NATUFIAN STRATEGY SHIFTS: EVIDENCES FROM
WADI MATAHA 2, PETRA, JORDAN

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Abstract
Excavations at Wadi Mataha 2 in the Petra Basin of southern Jordan has yielded evidence of a shift in Natufian strategies from a radiating (early) to a circulating (late) pattern despite minimal evidence for climatic stress due to the onset of the Younger Dryas. Evidences brought to bear on this issue include pollen, starches from Late Natufian pests, chipped stone, and vertebrate faunal remains. Starches representing *Triticum*, *Hordeum*, and *Aegilops*, were observed in four of the five samples. Faunal data suggest stability in diet breadth despite a richer assemblage in the Late Natufian.

Key words: Epipaleolithic, Natufian, residential mobility, paleoclimate, Younger Dryas.

INTRODUCTION
The Natufian period marks the shift from simple, highly mobile foraging to complex, even settled, foraging in the Levant of Southwest Asia (various, but see Bar-Yosef, 2001; Bar-Yosef and Meadow, 1995; Goring-Morris and Belfer-Cohen, 1998; Grosman, 2003; Munro, 2004 for discussions). Population growth, increasing social complexity, intensification of selected plant foods, specialized hunting of gazelles, high investment architecture, and proliferation of crafts are among the hallmarks of this precursor to the Neolithic that flourished between 11,000 and 8,000 BC. Natufian subsistence and the transition to plant and animal domestication has garnered much attention in the past (e.g., Bar-Yosef and Meadow, 1995; Bar-Yosef, 1998; Bar-Yosef and Belfer-Cohen, 2002; Grosman, 2003; see Munro, 2003 for a differing view and additional references). The impact of the Younger Dryas would have varied across the heterogeneous landscape of the Levant, and it is clear that in some areas this was actually a period of climatic amelioration due to attenuation of the rain shadow effect as a result of lower temperatures (Baruch and Goring-Morris, 1997; Vaks et al., 2003).

In any case, understanding the nature of human adaptations during the Late Natufian in the Levant is critical to understanding the emergence of agriculture. In this paper we present data from excavations and analyses at Wadi Mataha 2 in southern Jordan and their implications for strat-
Fig. 1. Map of the Levant showing the location of Wadi Mataha and selected Natufian sites
egy and subsistence trajectories from the Geometric Kebaran into the Late Natufian. We focus on multiple lines of evidence relevant to exploitation of botanical resources during the Late Natufian. Taken together these data allow a discussion of Late Natufian regional adaptations and some tentative ideas about how these adaptations differed from preceding periods.

SITE DESCRIPTION

Wadi Mataha 2 is a multi-component, Epipaleolithic site in the northern Petra Basin (Fig. 1). Three environmental zones are found in close proximity: the forested limestone highlands to the east, the shrubby Irano-Turanian steppe in the area surrounding the site, and the desert lowlands of the Wadi Araba to the south (Kirkbride, 1985). The landscape adjacent to the site is rough, broken terrain intermediate between the city of Petra and gentler, hilly uplands to the east that still contain vestiges of oak – pistachio woodlands. Human occupations at Wadi Mataha 2 lie at the top of and down a steep talus slope at the south edge of Maghur al Mataha, a large sandstone monolith. Elevation is about 950 m. The site slope is littered with sandstone rubble, chipped stone debris and tools, and occasional bone eroding into a secondary drainage of the site’s namesake, Wadi Mataha, a major drainage flowing into Petra proper 1.2 km to the south. The site size can be divided between the upper slope and the middle and lower slope with the former containing a Geometric Kebaran occupation overlain by Late Natufian material and measuring roughly 50 m² in size. The middle and lower slope is exclusively Early Natufian and is larger, measuring about 135 m².

Intact features are present in both the upper and lower areas.

Site age

Absolute dates have been elusive at Wadi Mataha as charcoal has been non-existent and bone collagen is present in only very minute quantities. Two AMS dates on humic acids from burned animal bone from the Upper Slope place a Geometric Kebaran occupation at 14,140 ± 130 BP and the Late Natufian at 11,200 ± 50 BP (Table 1). The latter places the Late Natufian occupation at the onset of the Younger Dryas (Hughen et al., 2000). Additional humic acid dates place the Early Natufian occupation between 12,025 ± 30 BP and 11,600 ± 25 BP.

GEOMETRIC KEBARAN

Given the Late Natufian focus of this paper, the Geometric Kebaran presence at the site is described only briefly here. The Geometric Kebaran levels lay directly below the Late Natufian in Test Area 2 in the upper slope (Fig. 2). In addition to artifact-and bone-rich midden, this level contained human remains of an infant and an adult (Stock et al., 2005).

EARLY NATUFIAN OCCUPATIONS

Two stone features (Structures 1 and 2) dominate the Early Natufian area; both are terracing walls with artifact-rich fill behind and, in the case of the lower wall (Structure 2), clear evidence of residential activities on a flattened area in front or the downslope side. Structure 1 stretches nearly six meters from the west to east and is about a 90

<table>
<thead>
<tr>
<th>Table 1</th>
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<tr>
<td><strong>Radiocarbon dates from Wadi Mataha 2</strong></td>
</tr>
<tr>
<td><strong>Lab No.</strong></td>
</tr>
<tr>
<td>CAMS-55897</td>
</tr>
<tr>
<td>UCIAMS-24863</td>
</tr>
<tr>
<td>UCIAMS-24864</td>
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<tr>
<td>CAMS-55899</td>
</tr>
</tbody>
</table>
cm in maximum height (Fig. 2). The wall abuts sandstone bedrock on the east end. All but a few stones were buried at the onset of excavation. It appears that the wall was remodeled at least once resulting in a masonry arc. No clear “floor” was present; rather the rubbly fill simply ceased above sterile sands. Structure 2, roughly parallel to and downslope from Structure 1, curves up and across...
the slope for just over 5 m. As with Structure 1, this wall is somewhat sinuous, perhaps due to some downslope slippage. The maximum height of the wall is just over 1.2 m. This feature was completely buried with no evidence of its presence visible on the surface. A series of amorphous roasting pits are present in an occupation zone at the same level as the basal stone course of Structure 2. Below these features are sterile sands. This occupation zone is rich in artifacts and faunal bone and relatively free of rubble.

LATE NATUFIAN OCCUPATION

Late Natufian occupations are restricted to the upper slope at the base of a short sandstone cliff (Fig. 3). Late Natufian features include a roasting area with dark midden and abundant chunky sandstone cobbles (Fig. 4). Stratigraphically below (but still Late Natufian) and slightly downslope from the roasting feature was a patchy surface of flat stones upon which lay several C. ibex horn cores and domestic items including pestles and chipped stone tools. The surface appears circumscribed by an arcing alignment of sandstone boulders. Sediments are dark and contain small, steeply backed lunates with bipolar retouch and crude notches and denticulates. On the eastern edge of the excavations, sediments have been disturbed by colluvial debris deriving from the cliff above. This activity deposited sandstone cobbles and red, sandy sediments, mixing a rich Late Natufian bone and lithic assemblage with some Nabatean pottery and modern debris.
Bedrock mortars

Five bedrock mortars as well as three cup mortars are present on a sandstone bedrock shelf abutting the east edge of the excavated area (we refer to these manmade features as bedrock mortars but acknowledge intriguing discussions of other possible functions by Nadel et al. (2008) based on findings at Raqefet Cave. Eitam (2008) refers to these installations as “Oblong conical mortars” which term could apply to the deep mortars here. The proposal by Grosman and Goren-Inbar (2007) that such features were used to quarry limestone or chert is not relevant in this context as the bedrock mortars are cut into sandstone). The bedrock mortars are roughly parallel sided for much of their length but taper to a rounded point at the bottoms. Depths range from 30 to 72 cm. Two (Mortars 1 and 2) exhibit fluting from intense grinding or pounding activity using stone pestles (Fig. 5). Deep mortar openings are oval measuring between 15 to 25 cm in diameter. The cup mortars are shallow (6 to 10 cm deep) and more bowl-like in profile; cup mortar opening diameters are 10 to 15 cm. Cup mortar interiors are characterized by multiple pick marks, presumably from manufacture. None of the cup mortars showed clear evidence of use such as smooth interior or abrasions.

All of the mortars except Mortar 5 were visible and exposed at the time we began site excavations making fill contamination likely. Nevertheless, several contained some sediment, especially Mortars 1 and 5. Mortar 1 proved to be the deepest (72 cm) and yielded the most artifacts. The mortar was largely filled with sediments which contained flint debitage, a hammerstone wedged in the hole at 35 cm below surface. Below the hammerstone were several small pieces of Dentalium, a Nerite bead, a few bone fragments, and additional stones tightly wedged in the tapered portion of the hole. The sides and bottom of the mortar were quite smooth, and pick marks, so visible in most of the others, are largely worn away. It is possible this feature was an exhausted mortar and was subsequently used as a cache pit. Mortar 5, which was covered by a few cm of sediment, contained sandy fill, but a plastic bag was present 20 cm below the top of the feature; how-
ever, a hammerstone and a flint chunk were present near the bottom. The obvious recent nature of this fill makes placing meaning on the presence of artifacts a tenuous proposition. The presence of stones in the bottom of deep mortars is not uncommon according to Eitam (2008).

**Late Natufian Pestles**

Six pestles appear to be of the appropriate shape to have been used in the bedrock mortars (Fig. 6). All are from sealed Late Natufian deposits. These pestles are sub-rectangular in profile and taper to the distal portion where use wear is clearly evident. All are sandstone. Two are very similar in size: FS 1723 is complete and measures 23 cm long (maximum dimensions in all cases) by 10.98 cm wide and 5.4 cm thick at the proximal end, while FS 694 is nearly complete, lacking only the distal portion, and measures 10.85 cm wide by 5.33 cm thick. Three others are more fragmented with two (FS 1694 and FS 1494) split longitudinally and one (FS 818) being a distal end. FS 818 is distinct from the distal portion of FS 1723 in that it is more rounded while FS 1723 is more flattened and chisel-like. The final specimen, FS 1784, differs from the others in that, although missing a portion of the proximal end, appears to have been used as-is. It measures 13.37 cm long by 9.32 cm wide and 5.72 cm thick (at the distal end). The distal end of this pestle differs yet again in that the end is more blunt and flatter with clear pecking visible. All pestles roughly conform to the shape of the flutes in the deep mortars, although FS 1784 seems unlikely to have been used in those features given its shorter length. It may have been useful for use in the shallow cup mortars. All pestles are shaped by percussion and intense pecking. These tools would have been quite heavy to wield (e.g., FS1723 weighs 2.7 kg), although efficient for crushing seeds or nuts.

**BOTANICAL ANALYSES**

**Pollen data**

The 19 pollen samples processed to date present tentative environmental insights for all three time periods represented at Wadi Mataha (Fig. 7). Pollen preservation was particularly poor, or de-
position particularly rapid, for the few Geometric Kebaran samples, while pollen in the Early and Late Natufian samples was better preserved and more abundant.

The Early Natufian (and to a certain extent the Late Natufian) pollen signature is dominated by Liguliflorae pollen. Many of the plants in the Liguliflorae (chicory tribe of the sunflower family) require more moisture than do other members of the sunflower family; therefore, recovery of moderately large to large quantities of Liguliflorae pollen is often interpreted to represent an increase in moisture (compared to today). The phenomenon of larger quantities of Liguliflorae pollen is not limited to this portion of the Middle East, as it is also observed throughout portions of North America during terminal Pleistocene and early Holocene deposits. The change in vegetation at this time is most likely related to a difference in the timing of precipitation and perhaps other important parameters, such as the length of the growing season, orbital parameters that are collectively known as the “Milankovitch cycle,” and factors that combine to make the terminal Pleistocene a much different experience than the Holocene. This mesic signature continues through the Late Natufian samples. Recovery of moderate to moderately large quantities of Caryophyllaceae, Tidestromia-type, Cheno-am, Cucurbitaceae, and Poaceae pollen probably reflects patchy vegetation in some areas of the site, as some of these plants might be growing as weeds in disturbed areas, and/or use or processing of some of these plants.

Additional evidence of more mesic conditions include Arecaceae, Typha, and Prosopis (representing palms, cattails, and a relative of mesquite respectively) that probably grew in the wadis. Although Prosopis is not part of the local vegetation today, the pollen record from Wadi Mataha indicates that it was part of the riparian vegetation community during the Early and Late

Fig. 6. Late Natufian pestles: a) FS 1784, b) FS 818, c) FS 1723, d) FS 694
Fig. 7. Pollen diagram representing Geometric through Late Natufian occupations as well as modern pollen rain.
Natufian Periods. Increases in Cheno-am pollen in two of the samples from the Late Natufian might reflect food processing activities, growth of weedy plants in these locations, or perhaps response to increasingly saline conditions in specific areas.

Of most importance was the recovery of Cerealia pollen from the Geometric Kebaran and Early Natufian levels. It is also significant that the frequency of Poaceae pollen was elevated in these samples, as it notes the presence of a relatively large population of grasses, the seeds of which potentially could have been collected as food.

**Starch data**

Recovery of starch grain from Late Natufian pestles provides direct evidence for cereal exploitation during this time period. Three of the pestles (FS 1694, FS 1723, and FS 1784) came from within and adjacent to an ashy depression in the Late Natufian levels in Test Area 2 (Fig. 3). The remaining three (FS 694, FS 1494, and FS 818) are from a contact zone between the Late Natufian occupation and the underlying Geometric Kebaran levels. All, however, are within a few centimeters of each other in depth. Five of these pestles (all except FS 694) were washed for phytolith analysis with negative results (Terry Ball, personal communication 2002). Those five samples were then submitted to PaleoResearch Institute, where examination yielded cereal starch grains from all five samples. Pestle FS1494 exhibited only two grains of starch (Table 2), neither of which represents cereals. Lenticular starch (Fig. 8a), found in *Triticum*, *Hordeum*, and *Aegilops*, were observed in four of the five samples, indicating that Pestles FS 818, FS 1694, FS 1723, and FS 1784 were used for grinding wheat or barley, probably the wild progenitors to the domestic wheat or barley. Pestles FS 818 and FS 1784 both yielded *Hordeum*-type starches, which exhibit more well-defined or obvious lamellae (concentric rings) than do the starches that are lumped under the *Triticum/Hordeum* category (Figs 8b and 8c representing regular light and cross-polar illumination, respectively). These distinctive lamellae have been observed on approximately 50 percent of the lenticular starches present in *Hordeum* and are described by Piperno _et al._ (2004:670) as being diagnostic of *Hordeum* when combined with the lenticular shape. Starches that are not diagnostic of wheat or barley, but are part of the wheat and barley starch assemblages, as well as being typical of grass seeds were observed in four of the five samples (FS 818, 1494, 1494, and 1484). Probable Apiaceae (umbel family) root starch was also observed on Pestle FS 1694.

Recovery of cereal pollen from all three time periods and starch from Late Natufian pestles suggests possible exploitation of wild cereal grasses through all time periods. In addition, the pollen record, combined with this evidence for use of cereals, indicates a relatively open landscape in the vicinity of Wade Mataha 2 throughout the Geometric Kebaran and Natufian occupations.
CHIPPED STONE

Analysis of Natufian lithic assemblages tends to focus on typological categorization of retouched tools and metrical analysis of debitage. A number of use wear studies have examined the function of retouched tools (see Anderson, 1991; Richter, 2007; Yamada, 2000 for reviews of this literature). Use wear analysis of unretouched flakes is rare. Richter (2007) included unretouched flakes in his sample to detect ‘background noise’ and was surprised to learn that use wear on these pieces was very common (reaching 50 percent of a sample of 18 flakes from Ain Rahub). However, the recent publication of a cache from the Early Natufian site of Wadi Hammeh that appears to represent a hunter/gatherer toolkit includes thirteen lunates and ten retouched bladelets (the latter set into a sickle) apparently without any unretouched flakes. The Wadi Hammeh discovery offers support for a focus on retouched bladelets in functional studies of Natufian lithic technology (Edwards, 2007).

From a typological perspective the Wadi Mataha assemblage is unremarkable. Although the typological analysis is still in process, the general outlines are clear. The Geometric Kebaran is dominated typologically by narrow obliquely truncated backed bladelets along with well-made endscrapers on blades. Cores are well-organized unidirectional blade/bladelet cores. For the Early Natufian, diagnostic large Helwan retouched lunates are common. Other major tool types are Helwan retouched bladelets, notches, and endscrapers. Cores tend to be amorphous bladelet cores. Typologically this assemblage is very similar to the nearby Early Natufian site of Beidha (Byrd, 1989). The Late Natufian is characterized by the presence of lunates (mean length 17 mm, mean width 6 mm.) with unipolar, bipolar, and Helwan retouch. These measurements fit well with the Late Natufian sites from the Negev, as well as the late Natufian occupation of Salibiya 1 in the Jordan Valley (Belfer-Cohen and Grosman, 1997; Goring-Morris, 1997). However, the mean length of lunates from the Late Natufian of Wadi Mataha is greater that the mean for the Final Natufian at the sites of Mallaha in the Hula Valley and Fazael IV in the Jordan Valley (Grossman et al., 1999; Valla et al., 2001). Other tool types include backed bladelets, notches, endscrapers, and rare burins. Cores are unidirectional bladelet cores often with multiple platforms.

Functional analysis of the Late Natufian assemblage has turned out to be challenging and the results reported here are based on a single context (FS 1465) within Feature 26, the patchy surface of flat stones in the upper slope. However, these results cohere with more qualitative observations made on the assemblage as a whole. The approach followed in this analysis is to begin by looking at the complete assemblage in terms of the technology of blank production and the functional qualities of both retouched and unretouched flakes. From a functional perspective the assemblage breaks down into four discrete components, each of which was produced following a distinct method. The first type consists of large flakes

<table>
<thead>
<tr>
<th>Starch type</th>
<th>FS 818</th>
<th>FS 1494</th>
<th>FS 1694</th>
<th>FS 1723</th>
<th>FS 1784</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triticum/Hordeum/Elymus</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Hordeum-type (obvious concentric rings)</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globular starch w/hilum, possibly grass seed</td>
<td>1</td>
<td>6</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Grass seed starch</td>
<td>5</td>
<td></td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Angular starch (grass seed)</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Apiaceae</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elongated starch, unknown origin</td>
<td>1</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>&quot;Starburst&quot; starch</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 2

Starches recovered from pestles
These large flakes include a simple burin (n = 1), a steep endscraper (n = 1), notches (n = 2), and unretouched flakes (n = 7). Flakes divide equally between cortical (cortex 60 percent; n = 4), partially cortical (n = 3), and non-cortical (n = 4). These tools present large robust working edges that could be used for aspects of butchery or scraping. Three of the flakes in the sample have convergent edges. There is no evidence for retouch to shape the tools for hafting and the shape of the flakes tends to be irregular. The second component consists of pieces that would normally be classified as angular debris. These are blocky pieces that were produced by purposefully fracturing flakes or blocks of chert. There is no obvious functional explanation for this class, as the pieces do not offer a clear working edge. These pieces can be divided into a group of smaller pieces (max. dim.  < 20 mm; n = 7) and larger pieces (max. dim. 25–46 mm; n = 5). One possibility is that the larger pieces were blocks that could be used for cores; however, one piece appears to have been retouched as a burin.

The third and dominant class includes flakes and blades with at least one straight cutting edge with an edge angle capable of longitudinal cutting (n = 139). This class of flakes can be further subdivided into flakes and blades with one oblique edge (often either retouched or cortical) (n = 11); parallel or near parallel straight edges (n = 60); an offset point (n = 56), and irregularly shaped flakes and blades (n = 11). Size of flakes and blades in this class ranges from 3 to 56 mm. (mean 18 mm.), and includes large narrow blades. The configuration of the cores in the sample indicates that very small flakes were desired endproducts. The three cores are exploited for unidirectional bladelet production. The two larger cores have two...
orthogonal working faces. The length of bladelet scars on these cores ranges from 46–28 mm. A third core is a small single pyramidal core with bladelet scars ranging from 15–20 mm. The smallest retouched piece is a micro-end scraper with length = 7 mm. The final component consists of waste products of knapping which includes 16 pieces with a maximum dimension greater than 1 cm, and 36 pieces with a maximum dimension less than 1 cm. There is one burin spall that rejuvenated a retouched edge.

Microscopic examination has focused on the pieces with edges that could be utilized for longitudinal cutting, as these are most relevant to the exploitation of plants (Fig. 9). Pieces were examined under a binocular microscope at a range of magnifications to look for evidence of rounding of edges and particularly for striations that would be consistent with the use of the flakes in harvesting cereals. Strongly developed sickle gloss is absent from the collection. Ventral striations are found on 57 retouched and unretouched flakes and blades covering the entire size range including lunates and backed bladelets. In addition to the pieces with ventral striations 56 pieces were found to have regular microscars along an edge on either the ventral or dorsal face (pieces with both striations and microfracture were counted as having striations). Striations were found on both retouched and unretouched flakes and blades in all size classes. Examination of striations under environmental SEM confirmed that they were in fact alterations of the surface of the flake formed by incision and that there was polish formation along the tool edge and between the striations. One concern during analysis was the potential to confound use wear striations with furrows produced by hackles, or what has also been described as lances (Cotterell and Kamminga, 1979). The consistent association of striations with rounded edges and the localization of striations to a limited part of the edge indicates that, although such an error is possible in particular cases, it does not affect the overall functional observations. However, further work is needed on the formation of striations and the relation of striations to features created by fracture. Micro-scarring was only identified if there was a continuous distribution of flaking scars along one face (either ventral or dorsal) of an edge.

The functional qualities of the flakes combined with the use wear evidence strongly suggest that longitudinal cutting was a major function of Late Natufian stone tools at Wadi Mataha 2. Combined with the other lines of evidence presented here, cereal harvesting would seem to be the most obvious function for these tools. One question that requires further research is why sickle gloss did not develop on these tools if they were used to harvest cereals. Anderson (1991) attributes the formation of striations to proximity of the tool to the soil during harvesting while the intensity of gloss is associated with the length or intensity of use. In the analyzed context debitage, in the sense of the waste products of lithic production, is exceedingly rare. This suggests that curated tools, perhaps complete sickles made up of multiple flakes and blades, were brought on to the site. Using the Wadi Hammeh cache as a guide we might see the cores and angular blocks as the raw material that was carried along for retooling. However, the results here point to a very different technology for harvesting than indicated by the Wadi Hammeh sickle as unretouched flakes are the dominant type of sickle element. The heavy-duty tool component indicates that other activities likely involving animal butchery and processing also took place at the site.

TEMPORAL TRENDS IN ANIMAL EXPLOITATION

Animal bones were a principal data set recovered from the Wadi Mataha excavations, with some 28,921 total bones recovered, 2,382 or 8.2 percent identifiable from all levels, including the Geometric Kebaran. Although the focus of this paper is the Late Natufian the Geometric Kebaran fauna are included for comparative purposes. Identified specimens include ungulates, carnivores, small mammals and rodents, reptiles, and a variety of birds (see Tables 3 and 4). As is typical of Epipaleolithic sites across the Levant, the best represented species are gazelle (Gazella spp.), land tortoise (Testudo graeca), wild goat/ibex (Capra spp.), hare (Lepus capensis), and partridge (Alectoris chukar). Caprines as the dominant ungulate species aligns Wadi Mataha with other Epipaleolithic sites in the steppe/desert regions of the Levant, whose climatic and topogra-
phy are more suitable for caprine species, the wild goat (*Capra aegagrus*) and the ibex (*Capra ibex*), and less favorable to forest dwelling species such as the roe and red deer (*Capreolus capreolus, Cervus elaphus*) and the wild boar (*Sus scrofa*) (Henry, 1998; Byrd, 1989).

The gazelle bones in the Wadi Mataha assemblage could be from one of three different species of gazelle that have inhabited the southern Levant, the goitered gazelle (*Gazella subgutturosa*), the mountain gazelle (*Gazella gazella*), and the dorcas gazelle (*Gazella dorcas*). *G. gazella* is a

### Table 3

NISP count of Wadi Mataha fauna

<table>
<thead>
<tr>
<th>Taxon</th>
<th>N</th>
<th>%</th>
<th>Taxon</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ass/Onager (<em>Equus spp.</em>)</td>
<td>29</td>
<td>1.2</td>
<td>Lizard (Sauria/Agamidae)</td>
<td>11</td>
<td>0.5</td>
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<tr>
<td>Aurochs (<em>Bos primigenius</em>)</td>
<td>18</td>
<td>0.8</td>
<td>Snake (Columbriidae)</td>
<td>4</td>
<td>0.2</td>
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<tr>
<td>Goat/Ibex (<em>Capra spp.</em>)</td>
<td>380</td>
<td>16.0</td>
<td>Land Tortoise (<em>Testudo graeca</em>)</td>
<td>420</td>
<td>17.6</td>
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<tr>
<td>Caprine (probably <em>Capra</em>)</td>
<td>352</td>
<td>14.8</td>
<td>Total</td>
<td>435</td>
<td>18.3</td>
</tr>
<tr>
<td>Sheep? (<em>Ovis orientalis</em>)</td>
<td>6</td>
<td>0.3</td>
<td>Aves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gazelle (<em>Gazella spp.</em>)</td>
<td>372</td>
<td>15.6</td>
<td>Fowl-like Birds (Galliformes)</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>Caprine/Gazella</td>
<td>46</td>
<td>1.9</td>
<td>Partridge (<em>Alectoris chukar</em>)</td>
<td>103</td>
<td>4.3</td>
</tr>
<tr>
<td>Fallow Deer? (<em>Dama mesopotamia</em>)</td>
<td>2</td>
<td>&gt;0.1</td>
<td>Diurnal Birds of Prey (Falconiformes)</td>
<td>14</td>
<td>0.5</td>
</tr>
<tr>
<td>Bovid/Cervid</td>
<td>331</td>
<td>13.9</td>
<td>Hawks and Eagles (Accipitridae)</td>
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<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1536</td>
<td>64.5</td>
<td><strong>Total</strong></td>
<td>251</td>
<td>10.5</td>
</tr>
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</table>

### Table 4

Proportion of different animal types by temporal component

<table>
<thead>
<tr>
<th></th>
<th>G. Kebaran</th>
<th></th>
<th>E. Natufian</th>
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<th>L. Natufian</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Ungulates</td>
<td>138</td>
<td>62.7</td>
<td>608</td>
<td>80.4</td>
<td>608</td>
<td>57.8</td>
</tr>
<tr>
<td>Carnivores</td>
<td>3</td>
<td>1.4</td>
<td>13</td>
<td>1.7</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>Sm Mammals/Rodents</td>
<td>17</td>
<td>7.7</td>
<td>33</td>
<td>4.4</td>
<td>63</td>
<td>6.0</td>
</tr>
<tr>
<td>Reptiles</td>
<td>42</td>
<td>19.1</td>
<td>56</td>
<td>7.4</td>
<td>220</td>
<td>20.9</td>
</tr>
<tr>
<td>Birds</td>
<td>20</td>
<td>9.1</td>
<td>46</td>
<td>6.1</td>
<td>144</td>
<td>13.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>220</td>
<td>100.0</td>
<td>756</td>
<td>100.0</td>
<td>1051</td>
<td>100.0</td>
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medium sized, slender built gazelle generally ranging north of the 150 mm isohyett, while the smaller G. dorcas general occupies more arid regions to the south of this isohyett (Tchernov et al., 1986/7). In the Paleolithic period, the mountain gazelle ranged as far as the Sinai and southern Negev, until the PPNB period, when the dorcas gazelle invaded the arid regions of the southern Levant from North Africa, limiting the range of the mountain gazelle to more Mediterranean environments (Tchernov et al., 1986/7). Goitered gazelles, now extinct in much of the southern Levant, were hunted in desert/steppe areas by means of drive installations and desert kites, both in the distant and more recent past (Bar-Yosef, 1986). The identification of horn cores from the goitered gazelle at Epipaleolithic sites in the Wadi Hasa sites indicates that Wadi Mataha 2 was probably also in its range (Clark et al., 1988:251). Of these three, only the goitered gazelle was migratory (Martin, 2000).

Distinguishing between different species of gazelle relies on measurements of size and on differences on cranial feature and horn cores (Tchernov et al., 1986/7). G. gazella horn cores have a wide groove on the anterior edge, while horn cores from G. dorcas lack an anterior groove, but have two grooves on the posterior surface. The horn cores of G. gazella also appear elliptical in cross section. Those of the G. dorcas are more egg-shaped and have a wider posterior edge (Tchernov et al., 1986/7). At Wadi Mataha 2, all gazelle bones fall within the size range of the mountain gazelle (Gazella gazella) (after Horowitz et al., 1990). In addition, the horn cores from Wadi Mataha appear elliptical in cross section and more closely resemble G. gazella.

The Wadi Mataha 2 fauna are useful for examining trends in animal exploitation and possible changes in site function through time. The number of identified specimens is greatest from Late Natufian contexts (n = 1051), followed by Early Natufian levels and features (n = 756) and Geometric Kebaran (n = 220) primarily due to larger samples of the Natufian deposits. A number of bones from levels transitional between the Late Natufian and Geometric Kebaran components in the Upper Slope are probably mostly from the earlier phase (n = 355), but are not used in this comparative analysis.

When comparing the proportions of identified specimens between the different temporal components, some trends in animal exploitation patterns are apparent (Table 5). First, the Early Natufian component has a higher percentage of ungulates (80 percent) compared to the Late Natufian (near 60 percent). Second, the percent of reptiles, primarily represented by the land tortoise, and birds remains are lowest in the Early Natufian (7 and 6 percent respectively) compared to a proportion of near 20 percent for reptiles in the other two periods, and a significantly higher proportion of birds in the Late Natufian (14 percent) with slightly higher percent in the Geometric Kebaran (9 percent). Carnivores are represented in small proportions in all periods, with small mammals and rodents also few, but slightly better represented in the Geometric Kebaran and Late Natufian components (Fig. 10).

To better gage the degree of reliance on large versus small game between the three periods, the relative proportions of carnivores, ungulates, and small game, which combines the numbers of birds, reptiles, and small mammals, were com-

<table>
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<tbody>
<tr>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>Equid</td>
<td>4</td>
<td>3.5</td>
<td>17</td>
</tr>
<tr>
<td>Bos</td>
<td>2</td>
<td>1.8</td>
<td>4</td>
</tr>
<tr>
<td>Caprine</td>
<td>55</td>
<td>48.7</td>
<td>315</td>
</tr>
<tr>
<td>Gazelle</td>
<td>52</td>
<td>46.0</td>
<td>124</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>113</td>
<td>460</td>
<td>458</td>
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pared together with a small game to ungulate ratio calculated using the formula of the $\Sigma$ small animals/ $\Sigma$ small animals + $\Sigma$ ungulates. In this index, values closer to one indicate a greater exploitation of small game, while numbers closer to zero evidence a greater focus on ungulates. Carnivores, rodents other than hares, and raptors were excluded from the small game, since their use as a food resource can be disputed. The results show the highest small game to ungulate ratio in the Late Natufian at 0.26, followed by the Geometric Kebaran at 0.23, and the Early Natufian showing the lowest ratio at 0.08. These ratios make clear the importance of small game in the Geometric Kebaran and Late Natufian periods relative to the Early Natufian. While the Geometric Kebaran and Late Natufian periods both have similar small game to ungulate ratios, some differences are apparent in the relative proportions of small prey exploited. Following Munro (2003) a small game index was calculated to gauge the relative reliance on slow prey (land tortoise) with low capture costs versus fast prey (birds and hares) with higher capture costs, and thus presumably lower net energetic gains relative to expenditures. The results indicate that the reliance on slow prey (tortoise) is greatest in the Late Natufian (0.69) with a similar, but slightly lower reliance on them in the Geometric Kebaran (0.63), and an even lower use of slow game in the Early Natufian (0.58). These results parallel the findings of Munro (2003), who demonstrates a similar trend towards a greater use of slow, small prey (tortoise) in Late Natufian occupations in the Mediterranean core, compared to the Early Natufian, when tortoise consumption declined significantly from earlier periods. The difference between the Early and Late Natufian in the Wadi Mataha 2 assemblage, however, is not as great and the Early Natufian index (0.58) is higher than any assemblage reported by Munro, suggesting changes in small game use were less dramatic in the Petra Basin.

To investigate trends in large game exploitation through time, the relative representation of ungulate species was calculated for each temporal component. The results show that equids are slightly more abundant in the earlier periods (G. Kebaran and E. Natufian), while *Bos* increases
somewhat in the Late Natufian period, although the numbers are few for both of these taxa in all periods. The greatest difference in ungulate ratios is in the proportion of gazelle to caprines. Gazelles and caprines are nearly equally represented in the Geometric Kebaran period (46 to 49 percent respectively), but caprines increase in the two Natufian phases to over 60 percent while gazelles drop to around 30 percent (Table 4).

In terms of overall species richness, the Late Natufian component had the greatest number of species represented (26), followed by the Early Natufian (16), and Geometric Kebaran (14), suggesting an increase in species richness, perhaps related to resource intensification through time. Most of the species unique to the Late Natufian component, however, are from various species of raptors, which are not considered taxa exploited for food, but rather exploited for their talons usable as tools and ornaments. When excluding these species and carnivores (probably not hunted for food either) the richness of each component is relatively even with twelve species represented in the Late Natufian, and eleven each in the Early Natufian and Geometric Kebaran components. The number of taxa from each component, then, does not appear to clearly indicate an expansion of diet breadth or resource intensification through time.

The increase in ungulates and harder-to-capture hares and partridges during the Early Natufian combined with a decline in high-ranked but slow-moving small game suggests a degree of resource depression in the vicinity of the site. Resource depression is a function of a central place foraging strategy often resulting in high-ranked prey being hunted out in the areas around a more permanently occupied residential base (various, but see Broughton, 1999). As a consequence of resource depression, hunters strike out on long distance forays during which they target high-ranked prey such as ungulates. This pattern is well documented in the American Southwest during the move to more sedentary farming societies (Speth and Scott, 1989; Diehl and Waters, 2006). Here large to small game ratios decline between 1200 BC and AD 150 when a mixed foraging and farming strategy was practiced. Those same ratios increased after AD 150 as societies intensified agricultural pursuits and increased logistical mobil-
occurs during periods of decreased residential mobility. In contrast to climatic models, the faunal data suggest favourable climatic conditions as species preferring more mesic conditions, such as aurochs and gazelle increase slightly in the Late Natufian from the Early Natufian period, and the more Mediterranean-dwelling marbled polecats and mole rat appear exclusively in this level.

However, there are multiple lines of evidence that occupants of Wadi Mataha shifted their use of the site relative to the Early Natufian sometime between 11,600 and 11,200 rcybp. The portion of the site occupied is reduced, a pattern consistent with increased residential mobility at this time (various, but see Bar-Yosef, 2001; Grossman, 2003; Munro, 2003). The increased frequency of ground stone tools points to the importance of low ranked cereals, and the identification of cereal starch grains on these tools confirm the association between ground stone tools and cereal exploitation. The emphasis on flakes with a sharp cutting edge in the lithic assemblage along with preliminary use wear evidence consistent with the use of these tools for harvesting plants offers further support to the identification of cereal exploitation as a major activity in Late Natufian at Wadi Mataha 2.

Unfortunately, we have no information from Wadi Mataha 2 regarding the importance of cereals in the Early Natufian, and direct evidence for cereal use is sparse in much of the Natufian region (Bar-Yosef and Meadow, 1995; Bar-Yosef, 2001; however, see Garrard, 1999 a review of plant remains at Abu Hureyra and Mureybet, and Hillman et al., 2001 for evidence of early cultivation there). The changes in the Late Natufian most likely correspond to the climatic shift to the Younger Dryas, a climatic episode known for colder and drier conditions beginning at about 11,000 rcybp or slightly later (Bar-Yosef, 2001; Munro, 2003, 2004; Haynes, 2007), although Hillman et al. (2001:387) present data from Abu Hureyra that suggests the onset of aridity on the Upper Euphrates occurred slightly earlier than 11,000 rcybp, and such may have been the case in the southern Levant as well (see Moore and Hillman, 1992:489).

Taken together the evidence suggests increased residential mobility characterized the Late Natufian occupation at Wadi Mataha 2. This change, which involved shifts in both settlement and subsistence strategies, was a response to the onset of increased regional climatic stress. These changes occurred in spite of apparent relative climatic stability in the close vicinity of the site, suggesting the severity of the impact of the Younger Dryas was great on the region as a whole regardless of local conditions (Robinson et al., 2006). The evidence from Wadi Mataha 2 provides a detailed record of such environmental impacts even for people living in niches that did not experience catastrophic change in precipitation or local availability of plant resources.

One possible explanation for the apparent contradiction between indications of strategy shifts and apparent stress despite local climatic stability may be social. There is considerable evidence for a widespread social network during the Natufian. The trade in shell beads from the Mediterranean and the Red Sea tracks an intensive network of social interaction. Therefore it is possible that scale of adaptation was not to the localized setting of a particular site but rather to the region as a whole. If this is the case, then the stress would be systemic to the network as a whole and would be apparent even in areas of relative climatic stability.

**SUMMARY**

The data from Wadi Mataha provides support for shifts in Natufian settlement and subsistence seen broadly across the region. Specifically, the Early Natufian occupation here appears more sedimentary with investment in terracing walls or residential facilities suggesting the site functioned as a residential base. Diet is focused on high-ranked gazelles and caprines supplemented with some small taxa such as hares and partridge. As noted above, the faunal data reflect a greater emphasis on larger game and lower ranked small game in the Early Natufian when compared to the subsequent period suggesting a central place foraging strategy. There is minimal evidence of plant use in the Early Natufian occupation with the exception of a single fragment of a finely crafted ground stone bowl or mortar.

The Late Natufian occupation at Wadi Mataha 2, dated to the onset of this period (Valla, 1995; Grossman, 2003; Bar-Yosef, 2001), is more
restricted in area than the Early Natufian, and architectural features are absent here. These characteristics are consistent with Late Natufian occupations elsewhere (various, but see Grossman, 2003; Kuijt, 2004; Nadel et al., 2008; Eitam, 2008), although house huts marked by boulders and terracing walls are present at a number of sites (see Munro, 2003:58 for a summary). Investment in modest site facilities, such as the bedrock mortars and cupmarks seen at Wadi Mataha 2, are likewise commonly associated with Late Natufian (e.g., Goring-Morris, 1997; see Nadel et al., 2008 and Eitam, 2008 for extensive discussions of these installations). The bedrock mortars, along with the several heavy sandstone pestles, and perhaps the roasting area, are indirect evidences for processing plant foods, while starch grains are direct evidence for cereal exploitation. Eitam (2008), for example, makes a convincing argument that bedrock mortars were used for processing barley, a conclusion reinforced by the starch evidence from the pestles Wadi Mataha 2 (see above). Investment in such features could suggest Late Natufian foragers intended return visits to Wadi Mataha as part of a more circulating pattern. Although the number of faunal species represented in this period is greater than the Early Natufian, diet breadth is probably not greater once non-food items are removed. The increase in tortoises is a common feature of the Late Natufian (Munro, 2001, 2003) and suggests an increase in site catchment consistent with a more extensive foraging strategy.

The above site characteristics are typical of Late Natufian sites elsewhere and have led most to conclude that residential mobility increased in this period while population density decreased (Bar-Yosef and Belfer-Cohen, 1991; Bar-Yosef, 2001; Grossman, 2003; Munro, 2003). It is thought that the more arid climate of the Younger Dryas had a negative impact on cereal grasses in the Mediterranean zone generally (various, but see Bar-Yosef and Belfer-Cohen, 2002; Bar-Yosef and Meadow, 1995; Munro, 2003); however, it appears difficult to argue for environmental stress based on the archaeology of Wadi Mataha 2 since diet breadth (based on faunal data) does not appear to increase. In fact, based on small game taxa alone Munro (2003:63) has argued that “foraging intensity decreased” during the Late Natufian. The data from the Early and Late Natufian occupations at Wadi Mataha 2 largely support that conclusion and provide evidence of the strategic changes made by these hunter-gatherers as they dealt with the onset of the Younger Dryas.

REFERENCES


Robinson, S. A., Black, S., Sellwood, B. W.,


