S. E. Allen 2002b.

PART IV

SUBSISTENCE STUDIES

17

PALAEOETHNOBOTANY: PRELIMINARY RESULTS

Susan E. Allen

I. INTRODUCTION

Archaeological investigation of early agriculture in the Levant has focused on the recovery of subsistence data from the initial, transitional phases of the Neolithic. Due to this temporal bias, large gaps remain in our understanding of later Neolithic agriculture and plant husbandry in the region, despite the importance of subsistence data to interpretations of changes in settlement patterns, architecture, and technology that appear in the late seventh and early sixth millennium BC (Banning *et al.*1994; Kafafi 1992, 1993; Kohler-Rollefson 1988, 1992; Kohler-Rollefson and Rollefson 1990). The adoption of systematic water-sieving of archaeological deposits from the Yarmukian site of Sha'ar Hagolan marks an important shift in the excavation of later Neolithic sites in the Levant. To date, only two Yarmukian sites other than Sha'ar Hagolan have produced botanical assemblages, neither of which has been fully published (Neef 1997). The Sha'ar Hagolan botanical assemblage, therefore, has the potential to increase our understanding of Yarmukian agriculture, as well as the environment to which it was adapted. This report presents the first results of the author's preliminary analysis of the macrobotanical remains from Sha'ar Hagolan. In addition, I describe in detail the recovery methods, so that readers might be aware of potential biases from sampling and recovery procedures. I then propose possible interpretations of the preliminary results from Sha'ar Hagolan and their relation to botanical evidence from other Yarmukian sites in Israel and Jordan.

A total of 279 samples were collected between 1997 and 1999. Botanical remains from 44 of these samples are presented below (Tables 17.1–17.4). The data are discussed on a year by year basis, due to differences in sampling and recovery methods for each year. An additional 19 samples collected in 1998 have been fully sorted, but were not scored in time for inclusion in this report. The data presented in this report comprise approximately 15% of the total assemblage. Although the shallowness of the archaeological deposits resulted in the recovery of much modern plant material, these remains are not reported. In general, the botanical assemblage from Sha'ar Hagolan shows fair preservation, a low density of botanical remains, and a high degree of fragmentation. Cereal remains and unidentified grasses are predominant in the samples, but seeds of legumes, fruits, and several wild species also occur. Wood charcoal, present in small quantities, has not yet been identified to species, but samples that have been examined are certainly all angiosperms.

II. METHODOLOGY

During the 1997 excavation season, Dr. M. A. Miller used manual flotation (Pearsall 1989) with 10-liter buckets to recover botanical remains from 15 sediment samples excavated from Building Complex I (Area E). These initial recovery attempts indicated that plant macrofossils were preserved at Sha'ar Hagolan, but did not yield significant quantities of botanical material.

In 1998 Garfinkel and Miller instituted a program of systematic water-sieving, which continued on a more limited scale during the 1999 season. With the help of many kibbutz members, we built a modified Ankara-type water-separator (French 1971). Due to the limited supply of water in the Jordan Valley, the ability of this system to recycle water was ideal for water-sieving in this location. The system recycled water by means of two settling tanks arranged on a slope with an electric pump to recirculate

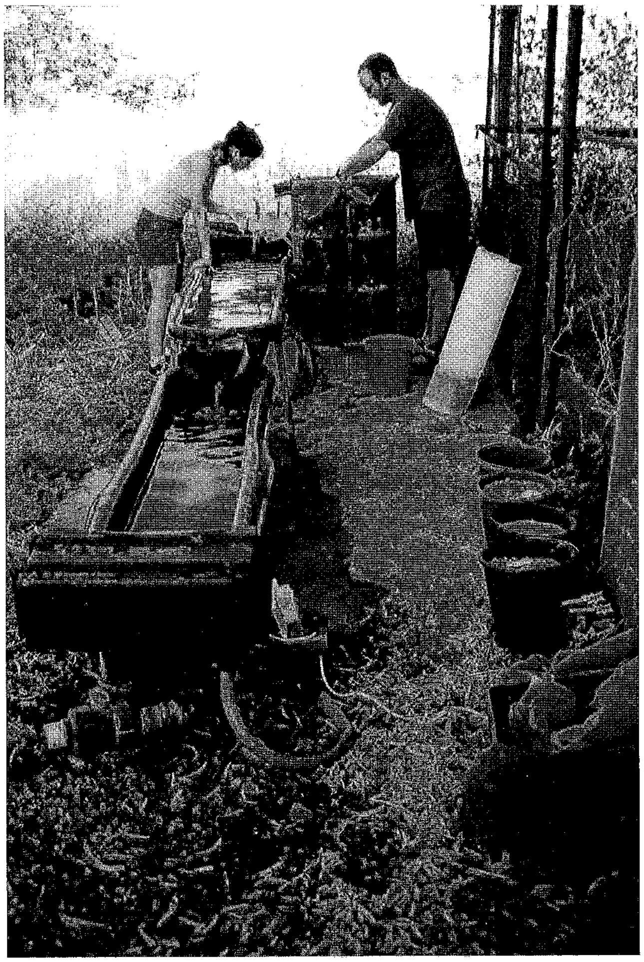

FIG. 17.1. The flotation system in operation

water to the main tank (Fig. 17.1). As is usually the case with flotation systems, we made use of materials that were locally available (Davis and Wesolowsky 1975; Wagner 1988). We built the main tank for sediment processing from a 55-gallon drum with the following modifications: a 15 cm. wide overflow spout cut into and welded to the rim, to allow the outflow of floating botanical remains; the attachment of a circular bracket below the overflow spout, to receive geological sieves for collecting the light fraction; the insertion through the side of the drum of a 1-inch diameter elbow pipe with a two-way valve for regulating water flow at its outer end and a shower head attachment on the end of the pipe inside the drum; and the addition to the base of the drum, on the same side as the water inflow pipe, of an approximately 3-inch diameter pipe with a two-way valve, to which a fire hose was attached to empty accumulated mud from the bottom of the tank. Two modified cattle troughs served as easily drainable settling tanks.

Rather than adding a permanent heavy fraction screen, we used pre-cut squares of fiberglass window screening (approximately 2 mm. mesh) that were secured to the top rim of the drum with a bungee cord and bulldog clamps. This allowed for easy removal of each sample of heavy fraction and facilitated cleaning of the solidified clays from the bottom of the drum, but necessitated care in removing heavy or sharp objects from the sample prior to flotation.

We filled the water-separator and settling tanks from a tap at the Sha'ar Hagolan Museum. A 1.5 horsepower electric sump pump, with a section of fine (less than 1 mm.) polyester mesh over its intake spout, circulated the cleaner water from the second settling tank up to the drum for processing new samples. Depending on the nature of the sediment and the concentration of stones and artifacts, we were able to water-sieve between 200 and 300 liters of dirt before needing to drain the sludge from the processing tank. The settling tanks were cleaned and refilled between one and two times per week.

Due to the heavy clay content of much of the sediment, powdered sodium hexametaphosphate, commercially available as Calgon, was added to the water to facilitate separation of fragile botanical remains from the dense matrix. Although Pearsall (1989) recommends pre-soaking of clay-rich samples with a deflocculant prior to flotation, field testing indicated little to no improvement in recovery from the Sha'ar Hagolan sediment after soaking samples in a 10% solution for between 30 minutes and one hour. We instead tried adding a 10% solution of Calgon and water (Pearsall 1989) to the system as a whole. Since this resulted in an increased delay in settling time and a need for more frequent water changes, we added only a small quantity of deflocculant to the tanks at more or less regular intervals. Unfortunately, this amount was not standardized throughout the season due to fluctuations in our Calgon supply, but remained below 5% at all times.

With this particular water-sieve and the Sha'ar Hagolan sediment, it was possible for two people to process between 200 and 300 liters per day. One person could process up to 200 liters per day, given the delays caused by stopping to prepare labels, record sample volumes, and rotate heavy fraction for drying. Samples from mud-brick and other solidified deposits, and clay-rich samples needing re-flotation of the heavy fraction also slowed processing time.

The resulting heavy fraction was screened into two fractions (1 mm.–5 mm.; >5 mm.) that were packaged separately for later scanning. Preliminary scanning in the field indicates that lithic materials, including complete tools, cores, and debitage, was the primary constituent of the heavy fraction. In addition, sherds and ground stone

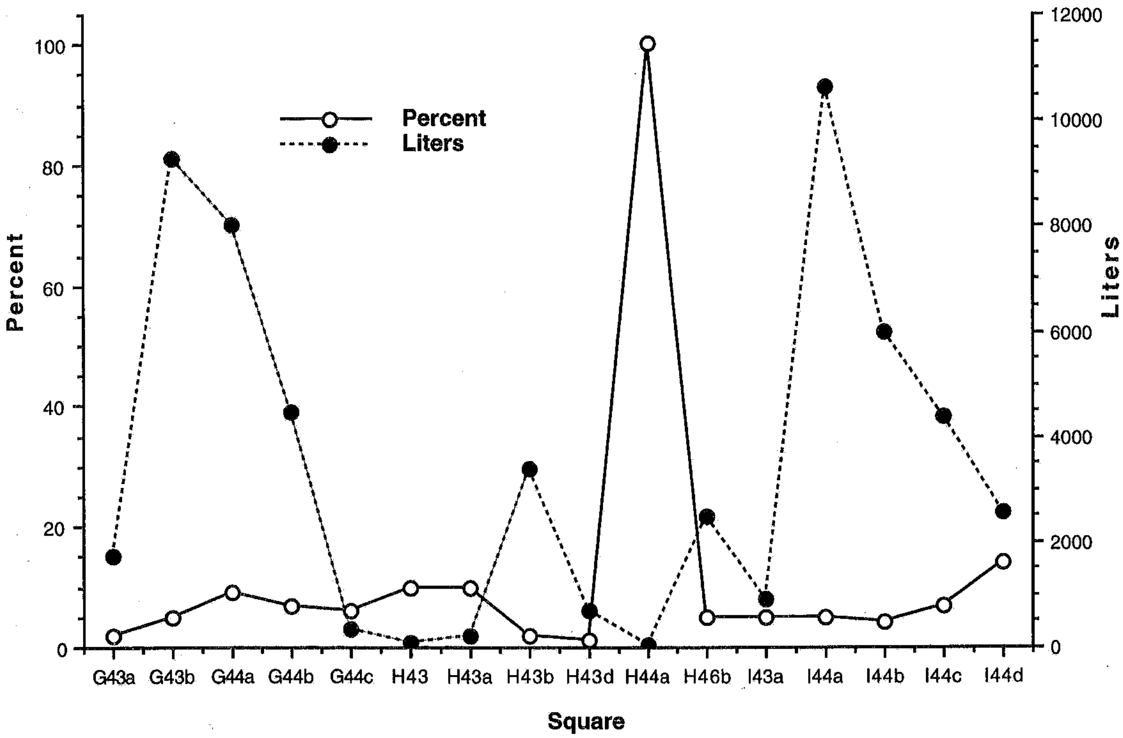

FIG. 17.2. Comparison of total excavated sediment versus sampling percentage by square for 1998

fragments were frequent. Figurine fragments and bone of all types were rare, and only modern botanical remains (e.g. uncarbonized olive pits) were recovered. This material has great potential for microrefuse analysis to clarify the location of activities and refuse disposal behaviors, but has not yet been fully analyzed. The heavy fraction is stored in Israel at the Sha'ar Hagolan Museum.

A systematic sampling strategy of at least 5% from each deposit (basket) was adopted to facilitate the potential for spatial analysis of the botanical assemblage, with the goal of sampling all Neolithic deposits. While most of these were sampled for botanical remains, it was necessary to revise the goal of at least a 5% sample from each deposit due to differences in the pace of flotation versus that of excavation. In general, features such as pits and installations were sampled at 100%. In total, 3,514.5 liters of sediment were processed by flotation in 1998 (Fig. 17.2). The water-sieved portion represents approximately 6% of the sediment excavated from the sampled deposits as a whole, but the sampling percentage varies widely across the site (Tables 17.2 and 17.3). Field recording of the total deposit volumes and the sample volumes enables comparison between samples and will facilitate further analysis of the spatial dimension of burning activity, plant processing, consumption, storage, and refuse disposal across the site.

III. DATA PRESENTATION

I present the data first as absolute counts by taxon and plant part on a year by year basis (Tables 17.1 through 17.3), and then by ubiquity measures for groups of taxa reported in the 1998 and 1999 assemblages (Table 17.4). Absolute counts are somewhat problematic, in that they reflect differences in sample volume, preservation, or differences in the rate of fracturation or number of seeds produced by different species (Popper 1988). Absolute counts are thus poor indicators of differences between deposits and the relative importance of different taxa (Popper 1988). Despite these problems, I have reported absolute counts in order to prevent the misinterpretation that might result from a purely descriptive report.

Comparison between deposits with different sample volumes is enabled by conversion of the absolute counts to density ratios, using the sample volume as the norming variable (Miller 1988). These measures are presented as the number of items per liter in each sample. In order to facilitate the comparison of different groups of taxa between deposits, I have also calculated the ubiquity of specific groups of plants from analyzed samples from the 1998 and 1999 seasons (Table 17.4). Ubiquity, the percentage of samples in which a taxon or group of taxa appears (Popper 1988), is another measure that removes the bias resulting from differences in sample volume. The available data and the density of botanical material recovered are not suitable for further statistical analysis at this time.

1. Plant Remains from the 1997 Season. During the summer of 1998, I examined the 15 samples from 1997 under 10X microscopy at the Institute of Archaeology of the Hebrew University of Jerusalem. Small shell fragments and rodent coprolites, possibly of modern origin, were noted in several samples. Both wood and seeds were preserved in fragmentary condition. Modern plant material also occurred in these samples. In no case was wood preserved in large enough pieces for positive species identification. In one case, however, enough wood was preserved to identify two fragments of a diffuse-porous angiosperm wood with abundant, singly-arranged vessels.

The non-wood remains, the sum absolute counts[1] of which are presented in Table 17.1, include several poorly preserved fragments of Gramineae that were not identifiable to species, and a single example each of emmer wheat (*Triticum turgidum* ssp. *dicoccum*) and einkorn wheat (*Triticum monococcum* ssp. *monococcum*). Fragments of a hulled variety of barley (*Hordeum* sp.), a small-seeded barley variety (*Hordeum* cf. *murinum*), and a possible example of brome grass (cf. *Bromus* sp.) constitute the remainder of identifiable grasses in the 1997 samples. A modern olive pit (*Olea europaea*), a carbonized nutshell fragment (cf. *Pistacia* sp.), and more than 300 fragments of unidentifiable non-wood carbon were the only other plant remains in these samples.

Since the volume of the samples is unknown, no quantitative conclusions may be drawn from this small data set. In addition, the relative density of plant remains from Building Complex I may not be compared with that of Building Complex II (Table 17.2). The low quantity of plant remains recovered from Building Complex I further limits their interpretive potential, but does demonstrate the potential utility of bucket flotation as a low-cost method for initial testing of plant preservation in archaeological deposits.

TABLE 17.1. Sha'ar Hagolan 1997, summed absolute counts of all samples (N=15)

Species	# whole [#frags.]
Gramineae, indet. species	3 [62]
Triticum monococcum	1 [2]
Triticum dicoccum	1
Hordeum sp.	[2]
cf. *Bromus* sp.	1
Hordeum cf. *murinum*	1
Olea europaea (modern)	1
cf. *Pistacea* sp.	[1]
unidentifiable non-wood	[334]

2. Plant Remains from the 1998 Season. During the 1998 excavation season, 3,514.5 liters of sediment were processed by water-sieving, according to the methods described above. Of the resulting 207 samples, 42 have been fully sorted, 23 of which have had full quantitative scoring and taxonomic identification and are reported here. These samples all derive from the area of Building Complex II, located in the area of a former olive grove (Garfinkel and Miller, Chapter 2 in this volume). Preliminary analysis of these samples indicates the same level of preservation as noted in the 1997 samples – fragmentary preservation of plant remains and a high frequency of modern rootlets and seeds.

In contrast to Building Complex I (Table 17.1), sampled only by bucket flotation, many small weed seeds were recovered from Building Complex II (Table 17.2). This difference between the two areas likely reflects differences in recovery methodology. Identified crop species include both cereals and pulses. Among the cereals, emmer wheat and hulled barley were both most abundant and most ubiquitous, while einkorn wheat has not yet been identified in this part of the site. The apparent absence of einkorn may reflect the particular samples chosen for analysis rather than a compositional difference between the two areas, however. In addition to the grains of cereals, processing debris was also identified, including rachis segments and nodes, glume bases, spikelet forks, and culm fragments, suggesting that some processing of cereals occurred on site.

Pulse crops are less well represented in these samples than are cereals. Of the pulses, lentils (*Lens* sp.) were most ubiquitous, while fava bean (*Vicia faba*) and bitter vetch (*Vicia ervilia*) occurred in a single sample each. One example of lentil exhibited a pronounced sprouting, suggesting that it may have originated from a stored deposit incompletely protected from humidity, as has been argued for chenopodium deposits from eastern North America (Smith 1992).

In addition to pulses and cereals, several fig seeds (*Ficus carica*), two examples of a pear or apple species (cf. *Pyrus*), and unidentified fruit and nutshell fragments were recovered. It should be emphasized that the total number of fig seeds from all samples represents fewer than the number of seeds in a single fig fruit, and the apparent abundance of fig seeds suggested by the absolute counts is misleading. These items do, however, suggest some use of wild fruit and nut species, all of which were likely to be locally available.

[1] Sum absolute counts are presented for the 1997 material due to the absence of information on sample volumes or contexts.

TABLE 17.2. Sha'ar Hagolan 1998, absolute counts (N=23)

	Square	?	I44b	G44a	G44a	G44b	G44b	G44b	I44b	H44a	I44b	I44c	I44c	I44d	I44b	G44b
	Locus	?	41	201	201	210	210	212	218	222	224	225	225	232	233	236
	Basket	852	839	824	826	818	827	832	828	836	843	867	879	882	866	873
	Context	?	Wall	Fill	Pit?	Int. Fill	Int. Fill	Pit	Silty Fill	Pit	Sandy Fill	Above floor	Fill	Fill	Mdbrk.	Int. Fill
	Sample Vol. L.	?	5	40	4.5	70	10	20	20	30	20	30	20	10	10	5
	Deposit Vol. L	?	20	490	4.5	700	130	180	700	30	740	610	480	260	?	11
	% Sample	?	25%	8.16%	100%	10%	7.60%	11%	2.80%	100%	2.70%	4.92%	4.20%	3.80%	?	45%
CEREAL CROPS	**Plant Part**															
Triticum dicoccum	seed	5 [1]	-	-	-	-	-	1	1 [1]	-	-	-	-	-	-	-
cf. Triticum dicoccum	seed	-	-	-	-	1 [2]	-	-	-	-	-	-	-	-	-	-
Triticum sp.	seed	1 [4]	-	-	[3]	-	-	-	-	1 [2]	-	-	-	-	-	-
Hordeum vulgare	seed	-	-	-	-	-	-	-	[1]	3 [1]	-	-	-	-	-	-
Hordeum sp.	seed	-	-	-	-	[1]	-	-	-	-	-	-	-	-	-	-
Cereals indet.	seed	3 [36]	-	-	1 [15]	-	-	-	-	[4]	1 [17]	[3]	-	[1]	-	[10]
LEGUME CROPS																
Lens sp.	seed	1 [2]	-	[1]	1	-	-	-	-	-	-	-	-	-	-	-
Vicia faba	seed	-		1	-	-	-	-	-	-	-	-	-	-	-	-
Vicia ervilia	seed	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
FRUITS and NUTS																
Ficus carica	seed	-	-	62	-	-	-	-	-	-	2	-	-	-	-	-
cf. Pyrus sp.	seed	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
Fruit, sp. indet.	fruit / seed	-	-	-	-	-	[3]	[2]	-	-	-	-	-	-	-	-
Nut, sp. indet	nutshell	-	-	-	-	-	-	[2]	-	-	-	-	-	-	-	-
WEEDS OF CEREALS																
Lolium sp.	seed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Lolium sp.	seed	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Bromus sp.	seed	-	-	-	-	-	-	-	-	2 [2]	-	-	-	-	-	-
Hordeum cf. maritimum	seed	-	-	-	-	-	-	-	-	[5]	-	-	-	-	-	-
Avena sp.	awn	-	-	-	-	-	-	-	-	[1]	[2]	-	-	[1]	-	-
WATER PLANTS																
Carex sp.	seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER WILD PLANTS																
cf. Adonis sp.	seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Polygonum sp.	seed	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Chenopodium cf. album	seed	1	-	-	-	3	-	-	-	2	-	1	-	-	-	-
Chenopodium sp.	seed	1	-	21	1	1	53	2	51[2]	-	-	2	7	-	-	-
cf. Silene / Stellaria sp.	seed	-	-	4	5	11	18 [2]	1	-	[1]	-	2	1 [1]	-	-	-
cf. Scrophularia sp.	seed	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
cf. Potentilla sp.	seed	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-
cf. Astragalus sp.	seed	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-
Medicago sp.	seed	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Malva sp.	seed	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
cf. Onobrychis sp.	capsule	-	-	-	-	-	-	[1]	-	-	-	-	-	-	-	-
Linum cf. bienne	seed	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
cf. Galium sp.	seed	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Echium sp.	capsule	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Verbena sp.	seed	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
cf. Lamium sp.	seed	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Verbascum sp.	seed	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
cf. Ashphodelussp.	seed	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
INDETERMINATE																
Leguminosae, sp. indet.	seed	-	-	-	[5]	[2]	-	-	-	[2]	[1]	-	-	-	[2]	-
Compositae, sp. indet.	seed	1	-	1	-	-	1	-	-	-	1	-	-	-	-	-
Gramineae, sp. indet.	seed	-	-	-	[1]	-	4 [2]	1 [1]	[5]	1 [9]	-	-	-	-	[1]	-
Gramineae, sp. indet.	glume base	-	-	-	-	-	[3]	-	-	-	-	-	-	-	-	-
Gramineae, sp. indet.	spikelet fork	-	-	-	-	-	-	-	-	[2]	-	-	-	-	-	-
Gramineae, sp. indet.	rachis internode	-	-	-	-	[2]	-	-	-	[1]	-	-	-	-	-	-
Gramineae, sp. indet.	rachis segment	-	-	-	-	-	[1]	-	-	-	-	-	-	-	-	-
Gramineae, sp. indet.	culm	-	-	-	-	-	-	[1]	-	-	-	-	[2]	[1]	-	-
Small Gramineae, sp. indet.	seed	1	-	-	1 [1]	5 [41]	-	-	-	2 [15]	-	-	-	-	-	-
Umbelliferae, sp. indet.	seed	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
species indet.	seed	7	-	15	2	17	[2]	16 [5]	1	-	-	2	1	[4]	7	2
species indet.	thorn	-	-	-	-	-	[1]	[4]	-	-	-	-	-	-	-	-
non-wood fragments indet.	unknown	[1]	-	[3]	[4]	-	[5]	[31]	[7]	[1]	[70]	[15]	[16]	[8]	[12]	[25]
fungal spore, indet.	spore	-	-	-	-	-	-	[1]	-	-	-	-	-	-	-	-
wood, sp. indet.	wood	[42]	-	-	-	-	-	[6]	-	-	[46]	[6]	[4]	-	-	-
	TOTAL Whole	22	0	105	15	41	77	79	53	21	4	11	10	0	8	2
	TOTAL Items	108	0	109	44	89	96	133	69	67	140	35	33	15	23	37
	# Items per L	?	0	2.72	9.8	1.27	9.6	6.65	3.45	2.23	7	1.17	1.65	1.50	?	7.4

TABLE 17.2. Continued

	Square	I44b	I44d	I44c	I44b	I44a	I44b	H46b	I44b	
	Locus	241	243	246	251	264	271	274	280	
	Basket	881	938	889	900	924	945	983	969	
	Context	Sandy Fill	Floor?	Mdbrk.	Mdbrk.	Pit	Below grinder	Int. Fill	Sandy Fill	
	Sample Vol. L.	10	5	5	20	10	10	10	10	
	Deposit Vol. L	570	20	200	180	150	?	110	500	
	% Sample	1.75%	25%	2.50%	11%	6.60%	?	9%	2%	
CEREAL CROPS	**Plant Part**									**Totals**
Triticum dicoccum	seed	-	-	-	1 [1]	-	-	-	-	8 [3]
cf. Triticum dicoccum	seed	-	-	-	-	-	-	-	-	1 [2]
Triticum sp.	seed	-	-	-	-	-	-	-	-	2 [9]
Hordeum vulgare	seed	-	-	-	-	-	-	-	-	3 [2]
Hordeum sp.	seed	-	-	-	-	-	-	-	-	[1]
Cereals indet.	seed	-	-	-	-	-	-	-	[1]	5 [87]
LEGUME CROPS										
Lens sp.	seed	-	-	-	-	-	-	1	-	3 [3]
Vicia faba	seed	-	-	-	-	-	-	-	-	1
Vicia ervilia	seed	-	-	-	-	-	-	-	-	1
FRUITS and NUTS										
Ficus carica	seed	-	-	-	4 [1]	3	1	-	-	72[1]
cf. Pyrus sp.	seed	-	-	-	-	-	-	-	-	3
Fruit, sp. indet.	fruit / seed	-	-	-	-	-	-	-	-	[5]
Nut, sp. indet	nutshell	-	-	-	-	-	-	-	-	[2]
WEEDS OF CEREALS										
Lolium sp.	seed	-	-	-	-	-	-	-	-	1
cf. Lolium sp.	seed	-	-	-	-	-	-	-	-	1
Bromus sp.	seed	-	-	-	-	-	-	-	-	2 [2]
Hordeum cf. maritimum	seed	-	-	-	-	-	-	-	-	[5]
Avena sp.	awn	-	-	-	-	-	-	-	-	[4]
WATER PLANTS										
Carex sp.	seed	-	-	-	-	1	-	-	-	1
OTHER WILD PLANTS										
cf. Adonis sp.	seed	-	-	-	-	-	-	-	-	1
Polygonum sp.	seed	-	-	-	-	-	-	-	-	2
Chenopodium cf. album	seed	-	20	-	2	-	-	-	-	30
Chenopodium sp.	seed	-	8	-	1	-	-	-	-	147 [2]
cf. Silene / Stellaria sp.	seed	-	-	-	2	-	-	-	-	44 [4]
cf. Scrophularia sp.	seed	-	-	-	-	-	-	-	-	1
cf. Potentilla sp.	seed	-	-	-	-	-	-	-	-	3
cf. Astragalus sp.	seed	-	-	-	-	-	-	-	-	3
Medicago sp.	seed	-	-	-	-	-	-	-	-	1
Malva sp.	seed	-	-	-	-	-	-	-	-	2
cf. Onobrychis sp.	capsule	-	-	-	-	-	-	-	-	[1]
Linum cf. bienne	seed	-	-	-	-	-	-	-	-	1
cf. Galium sp.	seed	3	-	-	-	-	-	-	-	4
Echium sp.	capsule	-	-	-	-	-	-	-	-	1
Verbena sp.	seed	-	-	-	-	-	-	-	-	1
cf. Lamium sp.	seed	-	-	-	-	-	-	-	-	1
Verbascum sp.	seed	-	-	-	-	-	-	-	-	2
cf. Ashphodelussp.	seed	-	-	-	-	-	-	-	-	1
INDETERMINATE										
Leguminosae, sp. indet.	seed	-	-	-	-	-	-	-	-	[12]
Compositae, sp. indet.	seed	-	-	-	-	-	-	-	-	4
Gramineae, sp. indet.	seed	-	-	-	[75]	-	[1]	[3]	-	6 [98]
Gramineae, sp. indet.	glume base	-	-	-	-	-	-	-	-	[3]
Gramineae, sp. indet.	spikelet fork	-	-	-	-	-	-	-	-	[2]
Gramineae, sp. indet.	rachis internode	-	-	-	-	-	-	-	-	[3]
Gramineae, sp. indet.	rachis segment	-	-	-	-	-	-	-	-	[1]
Gramineae, sp. indet.	culm	-	-	-	-	-	-	-	-	[4]
Small Gramineae, sp. indet.	seed	-	-	-	-	-	-	-	-	9 [57]
Umbelliferae, sp. indet.	seed	-	-	-	-	-	-	-	-	1
species indet.	seed	-	4	[3]	3	43	[3]	-	[11]	120 [28]
species indet.	thorn	-	-	-	-	-	-	-	-	[5]
non-wood fragments indet.	unknown	[12]	[21]	-	[61]	[16]	-	[9]	-	[317]
fungal spore, indet.	spore	-	-	-	-	-	-	-	-	[1]
wood, sp. indet.	wood	[4]	[7]	-	-	-	-	-	[1]	[116]
	TOTAL Whole	3	32	0	13	47	1	1	0	
	TOTAL Items	19	60	3	151	63	5	13	13	AVG =
	# Items per L	1.9	3	0.6	7.55	6.3	?	1.3	1.3	3.82 / L

Preliminary sorting of the heavy fraction yielded only modern botanical remains, suggesting that the more dense items frequently recovered from the heavy fraction (nutshell, legumes, olive pits, etc.) (Pearsall 1989) are here represented in the light fraction. Although the heavy fraction has not yet been fully processed, preliminary scanning suggests that the rarity of legumes and nutshell in the light fraction is not an artifact of the recovery process.

In contrast to the remains from 1997, significantly more small (<1.5 mm.) seeds of weedy and wild taxa are represented in the 1998 samples. This difference likely results from a difference in recovery methodology between the two seasons, such as a difference in mesh size. The few remains of ruderal species such as canary grass (*Lolium* sp.), brome grass (*Bromus* sp.), little barley (*Hordeum maritimum*), and oat (*Avena* sp.) may reflect weeds collected during cereal harvesting. Whether these remains represent human food or animal fodder remains unclear. Future analysis will focus on the ecology and seasonality of the species, and will facilitate interpretation of agricultural practices in use at Sha'ar Hagolan.

3. Plant Remains from the 1999 Season. Only six of the 57 flotation samples from the 1999 season have been fully analyzed, but preliminary analysis indicates better preservation and more dense remains in Area H than in Area E, sampled in 1998. This difference may result from a difference in modern land use rather than a difference in area function. Descriptions of the deposits from which the 1999 samples originate are not yet available to me, but a variation in sediment types may be an additional factor in the recovery differences between the two areas.

Among these six samples (Table 17.3), the remains of emmer and einkorn wheats were equally ubiquitous. As in the 1997 and 1998 samples, wheat predominates over barley, and legumes continue to be rare. The diversity of species in this area is much lower than in the 1998 samples. Of particular interest is the rarity of small weedy seeds that were frequent in Area E, such as small chenopods and Scrophulariaceae (e.g. *Silene / Stellaria* sp.). These seeds are generally less than 1.5 mm. in diameter and would be more likely to move within the soil column through bioturbation or seasonal shrinking and swelling

TABLE 17.3. Sha'ar Hagolan 1999, absolute counts (N=6)

	Square	AA42B	AA41D	BB42C	Z41B	Z41B	AA41D	
	Locus	H141	H187	H193	H164	H233	H187	
	Basket	H233	H466	H494	H499	H504	H510	
	Context	?	?	Jar	Jar #3	?	Mudbricks	
	Sample Vol. L.	8	8	8	7	6	2	
CEREAL CROPS	**PART**							**Totals**
Triticum monococcum	seed	-	[2]	-	4 [2]	[1]	-	**4 [5]**
cf. *Triticum monococcum*	spikelet fork	-	1 [4]	-	[1]	-	-	**1 [5]**
Triticum dicoccum	seed	-	1 [2]	-	1	[2]	-	**2 [2]**
Triticum sp.	seed	-	5 [38]	-	2	-	-	**7 [38]**
Hordeum vulgare	seed	-	-	-	2 [2]	[1]	-	**2 [3]**
cf. *Hordeum* sp.	seed	[1]	-	-	-	-	-	**[1]**
Cereals indet.	seed	2 [6]	-	[1]	3 [48]	[9]	[2]	**5 [66]**
LEGUME CROPS								
cf. *Vicia / Pisum* sp.	seed	-	-	[2]	-	-	-	**[2]**
FRUITS and NUTS								
Ficus carica	seed	1	51	-	-	2	2	**[56]**
WEEDS OF CEREALS								
Lolium sp.	seed	-	-	-	1	[1]	-	**1 [1]**
Bromus sp.	seed	-	-	-	1	-	-	**1**
OTHER WILD PLANTS								
Galium sp.	seed	-	-	-	[1]	-	-	**[1]**
INDETERMINATE								
Gramineae, sp. indet.	seed	[12]	3 [9]	-	2 [97]	-	[4]	**5 [122]**
Gramineae, sp. indet.	spikelet fork	-	-	-	-	[1]	-	**[1]**
Small Gramineae, sp. indet.	seed	-	-	-	2	-	[4]	**2 [4]**
Leguminosae, sp. indet.	seed	-	-	[1]	-	[3]	-	**[4]**
species indet.	seed	3	-	-	2	-	-	**5**
non-wood fragments indet.	unknown	[46]	[195]	[5]	[174]	[56]	[14]	**[490]**
wood, sp. indet.	wood	-	[4]	-	[10]	[12]	-	**[26]**
	TOTAL Whole	6	61	0	20	2	2	**91**
	TOTAL Items	71	253	9	335	88	26	**782**
	# Items per L	8.88	31.63	1.13	47.86	14.67	13	**20.05**

of clays. Therefore, this difference between the two areas may represent a difference in the integrity of the deposits, rather than areal differences in plant usage. Although these seeds were carbonized, they may be modern examples burned in a recent field fire (Garfinkel 1998, personal communication).

The small number of analyzed samples from the 1999 season precludes the use of ubiquity measures based solely on these remains, assessment of the relative importance of cultivated species in this area of the site, and comparison of this sector of the site with Area E. These issues may only be addressed after additional samples from 1999 have been analyzed.

IV. TAPHONOMIC FACTORS

In general, the density of botanical remains from the analyzed samples from 1998 and 1999 is quite low, ranging between zero to 47 items per liter. The preservation of material varies across the site, and is better in Area H than in Area E. This difference may be due in part to a difference in land use history between the two areas, with Area E lying below a former olive grove, and Area H lying below a former fishpond. Insect remains and rootlets were less frequently encountered in Area H than Area E, suggesting that bioturbation is less in Area H.

I suggest that the poor preservation results primarily from four taphonomic factors. These are the shallowness of the site, the modern history of land use, the shrinking and swelling tendency of the clay- and silt-rich soil, and bioturbation, as evidenced by the frequent occurrence of insects and rootlets in the samples. Each of these factors would increase the fragmentation of carbon and diminish the number of identifiable and whole items in the sediment. In addition, some fragmentation of plant remains may have occurred during the water-sieving process itself, particularly when it was necessary to refloat samples of the heavy fraction (Wagner 1988).

Other taphonomic processes may also affect the preservation of botanical remains. For example, wood appears in very limited quantities and only as fragments smaller than 1 cm.^{2}, perhaps reflecting the lack of contexts identified as hearth deposits. Similarly, the species of wood used at Sha'ar Hagolan may be of a type that fractures especially easily (Popper 1988). The behavioral context of floral remains also affects density, fragmentation, and the taxa represented. For example, a primary deposit of cereal processing debris *in situ* should be more dense than secondary deposits of the same material recovered from a swept surface or a mixed trash pit (Dennell 1976). Similarly, various stages in crop processing might be expected to result in different assemblages (Dennell 1974; Jones 1984).

V. DISCUSSION

In all deposits, cereal remains are both more ubiquitous and more abundant than pulses among the cultivated species (Table 17.4). There is not enough evidence at present to determine any correlation between the location of grinding implements and processing debris, so that the location of these remains in primary or secondary

TABLE 17.4. Ubiquity measures for 1998 and 1999 samples analyzed to date (N = 29, minimum ubiquity measure = 3.5%)

Group	Species included	Ubiquity
All Cereals	*Triticum dicoccum, Triticum monococcum, Triticum* sp., *Hordeum vulgare, Hordeum* sp.	62%
Wheats	*Triticum monococcum, Triticum dicoccum, Triticum* sp.	34%
Barley	*Hordeum vulgare, Hordeum* sp.	21%
Small Grasses	*Bromus* sp., *Lolium* sp., *Avena* sp., *Hordeum maritimum*, small Gramineae indet.	27%
Processing debris, grasses	all cereals and grasses	27%
Legume crops	*Vicia / Pisum* sp., *Lens* sp., *Vicia faba, Vicia ervilia*	17%
Fruits	*Ficus*, cf. *Pyrus* sp., fruit frags. indet.	41%
Chenopodium	*Chenopodium* cf. *album*, *Chenopodium* sp.	41%
Caryophyllaceae	*Silene / Stellaria* sp.	31%

contexts remains equivocal. The occurrence of processing debris in several contexts, however, may reflect small-scale processing of cereals as needed, as might be expected in a humid environment. Cereal processing debris appears to correlate with interior spaces. Similarly, B. Hesse (1999; Chapter 18 in this volume) has noted the rarity of faunal remains in street deposits as compared with interior areas at Sha'ar Hagolan. The paucity of botanical remains could equally reflect regular sweeping of plant waste into the streets, but sampling of street deposits is needed to support either of these interpretations.

The low frequency of wood is puzzling, particularly in light of the pronounced evidence of soot noted on several cooking vessels (Eirikh-Rose and Garfinkel, Chapter 7 in this volume) and the absence of burned dung deposits in all excavated deposits. The rarity of wood charcoal (Miller 1984) and the overall low density and high fragmentation of plant remains (Charles 1998) may suggest the use of dung for fuel (Miller 1984), but this interpretation may not be substantiated at present.

The investigation of fuel use, the question of *in situ* burning deposits, and the identification of the botanical remains as food, fuel or fodder will form a significant part of future analysis of material at the site, but at present the evidence is equivocal on these issues. Whether the apparent absence of hearths represents an artifact of excavation and recording or an absence of *in situ* deposits of burning activity will affect future interpretations of the taphonomy of the botanical assemblage. Despite the present limitations of the Sha'ar Hagolan floral data, some initial comparison may be made with the data from other Yarmukian sites with plant remains.

Sha'ar Hagolan Plant Husbandry in Context. To date, plant remains have been recovered from only three Yarmukian sites in Jordan and Israel: Abu Thawwab (Kafafi 1988, 1992) and 'Ain Rahub (Muheisen *et al.* 1988) in Jordan, and Sha'ar Hagolan in Israel. At a fourth site in Jordan, 'Ain Ghazal, floral remains were not preserved in the Yarmukian levels (Kafafi 1992; Rollefson and Kohler-Rollefson 1993). The plant remains at these sites have thus far been reported only in terms of presence or absence or as relatively more or less abundant, without quantitative data or information about sampling and recovery methods. In addition, wood charcoal (Neef 1997) is reported only from 'Ain Rahub. Therefore, present data from Yarmukian floral assemblages preclude a clear understanding of agricultural practices and the environment to which they were adapted. Although the data from 'Ain Rahub and Abu Thawwab may not be statistically compared with the data from Sha'ar Hagolan, some general statements of similarities and differences between the sites is possible.

Abu Thawwab is located in the Wadi er-Rummam of northwestern Jordan, adjacent to a perennial spring (Kafafi 1998, 1992). At this site, lentil (*Lens* sp.) and emmer wheat (*Triticum dicoccum*) are reported as predominant in the assemblage (Kafafi 1988, 1993). Cultivated flax (*Linum usitatissimum*) and bitter vetch (*Vicia ervilia*) were also identified (Kafafi 1993). Compared with Sha'ar Hagolan, the Abu Thawwab assemblage is similar in terms of the prevalence of emmer wheat. In contrast to Abu Thawwab, however, lentil and other cultivated legumes are rare at Sha'ar Hagolan. In addition, the single flax seed recovered from Sha'ar Hagolan falls within the dimensions of a wild flax such as *Linum bienne*, as opposed to the cultivated flax identified at Abu Thawwab. While two-row barley (*Hordeum distichum*) was identified at Abu Thawwab, the frequency of barley in the samples from Sha'ar Hagolan is too low to allow this level of precision in cereal identification. Further analysis of the better preserved, more dense deposits from Area H (1999) at Sha'ar Hagolan may allow more precise determination of the type of barley represented.

At 'Ain Rahub, located in the semi-arid environment of the north Jordanian highlands on the west bank of the Wadi ar-Rahub, Neef reports the predominance of emmer wheat and two-row barley in the floral assemblage (Muheisen *et al.* 1988). Among the remains of emmer wheat, spikelet forks, glume bases, and grains are all reported, but the taphonomy of the remains is not discussed (Muheisen *et al.* 1988). As at Sha'ar Hagolan, einkorn wheat is rare (a single occurrence) in comparison with emmer, and no cultivated legumes are reported (Muheisen *et al.* 1988). Neef reports a similar weed assemblage to that from Sha'ar Hagolan, including mallow (*Malva* sp.), medick (*Medicago* sp.), and canary grass (Muheisen *et al.* 1988). Neef has identified all wood charcoal from 'Ain Rahub as tabor oak (*Quercus ithaburensis*) which, in conjunction with relict stands of tabor oak in the area of the site, has suggested the existence of Mediterranean forest in the vicinity during the Yarmukian period (Muheisen *et al.* 1988). It is hoped that identification of the wood species from Sha'ar Hagolan will provide similar evidence of local environmental conditions during the pottery Neolithic.

A separation and specialization of plant and animal husbandry within the Yarmukian agricultural economy has recently been suggested (Rollefson 1997). However, differences between the reported floral and faunal remains from Yarmukian sites suggests that the degree of separation or integration of plant and animal husbandry probably varies between sites. Variations in the agricultural strategies of different Yarmukian sites should be investigated, rather than seeking a single characterization of Yarmukian economy. Further analysis and reporting of the Sha'ar Hagolan, 'Ain Rahub, and Abu Thawwab botanical assemblages, including wood and non-wood remains, will make a significant contribution to evidence for local environmental conditions and subsistence practices in the later Neolithic of the Levant. Such information is critical for understanding the transition to the Pottery Neolithic and the extent of environmental variation during the later Neolithic.

VI. CONCLUSIONS

Preliminary analysis of the plant remains, together with information from the faunal assemblage (Hesse 1999; Chapter 18 in this volume) suggests a fully agricultural economy at Sha'ar Hagolan based on both plant and animal husbandry. The plant husbandry system was cereal-based, and likely involved the use of cereals and their by-products for both food and fodder. The presence of cereal grains, weeds and processing debris, together with the high frequency of basalt grinding stones and flint sickles suggests that the Yarmukians of Sha'ar Hagolan were fully engaged in plant producing activities. The presence of fruit and nut species, although rare, suggests that wild plant resources also contributed to the diet.

The taphonomy of the plant remains and the question of fuel resources require further investigation. Future study of the plant remains will focus on these issues as well as the spatial and contextual associations of the recovered taxa, their ecology, and their seasonality. These investigations will provide additional evidence for the functions of areas within the site, the nature of agricultural practices, and the site's environmental context during the sixth millennium BC. In addition, identification of wood charcoal and wild plant seeds from the site may provide a more localized picture of environmental conditions during the later Neolithic than that already provided by regional environmental evidence.

Acknowledgements

I am grateful to Dr. Y. Garfinkel and Dr. M. Miller for inviting me to undertake study of this material, and to the Israel Antiquities Authority for granting permission to export the 1998 and 1999 flotation samples to Boston University, Boston, Massachusetts, for further analysis in the laboratory. The initial set-up of the water-sieve would not have been possible without the guidance of Dr. J. Hansen and the kind assistance of many members of Kibbutz Sha'ar Hagolan. Sincere thanks are also due to James Hirst, Chris Holmes, Natasha Rakovic, Shalom Sanchez, and most especially to Nick Franchino and Pam Smith for their invaluable help with the water-sieving. For her patient encouragement and careful reading of an earlier draft of this report, I thank Dr. J. Hansen. I retain culpability for any lingering interpretive errors.

BIBLIOGRAPHY

Banning, E.B., Rahimi, D., and Siggers, J. 1994. The Late Neolithic of the Southern Levant: Hiatus, Settlement Shift, or Observer Bias? The Perspective from Wadi Ziqlab. *Paléorient* 20: 151–164.

Charles, M. 1998. Fodder from Dung: The Recognition and Interpretation of Dung- Derived Plant Material from Archaeological Sites. *Environmental Archaeology* 1: 111–122.

Davis, E.M. and Wesolowsky, A.B. 1975. The Izum: A Simple Water Separation Device. *Journal of Field Archaeology* 2: 271–273.

Dennell, R.W. 1974. Botanical Evidence for Prehistoric Crop Processing Activities. *Journal of Archaeological Science* 1:275–284.

Dennell, R.W. 1976. The Economic Importance of Plant Resources Represented on Archaeological Sites. *Journal of Archaeological Science* 3: 229–247.

French, D.H.1971. An Experiment in Water-Sieving. *Anatolian Studies* 21:59–64.

Hesse, B. 1999. Rethinking the Place of Animals in the Neolithic Period: New Evidence from Sha'ar Hagolan and Ashkelon. Paper presented at the Annual Meeting of the American Schools for Oriental Research, Cambridge, Massachusetts, November 17–20,1999 (Abstract).

Hillman, G.C. 1981. Reconstructing Crop Husbandry Practices from Charred Remains of Crops. In Mercer, R. (ed.) *Farming Practice in British Prehistory*, pp. 123–162. Edinburgh: Edinburgh University Press.

Jones, G.E.M. 1984. Interpretation of Archaeological Plant Remains: Ethnographic Models from Greece. In Van Zeist, W. and Casparie, W.A. (eds.) *Plants and Ancient Man*, pp. 43-61. Rotterdam: A.A. Balkema.

Kafafi, Z. 1988. Jebel Abu Thawwab: A Pottery Neolithic Village in North Jordan. In Garrard, A. and Gebel, H.G. (eds.) *The Prehistory of Jordan: The State of Research in 1986*, pp. 452–471 (B.A.R. International Series 396). Oxford: British Archaeological Reports.

Kafafi, Z. 1992. Pottery Neolithic Settlement Patterns in Jordan. In Hadidi, A. (ed.) *Studies in the History and Archaeology of Jordan* IV, pp. 115–122. Amman: Department of Antiquities.

Kafafi, Z. 1993. The Yarmoukians in Jordan. *Paléorient* 19: 101–113.

Kohler-Rollefson, I. 1988. The Aftermath of the Levantine Neolithic Revolution in Light of Ecological and Ethnographic Evidence. *Paléorient* 14: 87–93.

Kohler-Rollefson, I., Gillespie, W. and Metzger, M.1988. The Fauna from Neolithic 'Ain Ghazal. In Garrard, A. and Gebel, H.G. (eds.) *The Prehistory of Jordan: The State of Research in 1986*, pp. 423–436 (B.A.R. International Series 396). Oxford: British Archaeological Reports.

Kohler-Rollefson, I. and Rollefson, G. O.1990. The Impact of

Neolithic Subsistence Strategies on the Environment: The Case of 'Ain Ghazal, Jordan. In Bottema, S., Entjes-Nieborg, G. and Van Zeist, W. (eds.) *Man's Role in the Shaping of the Eastern Mediterranean,* pp. 3–13. Rotterdam: A.A. Balkema.

Miller, N.F. 1984. The Use of Dung as Fuel. An Ethnographic Example and an Archaeological Application. *Paléorient* 10: 71–79.

Miller, N.F. 1988. Ratios in Paleoethnobotanical Analysis. In Hastorf, C.A. and Popper, V.S. (eds.) *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains* (Prehistoric Archeology and Ecology Series), pp. 72–85. Chicago: University of Chicago Press.

Muheisen, M, Gebel, H.G., Hannss, C. and Neef, R. 1988. Excavations at 'Ain Rahub, a Final Natufian and Neolithic Site near Irbid (1985). In Garrard, A. and Gebel, H.G. (eds.) *The Prehistory of Jordan: The State of Research in 1986*, pp. 473–502 (B.A.R. International Series 396). Oxford: British Archaeological Reports.

Neef, R. 1997. Status and Perspectives of Archaeobotanical Research in Jordan. In Gebel, H.G., Kafafi, Z., and Rollefson, G.O. (eds.) *The Preshistory of Jordan,* II. *Perspectives from 1997* (Studies in Early Near Eastern Production, Subsistence, and Environment 4), pp. 601–609. Berlin: *ex oriente.*

Pearsall, D. 1989. *Paleoethnobotany: A Handbook of Procedures.* San Diego: Academic Press.

Popper, V. 1988. Selecting Quantitative Measurements in Paleoethnobotany. In Hastorf, C.A. and Popper, V.S. (eds.) *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains* (Prehistoric Archeology and Ecology Series), pp. 53–71. Chicago: University of Chicago Press.

Rollefson, G.O. and Kohler-Rollefson, I. 1993. PPNC Adaptations in the First Half of the 6th Millennium B.C. *Paléorient* 19: 33–42.

Simmons, A.H., Kafafi, Z., Rollefson, G.O. and Moyer, K. 1989. Test Excavations at Wadi Shu'eib, a Major Neolithic Settlement in Central Jordan. *Annual of the Department of Antiquities of Jordan* 33: 27–42.

Smith, B.D. 1992. *Rivers of Change: Essays on Agriculture in Eastern North America.* Washington: Smithsonian Institution Press.

Wagner, G.E. 1988. Comparability Among Recovery Techniques. In Hastorf, C.A. and Popper, V.S. (eds.) *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains* (Prehistoric Archeology and Ecology Series), pp. 17–35. Chicago: University of Chicago Press.