J. Ethnobiol. 4(1): 15-28 May 1984

INTENTIONAL BURNING OF DUNG AS FUEL: A MECHANISM FOR THE INCORPORATION OF CHARRED SEEDS INTO THE ARCHEOLOGICAL RECORD

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ABSTRACT.—An important concern of paleoethnobotanists is accounting for the presence and charring of seeds recovered archeologically. The possibility that seeds can be brought to a site incorporated in animal dung and charred when that dung is burned as fuel is considered. Researchers have shown that animal dung can contain seeds. Ethnoarcheological data from the rural village of Malyan, Iran demonstrate that seeds can be charred when dung is burned as fuel and can be recovered from deposits analogous to those commonly encountered archeologically. A description of the residue from burning dung, based on an examination of modern samples from Black Mesa, Arizona, is provided. Four conditions for determining whether the use of dung fuel might account for the presence of a charred seed assemblage are presented. Finally, two specific archeological examples are discussed in which this interpretation seems plausible for some portions of the charred seed assemblage: the archeological site of Malyan, a third millennium B.C. urban center in southern Iran, and the Tierra Blanca site, a Late Prehistoric habitation site in the Texas panhandle.

INTRODUCTION

Over the last two decades paleoethnobotanists have been thinking a great deal about how seeds are brought to a site and become incorporated into the archeological record. While it has been recognized that both modern and prehistoric (or ancient) seeds can be recovered from an archeological site, only the latter will be considered in the present study (see Keepax 1977 and Minnis 1981 for a detailed discussion of modern seed contamination). Four types of processes have been considered through which seeds could have been brought to a site in the past: (1) prehistoric seed rain (Minnis 1981:145), which involves the natural dispersal of seeds into the site area (and is not a cultural process); (2) direct resource utilization (Minnis 1981:145), in which the seed itself is utilized; (3) indirect resource utilization (Minnis 1981:145), in which seeds are brought to the site as a by-product of the use of another part of the plant for some cultural purpose; and (4) incidental inclusion with utilized resources, in which seeds are brought to the site incorporated in a resource totally distinct from that seed or plant. For example, weed seeds may be brought to a site mixed with harvested seeds and later removed during food processing (Dennell 1972, 1974, 1976, 1978; Monk and Fasham 1980; Hillman 1981). These weed seeds are brought to the site as a by-product of cultural activities.

Except in certain unusual environments, such as dry caves or waterlogged deposits, seeds must be charred to be preserved archeologically (see Minnis 1981 for a discussion of the improbability of the preservation of uncharred seeds). Three mechanisms for the charring of seeds and other plant macroremains have been suggested (Hubbard 1976:262; Minnis 1981:145; Miller 1982:136-140): (1) the catastrophic burning of a site or a portion of a site; (2) accidental burning of the plant material itself; and (3) intentional burning of the plant material primarily through use as fuel, waste disposal or in rituals.

Obviously, not all seeds brought to a site have an equal probability of being charred.

The density of a seed affects the likelihood of its becoming charred instead of burning to ash (Munson et al. 1971:427). In addition, plant processing and other cultural activities that involve fire or that occur near a fire are more likely to lead to accidental burning of seeds than activities carried out away from fire (Monk and Fasham 1980:325-326; Minnis 1981:149; Miller 1982:135-138).

In this paper we would like to discuss a mechanism for bringing seeds to a site and charring them that has not been widely considered in paleoethnobotanical analyses. We suggest that seeds can be brought to a site incorporated in animal dung and become charred when that dung is intentionally burned as fuel. We believe this process can account for the composition of certain charred seed assemblages recovered archeologically.

We will begin with a brief discussion of ethnographic evidence for the use of dung as fuel. We will then demonstrate that burning dung as fuel can result in the charring and deposition of seeds. Evidence will be presented which shows that seeds can be incorporated in animal dung. Ethnoarcheological data will be provided which demonstrate that seeds are charred through intentional burning of dung as fuel and can be recovered from deposits analogous to those commonly encountered archeologically. A description of the residue from fires using dung fuel will be provided, based on the analysis of modern burned dung samples. We will then suggest criteria for evaluating whether it is possible that an archeological seed assemblage could reflect the intentional burning of dung as fuel. Finally, we will briefly discuss the paleoethnobotanical data from a third millenium B.C. urban center in Iran and a small Late Prehistorical habitation site in the Texas panhandle for which this interpretation is plausible.

THE USE OF DUNG AS FUEL

The use of animal dung as a source of fuel is a widespread practice in areas where other fuels are in short supply or unaffordable. Ethnographic and travelers' accounts report the use of dung fuel for domestic purposes in much of Africa and Asia, and in parts of South America (e.g. Becker 1979:35, 37, 97; Hill 1972:372; Miller 1982:92; Lewis 1958:40; Ekvall 1968:50-51; Teichman 1921:8; Winterhalder et al. 1974). Dung fuel is also used in pottery manufacture in southern Asia and the American Southwest (Saraswati and Behura 1966:105; Rye and Evans 1976:41; LeFree 1975:56, 63). These areas have arid, semi-arid, or alpine environments where wood for fuel is either naturally scarce or severely depleted due to deforestation. Older ethnographic and ethnohistoric accounts document the use of dung as fuel in the past not only in some of these areas, but also on the Plains in the American West (e.g. LeBruyn 1737:228; Cunningham 1854: 219, 222; Vázquez de Espinosa 1948 [1629] :456; Hornaday, cited in Roe 1970:605).

Large herbivores commonly provide the dung that is used as fuel. In the Old World, cattle *(Bos taurus)* and sheep *(Ovis aries)* are the primary sources of dung used for this purpose. Yak *(Poephagus grunniens)* dung is also important where locally available (MacDonald 1929:20). The use of dung from goats *(Capra hircus)*, camels *(Camelus)*, horses and donkeys *(Equus)*, and the Asiatic wild ass *(Equus heminous)* for fuel has also been reported in the literature, but these do not appear to be commonly used unless other types of dung are unavailable (e.g. Lhote 1944:85; Lattimore 1941:232; Kawaguchi 1909:91). In the New World, camelid *(Lama)* and bison *(Bison bison)* dung traditionally were used for fuel in South and North America, respectively. However, cattle, sheep, and horse dung are also used in these areas today (see ref. above).

EVIDENCE FOR THE PRESENCE OF SEEDS IN DUNG

A considerable amount of research has been conducted over the last 50 years to determine whether seeds can pass through an animal's digestive tract (Atkeson et al.

1934; Harmon and Keim 1934; Burton and Andrews 1948; Piggin 1978; Takabayashi et al. 1979; Schröder and Baart 1982). While the primary goal of this work was to determine whether animal dung could be a vector for the dispersal of field weeds, the results are directly relevant to our discussion. This research focused primarily on cattle and sheep, but some work has also been done with chickens *(Gallus domesticus)*, hogs *(Sus scrofa)*, and horses (Harmon and Keim 1934). In these experiments, test animals were either fed seeds from grasses (Gramineae) and/or forbs directly, or placed in pastures with plants that were in seed.

Seeds were present in nearly all the dung samples from the mammals tested in these experiments. However, the numbers of seeds recovered varied from one species of seed to another and from one test animal to another (both between and within animal species). The amount of time that had elapsed since the ingestion of the seeds also affected the number of seeds recovered. Interestingly, some of the dung samples in these experiments contained hundreds of seeds, and in one experiment seeds were found to be present in cattle dung for at least 10 days after they were ingested (Burton and Andrews 1948:98).

The results of this research clearly demonstrate that animal dung can contain seeds when they are part of the animal's diet. However, it must be remembered that the presence and quantity of seeds in the diet of herbivores will vary depending on the seasonality of fruiting of forage/browse plants and, in the case of domesticated animals, the nature of animal fodder. At certain times of the year seeds may be absent or very rare in the animal's diet and, therefore, in the animal's dung.

DUNG FUEL AS A SOURCE OF CHARRED SEEDS

In order to study the mechanisms through which seeds become incorporated into the archeological record, Miller examined four samples of modern debris from the rural village of Malyan in southwestern Iran that were analogous to deposits commonly encountered archeologicially. These included a prepared hearth, two samples from a midden and a fire pit.

The first sample was taken in the village of Malyan from a mud-plastered hearth located in the open air on the second story of a residential compound, above animal stalls occupying the ground level. The hearth was cleaned daily by the residents. The previous evening, a fire fueled with small pieces of wood and dung cakes of cattle dung and straw had been built in this hearth in order to cook rice. The hearth sample contained wood charcoal identified as willow or poplar *(Salix/Populus)*, probably from a planted grove of willow and poplar trees near Malyan that is owned by the family. However, most of the carbonized material from the hearth was dung. Three charred seeds were found embedded in this dung and 67 additional charred seeds were recovered in the sample (Table 1).

It is likely that these additional seeds also came from the dung for several reasons. At least one of the identified seed types, dock *(Rumex)*, is a wild fodder plant that is eaten by cattle and does not grow in grain fields. Other seeds are from weedy plants that are suitable for fodder and have no known use in this area today. While these could have grown in grain fields, it was not the household practice to dispose of the grain-cleaning residue in the hearth. In addition, there are few natural sources of seeds which are likely to accidently blow into a hearth on the second story within a walled compound in a Middle Eastern village. Herbivores housed in the village compounds will eat all the vegetation in their reach long before the plants have had a chance to go to seed.

Two samples were obtained from a midden area just outside the village wall. The first was taken from an ash deposit presumed to be hearth sweeping debris, and is analogous to an archeological ash lens. The sample contained charcoal of at least three woods.

Two of them, almond *(Amygdalus)* and oak *(Quercus)*, come from the mountains about 10 km north of the village. However, the sample was predominately burned dung. Twenty seeds were found embedded in burned sheep/goat dung including 16 seeds of *Astragalus*, a leguminous fodder plant (Table 1). Most of the other seeds recovered were from weedy plants; of 764 charred seeds, only 16 are from cultigens.

The second midden sample was collected from an area of uncarbonized material located just outside the village wall. Although actual dumping of the material was not observed, the proximity of the midden to residential areas as well as the nature of the deposit suggest that the sample represents household debris and courtyard sweepings. This deposit is most analogous to ordinary trashy fill from an archeological site. The sample contained virtually no carbonized material, and straw and unburned dung accounted for most of the volume. There were no charred seeds. Of the approximately 750 uncharred seeds, 1 was embedded in dung and fewer than 25 were from cultigens (Table 1). The noncultigens were weedy plants whose seeds are not collected by the villagers. They are used as fodder and occur as field weeds.

A fourth sample was taken from a fire pit located away from the village in the oak forest. It was a subterranean feature, 1 to 1.5 m in diameter and less than 0.5 m deep, which could have been used for a shepherd's or nomad's fire or in the manufacture of charcoal by a villager. Unlike the village hearths and courtyards, this pit was totally open to the elements. Nonetheless, it contained primarily oak charcoal and a small amount (ca. 5% by weight) of burned dung. There were no stray seeds either charred or uncharred in the sample (Table 1).

The analysis of the prepared hearth and hearth sweeping samples from Malyan demonstrates that seeds can be brought to a modern village site in dung and charred when that dung is used as fuel. This was also shown in the recent analysis of the contents of an outdoor, "burgul" fireplace from the Syrian village of Tell Hammam et Turkman (Bottema in press). The Malyan hearth and hearth sweeping samples also indicate that seeds from dung can be recovered either incorporated in burned dung or as stray charred seeds within a sample. The contents of the sample from the fire pit demonstrate that burned dung does not always leave a residue of charred seeds. All of these samples provide information regarding the types of archeological deposits which might contain charred seeds that are remnants of dung burned as fuel.

DESCRIPTION OF BURNED DUNG

When dung is burned as fuel it produces two end products, fragments of burned dung and ash. A burned dung fragment is an amorphous mass of charred stems oriented in various directions within a friable matrix of fine grained, charred material. The relative proportions of charred stems and matrix can vary considerably. While dung fragments

TABLE 1.—*Seeds Recovered in Modern Refuse Samples from Malyan.*

	Prepared Hearth	Hearth Sweepings	Household Debris	Fire Pit
Refuse Sample Wt. Examined	87 g	ca. 358 g	ca. 628 g	18 g
Seeds— Cultigens				
Total Count	1 (charred)	16 (charred)	22 (uncharred)	0
Taxa	*Vicia ervilia*	*Hordeum distichum* *Triticum*	*Citrullus* *Cucumis* *Hordeum distichum* *Triticum* *Vitis vinifera*	

TABLE 1.—*Seeds Recovered in Modern Refuse Samples from Malyan.* (Continued)

	Prepared Hearth	Hearth Sweepings	Household Debris	Fire Pit
Seeds— Weedy				
Total Count	69 (charred)	748 (charred)	ca. 721 (uncharred)	0
Taxa	*Astragalus* Compositae Cruciferae[2] Gramineae Leguminosae[3] *Lolium* Malvaceae *Papaver*[3] *Rumex*[2] *Silene* Unknown (Count=5) Unidentifiable[3] (Count=18)	cf. *Adonis* *Astragalus*[1] Caryophyllaceae *Chenopodium*[3] Compositae Cruciferae *Galium* *Glycyrrhiza glabra*[5] Gramineae *Heliotropium*[6] *Hordeum glaucum*[7] Labiatae cf. *Lathyrus* Leguminosae[3] Malvaceae *Medicago* *Physalis* *Plantago* *Polygonum*[2] *Rapistrum*[10] *Reseda* *Rumex* *Setaria* Solanaceae *Sophora* *Trifolium* *Vicia* Unknown[12] (Count=90)	*Adonis* *Ajuga* *Amaranthus* *Astragalus*[4] *Bromus* Caryophyllaceae *Centaurea* *Cephalaria* *Chenopodium* Compositae *Convolvulus* Cruciferae *Cynodon dactylon*[8] *Digitaria*[9] Fumaria *Galium* Gramineae *Hordeum glaucum* Labiatae cf. *Lepidium* *Lolium* Malvaceae *Medicago* *Physalis* *Plantago* ?*Polypogon*[11] *Polygonum* *Reseda*[3] *Rumex* *Setaria* *Silene* Solanaceae *Sophora* Umbelliferae *Vaccaria*	

[1]Includes 16 seeds embedded in sheep/goat pellets
[2]Plus 1 uncharred seed
[3]Includes 1 seed embedded in dung
[4]Includes 4 types
[5]All in 1 pod
[6]Plus 125 uncharred seeds
[7]Plus 2 uncharred seeds
[8]Plus 3 inflorescences
[9]Plus 1 inflorescence
[10]Silique
[11]Inflorescence
[12]Includes 2 seeds embedded in sheep/goat pellets

consisting primarily of charred stems are fairly distinctive, fragments made up almost entirely of charred matrix can be difficult to identify. Sometimes larger burned dung fragments retain some of the original shape of the dung, allowing identification of the animal taxon that produced it.

In order to provide some quantitative information regarding the relative amounts of ash and burned dung fragments produced by a fire fueled with dung, two modern samples were examined by Smart. These samples came from Black Mesa, Arizona, where dung was routinely burned in large, metal food cans to produce insect-repelling smoke around the work sites of the Black Mesa Archaeological Project. Cattle, sheep, and goat dung were used together as the primary fuel for these fires, although shrubby plants such as sage *(Artemisia)* and dried grass were sometimes used as kindling. Since these fires were built to produce smoke, handfuls of dirt and pebbles were sometimes tossed onto the burning dung when it began to flame (Alison Rautman and Heather Trigg personal communication). The remnants of two of these burning episodes were analyzed.

The contents of these burned dung samples were passed through three geological sieves (4.00 mm; 0.50 mm; and 0.25 mm) and the weight and volume of each fraction was recorded (Table 2). The fraction coarser than 4.00 mm consists of fragments of burned dung, clumps of gray ash, pebbles, and trash (such as cigarette butts, paper, aluminum foil, etc.). The fraction coarser than 0.50 mm contains small burned dung fragments, charred stems and other charred plant parts, clumps of gray ash, and small pebbles. The fraction coarser than 0.25 mm contains charred stems and other charred plant parts, clumps of gray ash, and sand grains. The fraction finer than 0.25 mm consists of fine, gray ash along with small flecks of charred plant material and fine sediment. This fraction was a major component of both samples (Table 2).

Charred seeds were recovered from these two samples both as stray seeds and embedded in dung (Table 2). The stray charred seeds are somewhat difficult to interpret since shrubs and grasses may have been used as kindling in these fires. However, the presence of charred seeds embedded in burned dung provides unambiguous corroboration for our contention that dung fuel can be a source of charred seeds.

It should be noted that these samples were from fires made to produce smoke. The residue of fires made for other purposes would probably look somewhat different. In addition, the nature of the burned dung will vary somewhat depending on the diet of the animal that produced it. However, these samples can provide a general impression of the nature of the residue from burning dung.

INTERPRETATION OF ARCHEOLOGICAL SEED ASSEMBLAGES

We have demonstrated that seeds can be brought to a site incorporated in animal dung and charred when that dung is used as fuel. We suggest that the use of dung as fuel be considered as one possible interpretation of an archeological charred seed assemblage when the following conditions are met: (1) the site occurs in an environment where wood for fuel might have been scarce; (2) suitable dung-producing animals were present in the area; (3) the assemblage of charred material contains burned dung and/or seeds from plants that could have been eaten by dung-producing animals; and (4) the archeological context of the samples suggests a primary hearth deposit or secondary dumping of hearth contents. Ethnographic and/or ethnohistoric evidence for the use of dung as fuel in the area can provide supporting evidence for this interpretation.

Obviously, other possible interpretations of a charred seed assemblage could be suggested even when these four conditions are met. A careful evaluation of the archeological context of the samples, the quantities of charred seeds recovered and their distribution within the site, and the evidence (ethnographic, experimental, etc.) for possible uses of identified plant taxa must be made to determine which interpretations are most plausible for each particular archeological case.

We would now like to describe briefly two very different archeological situations in which portions of the charred seed assemblages might reflect the use of dung as fuel. Our intent is to illustrate the utility of this interpretation; detailed presentations of the paleoethnobotanical data from these sites are provided elsewhere (Miller 1981, 1982; Smart 1982).

TABLE 2.—*Modern Burned Dung Samples from Black Mesa.*

Fractions	Sample 1	Sample 2
Total sample		
Volume	775 ml	950 ml
Weight	244.5 g	429.3 g
Coarser than 4.00 mm		
Volume	125 ml	75 ml
Total Weight	18.9 g	17.2 g
Trash Weight	0.6 g	1.6 g
Pebble Weight	0.7 g	3.1 g
Charred Seeds		
Total Count	5[1]	7[1]
Taxa	*Amaranthus* Chenopodiaceae *Chenopodium* Unidentifiable (Count=2)	*Chenopodium* Unidentifiable (Count=1)
Coarser than 0.50 mm		
Volume	250 ml	200 ml
Weight	44.4 g	50.8 g
Charred Seeds		
Total Count	29+6 frags	30+4 frags[2]
Taxa	*Amaranthus* *Chenopodium* Gramineae *Portulaca* *Salsola kali* Unidentifiable[4] (Count=13+4 frags)	*Chenopodium*[3] Gramineae Unidentifiable (Count=5+1 frag)
Coarser than 0.25 mm		
Volume	75 ml	75 ml
Weight	28.0 g	31.2 g
Charred Seeds		
Total Count	1[5]	1+1 frag[6]
Taxa	Gramineae	*Chenopodium* Unidentifiable (Count=1 frag)
Finer than 0.25 mm		
Volume	325 ml	600 ml
Weight	153.2 g	330.1 g

[1]All seeds embedded in dung
[2]Sample of 13.1 g was examined for seeds
[3]Includes 1 seed embedded in dung
[4]Includes 3 seeds embedded in dung
[5]Sample of 13.3 g was examined for seeds
[6]sample of 7.5 g was examined for seeds

CHARRED SEEDS FROM ANCIENT MALYAN

Background.—The first example comes from the archeological site of Malyan, a major urban center during the third millennium B.C., contemporary with Sumerian and Akkadian civilization in Mesopotamia (Sumner 1974; 1980). The site is located in the Kur basin, an intermontane valley in the Zagros of Iran. Today the region is largely deforested, although there is a remnant oak forest about 10 km north of the village and a degraded pistachio-almond *(Pistacia-Amygdalus)* forest about 100 km away at the southern end of the valley.

Plant remains from Malyan were analyzed by Miller (1981, 1982). Nearly 200 flotation samples were collected from a variety of deposits, including hearths, pits, room floors and trashy and non-trashy fill. The assemblage of plant materials recovered from Malyan is in many respects typical of Near Eastern sites. In general, the material was sparsely distributed. Approximately half of the samples contained less than 1.5 g of charred material per 10 liters of sediment. The deposits sampled contained an assortment of taxa and plant parts. The bulk of the material consisted of charcoal and charred seed and rachis fragments. The seeds represent a variety of taxa, cultivated and wild. The economic base was wheat *(Triticum)* and barley *(Hordeum)* agriculture; other common food plants were grape *(Vitis),* pistachio and almond. We believe that the seeds from weedy plant types from many, if not most of the samples from this site became charred because they were incorporated in animal dung burned as fuel.

Meeting the conditions for the dung fuel interpretation.—Based on charcoal analysis, it appears that deforestation progressed during the course of the third millennium B.C. in this highland region. In particular, charcoal percentages from tree species which could have grown in the valley close to Malyan decrease, and percentages of oak, which grows on the hill slopes, increase (Miller 1981, 1982:212-216, 221-231). Textual evidence provides some corroboration for deforestation in the third millennium B.C. in this area (Hansman 1976). This suggests an ancient environment in which wood for fuel was becoming increasingly difficult to obtain.

The main Middle Eastern domesticated animals, sheep, goats and cattle, have been reported from the site by Zeder (1980). All of these animals produce dung that is suitable for use as fuel. Dung cakes and dung are commonly used as fuel in this area today since wood is scarce. These are historical references for this practice as well. For example, in the eighteenth century a traveler commented that the main highway in this region was kept clean, as animal dung was collected for fuel (LeBruyn 1737:228).

Twelve flotation samples contained burned dung. Charred weed seeds were found embedded in burned dung in six of these samples. In addition, a substantial number of the charred seeds recovered in these and other samples from the site are from plants of no known economic importance today *except* as fodder (Table 3).

All 12 samples containing burned dung had charcoal in them as well, and 10 were from trashy deposits encountered in either the site matrix or within pits (Miller 1982: 205). These kinds of deposits could represent secondary dumping of the contents of hearths. This would be consistent with an interpretation that the burned dung and charred weed seeds from fodder plants are the remnants of dung burned as fuel. Other samples from similar contexts also contain these types of charred seeds and their presence may be the result of the use of dung fuel as well.

Interpretation.—While the conditions for considering the use of dung fuel as a possible interpretation of the charred seed assemblages from ancient Malyan have been met, alternative interpretations must be considered. There is no evidence for overall site burning in the third millennium B.C. levels of the site. Therefore, charring probably occurred either accidentally or intentionally in fires set for cooking, heating, industrial processes and waste disposal.

TABLE 3.—*Weedy Seed Taxa from Ancient Malyan.*

Adonis[1]	Gramineae[1,2]
Aegilops[1]	*Hordeum*[1]
Ajuga	*Hyoscyamus*
Astragalus[1,2]	Labiatae
cf. *Atriplex*	Leguminosae[1,2,3]
Avena	*Lepidium*[1]
Boraginaceae	cf. *Lithospermum*
Bromus[1]	*Lolium*[1]
Carex[1,2,3]	Malvaceae[1]
Caryophyllaceae	*Medicago*[1]
Centaurea[1]	*Neslia*
Ceratocephalus[1]	cf. *Panicum*
Chenopodiaceae	*Phalaris*
Chenopodium	*Polygonum*[1]
Compositae	*Potentilla*[1]
Cruciferae[1,2]	*Prosopis*[1]
Cucurbitaceae	*Rumex*[1]
Cyperaceae[1]	*Setaria*[1,2]
Cyperus[1,2,3]	*Silene*[1]
cf. *Cynodon*[1]	*Solanaceae*[1,2]
cf. *Delphinium*	cf. *Trifolium*[1]
cf. *Eremopyrum*[1]	Umbelliferae[1]
Euphorbiaceae	cf. *Vaccaria*[1]
Fumaria	cf. *Valerianella*
Galium[1,2]	*Vicia* (not *ervilia)*

[1]Taxon found in sample containing burned dung
[2]Taxon found in 10% or more of the samples from the same time period
[3]Taxon found embedded in burned dung

Ethnographic data from Malyan suggest that accidental burning of the natural seed rain is unlikely in architecture similar to that found archeologically at the site. Hence, the charred seeds were probably brought to the site as the result of direct resource utilization, indirect resource utilization or incidental inclusion with utilized resources.

There are no caches of charred seeds (weeds or cultigens) from the site that would suggest intentional collection for food, medicine or other culturally defined purposes. Most of the identified weedy taxa have no known use in the modern village of Malyan except as fodder for animals, indicating that these seeds probably were not brought to the site by direct or indirect resource utilization (although the possibility that plant use was different in ancient Malyan does exist).

The likelihood that the seeds represent the residue of the burning of crop processing by-products (cf. Hillman 1981) can be discounted for these deposits since most samples have low weedy seed densities. Those with the highest weedy seed densities (greater than 100 seeds per 10 liters of sediment) have high counts of precisely those taxa that are *not* field weeds, namely *Carex* and other sedges (Cyperaceae).

The presence of burned dung (some of which contains charred seeds) from trashy deposits strongly suggests that dung was burned as fuel in ancient Malyan. It is possible that some of the charred seeds from weedy taxa were brought to the site and became charred through other processes. However, since the chances of preservation are greater when plant material is regularly and/or intentionally burned, it is likely that much of the charred seed assemblage from this site is the result of the intentional burning of dung as fuel.

The interpretation that the charred seeds from ancient Malyan originated in dung used as fuel corroborates the charcoal evidence for deforestation during the third millennium B.C. in the valley. There was a ten-fold increase in charred seeds during the course of the third millennium, as measured by absolute numbers of seeds, the number of seeds per unit volume of sediment, and the proportion by weight of seeds to charcoal (Miller 1982:209-215, 219). As wood became scarcer around the settlement, dung became an increasingly important fuel source, resulting in the deposition of greater quantities of seeds relative to charcoal.

CHARRED SEEDS FROM THE TIERRA BLANCA SITE

Background.—Our second archeological example is the Tierra Blanca site (41DF3), a Late Prehistoric site located in the panhandle area of Texas (Spielmann 1982). This is a small habitation site which apparently was occupied several times from ca. A.D. 1200-1400 to ca. A.D. 1425-1525. It is situated on a bluff above the semi-permanent Tierra Blanca creek. The modern vegetation in the area is short-grass grassland with riparian species growing along the creek. This creek-side vegetation includes a number of tree species that were planted in the area in the 1940s.

The plant remains from the site, analyzed by Smart (1982; final report in preparation), include charcoal, charred seeds and a maize *(Zea mays)* cob and cupule fragments. Fifty-four flotation samples ranging in size from 0.75 to 2 liters were taken. These samples came from a variety of contexts including hearths, roasting pits, ash dumps, structures and other deposits rich in organic material. Slightly more than half (57%) of the samples contained charred seeds. The most commonly encountered identified seeds are members of the grass family. Other identified seed types are the sedge family and weedy plant types including goosefoot *(Chenopodium)*, the knotweed family (Polygonaceae) and purslane *(Portulaca)*.

Two particularly interesting flotation samples were taken from an ashy deposit within an impermanent habitation structure consisting of a ring of boulders possibly used to anchor a skin or brush superstructure (Spielmann 1982:284). The densities of charred seeds from these two samples were much greater than those from the other samples containing whole charred seeds. These two samples had an average density of ca. 575 whole seeds per liter of sediment while the densities from the other samples ranged from 0.5 to 26.5 whole seeds per liter of sediment with an average of 4.2 whole seeds per liter. Together the two samples from this ashy deposit contained over 1800 charred small grass seeds of the *Eragrostis/Sporobolus*-type[1] and more than 50 grass seeds of other types, smaller numbers of sedge seeds, and a few seeds of the weedy plant types, goosefoot and purslane. We believe the presence of grass and sedge seeds in this deposit could be the result of the use of dung as fuel.

Meeting the conditions for the dung fuel interpretation.—The results of the analysis of palynological samples from the Tierra Blanca site suggest that the environment of the area at the time this site was occupied was similar to the modern environment (Gish 1982). In this short-grass grassland environment, obtaining sufficient wood for fuel could have been a problem.

Prehistorically, the short-grass Plains region was the home of herds of bison, which produce dung that is suitable for fuel. The aboriginal use of bison dung as fuel is documented in several Plains Indian ethnographies (e.g. Hornaday, cited in Roe 1970:605; Grinnell 1923a:53-54; Wallace and Hoebel 1952:51, 90; Opler 1941:394). In addition, a number of historical accounts of early travelers in the American West refer to the use of "buffalo chips" or *"bois de vache"* for fuel (Roe 1970:346, 605-606). Faunal remains recovered from the site demonstrate that bison were present in the site area and in fact were the primary focus of the economic activities of its inhabitants (Spielmann personal communication).

A recent study of the foods eaten by modern bison inhabiting the short-grass Plains region of Colorado demonstrates that grasses and sedge make up the bulk of their diet (Peden 1972:36-39). Seeds from both these families were found in the two flotation samples from the ashy deposit. Interestingly, the diet of these modern bison includes *Sporobolus cryptandrus* and another species from a closely related genus (following Gould 1975), *Muhlenbergia torreyi* (Peden 1972:113).

The ashy nature of this archeological deposit suggests it is the product of secondary dumping of hearth contents. This is consistent with an interpretation that the charred grass and sedge seeds from this deposit are remnants of the use of dung as fuel.

Interpretation.—Although the conditions for considering the dung fuel interpretation have been met, alternative interpretations of this seed assemblage of course are possible. Since there is no evidence for general burning of this structure, these seeds must have been charred by accidental or intentional burning of the plant material.

Accidental charring of the natural seed rain can not be ignored on a relatively open site such as Tierra Blanca. However, the recovery of large quantities of the same seed taxon in these two samples is inconsistent with this interpretation. Therefore, these *Eragrostis/Sporobolus*-type grass seeds were probably deposited at the site as the result of direct resource utilization, indirect utilization or incidental inclusion with utilized resources. The larger grass and sedge seeds may have been deposited as a result of these processes as well.

The large quantities of *Eragrostis/Sporobolus*-type grass seeds present in these two samples could indicate that the seeds themselves were used, possibly as food. The use of *Sporobolus cryptandrus* seeds as food has been documented in the ethnobotanical literature for two Plains Indian groups, the Apache and the Kiowa (Castetter and Opler 1936:48; Vestal and Schultes 1939:17). Seeds from *Muhlenbergia*, a related genus, were reportedly used as food by the Apache as well (Reagan 1929:157; Castetter and Opler 1936:48). To our knowledge there is no report of the use of *Eragrostis* seeds as food by any Plains Indian group. They were utilized by the Paiute, inhabitants of the Great Basin, who had a very different hunting/gathering subsistence strategy than the Plains Indian groups (Doebley 1984).

The nature of the archeological deposit that contained these seeds rules out the possibility that they were part of a cache that accidentally burned. If these grass seeds were collected for food they probably became charred as the result of an accident during processing. Interestingly, the fruiting structure of *Sporobolus* is such that the naked grain is "easily freed from its membranous bracts. This may make processing simpler, as heating to free the grain from its bracts is not required" (Doebley 1984:59). This would also reduce the likelihood of charring due to processing accidents. However, parching of *Sporobolus cryptandrus* seeds as part of food preparation was reported among the Kiowa (Vestal and Schultes 1939:17).

The charred grass and sedge seeds from these samples could be the by-product of other cultural activities. For example, sedges, especially *Scirpus*, were commonly used to make mats in the Plains area (Gilmore 1919:69; Grinnell 1923b:170-171). Sedge seeds might have been a by-product of the mat-making process which were accidentally or intentionally added to the fire.

There are ethnographic accounts of the use of grass to cover foods roasted in outdoor pits (Castetter and Opler 1936:29; Opler 1941:367). This practice could easily result in the charring of grass seeds. However, the archeological context of these samples suggests that this was not the case. A roasting pit adjacent to the structure in question contained only one grass seed, and a dump which was directly associated with this pit contained no charred seeds at all. Another roasting pit associated with an earlier occupation of the site contained only a few grass seeds. None of these features contained sedge seeds. In addition, since the roasting pits were located outside of the structures, and the seed-rich ashy deposit was located within a structure, it seems more likely that the ashy deposit was residue from an internal hearth rather than a roasting pit.

It is not possible to discount the interpretation that the hundreds of charred *Eragrostis/Sporobolus*-type grass seeds from these samples were collected for use as food or that the sedge seeds were brought to the site as a by-product of the use of that plant. However, we feel that the dung fuel interpretation is equally plausible and can account for the presence of both grass and sedge in the charred seed assemblage from this deposit.

CONCLUSIONS

We have demonstrated that seeds can be brought to a rural village incorporated in dung and become charred when that dung is used as fuel. We believe that dung burned as fuel can account for certain archeological seed assemblages as well. Such charred seed assemblages reflect animal dietary patterns rather than the natural seed rain, direct use of the seeds or ther plant parts of those taxa, or plant processing practices.

We enumerated four conditions for assessing whether the use of dung as fuel might account for a given charred seed assemblage and presented two very different archeological cases in which this interpretation seems plausible, an urban center from the Middle East and a small hunter/gatherer habitation site from the southern Plains. These examples demonstrate that the dung fuel interpretation is applicable even in the absence of seeds actually embedded in burned dung from a given sample. Yet no interpretation is appropriate for every site, and even in these cases alternative explanations have been considered. Paleoethnobotanical interpretation always depends on careful evaluation of the particular and unique archeological deposits and associated plant remains under consideration.

We hope that this paper has demonstrated the value of identifying additional mechanisms that can account for the presence of seeds on a site and their incorporation into the archeological record. Ultimately, the better our understanding of depositional processes becomes, the more accurate our reconstruction of past economies and environments will be.

ACKNOWLEDGEMENTS

We would like to thank Vaughn M. Bryant, Jr., Richard I. Ford, John M. O'Shea, John D. Speth, and our anonymous reviewer for their useful comments on earlier versions of this paper. We are grateful to the assistant crew chiefs and crew members of the ethnobotanical lab of the Black Mesa Archaeological Project who took our request for burned dung samples seriously. The recent excavations at ancient Malyan were directed by William Sumner under the auspices of the University Museum of the University of Pennsylvania. Excavations at the Tierra Blanca site were conducted by Katherine A. Spielmann as part of her dissertation research while she was a student at The University of Michigan.

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NOTES

[1]These small grass seeds are very similar in appearance to seeds of the genera *Eragrostis* and *Sporobolus*. However, due to the very large number of grass genera native to the area and limitations in the available comparative material, the possibility that these seeds are from another grass genus can not be ruled out at this time.