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Paleoethnobotany: Modern Research Connecting Ancient Plants and Ancient Peoples

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Paleoethnobotany is a growing subdiscipline of archaeology that utilizes information from numerous other disciplines to show the relationships between ancient plants and ancient peoples. The two primary disciplines that underlie paleoethnobotanical research are archaeology and botany. As such, the results of ongoing botanical research on taphonomic processes, genetic identification of ancient plant types, pollen analysis, phytoliths analysis, and seed identification directly affect the strength of paleoethnobotanical models of past human behavior. Preserved seeds form a significant portion of the archaeobotanical record. They represent not only the environment that was present when they were deposited but also a connection to the activity and culture of ancient people. Using the type of archaeobotanical remains and the archeological context of the remains, paleoethnobotanists study a diverse range of topics. These topics include, but are not limited to, the use of plants in ancient cultures, the development and rise of agriculture, and the relationship between agriculture and settlement patterns.

Keywords archaeobotany, archaeology, archaeobotanical record, archaeobotanical taphonomy, prehistoric plant use

With the increasing capacity to access and distribute information, the distinction between many fields of research has blurred, and new perspectives on ongoing research have developed. The resulting overlapping research communities, or multidisciplinary fields, have significantly contributed to the understanding of human interactions with the environment. Research focusing on human-plant interrelationships is a good example of this development, where skills and knowledge gained from botany have been applied to the disciplines of archeology and anthropology. These applications are manifested in ethnobotany—the study of the interrelationship of plants and people in a contemporary or historic setting—and paleoethnobotany—the study of ancient plant-human interrelationships. Paleoethnobotany, the focus of this article, is considered a subdiscipline of archaeology that addresses the environmental and dietary questions associated with past cultures. It would not be possible to address these archaeological issues, however, without understanding numerous facets of botany.

Human alteration of the landscape, both intentionally (through cultural practices) and unintentionally, is necessitated by our dependence on the environment. Although not always obvious, many of the ways in which the landscape was altered by ancient peoples are recognizable and the remnants of their activities accessible. Structures, pottery, and beads are types of artifacts that often remain in the archeological record. Plants and other organic materials usually decay and are removed. Under certain conditions, however, plant remains will be preserved and become evident in the archeological record. For paleoethnobotanists, these preserved remains represent the means to discover connections between the people who deposited them and the environment in which they lived. In fact, preserved plant remains found in archaeological sites can tell us a great deal about the people who lived there.

Diet, nutrition, clothing, tools, shelters, fuels, cultivation practices, food preparation techniques, and medicinal and ceremonial activities are but a few of the human-plant interactions that paleoethnobotany attempts to reconstruct from the archeobotanical remains recovered from archeological sites (see Pearsall, 2001). Through the synthesis of information from archaeology, botany, other disciplines (including anthropology, ethnobotany), and ethnobiology, and the examination of ancient plant remains, paleoethnobotanists work to establish the extent and variety of activities involving ancient people and ancient plants. The synthesis of information from multiple disciplines and the extrapolation of data gathered from archeological sites into useful paleoethnobotanical information is not an easy task.

Seeds, wood charcoal, plant impressions, pollen, phytoliths, and residue remains on artifacts are all important parts of the archaeobotanical record that contribute to paleoethnobotanical research. Each type of remain is derived from different parts of

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the plant, accumulates and preserves differently in the archaeological record, and requires different techniques of study. Different scholars often specialize in their analysis (Weber, 2001; Pearsall, 2001). Although varying from region to region and site to site, archeological seeds are one of the most common forms of archaeobotanical data gathered for analysis. Preserved seeds can be easily recovered and identified and have been studied for a longer period of time in most regions of the world. And, while seeds may often represent the bulk of a site's archaeobotanical record and are the emphasis of this article, they comprise only one avenue of paleoethnobotanical research.

A HISTORICAL PERSPECTIVE

While the history of the development of archaeobotanical data collection and analysis varies from country to country in terms of when specific ideas and techniques were introduced, four general stages, roughly associated with a time period, are recognizable in most regions. For a more complete review of the history of paleoethnobotany see Ford (1979), Fuller (2002), and Pearsall (2001).

Seeds, as a type of archeological remain, have been recovered and identified from sites for some time. By the 1950s, plant remains were commonly recovered and were often presented at the back of archaeological site reports merely as a list of species associated with particular sites. Archeologists at this time were usually directed toward the discovery of artifact typology and the development of technology through time and not toward plant remains. Because of this, there were few or no references made toward the provenience or context of the recovered plant remains. Compounding this problem, the botanists that worked with archaeologists to identify the recovered remains were themselves usually neither trained nor knowledgeable in the practice of archaeology. This combination resulted in simple taxonomic lists that had little interpretive value other than to tell one which plants were present in prehistory. Although this process happens with less frequency today, it does continue.

The 1960s and 1970s saw an increased pace of excavating and writing about past cultures. These trends were associated with increased efforts at incorporating more disciplines into the understanding of archaeological sites (Weber, 2001). This shift toward interdisciplinary research also occurred at a time as the first efforts to systematically collect soil from archaeological sites for the purpose of finding archaeobotanical material. While dry screening was being practiced, it was the introduction of flotation (described below) that most dramatically effected paleoethnobotanical research. As more archaeobotanical material was being recovered, there developed a need for specialists to make sense of it. The demand for botanists experienced in the analysis of archaeobotanical material eventually led to the formation of "professionals" who specialized in archaeological plant remains, particularly the identification of archaeological seeds. These new professionals were being trained in both archaeology and botany, they were actually involved in excavation, and they had a greater understanding of material culture. With the growth of processual archaeology, and its emphasis on explanation, archaeologists were interested in cultural ecology and how agriculture and its origins influenced culture and culture change. Finally paleoethnobotanists were actively involved in the interpretation of past cultures.

By the 1980s, with large numbers of systematically collected seeds now available, paleoethnobotanists began comparing both the relative importance of different taxa present within a sample and the overall contents of different samples to one another. Efforts to understand archaeobotanical variability within sites and between sites led toward quantification and statistical analysis of the archaeobotanical record. As a result, more attention was given to the context of recovery and to the means by which seeds might have been preserved and deposited at the recovery location.

With the accumulation of archaeobotanical data and the development of their multidisciplinary skills, paleoethnobotanists began to look at how social processes might affect the occurrence of specific plants in the archeological record. Today, the agricultural models created from the perspective of paleoethnobotanists, with their emphasis on cultural practices, are challenging existing models derived from the perspectives of other disciplines. To strengthen the development of these models, two goals have been identified. The first is to try to reach consensus on interpretations of the archeological record within the multidisciplinary community. The second, closely linked to the first, is to push for the standardization of excavation, identification, and quantification techniques while fully acknowledging the particularities that come with each site and the different focus that each of the various disciplines brings to bear on the record. For more on this subject see Berggren and Hodder (2003). Efforts to achieve these goals are ongoing, and they reflect the continuing need for stronger communication among and between researchers in archeology, botany, and paleoethnobotany.

THE SEED RECORD

How seeds enter into the seed record is a more complicated issue than identifying the seeds themselves. The use of a plant and its involvement in a human behavior affects its chances of occurring in the archeological record. Activities involving plants that require heat or that occur around fire are more likely to lead to carbonization, and hence preservation (Hastorf, 1993; Hastorf and Popper, 1988; Miller, 1984). It is unlikely at most sites that prehistoric seeds will preserve in an uncarbonized state, except in unusual circumstances such as inside ceramic vessels or sealed containers. Although seeds can become carbonized "naturally" (*e.g.*, in a naturally caused fire), charred seeds have usually not been recovered from the nonarcheological samples around sites. It is a safe assumption that most charred seeds are a result of human activity.

Charring, baking, and cooking mean the use of fire, fire pits, hearths, ovens, and kilns. This information represents a range of human activities that are significant in recreating what the ancient inhabitants of an archeological site were doing on a daily basis. It is, perhaps, a humorous form of serendipity that "cooks" far in the past managed to burn dinner. Despite this image, most carbonized seeds do not represent food remains. Carbonized seeds from hearths, a common location to sample, often are a reflection of a fuel rather than a food. For example, where dung is commonly used for fuel, recovered seeds might represent what a cow ate rather than what was being prepared for people (Miller and Smart, 1984). It is important to note that the context from which the remains were recovered is not necessarily where carbonization occurred. Trash disposal areas often provide a trove of archeological data that has to be further associated with originating contexts.

To be clear, the seed record in any archeological site is a biased reflection of a once-living community (Fuller, 2002). Only a small portion of seeds ever become carbonized, a smaller number are preserved, and a smaller set are retrieved through excavation. To compensate for these limitations, methodological and analytical frameworks are used that logically relate archaeobotanical remains to human uses of plant materials.

What seed remains enter into the record and the taphonomic processes at work are therefore fundamental to paleoethnobotanical models. While preservation of plant parts can occur when they become waterlogged, desiccated, or mineralized, the key process of seed preservation is, again, carbonization or charring. The method of charring can further complicate interpretion of the remains. While charring in a lower temperature range can preserve seeds with their morphology retained, higher temperatures usually cause a loss of seed coats and glumes, and severe shortening and swelling (Pearsall, 2001). Seed type is another factor to consider—since oil burns off, the oilier the seed, the less likely it is to preserve under charring conditions. Less oily seeds, like most cereal grains, preserve more easily. Physical characteristics of the plant also affect the chances of preservation. Remains of plants producing only a few large seeds are less likely to be preserved in large numbers than from those that produce many small seeds.

SAMPLING THE SEED RECORD

Like artifacts, seeds can be identified and their spatial and temporal distribution determined (Dennell, 1974; Thomas, 1983). Existing knowledge of archaeobotanical data, and the context of the material, permits paleoethnobotanists to make determinations about if, how, and when a plant was being used. Context is fundamentally important as it determines both sampling patterns and archeological significance. Hearths are significant because of the likelihood that botanical remains are preserved and because of the clear connection to human activity. Other significant site locations like food procurement, processing, consumption, and disposal areas are also targeted for sampling. Samples from contexts where household activities, such as crop processing and food preparation, are more likely to have occurred are expected to yield much more information about agricultural production (Hastorf, 1993). Sites where no plant remains are expected are also targeted—to balance the sampling distribution, to attain adequate samples from a sufficiently large number of contexts, and to provide controls for samples from significant locations. Stringent methods are used in order to avoid identification of patterns in the archaeobotanical data that stem from excavation methods or bias due to various taphonomic processes.

Sampling strategies vary according to the research question that motivates them. Whether there are to be inter- or intrasite comparisons, the type of analysis available, and funding issues are all limiting factors. Optimally, however, sampling strategies attempt to include as wide a variety of contexts as possible and to sample these contexts multiple times. Samples are systematically collected and analyzed from each phase of occupation and within each context (Minnis, 1986; Hastorf, 1993; Dennell, 1976) located within a site. Activities relating to the manipulation of plant products are assumed to have been distributed systematically with respect to context type. Samples are thus collected to represent as many different structures and features as possible (Hillman, 1981). Many small samples from the same context are considered better than a few larger ones and statistically increase the ability to accurately interpret each sample (Hastorf, 1993; Dennell, 1976). Soil from each sampled location, commonly ranging from 3 to 15 l, is measured (weight and/or volume), bagged, and labeled. The plant remains then need to be separated from the archaeological sediments. While dry screening is often applied and may be the only option under certain conditions, water flotation is the preferred choice when a systematic sampling design employing large volumes of soil is required (Pearsall, 2001).

Flotation

The basic operation of a commonly utilized flowing water flotation system (Figure 1) utilizes a constant spray of water against a flotation reservoir, into which an entire soil sample is slowly poured. The reservoir, a circular container with a mesh bottom and a spillway, allows materials that float (light fraction) to pass through the spillway into a fine woven cloth or series of different meshed screens, as the sample is gently agitated to break up clumps. The heavier material, or heavy fraction, sinks to the mesh bottom of the reservoir. Water is kept running continuously until no further carbonized material floats to the surface and over the spillway. After each sample the flotation tank, heavy fraction mesh insert, and the light fraction receptacles are thoroughly cleaned. Materials that are separated into light and heavy fraction are determined by the strength of the water flow, the composition of the sediments, and the densities of charcoal, shell, insect parts, bone, pottery, and so forth. All materials are eventually sorted through and analyzed.

Mesh size, water pressure, clogged cloth, and accidents cause the flotation procedure to be far from problem free. On the whole, however, it is reliable, fast, and improving as a means to separate archaeobotanical remains from archeological sediments.

FIG. 1. Flotation system used at the site of Harappa, Pakistan.

Because biases in the recovered material may be introduced through the soil processing and recovery techniques, special care has to be taken to minimize contamination of samples (Wagner, 1982; Watson, 1976; Pendleton, 1983; Minnis, 1981). In anticipation of these problems, and because recovery rate poses significant problems for later interpretation and analysis if it is not measured, a simple test can be employed (see Wagner, 1982; Pearsall, 2001). A set number of carbonized seeds representing a species not found in the region being sampled can be placed in the archeological soil of some of the samples at the point of excavation (*e.g.*, poppy seeds placed in samples from archaeological sites located in the Americas). The condition and number of seeds of this specific species that are recovered from the samples during the sorting stage of analysis is deemed a good measure of the recovery rate accuracy for the flotation system.

Sorting and Identifying

After the samples have been floated and sorted they are usually shipped to where the analysis will be done. Care has to be taken when shipping samples, as the materials are particularly delicate. Charred remains pulverize easily if shipped in improper containers, or without proper packing materials, resulting in nothing to analyze by the time the samples are received. Once received, samples are processed carefully to retrieve items (such as seeds) for identification. Seeds are sorted by type, size, surface texture, or shape if they are not readily identifiable (Figure 2). It is during this stage that any test seeds (like the poppy seeds mentioned above) would be extracted.

Comparative collections and seed keys are used to attempt complete identification of recovered seeds. Consultation with botanists, archaeobotanists, paleoethnobotanists, and local residents with traditional knowledge is also a common practice. After identification, relative percentages, ubiquities, and densities for each taxa, for each kind of context (hearths, room floors, general fill, trash, etc.), and for period and subperiod are recorded for seed samples.

INFERENCES AND INTERPRETATION

How is it possible to hypothesize how people in the past lived from looking at an assemblage of ancient plant remains? Paleoethnobotany requires that differential preservation, seed production rates, mechanisms of dispersal, modes of accumulation, and postdepositional history all have to be brought into account (Minnis, 1981; Pearsall, 2001). To reiterate its importance, an understanding of archaeobotanical taphonomy and an acceptance that archaeobotanical remains represent only a portion of the plant communities within the site environment are also considered when interpreting the archaeobotanical record. Further, methods of excavation, knowledge of the prehistoric culture, and its material record are all important information in properly understanding the significance of the archaeobotanical remains.

Inferences and interpretations will always vary according to the context of an archeological site as a whole, and it cannot be expected that interpretations of evidence in one region will match those for sites in another. Though this is true, there are many commonalities in how archaeobotanical evidence is treated. On a broad scale, knowledge of the regions and growing conditions of particular plants can be used to assess the environment when the site was occupied, the seasonality of its occupation, as well as the plants that were utilized by the inhabitants. Archaeobotanical remains are used to assess climate and other environmental conditions for numerous reasons. Within the archeological context, climate reconstruction is important since it influences site location (*e.g.*, proximity to water), and tends to delimit the parameters of subsistence and settlement patterns. Any change in climate could drastically alter the way people live, drive them to another area, or dramatically affect access to productive resources (Butzer, 1982).

The variety and number of plant remains—both inedible and edible—that are found in excavations have to be related to their origin. Did they come from the immediate vicinity or were they transported from longer distances? Were they grown in plots

FIG. 2. Sample of archaeological barley and wheat seeds.

that are associated with other artifacts? Is there any evidence that plant materials were stored? Was the storage structure a pit, or some other construction? All of these questions and the interpretation of contextual evidence are, as detailed, beyond the simple identification of the plant itself. It is both the type of remains and the context of the remains that are critical to any interpretation.

An Example from Harappa

The site of Harappa is located between two major tributaries of the Indus River approximately 100 miles south of Lahore, Pakistan. It was a major center for both local and regional trade items, including agricultural products. It lay in the northernmost area of the Harappan civilization, an area based today on a winter cultivation strategy using wheat and barley. With good rainfall

TABLE 1
Periods and dates of the Harappan civilization

Period	Phase	Dates
Period 5	Late Harappan Phase (Cemetery H)	c. 1800–1700 B.C.
Period 4	Transitional	c. 1900–1800 B.C.
Period 3C	Harappan Phase	c. 2200–1900 B.C.
Period 3B	Harappan Phase	c. 2450–2200 B.C.
Period 3A	Harappan Phase	c. 2600–2450 B.C.
Period 2	Transitional (Kot Diji)	c. 2800–2600 B.C.
Period 1A and 1B	Early Harappan (Ravi)	c. 3300–2600 B.C.

and fertile soils, this area can have, and still does have, abundant harvests.

The objective of paleoethnobotanical inquiry at Harappa has been to utilize archaeobotanical remains to reconstruct the agricultural strategy for each period (Table 1) and subperiod of occupation. The preservation of carbonized seeds and fragments has been very good at Harappa (Tables 2 and 3), and research indicates that there appears to have been constant effort to diversify crops at the site of Harappa.

This diversification was neither rapid nor sudden. Each subsequent period contains a greater variety of plants and represents an increasing effort at cropping throughout the year. Associated with this pattern is an increase in the proportion of weed seeds. Their presence in the samples is useful for reconstructing crop husbandry practices since they commonly grow in agricultural fields and are removed prior to consumption. They also could reflect use as medicine, a food supplement, or even an increase in disturbed areas throughout the area.

What is significant with the Harappan data is that the diversification of crops at Harappa is accompanied by a shift in emphasis on certain plants. As an example of this shift in emphasis, the wheat-barley record at Harappa indicates a shift from barley to wheat (Early period to Harappan period) and back to barley (Late period) (Weber, 1999). Though environmental changes can certainly account for some shifts in agricultural strategies, the patterns in diversification and varying emphasis have stronger correlations to cultural changes at Harappa. For full treatment of this example see Weber (2003).

TABLE 2
The archaeobotanical database used in this study

Period	Samples	Liters floated	Seed density	Taxa
Early Period (1–2)	32	280	36	15
Harappan Period (3A–3C)	41	394	58	25
Late Period (4–5)	17	232	11	34
Total for Harappa	90	906	39	36

Grades of Interpretation

As noted, the archaeobotanical record from any archaeological site is an incomplete reflection of a once living community. Understanding that samples from different locations within one archaeological site have different interpretive potential further complicates the research process. The result of these factors is that there is variation in the potential of individual samples to contribute to the reconstruction of past human behaviors. This variation, or interpretive spectrum, ranges from those samples that provide little more than confirmation of the presence of particular species to those which can be analyzed as snapshots of past agriculture or other plant-based activities. The following interpretive spectrum, while developed for South Asian contexts, can be adapted and applied to different regions. The spectrum can be divided into the following four main grades (see Fuller and Weber, in Press):

- Grade 1. Samples in this grade have little interpretive value since they represent plant remains from poorly defined or recorded contexts. Seeds from archaeological sites that lack clear and unambiguous spatial or temporal knowledge mean that their interpretive value is limited. Seeds in this category generally represent accidental finds made when an excavator simply noticed some plant material, collected it, and sent it on to a botanist for identification. These samples usually result in simple statements about the presence of a specific species at a specific site.
- Grade 2. Samples in this grade are from defined contexts, but where presence or absence is the main interpretive value. These samples may represent seeds from isolated finds, floated soil, or even pockets of charred material, but they either lack the detailed recording necessary for quantification or contexts that imply specific behaviors. In grade two situations the presence of a particular species at a specific time can be demonstrated, and it can be associated with a particular culture. Its use and importance within the culture, however, is either unknown or can only weakly be demonstrated.
- Grade 3. These samples are attained through systematic soil collection and extensive flotation systems. They are usually associated with large archaeobotanical assemblages that provide data that can be summarized numerically. This allows results to be quantified and statistically analyzed. Since these samples have both well defined contexts and a quantitative value, paleoethnobotanists can compare differing sample contents as well as develop sophisticated comparisons of the relative importance of different taxa present within an individual sample. While it can be assumed that archaeobotanical distributions representing specific contexts have discrete depositional patterns that reflect human behavior (Hastorf, 1993), behavioral interpretations of Grade 3 samples should be seen as suggestive and needing further corroboration.

TABLE 3
Categories of cultivated plants recovered from Harappa based on seeds from flotation samples

Plant taxon	Cropping season	Early 3300–2600	Harappan 2600–1900	Late 1900–1700
Cereals				
Wheat (*Triticum*)	W	X	X	X
Barley (*Hordeum*)	W	X	X	X
Rice (*Oryza*)	S	—	?	X
Millets (*Panicum*)	S	X	X	X
Pulses and vegetables				
Peas				
Pisum	W	X	X	X
Cicer	W	—	—	X
Lathyrus	W	—	X	X
Lentils (*Lens*)	W	X	X	X
Gram				
Vigna	S	—	X	X
Medicago	S	—	X	X
Oilseed and fiber				
Linseed (*Linum*)	W	—	X	X
Mustard (*Brassica*)	W	—	X	X
Fruits				
Melon (*Cucumis*)	S	—	X	X
Date (*Phoenix*)	S	X	X	X
Jujube (*Ziziphus*)	W	X	X	X
Grape (*Vitis*)	S	X	X	X

Note: W, winter/spring-harvested; S, summer/fall-harvested; X, present; —, not recovered.

- Grade 4. These types occur least frequently. When they do occur, direct human behavior is easy to infer because of the context of recovery. An example of this kind would be seeds recovered from a sealed storage jar or plant residue on the interior surface of a cooking pot. Grade 4 samples provide the strongest means of connecting archaeobotanical material to human behavior, and they also serve as a basis for building models about human activities, plant–human interrelationship, and ultimately culture.

As with archaeological theory, paleoethnobotanical studies must include predepositional, depositional, and postdepositional theory. With the advent of experimental and ethnoarchaeological studies, paleoethnobotany is beginning to account for precharring formation of the seed plant assemblage, the charring process and eventual deposition, and a variety of postdepositional factors.

THE FUTURE OF PALEOETHNOBOTANY

The relevance of paleoethnobotany as a multidisciplinary field continues to be strengthened. Technologies and methods of analysis have significantly changed since the beginning of paleoethnobotany as a field, and with these changes there are now more ways to test and strengthen the theoretical frameworks that have been established. There is also a wider range of contributions that various disciplines can give to paleoethnobotanical research.

As the means to strengthen our understanding of ancient peoples grows there is also a greater ability to examine the connections to human behaviors that exist today. Paleoethnobotany has advanced to where the expertise of more disciplines is needed. The interconnectedness between people and plants that has been charted extends through broader research areas than botany and archeology. Ecology, ethnozoology, anthropology, ethnobotany, and other disciplines have increasing roles within paleoethnobotany and should be encouraged to view the varying methodologies and philosophies within paleoethnobotany as a strength.

Construction of viable models of the past using a paleoethnobotanical approach is evident. Interpretations made from the vantage of a paleoethnobotanist evolve, however, with the addition of data derived from all contributing disciplines. So long as strong communication and exchange of ideas continues between disciplines, advances in any one can advance the sophistication of our understanding of subsistence patterns, technologies, trade, settlement types, seasonality, ideology, and social status of ancient peoples. It is fitting that stronger connections between modern people involved in diverse disciplines foster the understanding of interrelationships of ancient people and ancient plants. It is, after all, these same connections that allow us to share what we have learned of the past, and to better examine our ongoing relationships with our environment.

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