

THE USE OF DUNG AS FUEL : AN ETHNOGRAPHIC EXAMPLE AND AN ARCHAEOLOGICAL APPLICATION

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ABSTRACT. — Modern plant use and garbage disposal practices in an Iranian village were observed in order to provide a framework for the interpretation of plant remains from ancient Malyan, a third millennium B.C. urban center in southern Iran. The ethnoarchaeological model suggested that many carbonized seeds originate in dung cake fuel. By applying this proposition to the archaeobotanical material from Malyan, it was possible to corroborate the evidence provided by the independent charcoal analysis for progressive deforestation during the third millennium.

RÉSUMÉ. — Une étude des différentes utilisations de plantes et des pratiques d'enlèvements d'ordures dans un village iranien sert de cadre pour une interprétation des résidus végétaux recueillis à Tepe Malyan, centre urbain du 3^e millénaire du sud de l'Iran. Le modèle ethnoarchéologique proposé suggère que beaucoup de graines carbonisées proviennent du combustible (pains d'excréments animaux). En appliquant cette proposition au matériel archéobotanique de T. Malyan, il devint possible de corroborer ces résultats à ceux obtenus indépendamment par l'analyse des restes de charbons de bois qui indiquent un déboisement continu au cours du 3^e millénaire.

In recent years, the systematic search for botanical remains from archaeological sites has become standard practice because paleoethnobotanical data provide direct evidence for ancient environmental conditions, diet, and economy. Unfortunately, it is difficult to relate this evidence to the sociocultural system in which the plants were used, so our ability to interpret the data lags behind our recognition of its importance.

Insofar as paleoethnobotanists are concerned with how plants were integrated into ancient cultural systems, we must answer two important questions. First, we must distinguish the cultural and natural processes which brought particular plant remains to their loci of discovery. Second we must establish how, if at all, the plant remains and quantities thereof reflect ancient economic or environmental conditions. To help make the connections between the archaeological record and its interpretation, a variety of bridging arguments is necessary (1). A knowledge of modern environmental conditions is of course extremely useful, especially in areas and for time periods in which economic regimes similar in at least some ways to today's exist. Relevant ethnographic information can also be used to help interpret the archaeobotanical record. For example, one can trace the paths through which items extracted from the natural environment pass, from entry into the sociocultural system to final archaeological deposition (2). Inferences about the sociocultural aspects of plant use must then be drawn from the points at

which these objects become incorporated into the archaeological record. Although the pattern of distribution of plant remains on a site is difficult to discern, we expect it to bear some interpretable relation to the cultural context of plant use. This study is primarily concerned with how seeds became charred at the third millennium B.C. site of Malyan, Iran. Consideration will be given to aspects of the quantitative analysis of charred seed remains as well.

THE ARCHAEOLOGICAL PROBLEM

Malyan was a major urban center in the Kur basin of southern Iran during the third millennium B.C. (fig. 1) (3). It has been identified as Anshan, known from texts to have been the highland capital of the Elamite state (4). The site was first occupied in Proto-Elamite times (Banesh period, 3200-2600 B.C.), and seems to have been the population center in the valley. During the Kaftari period (2400-1800 B.C.), the city more than doubled in size. On the basis of settlement pattern studies (5) major demographic and sociocultural changes seem to have occurred between the Banesh (3200-2600 B.C.) and Kaftari (2400-1800 B.C.) periods. In particular, population in the Kur basin is estimated at 5650-11,300 in the Banesh period and 13,000-26,000

(3) SUMNER, 1974, 1975; NICHOLAS, 1981; NICKERSON, 1983.

(4) HANSMAN, 1972; REINER, 1974; VALLAT, 1980.

(5) SUMNER, 1972; ALDEN, 1979; NICHOLAS, 1980; NICKERSON, 1983.

(1) e.g. SCHIFFER, 1976 : 11-18; BINFORD, 1978 : 1-6.

(2) HILLMAN, 1973 : 241-244, 1981; DENNELL, 1978.

during Kaftari times. Most people lived at Malyan during Banesh times (population ca. 4500-9000); by Kaftari times, about half the population of the valley lived in the city, and the rest were living in smaller towns, villages and hamlets (6). It seemed likely that population growth and reorganization of settlement would have had some impact on land use in the valley. The goal of the paleoethnobotanical analysis was to provide as complete a reconstruction of the environment and economy of Malyan as was permitted by the botanical data, and to trace changes in land use that may have occurred during the Banesh and Kaftari periods.

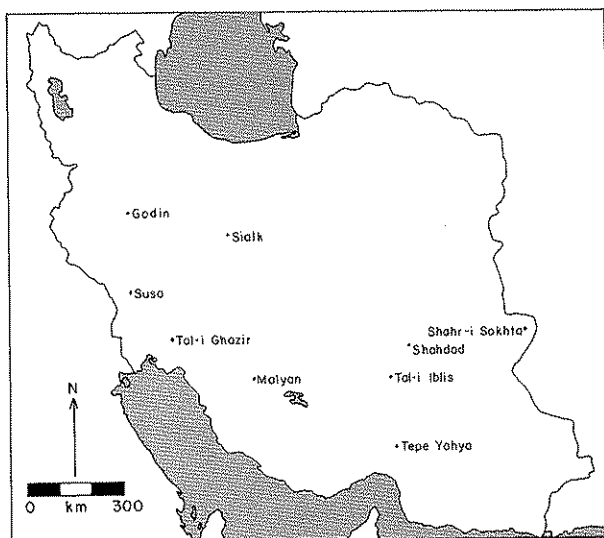


FIG. 1. - Iran.

Before it was possible to provide an environmental and economic reconstruction, it was necessary to develop a methodological and analytical framework which would logically and consistently relate the botanical debris of civilization to the human activities which produced it. One of the important results of the analysis reported here is the recognition that many weed and cultigen seeds become carbonized as a result of being incorporated in dung cake fuel, and are thus preserved in the archaeological record. The insights provided by this work may be applied to the analysis of archaeobotanical remains from analogous archaeological situations.

The assemblage of plant materials recovered from Malyan is in many respects typical of Near Eastern sites. In general, the material was sparsely distributed. The density of carbonized material in about half of the deposits is less than 1.5 g./10 l. of soil, or about a thimble-full per bucket (Table 1). The bulk of the material consisted of charcoal and carbonized

(6) Population estimates are based on modern population densities of about 100-200 people per hectare of occupied settlement (ALDEN, 1979; SUMNER, 1972).

TABLE 1
Flotation sample summary.

Period	Banesh	Kaftari
# deposits sampled	97	89
Vol. soil (l.)	1303	1310
Charcoal (wt., g.)	426.49	438.25
Seeds (wt., g.)	3.11	38.18
Charred material (tot. wt., g.)	429.60	476.43

seeds and rachis fragments. Some flotation samples contained burnt dung, and weed seeds were occasionally found embedded in it (7). Carbonization occurs when plant parts that have been burned in the absence of oxygen are reduced chemically to carbon. Bacteria and other soil organisms do not consume the carbonized material, and identifications can be based on morphology alone. In the presence of oxygen, burning plant material becomes morphologically unidentifiable ash. The only other means of preservation at Malyan was the mineralization of seeds, particularly from latrine deposits. Thus, the source of the preserved plant remains is primarily deposits whose contents have come into contact with fire, and secondarily those which absorbed dissolved minerals from the surrounding soil matrix.

The seeds represent a variety of taxa, cultivated and wild (Table 2). The proportion of weed seeds to cultigens (primarily cereals and grape) and nuts was quite high. Agriculturalists, including the present-day population of Malyan, may consume wild plants and seeds as food and medicine. However, taking into account the archaeological contexts of the sampled deposits, it is likely that the weed seeds found archaeologically were not destined for human consumption. If the high proportions of weed seeds were indicative of an important food source, we might expect concentrations of cleaned, stored seed to be found. Rather, most samples contained a mixture of several seed taxa, as well as charcoal. Thus, the need to explain the presence and distribution of relatively large numbers of "non-economic" plants became apparent early in the analysis. In turn, the analysis of the weed seeds highlighted the need to explicitly consider how the more obviously "economic" plants came to be preserved.

As a first step in developing a suitable interpretive framework, a study of the relationship between modern day villagers and their botanical environment was carried out.

(7) Six samples, all Kaftari, contain seeds embedded in dung; 2 have sedges, 1 has a leguminous seed, and 3 have unidentified seeds. A total of 10 Kaftari and 1 Banesh sample have probable dung. Burnt dung has an amorphous, fibrous texture. Modern burnt dung samples were examined for comparison with the postulated ancient dung. Only the clearest examples are reported; it is difficult to distinguish some burnt dung from burnt earth and certain other carbonized material found in flotation samples.

TABLE 2

Totals by period of comparable categories
of carbonized plant remains from flotation samples.

	Banesh	Kaftari
<u>Weed seeds (counts)</u>		
Prosopis	0	3½
Aegilops ^a	4	62
Irrigated field ^b	9	107½
Weed, indeterminate ^c	61	222
Wet area weed ^d	94	1394
<u>Fruit seeds (counts)</u>		
Date	0	1
Fig	2	6
Hackberry	2	13
Grape	3½	107½
<u>Miscellaneous seeds (counts)</u>		
Rosaceae	0	6
Pulse	4	32½
Unidentified	6	171
<u>Nuts & Cereals (weight, g.)</u>		
Pistachio	.03	1.78
Almond, cf. <u>Amygdalus</u> <u>scoparia</u>	.08	2.39
Almond (other)	.10	2.58
Barley	1.12	2.05
Wheat	.09	.16
Cereal, indet.	.89	18.02

^a Aegilops is the only genus that can confidently be ascribed to dry, unirrigated land in this area.

^b Weeds of irrigated fields include Avena, Medicago, cf. Trifolium, et al.

^c Weeds of indeterminate ecological zones include Centaurea, Lolium, Astragalus, Galium, et al.

^d Weeds of wet, but uncultivated areas include Carex, Cyperus, Phalaris, Setaria, Rumex, Polygonum, et al.

INFERENCES BASED ON MODERN VILLAGE LIFE

Malyan is located in the Kur basin, a major internal drainage basin of the southern Zagros. An open oak forest grows in the mountains to the north, and a very degraded pistachio and almond forest grows at the south end of the valley. In between, the slopes are deforested. Villagers reported occasional seasonal use of the oak forest for fuel and nut collection, but forest products play only a minor role in the village economy today.

The present-day village of Malyan occupies about 10 % of the 300 ha archaeological site. It is largely surrounded by a mud-brick wall. The population is about 500 (8). The major occupation of the people is subsistence farming based on the traditional Near Eastern crops (wheat and barley) and animals (sheep, goat, and cattle). The botanical landscape around the village is totally anthropogenic. Most of the land is cultivated, and today, all of the fields are irrigated. A variety of crops grows in the fields surrounding the village, a portion of the fields lies fallow, and there are protected gardens and groves. Areas utilized directly for pasture include the poorly drained center of the plain adjacent to the village, disturbed areas along roads, streams, and ditches, and uncultivated parts of the archaeological site itself.

Cultivated acreage is primarily devoted to cereal and sugar beet production. Wheat is grown for human consumption and sugar beet is raised as a cash crop. Fodder crops are grown, including the straw of cereals, barley grain, and alfalfa. Smaller quantities of sesame, sunflower, bitter vetch, lentils, beans, melons, maize, and a few garden crops such as tomatoes, potatoes, onions, and herbs are also grown. A number of families have planted grapes, and there are a few apple trees.

Present-day agricultural conditions are not completely analogous to those of ancient times. Malyan is after all a twentieth century peasant village. The organization of production is the result of modern technology and current sociopolitical conditions, so direct comparisons with ancient agricultural practices cannot be supported. In particular, production is geared only partially toward local subsistence; landlords who own much of the arable land hire villagers as wage laborers or use them as sharecroppers. Some of the landlords' harvest is destined for local consumption, but some is sent out to the larger markets in Marv Dasht and Shiraz. In addition, a sugar beet factory was built near Marv Dasht in 1934 (9), and much of the land (both peasant and landlord owned) is devoted to this revenue producing crop. Another limit to the use of analogy is that several crops are relative newcomers from an archaeological point of view. Clearly this is the case for species of New World origin, such as maize, sunflower, and tomato, but even some of the Old World crops, such as pomegranate and apple are not common archaeologically for the earlier periods with which we are here concerned. Finally, irrigation practices of today, dependent as they are on qanats (10) and mechanical pumps, cannot be considered the norm of the third millennium B.C.

Certain aspects of this system, however, are analogous to the archaeological situation. Although there is no reason to assume there has been cultural continuity over the past 5000 years in this area, some elements of the economy have persisted. Reliance on wheat, barley, sheep and goat has defined the subsistence system for millennia. Even mud brick construction techniques are essentially the same as they were in antiquity (11). As great as the differences are between modern village and ancient urban economies, the basic household activities considered here (cooking, heating and eating) took place in the past as well as the present, and occur regardless of settlement size and rank.

The flow of plant materials through the present-day village of Malyan is schematically presented in figure 2. My particular concern here is the identifica-

(9) KORTUM, 1976.

(10) A qanat is an underground canal built to tap an aquifer; the earliest qanats are mentioned in Assyrian texts of the seventh century B.C. and were in use during the Achaemenid period (ENGLISH, 1966 : 160, note 10).

(11) WULFF, 1966 : 102-117.

(8) NATIONAL STATISTICAL CENTER OF IRAN, 1970.

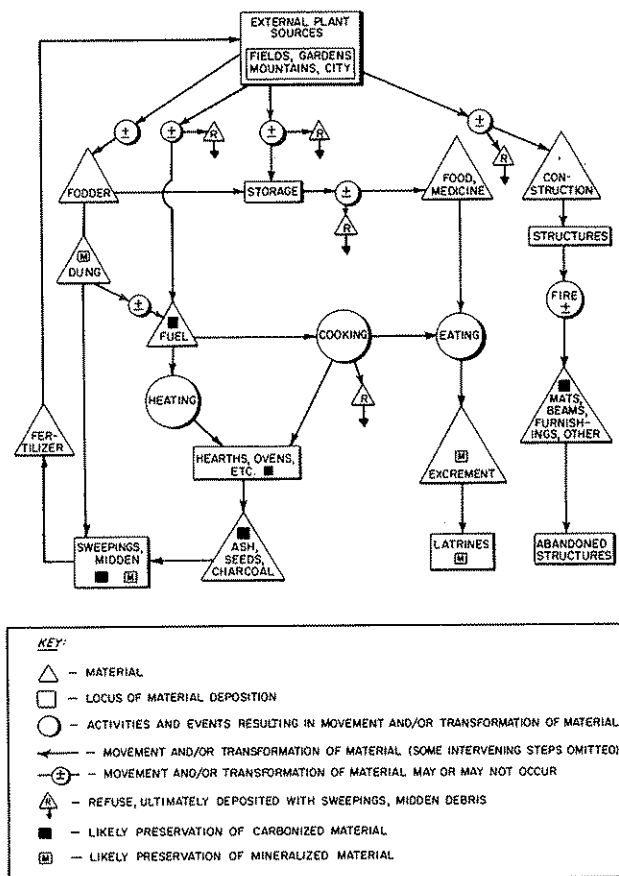


FIG. 2. - Flow of plant materials through the modern village.

tion of the likely loci of archaeological preservation of plants. Sources of plant materials external to the village are fields, gardens, the mountains, and the cities of Shiraz and Marv Dasht. Food, fuel, fodder, and construction material are all brought in to the village, having undergone varying amounts of processing outside the village. Some material is stored, and other items are used immediately. At Malyan today, no processing activities using fire except for cooking, baking and heating were ever observed. Other activities involving fire, such as grain parching or charcoal manufacture could have occurred in the past. However, evidence for ancient practices of this sort remains to be discovered at Malyan.

There is no industrial activity requiring fire (e.g. pottery manufacture or smelting) at present-day Malyan. In contrast, the ancient city of Malyan did seem to house some craft/industrial activities at various points in its history (12), and might as a result have been subjected to some localized fires at manufacturing areas.

Accidental burning of plant material might also occur. Small scale roof fires are fairly common

today (13). Many ceilings are black with soot above hearths, though I never noticed burned construction materials in village houses.

Nowadays, fodder and fuel are the bulkiest botanical items regularly brought into household compounds. Fodder supplies are consumed by the animals and transformed into dung. In turn, dung is either transformed into dung cake fuel or accumulated in temporary midden areas, to be trucked out to the fields as fertilizer. Fuel is also provided by wood, straw, and kerosene. Food is regularly brought in to the living areas and processed as needed. Residues of food and food processing are not as voluminous as those of fodder and fuel, however.

It is useful to consider possible weed seed sources specifically, since weed seeds are a substantial component of the archaeobotanical assemblage at Malyan. First, plants growing in courtyards where animals live are not likely to survive to their seed-dispersing maturity. Second, although some wild plants are consumed by villagers, it is generally in the form of sprouts; as the plants ripen and go to seed, they are considered fit only for animals. Third, household activities which are likely to produce botanical debris, such as grain-cleaning, are intermittent. Even if the by-products of these activities were swept into a hearth and deliberately burned, they would be a relatively minor source of seeds in household garbage.

In contrast, dung, the major component of debris in a house compound may contain numerous seeds (14). At Malyan, animals must be stall fed at least part of the year because of snow. They are fed hay (alfalfa, straw, weeds) and barley, so even cultigens may be found in dung. In addition, the manufacture of dung cakes requires straw, and some grains adhering to the rachis may be mixed into dung cakes. Finally, used as fuel, dung and the seeds it contains regularly come into contact with fire, enhancing the likelihood of charring and subsequent preservation.

In the absence of burnt structures, the final resting places of macroscopic plant remains within the village are middens and latrines. Hearths are cleaned frequently, so carbonized remains found in an abandoned hearth would be representative of no more than a few fires. Although organic material is plentiful in general midden deposits within and adjacent to the village, high densities of carbonized material do not occur except as a result of ash dumping. Although modern latrine deposits have not been examined for obvious reasons, phosphate mineralization has been reported for archaeological fecal deposits (15).

(13) William M. Sumner, personal communication.
 (14) See below; MILLER and SMART, 1984.
 (15) GREEN, 1979.

(12) NICHOLAS, 1980 : 365; ALDEN, 1978.

HEARTH AND MIDDEN ANALYSIS

Modern garbage disposal practices can provide us with more specific models for the formation of the archaeobotanical record. In order to better understand the nature of debris accumulation, four modern hearth and sweeping samples were taken (Table 3).

1) Shepherd/nomad campfire (August 20, 1978)

A shallow (less than 0.5 m) charcoal filled pit, about 1.0 to 1.5 m in diameter, was chanced upon in the open oak forest in the mountains about 10 km from Malyan. This hearth site contained only oak charcoal and a small quantity of burnt dung. There were no seeds.

2) Hearth at Malyan (April 14, 1977)

The previous evening's fire had been built of cow dung cakes and small pieces of firewood. That evening, rice had been cooked. Occasionally, straw fires are built in this particular hearth for bread-baking, but the contents are cleaned daily. The hearth has a plastered bottom. This household owns one of the small groves of poplar and willow at Malyan, and therefore has access to local wood. Generally, though not in this instance, this household's fires are made exclusively of dung cakes. The hearth is located outside, on the second story of the courtyard, so it is not subject to direct "contamination" from the animal stalls below. The charcoal consisted of willow/poplar, but most of the carbonized material was dung. It is likely that the presence of seeds is due to the dung as well. First, of the 70 seeds, 3 (ca. 4%) were actually found embedded in dung. Second, the most common type, *Rumex*, serves as fodder. It is most commonly found in wet areas adjacent to streams, although it should be noted that there is a stand of *Rumex* in the poplar grove. It does not grow in grain fields. The other seeds, primarily weedy, might have been brought in with harvested fodder, especially since grain is not in evidence in this sample.

3) Ash sample (August 22, 1978)

These hearth sweepings were collected soon after disposal, from the dump area at the base of the outer village wall. The sample includes the charcoal of at least three species of wood, two of which come from the mountains. It has proportionally many more weed seeds and greater variety than the hearth sample. Of 752 seeds, 16 are cultigens. Sixteen weed seeds (ca. 2%) were actually found embedded in sheep/goat dung, including 13 *Astragalus*, a leguminous weed. Many of the weeds found could easily have been brought in with straw.

4) Uncarbonized debris (August 22, 1978)

These courtyards sweepings are from the dump area at the base of the outer village wall. Virtually all plant materials found in courtyards are brought in as fodder, fuel, or in dung. This sample was virtually all uncarbonized material, with straw and dung providing most of the volume. There were no carbonized seeds. About 760 uncarbonized seeds were seen. Fewer than 25 were cultigens. There were a few fruit seeds, and an assortment of weedy species.

In summary, the material that becomes carbonized due to ordinary, modern household activities has been placed intentionally in a fire. Most carbonized seeds come from weedy plants. The most important source of carbonized weed seeds, and even of cultigens, seems to be animal fodder, perhaps transformed into dung or dung cakes. Furthermore, the modern debris most analogous to archaeological general soil matrix tends to have a low density of carbonized material, except for primary hearth deposits or secondary dumping of hearth sweepings.

TABLE 3
Modern refuse samples.

	Campfire	Hearth	Ash	Sweepings	
				Uncarb.	Carb.
Total sample wt., g. ^a	18	87	ca. 358	ca. 628	14
Large fraction wt., g. ^{a,b}	10.78	20.22	ca. 153	247	14
dung, burnt	.48	3.12	9.69	-	14
dung, unburnt	0	0	2.74	186 ^c	-
charcoal	10.30	.84	1.12	-	.23 ^d
straw & leaves	0	0	ca. 3	31	-
Charcoal examined, no., wt. (g.)					
oak	20(10.30)	0	2(.67)	-	0
poplar/willow	0	13(.40)	4(.10)	-	0
almond	0	0	3(.07)	-	0
diffuse porous	0	2(.11)	0	-	0
unknown, cf. fig	0	0	1(.05)	-	0
Seeds from total sample					
cultigens, burnt	0	1 ^c	16 ^e	-	0
cultigens, unburnt	0	0	0	22 ^h	-
wild & weedy, burnt	0	70 ^d	752 ^f	-	0
wild & weedy, unburnt	0	2	ca. 107	766	-
Wheat internodes, g. ⁱ	0	<.01	<.01	.44	0
Barley internodes, g.	0	<.01	<.01	.02	0

^a Includes soil, pebbles.

^b In order to obtain an idea of the proportions of the larger items without manually sorting the entire sample, the hearth sample was passed through a 2.38 mm. sieve, and the ash and sweepings samples through a 4.00 mm. sieve. The samples were examined in their entirety for seeds and internodes.

^c Bitter vetch.

^d Includes 3 embedded in dung.

^e Two-row barley and wheat.

^f Includes 16 embedded in sheep/goat pellets, and one embedded in other dung.

^g Includes ca. 50 g. sheep/goat pellets.

^h Watermelon, cucumber, two-row barley, wheat, grape.

ⁱ Includes charcoal smaller than 4.00 mm.

PALEOETHNOBOTANICAL ANALYSIS

As is true of artifacts in general and botanical remains in particular, the quantity of material recovered from an excavation is not necessarily proportional to its use or importance in the ancient economic system (16). It may even be inversely

(16) DENNELL, 1978 : 15-31.

related, as that which was useful to ancient peoples was consumed, and that which was discarded by them may be preserved archaeologically. Differential preservation of plant parts is a function of differential use and garbage disposal practices, as well as of the sturdiness of both utilized parts (17). How then is it possible to meaningfully compare diverse quantities of diverse botanical materials in archaeobotanical samples? There are at least as many approaches to this question as there are ethnobotanists.

The number and weight of seeds in archaeobotanical samples does not simply reflect the relative amounts of plants that were used in ancient times. First, plants produce different quantities of seeds. Differential breakage of various sizes of seeds means that in some cases, number cannot be determined, as only fragments remain. This is particularly the case with nut shells and cereals. Second, there is no direct relationship between weight (or number, for that matter) of seeds and usability of the plant or its fruits and seeds. With small quantities of seeds, weight measurements, even if accurate, would be uninterpretable. Seeds swell or shrink differentially on carbonization, and soil particles adhering to the surface of seeds distort weights.

As a result of these and other problems, it is very difficult to ascertain the economic significance of seeds of weeds as well as cultigens in archaeobotanical samples (18). Sometimes, the circumstances of seed carbonization are explicitly considered. Site-wide conflagrations and burnt funerary offerings (19) are obvious examples. More recently, extensive studies of crop processing have been carried out, with special attention to the likelihood of the debris of the various processing stages becoming charred (20). Often, seed carbonization is attributed to chance events, such as seeds blowing into a fireplace. When cultigens and weed seeds are found in place in storage jars in burnt buildings, there can be little doubt that the grain was a harvested crop and the weed seeds were threshing impurities (21). Unfortunately, many archaeological contexts cannot be that readily identified.

Observation of modern household activities focused on how preservable plant material is likely to enter the archaeological record. It was noted that plant products used in the village were in fact rarely burned, either intentionally or accidentally. This fact suggested an explanation for how seeds may become carbonized. Namely, many seeds become carbonized because they are contained in dung cakes used as

fuel. Several arguments supporting this proposition are:

- 1) One of the most likely ways for material in a settlement to become carbonized is by its intentional inclusion in a controlled fire.
- 2) Not surprisingly, the material most frequently burned intentionally is fuel (dung cakes and wood in this case).
- 3) Seeds do pass through the digestive systems of sheep, goats, and cows (22), and modern courtyard sweepings yielded several examples of seeds embedded in dung.
- 4) There are few sources of seeds which are likely to blow into a hearth accidentally in a Near Eastern village or town which houses herbivores, with the exception of seeds especially adapted for wind dispersal, such as the composites. Animals will eat all the vegetation in their reach, long before plants have had a chance to go to seed.

The proposition that many seeds at Malyan, both cultivated and wild, originated in dung fuel accounts for several aspects of the archaeobotanical samples. The ethnographic model presented above is appropriate because both the ancient and modern systems are based on domestic animals and occur in the relatively arid climate of southern Iran where wood may have been scarce (23). It is limited by the fact that we cannot know which particular seeds represent dung, even if most of them are thought to have come from that source. In addition, carbonized seed sources other than dung cannot automatically be ruled out, including:

- 1) Food residues, spat into a fire (e.g. nut shells, grape seeds, other fruit pits).
- 2) Intentionally discarded debris from the cleaning of grain and other crops (24).
- 3) Food processing near fires.
- 4) Cooking accidents (e.g. wheat, barley, other cultivated and cooked foods).
- 5) Ambient weed seeds blown or dropped into a fire (e.g. from sheep or goat hair, roofing debris, settlement weeds).

Conditions which favor the archaeological preservation of seeds in large part depend on the manner in which particular plants were used. For example, food is generally meant to be consumed, not charred, yet some seeds are most likely to represent food. This is particularly the case for nut shells, grape seeds, and other fruit pits. Such residues found at Malyan may well represent intentional disposal of waste products, but the weed seeds cannot be accounted for in this manner. When one considers the fragility and low density of carbonized material in ordinary household refuse, it is clear

(17) MUNSON *et al.*, 1971.

(18) HELBAEK, 1969; DENNELL, 1974; VAN ZEIST and BAKKER-HEERES, 1979.

(19) DENNELL, 1978; ELLISON, 1978.

(20) HILLMAN, 1981; BOTTEMA *n.d.*

(21) DENNELL, 1974.

(22) TOWNSEND, 1974: 41; BOTTEMA 1984; MILLER and SMART, *in press*.

(23) MILLER and SMART, 1984.

(24) HILLMAN, 1981.

that, short of a major fire, conditions which favor the preservation of some quantity of seeds are regularly occurring activities. Intentional disposal of crop processing debris might occur fairly regularly, and one would expect high densities of weed seeds and straw and rachis fragments in such deposits (25). Food processing regularly occurring in or near fires might be expected to produce carbonized remains, and such deposits have been described for other sites (26). Accidental deposition may account for some individual seeds, but is a less satisfactory explanation overall, since occasional burning would probably result in less charring of plant materials than the daily, intentional burning of dung fuel.

The archaeobotanical samples at Malyan do not have the high densities of weed seeds, straw and rachis fragments that would be expected of burned crop processing debris. Nor do they have the low charcoal densities that would be characteristic of burned food processing debris. Cooking accidents are not likely explanations for the plant distribution of the site of Malyan either; the few hearth deposits found in situ do not exhibit the unusually high cultigen proportions that would be expected if a cook's hand had slipped.

In contrast, cooking (and heating in winter) happens daily, and requires fuel. The relatively sparse distribution of charred seeds at Malyan, with relatively high proportions of weed seeds compared to cultigens fits the expectations for dung fuel. Finally, one Kaftari latrine sample provides unexpected corroboration for the proposition. It had identifiable, uncarbonized, mineralized grains with a wheat to barley ratio of 2:1, in sharp contrast to the carbonized assemblage which was somewhat less than 1:12 in both Banesh and Kaftari times. This is probably no accident, since wheat can be threshed more easily and might be expected to be preferred for human consumption, whereas barley would be preferred for fodder. Thus, even though not every seed found in an archaeological context passed through an animal's gut first, it is likely though not determinable for individual seeds, that most charred seeds of potential fodder plants came from dung cake fuel.

USE OF THE DUNG HYPOTHESIS TO INTERPRET ARCHAEOBOTANICAL REMAINS FROM MALYAN

The analysis of the charcoal from Malyan suggested progressive deforestation during the third millennium (27). I have elsewhere suggested that stands of juniper grew on the drier parts of the plain near

Malyan, and poplar grew in the poorly drained area that is located about 1 km from the village today. As these wood sources were depleted, people began to fetch wood from further away in the oak forest 10 km from the site. The fairly simple explanation for this phenomenon was that Malyan's growing population needed greater amounts of firewood than could be obtained close to home. It also needed to clear land for new fields (28). In addition, the use of metal increased in the Near East during the third millennium (29), and smelting uses large quantities of fuel (30). Some test implications for these propositions are that alternative sources of fuel, namely dung, would become more common as transport costs and scarcity reduced the availability of wood, and that cleared land would not be just abandoned, but used for food and fodder production.

By applying the arguments presented above for detecting the use of dung fuel, the seed evidence supports these test implications. Namely, between the Banesh and Kaftari periods, there is a ten-fold increase in both the numbers of identifiable seeds, as well as in the proportion of seeds relative to total carbonized material by weight ($S/(S + C)$), where S is the weight of seeds and C is the weight of charcoal in each sample, (Table 4). In addition, there is an increase in sedge seeds, suggesting that the postulated, poorly drained area covered with untended poplar had become meadow, much as it is today. The other fodder plant seeds which increase are those associated with agricultural fields, either as cultigens or weeds.

TABLE 4

Mean ratio of seed to carbonized material weight ($S/(S + C)$), based on samples with carbonized material density of greater than 1.5 g./10 l of soil.

Feature	N	Banesh	N	Kaftari
Fireplaces	15 ^a	.0035	2	.0802
Pits	9	.0059	14	.0962
Rooms	9	.0038	13	.0742
Burials	2	.0417	-	-
Fill	3	.0408	11	.1388

^a One Banesh hearth sample has been omitted because it had a carbonized material density of only .85 g./10 liters. It had many seeds, and if included would change the average $S/(S + C)$ ratio for Banesh fireplaces to .0322, still substantially less than the mean for the Kaftari hearths.

CONCLUSION

I have attempted to demonstrate that by a judicious use of ethnographic information it is possible to create a model of the formation of the archaeobotanical record. The substantive result, that many carbonized weed seeds and cultigens from Malyan

(25) Cf. HILLMAN, 1981.

(26) DENNELL, 1978; MILLER, 1983.

(27) MILLER, 1982 : 228-231; MILLER, 1980.

(28) MILLER, 1982 : 221-250.

(29) MALLOWAN, 1971 : 239-240, 305-306; cf. MOOREY, 1982.

(30) HORNE, 1982.

originated in dung used as fuel, can be directly applied to other Near Eastern sites where a similar economy prevailed. In order to elucidate ancient environmental and economic conditions through paleoethnobotanical analysis, it is important to consider the formation of the archaeobotanical record. Although every site presents its own problems of interpretation, I hope that the work reported here will provide a useful working hypothesis to explain the presence of carbonized seeds in some archaeological deposits.

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