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Burials: Dietary Sampling Methods

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Glossary

control sample A sample collected from an area that is not likely to be influenced by the phenomenon under study which is used to compare analytical results with those from areas that are likely to have been impacted by the phenomenon under study.

dental calculus Hardened plaque on the teeth which is formed by saliva, food debris, and minerals.

dental plaque An adherent substance made of mucus, food particles, and bacteria.

edaphic Resulting from, or influenced by, the soil.

pelvic girdle The bony ring supporting the lower limbs in humans composed of the two hip bones laterally and in front, and the sacrum and coccyx behind.

pollen aggregates Clumps of pollen composed of many grains of the same type. These signal economic use of buds, flowers, anthers, or sometimes seeds or fruits.

pollen concentration A method for calculating the number of pollen grains present per milliliter or gram of sediment based on adding known numbers of exotic pollen grains or spores to a sediment sample.

sacrum A triangular bone made up of five fused vertebrae and forming the posterior section of the pelvic girdle.

stratigraphic column In burial analysis, a stratigraphic column refers to the layers within the pelvic girdle that range from burial fill to intestinal remains. As a corpse decomposes, sediment from the burial fill enters the pelvic girdle from above and compresses the intestinal contents to the lowest part of the pelvic girdle, the sacrum. The uppermost sample from the highest part of the pelvic girdle is composed of burial fill. The middle of the pelvic girdle might contain some food remains. The lowest level is very likely to contain dietary residue from food.

Burials and Preservation Microenvironments

A burial contains numerous, individual microenvironments, each of which has a different preservation potential, which in turn can provide evidence of human diets. Animal and plant food residues can be recovered from the lower intestinal tract, oral cavity, associated vessels, other forms of burial offerings, and fragments or whole plants or animals deposited in the burial. Individual microenvironments at a burial site result from many aspects including, but not limited to: (1) preparation of the burial feature, (2) addition of burial offerings, (3) depth and orientation of the corpse, (4) edaphic conditions such as moisture and pH, (5) microbial activity, and (6) exposure of the burial when it is excavated. When burials are discovered at sites, the subsequent excavation and removal process should be done with caution and should take into consideration the subsequent types of laboratory analyses (*see* Burials: Excavation and Recording Techniques). Failures during the recovery phase, or the use of improper sampling strategies, will compromise the ability to provide valid interpretations. In addition, burial sampling must include control samples from the burial fill and surrounding contexts.

When found, a skeleton or mummified burial normally has two areas where dietary residues can be easily recovered. In life, dietary residues (*i.e.*, pollen grains, phytoliths, starch granules, plant fibers, animal hairs, *etc.*) are produced or released during mastication and some of these can become trapped in dental plaque (*see* Pollen Analysis). If not removed, within a few days, plaque is mineralized and adheres to the teeth in the form of dental calculus. Large deposits of calculus are often found on teeth (Figure 1). Dietary microfossils and residues that were trapped in the calculus are easily recovered during laboratory analysis (Figure 2). Sometimes artifacts or vegetal materials are placed in the mouth of the deceased, especially in the Andean region of South America. Such types of vegetal materials can often be recovered and identified as microfossils or macrofossils present in the area of the oral cavity of a burial.

The second burial area of dietary interest is the abdominal area, specifically the sacrum and the soil inside the pelvic girdle. In some well-preserved burials, distinct fecal pellets (coprolites) can be found in the abdominal area because the colon is located in that area. However, for most burials, distinct coprolites are not visible, but controlled sampling of sediments in the pelvic girdle area may reveal seeds, starch grains, phytoliths, pollen, and other types of residues of dietary and medicinal importance.

Figure 1 Photograph of dental calculus. Microfossils from dental calculus reflect diet for a few days prior to death.

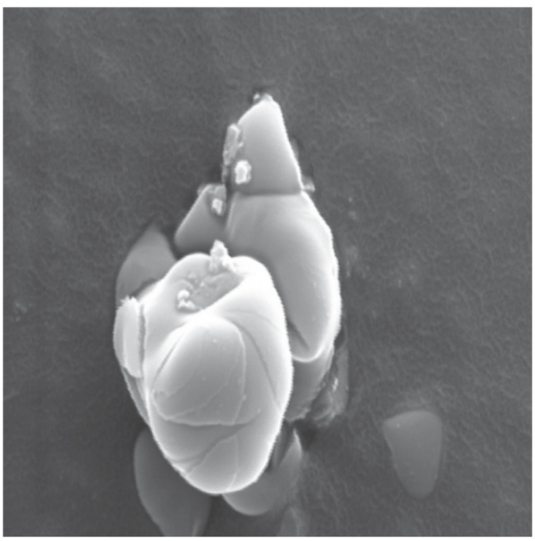

Figure 2 Microfossils, for example the starch grains illustrated here, are quite common in dental calculus.

In some types of burials, a variety of grave offerings are included with the body. If present, each bowl or other type of vessel in a burial becomes its own microenvironment, which can offer evidence of its original contents (i.e., pollen, starch, phytoliths, and macrofossils). Some types of grave offerings present better microenvironments of preservation. For example, basketry vessels are less durable than ceramic vessels, and therefore have less preservation potential. Objects made of copper or copper alloy promote preservation because the copper oxide produced by the object is toxic to most types of microbial decomposer organisms.

When containers are found in burials, there are various techniques that should be used to sample for dietary residues. For ceramic vessels, a rinsing of the inside, bottom portion is appropriate. Ideally, burial artifacts should be collected in the field, placed in sterile containers that are then sealed, and then sent to a laboratory where the contents can be removed in a controlled environment. A control sample of burial sediment around the exterior of each vessel should be collected, examined, and then used as a basis for comparison with the contents recovered inside the vessel. In burials where recovered ceramic vessels are cracked, it is often appropriate to remove the sediments in the vessel in the field. In cases where burial vessels are fragmented, analysis of the shard will sometimes provide useful palaeoethnobotanical data.

The importance of collecting control samples of the burial fill and from areas above and below the burial cannot be overemphasized. Any interpretations of paleoethnobotanical data recovered from burials (*i.e.*, mummy or skeleton, vessels, artifacts, burial floor surface) are dependent upon comparisons to data recovered from site and burial control samples. Extensive analysis of the contents of control samples will allow analysts to distinguish which items are probable evidence of diet or medicinal use and which items might instead reflect site contaminants.

Pollen Studies and Burial Sediments

As a general rule, the wind-pollinated plants produce and disperse millions of pollen grains in the hope that a few of them will be carried to their intended destination by the winds. As a result, in any given location there may be thousands or even millions of pollen grains falling to the earth's surface in what is called a region's 'pollen rain.' This is why the most frequent pollen types recovered in sediment and soil samples are from wind-dispersed plants. The insect-pollinated plants, which are sometimes pollinated by bats, humming birds, small mammals, or a host of insect species, usually produce flowers containing nectar and relatively few pollen grains. Normally, these plants need to produce only a few hundred or a few thousand pollen grains per flower because of the highly efficient method of direct pollination achieved by the various pollen carriers that visit the flowers. The pollen grain surface of most insect-pollinated types is usually covered with lipids so they will stick easily to insects that visit the flowers. In addition, these insect-pollinated plants usually produce highly ornamented pollen grains with thick, sturdy pollen walls designed to protect the pollen's cytoplasm from the often bumpy ride provided by the pollinators. In general, insect-pollinated pollen types are also heavy and overall are not designed aerodynamically for travel on wind currents. For all of these reasons, few of these types become part of the normal pollen rain of a region. One exception would be instances where flowers still containing a few pollen grains might fall to the surface underneath the parent plant, thus allowing the pollen to become released as the flowers decay. Another exception would be situations where insect-pollinated flowers are carried to a specific location by some animal or human.

Using several lines of logic and planned sampling strategies, pollen in burial soils that results from cultural activities, called 'economic pollen,' can be separated successfully from pollen that may have come from the normal pollen rain, referred to as 'background pollen.' First, if one of the pollen types in the soils of a burial matches an ethnographic or archaeological food plant species endemic to the region, or comes from a plant that may have been obtained in trade, then that pollen should be considered as potentially reflecting the use of that plant as a food source. However, roots, tubers, corms, and other underground plant organs will not carry attached pollen with them from the source plant, so there is reduced potential for the pollen from these types to be represented in the site. Seeds and fruits from some plant species that are brought to a site often do carry pollen on their outer surfaces and thus such pollen types can reflect plant usage. Nevertheless, even with such types of potential pollen sources, one must be careful to distinguish pollen evidence suggesting actual plant usage and pollen that may be from background sources. For example, a number of types of economic chenopods, including *Chenopodium* quinoa, and amaranths (*Amaranthus*) produce pollen that is nearly identical to the pollen of many noneconomic genera and species in these same plant groups. Trying to distinguish which pollen types are from economic plants rather than from noneconomic background types is often nearly impossible to determine without extensive studies using the resolution capability of a scanning electron microscope.

Pollen concentration values add another dimension to pollen data from burials and coprolites. For example, 10 maize pollen grains out of each 100 pollen grains recovered from a soil sample would be recorded as a 10% average. Similarly, 10,000 maize pollen grains out of 100,000 would also be recorded as a 10% average. However, there is a significant difference in terms of the potential importance and source of maize pollen in each of those two samples. That difference can only be realized by conducting pollen concentration values of both samples.

Low concentrations of some pollen taxa in coprolites or soil deposits may result from sources of ambient pollen in the normal pollen rain (pollen distribution in a region). However, high concentration values of the same pollen taxa would suggest some type of disturbance or cultural activity rather than resulting solely from normal pollen rain distributions. Knowing the types of percentages of pollen found in burial sediments and coprolites in burials is important because the relative pollen percentages may be roughly the same in both types of samples; however, there may be dramatically differences in the pollen concentration values. This is illustrated in the Mimbres burial (Table 1) examined by Shafer *et al.* For example, maize pollen percentages are not statistically different between the control sample and samples from the sacral coprolites. However, the maize pollen concentration values reveal an average concentration of only 266 pollen grains per gram for the control sample but 59,280 pollen grains per gram for the sacral coprolite sample.

The above discussion briefly describes some of the factors that should be considered during the analysis and interpretation of pollen materials collected from burials at archaeological sites. In addition to these, there are other, even more important considerations that must be applied to pollen studies of burial deposits. These include (1) the assurance that the person conducting the pollen analysis has not accidentally contaminated the field samples with other pollen types in the laboratory that come from the use of unclean laboratory equipment or facilities; (2) the knowledge that the researcher has not accidentally lost or

Table 1 Pollen concentration values of selected pollen types from Burial 109, NAN Ranch, New Mexico

Taxon	*Sacrum*		*Grave fill*		*Above pelvis*		*Below pelvis*	
	Conc.	*%*	*Conc.*	*%*	*Conc.*	*%*	*Conc.*	*%*
Mustard	303 240	53	0	0	0	0	0	0
Squash	6840	1	0	0	0	0	0	0
Cheno-am	43 320	7.5	2087	67	1083	54	645	59
Willow	149 340	26	15	1	0	0	0	0
Maize	59 280	10	266	9	418	21	194	18
Cattail	7410	1	0	0	0	0	0	0
Grass	3420	<1	326	11	342	17	133	12

destroyed potential pollen in a sample by using incorrect or harsh extraction procedures; (3) that the person has a working knowledge of the pollen flora of the region where he or she is conducting the analysis; and (4) that all identifications of pollen types are accurate and are based on comparisons with modern reference materials of known pollen taxa.

Case Studies – Dietary Residues from Burials

As noted above, Shafer *et al.* presented the first modern paleoethnobotanical analysis of fecal residues (coprolites) discovered within a burial. Shafer *et al.* presented multidisciplinary methods for the recovery of microscopic and macroscopic remains that related to diet and medicine. Control sediment samples were taken above the pelvic girdle, grave floor, and from the burial fill. Macroscopic evidence of finely ground maize cupules was found in the coprolites. The coprolites contained high concentrations of maize pollen. Pollen from a medicinal plant, willow, was also found in high concentrations in the coprolites (Table 1 and Figure 3). Pollen concentration adds another dimension to pollen data. In addition to knowing the types of percentages of pollen in sediments, pollen concentration provides an estimate of the number of pollen grains present per gram or milliliter of sediment. This is illustrated by the fact that maize percentages are not statistically different between the samples from the Mimbres burial. However, the pollen concentration

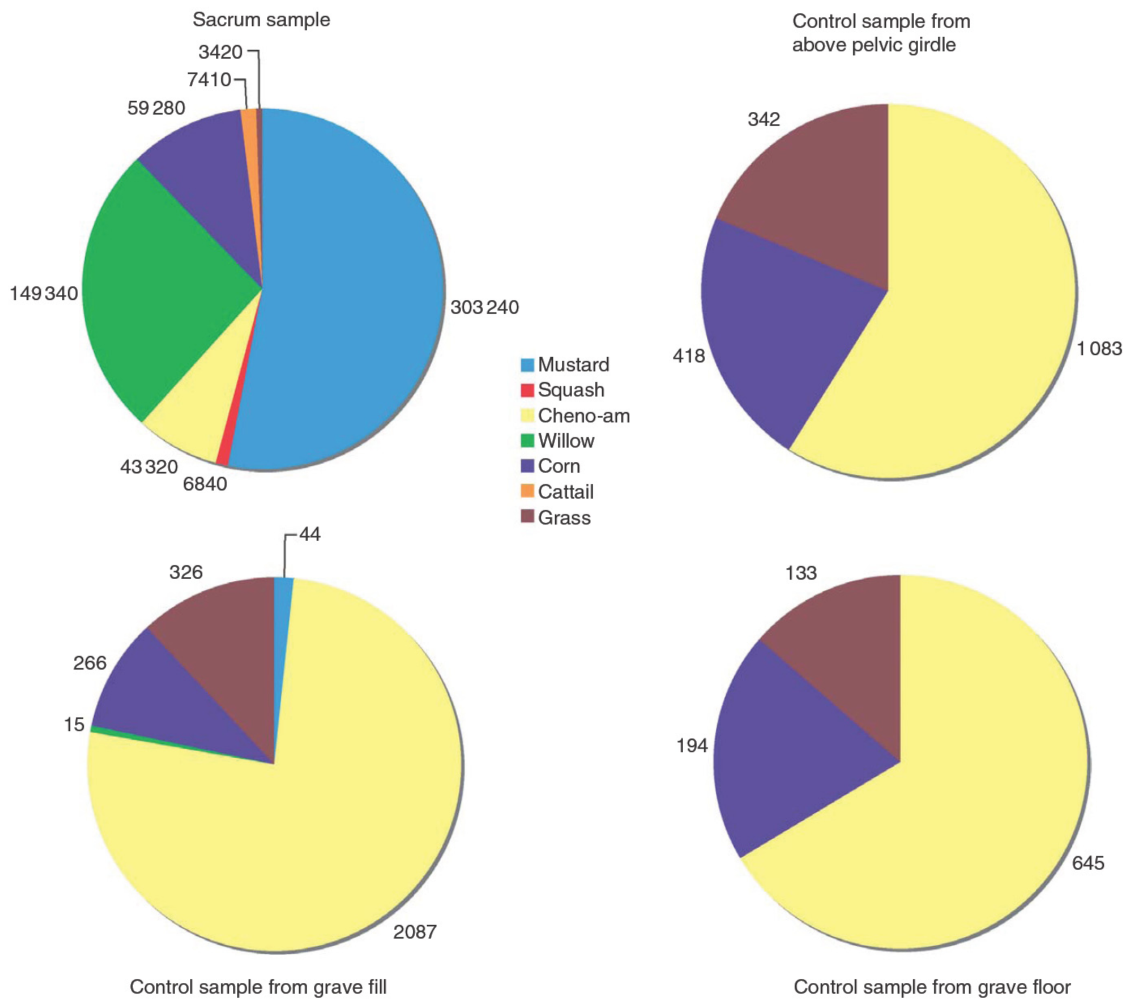

Figure 3 The pollen spectra from a coprolite and control samples from a Mimbres burial.

shows that compared to the average concentration of 292 pollen grains per gram for the control samples, the sacral coprolites contained 59-280 grains per gram.

Later, Reinhard *et al.* presented field and laboratory methods for recovering dietary residues from pelvic girdle sediments from a single burial. They recommended paleoethnobotanical study of burials as a nondestructive method to identify diet and season of death. In this case study, they emphasized the need to analyze multiple control samples to identify contamination. In this case, multiple samples were taken from a stratigraphic column within the pelvic girdle (Figure 4). The burial was excavated into a prehistoric house floor and there were a variety of contexts to sample for comparative evaluation. These included the burial fill, the house floor, a storage pit, the area of the lower legs, and the area of the skull. Seeds were found only in the sacrum (Figure 5) and 345 seeds were found in 4.3 g of sediment from the sacrum. No seeds were recovered in the 50-g control samples. Pollen aggregates (clumps of pollen of the same type) were found only in the sacrum. The seeds and pollen aggregates indicated that pigweed seeds, goosefoot seeds, sunflower seeds of two species, panic grass, and two other species were eaten. Pollen aggregates of grass, pigweed and/ or goosefoot type, sunflower type, and ragweed type were found. Therefore, the pollen and seed evidence show that the deceased ate a variety of wild plants before he died. The pollen spectra comparison shows an elevated percentage of grass pollen in the sacrum compared to the other samples (Table 2 and Figure 6).

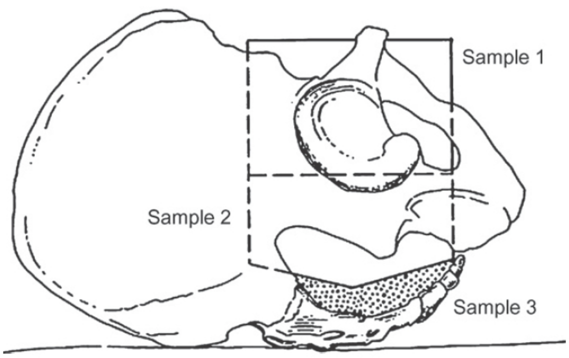

Figure 4 The pelvic girdle sampling strategy proposed by Reinhard *et al.* in their analysis of an ancestral Anasazi burial. Samples 1 and 2 are control samples taken from a stratigraphic column within the pelvic girdle. Sample 3 is a sediment sample that should be collected from the anterior surface of the sacrum, where dietary remains from the large intestine are trapped during decomposition.

Figure 5 Seeds from the ancestral Anasazi burial. The upper left shows goosefoot and pigweed seeds. The upper right shows wild sunflower seeds. The lower images are of unknown seeds. This shows that well-preserved plant foods can be recovered from burial sediments.

Table 2 Macrobotanical data from selected Arizona burials (Berg 2002)

Taxon	*Burial A*		*Burial B*		*Burial C*	
	Control	*Sacral*	*Control*	*Sacral*	*Control*	*Sacral*
Maize fragments	30	254	11	189	13	0
Agave fragments	5	424	17	491	3	35
Cactus seed	0	0	1	75	0	0
Cotton seed	2	0	8	302	0	105
Plant epidermis	0	0	13	264	6	0

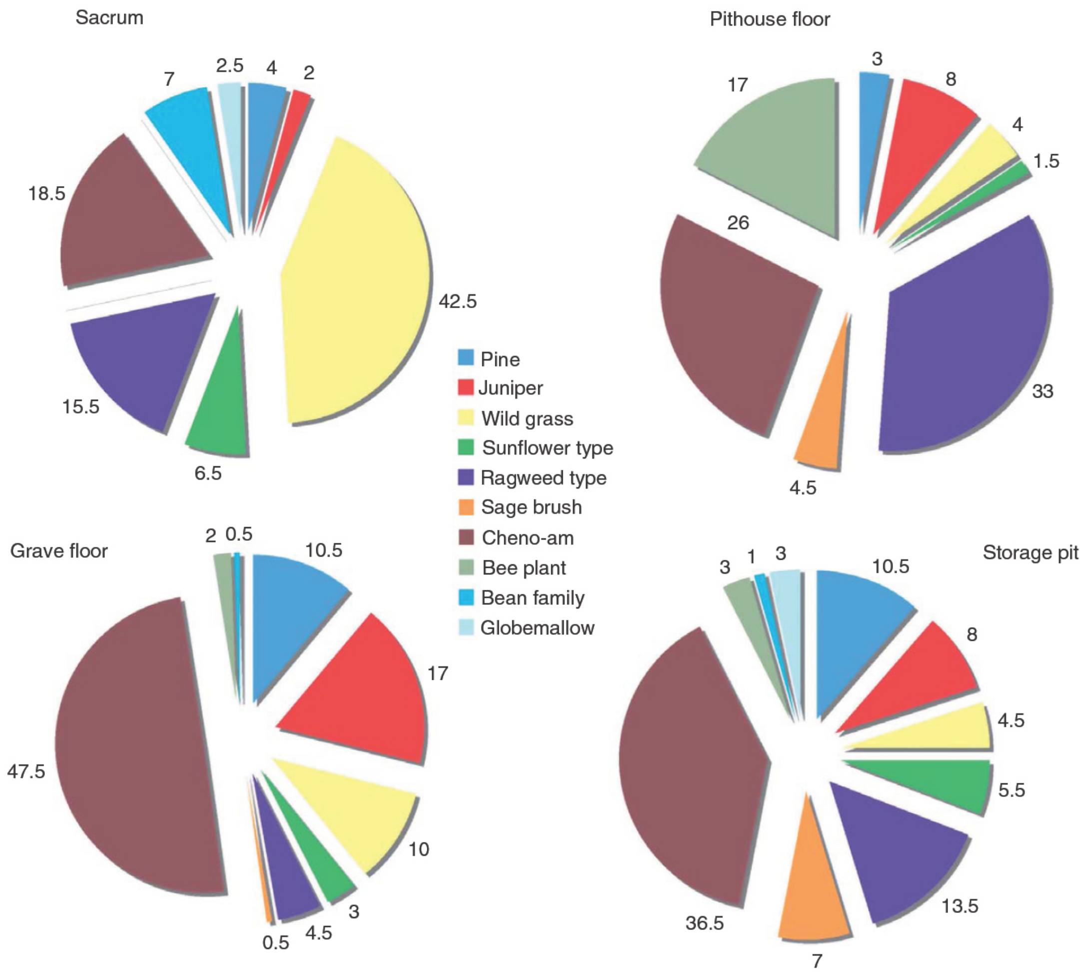

Figure 6 The pollen spectra from sacrum sediments and control samples from the ancestral Anasazi burial.

Berg expanded these methods to cemeteries in Arizona (Table 3) and Denmark and successfully demonstrated that the multidisciplinary approach presented in the first three case studies is extremely powerful when applied to detecting patterns of medicine and diet in groups of interments. He also formalized a consistent sampling strategy that can be applied to most burial excavations (Figures 7 and 8).

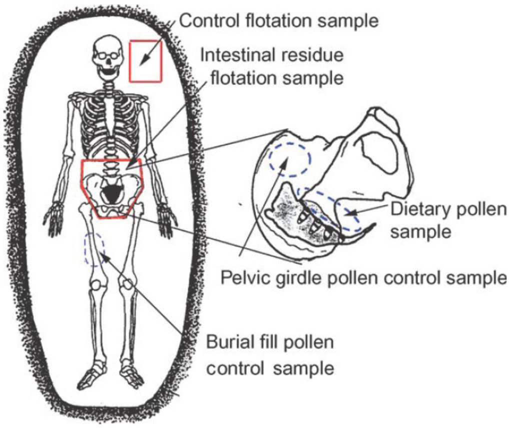

Figure 7 Berg (2001) formalized a sampling strategy for macroscopic flotation and pollen sampling for burials. He proposed that macrofossil sampling be focused on flotation samples from the pelvic area and from the grave fill near the head (red areas). He recommended that pollen control samples be recovered from long bone areas and a single control sample in the pelvic girdle. The dietary pollen sample should be recovered from the anterior surface of the sacrum (blue areas).

Table 3 Pollen data from the burial analyzed by Reinhard *et al.* (1992)

Taxon	*Sacrum*	*Burial floor*	*Pithouse floor*	*Storage pit*
Pine	4	10.5	3	10.5
Juniper	2	17	8	8
Wild grass	42.5	10	4	4.5
Sunflower type	6.5	3	1.5	5.5
Ragweed type	15.5	4.5	33	13.5
Sage brush		0.5	4.5	7
Cheno-am	18.5	47.5	26	36.5
Rocky Mountain bee plant		2	17	3
Squash				0.5
Mormon tea		1	1	2.5
Euphorbia type		0.5		
Bean family	7	0.5		1
Globemallow	2.5			3
Prickly pear				0.5
Gilia	1			
Oak		0.5		1.5
Willow		0.5		
Greasewood		0.5		
Solanaceae				0.5
Maize				1
Spruce		0.5		1

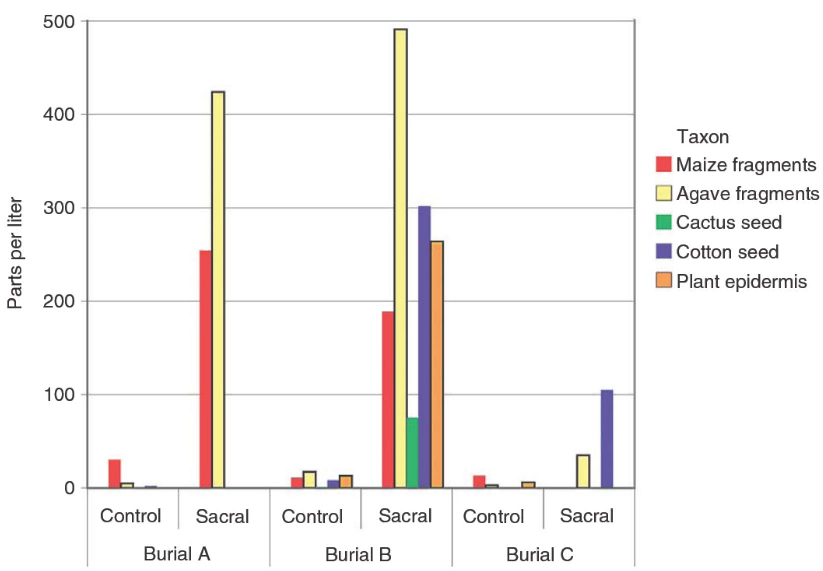

Figure 8 Macroscopic remains from Berg's analysis of three Arizona burials. Burial A shows an elevated frequency of maize and agave fragments in the sacrum sample compared with the control sample. In burial B, increased numbers of maize, agave, cactus, cotton, and plant epidermis macrofossils were found in the sacral sample relative to the control sample. Agave and cotton seed were evident in the burial C sacral sample.

Conclusion

The analysis of burials for botanical and zoological remains evidence of diet is a proven method of nondestructive analysis in the mortuary setting (see Archaeozoology; Pollen Analysis). The value of such analyses is directly dependent on sampling strategies that must include a number of control samples.

See also: Archaeozoology; Burials: Excavation and Recording Techniques; Pollen Analysis.

Further Reading

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