Prehistoric Agriculture in Highland Yemen: New Results from Dhamar

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Archaeological research to date has taken only small strides toward writing a prehistory of Yemeni agriculture. Several current American projects are addressing this subject; one is Dr. Joy McCorriston's work in Hadhramawt, and another is the Oriental Institute's Dhamar Survey in the western highlands. The latter project, initiated in 1994 by McGuire Gibson and Tony Wilkinson, has the basic objective of tracing the development of the terracing that so distinguishes Yemen's mountain landscape. In its six seasons of work to date, the project has developed a chronology for the area, investigated landscape and climate change over the past 10,000 years, addressed specific problems for the Bronze Age[2] (roughly speaking, 3000-1000 BC), the Iron Age and the Himyarite periods, and recorded South Arabian inscriptions and graffiti, among other topics.[3] In 2001 the authors undertook, as part of this continuing project, excavations at two Bronze Age sites in Dhamar. For the first time in the project, the excavations systematically searched for prehistoric botanical remains, in order to gain information about Bronze Age crops. The following report summarizes the results of work still in progress.

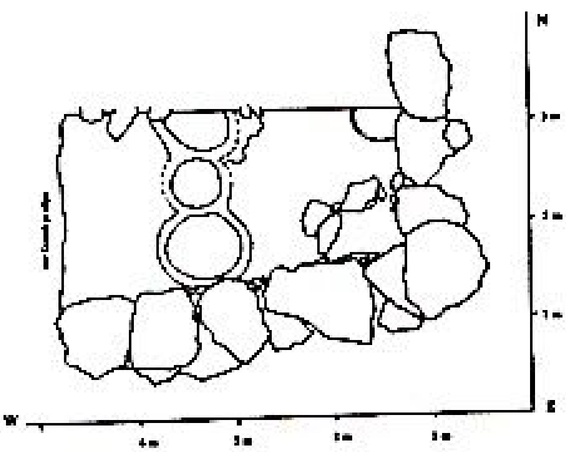

Fig. 1. Hayt al-Suad, the plan of the south sounding, showing the walls and the installations on the floor.

Excavation of Bronze Age Sites in Dhamar, 2001

Extensive excavation at Hammat al-Qaʿ (DS 101; see Wilkinson and Edens, Edens et al. for previous work at this important site) was the original intention of the Bronze Age program in 2001. When unsafe conditions in the local area made this plan impossible, the program selected two alternative sites for excavation, sites that promised to help fill several gaps in information about the Bronze Age and that also are under threat of destruction.

Hayt al-Suad (DS 324)

This site, first recorded during the 2001 survey season, is located at the eastern edge of Qaʿ Jahran. The site covers around 3 ha. on the rising western slope of a volcanic hill that culminates in an abrupt drop on its other three sides. Architecture of several different kinds and dates form clusters up the slope. The architecture across the mid-slope includes rectilinear buildings constructed of large rough stones stacked in courses or laid on edge. Despite presenting features strongly reminiscent of Bronze Age assemblages, the pottery on the surface around these buildings and in nearby ash middens did not fit comfortably with known pottery groups elsewhere in Dhamar. Since basic systematics – chronology and spatial variability – are still a high priority in the project, the site seemed worth investigation.

Recent stone quarrying and associated activities have severely damaged portions of the site through the mid-slope. Here a long quarry cut provided a roughly 30 m. long section through archaeological deposits and into volcanic bedrock. The quarry cut sectioned at least two different architectural units, to the south a building constructed of massive stones, and to the north a wall of more modestly sized stones. After cleaning and drawing these portions of the sections, test excavations made small exposures in each area of architecture visible in the quarry section.

The north sounding (a triangular excavation 2.6 x 2.7 x 3.6 m. in area) exposed the corner of a building

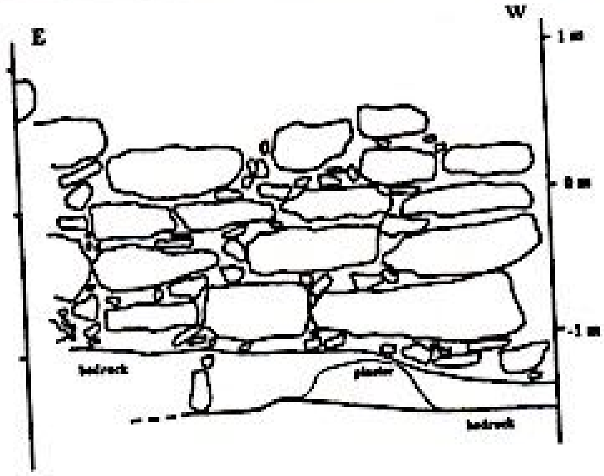

Fig. 2. Hayt al-Suad, the south sounding, the south wall of the room.

or room formed by two unbonded walls built of relatively small stones (generally 30-60 cm. long, 40 cm. wide, and 10-25 cm. high) set in rough courses above bedrock and preserved 1-1.2 m. high. Changes in appearance part way up both walls suggested that the original structure had been rebuilt at some point during its use; the lower (original) and upper (rebuilding) portions of the walls, together with associated soils, define two phases of occupation. An ashy compacted earth resting directly upon the bedrock represented the accumulating 'floor' of the room (?) defined by these walls. A broken cooking jar lay at the bottom of the floor deposit, directly on bedrock. Ashy soil and stone fall separated the latter floor deposit from looser ash deposits that belong to the second, rebuilt phase of the walls. A flimsy cross-wall also belongs to this upper phase.

The south sounding (a rectangular excavation 3.5 x 4.5 m. in area) uncovered a much more substantial structure, the southeast corner of a room the walls of which were constructed of stones up to 1.4 m. long, 1 m. wide and 40 cm. high; these walls still stand 2 m. high (figs. 1 - 2). These walls were erected upon bedrock, which had been cut down inside the room to a depth of 20-40 cm., leaving the walls on a sort of plinth (visible in figs. 2 and 3). The floor of the room, separated from bedrock by a thin band of compact soil, was a plastered surface well-preserved in some parts of the room but eroded in others. The plaster had been renewed at least twice, with a fine ashy silt separating each plaster surface. The room contained several installations: a round bedrock mortar cut into the floor against the east wall; a bin of vertical stone slabs set in the corner of the room; and a pair of plaster-lined circular installations/ovens arranged across the room from the south wall into the north section, with traces of a smaller third plaster installation between them, all built into the plastered floor. A very large grinding stone lay next to the southern oven. Ashy sediment on the floor and around these installations represent occupation debris, which provided relatively small samples of pottery, charred seeds, animal bones, and small finds. A stony silty soil and sloping deposits of rock fall covered the occupation deposit.

Charcoal samples taken from two different components of the occupation debris over the floor in the south sounding returned identical radiocarbon dates that place the building and its contents in the second quarter of the 3rd millennium BC (Table 1; location of dated samples shown in fig. 3). This date matches the oldest dates obtained for Bronze Age settlements in Dhamar and Khawlan (see Edens 1999: 107 for a summary of Bronze Age dating evidence).

Jubabat al-Juruf (DS 269)

Jubabat al-Juruf, recorded during survey in 1998, lies at the eastern edge of the plain around Jabal al-Isi east of Dhamar, on a broad spur that rises gently from the west before dropping off abruptly to the south, east and northeast. The small caves and narrow rock

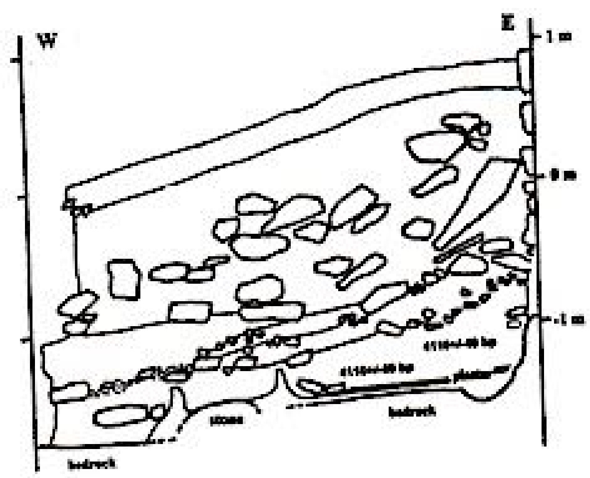

Fig. 3. Hayt al-Suad, the south sounding, the north section with the stratigraphic location of carbon 14 dates.

shelters that give the site its name occur mostly along the base of the cliff-like southern edge of the spur. South Arabian graffiti and rock art (mostly depictions of caprids and camels) appear in numerous locations around the southeastern and eastern edges of the spur, and additional material exists on other rock faces in the vicinity.[4] Modern agricultural terracing, related stone walls, several buildings, and earthmoving by bulldozers have obscured the size and boundaries of the Bronze Age site; the surface architecture remains relatively intact and visible only in a few areas. Bronze Age sites in Dhamar are typically very shallow, but this site held the promise of a deeper accumulation. A deep hole dug by a treasure-seeker revealed 1.4 m. of cultural deposits immediately adjacent to a well-preserved Bronze Age house. This site, therefore, seemed to offer the prospect of obtaining a stratified sequence, despite the heavy surface disturbances.

The sounding, a 7x7 m. square, encompassed the eastern end of the house near the looter's pit and the unbuilt space the north of the building (fig. 4). The house belongs to a standard highland Bronze Age type: a rectangular structure 3.2-3.4 m. wide and running at least 14 m. in length (the arrangement of its western end is not clear) with one and perhaps two cross-walls dividing the interior space into rooms, and a doorway framed by a pair of massive stones set on end within the long north wall. Two additional walls extend from the short east wall of the building, one wall running perpendicular to the east wall, and the other running obliquely from the building's northeast corner.

The remains of the main building within the excavation area proved to be relatively shallow, its walls constructed as a single line of stone slabs laid vertically around the edge of a shallow pit. A dense concentration of small stones, seemingly deliberately laid, but only intermittently preserved, formed the room's floor, 55 cm. below the modern surface. A bench of flat-laid stones, about 1.2 m. long and 25 cm. high, lay against the south wall; a large pottery jar was set at one end of this bench. The doorway in the north wall was fitted with a single flat stone as a threshold, set 5 cm. below the modern surface, with rough stairs of three low treads leading down into the interior of the building. The position of the threshold suggests that the building had been constructed from a surface approximately the same as the modern one, while the nature of the walls, the position of the floor, and the absence of exterior entry stairs all imply that the construction of the building was semi-subterranean. The same construction is also evident in the houses at other Bronze Age sites (e.g. de Maigret 1990, Wilkinson and Edens 1999).

The oblique wall off the corner of the house bordered a pavement of stone slabs 20 cm. below the modern surface; the pavement was exposed only at the eastern edge of the sounding (fig. 4). The pavement is clearly related to the oblique wall, but the temporal relationship between the oblique wall and the house remains uncertain.

The house, as well as the oblique wall and its pavement, had been constructed upon and into the upper layers of stratified deposits that were 2 m. thick (fig. 5). The upper meter of these deposits consisted of almost horizontally bedded ashy sediments that included large amounts of stone and rubble, which often gave the appearance of accumulations on temporary surfaces. A small structure, roughly rectangular in shape, 2 m. on one side and the other side running 70 cm. before disappearing into the section, appeared immediately below the floor of the house, in the lower portions of the horizontal ashy sediments (see figs. 4 - 5). The walls of this structure were oriented parallel to the walls of the upper building, and were preserved to a height of only 30 cm. Small stones and plaster patches marked the small structure's floor, upon which was a soft gray soil distinctive from the compact ashy sediments outside the small structure. The small structure appears to have been a construction not associated with, and older than, the upper building. Although the floor of the upper building could not be traced across the lower structure, the location of the small structure with respect to the upper building (in the center of the upper building, adjacent to the doorway), would make a functional connection between the two structures awkward and unlikely (e.g. the small structure serving as a storage bin within the upper building). More extensive exposure of both structures is needed to decide this question.

The lower meter of deposits, exposed in a limited area outside the house, was much more complex than the upper meter (fig. 5, cf. fig. 4); it contained a circular stone-lined bin or hearth similar to structures recorded at other Bronze Age sites (de Maigret 1990, Wilkinson et al. 1997), several small pits dug into existing ashy

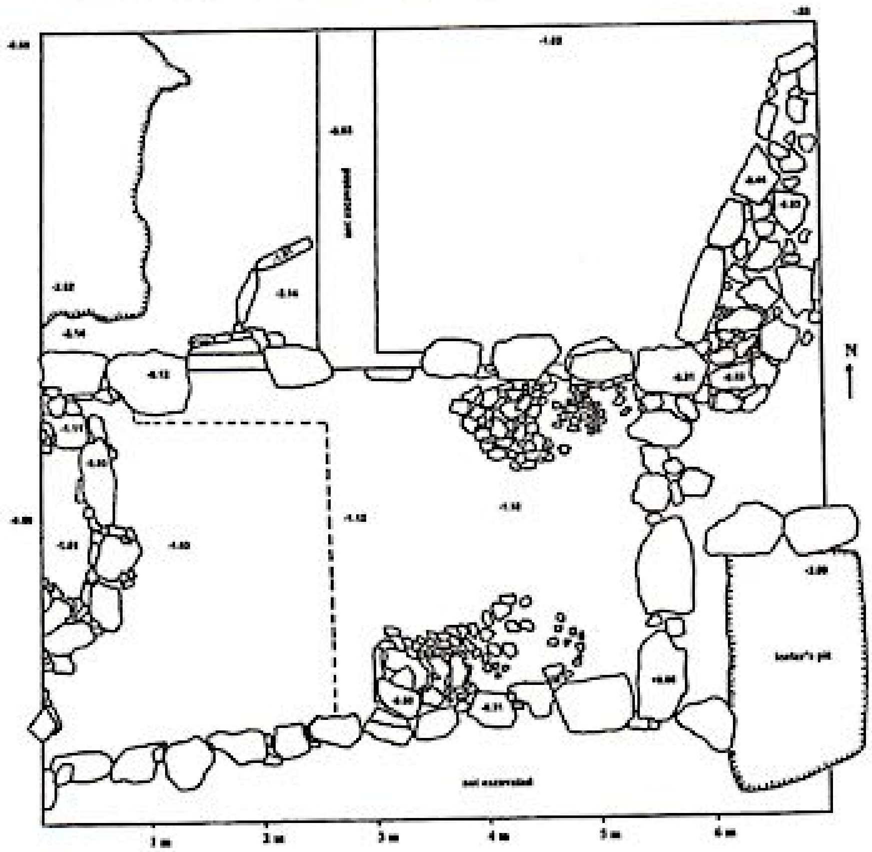

Fig. 4. Jubabat al-Juruf, the final plan of the sounding (with elevations).

and earthy deposits, and a wide shallow pit (well over 2m across but only 65 cm. deep). The bottom half of the latter pit contained four sets of alternating plastered surfaces and ashy soil, each set around 5-10 cm. thick; the ashy soil contained numerous charred seeds and other botanical remains. The function of the pit is unclear (a storage function seems unlikely because of the pit's shape).

Four radiocarbon dates coherently anchor this sequence in time (Table 2; see fig. 5 for stratigraphic location of two dates). The two oldest dates represent charcoal samples taken from a sediment into which the large pit was dug (Locus 3-34, 1.4 m. below the modern surface) and from the sediment that accumulated above this same large pit (Locus 3-24, 1.3 m. below the modern surface). The two dates (Beta-167970 and Beta-167969) present a slight chronological inversion, but are virtually identical; both refer to the final three centuries of the 4th millennium BC. The large pit, and the rich botanical samples it contains, must be assigned a similar date. The next date in the stratigraphic sequence is from Locus 1-18, a sediment unit immediately outside the small structure beneath the house, .8 m. below the modern surface; this date (Beta-167967) refers to the second quarter of the 3rd millennium. The fourth date comes from the sediment (Locus 3-6) immediately above a surface-like accumulation of stones, .6 m. below the modern surface; the date (Beta-167968) falls in the third quarter of the 3rd millennium. The house at the top of this sequence is not radiocarbon dated (a sample submitted for dating proved to be unusable). The pottery from the house and from the site's surface, however, bears a strong resemblance to pottery from Khurayb (DS 228), which has been assigned to the second half of the second millennium BC.[5] In other words, the 2 m. of stratified deposits at Jubabat al-Juruf represent at least 800 years, and perhaps as much as two thousand years, of accumulation. The earliest dates at Jubabat al-Juruf are the oldest yet obtained for a Bronze Age site in Dhamar, and are matched only by a set of dates from the Radman area (Ghaleb 1990).

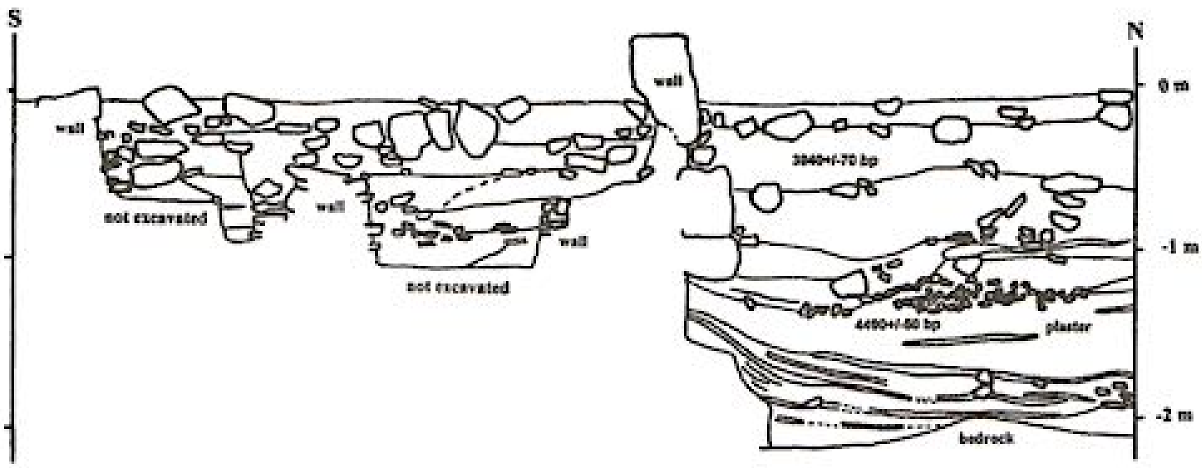

Fig. 5. Jubabat al-Juruf, the west section showing the upper building, the lower structure and the stratigraphic location of two carbon-14 dates.

General Results

The excavation results confirm that the highland Bronze Age patterns of architecture and pottery use were firmly in place already by the final quarter of the 4th millennium BC; analysis of the botanical samples reported below also confirm agriculture by the same time. In this respect, Yemen now matches southeast Arabia, where agriculture and, hesitantly, pottery use also appeared near the end of the 4th millennium BC (see Cleuziou and Tosi 1989 for late 4th millennium developments in southeast Arabia). The pottery and other finds from these excavations will be published in detail elsewhere, and the following passages merely highlight the more significant aspects before turning to the botanical remains.

Pottery-use seems well established at both sites, so the technological transition, and the social changes correlated with it, between aceramic and ceramic highland cultures must be sought in the mid-4th millennium. The pottery at Jubabat al-Juruf shows significant formal and decorative changes through the sequence. Pottery at the top of the sequence bears a resemblance to the Khurayb assemblage, but pottery from the mid-upper sections of the sequence is distinct from the coeval assemblages at Sibal, a mere 10 km. away, and at the more distant Hayt al-Suad. The pottery from the latter site includes several examples of simple designs executed in dull red paint, the first examples of painted decoration found in Dhamar. These observations show that sub-regional stylistic variation in Bronze Age material culture was already well established by the middle of the 3rd millennium, and probably earlier.

Both sites produced samples of beads and other ornaments. Carnelian was a favored material for the small (on the order of a half centimeter across) flat disc beads found at both sites, and was also used for a pendant from Jubabat al-Juruf. The use of carnelian is hardly surprising, given that carnelian is relatively common in the volcanic landscape (the famous ʿAns sources of carnelian are only 60 km. away), and that carnelian beads are occasionally reported from neolithic and BA sites in the western highlands. More significant is the recovery in the deeper levels at Jubabat al-Juruf of production debris – small nodules and flakes of carnelian plus several chipped rough-outs of beads that split during drilling and before polishing. The Jubabat al-Juruf production evidence is too scant to qualify as workshop debris, but is does mark the first documentation of craft activity within a highland Bronze Age settlement.

The other common small find at both sites are 'microbeads' – short tubes 2-3 mm. across and 2 mm. high, made from an unidentified white material apparently by cutting a longer tube into sections. Similar beads, made from a white composite material, perhaps baked chlorite, are recently reported from early 3rd millennium BC tombs at Jabal Jidran north of Marib (Braemer et al. 2001:34), and these microbeads are extremely common in 3rd millennium tombs in the Emirates and Oman, where the material is variously identified as serpentinite (Benton 1996:113) or talcose steatite (Frifelt 1991:114). The strong formal and technological similarity between the Yemeni and southeast Arabian beads adds to the slowly growing evidence for early links across southern Arabia (e.g. Newton and Zarins 2001, Vogt 1999).

A fragmentary stone ring found at Jubabat al-Juruf also deserves comment. The ring, estimated to have been about 3 cm. across, with a flat bottom, gently curved vertical outer face, and narrow rounded top, is similar to somewhat larger rings made of siliceous stones, marble or quartzite found in several neolithic sites of Yemen (Kallweit 1996, Fedele 1986, diMario 1989). The Jubabat al-Juruf example suggests that these rings – previously thought to be an exclusively neolithic product – continued to be used into the early phases of the Bronze Age.

Metals continue to be elusive in Bronze Age residential sites. Hayt al-Suad provided a fragment of a square-sectioned copper awl, found on the surface of the ash-midden at the northern edge of the site. Although similar to a piece attributed a Bronze Age date in Khawlan (de Maigret 1990: 22, fig. 83a), this surface find cannot definitively be assigned a Bronze Age date. Jubabat al-Juruf provided two pieces of metal, both from uncertain contexts, one a bit of sheet copper found just below the modern surface, and the other a small corroded lump from an animal burrow. None of these finds contribute to the still scant evidence of metal-work in prehistoric Yemen.

Early Agriculture in Dhamar

One frequently remarked feature of the archaeological record of the Arabian peninsula, including Yemen, is the scarcity of charred seeds and other plant parts in archeological sediments. Prior efforts to recover botanical samples in Dhamar had been rudimentary, and failed. The shallow deposits that are characteristic of Bronze Age sites in the highlands probably discourages the preservation of charred plant remains at most sites in the region.[6] Hayt al-Suad and Jubabat al-Juruf are unusual for their deep deposits, and the richness of the botanical samples from these settlements seems also to be unusual. There are over 1400 charred plant remains from Hayt al-Suad; the sample of 82 specimens from Jubabat al-Juruf presented here is but a tiny fraction of the total sample from this site. The samples were recovered using a Siraf-type flotation system, the light fraction collected in 500 µm and 250 µm sieves. Flotation samples were taken systematically from recognized stratigraphic units, with supplemental samples also taken from potentially rich contexts.

Crop plants

Domesticated cereals and legumes represent the crop plants. Among the cereals, barley (*Hordeum vulgare*) predominates, with several kinds of wheat (*Triticum durum/aestivum*, *T. monococcum*) also appearing. In the sample analyzed to date, barley outnumbers the wheats by a ratio of over 6:1 at Hayt al-Suad but is close to 1:1 in the much smaller analyzed sample from Jubabat al-Juruf. Panic grass appears in Jubabat al-Juruf sample, several examples of which appear to be broomcorn millet (*Panicum miliaceum*).[7] The samples also contain a large amount of other cereal plant parts, including rachises that can be identified to genus; here the barley predominates even more strongly.

The domesticated legumes are represented by the common lentil (*Lens culinaris*) along with specimens of several kinds of pea (*Pisum* sp., and *Lathyrus* or *Vicia* sp.), and chickpea (*Cicer arietinum*), plus a substantial number of fragmentary large legume fragments.

Wild plants

Wild or probably wild plants are far more abundant, but much less identifiable to genus or species than are the domesticates. The most frequent are small legumes; one unidentified species accounts for nearly 90% of this group, and a probable *Medicago* sp., a *Trigonella*-type (i.e. the genus that includes fenugreek), and an *Astragalus*-type also occur. Wild grasses are also common, with at least four different forms being distinguishable, among them a *Phalaris*-like type (accounting for two-thirds of this sample) and a *Setaria*-type; panic grasses may also occur (see n. 8). *Carex* sp., a grass-like rhyzomatous herb of the Cyperaceae family, probably also occurs. Four different types of Compositae form another significant contribution to the sample.

At least eight families of other herbs and shrubs make less frequent contributions to the sample, among them Ranunculaceae (*Ranunculus*), Amaranthaceae (*Amaranthus*), Chenopodiaceae (*Chenopodium*), Caryophyllaceae (*Silene* and *Gypsophila*), Polygonaceae (two types of polygonum, *Rumex*), Malvaceae (*Malva*), Boraginaceae (*Alkanna* and *Arnebia*), and Plantaginaceae (*Plantago*). Some of these plants were probably collected for human consumption[8] or for animal fodder, while others may have been valued for medicinal or other qualities.[9]

Several fruits – fig (*Ficus*) and eleven specimens tentatively identified pear (*Pyrus*) – along with fragments of unidentified nut shells, also appear. Edible wild species of fig exist in southwest Arabia, but pear is not indigenous to the region and its appearance here at such an early date would, if confirmed, make a significant contribution to the history of the species.

Discussion

These first results from the on-going botanical analysis of the Dhamar samples bear important similarities with, and obvious difference from, the sample of plant impressions in Bronze Age pottery from Khawlan and Hada (Costantini 1990). In both sets of samples, barley and wheat provide the majority of domesticated cereals, although with somewhat different species identification.[10] Broomcorn millet, if these are not in fact a wild panic grass, makes a minor appearance in both areas. The Dhamar samples, however, lack the oats (*Avena* sp., several wild species of which are indigenous to Yemen; Wood 1997:350) and, more importantly, the sorghum (*Sorghum bicolor*) identified in the Khawlan samples.[11]

In other respects the two sample sets differ significantly, hardly surprising given the differences in sample sizes (120 impressions in pottery from Khawlan, around 1500 charred plant remains in Dhamar). The Khawlan samples lack entirely the domesticated and wild legumes, the variety of wild grasses (*Tragus* (*Cenchrus*) *racemosus* is identified in Khawlan but not in Dhamar) and the other plant families that are so important in the Dhamar samples. The Dhamar samples are missing the date palm (*Phoenix dactylifera*) stones that appear twice in Khawlan, but this difference is not surprising because the date palm does not thrive in Dhamar's altitude and winter cold. The Dhamar samples are also missing the cumin (*Cuminum cyminum*) that figures as a minor element in the Khawlan sample.

The Dhamar Survey had in previous seasons made significant discoveries pertaining to early agriculture in the Yemeni highlands. Terrace construction for agriculture appears to have a deep history in southwest Arabia. A correlation in space between remnant terraces and Bronze Age settlements, and the extremely eroded condition of these terraces, strongly suggests that terracing was a regular feature of Bronze Age agriculture in Dhamar (Wilkinson and Edens 1999:5). A radiocarbon assay on charcoal from a soil associated with a terrace buried under six meters of silt in the valley floor near Sedd adh-Dhra' indicates that terracing may have begun by early in the 4th millennium BC (Wilkinson 1999). Elsewhere, Kallweit (1996:166) reports relic terraces in Wadi Dhahr, immediately north of Sana'a, of probable Bronze Age date.

The new archeobotanical results from Dhamar add to the previous Khawlan evidence to give a clearer picture of the crops grown on these terraces. Quite clearly agriculture depended on a typically Near Eastern suite of crops – 6-row barley, bread wheat, lentils, and other legumes – which was introduced to the Yemeni highlands by the last quarter of the 4th millennium BC. In addition to growing these crops, Bronze Age communities also collected a wide variety of wild plants, including figs, nuts, wild legumes, grasses and grass-like herbs. The high barley : wheat ratio found in both the Dhamar and the Khawlan samples is a feature of the traditional crop suite in Yemen, as a response to risk; barley is preferred over wheat under conditions of relatively low rainfall and high inter-annual variability of rainfall; barley is also more cold-tolerant than wheat, an important consideration for a winter crop in the highlands.

The scarcity of identified sorghum, relative to barley and wheat in Khawlan, and sorghum's absence from the Dhamar samples, strongly suggest that if sorghum did in fact have a place in Bronze Age agriculture in the Yemeni highlands, it was not yet the principle crop that it later became. Based on his sorghum identification,[12] Costantini (1990:199) raised the possibility of Bronze Age farmers growing two crops a year. With sorghum at best a minor crop, however, barley and wheat were surely the major summer crops, to take advantage of spring and late summer rains; indeed, barley and wheat may not have been grown over the winter which, in the traditional highland agricultural system, is a minor and usually 'wet-year' season. In other words, the traditional crop preferences and schedule of the western highlands had not yet taken shape by the end of the 3rd millennium BC.

The absence of sorghum in the Dhamar samples analyzed so far may also have wider implications. The early history of sorghum cultivation and domestication remain shrouded in uncertainty. The species has an African origin, and communities in northeast Africa consumed wild sorghum as long ago as 8500 bp. But the earliest evidence of domesticated sorghum in Africa is only two thousand years old, whereas domesticated sorghum is known from sites in northwest India and Pakistan from around 2000 BC. In the latter area, moreover, two other African crops also make an early appearance, finger millet during the second half of the 3rd millennium BC, and pearl millet by around 2000 BC (see Meadow 1996:399-401; Weber 1998). In addition, early domesticated sorghum is reported from two locations in southern Arabia, at Hili 8 (Abu Dhabi) in late 4th millennium and mid-3rd millennium BC contexts (Cleuziou and Costantini 1980, 1982), and at two sites in Khawlan (Yemen) dated to the second half of the 3rd millennium BC. Many pre-historians argue for the transmission of sorghum, and of finger millet and pearl millet, from northeast Africa across southern Arabia and into the Indian subcontinent during the 3rd and early 2nd millennia (e.g. Meadow 1996, Weber 1998, Tosi 1986). In this scenario, the morphological changes of domestication did not occur until sorghum was introduced to non-native regions such as Yemen during the 4th-3rd millennium BC (e.g. Haaland 1996). Other observers, however, suggest that many identifications of these African crops in Arabia and the Indian peninsula are in fact mistaken, and point out that sorghum does not appear in the growing number of archaeobotanical samples from eastern Arabia, and that neither pearl millet nor finger millet are reported from anywhere in prehistoric Arabia. In other words, the question is not settled.

The failure, thus far, to identify sorghum in Dhamar despite the rich samples of charred plant remains, poses a problem. There are several possibilities to consider:

1. since the Dhamar samples are older than the Khawlan evidence (late 4th millennium to mid-3rd millennium versus second half of the 3rd millennium BC), the evidence might be taken at face value as recording the arrival of sorghum in the Yemeni highlands around the middle of the 3rd millennium; or,

2. Costantini's sorghum identifications may in fact be incorrect, and the species may not have been present at all in the western highlands of Yemen during the 3rd millennium BC.

In either case, of course, sorghum and the two African millets may have been present along the coast, where taphonomic difficulties make bleak the prospect of recovering prehistoric botanical samples, except perhaps from deep shell-middens. Only considerably more research, and re-examination of the Khawlan impressions, can settle these questions.

Notes

1. The authors thank AIYS for a research grant to Ekstrom and for providing research funds to Edens; both were funded from AIYS' funds from the U.S. State Department's Bureau of Educational and Cultural Affairs. The co-author, Chris Edens, is also grateful that AIYS gave him flexibility in his Institute duties in Sana'a. Thanks also to: Tony Wilkinson for including us in the Dhamar Survey; Dr. Yusuf Abdullah, then director of the General Organization for Antiquities and Museums (GOAM), for permitting the excavations; Mr. Jamal Muhammad Thabit and Mr. Ahmad Haidary for representing GOAM during the field work; Mr. Ali Sanabani, head of GOAM's local office, for his assistance in Dhamar; Dr. Bakiye Yükmen and Ms. Lamya Khalidi for assisting in the excavations; Dr. Joy McCorriston and Dr. Naomi Miller for advice on plant identifications.

2. The "Bronze Age" is a purely conventional term in Yemen, and one fraught with ambiguity: very few metals are reported from "Bronze" Age sites, and the culture-complex found along the coast around Aden and in Tihama extended well into the 1st millennium, i.e. overlapped significantly with the "Iron Age" as identified in other parts of Yemen.

3. Among the project's publications are the following: basic field reports, Gibson and Wilkinson 1995, Wilkinson et al. 1997, Wilkinson and Edens 1999; landscape, climate change, and early terracing, Wilkinson 1997, 1999; Bronze Age pottery and settlement, Edens 1999, Edens et al. 2000; Iron Age/Himyarite architecture: Barbanes 2000).

4. Mr. Jamal Thabit recorded and photographed several dozen of these localities on behalf of GOAM. Among the graffiti are several executed in the cursive script that normally was used for inscribed sticks; de Maigret (1986) reports a similar site at Ghaha al-Harb, north of Jabal al-Isi. Their orthographic characteristics place most if not all the graffiti

in the last half millennium of the South Arabian civilization; the corresponding settlement has not been located.

5. This dating for the Khurayb pottery is based on two of the four radiocarbon dates available from the site. These two dates are from contexts containing the pottery characteristic of the site. The other two radiocarbon dates from Khurayb are far older, and match the range now obtained from Jubabat al-Juruf. But the pottery through most of the stratigraphic sequence at Jubabat al-Juruf is distinct from the Khurayb assemblage, an observation that appears to confirm the interpretation that the two older Khurayb dates refer to earlier occupation at that site (less than 5km separates the two sites, and intraregional variation seems an unlikely explanation of the ceramic differences; see Edens 1999 for details).

6. Various alternative interpretations may be offered the scarcity of archaeobotanical remains across Arabia (e.g. Nesbitt 1993, Willcox and Tengberg 1995; see also Young and Thompson 1999), among them the practices of the communities responsible for the archaeological record (e.g. consumption of relatively little plant material, processing plants in ways not conducive to charring, processing plant at locations distant from settlements, routine disposal of refuse outside of settlements), depositional factors (e.g. extremely slow deposition rates that allowed charred plant remains to break down before burial), and post-depositional factors (e.g. destruction as salt and gypsum crystals formed in charred plant remains, due to high evaporation rates).

7. The seeds seem identical to specimens from Khawlan that Costantini (1990) identifies as *Panicum* cf. *miliaceum*. However, several wild species of *Panicum* occur in Yemen, and Costantini hedges his identification; the identification of this species at Jubabat al-Juruf is therefore provisional, and they may prove to be wild panic grass(es). *P. miliaceum* is a domesticate thought to be of (East) Asian origin.

8. Chenopods and amaranths made important contributions to prehistoric diets in many parts of the world, and two species of *Amaranthus* were once cultivated in Yemen (Wood 1997: 87); *Malva parviflora* is still used today to make the slimy but delicious dish *mulukhiyya* (Varisco 1982: 490).

9. *Alkanna*, *Rumex*, *Malva*, and *Plantago* appear in the traditional Yemeni pharmacopoeia (Schopen 1983: 5-6, 104-5, 116; Varisco 1982:490) The root of *Arnebia* produces a purple dye (Wood 1997: 242).

10. 2-row barley appears in Khawlan and not Dhamar, but 6-row barley is the most common form in both areas; emmer is as frequent as hard/bread wheat, and einkorn is not reported, in Khawlan, whereas in Dhamar hard/bread wheat is the most common wheat, emmer absent, and einkorn makes a hesitant appearance.

11. A hedging of bets is required for the absence of sorghum from the Dhamar samples. All these samples include vesicular cereal fragments, some of which (particularly those from Hayt al-Suad) have a very "glossy" appearance. Experimental charring of modern sorghum at high temperatures shows that sorghum chars to a very "glossy" appearance, presumably a consequence of its high starch content. Further work on this identification problem may clarify the question.

12. Costantini reports as *Sorghum* sp. four grain impressions from two sites dated to the later centuries of the 3rd millennium BC. Although entertaining no explicit reservation about his identification, Costantini (1990: 193, 195) does state that two of the impressions are unusually large and refers to a third impression as "cf. *Sorghum* sp."

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Table 1: Radiocarbon Dates from Hayt al-Suad*

Lab#	Context	Radiocarbon Age	2-Sigma Calibration	Probability Distribution within 2-Sigma Range
Beta-156626	HS-S 15	4110+/-40 bp	2870-2470 calBC	.19 2870-2810 calBC .69 2760-2560 calBC
Beta 156625	HS-S 18	4110+/-40 bp	2870-2470 calBC	.19 2870-2810 calBC .69 2760-2560 calBC

*Radiocarbon age corrected for isotopic fractionation; calendrical calibration according to CALIB 3.0.3, rounded to the nearest decade.

Table 2: Radiocarbon Dates from Jubabat al-Juruf*

Lab #	Context	Radiocarbon Age	2-Sigma Calibration	Probability Distribution within 2-Sigma Range
Beta-167968	Loc. 3-6	3940+/-70 bp	2620-2200 calBC	.98 2580-2200 calBC
Beta-167967	Loc. 1-18	4120+/-40 bp	2880-2490 calBC	.21 2870-2810 calBC .68 2760-2570 calBC
Beta 167969	Loc. 3-24	4490+/-50 bp	3360-2920 calBC	.95 3350-3020 calBC
Beta 167970	Loc. 3-34	4470+/-40 bp	3350-2920 calBC	.94 3340-3010 calBC

* Radiocarbon age corrected for isotopic fractionation; calendrical calibration according to CALIB 3.0.3, rounded to the nearest decade.

Table 3: Identification of Charred Plant Remains from Dhamar

	Hayt al-Suad	Jubabat al-Juruf
Crop Plants:		
Hordeum vulgare	44	3
Triticum durum/aestivum	5	0
Triticum monococcum	1	0
Triticum sp.	1	2
Panicum miliaceum	0	2
cf. Panicum	0	6
Lens culinaris	44	6
Lathyrus/Vicia	2	1
Cicer arietinum	1	0
Pisum	3	0
large legume frag.	149	40
indet. cereal caryopsis	64	15
Hordeum rachis	40	0
Triticum rachis	3	0
indet. cereal rachis	1	0
indet. cereal rachis	62	1
spikelet fork	3	0
indet. Graminae part	14	0
Wild Plants:		
Small Legumes		
cf. Medicago	38	0
Trigonella type	4	0
Astragalus type	5	0
Unknown #1	37	0
Unknown #2	691	3
Graminae		
Setaria type	6	1
Unknown grass #1	18	0
Unknown grass #2	8	0
Unknown grass #3 (Phalaris-like)	112	0
indet. wild grass	28	1
Compositae		
Unknown #3	66	0
Unknown #4	1	0
Unknown #5	3	0
Unknown #6	3	0

Other Families:		
Ficus	7	0
Alkanna (silicified)	1	0
Arnebia (silicified)	2	0
Amaranth	1	0
Chenopodium	22	1
Silene	1	0
Gypsophilia	21	0
Ranunculus	1	0
Polygonum #1	12	0
Polygonum #2	1	0
Malva	1	0
Plantago	1	0
cf. Carex	3	0
Rumex	2	0
Other:		
Nut/fruit frag.	21	0
Misc. plant parts	3	0