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Use of Barley in the Egyptian Late Paleolithic

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Summary. Several grains of barley have been recovered from archeological sites at Wadi Kubbaniya, near Aswan in Egypt. The sites are typical Late Paleolithic and are firmly dated between 18,300 and 17,000 years ago. They seem to represent a very early use of ground grain in the Nile Valley, and evidence is presented for its continued use over the subsequent 6000 years. The Egyptian findings possibly record an initial stage of food production, and if they indeed do, then they suggest that food production may not have been brought about by environmental stress and may not have led inevitably to radical social changes.

A series of recently excavated Late Paleolithic sites located a short distance north of Aswan in southern Egypt has provided new evidence indicating that ground grain was an important economic resource in that area as early as 18,000 years ago. The evidence consists of carbonized, but not burned, plant remains, including several seeds and glumes of barley (*Hordeum vulgare*), associated with Late Paleolithic cultural debris on a buried living surface, and radiometrically dated (on charcoal and carbonized plant material) between 18,300 and 17,000 years ago. These discoveries may place the origins of food production nearly 10,000 years earlier than previously believed, would seriously question our previous assumptions concerning the role of food production in stimulating the social changes which characterize the "Neolithic," and may extend the probable locale where food production began from the Near East and "fertile crescent" areas to Northeast Africa.

It has long been recognized that the Nile Valley was the scene of early utilization of ground grain. The first indications of this early grain utilization were noted during the Nubian Salvage Campaign when sites containing numerous, shaped grinding stones and lustrous edged pieces, presumably sickles, were found near Tushka in Egyptian Nubia (Fig. 1), in a site with a radiocarbon date of 14,550 ± 490 years ago (WSU-315) (*1*). During this same period another site with numerous grinding stones was excavated at Kom Ombo, north of Aswan. This site had two dates of 13,560 ± 120 years ago (Y-1447) and 13,070 ± 120 years ago (Y-1375) (*2*). A few years later, and farther north, near Isna, yet another series of sites with grinding stones and sickle blades was excavated and dated as being between 12,600 and 12,000 years old (*3*). These three occurrences are associated with drastically different taxonomic units: the first is Qadan, the second is Afian, and the third is Isnan. It seemed, therefore, that intensive use of ground grain was a widespread phenomenon in the Nile Valley, that it began quite early and persisted for at least 2000 years, and that it transcended local cultural patterns.

The several sites did, however, share similar microenvironmental settings. All were located in valley embayments and existed during a period when levels of the Nile were exceptionally high. This high level of the Nile reduced the area of the floodplain along the main channel in the areas where cliffs abut the river, but at the same time the water level extended the floodplain up the wadis and embayments. The sites with grinding stones are associated with accumulating dunes, interdunal seepage ponds, or the floodplain immediately adjacent to the dunes, in areas where moisture would remain trapped after the flood had receded.

The actual grains of the utilized grasses were not found in any of the sites with grinding stones and sickle blades. At Tushka, however, pollens of large unidentified grasses as well as wheat rust spores were recovered from the associated interdunal pond sediments (*4*); at Isna, diatomaceous sediments from another interdunal pond contained relatively numerous fossil pollen grains, including examples of a large cereal-type pollen that was tentatively identified as barley (*5*). Other associated pollen included (i) some boreal types that obviously were a result of long distance transport and (ii) several elements suggesting a grassland. Pollen of aquatic plants was absent, an indication of the ephemeral character of the ponds. The barley pollen occurred occasionally throughout the pond sediment, but became suddenly increased in amount (between 10 and 15 percent of total pollen) near the top of the sequence,

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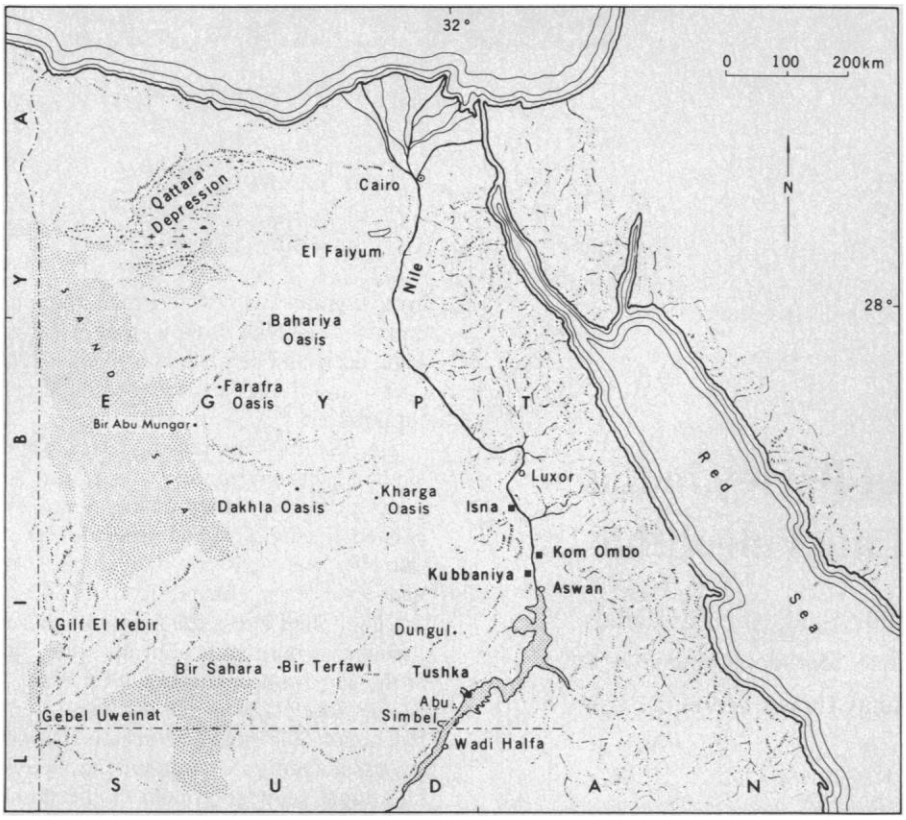

Fig. 1. Map of Egypt showing locations of Tushka, Wadi Kubbaniya, Kom Ombo, and Isna—the four localities where Late Paleolithic grain utilization is known.

coinciding with the beginning of a nearby occupation of the Isnan industry. The dramatic increase in the cereal-type pollen and the synchronous arrival of the Isnan industry might indicate the arrival of food production, or alternatively, it may reflect the effects of human protection of naturally occurring cereals and the elimination of their competition. In the absence of other supporting evidence, this more conservative interpretation was originally favored. Considering the new data from Wadi Kubbaniya, however, it now appears that this may have been too cautious an approach.

Lithostratigraphic Sequence

The recent excavations, which yielded the carbonized remains of barley, are located at a series of Late Paleolithic sites in Wadi Kubbaniya, a major wadi entering the Nile from the west, some 20 kilometers downstream from Aswan. Eight sites were excavated in two areas: one group within the wadi about 2 kilometers upstream from its mouth and the second group at the mouth itself. One of the sites is Aterian (Middle Paleolithic), one is Final Paleolithic (Qadan-related), and the other six are classified as Late Paleolithic.

Wadi Kubbaniya is one of three major wadis that reach the Nile from the southwestern desert. It is the most important drainage feature on the pediplain extending along the west bank of the Nile from southwest of Aswan to Luxor, and it drains most of the area between the river and the Sinn El Kaddab scarp of the Eocene plateau on the west.

The banks of Wadi Kubbaniya are well delineated and stand from 30 to 40 meters above the wadi floor. Sand and gravel remnants of older wadi aggradations are preserved as terraces in several areas, particularly in its lower portion. The Late Quaternary lithostratigraphic sequence consists of a series, more than 20 meters thick, of aeolean and fluviatile sediments resting directly on the eroded surface of these older wadi deposits, the most recent of which contain artifacts of Middle Paleolithic age. Two slightly different sequences are recorded, one near the sites up the wadi and the other near the mouth of the wadi. The former is of interest here. The sequence begins with the deposition of floodplain silts and occasional lenses of inblown dune sand at about 95 meters above sea level (Fig. 2). This complex process of simultaneous dune and silt accumulation continued as the dunes, moved by northerly winds, descended from the scarp. The combination of aeolean action and vegetation growing at the edge of the floodplain resulted in the building of an extensive dune field close to the northern scarp of the wadi, whereas the center of the wadi became a floodplain on which silts were deposited. The level of the Nile continued to rise, and each year the summer floods covered the lower parts of the dunes, leaving silty sediments on their foreset faces. Dense vegetation grew on the dunes close to the water, and extensive remnants of this vegetation still survive in the form of calcium carbonate casts of the lower portions of the buried trunks and roots.

During this time of silt and dune accumulation, the first Late Paleolithic occupants of Wadi Kubbaniya settled on the dunes and on the seasonally dry, sandy floodplain. The settlements in both areas are large, and their artifact densities indicate repeated occupations.

The dune accumulation was continuous throughout the whole period of Late Paleolithic occupation, after which it gradually filled this portion of the wadi, preventing the direct access of the Nile floods to the wadi west of the dune barrier. Seepage from the floods, however, formed extensive ponds behind the barrier, which left diatomites and snail breccias at various elevations, depending on the preexisting surface morphology. Occasional floods were also able to overflow the barrier, and these left thin silt lenses within the diatomites. Significantly, at no point did the wadi contribute any sediments to the accumulating dune, silts, and pond aggradation, which is in accord with the impressive body of evidence indicating that during this time period the entire high desert of Egypt was exceptionally arid and almost certainly drier than today (*6*). The last series of unusually high floods passed over the dune barrier and deposited silts over the diatomites and beyond, to an elevation of about 110 meters above sea level. A few badly destroyed sites, all of them of Final Paleolithic character, occur at this highest water level, resting on dunes (site 10). Although none of these latest sites yielded radiometrically datable material, the associated lithic artifacts closely resemble the Qadan industry of northern Sudan, dated to approximately 10,000 B.C. (*7*). This age would also agree with the evidence from several other areas along the Nile for a series of unusually high floods at about 10,000 B.C. (*8*).

Thereafter, the level of the Nile began to decline, and the complex series of aeolean and riverine sediments that choked the wadi must have stood for a long period as a mass of clays, sands, and silts. This mass was not breached

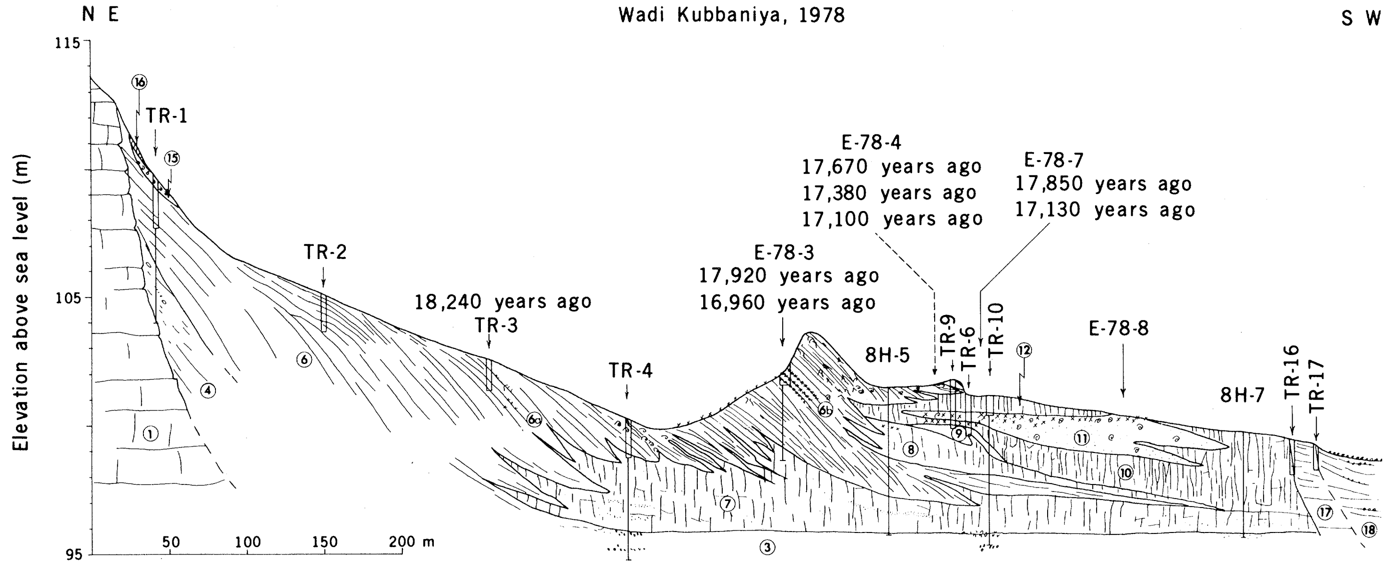

Fig. 2. Cross section through Wadi Kubbaniya. **(1)** Nubia sandstone. **(3)** Wadi sand, gravels, and silts under clastic series in left section of wadi. **(4)** Sandy slope wash, laminated with aeolian sand, pebbles, and angular fragments of Nubia sandstone. **(6)** Aeolian sand dune, progressing from the northern scarp toward the south and contemporaneous with Nile clastic series **(7)**; the dune appears very deflated, reduced in height, and shows almost uniquely foreset beds and foreset slopes interfingering with invading silt layers; the dune contains lenses of charcoal **(6a)** and numerous cultural layers of sites 3 **(6b)** and 4; snails, mostly *Bulinus truncatus*, were noted on foreset, washed slopes. **(7)** Undifferentiated silt and sandy silt bed interfingering with earlier dune. **(8)** Sandy silt and silty sand with clear aeolian sand admixture. **(9)** Coarse to fine, cemented, aeolian sand in slightly silty matrix. **(10)** Lower vertisol clay bed with angular, medium to small, blocky structure, slickensides, isolated sand grains, and rare, crushed bone; cultural material was found throughout trenches 9 and 10 at site 7. **(11)** Fine, cemented, silty sand with large blocky structure, crushed and unidentifiable snails, bone fragments, and rich cultural material (sites 7 and 8). **(12)** Upper vertisol clay with large blocky structure and large pronounced slickensides. **(15)** Light, diatomaceous snail breccia with small crumbly structure; snails mostly *Bulinus truncatus.* **(16)** Thin consolidated brown silt containing numerous *Corbicula* shells. **(17)** Wadi sands and gravels; laminated pea gravel with occasional pebbles and sand mostly of aeolian character. **(18)** Loose, laminated wadi sands and gravels; lithologically similar to **(17)** but separated from it by a cut.

until the wadi became active as a result of local rainfall along with the much lower level of the Nile. Paleoenvironmental studies of the Western Desert indicate that this breaching of the wadi could not have happened prior to an early phase of the Holocene wet period, perhaps not until after 7500 B.C. Since the breaching of the wadi, however, there seem to have been at least two late sand and gravel wadi terraces formed.

At the mouth of the wadi, the Final Pleistocene sequence is less complex and rather monotonous. Here, near the southern bank of the wadi, the silts rest immediately on a Nubia sandstone erosional shelf, while in the center the base was not exposed and is believed to be deeply buried. On the sandstone shelf, the floodplain silts were subjected to seasonal churning processes that resulted in the formation of a vertisol, whereas in the deep center fine fluvial sands and silts were deposited in a small embayment. Along the southern margin of the wadi, aeolean sands from the dune formed a thin bed over the vertisol silts near the maximum of the aggradational event. On this aeolean sand, two Late Paleolithic settlements occurred (sites 5 and 9), roughly contemporaneous with the dune and floodplain sites slightly up the wadi. These settlements at the mouth of the wadi were washed by high Nile floods, which deposited over them a bed of silt. The fine-grained Nile aggradational sediments in the wadi mouth were deeply dissected by the wadi channel when it cut through to rejoin the Nile in early Holocene times.

Associated Archeology

Neither the earliest (Aterian) nor the latest (Qadan-related) site is central to the problem of the use of barley, which is the subject of this article, and discussion of these two sites has therefore been omitted. Our primary interest is with the six Late Paleolithic sites, of which three occur in the dunes and three on the floodplain.

All of the Late Paleolithic sites seem to represent multiple occupations. For the dune sites, this is indicated by the numerous cultural horizons seen on the preserved foreset sections of the dunes. Most of these sites are now heavily deflated and appear as large, dense concentrations of artifacts on the surface, palimpsests of several occupations brought together by erosion. The in situ debris consists of numerous lithic artifacts, faunal remains, charcoal, and burned stones. The floodplain sites are also extensive and contain thick cultural layers; and, while this might seem to indicate large settlements, it is more likely a result of multiple occupations by rather small groups.

The fauna from all sites includes an edible unionid (*Unio abyssinicus*), catfish (*Clarias* sp., which was very frequent), Nile perch (*Lates niloticus*), barb (*Barbus* sp.), various birds that comprised, among others, several winter visitors to Egypt (the analysis of the avian fauna is not yet completed), hippopotamus (*Hippopotamus amphibius*), wild cattle (*Bos primigenius*), hartebeest (*Alcelaphus buselaphus*), gazelle (*Gazella* sp.), and fox (*Vulpes ruppeli*) (*9*). The distribution of the fauna suggests that hunting was practiced at all sites; but fishing, fowling, and shell collecting occur predominantly at the dune sites, which were apparently occupied after the peak of the Nile flood (autumn and early winter). The game animals indicate site catchment areas composed of open grassland very probably with dispersed stands of trees. A lower frequency of hartebeest combined with a higher frequency of gazelle at the floodplain sites may also be indicative of a concentration of game nearer to the river during the low-water period.

The lithics in all of the sites share common technological features and a polythetic range of tools. The technology is based on single and opposed platform bladelet cores, with rare multiple platform cores, and occasional Levallois and Halfan cores. At most sites, the tool structure is dominated by partially backed bladelets, almost exclusively with Ouchtata retouch. Scaled pieces are usually rare to absent, but in one site they are the most frequent tool form. Other tools are elegant burins, rare end scrapers, retouched pieces, notches, and denticulates (Fig. 3). A few simple bone points with cylindrical cross section also occur. Local wadi chert is the most common raw material, but Egyptian flint is present, usually as already finished tools, and seems to have been a prized raw material.

Numerous grinding stones and occasional mortars and pestles are associated with all of the dune sites. The mortars are made on thick, roughly shaped blocks of Nubia sandstone with one or more small (diameter, about 15 centimeters) but deep cuplike grinding concavities. The accompanying pestles are conical, with the working part at the base of the cone. The more common milling stones are also made on Nubia sandstone blocks or slabs, roughly broken to shape, but lacking any consistent shape or form, and with an oval grinding concavity, rather small and not as deep as those on the mortars. The handstones associated with these grinding slabs are for use in one hand and are made of quartz and basalt cobbles selected so as to require a minimum of shaping and have either one or two opposed grinding surfaces. Grinding stones of all types occur rarely or not at all in the floodplain sites.

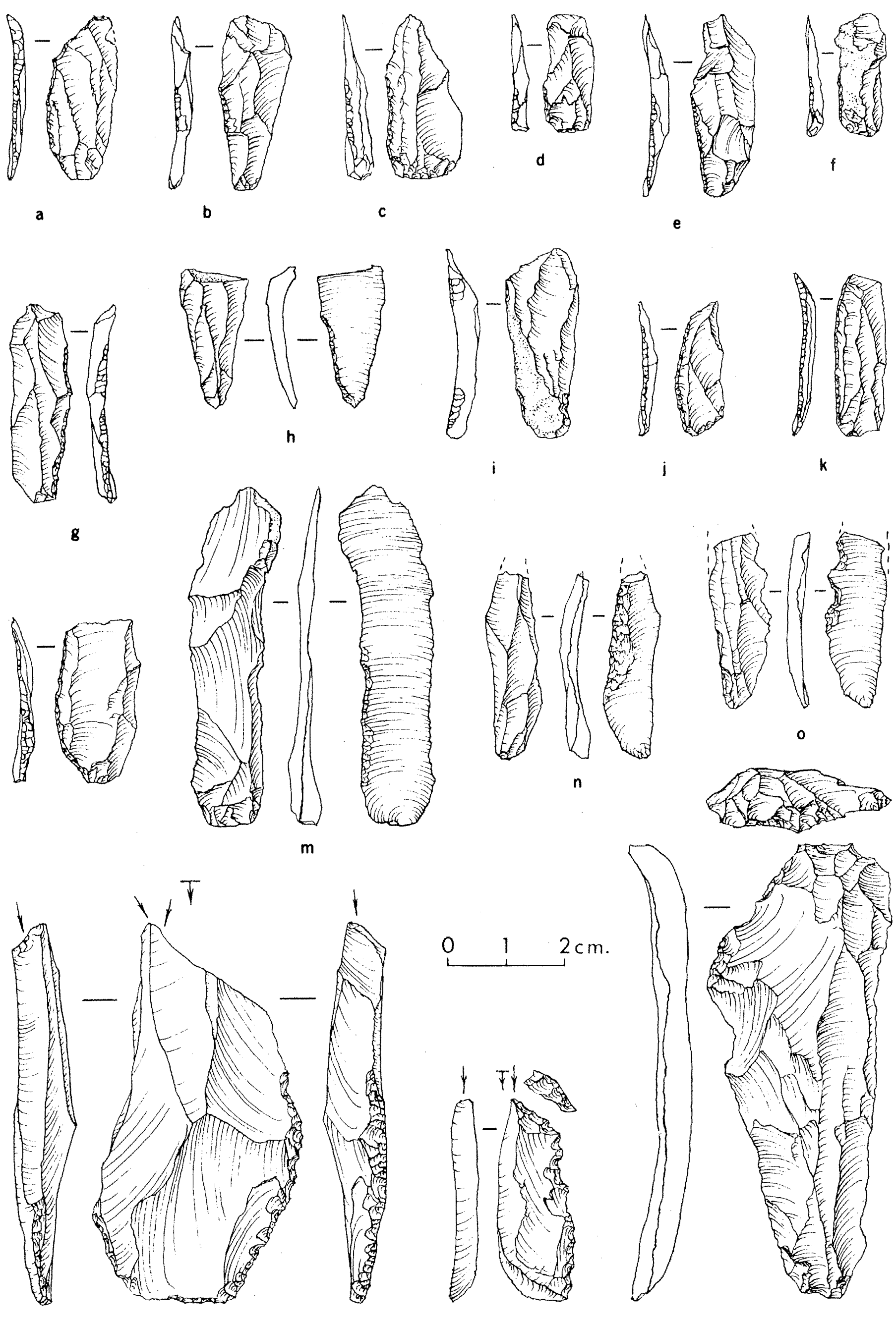

Fig. 3. Tools from site 3, Wadi Kubbaniya. (a) Arch-backed bladelet. (b to i) Partially backed bladelets. (j to l) Blunt-backed bladelets. (m and n) Retouched pieces. (o) Notch. (p) Dihedral burin. (q) Burin on oblique truncation. (r) End scraper on retouched blade.

All of these bladelet sites at Kubbaniya are seen as part of a single taxonomic cultural unit, and reflect an adaptation to this particular microenvironment. Differences between the sites may, to a large extent, reflect seasonal stresses or varying activities. These variations seem particularly significant when viewed with the local environment. The occupations occurred during an early phase of a rising Nile, during which the floodwaters reached up the wadi and deposited silts over the eroded wadi surfaces. These floods created a narrow bay with trees growing around the shores. Simultaneously, the surrounding excessively arid high desert was contributing aeolean sands, and this increasing influx of sand began to be trapped by the vegetation, resulting in the formation of a dune field near the northern bank of the wadi. In years of exceptionally high floods, the dunes were partially submerged, and water from the floods filled both the numerous concavities between the dunes and the wadi bottom behind them. Fish would become trapped in the pools and could easily be harvested after the water receded; all the dune sites give evidence of emphasis on fishing. The topographic lows also remained moist for some time after the very high floods had passed, thus creating a favorable environment where grain could have grown. The dune sites, therefore, contain the grinding stones needed to process the grain.

The floodplain sites, obviously, were occupied only well after the flood had passed and the floodplain had become dry. If the regimen of the Nile was the same then as today, the dune sites would have been used for fishing in late September, and the grains would have been harvested in early winter. The floodplain sites, in contrast, could be occupied only after the waters of the Nile had receded; that is, from November or December to August.

Stylistic analysis of the lithic artifacts, designed to provide a relative measure of social distance between assemblages (*10*), has shown that three of the sites—one on the dune (site 3) and two on the floodplain (sites 7 and 9)—form one cohesive group; a fourth site (site 4) is more loosely linked with this group. The tool samples from the other two sites (sites 2 and 8) were not large enough for stylistic analysis. Surprisingly, there is also near identity in stylistic, typological, and technological features between sites 3, 7, and 9 and site E71K13, near Isna, some 150 kilometers down the valley. This resemblance is further emphasized by the use of Egyptian flint, identical to the most common variety at site E71K13, as an exotic and highly prized raw material at Wadi Kubbaniya (Fig. 3). These links seem to indicate that either the same or closely related social groups were using both of these localities, a particularly interesting suggestion in view of the complete absence of grinding stones at site E71K13. If it was the same group, then this would imply that their territory extended for at least 150 kilometers along the Nile Valley. Rather close stylistic (and typological) similarities were also found between sites 3, 7, and 9 at Kubbaniya and two Halfan sites (sites 443 and 1028) in Sudanese Nubia. The Halfan was approximately contemporaneous with the Kubbaniyan sites; but again, the sites lack grinding stones.

Botanical Remains

Identifiable, well-preserved, carbonized plant remains were recovered from two of the dune sites. In both instances the plant materials occurred as scattered pieces within the several thick, darkly stained, buried occupation layers preserved on the front face of the dunes. The carbonized plant remains were probably not burned; burning temperature would normally be sufficient to remove all crystals from the plant tissue, but oxalate crystals were found, especially in the *Acacia* (*11*).

At site 3, two of the occupation horizons were thicker than the others, and both of these yielded plant materials. The upper one yielded fibrous roots of two categories of unidentified grasses, root fragments of a palm (either date or Dom), wood fragments of a common shrub, *Salsola baryosma*, and bark and wood fragments of *Tamarix* sp., another shrub. The lower occupation horizon contained only well-preserved fragments of palm root. Both *Salsola* and *Tamarix* are frequently used as firewood today.

The plant remains in site 4 were more numerous. The identifiable pieces included several carbonized or charred crumbs of *Acacia*; charcoal and wood fragments from *Salsola baryosma*, *Tamarix* sp., *Acacia*, possibly *A. albida* and *A. seyal*, an unidentified palm; and several carbonized grains of barley, *Hordeum vulgare* L., as follows (Fig. 4):

1) A well-preserved fragment of a fertile glume (lemma) attached to a rachilla of a spike, and a caryopsis (grain). The grain is elongated (5.18 by 1.49 millimeters), closer in this respect to wild than to cultivated barley (Fig. 4a, 1 to 3).

2) A moderately well-preserved grain without glumes. It is plump (5.88 by 2.59 millimeters) and has dimensions resembling many domestic varieties of barley (Fig. 4b).

3) A poorly preserved grain with empty glumes, again with the size and proportions of some domestic barleys (Fig. 4c) (no precise measurements are available).

4) A poorly preserved grain of barley without hull. This specimen is within the size range of the domestic form (no precise measurements are available).

It should be noted that the grains of barley were chemically carbonized (decayed), rather than charred, and still retained intact cell structure. Their sizes and shapes may, therefore, be regarded as essentially undistorted.

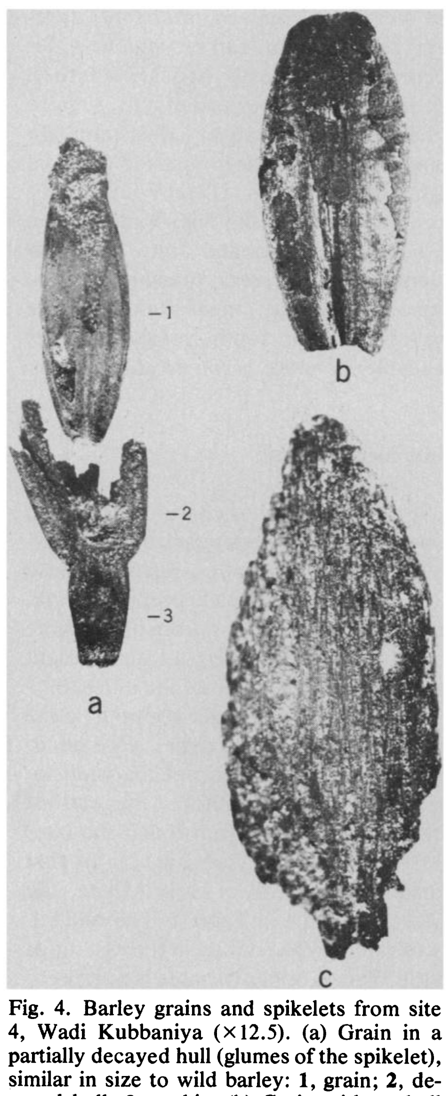

Fig. 4. Barley grains and spikelets from site 4, Wadi Kubbaniya (×12.5). (a) Grain in a partially decayed hull (glumes of the spikelet), similar in size to wild barley: **1**, grain; **2**, decayed hull; **3**, rachis. (b) Grain without hull (probably decayed) similar in size to domestic barley. (c) Spikelet similar in size to domestic barley.

A scanning electron micrograph was used to compare the glume, rachilla, and grain in (1) above with both wild and domestic modern barley (*12*). These photographs show that the portion of the rachis below the spikelets is long and slender and is definitely smooth at the base, indicating formation of an abscission zone as in modern wild barley. However, the region of attachment of the next node of the rachis is rather prominent, which is a departure from the wild type. This may indicate that the barley represents a very early stage in the process of domestication, although further comparative work is needed to clarify this point (*13*).

Barley occurs today in two forms—a wild form, which grows in disturbed habitats in much of the Middle East, and the domestic barley. Both the wild and the cultivated types are morphologically similar and belong to the same cytogenetic stock. The chromosome numbers in all forms are the same: $2n = 14$.

The wild forms, referred to as *Hordeum spontaneum* Koch., are annual herbs with two-rowed spikes. All species of *Hordeum* are characterized by three spikelets at each node of the spike. The lateral spikelets are reduced, male or neuter, while the central spikelet is female fertile and usually bears a caryopsis (grain); these are the two-rowed spikes. However, in many cultivars of domesticated barley, which are now generally accepted as constituting one species (*Hordeum vulgare* L.), the lateral spikelets also are fertile, producing six-rowed spikes.

The differences between wild and cultivated barley are found primarily in the spikelet morphology and, to a certain extent, in the size of the grain. The wild varieties of barley have generally narrower and smaller spikelets, not exceeding 4 millimeters in length and 2 millimeters in width; the spikelet is subtended with a short, brittle rachis and has a smooth base resulting from the formation of an abscission zone to facilitate the release and natural dispersal of the spikelet. The grains tend to be small, but there is a distinct overlap in size category with the domestic variety; they are always enclosed by the lemma and palea, which constitute the hull of the caryopsis (grain).

Cultivars of barley generally tend to have a larger and broader spikelet and a tough rachis. The base of an isolated spikelet would thus have a rough and torn appearance because no abscission

Table 1. Presumed dates and locations of samples from dune sites.

Date (years ago)	Sample	Location
18,240 ± 290	SMU-591, charcoal	Trench 3, 100 to 125 centimeters
16,960 ± 210	SMU-599, charcoal	Site 3, 80 to 100 centimeters
17,920 ± 380	SMU-596, charcoal	Site 3, 10 to 40 centimeters
17,670 ± 250	SMU-616, charcoal	Site 4, 0 to 10 centimeters
17,380 ± 340	SMU-617, humates from SMU-616	Site 4, 0 to 10 centimeters
17,100 ± 540	SMU-623, charcoal	Site 4, 20 to 30 centimeters
17,850 ± 200	SMU-592, charcoal	Site 7, trench 6, cultural layer
17,130 ± 200	SMU-595, charcoal	Site 7, trench 8, cultural layer

zone forms for grain dispersal in domesticated barley. Most cultivars are hulled, but some are naked. The grains are larger than in most wild races, but are smaller than some of those found in the Palestine regions.

The close morphological similarities between wild and cultivated barleys are coupled with tight cytogenetic affinities. The conspicuous differences between the spikes of two-rowed and six-rowed barley are controlled by a single major gene (the V locus). Harlan and Zohary (*14*) are of the opinion that the entire aggregate of cultivated, wild, and weedy forms should be lumped into a single biological species: *Hordeum vulgare*.

In the Middle East, wild barley grows side by side with cultivated barley and, since they are of the same cytogenetic stock, fertile hybrids occur between them. In areas with rich stands of wild barley, this similarity may actually have impeded the process of domestication since the genes for natural dispersal could have been continually transferred back to the populations being raised by man. The areas most favorable for domestication may, therefore, have been those in which wild barley was present (it would otherwise be difficult to domesticate) but was not common.

According to Zohary (*15*), wild barley occurs over a wide area in the east Mediterranean basin and the west Asiatic countries; it penetrates east as far as Turkmenia, Afghanistan, and Tibet. The center of its distribution lies in the "fertile crescent" area, from Palestine and Jordan in the southwest, northward into southern Turkey, and then southeast toward Iraq, Kurdistan, and southwest Iran. Farther west (the Aegean region and Cyrenaica) and farther east (northeast Iran, Soviet Central Asia, and Afghanistan), wild barley is rare and much more sporadic. In these marginal areas, it rarely builds large-scale stands and seems to be restricted to disturbed habitats.

In Egypt, wild barley is reported by Tackholm (*16*) as a rare plant on the Mediterranean coast of Sinai, and recently one of us (N.E.H.) discovered vast natural growths of wild barely in several wadis dissecting the coastal limestone tableland west of Alexandria, some 800 kilometers to the north of Wadi Kubbaniya. The barley is well represented in Wadi Habis and Wadi Um Rahkam where it dominates large-scale stands of annuals, particularly after a comparatively rainy season. These recently discovered stands of wild barley, and presumably those to the west in Cyrenaica, probably represent relics of an earlier, much wider occurrence in North Africa. Where it occurs, wild barley seems to require either winter rainfall or consistent late summer moisture accompanied by cool night temperatures (*17*). Wild barley does not occur in the Nile Valley, even in occasionally flooded dune areas adjacent to the river, presumably because either the night temperatures are too warm (in southern Egypt) or the available moisture is too erratic.

Radiometric Dating

Several samples of charcoal (*18*) were collected from the trenches and pits excavated in the dune sites. Seven of these were processed for radiocarbon dating, and the humate fraction from one sample was also dated, yielding a total of eight dates from three separate localities.

The stratigraphic sequence in the dune field indicates that the dunes were building from the north scarp of the wadi toward the south; therefore, the earliest site should be to the north and the later sites farther south (see Fig. 2). In that presumed order, from early to late, the dates are shown in Table 1. The reliability of radiocarbon dating in the age range of the Wadi Kubbaniya sites is quite sensitive to sample contamination. For instance, the presence of 1 percent foreign matter originating within the last 100 years will shift a true age of 18,000 years to 17,370 years, so that complete removal of all contamination is essential.

The process most commonly used consists of initial acidification to hydrolyze secondary carbonates deposited on and within the sample during burial. This is followed by one or several washings with a weak base solution, such as sodium hydroxide (NaOH), to dissolve humic acids absorbed within the charcoal. A final acidification prevents renewed absorption of carbon from the carbon dioxide content of the modern atmosphere.

The Wadi Kubbaniya charcoal samples SMU 591, 592, and 595 were solid enough to withstand a regular preliminary treatment sequence without decaying. The other samples were crumbly and decayed to a powdery cake when the humate was extracted (with 0.01 to 0.03 percent NaOH solutions), so that a continued loss of sample occurred as the very fine charcoal powder passed through the glass fiber filter. The resultant, continuous dark staining of the filtered NaOH solution meant that completion of the humate extraction could not be detected.

Sample SMU 616 was chosen to demonstrate that the above procedure nevertheless removed all contaminants from the charcoal. An initial humate extraction with 1.2 liters of 0.02 percent NaOH was discarded. An additional extraction with 2 liters of 0.02 percent NaOH was acidified, flocculated, and filtered; the solid was collected and dated (SMU 617). The two dates differ by 300 years and have standard deviations of 250 and 340 years, respectively (*19*).

Conclusions

Several major points emerge from the preceding discussion. First of all, the sites which contained the barley are typical Late Paleolithic occupations, with a lithic technology and typology wholly consistent with the associated radiocarbon dates. The tight clustering of these dates between 18,300 and 17,000 years ago indicates that the Late Paleolithic occupations at Wadi Kubbaniya probably occurred in a 1000- to 1500-year interval when the environmental conditions in the wadi were most favorable for both the harvesting of fish and the growth of barley. The essential question, however, is whether the barley was wild or domestic or in transition from the one to the other.

Wild barley normally grows in conditions of cool evening temperatures and winter rainfall, although theoretically it can occur with summer rainfall provided that the temperatures are sufficiently low. As was noted above, evidence from the Western Desert of Egypt indicates that this entire area was hyperarid during the period in question, so that the only moisture available in the Nile Valley would have been the summer floods, caused by heavy rains in the highlands of East Africa. There is no direct evidence concerning temperatures for this interval, but analysis of the diatom flora from Isna, dated between 12,600 and 12,000 years ago, indicated substantially lower summer temperatures than those of today (*20*); and it is not an unreasonable assumption, in view of the glacial conditions in Europe, that similar cool temperatures may have also existed about 18,000 years ago. It seems likely, therefore, that wild barley may have been present in the Nile Valley.

However, conditions were not ideal for the growth of barley. The annual floods varied considerably in their magnitude, thus only a few exceptional areas could have combined conditions of consistent moisture and suitable sandy soils. Most of the lower floodplain consisted of contracting clays in which wild barley cannot grow.

Wadi Kubbaniya provided the appropriate soils, but most of these soils lacked sufficient moisture, except in the few years of very high floods. Thus, while barley may have been present, the stands would not have been extensive, nor could the conditions have been unusually favorable for its growth and development. It is precisely this condition of variable moisture that is largely responsible for the absence of wild barley today in occasionally flooded dune areas in the Delta where temperatures and other factors are apparently otherwise favorable (*21*). Nevertheless, barley was obviously of importance in the economy of Late Paleolithic groups in Wadi Kubbaniya, indicating a greater availability than could be expected to occur naturally, although there may have been some dispersal of wild barley into the dune areas by the floods themselves. It is not unreasonable, however, to suggest that the available supply of barley may have been enhanced, possibly even by deliberate planting during those years of very high floods. Indeed, this may be indicated by the morphological divergence of one of the Kubbaniya examples from modern wild barley.

Given the limited sample of barley available from Wadi Kubbaniya, it is impossible to establish without reservation whether or not there are genetic differences from the true wild forms of barley. Archeologically, however, this question is of minor importance. A reasonable explanation for the abundance of barley in Wadi Kubbaniya, and for its importance in the economy of the inhabitants of the wadi, is that the barley, whether wild or domestic, flourished there in part through the intervention of man. If so, we may regard Wadi Kubbaniya as an example of an early food-producing society, and the ambiguity of the botanical remains may indicate that it was actually an incipient food-producing society. It is this which is of importance in behavioral terms, for if the Kubbaniya sites represent the first steps toward food production, then this process did not begin under adverse circumstances and did not lead rapidly to major social changes. There is no evidence for an association between this possibly incipient food production and population pressure, climatic deterioration, or other environmental stress.

Stylistic comparisons with other generally contemporary, lithic assemblages elsewhere along the Nile show remarkably close similarities with a site (E71K13) near Isna, some 150 kilometers to the north. There is a reasonable probability that the range of the Wadi Kubbaniya groups extended at least this far along the valley. Other resemblances, but not as close as those with the Isna site, are also seen with some more or less contemporaneous Halfan sites near Wadi Halfa, Sudan. None of these related sites contains grinding stones or other evidence of grain utilization. Wadi Kubbaniya may have been the major focus of this activity during the period in question. Slightly later sites with evidence of a grain-using technology do occur in the valley both to the north and south of Kubbaniya. Thus, the technology, once developed, continued to be used along this portion of the Nile throughout the Late and Final Paleolithic.

Grain was used intensively in the Nile Valley for more than 6000 years after the first occupation of Wadi Kubbaniya (until about 12,000 years ago, the period of the large and numerous Isnan sites) without any evidence for changes in settlement size, population density, or social organization which might have accompanied the development of this new economic resource. Instead, the settlements continued to be small, conventional hunting and gathering remained the basic subsistence activities, and there is no evidence for permanent habitations. Barley appears to have been no more than simply another resource used as part of a broad-based economy. If our interpretations of the Wadi Kubbaniya evidence are correct, then it would seem, in this case at least, that the development of food production was one of the great nonevents of prehistory.

References and Notes

1. F. Wendorf, Ed., *The Prehistory of Nubia* (Southern Methodist Univ. Press, Dallas, 1968), pp. 940-946.
2. K. Butzer and C. L. Hansen, *Desert and River in Nubia* (Univ. of Wisconsin Press, Madison, 1968), p. 114.
3. F. Wendorf and R. Schild, *Prehistory of the Nile Valley* (Academic Press, New York, 1976), p. 291.
4. L. H. Purdy, in *The Prehistory of Nubia*, F. Wendorf, Ed. (Southern Methodist Univ. Press, Dallas, 1968), pp. 934-935.
5. F. Wendorf and R. Schild, *Prehistory of the Nile Valley* (Academic Press, New York, 1976), pp. 73-74.
6. _____, R. Said, C. V. Haynes, A. Gautier, M. Kobusiewicz, *Science* **193**, 103 (1976); F. Wendorf *et al.*, *Geogr. J.* **143**, 211 (1977).
7. J. L. Shiner, in *The Prehistory of Nubia* (Southern Methodist Univ. Press, Dallas, 1968), pp. 535-629.
8. K. Butzer and C. L. Hansen, *Desert and River in Nubia* (Univ. of Wisconsin Press, Madison, 1968), p. 149; J. de Heinzelin, in *The Prehistory of Nubia* (Southern Methodist Univ. Press, Dallas, 1968), p. 47; F. Wendorf and R. Schild, *Prehistory of the Nile Valley* (Academic Press, New York, 1976), p. 280.
9. Faunal analyses by A. Gautier, Geologisch Instituut, Laboratorium voor Paleotologie, Rijksuniversiteit-Gent, Belgium.
10. This technique is described by A. E. Close, [*World Archaeol.* **10**, 223 (1978)].
11. G. E. Wickens, personal communication, 15 December 1978.
12. A. Stemler, R. Falk, N. Hadidi, F. Wendorf, in preparation.
13. A. Stemler, personal communication, 19 May 1979.
14. J. R. Harlan and D. Zohary, *Science* **153**, 1074 (1966).
15. D. Zohary, in *Plant Life of South-West Asia, Origin of South-West Asiatic Cereals*, P. H. Davis *et al.*, Eds. (Botanical Society of Edinburgh, Edinburgh, Scotland, 1971), pp. 235-258.
16. V. Tackholm, *Student's Flora of Egypt* (Cairo Univ. Press, Cairo, Egypt, ed. 2, 1974), pp. 703-707.
17. J. R. Harlan, personal communications, 12 January 1979.
18. The term charcoal in this context includes organic material that was only partly carbonized or altered in the ground by a chemical process not related to heating.
19. All charcoal samples were marginal or small relative to the amount of charcoal needed for a count in 2 or 1.5 milliliters of benzene, the two standard volumes used in scintillation counting at the Southern Methodist University (SMU) laboratory. Net combusted charcoal weights ranged from 1.4 to 4.9 grams. Samples yielding less than the standard volumes were diluted with spectrophotometric benzene (Baker 9155) which is a petroleum derivative free of ^{14}C. The important check date SMU 623 was diluted with benzene synthesized from Pennsylvanian anthracite by the same system as was used with the samples.
20. F. Wendorf and R. Schild, *Prehistory of the Nile Valley* (Academic Press, New York, 1976), p. 72.
21. We are indebted to M. Kassas for this observation, and particularly for his drawing our attention to the adverse effect variable flood levels would have on the growth of wild barley.

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