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Crop Storage and Animal Husbandry at Early Iron Age Khirbat al-Mudayna al-ʿAliya (Jordan): A Paleoethnobotanical Approach

by Alan Farahani, Benjamin W. Porter, Hanna Huynh, and Bruce Routledge

Archaeological investigations of Early Iron Age settlements in the Southern Levant have focused productively on the agricultural economies that developed in the two centuries following the collapse of the Bronze Age city-states. Excavations have documented an array of architectural evidence such as cisterns, terraces, and storage bins, as well as material culture such as bronze ploughshares, that together provided an infrastructure for production (Borowski 1987; Hopkins 1985). The analysis of faunal evidence recovered from these archaeological sites has determined that animal husbandry practices were largely based on a regime of animals of Southwest Asian origin such as sheep, goats, cattle, pigs, fish, and wild game (von den Driesch and Boessneck 1995; Hellwing and Adjeman 1986; Hellwing, Sade and Kishon 1993; Marom et al. 2009; Peters, Pöllath, and von den Driesch 2002; Raban-Gerstel et al. 2008), although selection and abundance varied according to the environmental context in which producers operated (Lev-Tov, Porter, and Routledge 2011). These data, combined with written sources commenting on Early Iron Age agricultural practices such as the Gezer Calendar (Albright 1943) and the Hebrew Bible's Books of Joshua, Judges, and First Samuel, paint a picture of an agricultural economy designed to meet the immediate consumptive demands of the producers' households and their settlements (Hopkins 1985; MacDonald 2008).

Agriculture was therefore key to sustaining Early Iron Age societies and was likely the principal daily food production practice for most groups. Agricultural production involved more than just the maintenance of plant foods for people and animals, but through its daily enactment promoted necessary social bonds through labor roles that created or maintained community (Fuller et al. 2014). The arrangement of food production routines included activities such as field preparation, sowing, weeding, harvesting, and processing; decisions regarding communal storage for animal foddering during the summer lean months; feasts; and how to prepare for inevitable periods of scarcity (Halstead and O'Shea 1989). Each of these practices involved negotiation between community members, and agricultural decision-making was most likely interwoven in the cultural micro-politics of the community (Jha 2004). Yet the investigation of "community," a notoriously slippery and difficult-to-define human social phenomenon (Varien and Potter 2008), has been largely avoided within the analysis of food production in Early Iron Age societies. This, even when some attempts to operationalize the concept archaeologically note the "role of the local community as a particular node of social interaction" and "subsistence production" as a core characteristic (Kolb and Snead 1997: 611). Since agriculture demands labor from nearly all members of a given group during fixed periods of the year, and therefore requires considerable coordination to maintain this labor, the study of agriculture should provide insight into the ways in which Early Iron Age societies organized a portion of their social worlds.

Given how suitable a window agriculture is for understanding Early Iron Age Levantine societies, the relative dearth of paleoethnobotanical studies in the area is surprising. This is not to say that paleoethnobotanical studies are completely absent from scholarly literature on the time period (e.g., Gilliland 1986; Neef 1989; Neef 1997; Riehl and Nesbitt 2003; Willcox 1992). Indeed, such studies have determined that agricultural communities in Iron Age Southwest Asia were active participants in many changes in agricultural practice in this period, such as the preference for free-threshing wheat varieties over glumed (hulled) ones, the more widespread use of recently domesticated plants such as pomegranate and almond (Riehl and Nesbitt 2003: 307), and the introduction of common and foxtail millet. However, these studies suffer from a few commonly shared issues. Most studies draw on evidence that has been collected using opportunistic (or, judgement) rather than systematic sampling strategies (Kislev and Melamed 2000), frequently on a very small scale (e.g., Gililland 1986). Furthermore, this research has emphasized species presence, rather than abundance and distribution. The publication of results is often limited to appendices in the final pages of excavation reports (e.g., Willcox 1992) in tabular form, rather than in a sustained, statistically informed study that integrates paleoethnobotanical evidence with other archaeological data in the broader research design.

As a result, paleoethnobotany has yet to contribute in a serious, analytical manner to an understanding of lifeways in the Early Iron Age of the Southern Levant. In particular, agriculture continues to be treated in homogenous and opportunistic terms, frequently based on textual and ethno-historical analogies rather than actual excavated evidence. This stands in contrast with faunal analysis, whose deployment has become both ubiquitous and analytically sophisticated on Iron Age sites in the Southern Levant over the past 20 years (e.g., Raban-Gerstel et al. 2008; Marom et al. 2009; Sasson 2010; Lev-Tov et al. 2011; Tamar et al. 2013; Sapir-Hen et al. 2014). As a result, faunal remains are now taking on an analytical role in the investigation of early Iron Age subsistence practices, economic strategies, and collective identification. If carried out systematically and on a representative scale, the analysis of archaeological plant remains could play a similar, and complementary, analytical role to faunal analysis through the reconstruction of cropping strategies, storage practices, and food consumption, to name just a few possibilities (Sherrat 1991; Jones and Halstead 1995; Palmer and Van der Veen 2002; van der Veen 2007). Indeed, if we are to go beyond these simple pictures of "typical" village life and begin to address the structure, variability, and historical dynamics of agro-pastoral production during the Early Iron Age, including its connections to the periods immediately before and after, then more systematic paleoethnobotanical research is needed beyond convenience sampling.

In this paper, we present and analyze paleoethnobotanical evidence from Khirbat al-Mudayna al-ʿAliya (KMA hereafter), a mid-11th to mid-10th century BCE settlement located on the Eastern Karak Plateau in west-central Jordan. The analysis of archaeological sediment samples excavated in various contexts between 1998 and 2004 recovered carbonized plant remains that provide insight into the settlement's agricultural economy. We argue three key points in what follows: 1) Paleoethnobotanical analysis at KMA provides evidence for the community's relationship with the surrounding wadi system, as seeds of sedges (*Cyperaceae*) and grape hyacinth (*Muscari* sp.)

indicate use of this riparian zone; 2) this evidence also points to an agro-ecosystem focused on the production of two-rowed barley (*Hordeum vulgare* subsp. *distichum*) as human, but primarily non-human, animal food. In other words, the production and storage of fodder was a key component of the agro-pastoral economy of KMA; 3) plant processing and consumption activities at KMA had a strong spatial component, with non-storage assemblages exhibiting compositional patterns that were very different from those of the storage assemblages. That is to say, non-storage assemblages at KMA do not appear to be the simple outcome of consuming the stored grain or any other plant foods. This lends support to the idea that access to stored grain, and perhaps also foddering and large-scale commensal activities such as feasting, were not equally distributed between households at KMA. In turn, the combined evidence could imply that foddering and commensal activities were either centralized and/or dominated by key households. Foddering and commensal politics are further linked in that the human production of barley would have nourished the same non-human animals that would later be essential in the KMA human community's commensal practices. As the individuals who staged these commensal acts would reproduce their own authority through them, the barley, domesticated animal, and human actors formed an interlocked chain bound together by these routine, everyday practices.

The Early Iron Age Wadi al-Mujib Settlement System

KMA was one of at least seven settlements founded in the final two centuries of the second millennium BCE along the edges of the winding Wadi al-Mujib canyon in west-central Jordan (fig. 2.1). The first settlements were identified in early 20th-century survey projects (e.g., Glueck 1934: 52–53; Musil 1907: 34). More intensive surveys during and after the 1970s accomplished a more thorough documentation, including Worschech's (1985) and Miller's (1991) projects on the Karak Plateau, Parker's (2006) on the Plateau's eastern desert fringe, Ji's (Ji and ʿAttiyat 1997; Ji and Lee 1998; 2000) on the Dhiban Plateau, Jacobs' (1983) in the Wadi Isal, and Clark's on the Wadi al-Hasa's northern edge (Clark et al. 1992; Clark et al. 1994). The best-documented settlements are presently ʿAroʿer (Olàvarri 1965; 1969; Olàvarri-Goicoechea 1993), Baluʿa (Worschech 1989; Worschech and Ninow 1994; 1999; Worschech, Rosenthal, and Zayadine 1986), Lahun (Homès-Fredericq 1992; 2000; Swinnen 2009), KMA (Lev-Tov, Porter, and Routledge 2011; Routledge 2000; Routledge et al. 2014; Routledge and Porter 2007), Khirbat al-Mudayna al-Muʿarradja (hereafter KMM) (Olàvarri 1977–1978; 1983), and Khirbat al-Muʿammariyya (Ninow 2004; 2006). Evidence for additional Early Iron Age settlement activity appears in poorly stratified contexts or in damaged contexts beneath later building activities (Lev-Tov, Porter and Routledge 2011: 72, no. 4).

The al-Mujib settlements exhibit similar settlement design elements. Stone-constructed buildings interpreted as domestic residences are positioned around large oval or elliptical central courtyards (fig. 2.2). The buildings' rear walls also contributed to a casemate fortification system that demarcated the settlement's perimeter and offered protection from attacks. Small gates gave access to the settlements' interiors. In some instances (e.g., KMA, KMM), towers were constructed to defend the settlements' vulnerable sides. Excavations in these settlements have documented a ceramic vessel assemblage consisting of bowls, kraters, storage jars, and lamps that are largely undecorated (Ninow 2006; Olàvarri 1983; Porter 2007; Routledge et al. 2014; Swinnen 2009). These assemblages help assign relative dates of occupation to the settlement, broadly spanning the mid-12th to the mid-tenth centuries BCE. AMS radiocarbon analysis of short-lived organic evidence from KMA determined that building construction took place between 1105 and 1016 BCE (2σ). The dating of final settlement abandonment at KMA is based on burnt organic evidence excavated in storage bins in Buildings 100 and 500. This evidence is modeled between 1001–921 BCE and 1011–941 BCE, respectively (2σ).

Problematic biblical sources describing this region as politically organized under a king (e.g., Numbers 21–24; Judges 3) have led some scholars

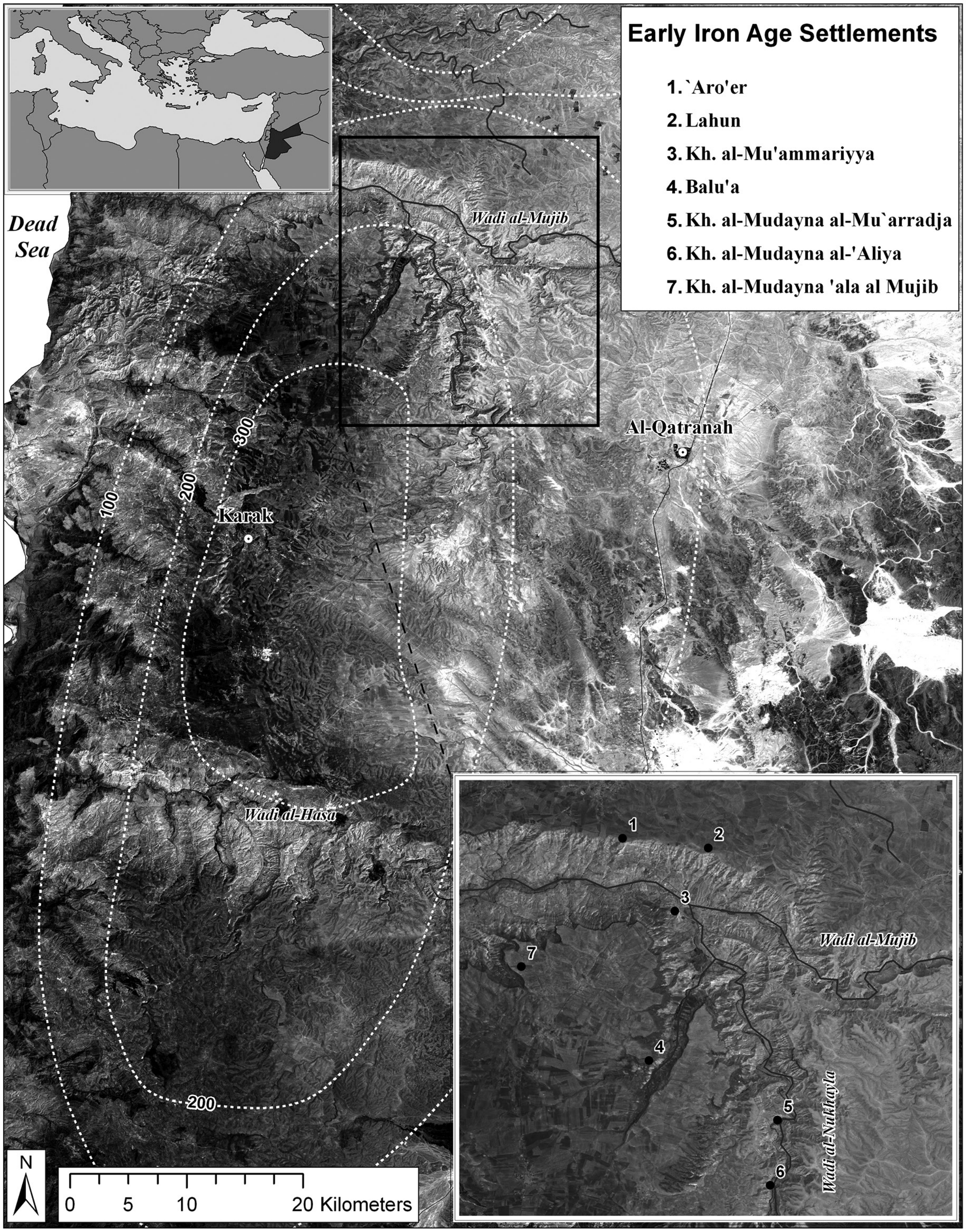

FIG. 2.1 *Map of Early Iron Age settlements in west-central Jordan with emphasis on settlements falling on either side of the Wadi al-Mujib and its tributaries. Precipitation isohyets are represented as dashed lines (Image modified from SPOT) (Image: A. Wilson).*

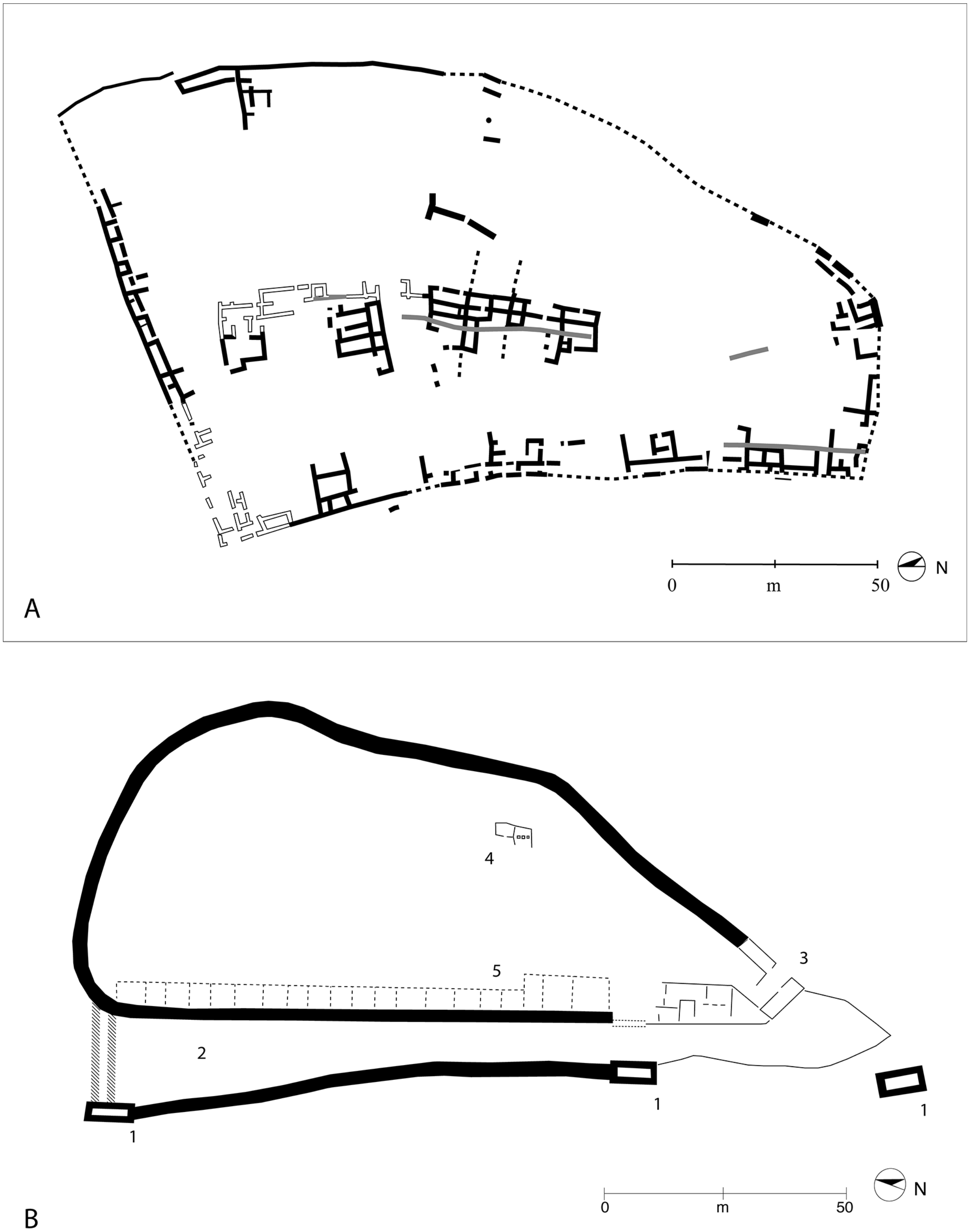

Fig. 2.2 *Maps of Lahun (A) and Khirbat al-Mudayna al-Muʿarrdjeh (B) (adapted from Homès-Fredericq 1997: fig. 41 and Olavarri 1983: fig. 3).*

to argue that the Wadi al-Mujib settlement system was one component of a larger Early Iron Age Moabite kingdom (Glueck 1934:82; 1939: 121–22; cf. 1940: 167–72; Finkelstein and Lipschits 2011; van Zyl 1960). The substantial labor investment evident in the fortification systems, their apparently marginal locations at the edge of the plateaus and the clear concern for defensibility evident in the choice of site locations all added to the impression that the al-Mujib settlements were the outer bulwark of an Early Iron Age kingdom.

This evidence, however, is complicated by the chronological date of the writing and editing of the biblical passages in question that likely took place centuries after the events described (Levine 2000: 37–59). Further complicating the identification of an Early Iron Age kingdom is the lack of a settlement hierarchy. Such hierarchies were symptomatic of Levantine territorial kingdoms, in which a markedly larger administrative center oversees small and medium-sized settlements. In west-central Jordan, however, Early Iron Age settlements are relatively similar to each other in area, that is, where broad horizontal exposures permit the measurement of site size (e.g., KMA [2.2 ha], KMM [1.6], Lahun [1.7]). Other settlements whose full extent is difficult to measure due to limited exposures and/or later construction activities (e.g., ʿAroʿer, Baluʿa) likely do not exceed 3 ha in overall size (Routledge 2004: 94, Table 5.2).[1] Furthermore, relative chronological dates based on ceramic vessel assemblages indicate that not all settlements were founded in a single event nor necessarily occupied at the same time. Rather, settlement activity occurred already at Baluʿa in the Late Bronze Age, and at sites such as Lahun on the north side of the al-Mujib in the 12th century BCE (Steiner 2013: 531). Finds now show that settlements such as KMM and KMA had spread south down the al-Mujib corridor by the 11th century BCE. Indeed, KMA may well be quite late in this sequence, spanning as it does the late 11th and early tenth centuries BCE. Although more research is required at settlements throughout the wadi system, it is currently hypothesized that those settlements whose occupations overlapped in time were part of a segmentary system of households which fused into small-scale communities that were loosely affiliated with each other and in position to collaborate on mutually beneficial projects when necessary.

Some authors included here have explained this iterative settlement expansion as a process of extensification in which producers expanded their activities into marginal lands where yield is potentially lower than other regions (Porter, Routledge, Lev-Tov, and Simmons 2014). Nearly all of the al-Mujib settlements were based in a semi-arid horizontal strip of land that transitions between a desiccated Mediterranean climate of the Karak and Dhiban Plateaus' western halves and the arid Arabian Desert. Precipitation data collected between 1960 and 1989 provides a cross-section of increasing aridity on the eastern Karak Plateau, with the field-station at Hmud on the west showing a mean annual precipitation rate of 283 mm, while the field-station at Qatrana, ca. 24 km east, registered a mean annual precipitation rate of 90 mm of rain a year, both with high inter-annual variability ($1\sigma = \pm$ 125 mm and 38 mm, respectively; el-Naqa 1993: 264). Paleoclimate proxies for the area near or around the Wadi al-Mujib in the late second millennium BCE are unfortunately not available. Nevertheless, there are a number of paleoclimate proxies found along or south of the Dead Sea in the State of Israel. The stable isotope evidence of $\delta^{18}O$ from speleoethems at Soreq Cave west of the Dead Sea (Bar Matthews and Ayalon 1997) and of land snail shells from the Negev (Goodfriend 1991) both indicate that the range in variation of more enriched $\delta^{18}O$ values from 3,500 BP to the present is similar to today. Nonetheless, some pollen cores from the Rift Valley west of the al-Mujib settlements indicate a contraction of the pollen of Mediterranean olive trees between 1250 and 1100 BCE, perhaps pointing to a period of increased aridity (Langgut, Finkelstein, and Litt 2013; Langgut et al. 2014). According to these results, cooler and wetter conditions returned in the 11th century BCE, but lasted for only a short period of time before warmer and drier conditions once again returned in the mid-to-late 10th century. Correlating these palynological studies with absolute dates as well as the archaeological record is still fraught with problems (Rambeau 2010: 5230–33), and more work is needed to refine this climate sequence.

Fig. 2.3 *The canyon riparian zone below KMA in July, 2011 (Image: B. Porter).*

The semi-arid conditions found today in the Eastern Karak Plateau were therefore likely similar to those encountered by the Early Iron Age Wadi al-Mujib settlements. These environmental conditions likely challenged, but did not prohibit, settlements from plant production and animal husbandry. The need for additional sources of water partly explains why the settlements positioned themselves on the edge of the steep al-Mujib canyon. Narrow riparian zones supported by ground water fed from karstic aquifers created perennial pools in the wadi bottoms (fig. 2.3). Here, water, wild animals, and naturally occurring plants could be found and obtained (El-Naqa 1993; Noubani et al. 2006; Disi and Amr 2010; Hamidan 2014). How and to what extent the al-Mujib communities used the riparian zones in the development of their agro-pastoralist economies is therefore a key question for research.

Faunal evidence recovered in excavations at KMA has been helpful in answering this question, as well as others concerning the settlements' agro-pastoralist economies (Lev-Tov, Porter, and Routledge 2011) (Table 2.1). Faunal analysis of 2,229 animal bones, 431 of which were identifiable at the species level, determined that the settlement organized a low-intensity, non-specialized animal economy based on a combination of domesticated and wild species. Domesticated species included goat (*Capra hircus*), sheep (*Ovis aries*) (with goats slightly more abundant than sheep), cattle (*Bos taurus*), pig (*Sus scrofa*), ass (*Equus sinus* or *hemionus*), and horse (*Equus caballus*). Wild species included a variety of birds, freshwater crabs (*Potamon potamios*), and red deer (*Cervus elaphus*). Overall, this profile indicates that KMA's animal economy consisted of a typical Mediterranean and southwest Asian regime principally focused on goats and sheep, with secondary emphasis on cattle, pigs, and wild animals. This evidence also points to the riparian zone's importance as a source of water for domesticates, particularly goat and sheep herds. The riparian zone also supported habitats where terrestrial and aquatic wild species could be hunted to supplement diets. An outstanding question, then, is to what extent did the al-Mujib settlements depend on the riparian zones for other components of their agro-pastoralist economy?

Khirbat al-Mudayna al-ʿAliya

KMA (UTMG: 773.4/464.5; Palestine Grid: 233.0/76.8) is the most southern settlement of the al-Mujib system, situated on a small promontory overlooking two of the Wadi al-Mujib's tributaries, the Wadi al-Mukhayris and Wadi al-Nukhayla (figs. 2.4–2.5). Late 19th- and early 20th-century explorers documented the site during their travels (Glueck 1934: 52–53), although given the number of sites bearing the toponym 'al-Mudayna,' an Arabic diminutive term for "little city," in the region as well as their similar oval-shaped features, scholars and visitors often confused KMA with other sites, particularly Khirbat al-Mudayna al-Muʿarradjeh 5 km to the north (Miller 1989).

Architectural preservation at KMA is such that the dry-laid stone walls of buildings are visible at or near the surface, in some cases standing 1–2 m above the ground. Most of these buildings are integrated into a casemate wall system totaling 4.0–4.6 m in width that surrounds and fortifies the entire inhabited portion of the site. The surface preservation at KMA makes it easy in many instances to discern building perimeters and interior rooms with little to no excavation. The spacing of rooms in the casemate wall suggested that there were originally between 35 and 45 buildings at KMA, of which nine were sufficiently visible on the surface to be mapped in detail. Two basic building patterns, an L-shape and a four-room house shape, are differentiated by the organization of internal spaces (Routledge 2000: 50–53). Both patterns echo the Levantine pillared buildings found throughout the Southern Levant at the end of the second millennium BCE (Holladay 1992; Ji 1997). A comparison of these buildings' dimensions reveals a range of sizes between 71.5 and 238.8 m^2 (Routledge 2000: Table 3; Routledge 2004: 101).

Table 2.1 Identification for all bones recovered at Khirbat al-Mudayna al-ʿAliya.

Scientific Name	Common Name	NISP	Percent	MNI
Ardeidae/Ciconiidae	Heron or stork	1	+	1
Aves	Unidentifiable birds	10	2	–
Bos taurus	Domestic cattle	11	3	1
Camelus sp.	Camel	1	+	1
Canis familiaris	Domestic dog	3	1	2
Capra hircus	Domestic goat	10	2	3
Cervus elaphus	Red deer	1	+	1
Equus asinus	Ass or onager	8	2	1
Equus caballus	Horse	12	3	2
Equus sp.	Horse, ass, or onager	16	4	3
cf. Erinaceidae	Possible hedgehog	1	+	1
Actinopterygii	Bony fish	1	+	1
Ovis aries	Domestic sheep	8	2	2
Ovis/Capra	Sheep or goat	229	53	7
Passeriformes	Perching bird	1	+	1
Potamon potamios	Freshwater crab	100	23	27
Rodentia	Rodent	12	3	2
Sus scrofa	Pig	6	1	1
Unidentifiable bones		1798	–	–
Total Identifiable		431		29
Grand Total		2229		

+ amount fell below one percent; NISP = Number of identified species; MNI = minimum number of individuals

Between 1994 and 2004, five seasons (1994, 1996, 1998, 2000, 2004) of field research were carried out (Routledge 2000). A total of 10 units were excavated in five of the nine identified buildings (Table 2.2). An additional three units were excavated in courtyard spaces. Excavations were often arranged using an artificial site grid of 5 × 5 m units. Units were often selected to ensure the collection of evidence within building walls, although doorways and courtyards were also sampled. Cultural deposits ranged in thickness between .30 and 1.5 m before reaching sterile marl. Excavated sediments were dry-screened on site with a 5 mm mesh screen

Fig. 2.4 *Aerial image of Khirbat al-Mudayna al-ʿAliya, looking north. (Image: Kh. Mdeinet Aliya [Miller, no. 143] © Aerial Photographic Archive for Archaeology in the Middle East. APAAME_20011005_DLK-0021. Photograph: David L. Kennedy).*

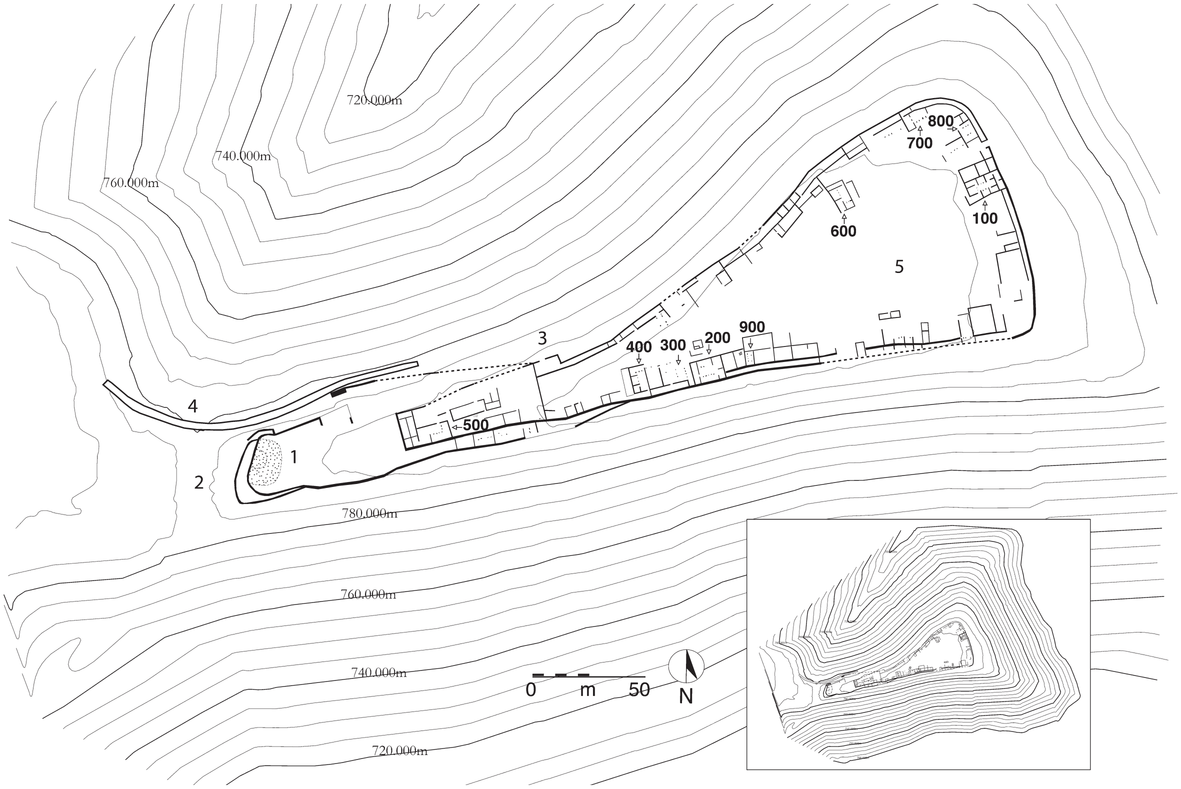

Fig. 2.5 *Map of Khirbat al-Mudayna al-ʿAliya denoting Buildings 100 through 800, tower (1), moat (2), a possible gated entrance (3), paved pathway (4), and courtyard (5) (Image: B. Routledge).*

to capture artifacts. Some sediments were collected for wet-screening and flotation off-site (see below). Ceramic vessel fragments were by far the most common artifact type (Porter 2007; Routledge 2000: figs. 5–7; Routledge et al. 2014), followed by various types of stone objects (e.g., grinders, beads).

Despite the observation that many buildings were variations on the well-known Iron Age Levantine pillared building, excavations revealed notable differences in their use and preservation. Buildings 200 (fig. 2.6) and 900, for instance, were multi-chambered buildings with their walls and pillars largely in-tact. Excavations revealed an array of domestic activities, the most visible being those concerned with food storage and cooking. Building 700, alternatively, was partially dismantled, a sign that the building had passed out of use before the settlement was abandoned and materials had been scavenged for other building projects. Artifacts and ecofacts were especially abundant in Building 700's cultural deposits, a strong suggestion that the remaining structure was used as a midden after it was abandoned. As will be demonstrated below, these differences in building use during the final decades of KMA's settlement inform the analysis and interpretation of paleoethnobotanical evidence.

Table 2.2 Number of samples analyzed by building with total volume of sediment.

Building	Unit (s)	Number of Samples	Total Volume (L)
100	4J41	20	148.5
200	2G86 / 2G87	22 (10 / 12)	155
500	2E22 / 2E23	19 (17 / 2)	178
700	5I05	15	89
900	3H04	9	53.5
	Total	**85**	**624**

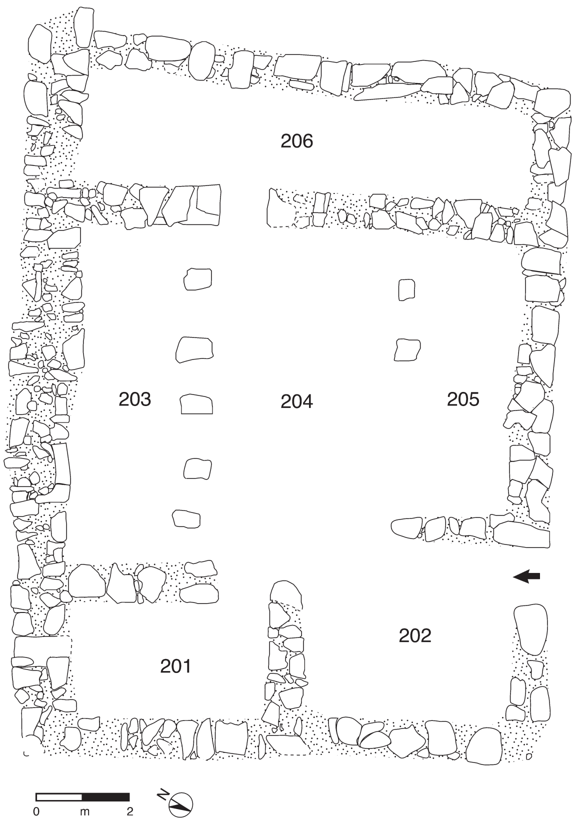

Fig. 2.6 *Khirbat al-Mudayna al-ʿAliya Building 200 (Image: B. Routledge).*

Building 500, although still interpreted as a domestic residence, stands anomalous among the other buildings for several reasons (fig. 2.7). The building is part of a larger complex located on the extreme western side of the settlement and sits at a slightly higher elevation that permits visibility over a large extent of the settlement to the east. This building was at least 238 m^2 in size. A Levantine pillared building is recognizable in the complex (Rooms 501–505). Unlike any other building at KMA, a structure interpreted as a granary was built adjacent to the pillared building (Room 504a). Excavations in Rooms 504a and 504b identified these chambers as bins, and large storage jars were documented. These bins were well-protected from natural elements. In order to access the bins, a user had to pass through a narrow corridor of rooms (Rooms 508a/b, 509).[2] While the contents of these bins are described in detail below, analysis reveals that the granary stored cleaned barley that was likely used for the production of grain-based food in a kitchen that was documented in Room 503. This kitchen included ovens of various sizes, grain processing installations with basalt grinders, limestone bowls and mortars, and platforms for cooling food.

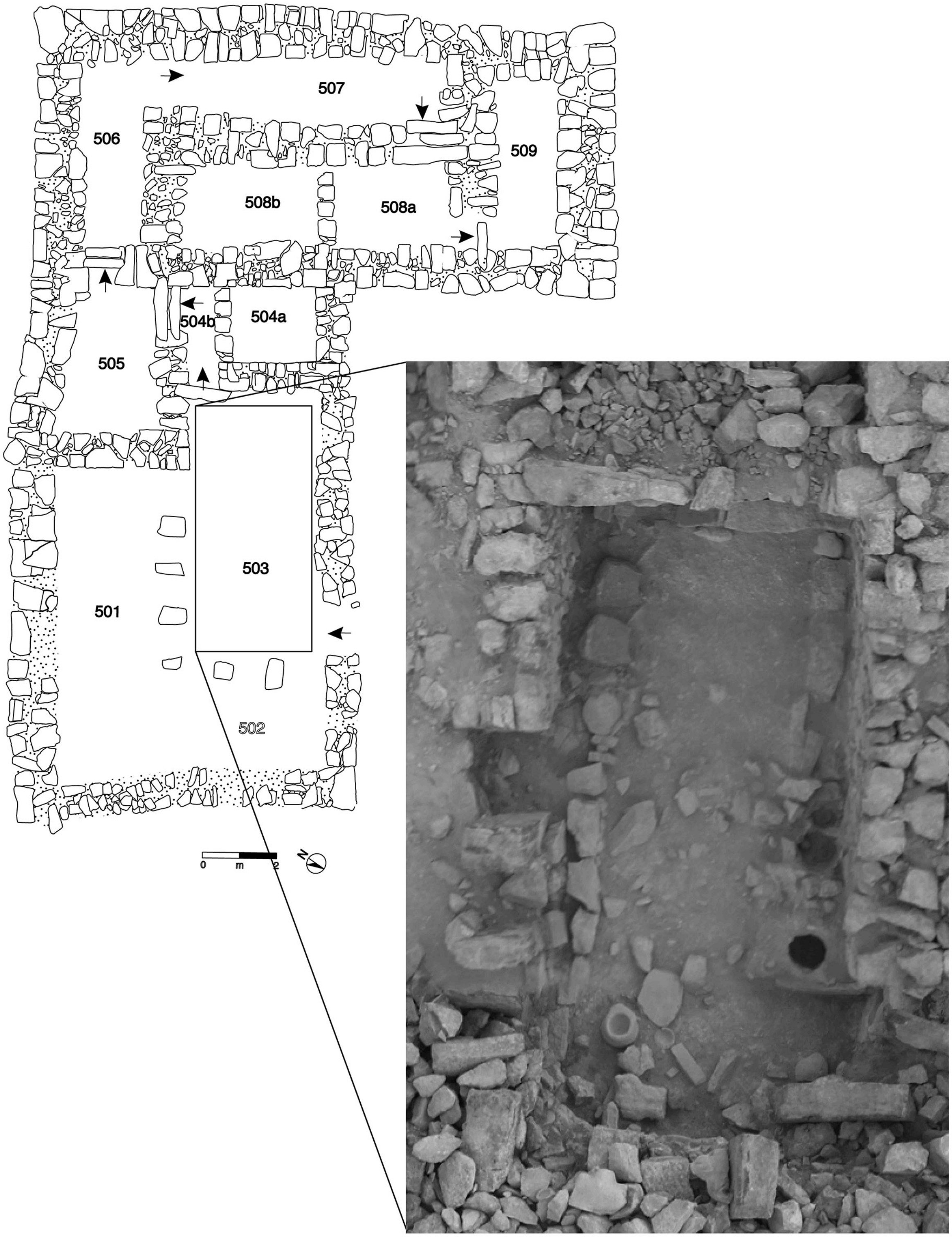

Fig. 2.7 *Khirbat al-Mudayna al-ʿAliya Building 500 and Room 503 kitchen (Image: B. Routledge and B. Porter).*

Building 100 is also distinct from KMA's other buildings (fig. 2.8). This building is 178 m² and is located on the settlement's eastern edge, next to a small postern gate that leads out to the descending cliffs and the wadi riparian zone. This gate's position is a logical entry and exit point for moving herds between the grazing and watering sources, and the settlement's large interior courtyard. Building 100's interior design is characterized by a central chamber (Room 105) surrounded by eight smaller chambers (Rooms 101–102, 104, 106–110).[3] A double bent-axis entrance (Room 103) constricts the building's entrance and suggests, like Building 500's granary, that the building's contents were valuable to its users. Excavations in Rooms 102 and 106 identified storage bins that were used for bulk storage of harvested materials (Routledge 2000: fig. 18). Carbonized plant materials were recovered from Room 106 and the contents are discussed below. Chambers that are similar in size and design to Rooms 102 and 106 are repeated around the perimeter of central chamber Room 105, raising the possibility that these too were designed as storage bins. Additional excavation of the rooms in Building 100 is necessary in order to confirm this interpretation.

The design of these bins also demonstrates that users anticipated the hazards of bulk grain storage. Room 102 is 2.6 × 2.8 m in size and is framed by three solid walls on the north, west, and south sides. Two pillars supporting a lintel on the east side created a small entrance for access from Room 105. Two bins were installed on either side of the east wall. Room 106 had a similar room design, this time the northern side remaining open to Room 105 for access. Inside the chambers, the marly subsoil in the central portion of the room was cut down to bedrock after the construction of the principal load-bearing walls. Low slab walls were inserted to support the soil beneath the outer walls and the bedrock was leveled with a surface, creating a bin in the center of the room. This careful design protected the bin's contents from moisture and rodents, two of the largest threats to bulk organic storage. This design also reflects the users' anxieties concerning food security in the semi-arid conditions of the Eastern Karak Plateau.

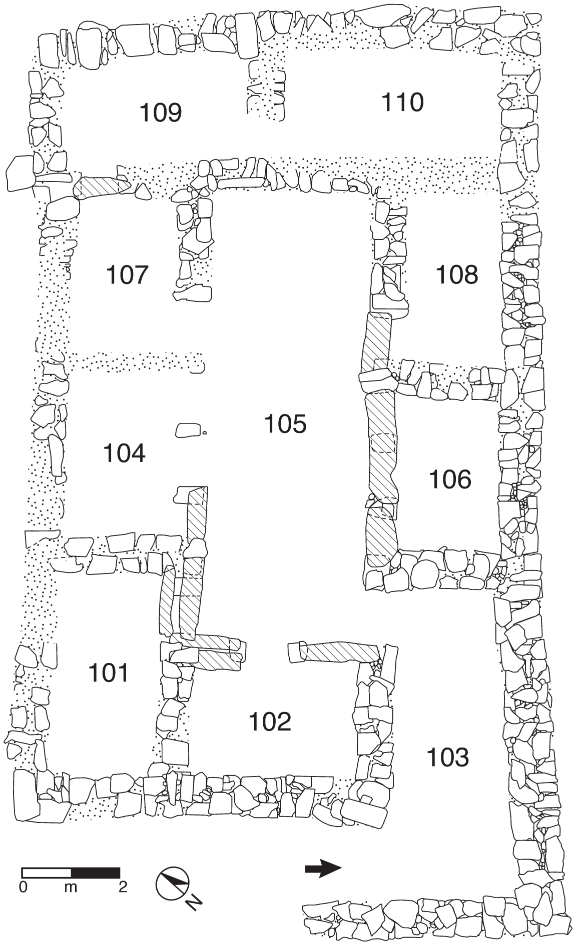

Fig. 2.8 *Khirbat al-Mudayna al-ʿAliya Building 100 (Image: B. Routledge).*

Paleoethnobotanical Sampling and Flotation

Sampling for paleoethnobotanical remains from each of the aforementioned archaeological deposits at KMA was conducted during each research season. In each, a blanket sampling approach, also known as *full coverage* or *total sampling* (Jones 1991) was employed (Simmons 2000: 16). Pearsall (2000: 66) defines blanket sampling as a systematic sampling strategy which entails the collection of sediment samples from every excavated context for flotation. A blanket sampling approach is recommended because it is less likely to introduce sampling bias due to the intentional selection of contexts by excavators that may appear to "contain material." Blanket sampling strategies also increase the probability of sampling areas where there are relatively fewer archaeobotanical remains, thereby providing data on the distribution of preserved remains, i.e., the potential to uncover the "evidence of absence" (Guedes and Spengler 2014: 79).

At KMA, bulk sediment samples were systematically recovered from each excavated context. Bulk samples are those samples which are collected from discrete, delimited areas of excavation units. Samples were also collected judgmentally, rather than systematically, at the discretion of the excavators when sampling features or ashy contexts. The excavation of surface contexts involved the creation of 50 cm² subgrids from which sediment samples were collected, when possible.[4] Manual "bucket" flotation was employed for samples from soundings in 1994 and excavations in 1998. A mechanized flotation machine based on the "Siraf" or "Ankara" style (Williams 1973), however, was employed for the 2000 and 2004 excavation seasons. Nested sieves with mesh sizes of 2 mm ("coarse flot") and 240 microns ("fine flot") were used to capture the light fraction residue that was recovered during flotation. Using these methods, 341 samples were generated across all three excavation seasons. Unfortunately, the volumetric data of 63 samples was not available at the time of laboratory examination, resulting in 278 samples available for analysis, totaling 1416 l of processed sediment. The heavy fraction was also processed using manual and mechanized flotation, although heavy fraction samples were not included in this analysis.[5]

Sample Selection and Laboratory Methods

An initial study of KMA's paleoethnobotanical evidence was carried out by Ellen Simmons as part of her M.Sc. dissertation at the University of Sheffield (Simmons 2000). She analyzed 20 samples, 19 of which derived from a storage bin in Room 106 of Building 100, and 1 of which derived from fill immediately above the floor in the central room of Building 200. Simmons argued that the multitude of barley grain found in the storage context in Building 100 was intended for animal fodder and stored in a semi-cleaned state. She based her argument on the large number of arable weed seeds in all samples containing barley grain, as well as the grass stems (Poaceae culms) and chaff (rachis nodes) found in a cluster of spatially proximate samples (Simmons 2000: 43–47). However, Simmons stressed that the analysis of 20 samples used for the thesis were not representative of the presence and abundance of archaeological plant remains across the entire settlement (Simmons 2000: 20). As 19 of the 20 samples were derived from one feature and one building, that is, the storage bin in Room 106 of Building 100, she emphasized that further archaeobotanical analysis was necessary in order to make more generalizable inferences about past agricultural practices at KMA. Many paleoethnobotanical studies also emphasize that the analysis of a variety of contexts, especially those that are spatially contiguous, is necessary in order to determine whether some areas are rich in archaeological plant remains, and whether others are not (see, especially, Lennstrom and Hastorf 1995).

With this in mind, the current project expanded the number of analyzed samples to those beyond this storeroom alone (Building 100, Room 106) to include each of the buildings excavated at KMA (100, 200, 500, 700, and 900) and a variety of contexts from them (see Table 2.2).[6] Initially, 68 additional samples were analyzed, but due to the fact that three did not contain volumetric data, the total number of analyzable samples is 65, and the inclusion of the primarily storage contexts equals 85 analyzed samples. Samples were chosen using a stratified random sampling method by excavation unit using the statistical software R.[7]

Once chosen, the samples were re-sieved in the McCown Paleoethnobotany Laboratory at the University of California, Berkeley, and the Cotsen Institute of Archaeology at the University of California, Los Angeles. The residues of the light fraction labeled "coarse flot" and "fine flot" were combined and then separated into different size fractions (>2 mm, >1 mm, >0.5 mm, and <0.5 mm) using size-graded US standard geological sieves. Each fraction size was weighed, sorted, and identified. Identification was completed using stereo-microscopes, reference material, and comparative seed collections at UC Berkeley by

Huynh and Farahani, and at UC Los Angeles by Farahani. All carbonized plant remains were sorted, identified, and counted at the >2 mm and >1 mm size fractions. For the >0.5 mm size fractions, only whole, intact carbonized seeds or Poaceae (grass) rachis remains were sorted, identified, and counted. The <0.5 mm size fractions were not examined, but retained. Due to the high density of archaeological plant remains, several samples were subsampled into quarter samples using a riffle box.[8] One of the four quarter samples was then sieved into the four aforementioned fraction sizes and analyzed. The latter include samples 22, 65, 66, and 68. Sample 21, also dense in plant remains, was subsampled into quarter samples for the >1 mm and >0.5 mm size fractions. Counts for the identified plant remains were quadrupled only for density plots, not for correlations or correspondence analysis (except for the smaller fractions of Sample 21).[9] The raw data contain the untransformed counts (see Appendix A)[10]. Fragments of seeds were recorded as the taxonomic category of that remain, plus the identifier "fragment," e.g., "*Vitis* sp. cf. *vinifera* fragment," but were not included in the count of whole seeds. The sole exception is for Poaceae seeds which have only one single identifiable embryo located in the *scutellum* of the caryopsis. Therefore Poaceae fragments with visible embryos in their apices were included in the whole seed counts for each sample.

Samples were designated *storage* if they were collected from the large rectangular bins found in Room 106 of Building 100, or Room 504a of Building 500. The *storage* contexts constituted 25 samples in total, with 20 samples deriving from Room 106, and five from Room 504a. Those samples that were not from archaeological contexts designated *storage* based on architecture or other archaeological data were labelled *non-storage*. Since many paleoethnobotanists have strenuously argued that the archaeological plant remains found within an excavated archaeological context may not be necessarily related to it (e.g., plant remains inside of a pit may have been secondarily deposited [Hillman 1984; Miksicek 1987; Lennstrom and Hastorf 1995]), these designations were for analytic purposes only. As it will be shown, some samples were in fact re-classified as storage due to their internal composition and resemblance to samples that were found inside the storerooms.

Summary of Assemblage

The analysis of the 65 additional samples from various additional buildings at KMA provides a complementary and yet distinct perspective from the published analyses of the storeroom in Building 100 (Porter et al. 2014). The majority of the assemblage (fig. 2.9) was composed of fragmented seeds identifiable to some taxonomic level (37 percent), followed by identified whole seeds (36 percent). Unidentifiable seed fragments composed 10 percent of the assemblage. Charcoal, here "large charcoal" (charcoal found in the >2 mm fraction), is low, at 8 percent of the total assemblage of 8,898 identified remains. This is likely due to the fact that in eight samples charcoal was not counted but only weighed because of its abundance. In fact, the total number of recovered charcoal remains is much higher than the 680 listed, as two of these uncounted samples contained 8.5 and 10.3 g of charcoal, respectively. Nevertheless the distribution of charcoal was patchy, with 29 samples containing no charcoal at all (44.6%), 32 samples containing between zero and one grams (49.2%), and four samples with charcoal in weights greater than one gram (6.2%), including the two aforementioned dense deposits. Future analyses will identify these carbonized wood fragments to taxonomic level, where possible.

Overall, 95 percent of the whole seed assemblage was identified. Preservation of remains was good, with little to moderate distortion among seeds, following assessment methods of Hubbard and al-Azm (1990) and modifications from Hastorf (2005). Nonetheless, there was a high degree of fragmentation throughout the samples, as fragments, whether identifiable or not, constitute 47 percent of the total assemblage, with some variability between structures. Fragmentation was especially notable in grain-rich samples from Room 504a in Building 500, where many hundreds of domesticated barley grain (*Hordeum vulgare*) fragments were recovered without visible embryos, and hence were not added to the final count of identified grains.

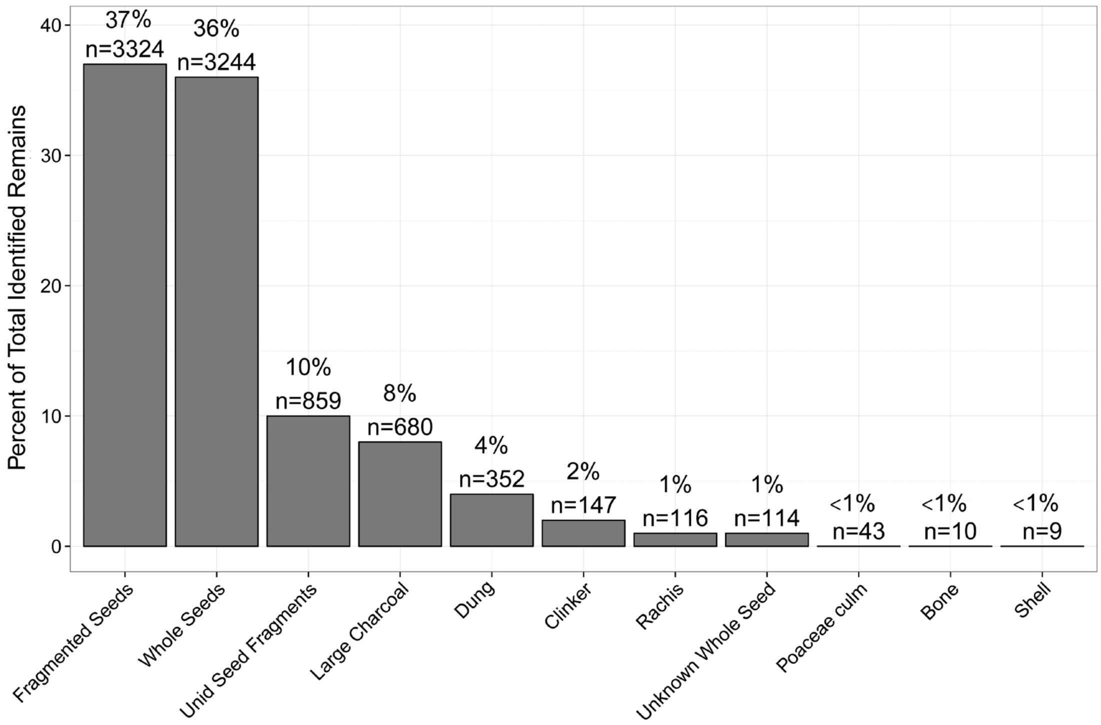

Fig. 2.9 *Contributions of individual items to analyzed assemblage (n=65), with counts and proportion of total assemblage (Image: A. Farahani).*

The analysis of 65 additional samples at KMA did not increase the number of identified crop-seed types, except for the occurrence of a new taxon, possibly a crop or more likely crop contaminant: broomcorn millet (*Panicum miliaceum*, aka common millet) (see fig. 2.11d). Although the abundance of broomcorn millet is low at KMA and restricted only to three samples within Building 500, it has considerable implications for greater regional trade and agricultural practice, as it is a crop with domestication origins in East Asia (Lu et al. 2009)[11] and which has not yet been reported in an Early Iron Age settlement in Jordan (cf. Neef 1997; Riehl and Nesbitt 2003). In addition, four raisins were identified from Building 200 (see fig. 2.11a). There were doubtless many other plants that were used by the KMA community, either as food, medicine, or ornamentally, which do not often preserve in the archaeological record, including herbs, oil rich seeds, and edible leaves (Van der Veen 2007). The assemblage, therefore, more strongly represents the agro-pastoral and crop-processing practices of the KMA community (cf. Miller and Marston 2012). Even still, the restricted presence of *Panicum* seeds in three samples all related to barley storage in Building 500, as well as the presence of raisins in a structure with the densest concentrations of grape remains (Building 200), all point to different uses of space for storage and/or deposition.

Apart from these new and uncommon taxa, the dominant domesticated crop seeds in the non-storage contexts of KMA are barley (*Hordeum* sp.) (fig. 2.10), most probably of domesticated two-row barley (*Hordeum vulgare* subsp. *distichum*), fig (*Ficus carica*), and grape (*Vitis vinifera*) (fig. 2.10; Tables 2.3 and 2.4). These three taxa alone comprise 96 percent of the non-storage and storage domesticated seed assemblages, by count of identified remains. There is, in fact, however, some variation between each of the buildings, which will be discussed below. But while this variation is important and linked to specific practices, especially to crop processing, storage, and fuel use, the delimited number of crop-types points to a deliberate system of production of these plant foods for human and non-human animal consumption. For instance, fig

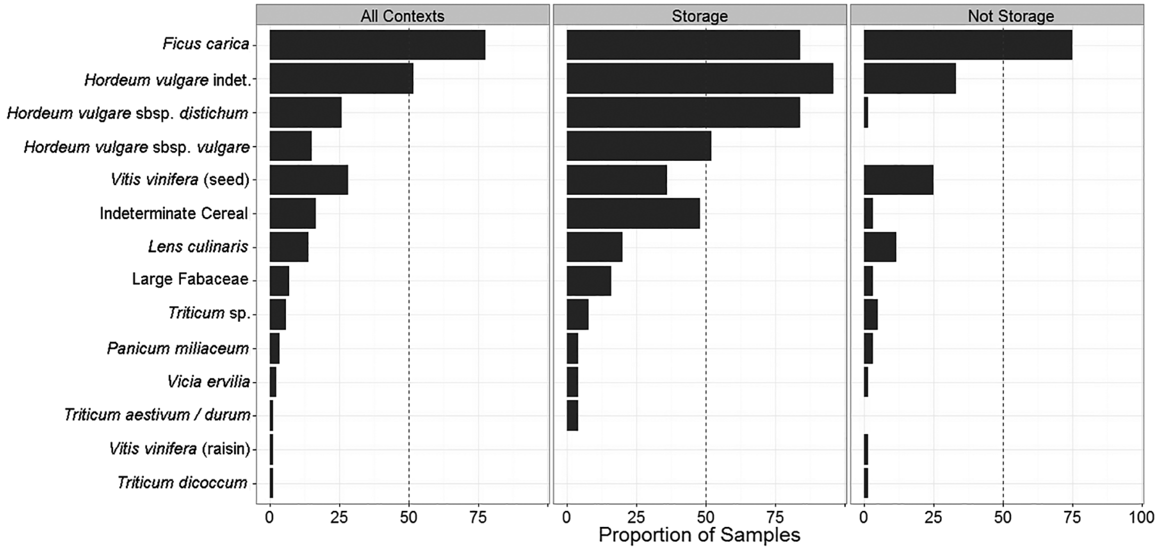

Fig. 2.10 *Proportion of samples that have at least one remain of indicated taxon in all of the samples (n=85) in the storage context (n=25) and excluding the storage context (n=60). The dotted line indicates a 50% threshold (Image: A. Farahani).*

Table 2.3 Absolute counts of the major domesticate seeds across all analyzed samples. NS signifies "not including the storage context," and WS signifies "with the storage context," i.e., considering all samples.

Common Name	Scientific Name	Count NS	% of Total	Count WS	% of Total
Domesticated Barley (subspecies indeterminate)	*Hordeum vulgare*	708	62%	4068	66.10%
Two-Row Domesticated Barley	*Hordeum vulgare* subsp. *distichum*	10	<1%	1021	17%
Fig	*Ficus carica*	289	25.40%	750	12.20%
Grape (seed)	*Vitis vinifera*	98	8.60%	120	2.00%
Indeterminate Cereal		4	<1%	90	1.50%
Six-Row Domesticated Barley	*Hordeum vulgare* subsp. *vulgare*	0		54	<1%
Lentil	*Lens culinaris*	9	<1%	14	<1%
Large Legume	*Fabaceae*	2	<1%	10	<1%
Common Millet	*Panicum miliaceum*	6	<1%	7	<1%
Wheat (species indeterminate)	*Triticum* sp.	4	<1%	6	<1%
Grape (raisin)	*Vitis vinifera*	4	<1%	4	<1%
Bitter Vetch	*Vicia ervilia*	2	<1%	4	<1%
Free Threshing Wheat	*Triticum aestivum/durum*	0		1	<1%
Emmer Wheat	*Triticum dicoccum*	1	<1%	1	<1%
Total		**1137**		**6150**	

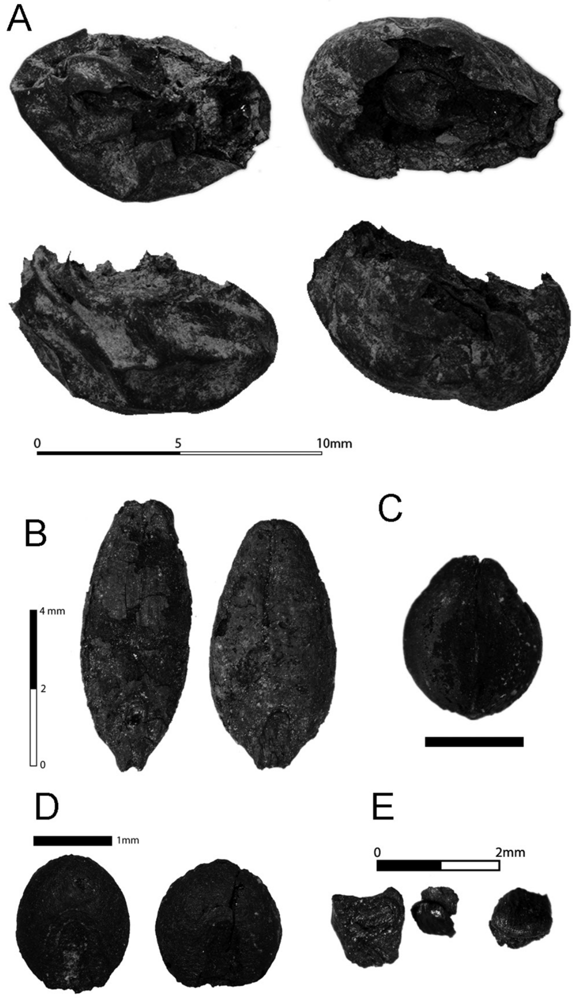

Fig. 2.11 *Remains of raisins (A), barley grains (B), sedge (bulrush) (C), broomcorn millet (D), and barley chaff (rachis nodes) (E) (A, B, E: A. Farahani; C, D: H. Huynh).*

seeds are found in 75 percent of the non-storage contexts (n=45) and in 84 percent of the storage contexts (n=21, Table 2.4). This ubiquity is most likely linked to the small sizes of fig seeds, as well as their suitability for both animal and human consumption. In comparison, when all barley types are considered in aggregate, they comprise only 33 percent of the total *non-storage* assemblage, and yet are more abundant (n=718) than fig (n=289), which is nonetheless more ubiquitous. This pattern exists because rather than being homogeneously distributed throughout the assemblage, there are only a few samples which contain a very large number of barley grains per liter of archaeological sediment, even when excluding the samples from storage contexts. The same occurs for grape seeds, which are present in every structure, albeit in only 28 percent of all of the samples. The three densest samples, however, contributing 60 percent of the total number of identified grape seeds, all occur within Building 200.

The most ubiquitous weed seeds across the non-storage contexts were from the legume family (Fabaceae; including *Melilotus/Trifolium* sp., *Astragalus,* and *Trigonella*), followed by weed seeds from the mustard (Brassicaceae) and goosefoot (Chenopodiaceae) families (Table 2.5).[12] Their abundance and corresponding ubiquity are due to the processes by which they were brought into the settlement and burned, discussed at length below, namely as dung fuel and crop processing debris. When all of the weed seeds from the grass family (Poaceae) are aggregated, they comprise only 20 percent of the non-storage contexts (i.e., 12 out of 60), whereas they comprise 100 percent of the storage contexts (25 out of 25).[13] As it will be shown below, this is likely because the areas outside of the storeroom context in Building 100 and outside of the kitchen in Building 500 were not dedicated to grain storage, processing, or cooking, and the presence of weedy grasses is linked to all three practices in these samples. Finally, there were numerous weeds pointing to, or strongly indicative of, irrigation, including plantain (*Plantago* sp.), fumewort (*Fumaria* sp.), and, importantly, sedges (*Cyperaceae*) including bulrush (*Scirpus* sp.) (cf. Miller 2010: 66). There are also several segetal weed seeds associated with disturbed agricultural soils, including *Malva* sp., *Silene* sp., *Polygonum* sp., *Galium* sp., and *Convolvulus* sp., which are common in fallow fields in areas around the Dead Sea that receive under 150 mm of rainfall (Zohary 1950: 401–5).

The richness, or the total number of identified taxa to any taxonomic level (Maurer and McGill 2011: 56),[14] of the identified plant seeds varied from structure to structure and particularly between storage and non-storage contexts. The storage contexts in Building 100 were the richest in both domesticate (median=4) and wild (median = 8.5) taxa, followed by the storage contexts in Building 500 ($\text{median}_{\text{dom}}$=3, $\text{median}_{\text{weed}}$=5). In contrast, the other structures had low richness: a median of two

Table 2.4 Ubiquity of major domesticate seeds across all analyzed samples in storage and non-storage contexts.

Taxon	All Contexts n=85		Storage n=25		Non-Storage n=60	
	Count	Proportion	Count	Proportion	Count	Proportion
Large Fabaceae	6	7.06%	4	16.00%	2	3.33%
Ficus carica	66	77.65%	21	84.00%	45	75.00%
Hordeum vulgare sbsp. *distichon*	22	25.88%	21	84.00%	1	1.67%
Hordeum vulgare indet.	44	51.76%	24	96.00%	20	33.33%
Hordeum vulgare sbsp. *vulgare*	13	15.29%	13	52.00%		
Indeterminate cereal	14	16.47%	12	48.00%	2	3.33%
Lens culinaris	12	14.12%	5	20.00%	7	11.67%
Panicum miliaceum	3	3.53%	1	4.00%	2	3.33%
Triticum aestivum durum	1	1.18%	1	4.00%		
Triticum dicoccum	1	1.18%			1	1.67%
Triticum sp.	5	5.88%	2	8.00%	3	5.00%
Vicia ervilia	2	2.35%	1	4.00%	1	1.67%
Vitis vinifera (seed)	24	28.24%	9	36.00%	15	25.00%
Vitis vinifera (raisin)	1	1.18%			1	1.67%

or under two domesticated taxa per sample. The latter difference in richness is likely tied to differences in sample size (fig. 2.12b), since the storage samples have many hundreds of remains, whereas those from the other contexts and buildings very often have less than 25 as an absolute count (even if the corresponding density is high because of the small volume of sampled sediment).[15] There is in most structures a correlation between the richness of domesticated plant taxa and wild (or weed) taxa: in Buildings 200, 500, and 700, as the number of kinds of seeds of food plants increases, so too do the weeds (fig. 2.12a), and in Building 900 the number of remains is too low for a reliable assessment. The correlation between these two is again likely tied to the fact that as the number of identified remains increases, so too does the number of species represented.

Comparative Evidence from Early Iron Age Levantine Settlements

Paleoethnobotanical data from other Early Iron Age archaeological settlements in the Southern Levant and beyond can help contextualize these archaeological plant remains temporally and regionally. In theory, the comparison of KMA with neighboring settlements, or with settlements geographically distant but contemporaneous, permit an understanding of how unique or similar KMA is in this time and place. Archaeological projects that have reported paleoethnobotanical material for comparison include Deir ʿAlla (van Zeist and Heeres 1973; Neef 1989), Pella (Willcox 1992), Tall al-ʿUmayri (Ramsay and Mueller, *this volume*), and Hesban (Gilliland 1986). Other settlements with comparatively less material include ʿIraq al-Emir (McCreery 1982), Timna (Kislev 1988), Tell Qasile (Kislev-Hopf 1985), and ʿIzbet Sartah (Liphschitz and Waisel 1986).[16]

While the community at KMA was similar to many of the nearby and contemporaneous communities in the southern Levant with respect to the widespread production of two-rowed barley, there are nonetheless many differences. One particular difference, perhaps motivated by KMA's location and low precipitation on the Karak plateau, is the reliance of the KMA community on barley as the sole grain crop. The only other settlement with a similar archaeobotanical profile is Deir ʿAlla,

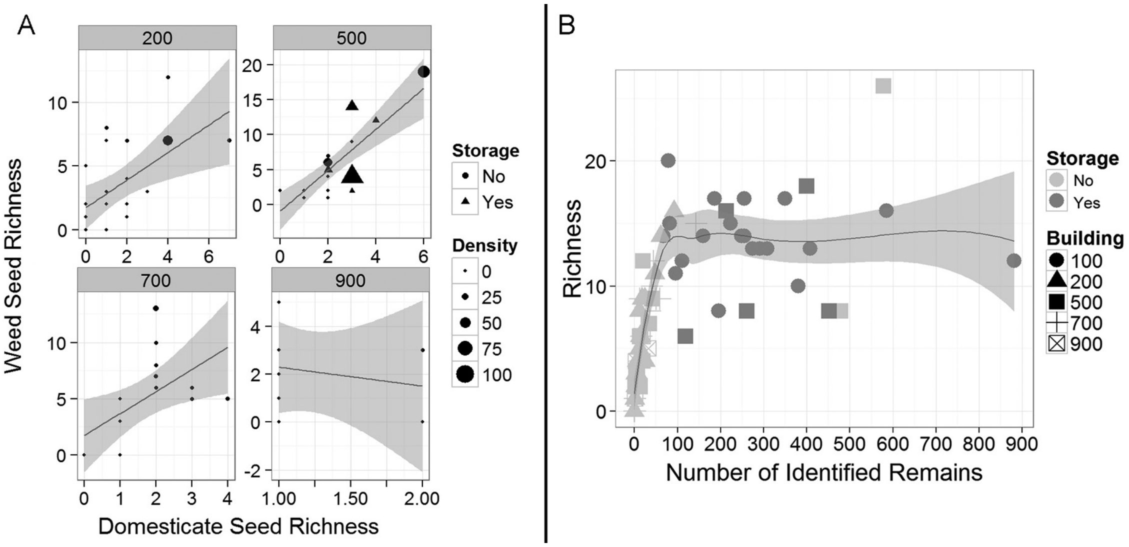

Fig. 2.12 *Richness of wild and domesticate seeds by building, with points sized to density (#/L) of seeds per sample. Shapes represent whether the sample was a priori identified as from a storage context. In (A), the black line is a linear best-fit, with the grey band representing the 95% confidence interval of the linear estimate, while in (B) the line represents a locally-weighted scatterplot smoothing (LOESS) with the grey band representing the 95% confidence interval of the estimate. (Image: A. Farahani).*

Table 2.5 Count and ubiquity of the twenty most frequent weedy or wild plant taxa at KMA.

	STORAGE n=25				NON-STORAGE n=60				
	N(samples)	Ubiquity	N(count)	Proportion		N(samples)	Ubiquity	N(count)	Proportion
Poaceae	23	92.0%	257	19.0%	*Melilotus / Trifolium*	33	55.0%	184	28.8%
Muscari	20	80.0%	151	11.2%	*Astragalus*	30	50.0%	112	17.6%
Hordeum spontaneum	18	72.0%	178	13.2%	Brassicaceae	17	28.3%	40	6.3%
Fabaceae	17	68.0%	103	7.6%	Chenopodiaceae	17	28.3%	33	5.2%
Astragalus	15	60.0%	73	5.4%	Poaceae	14	23.3%	33	5.0%
Polygonum	15	60.0%	147	10.9%	*Trigonella*	14	23.3%	32	3.9%
Phalaris	10	40.0%	43	3.2%	Fabaceae	12	20.0%	22	3.4%
Bromus	6	24.0%	23	1.7%	*Salsola*	9	15.0%	22	3.4%
Erodium	6	24.0%	58	4.3%	*Malva*	8	13.3%	14	3.4%
Malva	6	24.0%	15	1.1%	*Hyoscyamus*	7	11.7%	12	2.8%
Papaver	6	24.0%	34	2.5%	*Silene*	6	10.0%	13	2.2%
Suaeda	6	24.0%	25	1.8%	*Galium*	5	8.3%	7	2.0%
Polygonaceae	5	20.0%	12	0.9%	*Scirpus*	5	8.3%	12	1.9%
Melilotus \ Trifolium	5	20.0%	32	2.4%	Boraginaceae (mineralized)	4	6.7%	25	1.9%
Bupleurum	4	16.0%	14	1.0%	*Suaeda*	4	6.7%	4	1.1%
Carex	4	16.0%	15	1.1%	*Ajuga*	3	5.0%	3	1.1%
Silene	4	16.0%	8	0.6%	*Androsace maxima*	3	5.0%	5	1.1%
Aegilops	3	12.0%	3	0.2%	*Chenopodium*	3	5.0%	7	0.8%
Atriplex	3	12.0%	6	0.4%	*Heliotropium*	3	5.0%	3	0.6%
cf. *Cardamine*	3	12.0%	22	1.6%	*Vaccaria*	3	5.0%	3	0.5%

where two-rowed barley (*Hordeum vulgare* subsp. *distichum*) is reported among the identified domesticated taxa (van Zeist and Heeres 1973: 22) as the only grain crop for the period of 1150–1000 BCE. This could be due to sampling bias, however, as the authors did not utilize flotation (van Zeist and Heeres 1973: 21) but selectively hand-sampled. Otherwise, the lack of other agricultural crop remains would represent a large shift in crop choice from the earlier period of 1200–1150 BCE at the settlement, when two-rowed barley, bread/macaroni wheat (*Triticum aestivum/durum*), flax (*Linum usitatissimum*), and bitter vetch (*Vicia ervilia*) were present. Intriguingly, the samples from Tell Qasile, almost all of which were procured from a storage context, are of six-rowed barley, and not two-rowed barley as that found at KMA (Kislev-Hopf 1985).

At Hesban (Gilliland 1986), both barley and wheat are reported for the six samples corresponding to the Iron Age, but the variety or subspecies to which they belonged is not provided. Unfortunately, the available information does not indicate which samples belong to which strata, as some material belongs to the Early Iron Age, and others to the later Iron Age II period. The latter distinction between strata is important, as apart from cereals, grape and lentil are also reported at Hesban, both of which are also found at KMA.

At Tall al-ʿUmayri (Ramsay and Mueller, *this volume*), a variety of cultigens are found in archaeological deposits dated to the Late Bronze Age and Iron Age I transition (ca. 1300–1200 BCE). The latter include both wheat and barley, and importantly the assemblage of one building in particular (Building C) was composed almost of wild or two-rowed barley (Ramsay and Mueller 2016: 12), much like the storage contexts at KMA. Unlike KMA, however, and potentially owing to ʿUmayri's more favorable environmental conditions, wheat is abundant in other contexts at the site (Field H). Moreover, and again, unlike KMA, there are many more kinds of cultigens represented in these contexts, including several kinds of vetch (*Vicia*), lentils, grapes, and chick peas.

Finally, at Pella, the only barley type found for the period of 1000–900 BCE is two-row barley (Willcox 1992: 255). And yet, unlike Deir ʿAlla, there are also domesticate seeds which reflect local environmental opportunities—this includes hackberry (*Celtis* sp.) and pomegranate (*Punica granatum* L.) seeds. The soils, climate, and precipitation at KMA would have been unfavorable for either of these crops without substantial irrigation and/or environmental engineering. And although the KMA community seems to have been utilizing irrigation due to the evidence (and presence) of sedge and grape hyacinth seeds, they chose to grow water-demanding grapes rather than any of the other then-contemporary potential cultigens. On the other hand, the presence of flax at Pella seems to place the settlement within the same agricultural "orbit" as the community at Deir ʿAlla, which also reports flax in its earlier levels. The lack of flax or other plant remains similar to nearby settlements situates the KMA agricultural community as distinct in its choices from many of these sites.

In short, KMA is both similar to and distinct from other contemporaneous and/or geographically proximate settlements. Unfortunately, archaeobotanical data from contemporaneous settlements in the Wadi al-Mujib corridor have not yet been reported, and therefore KMA cannot be compared to them.[17] KMA is similar to other settlements in its use of two-rowed barley, which seems to be a common crop choice among communities during this period. Nevertheless, the KMA community is distinct in its more constricted range of cultigens, focusing heavily on barley, fig, and grape agriculture. The latter emphasis on only a few crops is probably enabled by an equally prominent reliance on animal husbandry at the semi-arid settlement, which included, despite the daunting water and food requirements, cattle and horses.

Agricultural Production, Storage, and Cereal Processing

There are three main conclusions to be drawn from the KMA paleoethnobotanical assemblage. The first is that the depositional origins of these samples indicate that agricultural production was intertwined with animal husbandry, an argument already advanced from the analysis of the storeroom in Building 100 (Porter et al. 2014:

141), especially given that the KMA community maintained sheep/goat, pigs, horses, and cattle (Lev-Tov et al. 2011: 73). The evidence for animal husbandry in these additional, non-storage samples includes a large number of samples with few to no crop seeds (except for fig seeds, which survive ruminant digestion and are found in dung assemblages: Valamoti and Charles 2005), and comparatively more weed seeds, particularly wild legumes (Fabaceae). These samples seem to indicate dung fuel burning, which explains the large number of leguminous weeds that were probably the result of animal grazing upon the Karak Plateau (cf. Miller and Smart 1984; al-Eisawi 1996: 111). The second conclusion is the possibility of a centralization (or centralizations) of plant food storage, preparation, and perhaps even communal consumption at KMA. The distribution of barley grains is highly uneven, but patterned. The densest concentrations of barley seeds occur in the storage structures of Building 500 ($\bar{x}$=35 seeds per L, s=31.3 seeds per L, n = 5) and Building 100 ($\bar{x}$=25.7 seeds per L, s=20.71 seeds per L, n=20), whereas other buildings contain few to no barley seeds (the median density of Buildings 200, 700, and 900 is zero). In this case the insights of the non-storage contexts are in what they *do not* contain, rather than what they do.

Finally, the occurrence of the seeds of sedges (Cyperaceae) as well as grapes, whether in seed or raisin form, indicates that the community was actively involved with the wadi riparian zone below the settlement. The wadi would have been used for procuring water to bring back to the settlement, as well as a source of irrigation water for plots on adjacent "tables" jutting out from the escarpment. Indeed, the seeds of sedges appear almost exclusively in places where plant foods were likely handled (Buildings 100, 200, 500), probably pointing to their presence in irrigated plots where plant foods were grown, except for one *Scirpus* seed found in a courtyard context in Building 900. Faunal remains of semi-terrestrial water freshwater crabs (*Potamon potamios*), as well as water-birds, provide independent evidence that the community traveled to this nearby water source (Lev-Tov, Porter, and Routledge 2011). The combination of all of these lines of evidence—that is, the emphasis on barley, the possible centralization of grain storage and commensal practices, and the use of the wadi as a locus of plant maintenance—reinforces the notion that like objects, these plant foods were not "passive markers" of community identity at KMA. Instead, they facilitated the creation and reinforcement of the KMA community's social bonds through the activities needed to secure their maintenance and harvest, which in turn nourished both human and non-human actors.

Understanding how the KMA community was provisioned with essential plant foods entails disentangling the depositional origins of the paleoethnobotanical samples associated with the archaeological storage and non-storage contexts at KMA. These depositional origins also highlight how animal husbandry, particularly of sheep and goat, was dependent on, but enabled by, agricultural production at KMA. Here, depositional origins means how plant remains come to be carbonized and then enter the archaeological record (Miksicek 1987; Gallagher 2014). The identification of these depositional pathways leads directly to the human and non-human behaviors and activities that produced these assemblages. In many cases, these pathways involve agricultural practices such as crop processing or dung fuel burning (Miller and Smart 1984; van der Veen 2007). There are multiple complementary and competing quantitative approaches as to how best identify the practices that produce carbonized botanical assemblages (Jones 1985; Campbell 2000; Van der Veen and Jones 2006; Van der Veen 2007; Stevens 2014). Each of these methods attempts to identify whether a given assemblage is, broadly speaking, food, fodder, or fuel (and the many combinations thereof). One aspect that unites these different approaches is the comparison of cereal plant elements related to processing, since cereals require threshing, winnowing, sieving, and sorting, all of which leave traces in the archaeological record (Hillman 1981; Jones 1987). The comparison of these preserved crop-processing remains with the seeds of agricultural and wild weeds also helps address an ever-present problem in paleoethnobotanical research in southwest Asia, namely, whether plant seeds recovered in a given sample were intended as human food or animal fodder (Jones 1998; Valamoti and Charles 2005).

One popular approach to resolve these issues is to investigate the "taphonomic pathways of individual samples" using the ratios of preserved cereal plant elements, such as straw nodes to grain, because of the potential internal complexity of even a single paleoethnobotanical sample (van der Veen and Jones 2006: 222). In the latter case, the emphasis is on comparison of large, individual samples. Nevertheless, as Lee (2012: 650) has illustrated, the item of analysis in paleoethnobotany is sediment sampled from a demarcated space, ideally with many samples collected from a single space, and therefore inferences are formed from the observed trends of the samples within that space, rather than from one sample to the other. Therefore, comparison across multiple samples is necessary in order to estimate the magnitude of variation around a chosen parameter (i.e., a mean, median, etc. of a plant element) and the extent to which the values of a parameter are common among some central value or not (Hammer and Harper 2006: 12–14). Rather than use ratios, which can often mask variation (Kadane 1988), direct comparisons of different crop seeds and plant parts are utilized throughout the following analyses.

As was mentioned previously, one of the main conclusions to be drawn from the KMA paleoethnobotanical assemblage is the relationship between animal husbandry, as identified through the faunal remains, and the storage of barley probably meant to provision those animals during the lean summer and winter months (Palmer 1998: 4). Although the architectural evidence is such that the bins in Room 106 of Building 100 and Room 504a of Building 500 appear to be meant for storage, much archaeobotanical research has shown that archaeological context and the content of paleoethnobotanical samples can often be distinct (Miksicek 1987: 224–28). It is necessary to understand the internal composition of samples in order to identify whether any given

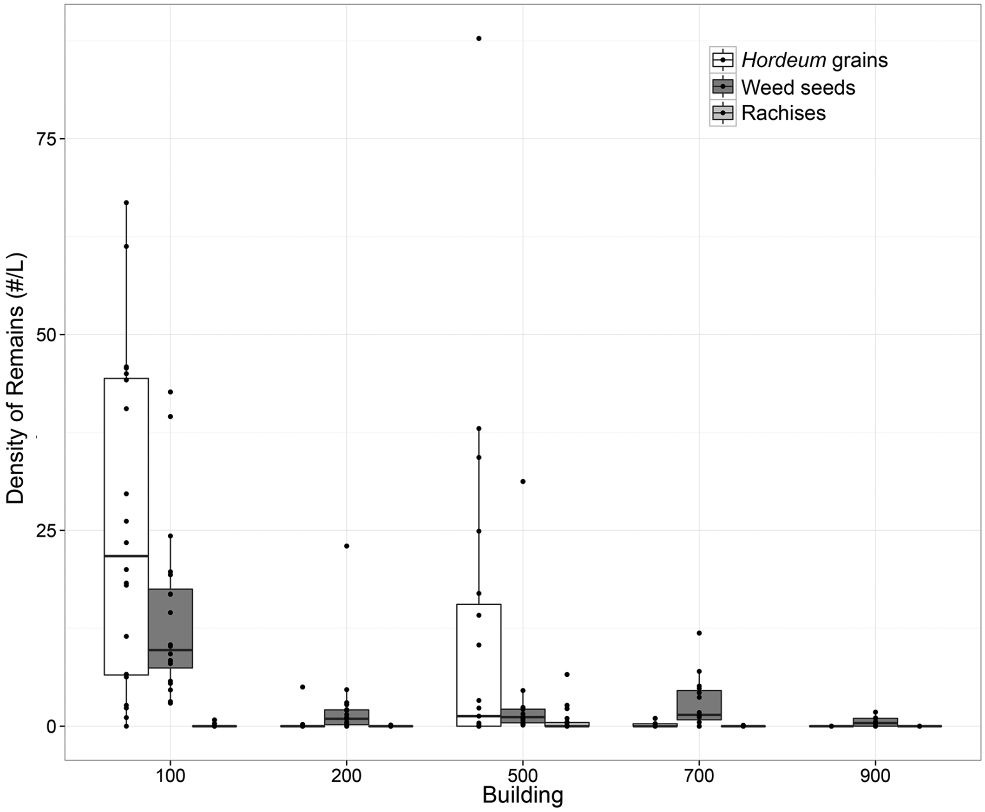

Fig. 2.13 *Density (#/L) of barley (*Hordeum*) grains, weed seeds, and barley chaff (*Hordeum *rachis nodes) by building, with points overlaying boxplots indicating the contribution of each sample (Image: A Farahani).*

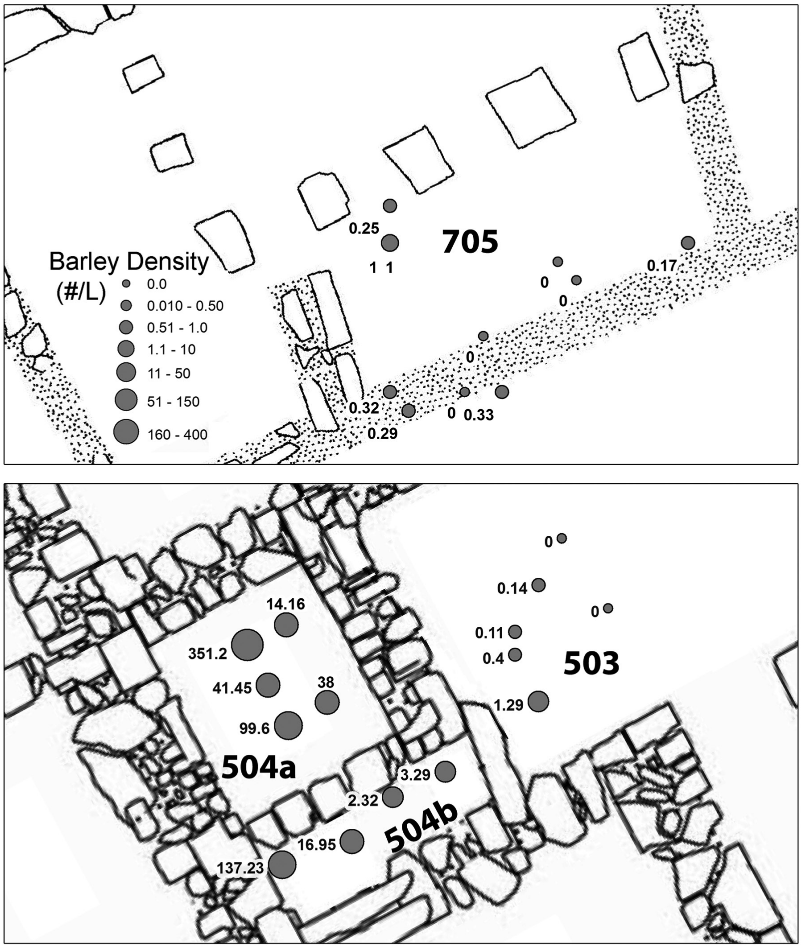

Fig. 2.14 *Densities of barley by sample in Building 500 (bottom) and Building 700 (top). The points represent individual samples, the text-labels indicate the density, and the sizes of the points are proportional to the density of remains (Image: A Farahani and H. Huynh).*

sample in fact has some use-relationship associated with that context. One of the main indicators that the archaeological plant remains found in these bins were *in situ* or *de facto* (cf. Schiffer 1972) is the density of nearly-pure barley grains recovered from them. The majority of the dense barley samples are found in Building 100 (fig. 2.13), followed by several samples from Building 500, most of which derive from the storerooms in Room 106 and 504a, respectively. The very high density values of barley grain, following some models, provides evidence of both large scale (van der Veen and Jones 2006) and communal storage (Stevens 2003) at KMA. In contrast to Building 500, the median density of weed seeds in Building 100 is much greater, and the greater density both of weed seeds and barley grains points to barley stored at an earlier stage of crop-processing, namely before the first sieving and hence stored as "semi-clean spikelets" (Stevens 2003: 73).

Summarizing the density trends in the other buildings is not as straightforward, however. The values of barley density are challenging to visualize because the median density of barley is zero for Buildings 200, 700, and 900. The nine analyzed samples in Building 900 are absent of barley grains altogether, and 200 and 700 contain median densities that, when empty samples are removed, are only 0.19 and 0.32, respectively (fig. 2.13). Moreover, there is considerable variation within structures themselves, as in the case of Building 500. When the samples from Room 504a are removed alongside two outliers, the median density of barley is only .0163. Therefore, it appears that activities related to barley handling and preparation were highly spatialized up to the point of the conflagration that engulfed the structure (Routledge 2004: 103). A comparison of the *in situ* densities in Building 500 and 700 in their sampled space illustrates this phenomenon more fully (fig. 2.14). Within Building 500, the greatest density values of barley grains are found in Room 504a, followed by 504b, and finally with few to no remains in Room 503.

In this case, the high densities of grain in Room 504a are evidence of "rapid or single deposition" (Van der Veen 2007: 987) due to a fire which preserved the grains in good condition. But the spatial arrangement of densities perhaps reflects the fact that Room 504a was a kitchen storeroom, and the two densest samples are outside of it, in Room 504b,

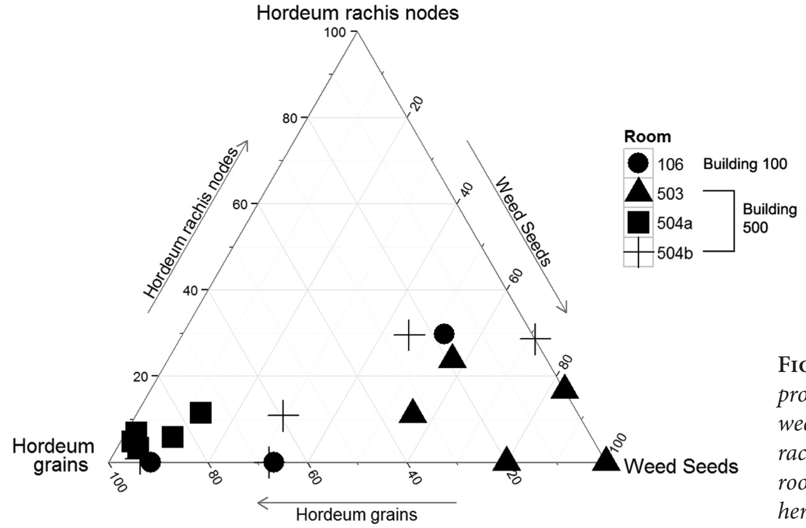

Fig. 2.15 *Ternary comparison of relative proportions of barley (*Hordeum*) grains, weed seeds, and barley chaff (*Hordeum rachis nodes*), with point shape indicating room. Buildings 100 and 500 are shown here (Image: A Farahani).*

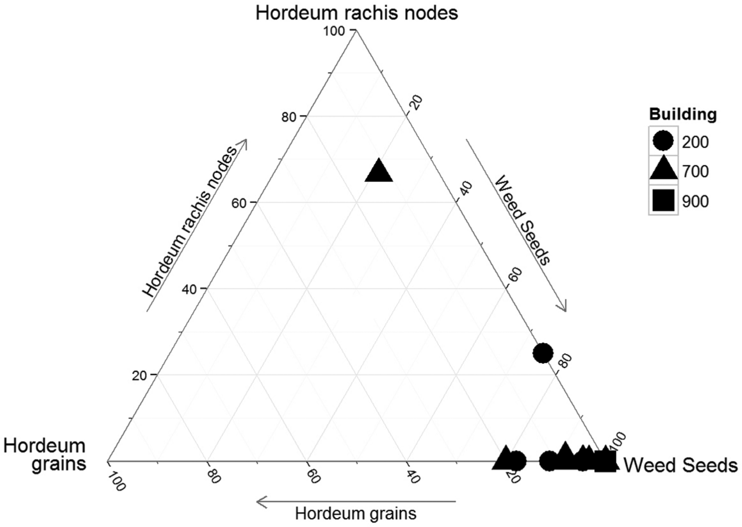

Fig. 2.16 *Ternary comparison of relative proportions of barley (*Hordeum*) grains, weed seeds, and barley chaff (*Hordeum rachis nodes*), with point shape indicating building. Buildings 200, 700, and 900 shown here (Image: A Farahani).*

a walkway. It could be that these samples were in transit at the time of the fire, either on their way into the storeroom, or being taken out of it. The density values of barley in Room 503 are low, if not zero in two instances, and are very similar to those in Room 705 in Building 700, which was identified as a domestic structure. While the storerooms in Building 500 and Building 100 both contain high densities of barley, there are important differences between the two contexts.

The differences between these two storage assemblages can be elucidated through the internal proportions of the absolute counts (Jones 1985) of barley (*Hordeum*) grains, barley chaff (*Hordeum* rachis nodes; see fig. 2.11d), and weed seeds in each sample, following the ratios found in Jones (1985), Stevens (2003), and van der Veen and Jones (2006). The comparison is aided by splitting the buildings into two groups: the first compares Room 106 (storage bin) from Building 100 and Rooms 503, 504a (storage bin), and 504b (walkway) from Building 500 (fig. 2.15). The second group compares Buildings 200, 700, and 900 (fig. 2.16). The analysis of internal proportions provides complementary information to density analyses, since a sample can have a high density of grain, but the grain may

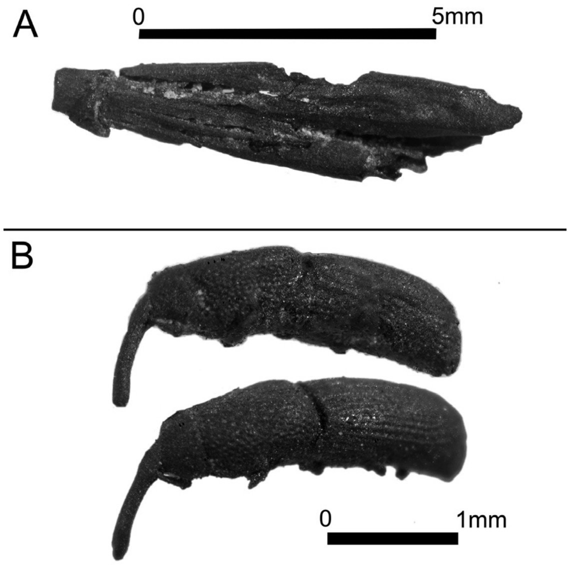

Fig. 2.17 *Remains of infertile lateral spikelet of two-rowed barley (A) and of the grain weevil,* Sitophilus granarius *(B). All of these specimens derive from Room 504 of Building 500 (Image A. Farahani).*

constitute a smaller proportion of the total absolute count of crop and crop processing products. In the analysis of the first group, it is clear that there are two groups of samples: those richer in weed seeds, and those richer in barley grains (fig. 2.15).[18] All of the samples from Room 504a contain proportionally more barley grains than either chaff or weed seeds. These dense samples are joined by samples in Room 106, as well as some of the material found in the "walkway" Room 504b.

The samples that contain proportionally more barley grains as an absolute count are also, on average, the densest in barley grain. It is important to note that included among them are samples from the walkway of Building 500 (504b). These samples contain the densest barley concentrations apart from those from Room 106 or Room 504a. Although one sample does contain some weed seeds (fig. 2.15), it is arguable that the grain represented in these samples was intended for human consumption. This grain-rich but also weed-containing sample (Sample 21) may have been intentionally stored as semi-clean grain, while the adjacent sample (Sample 22) represents the cleaned product ready for preparation for consumption. If additional samples from Room 106 had been included, there would have been at least four samples with proportionally more chaff and weed seeds, although also dense in barley grains (E05, E10, E12, E17). These are samples that Simmons (2000: 37) referred to as being separated by "proportions of chaff and culm material versus proportions of the grain." Therefore, the barley-rich samples in Room 504a, and even those immediately adjacent in Room 504b, were on average "cleaner" than those found in Room 106 in Building 100, i.e., containing fewer weed seeds and chaff remains (including straw, i.e., culms and culm nodes). Although there were some chaff remains found in 504a, including some entire sterile spikelets diagnostic of two-grain barley (fig. 2.17a), the overwhelming proportion of each of the five samples in Room 504a was of barley grain.

Supporting the argument of nearly clean grain in Room 504a is the observation that every analyzed sample from it contained either whole or parts of the grain weevil, *Sitophilus granarius* (fig. 2.17b), identified by its prominent rostrum. A total of eleven whole specimens were found, including three thoraxes, two abdomens, four larvae, and one possible wasp (cf. Hymenoptera) which may have been a parasitoid. Their sexes were not determined. The insect is found in many archaeobotanical storeroom assemblages throughout the southern Levant, including at Ḥorbat Rosh Zayit, an Iron Age site in the Galilee dated to the tenth to ninth centuries BCE, which contained over 700 specimens in a storeroom for wheat (Kislev and Melamed 2000: 212–13). The storage structure in Building 100 (Room 106) did not contain any remains of the weevil, although in many samples only a smaller proportion of the "fine fractions" was analyzed, which is most likely to contain these small (<2mm) insects. If the absence of weevil remains from Room 106 is in fact evidence of absence, then the contrast between Room 504a and Room 106 in terms of storage patterns is striking. Granary weevils are synanthropic insects whose complete larval development occurs inside of grain, and there is no evidence of this animal in non-anthropogenic settings. As it has no wings, its propagation is entirely tied to the movement of grain already containing its larvae (Plarre 2010: 1). Therefore, its presence at KMA means that the

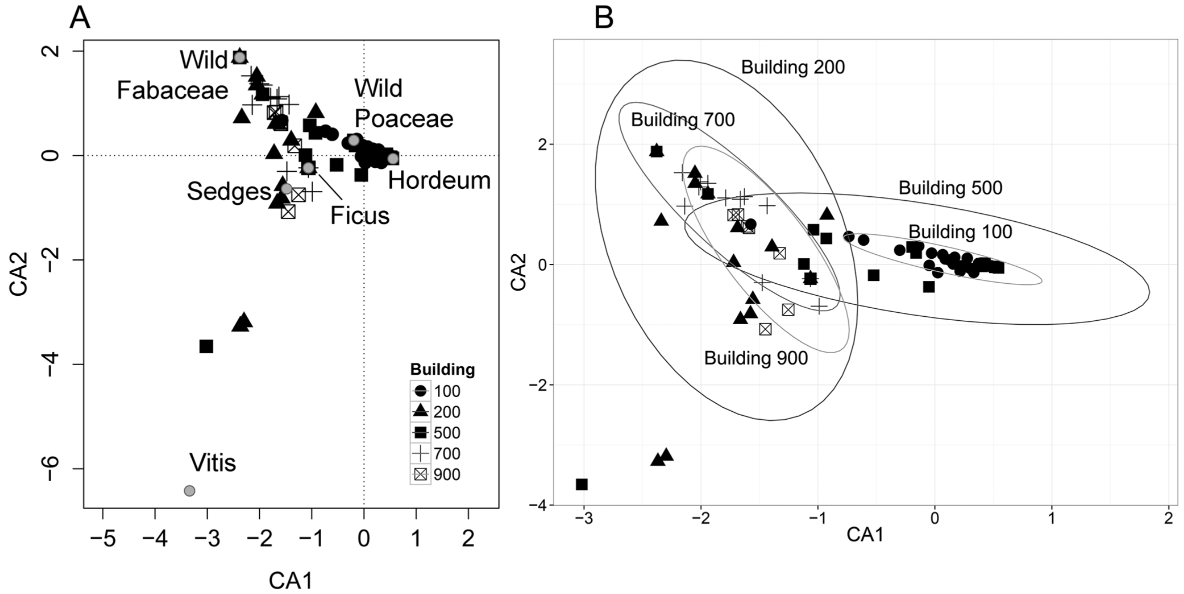

FIG. 2.18 *Correspondence analysis plot showing the first two axes (CA1, CA2) scaled so that the centroids are of samples (for the computation see Legendre and Legendre 2012: 464–91, implementation was achieved in R using the package "vegan"). In (A) the text signifies a variable of the analysis and its location indicates its contribution (i.e. more or less). The relative position of the objects, which are archaeobotanical samples, indicate their relative similarity, i.e., samples that are closer together are compositionally more similar given the variables. In (B) the axes have been extracted, point shapes indicate building structure, and ellipses at the 95% confidence level (based on the multivariate t-distribution) are drawn around each building cluster (Image: A Farahani).*

Table 2.6 Specifications of the correspondence analysis.

Importance of Components

	CA1	CA2	CA3	CA4	CA5
Eigenvalue	0.47	0.29	0.15	0.12	0.05
Proportion Explained	0.43	0.27	0.13	0.12	0.04
Cumulative Proportion	0.43	0.71	0.84	0.96	1.00

Variable Scores

	CA1	CA2	CA3	CA4	CA5
Ficus	-1.06	-0.24	0.07	-2.66	-0.07
Hordeum	0.56	-0.06	0.29	0.16	0.07
Vitis	-3.34	-6.42	0.44	2.31	-0.67
Wild Fabaceae	-2.38	1.88	0.84	1.18	-0.03
Wild Poaceae	-0.19	0.29	-2.96	0.38	-0.98
Sedge	-1.48	-0.64	-4.25	0.55	14.18

community would have inherited grain already containing this weevil, and that the grain would have been stored long enough to support a full generation of growth (i.e., to the adult form).

In contrast to Buildings 100 and 500, there is a greater homogeneity of sample composition for Buildings 200, 700, and 900 (fig. 2.16). The sole exception is Sample 5 from Building 700, which contains a proportionally greater number of chaff remains, even though the absolute abundance and density of these remains is low.[19] All of the other samples from the other structures were similar: few to no chaff remains, proportionally more weed seeds in each sample, and few to no grains. Notably, barley grains were completely absent from Building 900. These samples, which are not dense in remains and contain a proportional majority of weeds, are most likely in secondary context, i.e., the result of dung fuel, crop processing burnt as fuel, or the sweepings of it, as they contained only weed and fig seeds, with an occasional grape seed.

While the category of "weed seeds" is useful in making broad inferences, the analysis of ubiquity and abundance in the KMA archaeological plant

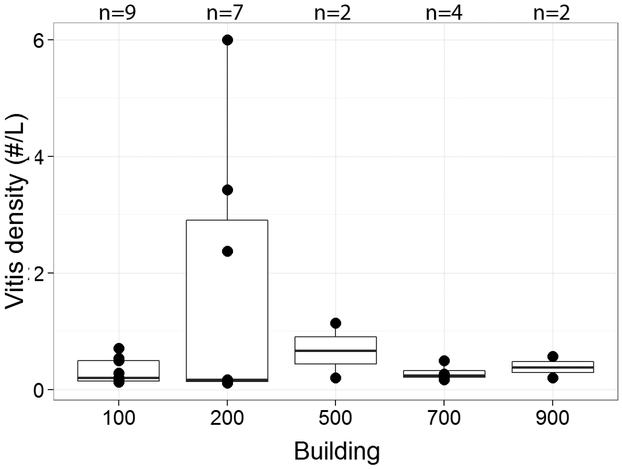

Fig. 2.19 *Density of grape (*Vitis vinifera*) seeds by building. Points represent the contributions of individual samples, and samples with no grape remains were excluded (Image: A. Farahani).*

assemblage illustrates that the most abundant weed seeds are those of the grass (Poaceae) and legume (Fabaceae) families. Since these two plant families can enter into the archaeological record in different ways due to their growth habit (Charles 1998: 114), other methods are necessary to evaluate the influence of these two kinds of weed seeds alongside a variety of domesticate seeds, such as of grape, barley, and fig, which are also the most abundant and ubiquitous. By examining the correlations of taxa (Zuur et al. 2007: 164), and a correspondence analysis of them (Zuur et al. 2007: 171), it becomes possible to differentiate these possible routes of entry. Correlations of these taxa illustrate that across all samples barley and fig seeds are not correlated (*r*=.14, p=.24, 95% CI = -0.10 – .37), nor are leguminous weeds correlated with any of the domesticated taxa, except for fig seeds, albeit weakly (*r*=.29, p=.01, 95% CI = 0.06 – .49). Moreover, grasses are highly correlated with barley grains (r=.79, p=1.78e-15, 95% CI = .68 – .87) and fig seeds (r=.45, p=.00016, 95% CI = .23 – .62) alone. Importantly, grass weeds and leguminous weeds are not correlated with each other (r=.10, p=.44, 95% CI = -0.15 – .33), that is to say, the presence of one is not likely to indicate the presence of the other. Therefore, leguminous weeds and grass weeds likely entered through different taphonomic pathways, and hence were the result of different agricultural practices.

In order to identify which samples are associated with which clusters of taxa, correspondence analysis (CA hereafter) is necessary. CA is a multivariate, unconstrained ordination technique of samples by parameters (n × p) using the chi-square distance computed on an association matrix (Borcard et al. 2011: 132). It is a popular technique in paleoethnobotany and ecology, more broadly (Smith 2014). The advantage of CA is that it accepts untransformed counts of taxa, is unaffected by "double-zeros," and can scale eigenvalues such that the plotted distances among objects approximate their chi-square distances (i.e., samples close to each other are likely to have similarities in taxonomic frequencies). In essence, CA attempts to understand how similar samples (n) are based on the frequency and association of a set of parameters (p), usually a set of taxa. It is important to note that CA is descriptive and oriented toward explaining trends in data, and is therefore not a hypothesis-testing technique (Borcard et al. 2011: 116). The first two extracted axes of the correspondence analysis, which together explain 71 percent of the variation in the data (fig. 2.18a; Table 2.6), illustrate that samples that contain barley grains are more associated with samples that contain weedy grasses, while samples that contain wild legumes are separate from both.

Overlaying the buildings to which these samples are associated (fig. 2.18b), as well as adding ellipses around them, illustrates the similarity of Buildings 200, 700, and 900, the ellipses of which not only overlap but are nested. This overlap includes those samples more associated with leguminous weed seeds, the seeds of sedges, and fig seeds. In contrast, the samples from Room 106, the storage context, are almost exclusively associated with barley grains and weeds of grasses, alongside the storage context samples from Building 500. The wide ellipse of Building 500 illustrates the bimodal quality of crop processing by-product densities in this structure, a bimodality also identified in the spatial analysis of densities. Therefore, the entry of grasses into the storage context samples was most likely as field weeds accidentally harvested and awaiting cleaning, while the entry of leguminous weeds and figs into the archaeological record was more likely as a result of dung burned as fuel.[20]

Finally, the CA also reveals a very long, arching gradient for samples associated with grape, to the extent that there are three samples far from the others. Two of the samples are from Building 200, and these two samples, not coincidentally from the same deposit, contain the greatest density of grape remains found at the site. While all of the buildings contained grape remains of some sort, the two buildings that contained the greatest ubiquity and density of grape remains were Buildings 100 and 200 (fig. 2.19). Building 200 contains a bimodal distribution of grape densities: three samples contain the densest concentration of grape remains on the site, at more than 2 grape seeds per liter, while the remaining four samples contain virtually none. It was also in one of these dense caches of grape seeds in Building 200 that four remains of what appear to be raisins were found with the seeds still embedded (fig. 2.11a).

From these analyses it is possible to identify three depositional routes in KMA, where a) some stored grains were semi-clean awaiting further human processing (Room 106, 504b) and animal consumption (Room 106), b) others were cleaned and awaiting human consumption (Room 504a), and c) dung was burnt as fuel (Building 200, 700, 900). Based on densities and proportions, (a) and (b) are in primary context and (c) is in secondary context. In particular, those samples identified as dung fuel were likely a combination both of crop processing byproducts burnt as fuel and dung fuel.

Conclusion

The depositional origins of the paleoethnobotanical assemblage at KMA yield important insights regarding not only the manner in which economic plants were stored and used, but also the relationship of agriculture to the many animals that would have been a part of the community's daily life. The samples in Room 106 of Building 100 all contained dense concentrations of barley grain, but some samples contained large amounts of chaff and straw, while other samples in that context included weed seeds intermixed with the grain. These samples also contained carbonized grass roots, most likely of the stored barley, which indicates that the grain was probably harvested by up-rooting and by sickle (cf. Simmons 2000: 46; Jones 1998: 97). It is possible that these straw and chaff-rich samples were intended for animal consumption (cf. Porter et al. 2014: 141), as both ethnographic and experimental data have shown that Mediterranean fodder regimes include roughage and grain (Palmer 1998: 4, Valamoti and Charles 2005: 529). Intriguingly, in contrast to the storage bin in Room 504a, which contained a nearly pure assemblage of barley grain, Room 106 contained numerous fig seeds and even grape seeds. Thus, Room 106 may have served as multiple-purpose storage and might represent an intermediate stage between the suggestion by Stevens (2003) that these kind of grain assemblages (semi-cleaned grain spikelets, indicated by weed seeds and chaff remains) point to communal storage, and van der Veen and Jones (2006), who see these associations as deriving more from the scale of production of grain, as well as its processing. In a sense, the scale of barley storage enabled the keeping of flocks, but the flocks also enabled agricultural production, as the evidence of the cattle and equid faunal remains indicates their use toward labor rather than as meat (Lev Tov et al. 2011: 75).

The structures without evidence of storage also provide additional clues concerning the interrelationship of animal husbandry and cereal agriculture at KMA. It is within these buildings that most samples seem to be the result of dung and/or crop processing debris burned as fuel, especially because of the prevalence of the seeds of figs and wild legumes, the low densities of barley remains, and the lack of wild grass seeds associated with them. It has already been noted that figs seeds survive ruminant digestion and are often chosen as fodder in the winter throughout the Mediterranean (Valamoti and Charles 2005: 529). Moreover, Ertug-Yaraş and Anderson note (1998: 101) that in an ethnographic study of village agriculture in Turkey, dung from animal byres, particularly of sheep and goat, was a preferred source of fuel, as the animals trampled their dung and urine into hard sheets. The KMA community likely kept their animals inside the settlement's walls at night, and it might have been in these places where dung fuel was collected. While there are two samples that contain extremely dense concentrations of charcoal that was likely burned as fuel, it should be noted again that the majority of samples contained little to no charcoal. In fact, the sample that contained the most charcoal (Sample 53, Building 900, 10 g or 1.7 g per liter) was also completely devoid of any seeds or plant parts whatsoever, indicating that it was likely used for heating or other industrial purposes.

The scale of barley storage and processing, particularly evident in Rooms 504a and 106, deserves notice for the insight it provides into the social dynamics of the KMA community. Buildings 100 and 500 were by far the largest at KMA (Routledge 2000: 62, Table 3; 2004: 103) and most prominently located (Routledge 2004: 103). In fact, Building 100 contains little archaeological evidence that would suggest domestic use or occupation (Porter 2014: 94), and the storage bins in Room 106 were located in rooms that were not made to be easily accessible. The latter mirrors the locations of the storage contexts (504a) in Building 500, which were well-protected deep inside the building's core. In contrast to Building 100, Building 500 contained the most archaeological evidence for food production for humans, which included three ovens, permanent grinding installations, and a large oven nearly 0.5 m in diameter and depth (Porter 2014: 118). Building 100, on the other hand, contained architectural evidence for the presence of animals, as there were two bins on the east wall of Building 102 that could have potentially been mangers.

It is tempting to infer that the two separate storage bins in Building 100 and 500 were dedicated toward separate ends, namely, the storage of food intended for humans (Room 504a) and for animals (Room 106). Many archaeobotanical studies emphasize that it is often difficult to identify storage for fodder versus human consumption on the internal composition of samples alone (cf. Jones 1998: 96). In this case, it is the conjunction of architecture, archaeological features such as cooking installations, and the density and proportion of barley, and grain weevils that seem to indicate that Room 504a was dedicated to human food storage. The inaccessibility of these stored remains to the KMA community points to the potential for the display and continual emphasis of social differentiation. The entrance to Building 500 was not oriented toward the central plaza of the settlement, perhaps signifying that the interior activities were not meant to be communally shared. The absence of those who would have entered into the structure in order to engage in food production practices, for instance, would have been highly salient to others in the central plaza. One of the enduring questions about KMA, given the somewhat internally differentiated architecture (Routledge 2004: 101), is the degree to which households, represented by different structures containing domestic refuse, were responsible for individual production or instead coordinated their agricultural efforts (Porter 2014: 112). The conjunction of the paleoethnobotanical data and other archaeological data appears to indicate that, at minimum, centralized storage and distribution of grains, as well as food processing, was a part of daily life for the community.

The uniqueness of Buildings 100 and 500 at KMA is made all the more apparent by the assemblages of Buildings 200, 700, and 900. It should be recalled that the samples from these buildings were, for the most part, similar in composition. They contained few seeds of economic crops, low to moderate amounts of weed seeds, mainly leguminous, and almost no chaff. Differential preservation may also play a role in the formation of these assemblages, since the surfaces of these buildings were poorly preserved, no roofing material was found, and there appear to be mainly post-occupation deposits (Routledge 2004: 107). The similarity of these buildings is not restricted to paleoethnobotanical data, however; Instrumental Neutron Activation Analyses (INAA) of ceramic vessels across KMA indicate that Buildings 200 and 700 are nearly identical compositionally, while Building 500, while similar, has variability in its composition source (Porter 2014: 101).

One interpretation of the sum of this evidence is that Buildings 200, 700, and 900 were abandoned structures, which were later re-used as garbage dumps (Routledge 2004: 108), with Buildings 100 and 500, representing wealthy households, abandoned last. Another alternative is that food storage and production was a communal endeavor, restricted to Buildings 100 and 500, and that the lack of any comparable evidence in the other structures strongly points to managed or controlled plant management. The extent to which this is identifiable in the current evidence is constrained by the sizes of the excavations: most units were five by five m in size, and in many cases only one unit was placed in buildings that had floor areas between 50 and 111 m^2. Further excavations will be necessary in order to resolve this thorny problem, especially if it becomes apparent that storage structures are not found in buildings other than 100 and 500. Moreover it does not appear that barley was the only crop that may have been subject to some manner of restriction or centralization—the greatest abundance of grape seeds occurs in Building 200, and it is also in this building alone that raisins are found. The presence of raisins implies their long-term storage (Margaritis and Jones 2006: 791), and their location in only one structure may also indicate differential access to other plant foods by members of the KMA community.

In conclusion, the paleoethnobotanical evidence from KMA points to a community strongly dependent on the careful management of a few crops, the growth of which was coordinated with many domesticated mammals, including sheep/goat, pigs, horses, and cattle. These crops were probably grown on flat ground on the sides of the escarpment on the wadi bottom, the evidence for which can be found in riparian plants such as sedges, but also through faunal remains such as semi-terrestrial freshwater crabs and freshwater birds. Providing food for animals seems to have been as great an occupation for the KMA community as preparing food for its human members, and yet the ways in which these plants were stored and provisioned appears to have been carefully controlled through the use of space and architecture. Indeed, this paleoethnobotanical assemblage illustrates the ways in which archaeological plant remains can also provide information about concepts such as "community" beyond commensal politics restricted to the unique and occasional circumstances of feasting (Bray 2003). Much of the time of the short-lived KMA community would have been spent preparing and coordinating for the movement and provisioning of animals, as well as the maintenance of fields. It is clear from the conjunction of the available evidence that it was not only consumption but also the daily practices of plant production, processing, and storage that figured deeply into the micro-politics of this community, namely, that these seem to have been communal endeavors perhaps controlled by groups of individuals having either inherited or been ascribed authority to do so. In this case, the notion of community might extend beyond the human alone to include the animals and plants into which the community invested itself so intensely. Without control of, or access to, these desired crops and the animals which they sustained, those individuals coordinating the storage and processing of barley and grapes would have been unable to reproduce their own authority. Thus, the assemblage at KMA provides more evidence that sampling strategies which take space into account, rather than the collection of massive, singular convenience samples, are essential (Guedes and Spenger 2014). Without knowing the spatial location of these samples, or if only the storeroom samples had been analyzed, the extent to which these contexts were unique would have been unknown, as well as the implications for understanding the organization of the KMA community's food producing ventures.

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Chesson, Christine Hastorf, Justin Lev-Tov, Kevin McGeough, Charles Morse, Loren Murch, Ellen Simmons, Rudi Vanzin, and Andrew Wilson.

Routledge and Porter collected the evidence used in this and related studies. Farahani and Huynh conducted paleoethnobotanical analysis. A portion of this evidence appeared in Huynh's undergraduate thesis for UC Berkeley's Anthropology Department. All four authors shared in the writing and revising of this publication. Some data presented in this article are or will be available at Open Context (http://opencontext.org/), an open-access repository for archaeological data.

Notes

1 Currently available evidence (e.g., the Mesha Inscription and other epigraphic evidence; monumental architecture [Porter et al. 2012: 120–25; Routledge 2004: 133–53]) indicates that west-central Jordan was organized into the ethno-territorial polity 'Moab' certainly by the mid-ninth century BCE. Evidence for how this political and economic transition occurred during the tenth and early ninth centuries BCE is lacking and more research is needed.

2 Room 509 has not yet been excavated but could also possibly be a bin.

3 Khirbat al-Mu'ammariyya's "Citadel Building" has a similar design to Building 100, although the former is much larger, being over 400 m^2 if the excavator's calculations are correct. The al-Mu'ammariyya building has so far seen only limited excavation, so it is not possible at this time to determine the extent to which it was used for grain storage (Ninow 2004; 2006).

4 This grid-system was also employed for the excavation of contexts that appeared to be possible surfaces.

5 Neither Farahani nor Huynh, the analysts of the new paleoethnobotanical evidence, participated in the excavation of the KMA evidence or flotation of the archaeological sediments, although Farahani worked on and around the archaeological site in later years.

6 One sample was included from 4J41 in the current analysis to bring the total number of analyzed storeroom samples to twenty. In Simmons' analysis, 19 samples from the storeroom were chosen (Building 100, Unit 4J41) along with one sample from Building 200 (2G86/2G87; Simmons 2000).

7 The "strata" function was employed from the package "sampling." All graphs and statistics used in this paper were generated using R 3.2.2, unless indicated otherwise.

8 The incorporation of the samples originally analyzed by Simmons requires special notice. Of the twenty samples she analyzed, only two were sorted in their entirety, and the rest were sub-sampled (see Appendix A) due to the density of remains. Of those samples that were sub-sampled, only one was analyzed in equal halves, i.e., 50 percent of the "coarse", and 50 percent of the "fine" fractions. The remaining seventeen samples are unequal in the way that they were individually sub-sampled, often with 100 percent of the "coarse" fraction analyzed, and 25 or 50 percent of the same "fine" fraction. The latter proportion is often smaller, sometimes "3.13 percent or "6.25 percent." Since the published final counts for each sample combine the coarse and fine fractions, it is not possible to estimate the potential contributions of each fraction size within the "unbalanced" subsamples. This means that samples with unbalanced sub-samples were not used for any analyses that rely on the internal composition (i.e., counts in each fraction) of remains. For instance, in ascertaining the weed to grain ratio in a sample, if most of the weed seeds occur in a subsampled fine fraction (e.g., 25 percent), and most of the grain in a totally analyzed coarse fraction (100 percent), then the comparison of the two has the possibility for up to four times the magnitude of error. Nonetheless, these unequally sub-sampled samples can be used in analyses of density for certain taxa more likely

to occur in the "coarse" fraction (such as large grains) and for analyses of richness, which is more dependent on the number of identified specimens (NISP) (Gotelli and Colwell 2001).

9 Correlations identify the relationships between two variables regardless of magnitude (i.e., 1:1 and 100:100 are equivalent) and therefore sample size does not affect correlation, provided that both variables increase equally. Therefore, transformation will not affect underlying correlations. Since density is a ratio, however, transformation of the numerator variable (the count) will affect the total outcome.

10 The data are also available in digital format via Open Context and are available at the following link with the corresponding DOI: <http://opencontext.org/projects/1ae2a5d9-5515-4796-92e3-52400293f8e0> DOI:http://dx.doi.org/10.6078/M70K26H6. The data can be utilized and cited by referencing Farahani 2016 (see the corresponding bibliographic entry below).

11 There is still some disagreement as to whether the wild progenitors of *Panicum miliaceum* that became domesticates in southwest Asia were from western Central Asia or from mainland East Asia (see Zohary et al. 2012: 69–71). The place of origin of this plant affects the archaeological interpretation of the distance of trade or agricultural communication networks which led to its adoption in southwest Asia, but it is nonetheless clear that it is not native to the area, and was not part of the "Neolithic package."

12 Some of the taxa identified as "Brassicaceae" among the non-storage samples might in fact include *Cardamine* cf. *hirsuta,* which was identified by Simmons tentatively.

13 The weed seeds from the family Poaceae include those seeds that were identified only to family (i.e., Poaceae), *Hordeum spontaneum, Hordeum* cf. *murinum/boeticum, Phalaris* sp., *Bromus* sp., *Aegilops* sp., *Lolium* sp., *Stipa* sp., and *Phleum* sp.

14 Richness calculations were made by including only identified taxa. Nevertheless, in cases where there were identifications made to a specific genus, i.e., *Alyssum,* as well as family, e.g., Brassicaceae, the corresponding richness would be scored as "2," because the Brassicaceae were not of any of the identified genera and therefore distinct. Thus, this method is likely to underestimate the degree of differentiation between weed richness assemblages, as it is possible that some seeds marked only to family contain multiple, distinct genera.

15 As the number of identified specimens (NISP) affects the richness of the samples (Gotelli and Colwell 2001: fig. 12:B), rarefaction would be necessary to assess how much of the difference in richness between structures is due to the number of seeds recovered, rather than differences in the activities occurring in each of these structures.

16 Samples were also collected at Lachish (Helbaek 1958) and Horbat Rosh Zayit (Kislev and Melamed 2000), but only 3 and 4 samples were obtained from these sites, respectively.

17 There is archaeobotanical data available for Khirbet al-Mudayana Wadi ath-Thamad (Buffington 2012), but the site is dated to the Iron II period based on radiocarbon evidence.

18 In this analysis, many of the samples from Room 100 were excluded because of the "unbalanced subsample" issue mentioned above. Only those samples sub-sampled in equal proportions were included (n=3).

19 The density of remains in this sample is 4.25, because of the small volume size (4 liters), and there were 7 weed seeds, 4 barley grains, and 22 chaff remains.

20 Dung was found in four samples in Building 500, which included barley seeds covered in dung (Samples 12, 13, 14), further pointing to the fact that barley was used as fodder for the many animals at KMA. It is important to note, however, that these samples were not the barley-dense samples, but may represent dung fuel that was to be used for cooking in the adjacent kitchen structure.

APPENDIX: RAW ARCHAEOBOTANICAL DATA

Samples 1–10

Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Unit	5I05	5I05	5I05	5I05	5I05	5I05	5I05	5I05	5I05	5I05
Locus	32	32	32	32	12	12	12	32	12	32
Subgrid	6.3	11.1	15.1	21.1	11.2	21.2-3	17.1-4	22.2	22.2	13.4
Volume	8	9	6	9.5	4	7	1	6	0.3	7.5
% Analyzed	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT	13	12	7	24	42	3	0	10	0	12
Charcoal WT	0.1472	0.0819	0.0095	0.0812	0.0344	0.0015	0	0.0307	0	0.0113
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica	16	27	6	6	4	2		5		6
Hordeum vulgare sbsp. *distichum*										
Hordeum vulgare sbsp. *Indet*	2	9	1	3	4	2		2		
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal										
Lens culinaris								1		
Panicum miliaceum										
cf. *Triticum dicoccum*										
Triticum sp.										
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera					2			1		2
Vitis vinifera raisin										
Vitis vinifera pedicel					1					
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)										
Brassicaceae		2		4		1				
Caryophyllaceae										
Chenopodiaceae	4	1	1	1	1					
Convolvulaceae										
Cyperaceae										
Fabaceae		1				1				1
Lamiaceae										
Malvaceae										
Poaceae	2	7		3	2			2		1
Polygonaceae	1									
Solanaceae				1				1		
WEEDS / WILD										
Adonis										
Aegilops										

Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ajuga		1		1						
Amaranthus										1
Androsace maxima		1								
Astragalus	9	19	6	6	1	2		14		10
Atriplex										
Brassica										
Bromus										
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex										
Cerastium										
cf. *Onopordum*										
Chenopodium				1						
Convolvulus										
Coronilla		2								
Erodium										
Euphorbia										
Fumaria										
Galium		2	1							
Heliotropium						1				
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum										
Hyoscyamus	1		1							1
Juncus						1				
Lolium										
Malva		1			1			1		1
Medicago										
Melilotus/Trifolium	17	38	13	12	1	1		20		11
Muscari										
Nepeta										
Papaver										
Phalaris										
Phleum										
Plantago										
Polygonum										
Rumex										
Salsola										
Scirpus										
Scorpiurus				1						
Silene		2								
Stipa										
Suaeda					1					
Trifolium repens										

Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Trigonella	7	5	3			1				3
Trigonella astroites										
Vaccaria				1						
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed		25	4	4				4		3
Clinker					3					
Unidentifiable Seed Fragments	25	33	19	59	51	4		16	1	3
CHAFF REMAINS										
Poaceae culm		1			7					
Poaceae roots										
Hordeum sp . rachis					22					
Triticum sp. rachis										
OTHER										
Bone										
Carbonized rodent dung					2					
Dung										
Fish Scale		3		1						
Shell			1			1				1

Samples 11–20

Sample	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Unit	5I05	2E22	2E22	2E22	2E22	2E22	2E22	2E22	2E22	2E22
Locus	12	9	9	13	27	29	31	31	31	31
Subgrid	13.1-2	1	2	6			5.2	9.2	15.1	18.2
Volume	0.75	7	9.5	9	9	10	6	7	7	7
% Analyzed	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT	0	5	27	38	13	15	1	1	7	26
Charcoal WT	0	0.127	0.4647	0.4207	0.0929	0.3052	0.0124	0.0181	0.0048	0.1749
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica	1	6		5	15	3	2	2		9
Hordeum vulgare sbsp. *distichum*										
Hordeum vulgare sbsp. *Indet*		23	22		1	4		1		9
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal										
Lens culinaris						1				
Panicum miliaceum			2							
cf. *Triticum dicoccum*										

Sample	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Triticum sp.										
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera										
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)										
Brassicaceae			1							
Caryophyllaceae										
Chenopodiaceae		2			1	1		1	2	
Convolvulaceae										
Cyperaceae										
Fabaceae		2				1				
Lamiaceae										
Malvaceae										
Poaceae										1
Polygonaceae										
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops										
Ajuga										
Amaranthus										
Androsace maxima										
Astragalus		2	1			1	3			2
Atriplex										
Brassica		1								
Bromus										
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex										
Cerastium										
cf. *Onopordum*										
Chenopodium		1								
Convolvulus										
Coronilla										
Erodium						1				
Euphorbia										
Fumaria										
Galium										
Heliotropium			1							

Sample	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum										
Hyoscyamus						2				1
Juncus										
Lolium										
Malva			2							
Medicago										
Melilotus/Trifolium					2	3				6
Muscari						1				
Nepeta										
Papaver										
Phalaris										
Phleum										
Plantago						1				
Polygonum										
Rumex										
Salsola		1	3	2						1
Scirpus						1				1
Scorpiurus										
Silene										
Stipa										
Suaeda									1	
Trifolium repens										
Trigonella		1					1			
Trigonella astroites										
Vaccaria										
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed		1	3	4	1		1			4
Clinker			13	12						
Unidentifiable Seed Fragments		186	134	51	5	34	6	11	3	2
CHAFF REMAINS										
Poaceae culm		1				3				
Poaceae roots						1				
Hordeum sp . rachis			4	27		5	1	2		3
Triticum sp. rachis				1				1		
OTHER										
Bone										
Carbonized rodent dung										
Dung		14	308	7		7				
Fish Scale										
Shell										

Samples 21–30

Sample	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Unit	2E22	2E22	2G87	2G87	2G87	2G87	2G87	2G87	2G86	2G87
Locus	8	7	7	7	7	21	27	5	13	27
Subgrid		17.2	1	1	1	1	11	7	24	
Volume	10.5	13	16	4	7	9	5.5	7	3	10
% Analyzed	100% (>2mm) 25% (>2mm)	25%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT	321	111	5	3	0	3	0	2	1	0
Charcoal WT	1.2046	0.8563	0.0413	0.0473	0	0.002	0		0.004	0
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica	15	3	21		3	5	1	1		
Hordeum vulgare sbsp. *distichum*	10									
Hordeum vulgare sbsp. *Indet*	168	446	3							
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal										
Lens culinaris	1									
Panicum miliaceum	4									
cf. *Triticum dicoccum*										
Triticum sp.			2							
Triticum aestivum / durum										
Vicia ervilia	2									
Vitis vinifera	12		38			1				
Vitis vinifera raisin			4							
Vitis vinifera pedicel	2			1						
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)			1	3		18				
Brassicaceae	14	1	1							
Caryophyllaceae										
Chenopodiaceae	10	2	2		1					
Convolvulaceae	1									
Cyperaceae										
Fabaceae				1						
Lamiaceae					1					
Malvaceae										
Poaceae	4		2							
Polygonaceae										
Solanaceae										
WEEDS / WILD										
Adonis			1							

Sample	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Aegilops										
Ajuga		1								
Amaranthus										
Androsace maxima	3			1						
Astragalus			1					1	2	
Atriplex	1									
Brassica										
Bromus										
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex					1					
Cerastium	1									
cf. *Onopordum*	1									
Chenopodium	5									
Convolvulus	1									
Coronilla										
Erodium										
Euphorbia										
Fumaria										
Galium	2	1	1							
Heliotropium										
cf. *Hordeum murinum/boeticum*		22								
Hordeum spontaneum										
Hyoscyamus	5									
Juncus					1					
Lolium			2							
Malva	5									
Medicago										
Melilotus/Trifolium			6	4	2	1		1	1	
Muscari	2									
Nepeta										
Papaver										
Phalaris										
Phleum										
Plantago	6									
Polygonum										
Rumex	1									
Salsola	11	1	1							
Scirpus			2							
Scorpiurus										
Silene	7			1	1					
Stipa										
Suaeda	1									

Sample	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Trifolium repens										
Trigonella			2							
Trigonella astroites					1					
Vaccaria										
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed	4	1	2	1						
Clinker			7	5		2				
Unidentifiable Seed Fragments	33	27	61	2	1	1		1		
CHAFF REMAINS										
Poaceae culm										
Poaceae roots										
Hordeum sp . rachis	53	4								
Triticum sp. rachis										
OTHER										
Bone	8		1							
Carbonized rodent dung										
Dung									1	
Fish Scale					1					
Shell	4	1								

Samples 31–43

Sample	**31**	**32**	**33**	**34**	**35**	**36**	**40**	**41**	**42**	**43**
Unit	2G86	2G86	2G86	2G86	2G86	3H04	2E23	2E23	2G86	2G86
Locus	13	15	8	9	13	13	5	17	14	4
Subgrid	17				13.2	10	17.4	18		
Volume	4.5	4.5	12	8	5	7	5.5	20	1	8.5
% Analyzed	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT	6		5	1	3	239		1	7	7
Charcoal WT	0.0088	0.0084	0.0571	8.00E-04	0.0274	0.4191	0.0023	1.00E-04	0.0608	0.2873
DOMESTICATE SEEDS										
Large Fabaceae									1	1
Ficus carica	3	2		1	3	22			12	
Hordeum vulgare sbsp. *distichum*										
Hordeum vulgare sbsp. *Indet*		1							5	
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal										
Lens culinaris			1	1						
Panicum miliaceum										
cf. *Triticum dicoccum*										

Sample	**31**	**32**	**33**	**34**	**35**	**36**	**40**	**41**	**42**	**43**
Triticum sp.							1			
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera						4			6	
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)	3									
Brassicaceae		1		1	3				1	
Caryophyllaceae										
Chenopodiaceae					1					
Convolvulaceae										
Cyperaceae										
Fabaceae		2			1					
Lamiaceae										
Malvaceae		1								
Poaceae			2				1		2	
Polygonaceae						1				
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops										
Ajuga										
Amaranthus					1					
Androsace maxima										
Astragalus		3			4	1		1	3	
Atriplex										
Brassica										
Bromus										
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex										
Cerastium										
cf. *Onopordum*										
Chenopodium										
Convolvulus						2				
Coronilla					1					
Erodium										
Euphorbia										
Fumaria										
Galium										
Heliotropium										

Sample	**31**	**32**	**33**	**34**	**35**	**36**	**40**	**41**	**42**	**43**
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum										
Hyoscyamus		1								
Juncus										
Lolium										
Malva									1	
Medicago		1								
Melilotus/Trifolium	1	8	1	3	3			3	7	
Muscari										
Nepeta										
Papaver										
Phalaris										
Phleum										
Plantago										
Polygonum										
Rumex										
Salsola										
Scirpus									7	
Scorpiurus										
Silene										
Stipa										
Suaeda										
Trifolium repens										
Trigonella									1	
Trigonella astroites										
Vaccaria					1					
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed		4	3			3		1	1	
Clinker	1					1			62	
Unidentifiable Seed Fragments		4		3	8	1		2	2	
CHAFF REMAINS										
Poaceae culm	1	1								
Poaceae roots								1		
Hordeum sp . rachis								1		
Triticum sp. rachis										
OTHER										
Bone										
Carbonized rodent dung										
Dung		1								
Fish Scale										
Shell						1				

Samples 44–53

Sample	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Unit	2G86	2G87	2G87	2G87	3H04	3H04	3H04	3H04	3H04	3H04
Locus	10	27	20	18	9	9	9	13	13	13
Subgrid		11.3	1.4	17.3	7.2	1.4	5.4	5.1	4.1	15.1
Volume	10	5	8	7	5	5	5	5	6	6
% Analyzed	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT					0	0	1	2	1	
Charcoal WT	0.0028	0.0003	0.0005	0.0009	0.0000	0.0000	0.0051	0.0073	0.0202	11.66
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica			3	1	1	11	4	3	4	2
Hordeum vulgare sbsp. *distichum*										
Hordeum vulgare sbsp. *Indet*			1							
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal										
Lens culinaris										
Panicum miliaceum										
cf. *Triticum dicoccum*										
Triticum sp.										
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera			1	1		1				
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)										
Brassicaceae	1		2	3						
Caryophyllaceae										
Chenopodiaceae					1					
Convolvulaceae										
Cyperaceae							1			
Fabaceae										
Lamiaceae										
Malvaceae										
Poaceae							1			
Polygonaceae										
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops										
Ajuga										
Amaranthus										

Sample	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Androsace maxima										
Astragalus			2	2			5	1	1	
Atriplex										
Brassica										
Bromus										
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex										
Cerastium										
cf. *Onopordum*										
Chenopodium										
Convolvulus										
Coronilla										
Erodium										
Euphorbia										
Fumaria										
Galium										
Heliotropium										
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum										
Hyoscyamus										
Juncus										
Lolium										
Malva										
Medicago										
Melilotus/Trifolium			2	2	1		1	1		
Muscari										
Nepeta										
Papaver										
Phalaris										
Phleum										
Plantago										
Polygonum										
Rumex										
Salsola					1					
Scirpus							1			
Scorpiurus										
Silene										
Stipa										
Suaeda										
Trifolium repens										
Trigonella				3						
Trigonella astroites										

Sample	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Vaccaria										
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed			2	4						
Clinker		2		5		5				
Unidentifiable Seed Fragments		2			1	2	9			
CHAFF REMAINS										
Poaceae culm										
Poaceae roots										
Hordeum sp . rachis										
Triticum sp. rachis										
OTHER										
Bone										
Carbonized rodent dung										
Dung		1					2			
Fish Scale										
Shell										

Samples 54–63

Sample	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**
Unit	3H04	3H04	4J41	5I05	5I05	5I05	5I05	2G87	2G87	2E22
Locus	13	10	23	12	10	15	15	6	15	9
Subgrid	9.1	16	21	16.1.4	6	9	14	4	1	3
Volume	6	8.5	7	2	9	8	11	6	7	10
% Analyzed	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CHARCOAL										
Charcoal CT	2			0					0	
Charcoal WT	0.0183	0.0047	0.0823	0	0.0086	0.0049	0.0015	0.0012	0	0.2127
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica	2	10	15		20	2	2	4	4	
Hordeum vulgare sbsp. *distichum*										
Hordeum vulgare sbsp. *Indet*			44							
Hordeum vulgare sbsp. *vulgare*										
Indeterminate Cereal					1					
Lens culinaris										3
Panicum miliaceum										
cf. *Triticum dicoccum*										
Triticum sp.										
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera			1		2			1		2

Sample	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae			2							1
Boraginaceae (mineralized)										
Brassicaceae		1			2		1			
Caryophyllaceae										
Chenopodiaceae			1							1
Convolvulaceae										
Cyperaceae										
Fabaceae		2	1			7		1		
Lamiaceae										
Malvaceae										1
Poaceae			5			1				
Polygonaceae										
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops										
Ajuga										
Amaranthus										
Androsace maxima										
Astragalus		1			2		3			
Atriplex			1							
Brassica			2							
Bromus										
Bupleurum										
Camelina Alyssum			2							
Cardamine										
Carex										
Cerastium										
cf. *Onopordum*										
Chenopodium										
Convolvulus										
Coronilla										
Erodium										
Euphorbia										
Fumaria					1					
Galium										
Heliotropium									1	
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum										
Hyoscyamus										
Juncus										

Sample	54	55	56	57	58	59	60	61	62	63
Lolium										
Malva			1							
Medicago										
Melilotus/Trifolium		3			3		5			1
Muscari			1							
Nepeta										
Papaver										
Phalaris			1							
Phleum										
Plantago										
Polygonum										
Rumex										
Salsola									1	
Scirpus										
Scorpiurus										
Silene			1				1			
Stipa										
Suaeda					1					
Trifolium repens										
Trigonella		1				1	2			
Trigonella astroites										
Vaccaria									1	
Valerianella										
Ziziphora			3							
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed		1	1	1	4	1	2			6
Clinker	3				21					
Unidentifiable Seed Fragments	3	11			18	8	3		12	1
CHAFF REMAINS										
Poaceae culm										
Poaceae roots										
Hordeum sp . rachis									1	4
Triticum sp. rachis					1					
OTHER										
Bone										
Carbonized rodent dung										
Dung							1			5
Fish Scale										
Shell										

Samples 64–E05

Sample	**64**	**65**	**66**	**67**	**68**	**E01**	**E02**	**E03**	**E04**	**E05**
Unit	2E22	2E22	2E22	2E22	2E22	4J41	4J41	4J41	4J41	4J41
Locus	12	12	12	12	12	6	11	13	13	11
Subgrid	4	7	11	12	3	12.-13	11			
Volume	9	11	5	12.5	10	8	6	6	4	6.5
% Analyzed	100%	25%	25%	100%	25%	100% CF 50% LF	100% CF 100% LF	100% CF 50% LF	50% CF 50% LF	50% CF, 25% LF
CHARCOAL										
Charcoal CT										
Charcoal WT	0.9046	8.57	0.0704	0.0732	1.43					
DOMESTICATE SEEDS										
Large Fabaceae										
Ficus carica	17		2	4		3	11		3	4
Hordeum vulgare sbsp. *distichum*	13	9	41		17			44	126	34
Hordeum vulgare sbsp. *Indet*							16	113	114	82
Hordeum vulgare sbsp. *vulgare*	10	1	2		14				5	1
Indeterminate Cereal							1	7	3	5
Lens culinaris		1					1	1		
Panicum miliaceum				1						
cf. *Triticum dicoccum*										
Triticum sp.										
Triticum aestivum / durum				1						
Vicia ervilia							2			
Vitis vinifera						1		3		
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae										
Boraginaceae (mineralized)										
Brassicaceae				3			1			
Caryophyllaceae				1				2		
Chenopodiaceae				1						
Convolvulaceae										
Cyperaceae	1									
Fabaceae	3		1	1	1	4	4	12		6
Lamiaceae										
Malvaceae										
Poaceae	10	2	4	9		2	8	29	3	6
Polygonaceae						2		2		2
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops								1	1	
Ajuga										

Sample	**64**	**65**	**66**	**67**	**68**	**E01**	**E02**	**E03**	**E04**	**E05**
Amaranthus										
Androsace maxima					1					
Astragalus	1			1		2	7	2	1	
Atriplex							1			
Brassica										
Bromus							1			4
Bupleurum										
Camelina Alyssum										
Cardamine										
Carex	1									2
Cerastium										
cf. *Onopordum*										
Chenopodium										
Convolvulus										
Coronilla			1		1					
Erodium	2					2		2		
Euphorbia							3			2
Fumaria										
Galium	1	1								
Heliotropium										
cf. *Hordeum murinum/boeticum*										
Hordeum spontaneum			5	3	5		2	7	4	6
Hyoscyamus	2									
Juncus										
Lolium										
Malva				1			1	2		
Medicago										
Melilotus/Trifolium						2				6
Muscari	1			3			3	8	1	4
Nepeta				1						
Papaver	1			1		16				
Phalaris						2	1		1	2
Phleum							2			
Plantago										
Polygonum						2	1	4	4	2
Rumex										
Salsola						2				
Scirpus	1									
Scorpiurus										
Silene							1			2
Stipa				1						
Suaeda	3					4	6			
Trifolium repens						2				
Trigonella	2				1			4		

Sample	**64**	**65**	**66**	**67**	**68**	**E01**	**E02**	**E03**	**E04**	**E05**
Trigonella astroites										
Vaccaria									2	
Valerianella	1									
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed	11			4	3	22	6	12	6	16
Clinker	2	2			1					
Unidentifiable Seed Fragments										
CHAFF REMAINS										
Poaceae culm	5	3	6	13	2		11	3	2	36
Poaceae roots										
Hordeum sp . rachis	24	6	33	27	9		27	12		212
Triticum sp. rachis				1	1			2		
OTHER										
Bone				1						
Carbonized rodent dung										
Dung	3				2					
Fish Scale										
Shell										

Samples E06–E15

Sample	**E06**	**E07**	**E08**	**E09**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**
Unit	4J41	4J41	2G87	4J41	4J41	4J41	4J41	4J41	4J41	4J41
Locus	13	13	7	13	13	13	11	13	13	13
Subgrid			1							
Volume	7.5	3	7	3.5	7	6	3	5	7.5	5
% Analyzed	50% CF 12.5% LF	100% CF 50% LF	100% CF 100% LF	100% CF 50% LF	50% CF 12.5% LF	25% CF, 6.25% LF	100% CF, 12.5% LF	50% CF, 25% LF	50% CF, 25% LF	25% CF 6.25% LF
CHARCOAL										
Charcoal CT										
Charcoal WT										
DOMESTICATE SEEDS										
Large Fabaceae				1					2	
Ficus carica	32	8	9	24	8	72	8	8	14	28
Hordeum vulgare sbsp. *distichum*	64	35		86	58	72	11	72	52	73
Hordeum vulgare sbsp. *Indet*	237	54	1	73	106	327	49	148	80	151
Hordeum vulgare sbsp. *vulgare*	3			1		2		1	5	1
Indeterminate Cereal		5	3		8	11		12	8	2
Lens culinaris			1							
Panicum miliaceum										
cf. *Triticum dicoccum*			1							
Triticum sp.			1			1				

Sample	**E06**	**E07**	**E08**	**E09**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**
Triticum aestivum / durum										
Vicia ervilia										
Vitis vinifera	4		24	1					1	1
Vitis vinifera raisin										
Vitis vinifera pedicel										
GENERAL FAMILIES (WEEDS / WILD)										
Asteraceae				2						
Boraginaceae (mineralized)										
Brassicaceae										
Caryophyllaceae										
Chenopodiaceae										
Convolvulaceae										
Cyperaceae										
Fabaceae		2	2	10	4	4		6		
Lamiaceae										
Malvaceae										
Poaceae	12	10	3	4	20	8	24	1	8	4
Polygonaceae				2						4
Solanaceae										
WEEDS / WILD										
Adonis										
Aegilops										
Ajuga										
Amaranthus										
Androsace maxima										
Astragalus		10	3		8	4	8	4	8	4
Atriplex					4					
Brassica										
Bromus		2			4	4				
Bupleurum	4							2		4
Camelina Alyssum										
Cardamine								2		
Carex					4					
Cerastium										
cf. *Onopordum*										
Chenopodium										
Convolvulus										
Coronilla										
Erodium										4
Euphorbia		2								
Fumaria										
Galium										
Heliotropium										
cf. *Hordeum murinum/boeticum*										

Sample	**E06**	**E07**	**E08**	**E09**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**
Hordeum spontaneum	5	4		13	18	25	16	2	10	
Hyoscyamus										
Juncus										
Lolium			1				8			
Malva			2						2	
Medicago										
Melilotus/Trifolium					16				4	
Muscari	4	2		2	20	4	24	4	10	
Nepeta										
Papaver										
Phalaris		4			8	12				4
Phleum										
Plantago										
Polygonum	12	10		26	16	28		16	6	8
Rumex										
Salsola										
Scirpus										
Scorpiurus										
Silene			1		4					
Stipa										
Suaeda		2		6		4				
Trifolium repens					16				4	
Trigonella			1							
Trigonella astroites										
Vaccaria						4				
Valerianella										
Ziziphora										
UNIDENTIFIED AND UNIDENTIFIABLE										
Unknown but identfiable seed	4	10	8	4	28	4	48	14	10	20
Clinker										
Unidentifiable Seed Fragments										
CHAFF REMAINS										
Poaceae culm	1	7			193	16	56	2	4	4
Poaceae roots										
Hordeum sp . rachis	4	8		16	267	16	240	2	10	4
Triticum sp. rachis						8			6	
OTHER										
Bone										
Carbonized rodent dung										
Dung										
Fish Scale										
Shell										

Samples E16–E20

Sample	**E16**	**E17**	**E18**	**E19**	**E20**
Unit	4J41	4J41	4J41	4J41	4J41
Locus	13	11	11	6,7,12	12
Subgrid					
Volume	8	12.5	24.5	8.5	10
% Analyzed	100% CF, 25% LF	100% CF, 12.5% LF	25% CF, 3.13% LF	100% CF, 6.25% LF	100% CF, 25% LF
CHARCOAL					
Charcoal CT					
Charcoal WT					
DOMESTICATE SEEDS					
Large Fabaceae	4			1	
Ficus carica		8	48	128	16
Hordeum vulgare sbsp. *distichum*	10	11	154	28	1
Hordeum vulgare sbsp. *Indet*	43	18	119	362	10
Hordeum vulgare sbsp. *vulgare*			8		
Indeterminate Cereal			3	21	
Lens culinaris	1	1			
Panicum miliaceum					
cf. *Triticum dicoccum*					
Triticum sp.	1				
Triticum aestivum / durum					
Vicia ervilia					
Vitis vinifera			4	6	
Vitis vinifera raisin					
Vitis vinifera pedicel					
GENERAL FAMILIES (WEEDS / WILD)					
Asteraceae					
Boraginaceae (mineralized)					
Brassicaceae					
Caryophyllaceae					
Chenopodiaceae					
Convolvulaceae					
Cyperaceae					
Fabaceae	4			32	8
Lamiaceae					
Malvaceae					
Poaceae	4		16	64	4
Polygonaceae					
Solanaceae					
WEEDS / WILD					
Adonis					
Aegilops	1				
Ajuga					

Sample	**E16**	**E17**	**E18**	**E19**	**E20**
Amaranthus					
Androsace maxima					
Astragalus		9	4		
Atriplex					
Brassica					
Bromus		8			
Bupleurum			4		
Camelina Alyssum					
Cardamine				16	4
Carex		8			
Cerastium					
cf. *Onopordum*					
Chenopodium					
Convolvulus					
Coronilla					
Erodium		24			24
Euphorbia					
Fumaria					
Galium					
Heliotropium					
cf. *Hordeum murinum/boeticum*					
Hordeum spontaneum	4	41	8		
Hyoscyamus					
Juncus					
Lolium		8		16	
Malva		8			
Medicago					
Melilotus/Trifolium					4
Muscari	20	16	4	16	4
Nepeta					
Papaver		8	4		4
Phalaris		8			
Phleum					4
Plantago					
Polygonum	4		8		
Rumex					
Salsola					
Scirpus					
Scorpiurus					
Silene					
Stipa					
Suaeda					
Trifolium repens					4
Trigonella					

Sample	E16	E17	E18	E19	E20
Trigonella astroites					
Vaccaria				16	
Valerianella					
Ziziphora					
UNIDENTIFIED AND UNIDENTIFIABLE					
Unknown but identfiable seed		73	24	176	24
Clinker					
Unidentifiable Seed Fragments					
CHAFF REMAINS					
Poaceae culm	4	122		16	4
Poaceae roots					
Hordeum sp . rachis		392		16	4
Triticum sp. rachis					
OTHER					
Bone					
Carbonized rodent dung					
Dung					
Fish Scale					
Shell					

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