



Plant-food preparation area on an Upper Paleolithic brush hut floor at Ohalo II, Israel

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ABSTRACT

While a division of domestic space into separate sectors dedicated to different activities has been suggested for a number of Upper Paleolithic hunter-gatherer sites, it has never been demonstrated based on plant remains from this period. Moreover, due to the usual scarcity of plant macrofossils in archaeological deposits, only animal food preparation activities associated with hearths have been reported in the literature on Near Eastern prehistory. Ohalo II (Israel) is the first Upper Paleolithic site where such a patterned use of interior space and plant processing are evidenced by the distribution of plant remains on a sealed floor of a brush hut. This paper describes and interprets the distribution of almost 60,000 identified seeds and other plant remains on that floor, proposing a reconstruction of three activity areas in the interior of the 12-m² hut: processing of food centered on a grinding stone; a flint knapping area; and an access area in between. Finally, it is suggested that these activity areas might represent male-female division of labor.

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1. Introduction

Detailed analyses of intrasite spatial patterns are the key to reconstructing activity areas, the finest scale of past spatial behavior revealed by archaeological assemblages. The reconstruction of activity areas and their locations, in turn, can help us understand the internal social and economic organization of ancient households (Balme and Beck, 2002; Hayden, 1997). Intrasite studies are predicated upon the assumption that an association of archaeological remains in a limited space is indicative of a particular human activity. Most such clusters identified at prehistoric sites are related either to hearths or to stone-tool manufacturing (see references in Balme and Beck, 2002; Gowlett, 1997). Due to the relative scarcity of plant macrofossils in archaeological deposits, to this date only animal-food preparation activities associated with hearths have been reported in the literature on Near East prehistory. The present paper interprets patterned distributions of plant remains as evidence of a specialized plant processing area on a brush hut floor, at the Upper Paleolithic site of Ohalo II in Israel.

In recent years, archaeologists have studied patterns of intrasite spatial organization at Middle Paleolithic sites as proxies of evolving human cognitive capabilities (see references in Vaquero and Pasto, 2001). However, ideas and models of “high resolution” or “high definition” archaeology go back much longer (see Gowlett, 1997 for review). Eventually, the rise of the New Archaeology during the 1960s, with its quest for objectivity in analyzing archaeological data, led to the development of quantitative, formal approaches to spatial archaeology (Clark and Stafford, 1982). This approach is exemplified by the works of Clarke (1977) and Binford (1981, 1983). The meticulous recording and analysis of archaeological finds proposed by these scholars was expected to reveal patterned spatial relationships between the finds that would provide insights into their sociological, economic, or ecological meaning.

Understanding the formation processes that affected the archaeological deposits both during and after a site's occupation is crucial for high-resolution intrasite spatial analysis. Meaningful interpretations of the spatial relationships between objects depend on there having been no more than minimal disturbance after initial deposition. However, many studies have documented sources of site disturbance that may alter the original spatial distribution of archaeological materials. They include both factors that act at the time of initial deposition or shortly thereafter (cf. Binford,

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1978) and post-depositional processes, such as human trampling, displacements caused by wind and water, and animal activity (Balme and Beck, 2002). Many of the sites where these sources of disturbance have been examined in detail are cave sites. Goldberg's studies (Goldberg, 2000; Goldberg and Bar-Yosef, 1998) of geomorphological and geochemical profiles of cave sites demonstrate the significance of geogenic, biogenic, and anthropogenic factors in causing horizontal and vertical movements of small archaeological remains.

In contrast to cave sites, Ohalo II is uniquely suited for fine-grained, intrasite spatial analysis. While there are studies that analyze the distribution of charred plant macrofossils to interpret human use of space (good examples are Hayden, 1997, 2000), we are not aware of any other Levantine or, for that matter, Upper Paleolithic site that has produced a similarly sealed, "Pompeii-like" floor, rich enough in plant remains to allow detailed spatial analysis. Its short-term, open-air occupation further distinguishes Ohalo II from contemporaneous cave sites. This paper examines floor II in hut 1 at Ohalo II. The plant assemblage from all excavation units of this 12-m² floor includes close to 60,000 analyzed specimens. This assemblage puts us in a position to reconstruct the use of space inside an Upper Paleolithic hut.

Due to the uniquely favorable conditions of preservation at Ohalo II, as well as the complete excavation and fine-grained recording of the hut 1 floor, the plant assemblage analyzed here is so large and its distribution so clear that statistical manipulation of the data can be kept to a minimum. Most concentrations stand out immediately on the distribution maps, without any massaging of the data. The only fundamental quantitative assumption made here is one that underlies any archaeobotanical study (without always being made explicit)—namely that different taxa have roughly equal preservation rates.

2. Ohalo II

2.1. The site and its setting

Ohalo II is a submerged late Upper Paleolithic (locally termed Early Epipaleolithic) site radiocarbon dated to 22,500–23,500 cal B.P. (Nadel et al., 1995, 2002). The site is located on the southwestern shore of the Sea of Galilee (Lake Kinneret), Rift Valley, Israel (Fig. 1). This hunter-gatherer-fisher camp, covering more than 2000 m² (0.2 ha), includes the remains of six brush huts, open-air

hearths, and a human grave (Fig. 1) (Nadel, 2002a; Nadel et al., 2002). The site was occupied during the Last Glacial Maximum (LGM), a period of cold and dry climate when ice sheets covered parts of North America and Europe.

Three successive seasons (1989–1991) of excavations at Ohalo II were conducted immediately following its discovery, when the lake level had dropped and much of the site was exposed. Subsequently, the site was submerged again for several years, rendering fieldwork difficult. However, additional three seasons of fieldwork took place in 1999–2001, after droughts and heavy water pumping from the lake had caused the water level to drop to ca. 213.80 m below msl.

The archeological remains are located on the clay/silt Lisan Formation bedrock. The Lisan Formation into which the Ohalo II hut floors were dug is composed of lacustrine sediments, dated between 70,000 and 15,000 years B.P. (Bartov et al., 2002). The huts were located on the shores of the newly formed Sea of Galilee (Belitzky and Nadel, 2002a).

Ohalo II is an exceptional site on a number of accounts. No other Levantine Upper Paleolithic site has produced such well preserved huts, hearths, a grave, and large quantities of archaeological materials. These include flint and ground stone tools, a broad spectrum of animal remains (mammals, birds, rodents, fish, mollusks), and a rich plant assemblage (Bar-Yosef Mayer, 2002; Belmaker et al., 2001; Kislev et al., 1992; Nadel and Werker, 1999; Nadel et al., 1994, 2002; Rabinovich, 2002; Rabinovich and Nadel, 1994, 2002; Simmons, 2002; Simmons and Nadel, 1998; Weiss, 2002).

The probable reason for the outstanding preservation is the rise of the lake level, which sealed the site immediately after its abandonment (Nadel, 2002a; Nadel et al., 1995, 2002, 2004). The plant material, in particular, was protected by two successive events. The first was charring by fire, which preserved most of the archaeobotanical remains. Then, very shortly after the site was abandoned, the water level of the newly formed lake rose. We do not know whether the rise of the lake level was the reason for the abandonment. It is clear, however, that the deposition of silt and clay by the lake sealed the submerged site. This combination of charring, evidently in low-oxygen conditions (perhaps under the cover of the hut's walls), and sealing under lake sediments and water apparently created ideal conditions for preservation of organic materials (Weiss, 2002). The vast majority of the site's plant remains—all but 152 seeds—were charred (Kislev et al., 1992, 2002; Simchoni, 1998; Weiss, 2002). The botanical remains are distinguished by exquisite preservation. As a result, they can be identified to the family, genus, and in many cases even to the species level.

2.2. Site formation processes

Inferences from spatial relationships between archaeological finds are legitimate only if these finds are contemporaneous and were laid down by the same deposition-accumulation process. Tsatskin and Nadel (2003) reconstructed Ohalo II's site formation history and distinguished anthropogenic from natural deposits. They used soil-geomorphic analysis coupled with micromorphology, SEM/EDS, magnetic susceptibility, and conventional sedimentological techniques, such as measurements of organic matter and soluble salts. Their research confirms the field observation (Nadel and Werker, 1999) of three successive floors in hut 1 and shows that the dark organic layers of brush hut 1 are indeed human-made floors, rather than effects of natural forces, such as water and wind (Figs. 2,3) (Tsatskin and Nadel, 2003). Our reconstruction of human activities that were responsible for the deposition of copious plant remains on one of these floors points in the same direction.

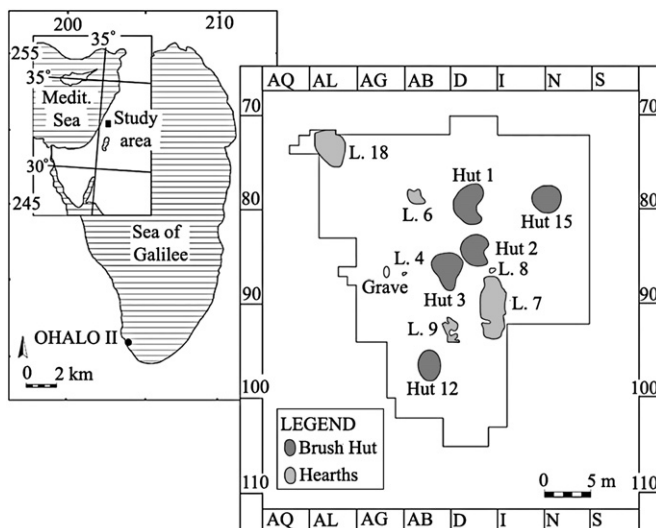


Fig. 1. Location map of Ohalo II and central area of excavation at the site.

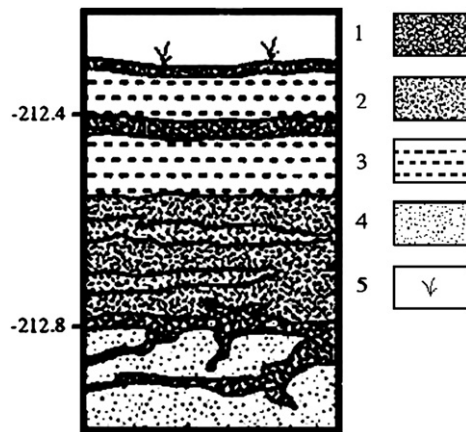


Fig. 2. Geo-archaeological cross-section through the floors of brush hut 1, square E80b. 1, dark cultural layer and soil; 2, cultural layer mixed with ash; 3, homogeneous lake marl; 4, bedded lacustrine sand; 5, surface covered with pebbles and sand from Lake Kinneret, prior to excavation. The numbers along the vertical axis represent meters below msl (after Tsatskin and Nadel, 2003).

2.3. The Grinding stone

A grinding stone found *in situ* in the northern part of floor II in hut 1 (Figs. 3, 4) apparently was a focal point of activities inside the hut. This stone is a roughly trapezoidal, flat, 40-cm long slab of basalt, deliberately embedded in horizontal position in the floor. It was tentatively named “the anvil” by the excavator (Nadel, 1997), who remarks on the special attention it received from the inhabitants of the hut. To keep the stone horizontal and firmly set within the floor, non-local sand was brought in to form a bed underneath the grinding stone, further stabilized with small cobbles (Nadel, 1997). These efforts suggest that its intended use required the stone to be in a stable, horizontal position inside the hut.

In order to ascertain whether the stone was used to grind plant material and specifically establish which taxa were processed, Piperno et al. (2004) conducted a starch grain study. A total of 150 starch grains were recovered from the grinding stone; 23 of these were identified as *Hordeum* sp. grains (Piperno et al., 2004). This study produced direct evidence demonstrating that the stone did indeed function as a grinding stone. However, comparative ethnographic evidence shows that grinding grass grains is not usually the sole function of grinding stones in hunter-gatherer societies. Several African and Australian groups employ grinding stones as multi-purpose tools that serve such diverse functions as flint tool manufacturing, pounding of ochre and bones, cracking of nuts and eggs, and processing of bark (Kraybill, 1999; McCarthy, 1946). In light of this comparative evidence and the distributions of plant remains to be discussed here, it is likely that the Ohalo II grinding stone was used both as a grinding stone and as a general-purpose working surface.

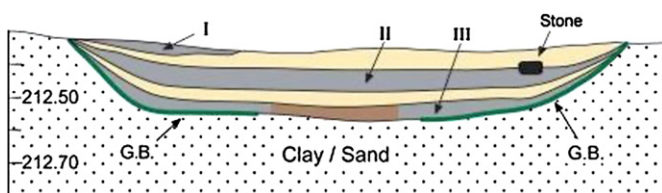


Fig. 3. An east-west cross-section through the floors of brush hut 1. Note the exaggerated vertical scale. I, II, III, the three floors, stone on right—the grinding stone discussed in text; GB, grass bedding.

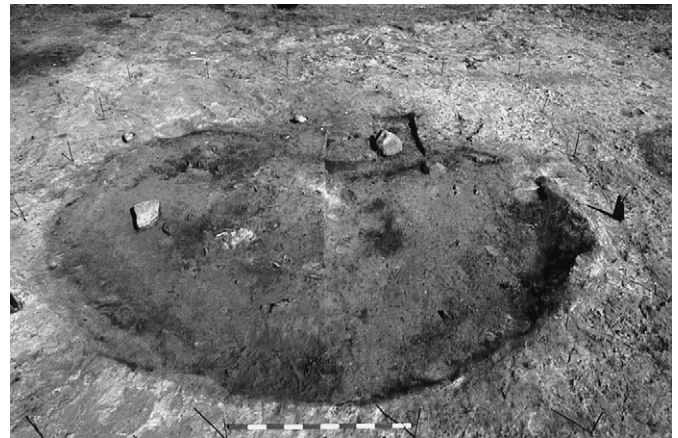


Fig. 4. Hut 1 during excavation of floor II, facing east. Note the diamond-shaped grinding stone in the northern (left) part of the floor.

2.4. Sub-sampling floor II

The second of three superimposed floors of hut 1 received special care in the analysis of the Ohalo II plant remains. This floor is a kidney-shaped, ca. 3-by-4 m feature, measuring some 12 m² in area. Like the rest of the site, it was excavated in 0.5-by-0.5 m units. Botanical remains from this floor were sampled in a two-step process. First, we examined all samples from the floor and rated them according to relative richness in plant remains. Subsequently, we analyzed the 80% richest samples. To ensure full coverage of the entire floor area, we also analyzed samples from those units that initially scored as poor. The last 20%, which were either poor or originated from squares that had already been sampled, were skipped. This procedure resulted in a sample of almost 60,000 plant remains from this floor (Weiss, 2002).

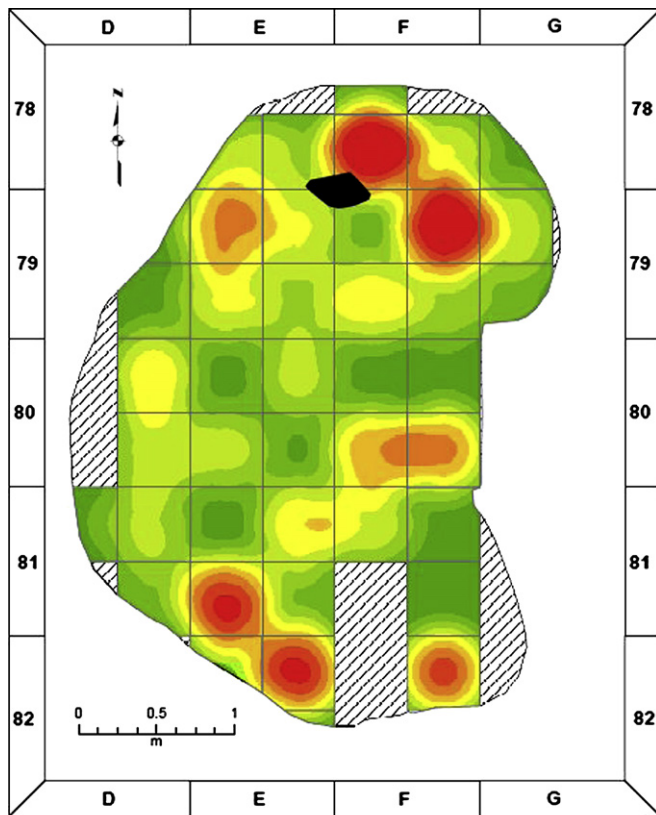
3. Results: plant distribution

Figs. 5–19 and Figs. 22, 23 illustrate the spatial distributions of various taxa of plant remains in form of continuous kernel density plots interpolated between the centroids of the excavation grid squares. As used here, the term taxon (plural taxa) designates any level of plant identification from species to family. The excavation squares devoid of botanical samples are marked on the figures by a diagonal hatch pattern.

Almost 100 taxa are represented among the identified plant remains from floor II (Simchoni, 1998; Weiss, 2002). The spatial distributions of those 13 taxa that display distinct concentrations in restricted floor areas will be discussed in the following sections. As expected of archaeological assemblages, other taxa are represented by small quantities with no discernible patterns of distribution. The 13 taxa that will be examined here represent over 80% of the total plant assemblage from the floor (Table 1).

3.1. Distribution of the total plant assemblage

Before we search for concentrations of individual taxa, we first need to examine the distribution of the plant assemblage as a whole. An even distribution of the entire plant assemblage, without any notable clusters or gaps, would imply that the distribution of plant remains is not skewed by restricted or unused floor areas or by recovery bias. In this case, any concentrations or clusters of remains of one or more individual taxa would be distinctive of those taxa rather than of the assemblage as a whole. On the other hand, such concentrations would be much less meaningful if the bulk of the plant assemblage originated from a limited number of



Ohalo II, hut 1, floor II

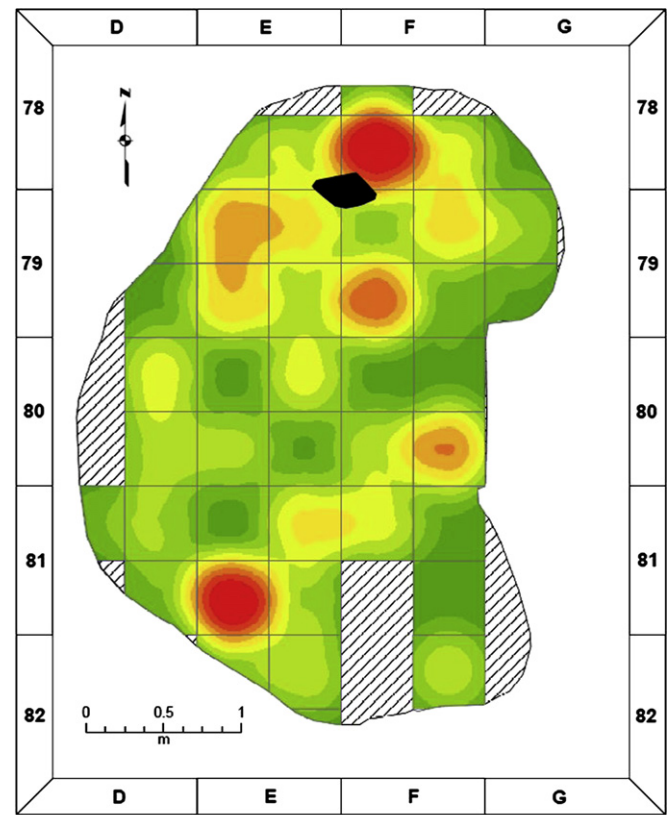
All species



Fig. 5. Distribution of the total plant assemblage, some 60,000 seeds and fruits, on floor II. Continuous kernel density plot interpolated between the centroids of the excavation grid squares. Squares devoid of botanical samples are marked by a diagonal hatch pattern. Scale in units of percent standard deviation from mean density (10% steps). The following distribution maps, Figs. 5–18 and Figs. 21, 22, follow the same convention.

grid squares or from a particular sector of the hut. Under these circumstances, the distribution might have been created by any one or a combination of factors during and after the site's occupation, as well as during field recovery and laboratory processing, such as accumulation, preservation, excavation, extraction, sorting, etc. Patterned distributions might be attributable to differential preservation rates, too, but given the intractable nature of this problem it is common practice to disregard it, treating it as yet another uncontrollable vagary of preservation whose effects hopefully will cancel each other out.

Fig. 5 shows the distribution of the complete plant assemblage across the floor. It is clearly a regular, anti-clustered distribution: most squares contain no more than 3% and even the highest number of plant remains in any one square (F78c) represents less than 10% of the total. Since a single taxon, *Suaeda palaestina/fruticosa* (sea-blite) (nomenclature in this paper after Danin, 2004), constitutes around 35% of the total assemblage, we checked whether and to what extent its distribution determines that of the entire assemblage. Fig. 6 shows the distribution of the total plant assemblage from floor II excluding *S. palaestina/fruticosa* seeds. The removal of the single most common taxon does not significantly alter the general distribution. This suggests that the regular distribution



Ohalo II, hut 1, floor II

All species except *S. palaestina/fruticosa*



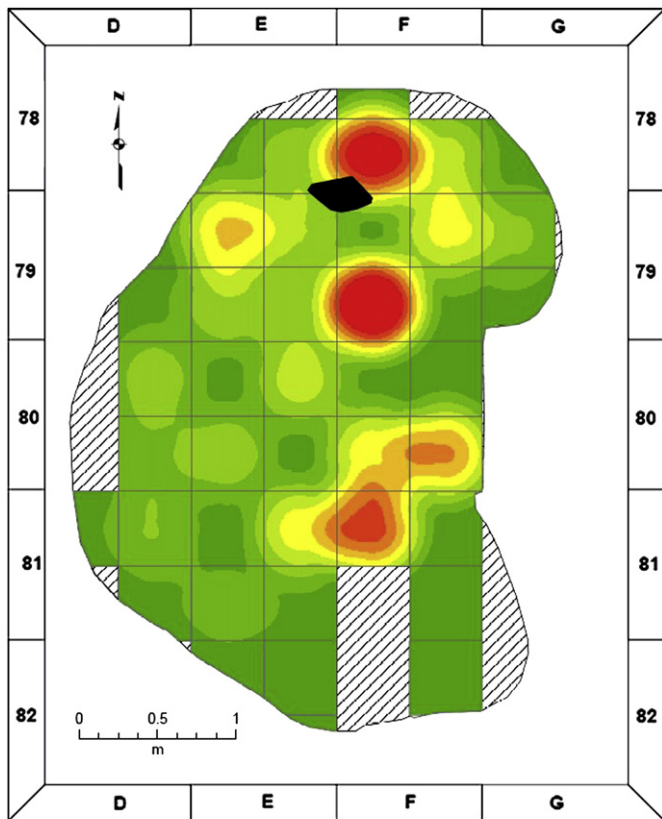
Fig. 6. Distribution of the total plant assemblage, excluding *S. palaestina/fruticosa* seeds, on floor II ($N = 29,451$).

described is representative of the whole assemblage and no single contributor is responsible for it. Therefore, we may conclude that any clusters of a single taxon that may be found will be indicative of the distribution of that particular taxon and the activities in which it was involved.

3.2. The distributions of individual taxa

Figs. 7–19 and Figs. 22, 23 display the distributions of major taxa found on floor II. It is readily apparent that these distributions are not random. Different taxa are concentrated in different, clearly delimited zones. The following discussion will demonstrate that there are correlations both among the patterned distributions of several plant taxa and between these taxa and the structure and internal features of the hut. These correlations will then allow us to offer an explanation of the observed distributions of plant remains. Since different plants produce different amounts of seeds and fruits, it is important to distinguish between concentrations of plant remains resulting from a single deposition of one plant or fruiting branch and cumulative concentrations that represent multiple plants or deposition events. Our discussion will take this distinction into consideration. Please note that each excavation grid square is approximately 2.5% of the floor area.

The most salient characteristic that leaps to the eye when examining the different plant distributions is the correlation between several taxa that cluster around the grinding stone toward

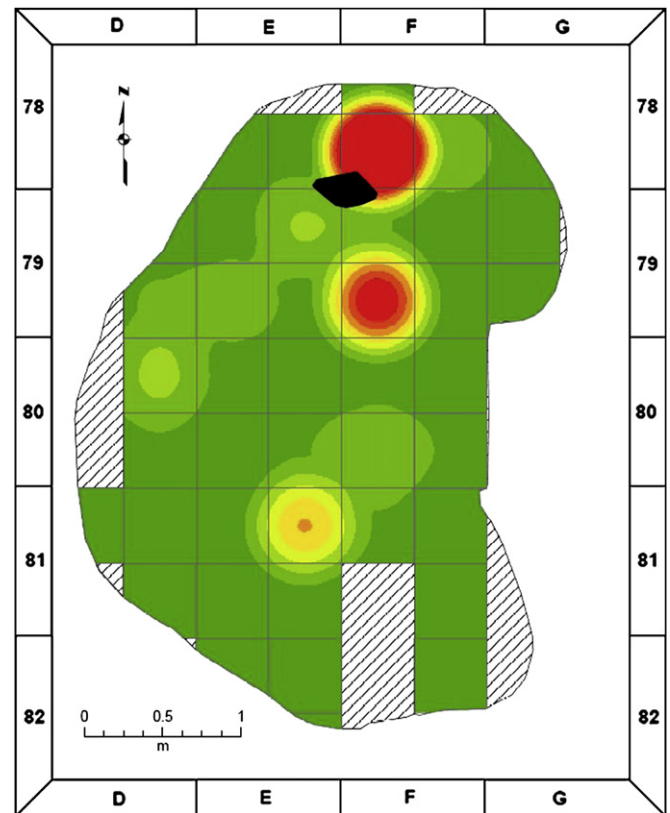


Ohalo II, hut 1, floor II

Bromus pseudobranchystachys/tigridis



Fig. 7. Distribution of *Bromus pseudobranchystachys/tigridis* (9904 grains) on floor II.



Ohalo II, hut 1, floor II

Hordeum marinum/hystrix



Fig. 8. Distribution of *Hordeum marinum/hystrix* (505 grains) on floor II.

the north wall of the hut. The densest concentrations are in square F78c, the northeastern one of four squares that touch the grinding stone. This square alone produced 15% of all 9904 *Bromus pseudobranchystachys/tigridis* (brome) grains (Fig. 7); 45% of the 505 *Hordeum marinum/hystrix* grains (Fig. 8); 16% of the 606 *Hordeum spontaneum* (wild barley) grains (Fig. 9); and 36% of the 819 *Piptatherum holciforme* (syn. *Oryzopsis holciformis*) (millet grass) grains (Fig. 10). In addition, it contained 13% of the 115 *Silybum marianum* achenes (Fig. 11); 24% of the 594 *Malva parviflora* mericarps (Fig. 12); and 58% of the 134 *Melilotus indicus* seeds (Fig. 13).

Visual inspection of distribution maps thus suggests that these seven taxa form a tightly defined cluster around the grinding stone, with secondary concentrations in the center-south of the floor. K-means clustering of the excavation grid squares on the densities (count/m²) of these seven taxa, assuming two clusters (high vs. low concentrations), confirms this interpretation of the distribution maps. Squares with extremely high probabilities of membership in the “high concentration” cluster form a U-shaped group around the grinding stone and another block in the center south of the floor. The result is spatially identical when only the densities of the four grass (Poaceae = Gramineae) taxa (*H. spontaneum*, *B. pseudobranchystachys/tigridis*, *P. holciforme*, and *H. marinum/hystrix*) are included in the cluster analysis. Clustering on the remaining three taxa produces a “high concentration” cluster that includes only one or perhaps two squares immediately to the north of the grinding stone. Similarly, local spatial autocorrelation analysis (Anselin’s Local Moran’s *I*) (Anselin, 1995) reveals a tight and statistically

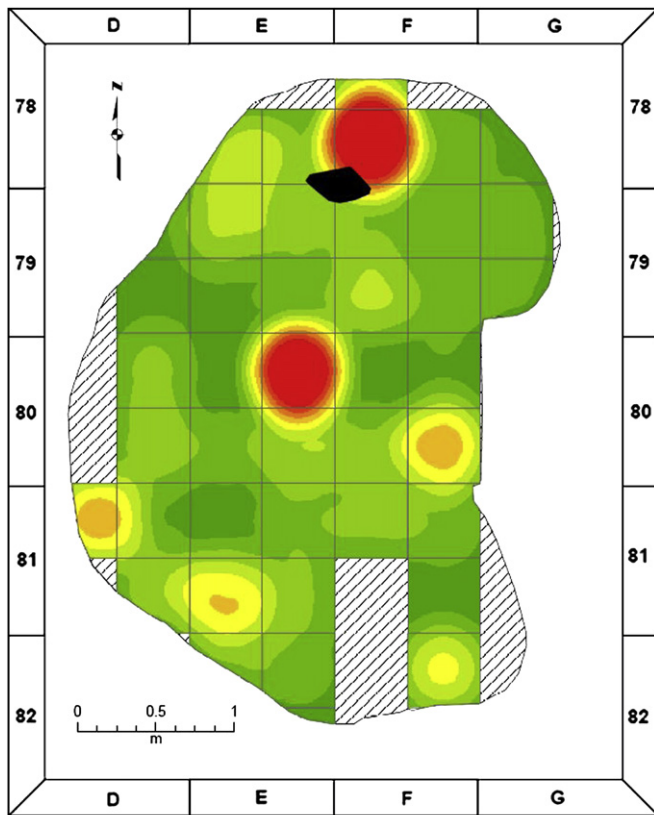
highly significant cluster of squares with exceptionally high densities of the four grass taxa next to the grinding stone (Fig. 14). However, the secondary concentration of grass grains in the center south of the floor is not statistically distinguishable from grain counts in the adjacent squares. The following paragraphs will discuss the meaning of these associations in light of possible uses of the plants involved.

The grains of the four grass taxa were part of the diet of the site’s inhabitants (Weiss et al., 2005), and their grains most probably were ground on the grinding stone or processed in other ways near it (Piperno et al., 2004).

Holy thistle (*Silybum marianum*) has many potential uses. Its leaves and stalks are eaten both fresh and boiled and its achenes (fruitlets) have medicinal properties. Pharmaceutical analyses have discovered that glycoside compounds in its achenes help to cure liver inflammation and poisoning. Extracts of *S. marianum* achenes are a common alternative medicine today (Dafni, 1984; Hedrick, 1972; Palevitch and Yaniv, 2000).

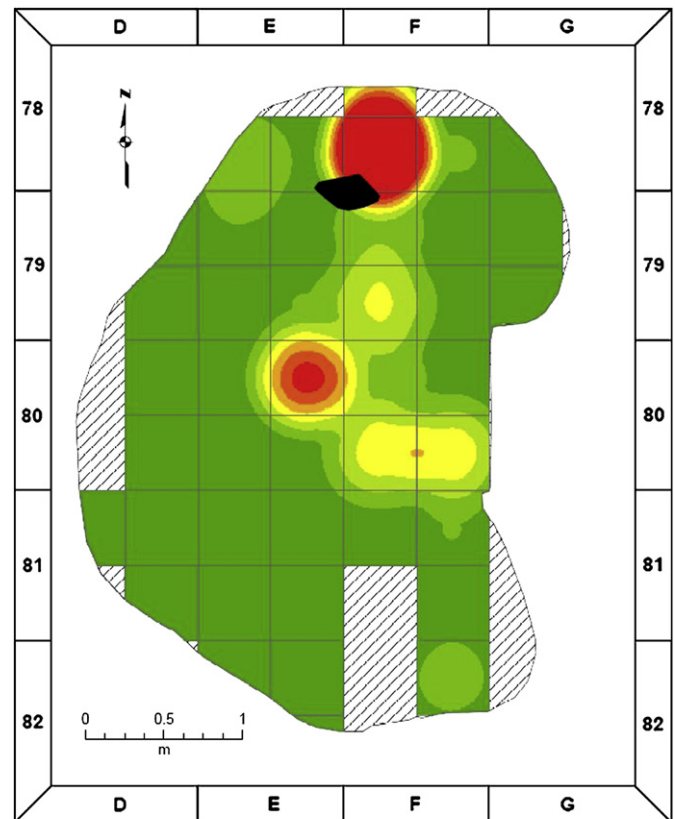
Mallow (*Malva parviflora*) is an important food plant. Its leaves and young fruits are eaten fresh, and all its parts are edible when boiled. The immature mericarps, which are sometimes gathered separately, are edible and also used in traditional medicine. In India, the roots are used for washing hair and wool (Beily and Danin, 1981; Dafni, 1984; Zohary and Feinbrun, 1930).

As a note of caution, we must point out that medicinal uses by present or historic societies, as documented in the literature, *do not prove* that prehistoric people used these plants in the same



Ohalo II, hut 1, floor II
Hordeum spontaneum
 low high 0 - 414 grains/m²

Fig. 9. Distribution of *Hordeum spontaneum* (606 grains) on floor II.



Ohalo II, hut 1, floor II
Oryzopsis holciforme
 low high 0 - 1,082 grains/m²

Fig. 10. Distribution of *Piptatherum holciforme* (819 grains) on floor II.

way. Only archaeological contexts such as gut contents, coprolites (palaeofaeces), or stew remains within a cooking pot, provide direct evidence for human use. Given that there is no such evidence from Ohalo II, the references to medicinal uses are meant merely to call attention to the wide range of potential uses of the plants found on floor II. However, we do want to suggest that concentrations of these plants as dense as those we found on floor II in direct association with a grinding stone constitute the strongest of indirect evidences of their use. Additionally, it is important to notice that the relative quantities needed in medicinal plants are very small.

Melilotus indicus displays the most densely packed distribution of all taxa in this group (Fig. 13). Eighty-four percent of the 134 *Melilotus* seeds come from two squares, F78a and F78c. *M. indicus* pods grow on multi-pod racemes; each pod usually contains a single seed. Thus, the concentration on floor II may represent a single deposition event. *M. indicus* is used in India to stop bleeding and as narcotic (Boulos, 1983; Townsend and Guest, 1974). In Egypt, seeds of this species are used to treat diseases of the genital organs of both sexes (Boulos, 1983).

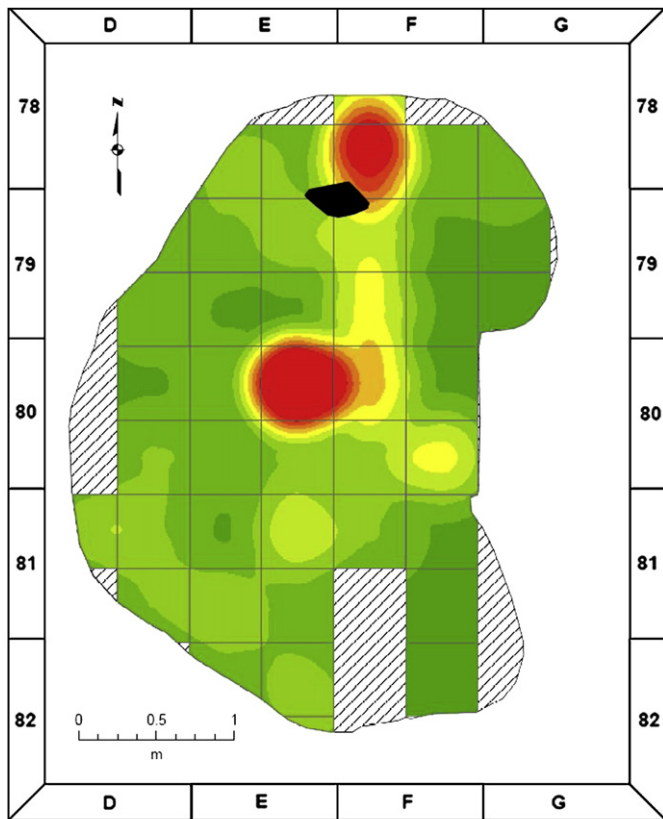
Two additional taxa were heavily concentrated in squares F78a and F78c. 85% of the 31 fumitory (*Fumaria macrocarpa*) nutlets and 60% of the 55 *Aegilops* spp. (including *Ae. peregrina* and *Ae. geniculata/peregrina*) grains were found in square F78c.

The dense concentrations of food plants in square F78c point to food preparation or storage activities in this area. Medicinal plants may also have been processed on or near the grinding stone. We

previously mentioned ethnographic evidence of grinding stones serving as multipurpose working surfaces in hunter-gatherer societies (Kraybill, 1999; McCarthy, 1946). The fact that the concentrations of plant remains around the floor II grinding stone include both plants that do and others that do not require pulverizing as preparation for human use makes sense in light of these ethnographic observations.

Similarly high densities of plant remains as in F78a and F78c were observed in two adjacent grid squares, including *H. spontaneum*, *P. holciforme*, and *S. marianum* in E80b and *B. pseudo-brachystachys/tigridis* and *H. marinum/hystrix* in F79c. These two squares are adjacent to each other and to the grinding stone. A fourth square with much lower densities of botanical remains is between the high-density squares and also adjacent to the grinding stone. A plausible explanation of this U-shaped constellation of densely distributed plant remains around a grinding stone and a single square notably poorer in plant remains is a person squatting in the low-density square F78a, operating the grinding stone.

Also clustered around the grinding stone were the dispersal units of *Atriplex rosea* and *A. leucoclada* (orache) (Fig. 15). Due to their morphological proximity, only half of these could be identified to the species level, while the rest was identified as *A. rosea/leucoclada*. Fig. 15 therefore illustrates the pooled distribution of *Atriplex* on the floor. It is uniformly sparse across the floor, with one major concentration in the squares surrounding the grinding stone,

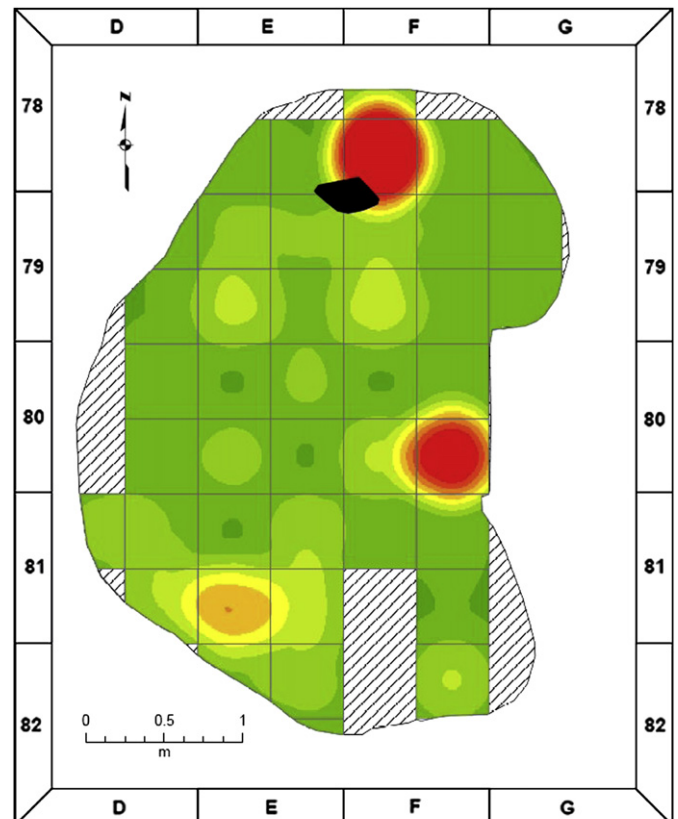


Ohalo II, hut 1, floor II

Silybum marianum



Fig. 11. Distribution of *Silybum marianum* (115 achenes) on floor II.



Ohalo II, hut 1, floor II

Malva parviflora



Fig. 12. Distribution of *Malva parviflora* (594 mericarps) on floor II.

which contained about 50% of the total of 1300 *Atriplex* fruits. This large number of fruits clearly represents several fruiting branches. Young *A. rosea* plants are eaten pickled (Zohary and Feinbrun, 1930). All local species of this genus are eaten either fresh or pickled (Dafni, 1984; Palevitch and Yaniv, 2000).

It is likely that *Atriplex* branches were used in the construction of the Ohalo II hut. Charcoal analysis by Nadel and Werker (1999) of remains of the walls of hut 1 identified *Atriplex/Seidlitzia* charcoal. According to these authors, *Atriplex* is the more plausible of the two identifications since the only *Seidlitzia* species in Israel, *S. rosmarinus*, thrives in hot deserts and is not native to the Ohalo II region.

Thus, there are two plausible explanations for the presence of *Atriplex* fruits at Ohalo II. Either the fruits were used for food, which was prepared on or near the grinding stone, or the branches might have been used for roofing, more so on the northern side of the hut, and their fruits accidentally fell to the floor. These two explanations are not mutually exclusive.

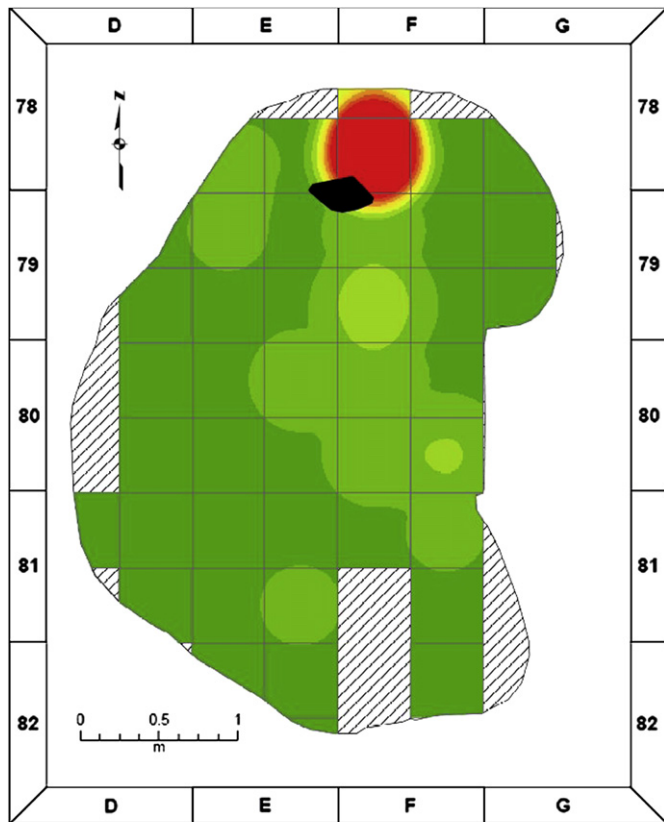
The distribution of *Rubus sanguineus/canescens* (bramble) nutlets is also densely clustered (Fig. 16). Seventy-two percent of the 175 nutlets on floor II are concentrated in four adjacent squares, i.e. a single square meter. *Rubus* fruits are apocarpic; their many carpels develop into many nutlets covered with juicy pulp. Since *Rubus* fruits grow in groups, the 175 nutlets on floor II might represent several fruits from one branch or several branches. About half of the nutlets are not charred. Due to the very high lignin content in their seed coating, some

archaeological *Rubus* seeds preserve in an uncharred state (G. Hillman, personal communications). The fleshy *Rubus* fruits prevent fire from touching most of the nutlets, but this protection was not sufficient for all them. The concentration of the *Rubus* nutlets within a one-square-meter area near the southwest end of the grinding stone points to a single deposition event. *Rubus* fruits are edible and nutlets of several *Rubus* species have been found at many European sites, from the Neolithic period onward (Renfrew, 1973; Zohary and Hopf, 1994). It is most likely that these fruits were eaten by the Ohalo II dwellers, as they are eaten today.

Rubus fruits are juicy, fragile, and difficult to transport. Usually, they are consumed right in the field on an eat-as-you-go-along basis. Why, then, were these berries carried back to the Ohalo II hut? They may have been dried by fire or in the sun for storage, a practice reported for several native North American groups (e.g. Moerman, 1999). In any event, this is likely an early case of advanced planning of plant food consumption.

Uncharred plant remains reveal an interesting pattern of distribution on floor II. They form two concentrated patches, one mainly composed of the *Rubus* nutlets, the other in the northeast corner of the floor. Besides these 82 *Rubus* nutlets, only 56 uncharred seeds have come to light at Ohalo II, and all of them are from this floor. Apparently, the conditions of preservation on floor II were exceptional even by Ohalo II standards.

Adonis dentata/microcarpa (peasant's eye) is another taxon with a clustered distribution (Fig. 17). Some 30% out of the 71 mericarps



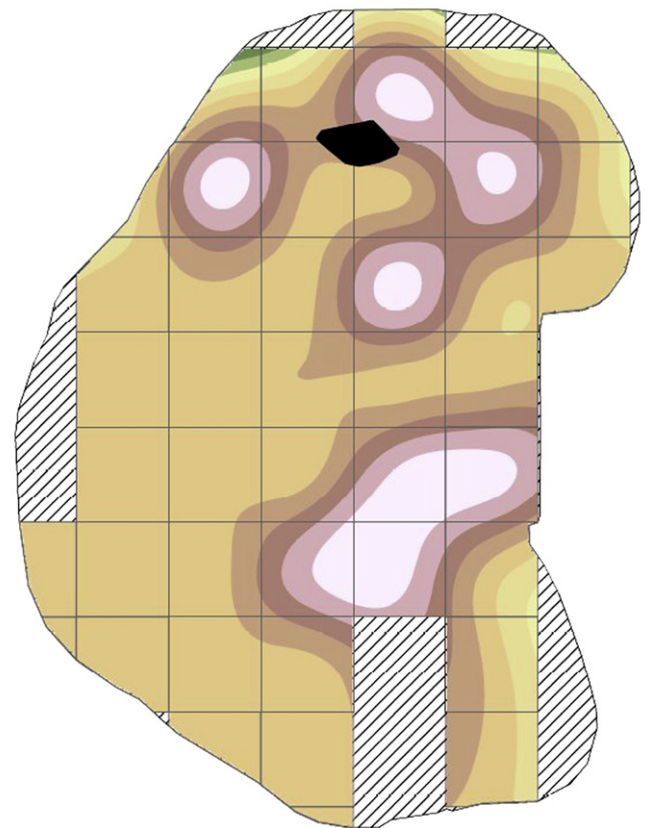
Ohalo II, hut 1, floor II
Melilotus indicus
 0 - 340 seeds/m²
 low high

Fig. 13. Distribution of *Melilotus indicus* (134 seeds) on floor II.

were found in two adjacent squares, or one-half square meter, and the bulk of these mericarps tend to come from the center-north of the floor, rather than from its perimeter. *Adonis* spp. fruits are spike-like, dense, and apocarpic, bearing many mericarps. Thus, it is possible that all these remains stem from a single plant. *A. vernalis* contains the glycoside Adonidin, which in Europe has been used as an effective medicine for the heart. It increases the activity of all types of muscle tissue, regulates the pulse, and elevates blood pressure (Grieve, 1984). Local traditional healers use a decoction of the whole dry plant for the same purposes (Heyn and Pazy, 1989).

Umbels (flowers) and umbellules (partial umbel) of the Apiaceae (=Umbelliferae) family were concentrated in and south of the entrance to the hut (Fig. 18). All these umbels and umbellules are similar and apparently belong to the same species. 36% of them were found in a single square (F79d) and some 60% came from three adjacent grid squares (0.75 m²). We were unable to identify this Apiaceae beyond the family level, as these are flowers and not fruits, and some of them had their petals rolled inward. The inflorescence of the Apiaceae family is an umbel that is often made up of several umbellules. The Ohalo II umbels were composed of eight umbellules. Therefore, they may be the remains of one or two plants, if they were laid down in a single deposition event.

Apiaceae were not the only family of flowers represented in the Ohalo II botanical assemblage. Square F80d, located in the entrance area of the hut, south of square F79d where the Apiaceae flowers concentrated, produced two *Senecio*

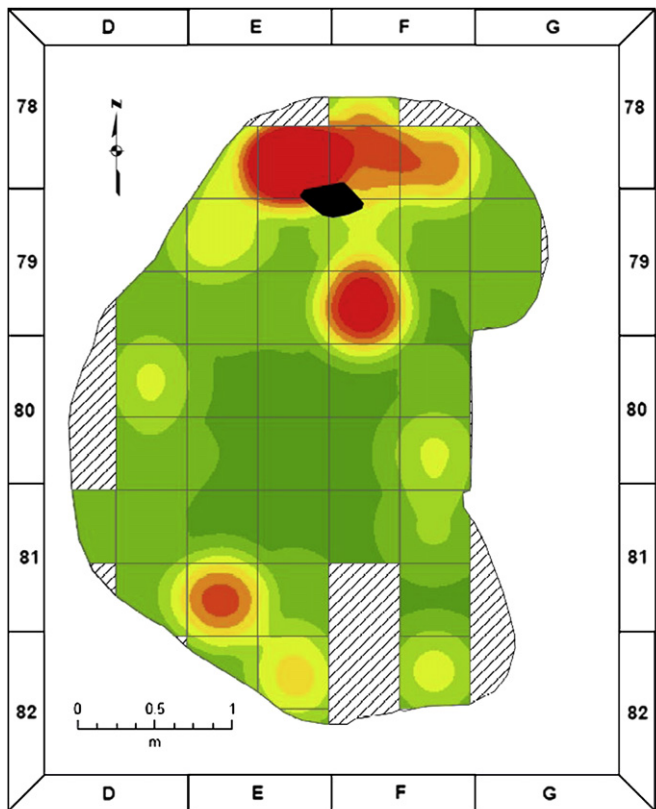


Ohalo II
Membership probability in Group 2, 4 Poaceae taxa
 low high

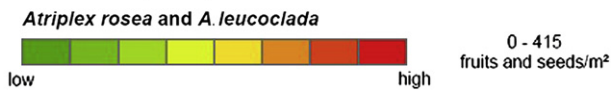
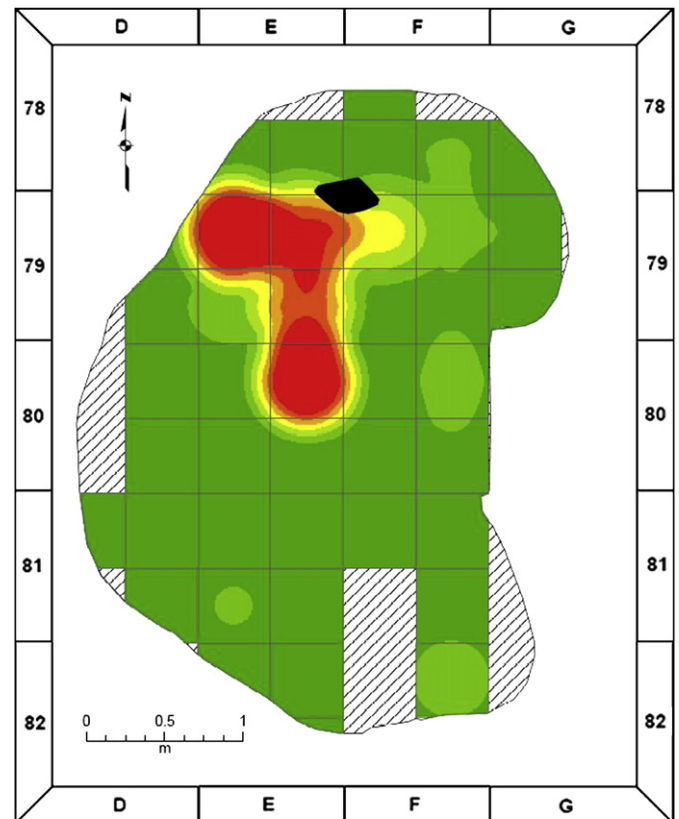
Fig. 14. Local spatial autocorrelation (Anselin's Local Moran's *I*) of counts of four grass taxa (*H. spontaneum*, *B. pseudobrachystachys/tigridis*, *P. holciforme*, and *H. maritimum/hystrix*,) on floor II: cluster membership probabilities. The grid squares next to the grinding stone display exceptionally high densities of the four grass taxa that are statistically distinguishable from those of surrounding grid squares. In contrast, the secondary concentration in the center south of the hut (see Fig. 14) is not statistically significant.

glaucus (groundsel) capitula (heads) (Compositae (=Asteraceae)) (Figs. 19, 20). In addition, 20 Compositae heads were found just outside the entrance (square G80c). *S. glaucus* flowers from February to April, and during seed dispersal its involucre bracts bend backward (Mabberley, 2002). The involucre of the Ohalo II specimens are erect (Fig. 19), and their achenes are mature (Fig. 20). Both observations suggest that at the time of charring these heads were near the end of their flowering period. Because we could not identify the 20 Compositae heads to their species, we could not reconstruct their exact flowering months. However, since all of these heads came from a single excavation grid square and spring is the flowering season of most local plants, it is safe to infer that these flowers were picked in the spring. Thus, we have both indirect spatial and direct evidence for the seasonality of the hut's occupation. *S. glaucus* provides direct flowering dates, and the provenience of the two heads points to a single deposition episode. Therefore, the botanical macro remains in the entrance area support an occupation of the hut during the spring or early summer.

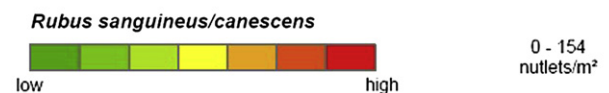
The appearance of *S. glaucus* in Ohalo II is not self-evident. First, its identification relies on minute differences in bracts whorls on the flower head. In *S. glaucus*, thin and pointed bracts are present in



Ohalo II, hut 1, floor II

Fig. 15. Distribution of *Atriplex rosea/leucoclada* (1228 fruits and seeds) on floor II.

Ohalo II, hut 1, floor II

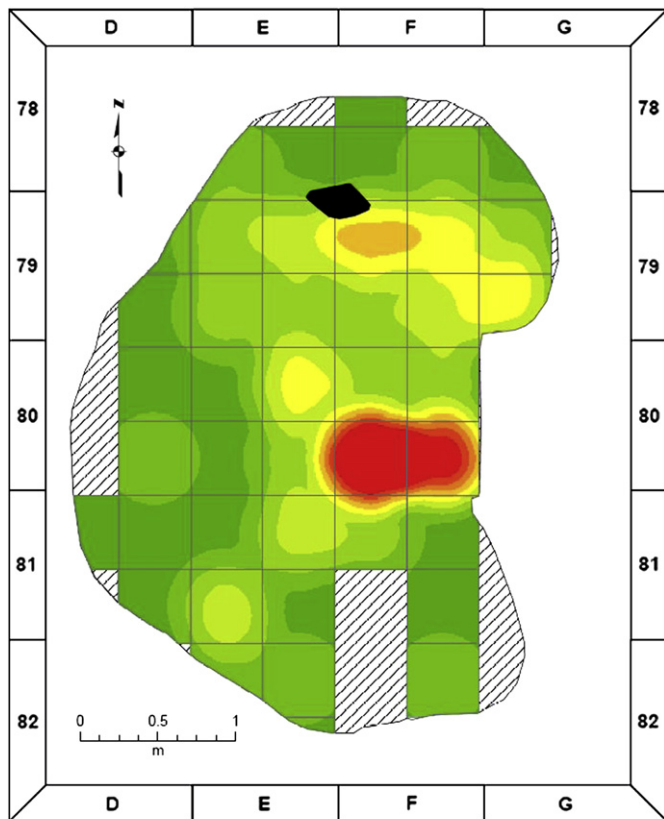
Fig. 16. Distribution of *Rubus sanguineus/canescens* (175 nutlets) on floor II.

a lower whorl in the base of the head, attaches, and go beyond the base of the upper whorl, while in other species in the same genus they are shorter (Fig. 19). Second, *S. glaucus* chorotype is Irano-Turanian and Saharo-Arabian, growing today as north as Samarian Desert and Lower Jordan Valley, some 40–60 km south of the site (Danin, 2004). Therefore, the appearance of southern plant in Ohalo represent the drier conditions prevailed in that time (Weiss et al., 2005).

While the distribution of *Puccinellia* cf. *convoluta* grains is non-uniform like those of the other taxa discussed so far (Fig. 21), the pattern is a markedly different one, with a mean center at the southern extreme of the hut, close to the perimeter wall. 34% of the 673 *Puccinellia* grains were found in squares E82b and E82d, an additional 14% in square F82b just east of these two, and no more than four 0.25-m² squares at the south end of the hut account for 54% of all *Puccinellia* grains. The possible use of *Puccinellia* grains for food is discussed elsewhere (Weiss et al., 2005). If these grains were actually eaten, their preparation and/or consumption must have differed in some way from those of other food plants, which were deposited in the northern part, near the grinding stone. Weiss et al. (2005) and Piperno et al. (2004) point out that the minute *Puccinellia* grains are similar to the smallest known grains used for food today, those of *Eragrostis tef* (tef). Moreover, the *Puccinellia* inflorescence is a panicle bearing hundreds of grains, so the grains found at Ohalo II may conceivably originate from as few as one or two plants. We suggest, therefore, that the *Puccinellia* distribution attests to a pattern of use different from that of other grasses, possibly due to the minute size of *Puccinellia* grains.

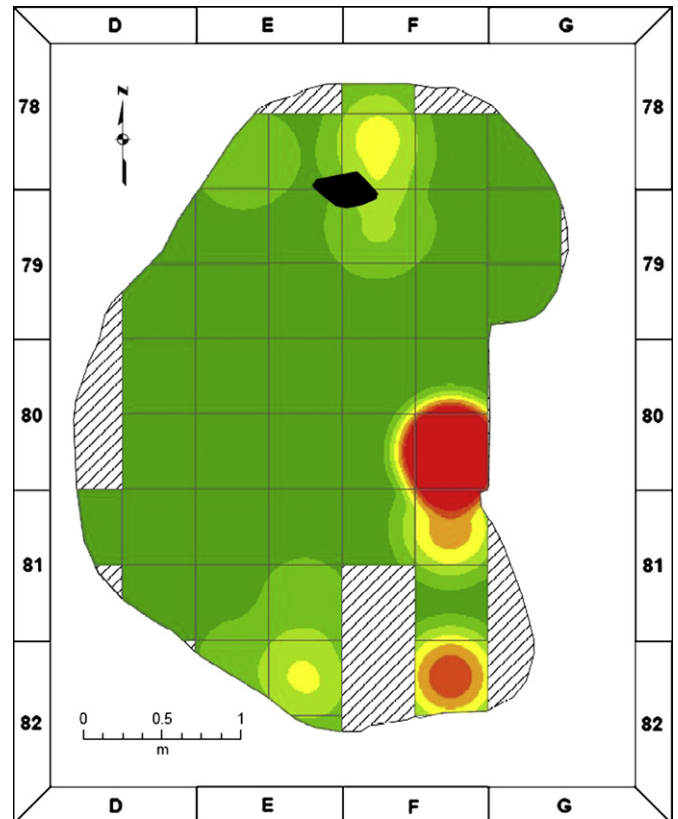
The concentration of *Puccinellia* grains near the south wall is reminiscent of the *Puccinellia* grass bedding found in the same area directly underneath on floor III (Nadel et al., 2004). On floor III, the residents of the hut had created a comfortable cover by spreading a layer of *Puccinellia* shoots oriented with their base toward the center of the hut and the heads toward the walls. However, the southern part of floor II was also used for flint knapping (see below). Considering the typically opportunistic nature of hunter-gatherer economic behavior, the use of the shoots as bedding material does not preclude the use of the grains as a source of food.

A different pattern of distribution was observed for *Suaeda palaestina/fruticosa* seeds (Fig. 22). Although the relative distribution of the 28,373 seeds is rather uniform across most of the squares, those squares that display modestly higher densities are located along the hut's perimeter walls. Moreover, while most taxa are absent from at least a few grid squares, *S. palaestina/fruticosa* seeds are ubiquitous. Villagers in the Euphrates valley in northern Syria used to collect large quantities of *S. fruticosa* branches for soap making, in much the same way as *Salsola kali* (Hillman, 1995; Maberley, 2002). Since it is hard to imagine that the kind of fire required for soap making was lit inside the hut, it is likely that the tens of thousands of *Suaeda palaestina/fruticosa* seeds came from the branches that formed the walls of the hut, as suggested by Nadel and Werker (1999). The huge number of seeds found on floor II represents at least several branches.



Ohalo II, hut 1, floor II
Adonis dentata/microcarpa
 0 - 47 mericarps/m²
 low high

Fig. 17. Distribution of *Adonis dentata/microcarpa* (71 mericarps) on floor II.



Ohalo II, hut 1, floor II
Apiaceae (Umbelliferae)
 0 - 424 umbels and umbellules/m²
 low high

Fig. 18. Distribution of *Apiaceae (Umbelliferae)* family (253 umbels and umbellules) on floor II.

3.3. Reconstruction of activity areas

The above review of the distributions of various plant taxa on floor II makes one point abundantly clear. All taxa whose distributions are not uniform are concentrated in the northern and southern parts of the floor, separated by a west-east triangle of relatively low density of plant remains. The base of this triangle is the middle portion of the hut's west wall, its apex is near the middle of the east wall. Given that the entire floor was excavated in the same way and the same retrieval and analysis techniques were used, recovery or analytical biases clearly do not account for the patterned distribution of botanical remains. Since there are good reasons to believe that this floor was rapidly abandoned and sealed (see above), and the plant assemblage unequivocally represents a single occupation, the patterned distribution of botanical remains allows us to infer two plant-related activity areas inside the hut, one in the north and one in the south, separated by an entrance area (Fig. 23). The northern activity area is centered around the grinding stone, which was used for the preparation of food (Piperno et al., 2004) and possibly medicinal plants. There is limited evidence to suggest that the southern activity area was used for sleeping. Recently, Nadel et al. (2004) described the use of stems and leaves of *Puccinellia cf. convoluta* as bedding material on the third floor of this hut, just below this floor. Most of floor III was covered with grasses, with the exception of the central part, where a hearth was found. We suggest, therefore, that the concentration of

Puccinellia cf. convoluta grains near the southern wall of the hut on floor II, represents a comparable arrangement of bedding material. Apparently, the bedding material covering the floor did not prevent other activities; as flint knapping was practiced there as well, see below.

4. Discussion: implications for the economy and social organization of Upper Paleolithic Ohalo II

Our exhaustive analysis of most of the Upper Paleolithic plant assemblage from floor II of hut 1 paints a consistent, representative picture of relevant activities on this floor. These findings, along with the excellent preservation of plant remains retrospectively validate our decision to embark on such an extensive analysis of the plant assemblage. Any sub-sampling technique would likely have failed to reveal the spatial patterns described in this paper. The Ohalo II assemblage proved deserving of exhaustive analysis, as most taxa represented by an adequate number of specimens, say a few dozen or more, produced meaningful patterns of distribution.

These results allowed us to understand some aspects of the way of life of the hut's late Upper Paleolithic residents and their use of its interior space, which was consciously planned rather than haphazard. In our opinion, the ability to reconstruct past human activities with such a high degree of spatial resolution from the

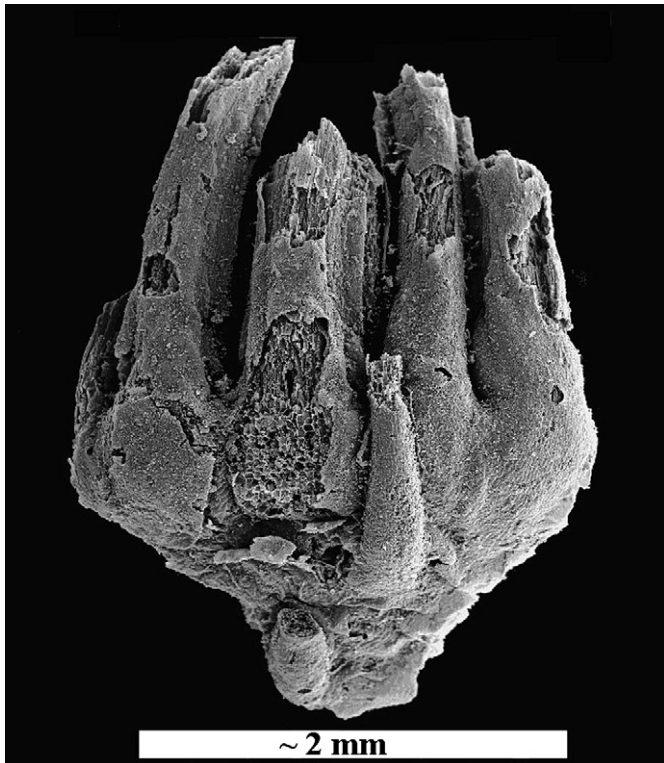


Fig. 19. SEM photograph of archaeological *Senecio glaucus* (groundsel) head. The head is seen from the outside. It has five upper whorl bracts; the one on the left is broken. Attached to these bracts is another, thinner and pointed bract from a lower whorl (Weiss, 2002).

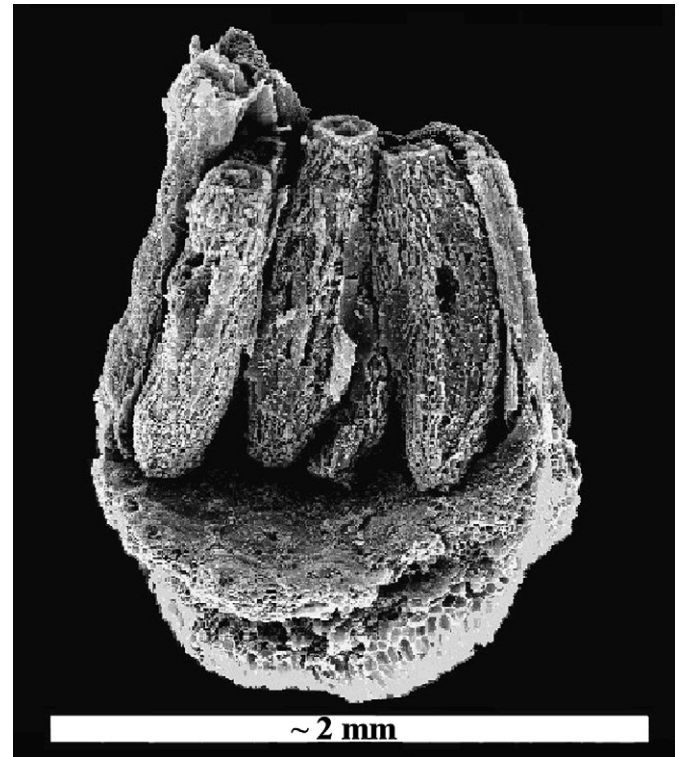


Fig. 20. SEM photograph of another archaeological *S. glaucus* head. This photo shows the outside of the head. In the foreground, three of the originally five achenes, with bracts behind them. The achenes are covered with short hairs; the pappus' attachment scar can be seen on their top. The depressions in front of the achenes indicate where the missing achenes were attached to the head (Weiss, 2002).

distribution of plant remains makes an exhaustive analysis of a large plant assemblage well worth the effort.

We have demonstrated elsewhere (Piperno et al., 2004) that the stone placed on the floor functioned as a grinding stone. The distribution of the plant assemblage relative to the grinding stone, in particular the concentrations of grass grains surrounding it, reinforces this functional interpretation of the stone. The clusters of two groups of plant remains around the grinding stone—food and medicinal plants—suggest that this stone was used for grinding and as a general-purpose working surface. Australian aborigines, for example, reportedly use grinding stones for an array of tasks (Kraybill, 1999; McCarthy, 1946). Inferences of medicinal use of plants in a prehistoric context are inherently uncertain. However, the massive presence of plants with medicinal qualities clearly shows that such

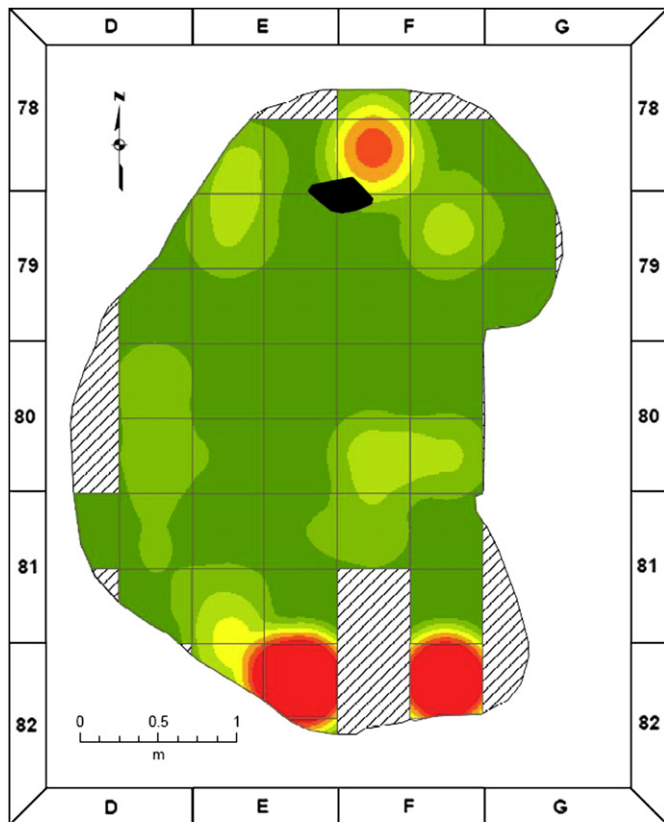
plants were available to and collected by the Upper Paleolithic residents of the site. The presence of hundreds of seeds of this group in the archaeological assemblage makes it exceedingly unlikely that these plants were accidentally deposited or drifted into the hut. Some of these plants are still in use in the area, but we do not know whether this is an unbroken tradition transmitted from generation to generation since the area's early prehistory.

Our spatial analysis revealed several patterns in the distribution of plant remains on floor II. Different groups of plants display distinct distributions. Food and possibly medicinal plants tend to cluster around the grinding stone in the north, while plants probably used as roofing material, such as *Atriplex* and *Suaeda*, tend to be distributed uniformly across the floor. Some taxa show concentrations in restricted areas, sometimes as small as one square meter or less; these include *A. dentata/microcarpa*, *B. pseudobrachystachys/tigridis*, *F. microcarpa*, *M. indicus*, *P. holciforme*, *P. convoluta*, *R. sanguineus/canescens*, and Apiaceae. This pattern of distribution is in agreement with the findings of Tsatskin's (Tsatskin, 2002; Tsatskin and Nadel, 2003) soil micromorphology and magnetic susceptibility studies. Both approaches independently show that the accumulation of materials on this floor is the result of human activities rather than natural forces. Wind and water, for example, would hardly have selectively concentrated some taxa but not others around the grinding stone. Differential, non-uniform, clustered distributions of several taxa cannot be attributed to such forces. The apparent stockpiling of juicy *Rubus* berries, which are fragile and usually eaten on the spot, suggests long-term planning and storage.

There is, in fact, evidence that such an individual did live at Ohalo II. Locus 5 (Fig. 2) is a grave of an adult male who, in addition to suffering from a disabled hand, also sustained a penetrating

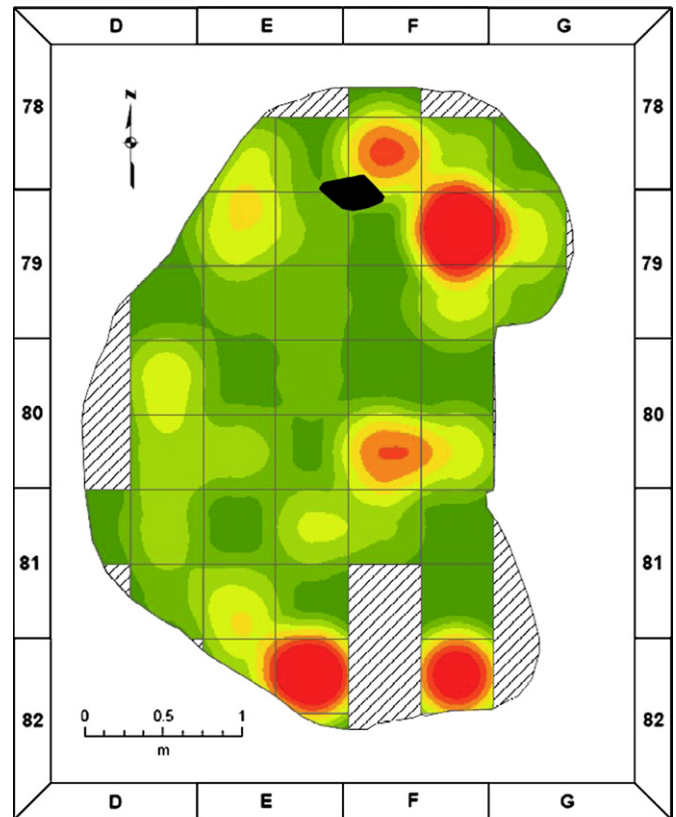
Table 1
Representative plant assemblage from floor II

| Taxon (organ) | Quantity | Figure no. |
|--|----------|------------|
| <i>Adonis dentata/microcarpa</i> (mericarp) | 71 | Fig. 17 |
| Apiaceae (=Umbelliferae) (umbel and umbellule) | 253 | Fig. 18 |
| <i>Atriplex rosea/leucoclada</i> (fruit and seed) | 1228 | Fig. 15 |
| <i>Bromus pseudobrachystachys/tigridis</i> (grain) | 9904 | Fig. 7 |
| <i>Hordeum marinum/hystrix</i> (grain) | 505 | Fig. 8 |
| <i>Hordeum spontaneum</i> (grain) | 606 | Fig. 9 |
| <i>Malva parviflora</i> (mericarp) | 594 | Fig. 12 |
| <i>Melilotus indicus</i> (seed) | 134 | Fig. 13 |
| <i>Piptatherum holciforme</i> (grain) | 819 | Fig. 10 |
| <i>Puccinellia cf. convoluta</i> (grain) | 673 | Fig. 21 |
| <i>Rubus sanguineus/canescens</i> (nutlet) | 175 | Fig. 16 |
| <i>Silybum marianum</i> (achene) | 115 | Fig. 11 |
| <i>Suaeda palaestina/fruticosa</i> (seed) | 28373 | Fig. 22 |



Ohalo II, hut 1, floor II
Puccinellia cf. convoluta
 0 - 563 grains/m²
 low high

Fig. 21. Distribution of *Puccinellia cf. convoluta* (673 grains) on floor II.



Ohalo II, hut 1, floor II
Suaeda palaestina/fruticosa
 0 - 11,759 seeds/m²
 low high

Fig. 22. Distribution of *Suaeda palaestina/fruticosa* (28,373 seeds) on floor II.

wound to the rib cage (Hershkovitz et al., 1993). The survival of such a disabled and heavily wounded individual is strong evidence of medicinal care giving by members of the Ohalo II late Upper Paleolithic group.

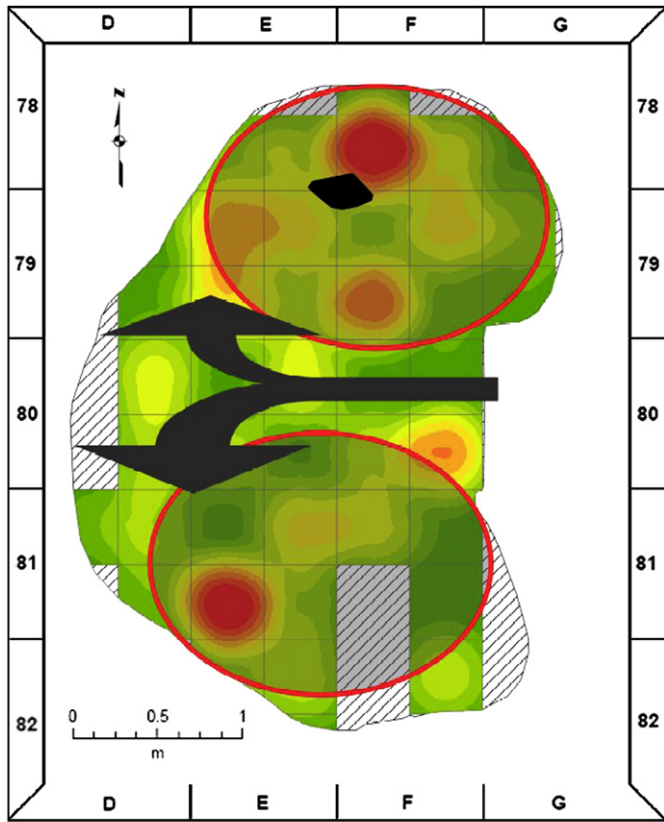
The accumulation of flowers in the entrance area demonstrates both the residents' appreciation of different types of flowers and the use of the hut during the spring. It is hard to say whether these flowers served practical or aesthetic purposes. The *S. glaucus* capitula are in a stage after the beginning of flowering, maybe not strictly a flower at the time they were preserved by fire. However, since these stages succeed one another quite rapidly and there is no known economic use for *S. glaucus* seeds, we have to conclude that the Upper Paleolithic residents of Ohalo II brought them home as flowers. This is, to the best of our knowledge, the earliest evidence of human use of flowers. Three decades ago, the discovery of the Shanidar IV "flower burial" (Leroi-Gourhan, 1975a,b; Solecki and Solecki, 1974) made enormous waves, opening a cultural and even spiritual dimension of Neanderthal life. It has since been argued convincingly, however, that a local rodent, *Meriones persicus* (Persian Jird), was most likely responsible for the introduction of pollen into the cave (Sommer, 1999), making the Ohalo II floral assemblage the earliest known human use of flowers. Given that the residents of Ohalo II were Anatomically Modern Humans (Hershkovitz et al., 1995), their appreciation of flowers is much less surprising and sensational than was that by the Shanidar Neanderthals.

5. Distribution of flint tools and debitage

Like the plant remains, the flint assemblage from floor II also displays a patterned distribution (Nadel, 1997, 2002a,b). The analyzed assemblage includes all retrieved pieces ($N = 8127$). Among these, the debitage category ($N = 1840$) is dominated by bladelets—the target products, accompanied by blades, flakes, primary elements, core trimming elements, and cores. There are 132 retouched tools, and the assemblage as a whole reflects all stages of core reduction.

The class of minute flints ($N = 6155$) includes several categories, among which tiny bladelets and flakes, as well as fragments of regular bladelets are conspicuous. There are also many angular and fire-cracked fragments. All of these categories display high find densities within the 2-m² area near the entrance (Fig. 24; Nadel et al., 2006). Furthermore, square E81b has one core, the highest per-square numbers of bladelets (62) and core trimming elements (7), the second highest of retouched tools (11), and the highest of minute pieces (340).

The analysis of the flint assemblage reveals a concentration of flint products spatially dissociate from those of plant remains. Flints are concentrated in the southern part of the hut, in front of the entrance. This concentration includes all stages of flint production, from heavy cores and primary elements to a wealth of bladelets (the principal knapping product) and thousands of tiny, millimeter-sized specimens. No natural processes could have created the observed pattern. Rather, it points to two or three persons knapping flint near the entrance, facing the light from the door (61).



Ohalo II, hut 1, floor II
 All species except *S. palaestina/fructicosa*
 0 - 10,760 specimens/m²
 low high

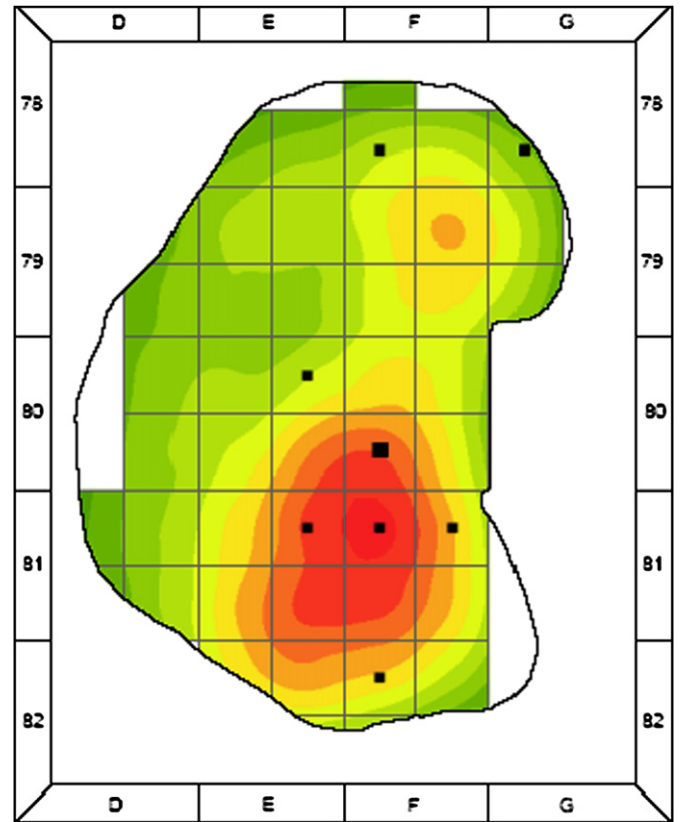
Fig. 23. Suggested use of space on floor II, as inferred from distributions of plant remains.

6. Conclusions: spatial distribution to suggest gender-related use of space

The well-defined distribution patterns of plant remains and flint products on the same floor reveal a structured division of space inside this Upper Paleolithic brush hut. One part was dedicated to plant processing, with a grinding stone firmly set in a unique way. The other part was devoted to flint knapping. Naturally, seeds and flints are not restricted to the two concentrations, and it is possible that in several occasions certain relevant activities were not exclusive to the two areas.

While this spatial separation of tasks is abundantly evident, it is not clear whether it maps onto a gender-specific division of labor (Nadel et al., 2006). The division of labor between male and female is deep-rooted in many human societies, though culture-specific variability is high. The anthropological literature indicates that the two groups of tasks differ in their degree of male-female affinity. Plant-food preparation is reported to be an *almost exclusively* female task. Flint knapping, on the other hand, is *commonly* a male task, but exceptional cases of female knappers have been documented as well (Hays-Gilpin and Whitley, 1998; Kelly, 1995; Kent, 1998; Kuhn and Stiner, 2006).

Consequently, the spatial separation of such tasks is to be interpreted with caution. We can only *suggest* that distinct locations dedicated to seed processing and flint knapping within the Ohalo II hut reflect a gendered division of floor space. This would be the oldest



Cores
 ■ 1
 ■ 2
 Blades and bladelets: density [n/m²]
 0 178

Fig. 24. Distribution plan of flint objects on floor II, brush hut 1: cores and blades-bladelets. Presented as densities calculated for 0.5 × 0.5 excavation units (Nadel et al., 2006).

documented case of a gendered division of domestic space, with men preparing flint tools in the well-lit area near the entrance and women processing food in the darker northern part of the hut (Fig. 25).

The combined picture of two distinct indoor activities provides a rare glimpse into the way in which Upper Paleolithic hunter-gatherers in the Jordan Valley organized and conceived of their



Fig. 25. A reconstruction of brush hut 1 showing the location of two activity areas on the floor: flint knapping on the left and seed processing on the right. Drawing by Rachel Brown-Goodman (Nadel et al., 2006).

dwelling space. It might also supply us with an insight into their male–female interrelationship.

Acknowledgments

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