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ORIGINAL ARTICLE

Olive cultivation and oil production in Palestine during the early Bronze Age (3500–2000 B.C.): the case of Tel Yarmouth, Israel

Aurélie Salavert

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Abstract Identification of numerous remains (stones, seeds, charcoal) of *Olea europaea* (olive) at the early Bronze Age site of Tel Yarmouth, Israel, shows the importance of olives in the local economy. Production of olive oil is indicated by the presence of crushed olive stones as well as an oil extracting area. The role of olive oil production in the Levantine area and at Tel Yarmouth in particular during the early Bronze Age is discussed.

Keywords Olea europaea · Jif · Charcoal · Early Bronze Age · Tel Yarmouth · Palestine

Introduction

Olea europaea L. (olive tree) is an emblematic plant of the Mediterranean basin, symbolising strength, peace and longevity as well as playing an important role in local economies (Domont and Montelle 2003). For some years, the domestication process of this species has been subject to intensive research through molecular studies, morphometry and archaeobotany (Liphschitz et al. 1991; Terral et al. 2004; Terral et al. 2005a, b; Besnard and Bervillé 2005; Elbaum et al. 2006). DNA analysis has confirmed that the wild ancestor of the cultivated olive is *Olea oleaster* (Mediterranean oleaster) (Besnard and Bervillé 2005), present in the eastern Mediterranean area since the Pleistocene as shown by palynological data (Bottema cited in Neef 1990).

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A. Salavert (✉)
UMR 7041, Archéologie et Sciences de l'Antiquité (ArScAn), CNRS, 21 allée de l'Université, 92023 Nanterre cedex, France
e-mail: aureliesalavert@hotmail.com

The earliest evidence for the use of wild olives dates to the Palaeolithic at Ohalo II at ca. 19000 B.P. (Kislev et al. 1992). Gathering of wild olives is further attested during the Natufian and early Neolithic periods at Nahal Oren (Noy et al. 1973), with the first evidence of olive oil production found at submerged sites along the Carmel coast ca. 6,500 years ago (Galili et al. 1997). Actual cultivation of olives is considered by most authors to have begun during the Chalcolithic (Zohary and Spiegel-Roy 1975; Neef 1990; Frankel 1999; Zohary and Hopf 2000) when the presence of wood and/or fruits of olive is recorded at several sites in the Levant, for example at Rasam Harbush in the Golan (Liphschitz et al. 1991; Frankel 1999), Teleilat Ghassul north of the Dead Sea (Neef 1990) and at Tel Saf (Gophna and Kislev 1979), Abu Hamid and Tell es Shuna in the Jordan valley (Neef 1990; Zohary and Hopf 2000). However, some researchers interpret these finds as the result of continuous use of wild oleasters and prefer to place the beginning of olive cultivation somewhat later, in the early Bronze Age, when olive remains, both charcoal and stones, become more abundant at sites such as at Tel Erani, Tel Qashish and Tel Taanach (Liphschitz et al. 1991, Table 2).

This paper discusses olive cultivation in early Bronze Age Palestine, illustrating by the example of Tel Yarmouth. The role of olive oil production at local and regional scale is discussed in the context of the emergence of urban societies in the Levant during the third millennium B.C.

The site of Tel Yarmouth

Archaeological remains

Tel Yarmouth, situated 25 km southwest of Jerusalem (Fig. 1), has been excavated since 1980 under the direction of Pierre de Miroschedji (Centre Français de recherche de

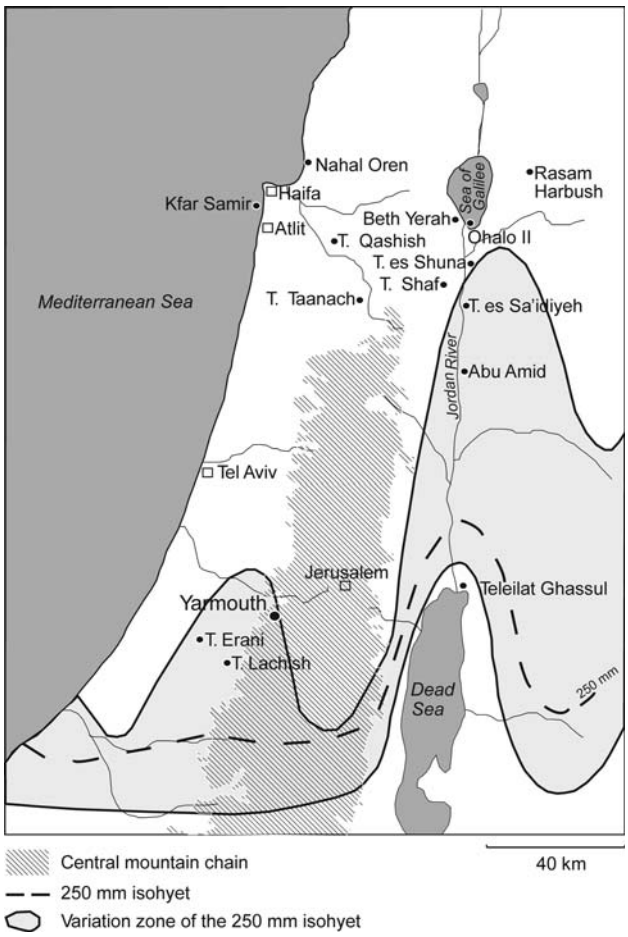

Fig. 1 Location of the semi-arid zone and sites mentioned in the text

Jérusalem). The site is 640 m long and 420 m wide and covers an area of around 16 ha. It is divided into an acropolis (1.5 ha) and a lower city (Fig. 2; de Miroschedji 1999). While the acropolis reaches 405 m a.s.l., the lowest point of the city is at 290 m a.s.l. The topography of Tel Yarmouth is characterised by a succession of large terraces surrounding the acropolis, as well as a deep gully that could have been used to canalise flowing water towards a reservoir (de Miroschedji 1999). The entire city is surrounded by a 1.8 km long fortification wall (Nodet 1988).

Tel Yarmouth was first occupied in the early Bronze Age I (3500–3100 B.C.). Little is known about this early phase in which the site was a non-fortified village (Sebag 2005). During the early Bronze Age II (3100–2700 B.C.) the site grew into a regional urban centre, surrounded by a fortification wall. The early Bronze Age III (2700–2300 B.C.), contemporary with the Old Kingdom in Egypt and Sumerian dynasties in Mesopotamia, constitutes the "golden age" of Tel Yarmouth. The appearance of monumental architecture and the differentiation of urban space into specific quarters where different activities took place (political, religious, crafts, residential areas) date to this period. Occupation ceased during the early Bronze Age IIIC phase (ca. 2300 B.C.) but traces of some activity exist for the middle Bronze Age II (17th/16th century B.C.). The acropolis was finally reoccupied from the late Bronze Age (14th/13th century B.C.) to Byzantine times when Tel Yarmouth was finally abandoned (de Miroschedji 1999).

Present-day environment

Tel Yarmouth is located in the gently sloping region of the Shephelah, delimited by the Judean mountains to the east and the coastal plain to the west. The river Soreq forms the northern border of the region that stretches to 10 km south of Tel Laschich (Nodet 1988) (Fig. 1). Mean annual rainfall in this region is around 500 mm and the mean annual temperature is around 20.5°C according to measurements taken at the meteorological station at Beit Jimal, 360 m a.s.l., 2 km from Tel Yarmouth (Goldberg 1988). Nevertheless, the isohyet of 250 mm rainfall, usually considered to mark the transition from semi-arid to arid conditions, is not very far south of Tel Yarmouth. As today this isohyet fluctuates from one year to another, Tel Yarmouth can be considered to suffer rather unstable climatic conditions that may have affected past agricultural and social systems (Fig. 1) and may have contributed to soil degradation and erosion. It is difficult to know whether mean annual rainfall fluctuations occurred during the EBA and if they would have had an impact on olive cultivation at Tel Yarmouth. According to Rosen (1991, 1995), geomorphological and alluvial data indicate that there was more rainfall during the early Bronze Age than today. In this case, the use of an irrigation system to maintain olive groves would not have been essential even during the driest years. More arid conditions seem to have appeared at the end of the EBA in the Near East area around 2250 B.C. (Riehl and Bryson 2007). Rosen (1991) notes this phenomenon in the Shephelah region as well, at the time of the abandonment of Tel Yarmouth and other sites (de Miroschedji 1999). Baruch (1986) has detected a decrease of olive cultivation at the same period in the pollen records in the area of the Sea of Galilee. An increase in aridity around 2250 B.C. could indeed have had an impact on olive cultivation and perhaps even have led to the abandonment of Tel Yarmouth, but we do not have enough evidence to establish this hypothesis.

Two types of soils exist around the site, alluvial and colluvial soils in the valley bottoms and different types of rendzinas on the plateau. Natural wells and water sources concentrate in the Wadi Boulos (Goldberg 1988; Nodet 1988; Nir 1975).

Present vegetation around Tel Yarmouth is characterised by the presence of *Ceratonio-Pistacietum lentisci* type associations (Zohary 1982). Isolated *Ceratonia siliqua*

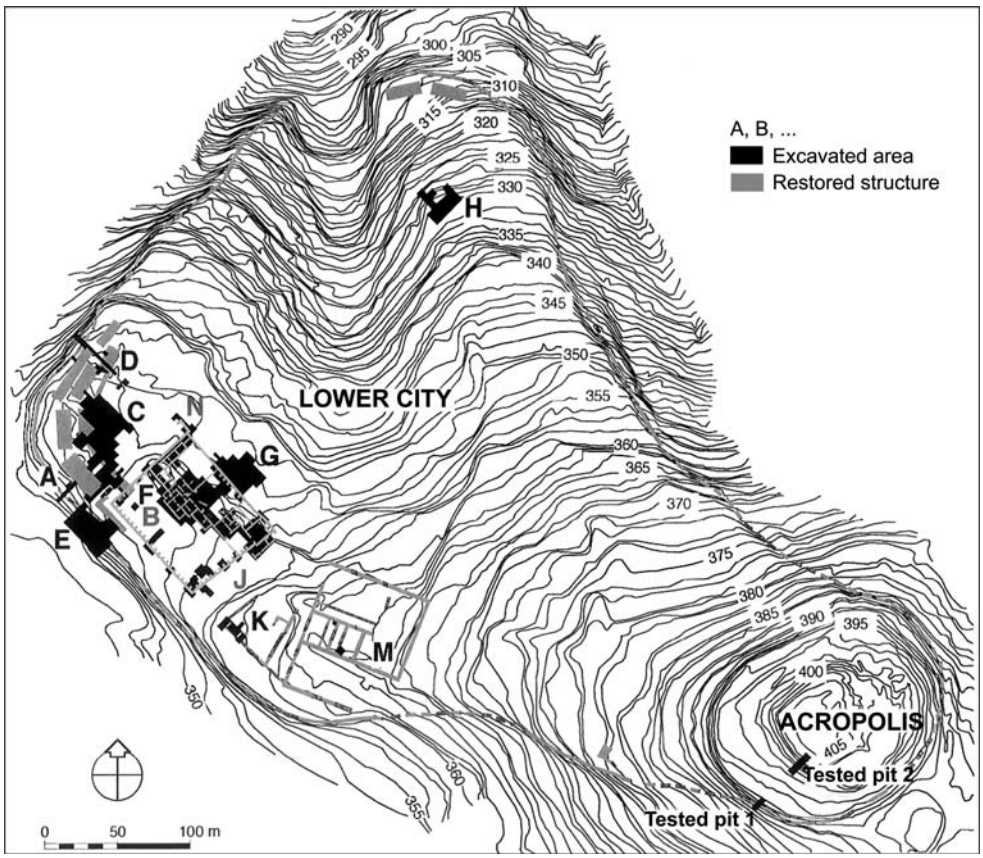

Fig. 2 The site of Tel Yarmouth (from de Miroschedji 1999, Fig. 1)

(carob trees) are surrounded by a scrub dominated by *Pistacia lentiscus* and *Rhamnus palaestina* (syn. *R. lycioides* ssp. *graecus*). Other species belonging to this association are *Olea europaea* var. *oleaster*, *Ephedra campylopoda*, *Salvia triloba*, *Phillyrea media* and *Asparagus aphyllus* (Danin 1983).

Materials and methods

Archaeobotanical remains were recovered from 27 sediment samples by flotation during the 2004 excavation season. These included 14 samples collected from excavation area C situated in the western part of the site and consisting of a succession of domestic buildings, the oldest dating from the early Bronze Age II. Area C was sampled in 1984, 1987 and 1989 without recording sample volumes and extraction techniques, but provided the only evidence for plant use from the EB II occupation. New samples were also collected and processed during the 2004 season from newly excavated ashy layers corresponding to occupation levels within buildings in excavation areas B and J (Salavert 2005).

Area B was located in a palatial complex in the south-eastern part of the site and adjacent to a group of domestic dwellings. Palace B dates to the early Bronze Age IIIC (ca. 25th century B.C.) but was constructed on the remains of an older "proto-palace" building dated to an earlier phase of the same period. A total of 274.5 litres of sediments and three samples were retrieved from two distinct layers in area B: one belongs to the EBA IIIC (L.89) and one corresponds to proto-palace occupation (L.2632). Ashy layers were associated with numerous animal bone fragments, which suggest that cooking activities and/or food preparation activities took place in this room.

Settlement area J, dated by pottery to the early Bronze Age IIIB, had been destroyed by fire. It corresponds to a domestic context with a succession of little rooms. A total of 836 litres of sediment and ten *loci* were sampled there in 2004.

Carbonised macro-remains (seeds, fruits and wood charcoal) were extracted from the surrounding sediment by manual (bucket) flotation using 1–4 mm meshes. They were studied in the archaeobotanical laboratory of the *Maison de l'Archéologie et de l'Ethnologie* (UMR 7041-CNRS, Nanterre, France). Charcoal fragments were

Table 1 Charcoal results from Tel Yarmouth

	Area B				Area J				Sum	
	L. 89 Level 1 EB IIIC		L. 2632 Level 2 Proto-palace		L.2137 1–2 Level 2 EB IIIB		L.2104 Level 2 EB IIIB			
Sediment volume (l)	28.5		123		159		304		614.5	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
Olea europaea	110	76.92	101	67.33	68	67.32	21	40.38	300	67.26
Quercus sp.	9	6.29	21	14	10	9.9	17	32.69	99	22.19
Quercus sp. (deciduous)	4	2.79	8	5.33	5	4.95	–	–		
Quercus sp. (evergreen)	12	8.39	5	3.33	8	7.92	–	–		
Pistacia sp.	4	2.79	1	0.66	5	4.95	3	5.76	13	2.91
Amygdalus sp.	1	0.69	1	0.66	–	–	1	1.92	3	0.67
Fraxinus sp.	2	1.39	4	2.66	–	–	1	1.92	7	1.56
Phillyrea latifolia/Rhamnus sp.	–	–	–	–	2	1.98	1	1.92	3	0.67
Prunus spp.	–	–	6	4	3	2.97	–	–	9	2.01
Tamarix sp.	1	0.69	2	1.33	–	–	–	–	3	0.67
Pomoideae	–	–	–	–	–	–	6	11.53	6	1.34
Styrax officinalis	–	–	1	0.66	–	–	–	–	1	0.22
Gymnosperm (cf. *Pinus*)	–	–	–	–	–	–	1	1.92	1	0.22
Unspecified	–	–	–	–	–	–	1	1.92	1	0.22
Sum	143		150		101		52		446	

Absolute and relative results are presented for areas B and J (N = number of remains)

usually very small (*c.* 1 mm) and identification often did not reach beyond genus level. Wood anatomical atlases covering Israel (Fahn et al. 1986) and the Mediterranean region (Schweingruber 1990) were used for identification work, as well as modern reference specimens.

Results

Results of charcoal and archaeobotanical analyses are presented in Tables 1 and 2. Wood charcoal analysis of 446 charcoal fragments identified 12 different taxa originating from four *loci* in which large quantities of wood charcoal were preserved in areas B and J (L.89, L.2632, L.2137, L.2104) (Table 2). The identified assemblage was dominated by *Olea europaea* (63%), followed by *Quercus* spp. (24%) and *Pistacia* sp. (3.5%), which were present in all samples. The Pomoideae subfamily of the Rosaceae (2.88%), *Prunus* (1.74%) and *Fraxinus* sp. (1.49%) were less frequent, with *Phillyrea latifolia/Rhamnus*, *Prunus amygdalus*, *Tamarix* sp. and *Styrax officinalis* represented by fewer than 1% of the identified fragments. A gymnosperm charcoal fragment was also noted.

Analysis of almost 3700 seed and fruit remains from areas B, C and J identified 33 taxa (Table 1). The cereals *Hordeum vulgare* and *Triticum turgidum* ssp. *dicoccum* made up around 40% of identified remains, with chaff elements (rachis segments, spikelet bases, glumes) being common. *Lens culinaris* was the most frequently encountered pulse species, accounting for 3% of the total. Four fruit species representing 40% of the identified remains were noted, *Olea europaea*, *Pistacia* sp., *Vitis vinifera* and *Ficus carica*. The bulk of the fruit remains (78%) belonged to olive, attested by endocarp fragments, whole fruit stones and seeds (Fig. 3). Even though weed species represent less than 10% of the remains, this category is floristically rich, with *Lolium* sp. the dominant taxon.

Charcoal study shows that Tel Yarmouth was surrounded by maquis type vegetation dominated by *Quercus* sp. (oak) and *Pistacia* sp. (terebinth). Agriculture was based on the cultivation of *Triticum dicoccum* (emmer), *Hordeum distichum* (hulled barley) and *Lens culinaris* (lentil). This is in accordance with what is known from other sites in early Bronze Age Palestine (Liphschitz 1989; Hopf 1978, 1983; Helbæk 1958). Predominance of olive in both the charcoal and seed samples suggests that it was particularly important at Tel Yarmouth.

Table 2 Archaeobotanical results from Tel Yarmouth

			TY-B				TY-C																TY-J															
			L.89 EBIIIC	L.91 EBIIIC	L.2632-1 Proto-Palace	Sum B	L.6-3-2 EBII	L.657-1 EBII	L.657-2/b EBII	L.669-4/5 EBII	L.669-e EBII	L.9-6-1 EBII	L.921 EBII	L.922-1 EBII	L.925 EBII	L.927-2 EBII	1-3--a EBII	1-37-2 EBII	1-46-2 EBII	1-54-a EBII	Sum C	L.21-4 EBIIIB	L.2135-a EBIIIB	L.2137-1/2 EBIIIB	L.2137-2 EBIIIB	L.214- EBIIIB	L.2144 EBIIIB	L.2148-1 EBIIIB	L.2816-2 EBIIIB	L.2819 EBIIC	L.2821-1 EBIIC	Sum J	N total	% total
	Volume of sediment (l)		29	90	123	242	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	304	48	159	29	12	21	81	24	140	22	839	1,081	
	Volume after flotation (ml)		100	130	200	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,400	170	400	100	90	50	400	150	600	50	2,010	3,840	
	Volume sorted (ml)		100	130	200	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	500	170	300	100	90	50	150	170	500	50	2,080	2,510	
Cereals	*Triticum turgidum*	seeds	3	-	8	11	-	-	-	-	-	3	-	-	4	2	1	2	-	-	12	1	-	-	2	-	-	-	-	4	6	13	36	0.98
	ssp. *dicoccum*	glumes	99	15	133	247	-	-	-	-	14	-	-	-	-	-	-	3	-	-	17	27	17	188	66	-	5	1	2	75	158	539	803	21.77
		spikelet bases	38	2	65	105	-	-	-	-	4	-	-	-	-	-	-	2	-	-	6	5	3	37	16	-	2	-	-	22	55	140	251	6.81
	Hordeum vulgare	seeds	3	-	6	9	-	1	3	-	4	1	-	1	1	-	-	1	-	-	12	-	1	4	4	-	-	-	1	4	4	18	39	1.06
	Indeterminate cereals	seeds	28	4	30	62	7	6	4	-	26	6	-	3	-	-	-	14	-	-	66	7	14	54	19	-	-	-	-	39	95	228	356	9.65
Leguminosae	*Lens culinaris*	seeds	2	3	8	13	-	1	2	-	3	1	-	3	2	-	-	1	-	-	13	9	6	18	3	1	1	-	-	37	21	96	122	3.31
	Pisum sativum	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-	3	1	-	-	-	-	23	1	29	30	0.19
	Lathyrus/Vicia sp.	seeds	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	2	1	-	-	-	-	1	-	4	5	0.14
	cf. *Lathyrus/Vicia/Pisum* sp.	seeds	-	1	1	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	2	-	16	7	-	-	-	1	5	1	32	36	0.98
	cf. *Vicia faba*	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	3	-	-	-	-	-	-	4	5	0.14
	Fabaceae	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	9	3	-	-	-	1	5	8	28	28	0.76
Fruit trees	*Olea europaea*	whole stones	1	1	1	3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	6	3	-	-	-	-	3	-	12	17	0.46
		half stones	3	2	3	8	-	3	-	6	-	1	-	-	7	-	-	3	-	2	22	1	-	21	5	-	-	-	-	18	-	45	75	2.03
		fragments	58	16	34	108	-	1	1	11	-	-	-	-	-	-	-	1	-	11	25	39	15	359	129	-	6	-	4	224	150	926	1,059	28.71
		seeds	-	-	-	-	-	1	1	-	-	-	-	-	4	-	-	-	-	1	7	1	-	4	2	-	-	-	-	2	-	9	16	0.43
	Vitis vinifera	whole pips	1	2	-	3	1	2	-	-	-	1	-	-	-	-	-	3	3	-	10	-	-	6	3	-	1	-	-	4	2	16	29	0.79
		pip fragments	-	2	-	2	3	-	2	-	14	-	-	-	-	-	-	6	-	-	25	-	-	14	10	-	-	-	-	12	2	38	65	1.76
		fruit fragments	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	6	-	8	-	-	2	-	-	-	-	-	7	-	9	17	0.46
		peduncles	2	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	1	1	3	6	0.16
	Pistacia sp.	whole seeds	-	-	1	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	1	-	-	5	2	8	11	0.30
		fragments	3	1	9	13	-	-	-	-	4	-	-	-	-	1	-	2	-	-	7	-	-	8	-	-	1	-	-	14	11	34	54	1.46
	Ficus cf. *carica*	seeds	2	-	-	2	2	-	-	-	2	-	-	-	-	-	-	1	-	-	5	-	2	-	1	-	-	-	-	8	5	16	23	0.62
	Indeterminate fragments	fruits	-	6	4	10	-	2	-	1	2	2	-	-	-	-	-	-	-	-	7	16	9	10	5	-	-	3	-	30	24	97	114	3.09
Weeds and wild plants	*Lolium* sp.	seeds	4	-	12	16	-	7	4	-	30	2	1	-	6	3	-	2	-	-	55	3	2	11	4	-	-	-	-	22	29	71	142	3.85
	Phalaris sp.	seeds	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	1	-	-	-	-	-	1	5	7	0.19
	cf. *Avena* sp.	seeds	-	1	2	3	-	-	-	-	2	1	1	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	3	3	10	0.27
	cf. *Hordeum spontaneum*	seeds	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	2	3	0.08
	Galium sp.	seeds	-	1	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	1	5	7	10	0.27
	Scorpiurus sp.	seeds	2	1	1	4	-	-	2	-	3	1	2	22	-	-	-	-	-	-	30	-	-	1	-	-	-	-	-	2	4	7	41	1.11
	cf. *Melilotus/Trifolium* sp.	seeds	-	1	-	1	-	2	3	-	-	-	-	1	-	-	-	1	-	-	7	-	-	-	-	-	-	-	-	-	1	1	9	0.24
	Medicago sp.	seeds	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	1	2	0.05
	M. rotata/polymorpha	fruits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-	-	4	4	0.11
	Onobrychis spp.	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7	7	0.19
	Fabaceae type	seeds	-	-	1	1	1	1	2	-	2	-	1	2	-	-	-	1	-	-	10	-	1	6	2	2	-	2	-	4	3	20	31	0.84
	Thymelaea sp.	seeds	-	-	1	1	-	-	-	-	-	-	-	-	1	7	-	-	-	-	8	58	-	5	-	1	1	7	-	-	-	72	81	2.20
	cf. *Lithospermum/Arnebia* sp.	seeds	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	4	-	-	1	-	6	8	0.22
	cf. *Schrozophora* sp.	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	3	3	0.08
	Silene type 1	seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	0.03
	Silene type 2	seeds	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2	0.05
	Apiaceae	seeds	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1+1d.	-	-	-	-	-	-	-	-	-	-	2	0.05
	Indeterminate	indeterminate	8	4	3	15	-	15	8	-	4	9	4	8	4	4	-	-	-	-	56	17	5	5	-	-	-	-	-	14	14	55	126	3.42
	Total		259	65	324	648	14	44	32	19	123	29	10	40	29	18	2	45	9	14	428	193	75	806	291	7	22	13	9	589	607	2,612	3,688	

Absolute results are presented for areas B, C and J (N = number of remains, d. = dessicated)

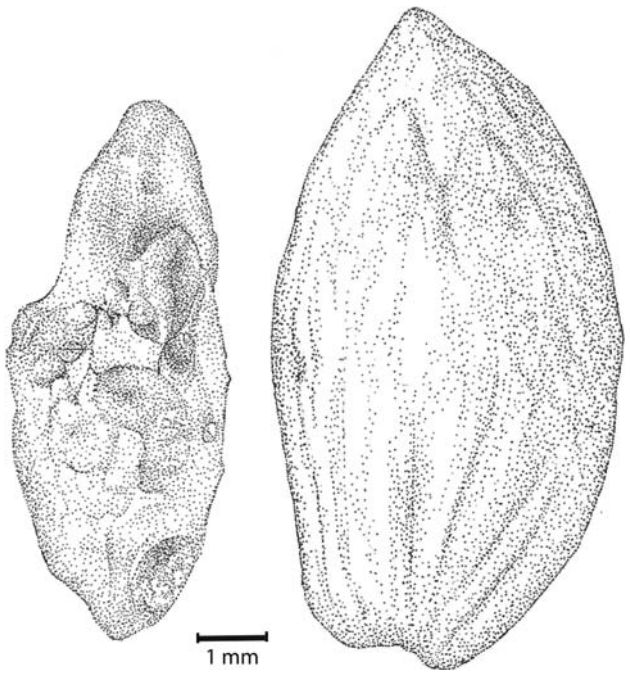

Fig. 3 Drawing of an olive seed and an olive stone (TY- Ja, L.2819), scale: 1 mm (*drawing*: A. Salavert)

Evidence of olive cultivation and oil production at Tel Yarmouth

Several lines of evidence point to the importance of olives and olive oil production at Tel Yarmouth. Olive charcoal fragments represent 77% of the wood charcoal pieces from L.89 (EBA IIIC), 67% from L.2632 (EBA III), 67% from L.2137 to 33% from L.2104 (Table 2). The extensive sampling in occupational levels suggests a long-term use of olive wood as domestic fuel (Chabal 1997; Asouti and Austin 2005). The dominance of olive in the charcoal assemblage of Tel Yarmouth suggests that it played an important role in the local vegetation cover. Olive charcoal fragments probably resulted from activities linked to the cultivation and maintenance of the trees. Pruning of olive trees produces leaves, twigs and branches that can be given as fodder to livestock before being used as fuel (Sansoucy et al. 1985). Olive wood is considered as rather mediocre for heating but is appreciated for cooking as it burns slowly and with a small flame while producing much charcoal (Nefzaoui 1988). Nowadays, this use of olive wood is known, for example, in Greece and North Africa (Terral 1997). However, we do not have enough data to evaluate the importance of olive groves in comparison to fields and pastures around the site. Pastoral and agricultural activities could have coexisted within olive groves.

Olive oil production results in two products: the liquid oil and solid crushed olive stones (endocarps), known as *jift* in Arabic (Nefzaoui 1988; Brun 2003), noted at several

Fig. 4 Archaeological crushed olive stones, interpreted as *jift* (TY J, L.2819), scale: 1 cm (*photo*: A. Salavert)

archaeological sites (Fig. 4; see Neef 1990). At Tel Yarmouth, crushed fragments of olive stones resembling *jift* dominated the fruit assemblages in areas B, C and J, representing 84%, 35% and 89% of fruit remains respectively. In many cases, olive stone fragments had weathered or rounded fractures which indicate that fragmentation preceded charring and thus was not the result of flotation or post-depositional damage (Fig. 4; Margaritis and Jones 2008a, b). Therefore, crushed olive stones, preserved in a carbonised state, were apparently burnt after the pressing of olives and may have been a useful fuel. Use of *jift* as a fuel is well-known (Brun 2003). It does not produce much smoke and is therefore particularly well-adapted for an indoor use. Sometimes *jift* mixed with animal dung is used as fuel, as is the case in the modern village of Suleikhat, in the Jordan valley (Neef 1990). That could explain presence of some weed taxa in carbonised archaeobotanical remains.

A sector consisting of five or six rooms in area H, in the lower city, is dated by the presence of numerous pottery remains, some of which were found in situ, attributed to the early Bronze Age IIIB. Installations found there consist of paved floors, *pithoi*, basins, basalt grinding stones and calcareous mortars and are thought to be linked to olive oil production (Fig. 5; de Miroschedji 1999). Similar installations have been found at other early Bronze Age sites such as Tell es-Sa'idiyeh in the Jordan valley, Beth Yerah on the sea of Galilee and Mitham Leviah (de Miroschedji 1999; Genz 2003). However, even though these installations are considered to be associated with oil production, no actual presses or archaeobotanical remains were found in the same contexts (Genz 2003).

Olive oil may also have been consumed at the site (see Genz 2003). Small ceramic vessels found in the early

Fig. 5 Craft area interpreted as an oil extraction (area H). *Foreground*: pit in a ceramic/paved floor. *Background*: half-buried mortar (from de Miroschedji 1999)

Bronze Age III levels at Tel Yarmouth can be interpreted as oil lamps. They possess one to four lips on which a wick could be placed (de Miroschedji, personal communication). Although use of olive oil in such lamps is not directly attested, absence of other oil producing taxa and the large amount of olive stones remains suggest that olive oil might have been available as a lighting source.

No particular differences in the archaeobotanical record of olive were noted between various chronological periods or areas at Tel Yarmouth. Olive trees were grown during all occupational periods from the early Bronze Age II to the early Bronze Age IIIC. Furthermore, olive remains were found both in palatial and domestic contexts. The importance of olives and olive oil at Tel Yarmouth may have gone beyond daily use by the inhabitants of the site. Indeed, olive cultivation may have played an important role in the development of the site during the Bronze Age.

The importance of olive cultivation at Tel Yarmouth during the early Bronze Ages II and III

Palestine went through important changes during the early Bronze Age with the emergence of walled settlements, population growth and urbanisation (Broshi and Gophna 1984; Gophna and Portugali 1988; Finkelstein and Gophna 1993; Philip 2003). According to Finkelstein and Gophna (1993), strong demand in Egypt for Palestinian horticultural products during the late fourth millennium B.C. stimulated demographic expansion to hilly areas favourable to their production. During the early Bronze Age I, there is evidence of an important export of wine from Palestine to Egypt, especially from the southern coastal plain and the Shephelah regions (Finkelstein and Gophna 1993). In contrast, there is little archaeological evidence for olive oil trade. The development of olive cultivation in the area may have been totally unrelated to the Egyptian trade (Genz 2003). In the early Bronze Age II, when urban sites emerged in Palestine, these trade activities seem to have come to an end (Genz 2003). Even though commercial relations between Egypt and Palestine may have triggered the establishment of specialised olive oil production in Palestine, it does not seem to have been crucial for its continuation.

So far, no archaeobotanical samples from the early Bronze Age I have been studied from Tel Yarmouth. It is thus impossible to evaluate the importance of the olive in the site's economy during this period. During the subsequent early Bronze Ages II and III, evidence for olive oil production is considerable, as seen above. Production of perennial fruit such as olive constitutes a long-term investment. It is also dependant on political and socio-economic stability that allows the maintenance of olive groves and development of inter-regional and international trade (Finkelstein and Gophna 1993; Philip 2003). During the early Bronze Ages II and III, an agricultural economy at Tel Yarmouth seems to have been well established. It was diversified with production of several annual crops as well as fruit. Use of *jift*, waste from pruning of olive trees, and cereal chaff as fuel shows moreover the optimisation of agricultural by-products.

Beyond direct evidence of oil production, Tel Yarmouth possesses a large storage area situated in palace B, one of the biggest palatial complexes in the southern Levant during this period (de Miroschedji 1999). Excavation of the storage area yielded large quantities of pottery in situ including hundreds of *pithoi* (storage jars), several vats and many jars. This ceramic assemblage is distinctive as it brings together ceramic types not found in contemporary domestic structures at Tel Yarmouth. These ceramics were probably used for the storage, management and redistribution of an agricultural surplus (de Miroschedji 2000; Genz 2003). The amount of pottery in the storage room exceeds the basic needs of the Tel Yarmouth population (Genz 2003). Despite the absence of organic residues preserved on the inner surfaces of pottery, the importance of olive oil production on the site suggests that these containers could have been used, at least in part, for the storage of oil.

Storage of agricultural products in walled centres was one of the attributes of power in the Near Eastern Bronze Age (Chesson and Philip 2003). If we compare the early Bronze Age III ceramic assemblage in Yarmouth with those of contemporary settlements, we can delimit a region

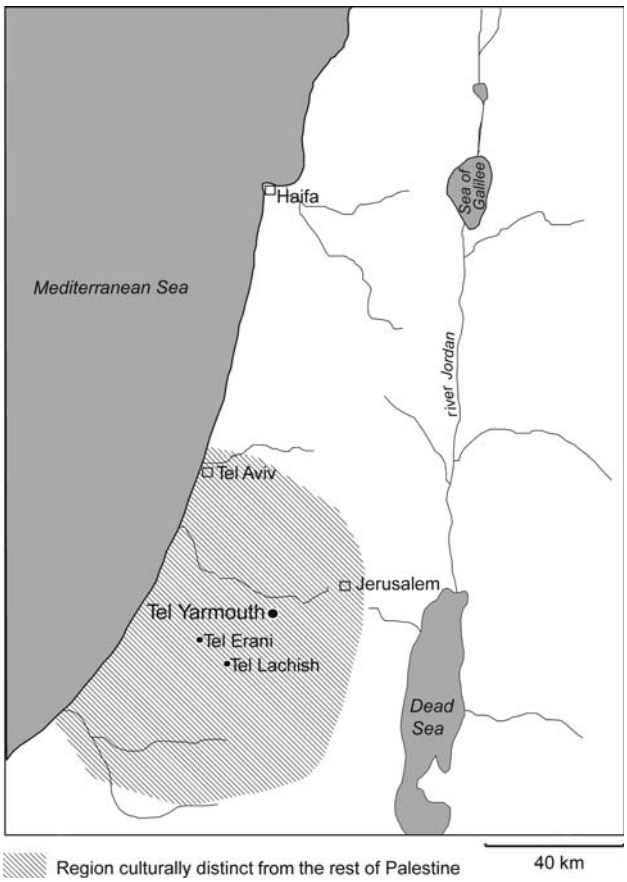

Fig. 6 Region which is culturally distinct from the rest of the Palestine (*hatched area*) (from de Miroschedji 2000)

which is culturally distinct from the rest of Palestine (Fig. 6), including the northwestern and southern portions of the coastal plain, the Shephelah and maybe the Judean Hills (de Miroschedji 2000). Olive oil production and centralised storage of agricultural surplus confers a certain regional importance to Tel Yarmouth. Diversification of the agricultural economy allowed the site to be less subject to risks linked to climate variations, particularly in the semi-arid zone (Harrison and Savage 2003). The location of Tel Yarmouth offered access to an irrigated lowland adapted to cultivation of annual crops such as cereals and pulses, as well as to higher altitude soils suitable for olive trees (Miller-Rosen 1997). This agricultural potential may have encouraged the choice of the site's location in the Shephelah region (Rosen 1995). Tel Lachish, belonging to the same cultural entity as Tel Yarmouth, is located in a similar environment (Miller-Rosen 1997). According to archaeobotanical analysis, production of olive oil was carried out at this site at more or less the same scale as at Tel Yarmouth (Helbæk 1958). This is probably also the case for Tel Erani, located near Yarmouth and where remains of olive charcoal and stones are noted (Liphschitz et al. 1991). Tel Yarmouth was thus not necessarily the only centre where an elite was in control of oil production in the region. Thus, settlement organisation may have based on an interdependent network of cities, villages and rural communities and not on a centralised and hierarchical society, as often suggested for the early Bronze Age in Palestine (Harrison and Savage 2003).

Conclusion

Cultivation and use of olives was well controlled in the Levant in the early Bronze Age and held an important place in local economies. At Tel Yarmouth archaeobotanical remains and installations associated with olive oil production show that it continued during most of the third millennium B.C. Indeed the suitability of the Shephelah for olive growing may have influenced the site's founding in that region. Further sampling and analysis, especially of the earlier occupation phases at Tel Yarmouth are required to determine whether olives were also cultivated at the site in the early Bronze Age I period and thus to fully understand the historical development of olive growing and settlement history.

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