.6	1.4	17.6
cf. *Pisum* sp.		1.3				
Vicia ervilia	1.9	26.9	0.7	17.2	0.7	5.9
V. faba	0.2	5.1				
cf. *V. faba*		1.3	0.2	6.9		
cf. *V. sativa*	0.1	3.8				
Vicia sp.			0.1	3.4		
Vicia sp./*Lathyrus* sp.	0.3	3.8	0.1	3.4	1.4	5.9
Leguminosae indet., cultivated	5.2	64.1	2.5	41.4	6.2	44.1
Cereals						
Hordeum vulgare	3.7	23.1	0.7	20.7	0.2	2.9
H. vulgare ssp. *distichon*, rachis		1.3				
cf. *H*. vulgare	0.1	1.3			0.5	8.8
H. vulgare, rachis			0.1	3.4		
Triticum sp.	1.3	23.1	0.6	17.2	0.7	11.8
T. dicoccum	0.4	5.1			0.2	2.9
T. cf. *dicoccum*	0.2	2.6				
T. dicoccum, spikelet	0.1	2.6			0.2	2.9
T. cf. *dicoccum*, glume	0.1	2.6				
T. di./monococcum	0.8	6.4			0.2	2.9
T. di./monococcum, spikelet	0.1	2.6	0.1	3.4		
T. di./monococcum, glume base fragm	0.3	2.6	0.8		1.2	2.9
T. di./monococcum, glume base	0.1	3.8				
T. aestivum, rachis		1.3				
T. durum/aestivum	7.3	30.8	0.8	20.7	1.4	17.6
T. durum/aestivum, rachis						
Cerealia	15.1	73.1	2.4	44.8	6.9	44.1
Cerealia, culm	0.2	3.8				
Fruits						
Pistacia lentiscus	0.2	7.7				
Punica granatum			0.6	6.9	0.2	2.9
Ficus carica	0.4	11.5	0.1	3.4	1.8	23.5
Ficus carica, mineralised	0.1	1.3				
cf. *Ficus* sp.	0.1	1.3	0.5	10.3	0.2	2.9
Olea europaea	5.6	85.9	3.4	65.5	7.8	85.3
Vitis vinifera	11.3	87.2	55.3	89.7	26.1	91.2
Vitis vinifera, mineralised	0.2	3.8	0.5	10.3	0.4	5.9
Vitis vinifera, undeveloped	0.4	9.0	1.1	27.6	1.4	20.6
cf. *Vitis vinifera*					0.2	2.9
Vitis vinifera, undeveloped fruit	0.2	7.7	8.2	17.2	0.7	11.8
Vitis vinifera, pip with remains of fruit	0.2	3.8	0.1	3.4		
Vitis vinifera, pedicel	0.6	14.1	1.7	24.1	0.5	5.9
Other cultivated taxa						

Table 5 (continued)

Occupation period	Early		Middle		Late	
No. of samples/volume (litres)	78/3,021		29/916		34/850	
No. of remains	2,465		843		564	
	%	U	%	U	%	U
Coriandrum sativum	0.1	2.6				
Cucumis sp.		1.3			0.4	2.9
Linum usitatissimum	0.1	2.6			0.2	2.9
Linum usitatissimum, capsule		1.3				
Wild taxa	40.9	10	17.7	89.7	38.8	10

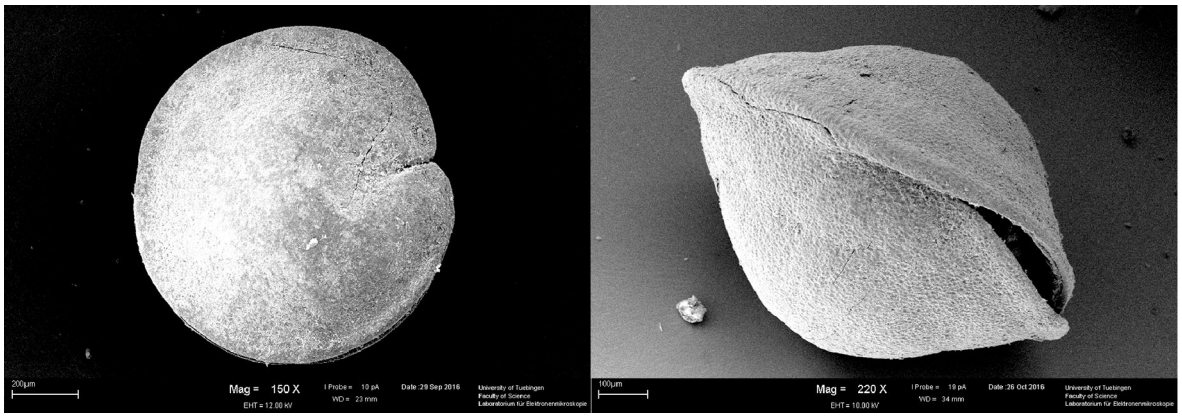

Fig. 5 SEM images of *Chenopodium murale* seeds from the fire pit; left, seed in top view; right, seed in lateral view

(pomegranate), *Hordeum* (barley), *Triticum* (hulled wheat) and *Olea* (olive) in small amounts. Wild plants (6.7%) account for the lowest proportion in all rooms or structures. The charcoal remains are strongly dominated by *Olea* sp. in the samples from Room II.1, making up 61% of the fragments. *Quercus* sp. charcoal also occurs in a large proportion at 35%. Although dominant among the seed and fruit remains, *Vitis* sp. only forms a minor proportion of the charcoal taxa from this room.

A fire pit for the preparation of lime outside the settlement

Compared to the other structures and rooms described above, the number of charred remains from the fire pit samples was enormous. This is due to one sample, which contained more than 1,000 seeds of *Chenopodium murale* (Fig. 5). The data are therefore highly affected by the seeds of this plant with 88.5% wild taxa in this sample. Apart from this, single remains of barley, naked and hulled wheat, grape, fig, pomegranate, lentil, bitter vetch, broad bean and *Cucumis* sp. (cucumber) were found. Charcoal samples from the fire pit contained a large amount of *Quercus* sp. (34%). *Pinus halepensis/brutia* and *Olea* sp. were about equally present (ca. 15%). *Vitis* sp. formed only a small proportion of the charcoal samples from the fire pit (4.5%), while *Ficus* sp. with 1% of the fragments most probably represents a further cultivated taxon. Furthermore, a small proportion of Chenopodiaceae (ca. 2%) was found amongst the charcoal remains, which may relate to the find of *Chenopodium murale* seeds. Besides these, two typical Mediterranean taxa were also present although in small proportion, *Pistacia* sp. (ca. 3%) and *Rhamnus* sp./*Phillyrea* sp. (ca. 6%).

A large basin outside the settlement

The samples from the basin came from the backfill of this feature, which went into the basin after its partial collapse. No sediments were available from the time of its use. There were more cultivated taxa (60.9% proportion of all seeds from the basin; Table 7), of which *Vitis vinifera* is represented by 31.5%, than wild plants (39.1%). The proportions of other seeds and fruits are similar to those from the other contexts. In addition, a few seeds of *Cucumis* sp. (0.6%) were also identified within the fill of the basin. As mentioned above (in the section on trends over time), the charcoal in the samples from the basin fill was dominated by *Vitis* sp. (ca. 37%) and this is the only context from the site so far with such high proportions of grapevine. At least eleven other

Table 6 Charcoal from Tell-el Burak for the early, middle and late occupation periods shown as total fragment percentages per period

Occupation period	Early	Middle	Late (Basin)
	N = 1,052	*N* = 1,577	*N* = 128
	725–600 BCE	600–550/500 BCE	550/500–350 BCE
Dicotyledons			
Acer sp.		0.3	
Amygdalus sp.	0.2		
Arbutus sp.	1.4	0.1	2.3
Calycotome sp./*Genista* sp.		0.1	
Chenopodiaceae	0.3		2.3
Dicotyledon	16.2	3.4	9.4
Ficus sp.	0.5		
Fraxinus sp.	0.1		2.3
Leguminosae	1.1	0.2	1.6
Maloideae	0.1		1.6
Olea europaea	34.0	47.1	6.3
Pistacia lentiscus	2.0	8.9	4.7
Pistacia sp.	0.7	0.4	
Punica sp.	0.1	0.1	1.6
Quercus sp., deciduous	1.0	9.4	
Quercus sp.	23.3	26.4	25.0
Quercus sp., evergreen	2.1	0.2	0.8
Rhamnus sp./*Phillyrea* sp.	0.5		0.8
Tamarix sp.	0.2		
Vitis vinifera	4.3	0.5	36.7
Monocotyledons			
Monocotyledon		0.9	
Phoenix sp.	0.1		
Gymnosperms			
Cedrus sp.	3.7		
Conifer	1.5	1.6	3.9
Conifer without resin ducts	2.2		
Cupressus sp.	1.1		
Juniperus sp.	0.5	0.3	
Larix sp./*Picea* sp.			0.8
Pinus halepensis/brutia	2.9	0.1	
Taxus baccata	0.1		
	10	10	10

charcoal taxa are also present in this context, of which the second most common taxon is *Quercus* sp. (26%). About 6% of the identified charcoal fragments were *Olea* sp., while about 5% were *Pistacia lentiscus*. About 5% coniferous wood charcoal was also found, as well as some typical Mediterranean taxa, like *Arbutus sp*., Leguminosae, Maloideae and *Rhamnus* sp./*Phillyrea* sp., which were present in small percentages and finally very small amounts of *Punica* sp..

Discussion

Comparable archaeobotanical data from other late iron age sites in the region

There are few other data from this region, but recent excavations at the College site at Sidon also provided archaeobotanical remains (de Moulins 2015). Previously, 12 samples from the Iron Age II from different contexts had been published. The density of charred macroremains per sample (0.5 to 5 seeds per litre) was as low as at Tell el-Burak (1.1 seeds per litre; Table 8). The variety of crop

Table 7 Seeds and fruits from Tell el-Burak from selected contexts as percentages of all seeds from each context

Area	3 (Intramural)				4 (Extramural)	
Structure	House 3			Structure II		
Context	Room 3.1	Room 3.2	Room 3.3	Room II.1	Fire pit	Basin
Occupation period	Early	Early	Early	Middle	Early	Late
No. of samples	10	17	9	6	20	13
Volume of sediment (litres)	424	640	395	301	875	538
Total numbers of seeds	144	212	282	584	2,692	317
Pulses						
Cicer arietinum						0.3
Lens culinaris	6.9	2.8		0.5	0.9	0.6
Vicia ervilia	1.4	2.4	1.1		0.2	0.9
V. faba			0.4		0.1	
cf. *V. faba*				0.3		
cf. *V. sativa*			0.4			
Vicia sp./*Lathyrus* sp.		1.4				2.2
Leguminosae indet., cultivated	8.3	4.2	5.3	1.9	0.6	8.2
Cereals						
Hordeum vulgare	2.1	1.4	0.7	0.3	1.1	
Triticum sp.	4.2	1.9	0.4	0.2	0.2	
T. aestivum, rachis			1.1			
T. dicoccum	0.7					
T. cf. *dicoccum*		0.5				
T. dicoccum, spikelet		1.4				
T. cf. *dicoccum*, glume		0.5				
T. di./monococcum, spikelet		3.3	2.5	1.2	0.3	2.2
T. di./monococcum, glume base fragm	4.9				0.1	
T. di./monococcum, glume base	0.7					
T. durum/aestivum	0.7	2.8	4.6		0.7	1.3
Cerealia	5.6	11.3	9.9	0.7	1.9	5.7
Cerealia, culm	0.7		0.7		0.1	
Fruits						
Pistacia lentiscus	0.7					
Punica granatum				0.9	0.1	0.3
Ficus carica		1.9			0.2	1.9
cf. *Ficus* sp.				0.2		0.3
Olea europaea	3.5	8.5	3.2	0.3	0.7	4.7
Vitis vinifera	16.7	14.2	29.4	72.4	3.6	27.4
V. vinifera, mineralised				0.2		
V. vinifera, undeveloped	1.4		1.1	0.7	0.1	1.9
V. vinifera, undeveloped fruit		0.5	0.7	11.6	0.2	1.3
V. vinifera, pip with remains of fruit				0.2		
V. vinifera, pedicel		0.9	1.1	1.7	0.2	0.9
Other cultivated taxa						
Cucumis sp.						0.6
Wild taxa	41.7	40.1	37.2	6.7	88.5	39.1

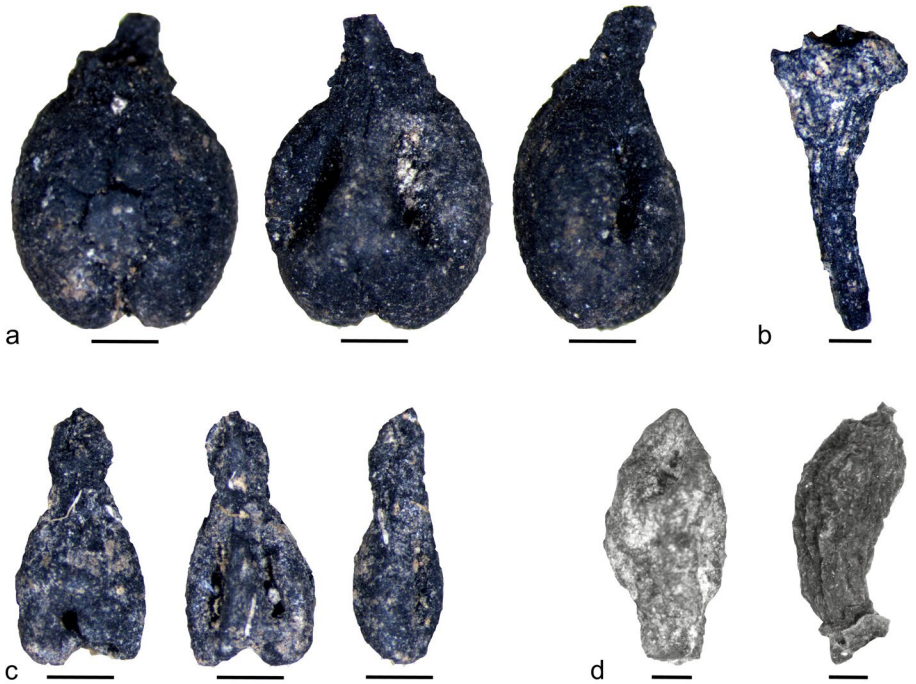

Fig. 6 Finds of *Vitis vinifera* from Tell el-Burak, Room II.1. **a** pips; **b** pedicel; **c** undeveloped pips; **d** left, undeveloped fruit, Tell el-Burak; **d** right, modern reference material from Turkey (Kat. nr. 8527, archaeobotanical reference collection, University of Tübingen), scale bars a, c = 1 mm, b, d = 0.5 mm

Table 8 Comparison of the seed material from Sidon (de Moulins 2015) and Tell el-Burak

	Sidon	Tell el-Burak
Number of seeds	443	6,543
Number of samples	12	161
Volume in l	281	5,662
Number of all taxa	27	141
Number of crop taxa	17	47
Number of wild taxa	10	94
Proportion of grape remains	4%	17.8%

plants was less than at Tell el-Burak, and the samples were mainly cereals such as, for example, free threshing wheat, emmer wheat and barley as well as legumes like lentil, broad bean and *Cicer arietinum* (chickpea). Olive was the second most abundant charred macroremain after cereals, with very large amounts found at Sidon. Compared to Tell el-Burak, the amount of grape pip finds was, however, low. Only ten wild taxa were identified, compared to 94 from Tell el-Burak. Because of the few wild plants in the Sidon assemblage, it is assumed that the crops and especially the cereals had already been cleaned, processed and made ready for trade or consumption when they arrived at the site (de Moulins 2015).

At another site, Tyre-al Bass, among several samples from an Iron Age cemetery, 24 seeds were identified as grape, which was the most strongly represented and abundant species. Only one barley and two unidentifiable cereal grains represented the remaining crops. Wild plants were not listed (Rovira 2015).

Other archaeobotanical data from Iron Age sites are unfortunately not available. The differences between the archaeobotanical assemblages of Tell el-Burak and Sidon affirm the high significance of *Vitis vinifera* at Tell el-Burak.

Deposition of the archaeobotanical material, taphonomy

According to archaeological analysis, Rooms 3.1 and 3.2 (early occupation period) were used for storage. The amount of archaeobotanical material there was low compared to other contexts (Table 7). The major taxa of cultivated legumes, cereals, grape and wild plants are almost equally distributed in both rooms. The charred macroremains probably do not represent the products stored in the many storage jars, but they were most probably residues from the roof, which crashed down and smashed the storage jars into thousands of sherds at the end of the early occupation period (Kamlah 2016). This also explains the presence there of wood charcoal from various taxa.

The distribution of the taxa in Room 3.3 resembles that of Rooms 3.1 and 3.2, but *Vitis vinifera* seed remains and *Vitis* sp. charcoal have a higher presence in Room 3.3. Residue analyses of the crushed amphorae in the storage rooms 3.1 and 3.2 are still in progress.

The remains found in the fire pit are dominated by *Chenopodium murale* (Table 7). This plant grows mainly in disturbed habitats and, as the name *murale* indicates, on

walls and building rubble. Therefore, the masses of goosefoot seeds are not surprising and they probably got into the fire pit after the abandonment of the site, when the enclosure wall went out of use. The concentration of *C. murale* seeds might have been stored by rodents or insects which had brought the seeds into the context (Cappers and Neef 2012). Remains of cultivated taxa were only found in small amounts.

More than half of the macroremains from the middle occupation period came from Room II.1. They are dominated by grape (Table 7), resulting in the high proportion of *Vitis vinifera* in the period. This fact has to be kept in mind when comparing these changes in proportions of crops through time. There was, however, no increased presence of *Vitis* sp. charcoal in Room II.1, and there is a general decrease in *Vitis* sp. percentages in the middle occupation period. Comparative data from the sites Komboloi, Timna and Aphek (see below) support the interpretation of the deposition of the various grape remains from Room II.1.

The grape remains from Hellenistic Komboloi, Greece (Margaritis and Jones 2006) can be taken as comparative material to explain the large amount of *Vitis* remains inside Room II.1. At Komboloi the filling of a large pithos (storage jar) and the sediment in its near vicinity revealed a large amount of charred grape remains represented by pips, endosperms, pedicels, parts of whole grapes and fragments of pressed skins. Moreover, ethnobotanical observations in Greece performed by Margaritis and Jones (2006) accompanied by the sampling of material from the different steps of wine making provided significant reference material to help interpretation of this find. The samples from Room II.1 also contained many grape pips and few pedicels. According to Margaritis and Jones (2006), these by-products derive from the sieving of the must, or grape juice, when it is poured from the treading pit (where the grapes are crushed) into the vat; in the case of Tell el-Burak, from the treading floor into the basin. The ethnobotanical observations in Greece showed that despite sieving, remains of pips, pedicels and skin fragments can flow into the vat (Margaritis and Jones 2006). Therefore, the remains from Tell el-Burak probably represent the by-product of making grape juice (wine must) which came from the cleaning out of the basin and which was kept for fuel or fertilizer (Margaritis and Jones 2006).

At Site 34 in the Timna valley, Israel, which is situated in the Arava desert and dates to the late 11th to 10th century BC (Ben-Yosef 2016; Ben-Yosef et al. 2017), masses of charred grape pips were found inside intact pieces of dung from large and medium mammals, north and south of the excavated entrance complex (Area G). The frequency of donkey bone remains in the skeletal assemblage suggests that most of the dung remains were theirs. Donkeys were kept as pack animals for the tin mining and they were fed with the residue of pressed grapes and then the resulting droppings were used as fuel in the smelting furnaces at the site. However, remains indicating wine making have not yet been found at Timna (Ben-Yosef et al. 2017).

At LBA Aphek, Israel, thousands of *Vitis vinifera* remains such as pips, skin fragments, undeveloped pips, fruit stalk fragments and pedicels were found on a plastered floor behind an outer wall of Palace VI (Kislev and Mahler-Slasky 2009). Presumably, the composition of the grape finds, especially the fruit stalk fragments as well as the frequency with which they were found, are indicative of residues from grape pressing according to the comparative material provided by Margaritis and Jones (2006). According to Kislev and Mahler-Slasky (2009), the grape remains were dried and then used as fodder, or as fertilizer for the nearby fields.

The *Vitis* remains from Room II.1 at Tell el-Burak consist of many grape pips and a few small plant parts like undeveloped pips, undeveloped fruits and pedicels (Table 7). This composition might indicate burning of the grape pressing residue rather than in dung. Additional indications of dung burning such as typical remains of fodder including seeds of *Trifolium*, various pulses, barley and chaff remains of hulled wheat (Jones 1998; Valamoti and Charles 2005) are only present in small amounts compared to the grape finds (Table 7; ESM 1), which do not allow firm conclusions whether dung was burnt at all.

Nearly half of the archaeobotanical remains from the layers of basin fill were grape pips, but cereals and legumes were represented only in smaller amounts (Table 7). The basin fill was also dominated by *Vitis* sp. charcoal and small percentages of *Olea* sp. charcoal, which may relate to the function of the basin, but does not necessarily suggest a reduction in *Olea* cultivation during the late phase, as indicated by the presence of olive stones. Compared to the other rooms, the macroremains revealed a greater variety of finds, including cultivated plants such as pomegranate and fig.

Phoenician agriculture

Although the state of preservation of the archaeobotanical remains was not good compared to other archaeological sites, thanks to the special efforts given to the archaeobotanical investigations of the 161 samples from the Phoenician settlement it is possible to draw conclusions about the function of Tell el-Burak and its environment. The comparison of the archaeobotanical results from the seeds and the charcoal shows similarities as well as differences. Grape pips were the most numerous and ubiquitous seeds at Tell el-Burak, and *Vitis* sp. charcoal had fairly high fragment percentage values as well as a high ubiquity at the site. However, olive and oak charcoal had considerably higher fragment percentages and were present in more samples. We see opposite results for olive remains, as the proportion of stone finds is low, although the ubiquity reaches almost that of *Vitis*

vinifera. Moreover, the importance of *Olea* sp. at the site is underlined by the fact that olive was most strongly represented in charcoal. *Punica granatum* and *Ficus carica* were represented amongst the seed material as well as *Punica* sp., and *Ficus* sp. among the charcoal, suggesting that both, pomegranates and figs, were locally cultivated even though they were only present in small proportions and with a low ubiquity. As mentioned above, *Pistacia lentiscus* was also found among the charcoal and was present in rather large percentages and ubiquities in contrast to the few finds of *P. lentiscus* nuts; local cultivation might have been possible.

Away from the orchards and cultivated fields on the coastal plain, the vegetation would have consisted of maquis scrub with isolated trees (Marriner et al. 2004). Typical eu-Mediterranean taxa, found as charcoal, that probably grew locally on the plain or in the adjacent hill country surrounding Tell el-Burak consisted of *Quercus* sp., *Pistacia* sp., *Amygdalus* sp., *Arbutus* sp., Maloideae, *Calycotome* sp./*Genista* sp., *Rhamnus* sp./*Phillyrea* sp., Leguminosae, *Juniperus* sp. and *Pinus halepensis/brutia*. All other coniferous woods, according to their present day distribution, had most probably been brought to the site from further north and/or northeast. The nearest *Cedrus* sp. stands, for example, today occur about 50 km northeast of Tell el-Burak, while *Abies* sp. today is found only in the north of Lebanon (Talhouk et al. 2001). The occurrence of proportionally more conifers during the early occupation period of the site, in comparison to the later periods, may relate to the fact that the place was probably constructed in a single concentrated effort during the early occupation period. In its later phases, less effort was put into building at the site and in turn, less coniferous wood waste was present.

Wine making at Tell el-Burak

The large basin on the hill slope outside the settlement dating to the late occupation period demonstrates a lively and ongoing community thriving from production and trade. The plastered basin was most probably used for wine making and with a capacity of 5,500 l, it was too large for simple household requirements, but was more than adequate for intensive wine production. Recent excavation works have uncovered the whole extent of the basin. In addition, on its northern side a spacious treading platform was found (H. Sader, personal communication).

Similar features with wine presses were excavated at Ashkelon and Tel Michal. The winery at Ashkelon (building 776, grid 38) incorporated four wine presses, each consisting of a treading pool and a vat (Stager et al. 2011). The vats were built with cobblestone walls, which were covered with white plaster. The winery, however, was destroyed along with the rest of the settlement during Nebuchadnezzar's campaign in 604 BC (Stager et al. 2011). The wine presses were unfortunately not sampled, yet thousands of grape remains which were found in Grid 50 in the so-called market place resemble by-products of wine making similar to those at Tell el-Burak. More than 20,000 grape pips were accompanied by pedicels and a few undeveloped pips (Weiss and Kislev 2004; Weiss et al. 2011). The grape assemblage was supplemented by raisins, which were not found at Tell el-Burak.

The potential wine press at Tell el-Burak is situated outside the walled settlement, as at Tel Michal, where four wine presses were located about 180 m outside the Iron Age IIA settlement (Herzog 1989). Although the construction of the Ashkelon and Tel Michal wine presses is slightly different from the Tell el-Burak basin, its size and construction both point to its use as a wine pressing vat.

The high proportion and high ubiquity of grape pips in all phases point to wine making as a major economic activity. The importance of *Vitis vinifera*, its processing into wine and the trading of this commodity resembles a similar site on the shore of the Mediterranean near Ashdod. In 2006–2007, two areas of this site were excavated at the southern beach of Ashdod near the city tell of Ashdod, Israel (Nahshoni 2013; Melamed 2013). Area A (13th century BC) revealed some oval structures which were cut into the Kurkar bedrock. Based on the archaeobotanical record with about 95% of *Vitis vinifera* finds of pips, fruit remains and pedicels, these features were interpreted as wine presses. In Area B (13th century BC), a complex of buildings was found. About 18,000 finds of *Vitis vinifera* pips, fruit remains, pedicels and unfertilized flowers were recorded in two rooms of this building. Although these structures and finds at the southern beach of Ashdod date to the 13th century BC, they are comparable to the ones from Tell el-Burak for the following reasons: First, the great variety of plant parts from *Vitis vinifera* is very similar at both sites. Second, both sites are located near the Mediterranean shore. Finally, both settlements show signs of maritime trade, such as imported pottery fragments (Melamed 2013; Nahshoni 2013; Schmitt 2016). The site at the southern beach at Ashdod has been interpreted as an administrative complex connected with a wine production centre outside the ancient city of Ashdod. The location benefits from its closeness to vineyards and to the Mediterranean, which favoured sea trade (Melamed 2013). Therefore, there may also have been a similar function and a very specific use of agricultural resources at the Phoenician settlement of Tell el-Burak controlled by the city of Sidon or Sarepta. Cultivation of grapes was certainly possible both near the settlement and on the slopes of the hill country (Orendi 2016). A pollen core that covers the 1st millennium BC from near Sidon underlines the importance of *Olea* sp.

and *Vitis* sp. cultivation on the coastal plain there (Marriner et al. 2004).

The trade in wine from Sidon is also known from written sources. A papyrus from southern Egypt dating to the end of the 5th century BC lists the inventory of an Egyptian household on the Nile island of Elephantine and mentions among other things, wine from Sidon (Kamlah 2016).

Olive oil production at Tell el-Burak

Olive oil was probably also pressed and stored at Tell el-Burak, but the proportion of olive stones was not as high as the presence of the other crop plants. On the other hand, the ubiquity of olive remains nearly reached the values shown by *Vitis vinifera* and *Olea* sp. charcoal, which dominated these remains in the overall records of all periods, indicating the importance of olive for the economy of the site.

As a comparison, crushed olives and features related to olive oil production were found at Early Bronze Age (EBA) Tel Yarmouth in the southern Levant, where 67% of the charcoal fragments identified were from *Olea* sp. (Salavert 2008). This percentage is higher than at Tell-el Burak, but the samples from Tel Yarmouth also came from contexts related more clearly to olive oil production, which at Tell el-Burak probably may have taken place in a different part of the site.

Tell el-Burak was not an independent town, but it was possibly part of a greater settlement system controlled by the city of Sidon. The archaeological remains, as well as the archaeobotanical results, may indicate the function of Tell el-Burak as an agricultural centre. First, the basin was probably intended for the commercial production of wine and second, the numerous storage jars found in Rooms 3.1 and 3.2 point to a flourishing centre of trade. It is assumed that Tell el-Burak used the regional agricultural resources for production, and the temporarily stored products like wine or olive oil were then used for local as well as long distance maritime trade.

Conclusions

As Tell el-Burak is situated directly on the coast, it was a perfect location for local production and trade nearby as well as overseas. The study of plant macroremains suggests that the site specialized in the production of wine, and probably also olive oil for long distance trade, between the 8th and 4th century BC. The comparison with data from other coastal sites in the southern Levant provides further proof of the importance of Tell el-Burak as a centre for wine production and commercialization during the Iron Age. The changes in the seed material through time reveal that *Vitis vinifera* was the dominant crop at least from the 6th century BC onwards, while the detailed investigations of single contexts complete the archaeological assumptions of their use and function. The results of the seed and charcoal analyses certainly complement each other. Both show similarities in the economic importance of grapes and olives at Tell el-Burak and the possible local cultivation of other fruit trees like fig and pomegranate. The differences in the results from the seed and the charcoal analyses are mainly connected to the state of preservation of the two materials. The present study not only improves our understanding of the ecology and the agricultural system of the core Phoenician territory, but also shows that close collaboration between archaeology and archaeobotany allows better interpretations of the function of features and structures discovered at archaeological sites.

Acknowledgements This study is part of the SFB 1070 ResourceCultures (Project A05) of the University of Tübingen and was funded by the Deutsche Forschungsgemeinschaft (German research agency). We would like to thank Jens Kamlah and Simone Riehl for their continuous support and critical reading of first drafts of this paper. Many thanks go to Hélène Sader, Aaron Schmitt and the whole team of the Tell el-Burak project. We are also grateful for the comments of two anonymous reviewers that helped us to improve this paper.

References

Asouti E, Austin P (2005) Reconstructing woodland vegetation and its exploitation by past societies, based on the analysis and interpretation of archaeological wood charcoal macro-remains. Environ Archaeol 10:1–18

Aubet MA (2014) Phoenicia during the Iron Age II period. In: Steiner ML, Killebrew AE (eds) The Oxford handbook of the archaeology of the Levant. Oxford University Press, Oxford, pp 707–716

Baas J (1980) Ein bedeutsamer botanischer Fund der Gattung *Echium* Linné aus Kamid el-Loz. In: Hachmann R (ed) Bericht über die Ergebnisse in Kamid el-Loz in den Jahren 1968 bis 1970. (Saarbrücker Beiträge zur Altertumskunde 22) Habelt, Bonn, pp 111–115

Behre K-E (1970) Kulturpflanzenreste aus Kamid el-Loz. In: Hachmann R (ed) Bericht über die Ergebnisse der Ausgrabungen in Kamid el-Loz (Libanon) in den Jahren 1966 und 1967. (Saarbrücker Beiträge zur Altertumskunde 4) Habelt, Bonn, pp 59–69

Ben-Yosef E (2016) Back to Solomon's era: Results of the first excavations at Slaves' Hill (Site 34, Timna, Israel). BASOR 376:169–198

Ben-Yosef E, Langgut D, Sapir-Hen L (2017) Beyond smelting: New insights on Iron Age (10th c. BCE) metalworkers community from excavations at a gatehouse and associated livestock pens in Timna, Israel. J Archaeol Sci Reports 11:411–426

Bondì SF (1995) Le commerce, les échanges, l'économie. In: Krings V (ed) La civilisation Phénicienne et Punique. Brill, Leiden, pp 268–281

Cappers RTJ, Neef R (2012) Handbook of plant palaeoecology. (Groningen Archaeological Studies 19) Barkhuis, Groningen

Crivellaro A, Schweingruber FA (2013) Atlas of wood, bark and pith anatomy of eastern Mediterranean trees and shrubs: with a special focus on Cyprus. Springer, Berlin

De Moulins D (2009) Sidon: Grain from the storerooms. Archaeol History Lebanon 29:11–15

De Moulins D (2015) Plant remains from Middle Bronze Age to Iron Age: Samples of the College site, Sidon. Archaeol History Lebanon 42/43:32–54

De Moulins D, Marsh A (2011) Sidon: Plant remains from the Middle Bronze Age. Archaeol History Lebanon 34/35:236–258

Fahn A, Werker E, Baas P (1986) Wood anatomy and identification of trees and shrubs from Israel and adjacent regions. The Israel Academy of Sciences and Humanities, Jerusalem

Gale R, Cutler D (2000) Plants in archaeology. Identification manual of vegetative plant materials used in Europe and the southern Mediterranean to c. 1500. Westbury and Royal Botanic Gardens, Kew, Otley

Herzog Z (1989) A complex of Iron Age winepresses (Strata XIV-XIII). In: Herzog Z, Rapp G, Negbi O (eds) Excavations at Tel Michal, Israel. University of Minnesota Press, Minneapolis, pp 73–75

Isserlin BSJ (1983) Phoenician and Punic settlement and agriculture: some archaeological considerations. In: Bartoloni P, Bondì SF (eds) Atti del I Congresso Internazionale di Studi Fenici e Punici, vol 1. Consiglio Nazionale Delle Ricerche, Rome, pp 157–163

Jacomet S (2006) Bestimmung von Getreidefunden aus archäologischen Ausgrabungen, 2nd edn. IPNA, Basel

Jones G (1998) Distinguishing food from fodder in the archaeobotanical record. Environ Archaeol 1:95–98

Kamlah J (2006) Sakraler Baum und mythische Jagd. Zur ikonographischen Verbindung zweier mythologischer Motive auf einem eisenzeitlichen Rollsiegel aus Phönizien. Baghdader Mitteilungen 37:549–563

Kamlah J (2016) Südlich von Sidon. Forschungen zu regionalen Ressourcen einer phönizischen Hafenmetropole. Antike Welt 2016/4:40–48

Kamlah J, Sader H, Schmitt A (2016a) The Tell el-Burak archaeological project: preliminary report on the 2011, 2013, and 2014 Seasons in Area 3. Bulletin d'Archéologie. et d'Architecture Libanaises/BAAL 16:79–130

Kamlah J, Sader H, Schmitt A (2016b) A cultic installation with a standing stone from the Phoenician settlement at Tell el-Burak. Berytus 55:135–168

Kislev ME, Mahler-Slasky Y (2009) Food remains. In: Gadot Y, Yadin E (eds) Aphek-Antipatris II. The remains on the Acropolis, the Moshe Kochavi and Pirhiya Beck excavations. Emery and Claire Yass Publications in Archaeology, Tel Aviv, pp 499–525

Margaritis E, Jones M (2006) Beyond cereals: crop processing and *Vitis vinifera* L. Ethnography, experiment and charred grape remains from Hellenistic Greece. J Archaeol Sci 33:784–805

Markoe G (2000) Phoenicians: people of the past. British Museum Press, London

Marriner N, de Beaulieu J-L, Morhange C (2004) Note on the vegetation landscapes of Sidon and Tyre during Antiquity. Archaeology History in the Lebanon 19:86–91

Marston JM (2009) Modeling wood acquisition strategies from archaeological charcoal remains. J Archaeol Sci 36:2,192–192,200

Melamed Y (2013) Botanical remains of the excavation on the Southern Beach of Ashdod. 'Atiqot 74:127–131

Mouterde PSJ (1966) Nouvelle flore du Liban et de la Syrie: Texte. Éditions de l'Imprimerie Catholique, Beirut

Nahshoni P (2013) A 13th-century BCE site on the Southern Beach of Ashdod. 'Atiqot 74:59–122

Neef R, Cappers RTJ, Bekker RM (2011) Digital atlas of economic plants in archaeology. Barkhuis, Groningen

Nesbitt M (2008) Identification guide for Near Eastern grass seeds. Left Coast Press, London

Neumann M (2016) Structures I and II at Tell el-Burak in their Levantine context. Bulletin d'Archéologie. et d'Architecture Libanaises/BAAL 16:119–122

Orendi A (2016) Agricultural resources of the Phoenician settlement at Tell el-Burak: A preliminary report on the archaeobotanical investigations. Bulletin d'Archéologie. et d'Architecture Libanaises/BAAL 16:123–130

Riehl S (in press) Flourishing surplus economy in coastal lands: Archaeobotany and stable carbon isotopes. In: Genz H (ed) Tell Fadous-Kfarabida I: The site and its environment

Riehl S, Deckers K (2007) Plant remains. In: Badreshany K, Genz H, Sader H (eds) The AUB Tell Fadous (Kfarabida) rescue project - a preliminary report on the 2004 season. Bulletin d'Archéologie et d'Architecture Libanaises/BAAL 9:84–88

Riehl S, Deckers K (2010) The botanical finds from the 2007 and 2008 seasons of excavations. In: Genz H (ed) Excavations at Tell Fadous-Kfarabida: Preliminary report on the 2009 seasons of excavations. Bulletin d'Archéologie et d'Architecture Libanaises/BAAL 13:110–116

Rovira N (2015) Les grains et les fruits. BAAL Hors-Série 9:487–501

Sader H, Kamlah J (2010) Tell el-Burak: A new Middle Bronze Age site from Lebanon. Near East Archaeol 73:130–141

Salavert A (2008) Olive cultivation and oil production in Palestine during the Early Bronze Age (3500–2000 BC): the case of Tel Yarmouth, Israel. Veget Hist Archaeobot 17:53–61

Schmitt A (2016) A preliminary report on the Iron Age pottery from Area 3. Bulletin d'Archéologie. et d'Architecture Libanaises/BAAL 16:105–118

Schweingruber FH (1990) European wood anatomy. Haupt, Bern

Shackleton CM, Prins F (1992) Charcoal analysis and the principle of least effort - a conceptual model. J Archaeol Sci 19:631–637

Smart TL, Hoffman ES (1988) Environmental interpretation of archaeological charcoal. In: Hastorf CA, Popper VS (eds) Current palaeoethnobotany. University of Chicago Press, Chicago, pp 165–205

Spanò Giammellaro A (1999) The Phoenicians and the Carthaginians: The early Mediterranean diet. In: Flandrin J-L, Montanari M (eds) Food: a culinary history from antiquity to the present. Columbia University Press, New York, pp 55–65

Stager LE, Master DM, Schloen JD (2011) Ashkelon 3. The 7th century BC. Final reports of the Leon Levy expedition to Ashkelon. Harvard Semitic Museum Publications, Eisenbrauns

Talhouk SN, Zurayk R, Khuri S (2001) Conservation of the coniferous forests of Lebanon: past, present and future prospects. Oryx 35:206–215

Théry-Parisot I, Chabal L, Chrzavzez J (2010) Anthracology and taphonomy, from wood gathering to charcoal analysis: A review of the taphonomic processes modifying charcoal assemblages in archaeological contexts. Palaeogeogr Palaeoclimatol Palaeoecol 291:142–153

Valamoti SM, Charles M (2005) Distinguishing food from fodder through the study of charred plant remains: an experimental approach to dung-derived chaff. Veget Hist Archaeobot 14:528–533

Van Gucht W (1992) Agriculture. In: Lipiński E (ed) Dictionnaire de la civilisation Phénicienne et Punique. Brépols, Turnhout, pp 9–10

Van Dommelen P, Bellard CG (2008) Rural landscapes of the Punic world. (Monographs in Mediterranean Archaeology 11) Equinox, London

Verheyden S, Nader FH, Cheng HJ, Edwards LR, Swennen R (2008) Paleoclimate reconstruction in the Levant region from the geochemistry of a Holocene stalagmite from Jeita cave, Lebanon. Quat Res 70:368–381

Weiss E, Kislev ME (2004) Plant remains as indicators for economic activity: a case study from Iron Age Ashkelon. J Archaeol Sci 31:1–13

Weiss E, Kislev ME, Mahler-Slasky Y (2011) Plant remains. In: Stager LE, Master DM, Schloen JD (eds) Ashkelon 3: the seventh century BC final reports of the Leon Levy expedition to Ashkelon. Harvard Semitic Museum Publications, Eisenbrauns, Winona Lake, pp 591–613

Wolfart R (1967) Syrien und Libanon. (Beiträge zur Regionalen Geologie der Erde 6) Bornträger, Berlin