1995

Cluster Analysis of the Coprolites from Antelope House: Implications for Anasazi Diet and Cuisine

Mark Q. Sutton

California State University, Bakersfield, msutton@csub.edu

Karl Reinhard

University of Nebraska-Lincoln, kreinhard1@mac.com

Follow this and additional works at: <http://digitalcommons.unl.edu/natresreinhard>

Part of the [Archaeological Anthropology Commons](#), [Ecology and Evolutionary Biology Commons](#), [Environmental Public Health Commons](#), [Other Public Health Commons](#), and the [Parasitology Commons](#)

Sutton, Mark Q. and Reinhard, Karl, "Cluster Analysis of the Coprolites from Antelope House: Implications for Anasazi Diet and Cuisine" (1995). *Karl Reinhard Papers/Publications*. 29.

<http://digitalcommons.unl.edu/natresreinhard/29>

This Article is brought to you for free and open access by the Natural Resources, School of at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Karl Reinhard Papers/Publications by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

Cluster Analysis of the Coprolites from Antelope House: Implications for Anasazi Diet and Cuisine

Mark Q. Sutton

Department of Sociology and Anthropology, California State University, Bakersfield, CA 93311, U.S.A.

Karl J. Reinhard

Department of Anthropology, University of Nebraska–Lincoln, Lincoln, NE 68588, U.S.A.

Abstract

This paper reports on a cluster analysis of 155 coprolites from Antelope House, a prehistoric Anasazi site in Canyon de Chelly, Arizona. The analysis revealed three primary clusters; whole kernel maize, milled maize, and nonmaize, which we believe to represent seasonal- and preference-related cuisine. Protein residue analysis on a subsample of the specimens added depth to the analysis.

Keywords: Coprolites, Anasazi Diet, Cluster Analysis

Introduction

Coprolites contain direct evidence of substances consumed (as opposed to standard faunal and floral remains that offer indirect dietary evidence), although not always as food. Archaeologists studying coprolites make a number of assumptions (often with great merit) regarding the nature and origin of the specimens. First, it is assumed that the materials present in coprolites were ingested by the person from whom the coprolite came and that such materials can be readily identified. Secondly, coprolites are usually viewed largely as representing the subsistence aspect of diet, with the identification of substances ingested for ceremonial and/or medicinal purposes (Shafer, Marek & Reinhard, 1989; Reinhard, Hamilton & Hevly, 1991; Sobolik & Gerick, 1992) being more difficult to interpret. Third, it is assumed that each specimen represents a unique elimination event and is not mixed or combined with other such events. (In spite of this, obvious fragments, possibly representing separate events, frequently are grouped together as one specimen for analysis.) Further, it is generally assumed that materials present in a coprolite represent the food consumed within the 24 h period preceding its deposition (e.g. Fry, 1985: 128), although this may not be the case (e.g. Jones, 1986; Sobolik, 1988a: 207). As such, they are likely to be a combination of several meals (e.g. Watson, 1974: 240). However, recent analysis of mummy intestinal contents indicated that several meals can be segregated in the intestine and passed independently (Reinhard, 1993).

Other factors are of note in coprolite analysis (see Sobolik, 1988b: 114). As the surviving (e.g. visible) materials are those that were not digested, only the indigestible part of the diet is visually represented and we do not understand the taphonomic problems (digestion, processing, preservation, etc.) associated with coprolites. However, this is changing with the addition of protein analyses that can identify nonvisible constituents (e.g. Newman et al., 1993). Coprolites may be discovered singly or in concentrations that probably represent latrines. While the population responsible for a latrine coprolite deposit is generally assumed to be homogeneous, this may not be the case. If a particular segment of the population (e.g. with perhaps particular culinary customs) used a specific latrine the sample would be skewed and the interpretations incorrect (latrine reuse over time is an additional concern). However, since these factors cannot currently be controlled, most researchers appear to assume sample homogeneity. (Cummings' 1989 study of coprolites from Nubian mummies is a rare example of these factors being known.)

Most researchers focus on a general analysis of constituents present in a coprolite, usually listed and discussed as to their importance (relative abundance is assumed to represent relative importance) in the diet (e.g. inter-specimen variation). However, little attention is given to patterns of resource combination and utilization (e.g. intra-specimen variation). The goal of the present study is to determine the patterns of food preferences and combinations within a sample of coprolites from Antelope House, an Anasazi village site in Canyon de Chelly, Arizona (Figure 1).

Figure 1. Location of the Antelope House site in the southwestern United States.

Background and Previous Study

There is increasing interest in the refinement of coprolite analysis. One site that is well suited for continued study of coprolites is Antelope House, Arizona (Figure 1). This site has been thoroughly documented (Morris, 1986) and thousands of coprolites were excavated from it. These coprolites have been the focus of several studies during the past 25 years (Williams-Dean & Bryant, 1975; Fry & Hall, 1975, 1986; Reinhard, 1985, 1988, 1992; Williams-Dean, 1986).

Antelope House is located in a cave in the bottom of Canyon de Chelly. The mesic environment of the canyon bottom makes it an ideal place for agriculture, and consequently it was inhabited by the Anasazi between AD 500 and 1250. Antelope House was excavated by Don P. Morris of the National Park Service between 1970 and 1974. A major goal of the excavation was the recovery of biological remains for study (Don Morris, pers. comm. 1983). Preliminary analyses were presented at the SAA annual meeting in 1974 and published in 1975 in *The Kiva* 41(1). Final reports of the excavation and analyses were published in 1986 (Morris, 1986).

Antelope House was a typical Anasazi village of moderate size. Using ethnographic analogies of the number of people that utilize rooms in modern pueblos, Morris (1986: 55-57) calculated the population of Antelope House on the basis of architectural reconstruction. He concluded that about 150 people lived in Antelope House during the peak period of Pueblo III occupation, at which time at least 36 rooms were used for various purposes.

Based on coprolite analyses (Williams-Dean, 1986), Morris (1986: 55) concluded that Antelope House was

occupied year-round. Williams-Dean (1986) approached seasonality as part of her palynological study of coprolites and included macrofossil analysis as well as palynological analysis in her assessment. She identified two types of coprolites, "Spring-Summer" and "Four Seasons". The first category includes coprolites that contain components that could only be gathered in the warm months. The second category includes items that were available year-round. She noted that year-round occupation of Antelope House is probable but concluded with the caveat that "occupation ... during cold months cannot be empirically demonstrated, but can be suggested from the storable nature of the food remains ... and from ethnographic records of out-of-season use of these plants" (Williams-Dean, 1986: 205).

The analyses of dietary plants, non-dietary plants, and avian remains indicated that Antelope House inhabitants utilized wetland resources to a greater degree than did other Anasazi sites in general. Fifty percent of the wild bird remains recovered from Antelope House are water birds (McKusick, 1986) and include mallards, gadwall, green-winged teal, American widgeon, shoveler, bufflehead, lesser sandhill crane, and Brewer's blackbird. Of these, mallards have been found at four other Anasazi sites and American widgeons have been found at one other Anasazi site. All of these ducks except buffleheads prefer standing, shallow pools. Osteological analysis of terrestrial animals demonstrates that a wide variety of animals were eaten. These include mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), bobcat (*Lynx rufus*), black bear (*Ursus americanus*), grey fox (*Urocyon cinereoargenteus*), dog (*Canis familiaris*), coyote or dog (*Canis* spp.), porcupine (*Erethizon dorsatum*), muskrat (*Ondatra zibethicus*), voles (*Microtus* spp.), woodrats (*Neotoma* spp.), mice (*Peromyscus* spp.), beaver (*Castor canadensis*), pocket mice (*Perognathus* spp.), Abert's squirrel (*Sciurus aberti*), Gunnison's prairie dog (*Cynomys gunnisoni*), ground squirrels (*Citellus* spp.), rabbits (*Sylvilagus* spp.), hares (*Lepus californicus*), sidewinders (*Crotalus* cf. *cerastes*), garter snakes (*Thamnophis* spp.), Plateau whiptail lizards (*Cnemidophorus velox*), and the common turkey (*Meleagris gallopavo*).

Plant remains were analyzed from coprolite (Fry & Hall, 1986) and non-coprolite contexts (Hall & Dennis, 1986). Pollen analysis of coprolites was particularly insightful regarding dietary use of mesic genera which do not appear in macroscopic remains. A pollen study of 30 coprolites by Reinhard (1992) shows that horsetail (*Equisetum*) is present in 7% of the Antelope House coprolites but is rare at other Anasazi sites. Cattail (*Typha*) pollen is also a common pollen constituent in the coprolites from Antelope House. The strobili of horsetail and the inflorescence of cattail were common food sources for Antelope House Anasazi.

Although the coprolite macroscopic remains were dominated by maize (*Zea mays*), foods of secondary

importance are amaranth (*Amaranthus*) seed, beeweed (*Cleome*) seed, cactus (probably prickly pear; *Opuntia*), cotton (*Gossypium*) seed, ground cherry (*Physalis*) seed, pine (*Pinus edulis*) nuts, purslane (*Portulaca*) seeds, and squash (*Cucurbita*) seeds. Foods of minor importance include bean (*Phaseolus*) seed, grass seed, dropseed (*Sporobolus*), chenopodium (*Chenopodium*) seed, grape (*Vitis*) fruits, horsetail (*Equisetum stroboli*), Indian rice grass (*Oryzopsis*) seed, panic grass (*Panicum*) seed, pepper-grass (*Lepidium*) seed, saltbush (*Atriplex*) foliage, sumac (or squawbush; *Rhus trilobata*) fruit, sunflower (*Helianthus*) seeds, wild rye (*Elymus*) seed, and Yucca (*Yucca*) pods.

Pollen examination of pottery vessels and grinding stones revealed several plants that were processed at the village (Bryant & Morris, 1986). In addition to maize, beeweed, and cheno-am (pollen of the families Chenopodiaceae and Amaranthaceae), cottonwood (*Populus*) and cattail were processed and stored at the site.

A large variety of plants was recovered in soils from the site. Of plant remains found in non-fecal contexts, 37% of 78 species found in the Antelope House excavations come from what is termed "wet places" (Harlan & Dennis, 1986). It is concluded from these remains that "the canyon bottom, in general, provides more plant species suitable for food than do any of the other (ecological) areas" (Hall & Dennis, 1986: 139).

Riparian plants were widely used at Antelope House for construction and weaving. Roof beams were made from cottonwood. Willow (*Salix*) and arrow wood (*Phragmites*) were used as structural support and willow in basketry. Arrow shafts were manufactured from *Phragmites*. The standard plant used in the manufacture of matting was bulrush (*Scirpus*). Morris (1986: 548-549) concluded with respect to Antelope House, "Riparian plants perhaps were the most heavily used plants of the area".

Current Analysis

The objective of this study was to conduct a comparative analysis of the intra-coprolite constituents to determine whether any patterns of resource utilization were present. Such patterns might include food combinations that could be used to delineate dietary preference or habits (e.g. meals) and differences in the seasonal use of resources.

The macroscopic data extracted from 172 coprolites by Reinhard (1992) were never statistically analyzed beyond basic description. A total of 155 of these coprolites was selected for study specifically for information regarding the association of dietary components of single meals. Analysis of mummies (Reinhard et al., 1991; Reinhard, 1993) has shown that macroscopic remains (and sometimes pollen) move down the intestine in discrete units. Therefore, analysis of small fragments of coprolites should provide evidence of what types of plants were eaten as specific

meal components. A similar analysis was successfully conducted by Sutton (1993) on a coprolite series from southeastern California.

The 155 coprolites came from 34 separate dated latrines (between late Pueblo II and Pueblo III occupations). The latrines were dated based on association with tree-ring dated structures, temporally diagnostic artifacts, and stratigraphy. The time phase associations are presented in Table 1 under the following key: 1: Pueblo I-Pueblo II; 2: Pueblo II; 3: Late Pueblo II; 4: Pueblo II-Early Pueblo III; 5: Early Pueblo III; 6: Middle Pueblo III; 7: Middle-Late Pueblo III; 8: Late Pueblo III. Differences in coprolite texture, coloration, and size were considered to avoid sampling the same defecation twice. A 1 g fragment from each coprolite was rehydrated and processed for macroscopic remains following described extraction procedures (Bryant, 1974; Pearsall, 1988). After the macroscopic remains were separated from the fecal matrix, they were identified with a dissecting scope.

Methods

Of the original 172 specimen samples, a number were eliminated due to laboratory problems and the subsequent identification of several as dog feces; leaving a total of 155 specimens for this analysis. The various constituents (see Table 1) identified in the Antelope House coprolites by Reinhard (1992) were compared using a hierarchical cluster analysis, part of SPSS-PC (Statistical Package for the Social Sciences, Personal Computer). Membership to a cluster was based on nearest neighbor to the center of the clusters, using a squared Euclidean measure. Average mean of the cluster was used to determine the center. Numeric values (1 and 0) were assigned to designate presence or absence of specific constituents as determined in Reinhard's original study with zero being used to designate absence.

The resulting tree diagram cluster graph (Figure 2) is quite complex. This is due, at least in part, to the simplicity of the data (presence or absence) and to the relatively large number of categories that contained a small number of positives. The clusters can, perhaps, be better distinguished in Table 1, the original data reordered in the sequence determined by the cluster analysis (the columns in Table 1 identifying feature and temporal associations were not included in the cluster analysis and so did not influence cluster membership).

A subsample of 24 of the 155 coprolites was selected for immunological analysis. Crossover immunoelectrophoresis (CIEP) was the technique employed (Newman, 1993) and the samples were tested against bear, cat, chicken, deer, dog, guinea-pig, human, mouse, rabbit, sheep, and pronghorn (Newman, 1993: Table 1). These data could not be included in the cluster analysis since the remaining samples were "unknown". The results of this study are discussed below.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	Immuno.
160	44	07	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	—
169	44	07	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	—
100	24	08	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
106	23	08	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
054	06	08	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
076	15	08	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
021	03	08	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
171	31	05	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
117	27	05	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
134	20	08	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
019	03	08	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
158	31	05	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
001	01	05	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
170	44	07	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
139	31	05	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	—
159	31	05	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	negative
042	11	08	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	human, pronghorn
165	31	05	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	—
146	31	05	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	—
024	05	08	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	negative
154	40	06	1	0	0																									

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	Immuno.
131	20	08	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	—
123	02	08	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	—	
118	28	02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	—
138	31	05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	—
114	23	08	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	—
010	03	08	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	negative
015	02	08	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
012	04	05	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
136	29	07	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
150	31	05	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
011	01	05	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	cat
088	09	02	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
162	31	05	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	—
049	12	03	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
053	06	08	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
164	31	05	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
030	08	08	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	—
033	02	08	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	—
022	05	08	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	—
025	06	08	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
085	22	07	1	0	0	0	0																							

Table 1. Raw data shown in order determined by cluster analysis. (continued)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	Immuno.
105	19	08	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	—
101	26	07	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	—
062	16	08	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	pronghorn, rabbit, deer
090	16	08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	—
017	01	05	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	human
168	31	05	1	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	negative
006	01	05	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
007	01	05	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
099	19	08	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	—
115	26	07	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	—
051	09	02	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	dog
166	31	05	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	—
104	23	08	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	—

A, sample number; B, provenience (group no.); C, phase (1 = PI-PII; 2 = PH; 3 = LPII; 4 = PII-EPIII; 5 = EPIII; 6 = MPIII; 7 = M-LPIII; 8 = LPIII; 9 = PIII; 10 = ML-LPIII; 11 = PII-PIII; 12 = PII-LPIII); D, maize (kernels); E, maize (ground-up); F, *Phaseolus* (bean); G, *Portulaca* (purslane); H, *Rhus* (sumac or squawbush); I, *Opuntia* (probably prickly pear); J, fibre (thought to be *Yucca*); K, *Chenopodium* (goosefoot); L, cheno-am; M, *Pinus edulis* (pinyon); N, *Physalis* (cherry); O, *Celtis* (hackberry); P, *Equisetum* (horsetail); Q, *Sporobolus* (dropseed); R, bone fragments; S, *Vitis* (grape); T, *Amaranthus* (amaranth); U, *Cleome* (beeweed); V, *Gossypium* (cotton); W, unidentified grass; X, charcoal; Y, *Yucca* (yucca); Z, *Orozopsis* (ricegrass); AA, *Typha* (cattail) pollen; BB, turkey feather; CC, unknown; DD, *Juniperus* (juniper). —

Figure 2. Plot of raw cluster analysis.

Constituent Analysis: Food Choice and Cuisine

The clusters identified by the computer program could be categorized in several different ways. The presence or absence of the most ubiquitous resource, maize, was the prime criterion for the initial clustering and resulted in three main clusters: (1) maize kernels present; (2) ground or milled maize present; and (3) no maize present (perhaps better seen in Table 1 than in Figure 2). Within each of these three primary clusters are a number of interesting patterns.

Maize is clearly the most consistently occurring constituent of Antelope House coprolites, occurring in 114 (74%) of the samples. However, maize appears in two nearly mutually exclusive forms: whole kernel or milled (only one specimen (067; Table 1) contained both forms). The fact that milled maize and whole kernel maize do not occur in the same coprolites indicates that the two forms of preparation made up distinct aspects of Antelope House cuisine. The analysis of the whole kernel cluster is suggestive that the kernels were from fresh ears. This

is clearly indicated by Specimen 168 which contained a small fragment of cob. Thus, it appears that the whole kernel coprolites represent consumption of corn at harvest or shortly thereafter. Milled maize reflects the consumption of dried maize, probably stored for a period of time, milled on grinding stones, and then consumed in a processed form such as pinole (milled maize combined with water and perhaps spices), in stews, or in "breads" (see Rylander, 1994). The fact that milled maize and whole kernel maize are mutually exclusive suggests a seasonal difference in their consumption. It is probable that the whole kernel cluster represents harvest binging of corn when it was abundant in the late summer and fall. The milled maize cluster probably represents winter consumption when fresh maize was absent.

Whole Kernel Cuisine

Whole kernel maize was found in 96 (62%) specimens. In addition, 14 other resources were identified in the kernel maize coprolites. Most of these resources are wild plants that become available in summer and fall,

supporting our suggestion that kernel maize is a harvest season food. However, kernel maize usually occurs alone or with only one or two other resources. This provides an opportunity to examine details of Anasazi cuisine. This can be done by identifying patterns of co-occurring foods and interpreting the function of those foods as staples (bulk foods, a significant caloric contribution), condiments (with minor caloric value), or spices (rare, with few calories but perhaps with important vitamins and/or minerals). Once this has been accomplished, one can reconstruct the patterns of resource selection for the preparation of meals. One can then speculate on the nature of the meal, whether a combined pattern of stew, or of independently varying components that may represent "courses" of a multi-dish meal.

Kernel maize was found in association with many other resources, but there is very little overlap between the non-maize constituents (with only one or two other resources in any given sample). This suggests that maize was a common staple that was combined with various other components, but that the use of those other components was selective. It is interesting that beans were found associated only with kernel maize (only once with milled maize and never alone). If we are correct in our assessment that milled and kernel maize reflect seasonal differences, then beans were a seasonal food source. The fact that they are not found alone suggests the possibility that they may not have been a dietary staple. Instead, beans were cultivated at Antelope House as a maize supplement (beans form a nutritional complement to maize).

Also of interest is that bone only occurs with kernel maize (with one exception, with amaranth). This indicates that small animals were consumed on a seasonal basis, perhaps as a constituent of maize "stew". It is also possible that differential processing of these small animals occurred on a seasonal basis, masking them as visible constituents of coprolites.

Other plant foods appear to have been used as spices or condiments. This is especially true of purslane, sumac, beeweed, cherry, and cactus. Beeweed and purslane are documented historic Pueblo spices. At Antelope House, purslane occurs only with maize and is a clearly associated spice. Beeweed occurs predominantly with maize (10 of 14 occurrences), twice with cheno-am seeds, and twice alone. This indicates that beeweed was a more versatile plant that was used predominantly as a spice for maize, but was also used as a spice with other foods, and was occasionally consumed by itself. Purslane and beeweed were occasionally used together as a combined maize spice.

It is surprising that sumac often occurs with maize, since ethnographically it is prepared as a meal in itself. In eight of 13 occurrences, sumac is associated with maize, and in six instances it is used only with maize. This indicates that sumac fruits were used as a maize supplement, and with it maize composed a frequent meal. Ground

cherry has almost an identical pattern as that of sumac, which indicates that ground cherry was used as a maize supplement. Prickly pear seeds are derived from the consumption of the fruit. Fourteen of the 22 occurrences of prickly pear seeds are with kernel maize. Thus, prickly pear fruit was once a seasonal staple in Archaic times (Reinhard, 1992) but became a maize supplement with the introduction of horticulture.

Some difficulty was encountered in separating chenopods from amaranths as they both appear in milled form in the coprolites. Thus, we are treating these taxa as one; "cheno-am". Most (11 of 16) of the cheno-am seed occurs with either kernel or milled maize, indicating that it was consumed as a maize supplement.

Milled Maize Cuisine

Milled maize as seen in Antelope House coprolites (N = 18; 12%) is essentially the residue of corn flour. There are pronouncedly fewer associations with milled maize than with kernel maize. Only six other resources were found with milled maize: milled or whole chenopods, milled or whole amaranths, purslane, dropseed, fiber, and sumac. Milled maize occurs either alone, with one other resource, or rarely with two others. The most common associations are with amaranthus (N=4) and cheno-am (N=3). This suggests that ground seeds other than maize could be incorporated or substituted in the recipe for whatever food required milled seeds.

Milled maize requires drying, processing from the cob, and grinding. What exactly milled maize was made into is unknown. It is possible that it was made into some sort of bread or gruel, combined with a limited number of other foods. Most of these other constituents are storable and probably reflect the sorts of foods that could be collected and stored for winter use.

Nonmaize Cuisine

Forty-one (26%) of the specimens did not contain maize at all. Thirteen resources are present in this cluster: pinyon, cherry, goosefoot, horsetail, dropseed, amaranth, beeweed, prickly pear, sumac, cotton, unknown fiber, grass, yucca, ricegrass, and cheno-ams. The fact that ground cheno-ams occur independently of maize indicates that there was a processed food that was derived solely from wild seeds. The remaining constituents probably represent either seasonal binge eating of wild foods when available, or perhaps famine foods as defined by Minnis (1992). However, we should not depreciate the contribution of wild foods to the Anasazi diet; they may have constituted a major resource group (Sullivan, 1992).

Immunological Results

Samples from 30 coprolites were originally tested (Newman, 1993), but the results of six were eliminated as those specimens were dropped from the analysis.

Of the 24 samples included, eight tested positive to pronghorn, five to human, three to rabbit, and one each to deer, guinea-pig, cat, and dog. Eleven tested were negative.

Pronghorn (*Antilocapra americana*) was identified in eight samples, three times in conjunction with human and three times in conjunction with rabbit. The pronghorn occurred in three samples that contained kernel maize, three with milled maize, and in two no maize, suggesting that pronghorn was utilized at all times. Three samples tested positive to rabbit anti-sera (representing the order Lagomorpha; rabbits, hares, or pikas), always in association with pronghorn. These results suggest that a pronghorn/rabbit meat combination was utilized both with and without corn. No other resource association is readily apparent.

Single specimens reacted positively to deer (*Odocoileus* sp.), guinea-pig (probably representing either porcupine or (more likely) squirrel), cat, and dog, indicating that these animals were used as food. The deer protein was identified in association with pronghorn and rabbit, suggesting a common meal of origin.

Human proteins were identified in five of the samples. As humans are the species of origin for the samples, positive results may be expected and do not require further explanation. The absence of identified proteins in the other specimens may be the result of poor protein preservation or that the coprolites contained proteins from animals or plants other than those covered by the anti-sera used.

The macrofaunal data from the site reflected the use of six major mammalian species: deer; pronghorn; bighorn; dog; jackrabbit; and cottontail (Morris, 1986: 159-164). Interestingly, bighorn sheep was not identified in the immunological data (sheep anti-sera was used) and only one sample tested positive to deer and dog. Judging from the immunological data, pronghorn was the most important source of meat, and seems to have been used year-round.

Temporal Trends in Resource Use

Using coprolite data from the Four Corners area, Minnis (1989) presented a case that the dietary patterns among the Anasazi were regionally differentiated and stable through time. The data derived from the 155 coprolites from a single site allows us to evaluate the temporal stability of the diet.

The Antelope House reliance on maize was variable. In middle-late Pueblo II times, relatively little maize was consumed (found in 43% of the coprolites, N=7), none of it being milled. In early Pueblo III times, maize occurred in 82% of the 34 coprolites. In middle-late Pueblo III times maize also occurred in 82% of the coprolites (N= 11). In late Pueblo III times, maize use declines to 72% of the 98 specimens. The decrease in maize used in late Pueblo III, coupled with an increase in the frequency of

wild foods, may reflect local environmental deterioration that eventually led to the abandonment of the site (Morris, 1986), or possibly an increasing sophistication in the gathering of wild foods (e.g. Sullivan, 1992). Interestingly, the frequency of milled maize (as a percentage of identified corn) increases through time. During middle-late Pueblo II times, none of the maize was milled, in early Pueblo III 7% was milled, in middle - late Pueblo III the frequency is 11%, and in late Pueblo III it jumps to 21%.

Bean cultivation and consumption reaches a peak in early Pueblo III times. None of the seven middle-late Pueblo II specimens contained beans in comparison to 24% (8 in 34) during early Pueblo III, 9% (1 in 11) during middle to late Pueblo III, and 5% (5 in 98) during late Pueblo III times. Although the sample sizes vary from period to period, the large late Pueblo III sample (N=98) indicates that the decline in bean consumption from early-late Pueblo III is real. The absence of beans in late Pueblo II could be a function of sample size (N=7); however, the macrobotanical analysis of refuse deposits at the site indicates the same trends as reflected in the coprolite data (Ambrose, 1986: 95).

Other resources show fluctuation through time as well. With regard to gross diversity of resources, the trend is toward greater diversity through time. The least diverse resource assemblage is that of the middle to late Pueblo II (seven resources), then early Pueblo III with 12 resources, then middle to late Pueblo III with 13 resources, and finally 19 resources in late Pueblo III (again, sample size may be a factor).

Discussion

It is clear from examining the Antelope House coprolite data that maize was the main dietary mainstay. Other crops such as beans and squash have been suggested to have had equal importance as dietary staples, but maize was the primary staple and other cultivated or gathered food plants were, at best, supplements to a maize-based diet. Three primary patterns of food combinations were tentatively identified: whole kernel maize; milled maize; and nonmaize. We believe that these patterns reflect seasonal availability of different foods and form the basis of Anasazi cuisine.

Also of interest are the differences in the utilization of wild plant foods between Archaic hunter-gatherers and horticulturalists in the Southwest. Reinhard (1992) identified a surprising trend towards the utilization of a wider variety of wild food plants among horticulturalists at Antelope House than the Archaic hunter-gatherers of the same area. He presented five alternative hypotheses regarding these trends that can be tested using the Antelope House data. It is important to remember three major points when considering the following hypotheses: (1) the key prominence of maize in Antelope House diet; (2)

when making relative comparisons with hunter-gatherers, we tend to assume that the dietary regimes and exploited resource diversity among hunter-gatherers is understood, an assumption that is likely not true; and (3) archaeologists tend to assume that the contribution of wild foods to the Anasazi diet was supplemental rather than staple, also an assumption that may not be true (Sullivan, 1992).

First, horticultural peoples may have routinely included in their diet a diversity of collected plants. It is probable that augmenting the maize-based diet with foods such as pinyon, sumac, cheno-ams, beans, cherry, and others would have served an important role in adding micro-nutrient-rich foods to the carbohydrate-rich maize staple. Some such plants (e.g. pinyon, Sullivan, 1992), may have been critical components to the diet, rather than just occasional supplements.

Second, as horticultural sites likely represent a more sedentary lifestyle, the diets may involve year-round exploitation of a diversity of plants, which results in more genera being recovered from the coprolites. This idea has less merit from the Antelope House perspective. It would seem that dietary diversity reaches its peak in the summer and fall months and that prolonged occupation does not necessarily increase the variety of foods recovered from a coprolite.

Third, horticulture may broaden the range of available food plants by encouraging the growth of weedy wild plants. This hypothesis is viable. Some of the more common wild plants in Antelope House diet are disturbance annuals and include *Cleome*, *Portulaca*, *Amaranthus* and *Chenopodium*.

Fourth, horticultural peoples may have exploited more species to spice a relatively bland maize-dependent diet. This idea seems especially attractive since the Antelope House data indicate that a variety of wild plants was selectively used to supplement and spice maize meals and resulted in a diverse array of kernel maize recipes and milled maize recipes. Thus, it does appear that the inhabitants of Antelope House exploited more species to spice a relatively bland maize-based diet.

Finally, population growth associated with horticulture may stress the subsistence base with resultant utilization of a broad range of gathered plants. This hypothesis is rejected from the perspective of Antelope House. Had the Anasazi at the village used a broad range of gathered plants as subsistence staples, then the number of coprolites containing nonmaize items should have been larger. In addition, some plants that were staples in Archaic times were reduced to supplements in the Antelope House diet.

In sum, hypotheses one, three, and four are most acceptable for the Antelope House situation. We feel that the main reason for incorporating more wild plants was to spice up a relatively bland maize-based cuisine. The incorporation of weedy annuals was a secondary development of agricultural disturbance, and the nutritional advantage of incorporating wild species and

supplements was also of secondary cognitive importance to the Anasazi at Antelope House. However, we must not minimize the possibility that wild foods were important staples through time.

Beyond the issue of food diversity, it is clear from the temporal comparison that diet was not consistent from time period to time period. This suggests that the coprolite picture of regional dietary continuity developed by Minnis (1989) must be refined to account for dietary variation over time at single villages.

Acknowledgments — This paper is a revised version of one presented at the 1993 annual meetings of the Society for American Archaeology. T. Michael Fink aided in the collection of the Antelope House coprolite data. We appreciate the assistance of Mike Kaberline and Adella B. Schroth in the statistical work. The comments of Jill Gardner, Robert E. Parr, Nelson Siefkin, Kristen D. Sobolik and an anonymous reviewer were most useful, but we retain responsibility for errors in logic.

References

- Ambrose, J. E., Jr. (1956). The past environment of Canyon de Chelly. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 54–109.
- Bryant, V. M., Jr. (1974). The role of coprolite analysis in archaeology. *Bulletin of the Texas Archaeological Society* 45.
- Bryant, V. M., Jr. & Morris, D. P. (1956). Uses of ceramic vessels and grinding implements: The pollen evidence. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 489–500.
- Cummings, L. S. (1989). Coprolites from medieval Christian Nubia: An interpretation of diet and nutritional stress. Ph.D. Thesis, University of Colorado, Boulder.
- Fry, G. F. (1985). Analysis of fecal material. In (R. I. Gilbert, Jr. & J. H. Mielke, eds.) *The Analysis of Prehistoric Diets*. Orlando, FL: Academic Press, pp. 127–154.
- Fry, G. F. & Hall, H. J. (1975). Human coprolites from Antelope House: Preliminary analysis. *The Kiva* 41, 57–96.
- Fry, G. F. & Hall, H. J. (1986). Human coprolites. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 165–158.
- Hall, R. L. & Dennis, A. E. (1986). Cultivated and gathered plant foods. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 110–141.
- Harlan, A. & Dennis, A. E. (1986). A preliminary plant geography of Canyon de Chelly National Monument. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 72–83.
- Jones, A. K. G. (1986). Fish bone survival in the digestive systems of the pig, dog and man: Some experiments. In (D. C. Brinkhuizen & A. T. Clason, eds.) *Fish and Archaeology: Studies in Osteometry, Taphonomy, Seasonality and Fishing Methods*. BAR International Series 294, pp. 53–61.

- McKusick, C. (1986). The avian remains. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 142-164.
- Minnis, P. E. (1989). Prehistoric diet in the northern southwest: Macroplant remains from Four Corners feces. *American Antiquity* 54, 543-563.
- Minnis, P. E. (1992). Famine foods of the North American desert borderlands in historic context. *Journal of Ethnobiology* 11, 231-257.
- Morris, D. P. (1986) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service.
- Newman, M. E. (1993). *Immunological Analysis of Coprolites from Antelope House, Canyon de Chelly National Monument, Arizona*. Report on file at the Laboratory of Archaeological Science, California State University, Bakersfield.
- Newman, M. E., Yohe II, Robert M., Ceri, H. & Sutton, M. Q. (1993). Immunological protein analysis of non-lithic archaeological materials. *Journal of Archaeological Science* 20, 93-100.
- Pearsall, D. (1988). Interpreting the meaning of macroremain abundance: The impact of source and context. In (C. A. Hartorf & V. S. Popper, eds.) *Current Paleoethnobotany*. Chicago, IL: University of Chicago Press, pp. 97-115.
- Reinhard, K. J. (1985). *Recovery of Helminths from Prehistoric Feces: The Cultural Ecology of Ancient Parasitism*. Masters Thesis, Northern Arizona University.
- Reinhard, K. J. (1988). *Diet, Parasitism and Anemia in the Prehistoric Southwest*. Ph.D. Thesis, Texas A&M University.
- Reinhard, K. J. (1992). The impact of diet and parasitism on anemia in the prehistoric west. In (P. S. MacAdam & S. Kent, eds.) *Diet, Demography, and Disease: Changing Perspectives on Anemia*. New York, NY: Aldine, pp. 219-258.
- Reinhard, K. J. (1993). The utility of pollen concentration in coprolite analysis: Expanding upon Dean's comments. *Journal of Ethnobiology* 13:1, pp. 114-128.
- Reinhard, K. J. & Bryant, V. M., Jr. (1992). Coprolite analysis: A biological perspective on archaeology. In (M. B. Schiffer, ed.) *Archaeological Method and Theory* 4. Tucson, AZ: University of Arizona Press, pp. 245-288.
- Reinhard, K. J., Hamilton, D. L. & Hevly, R. H. (1991). Use of pollen concentration in paleopharmacology: Coprolite evidence of medicinal plants. *Journal of Ethnobiology* 11, 117-134.
- Rylander, K. A. (1994). Corn preparation among the basket-maker Anasazi: A scanning electron microscope study of *Zea mays* remains from coprolites. In (K. D. Sobolik, ed.) *Paleonutrition: The Diet and Health of Prehistoric Americans*. Carbondale, IL: Southern Illinois University Center for Archaeological Investigations Occasional Paper No. 22. pp. 115-133.
- Shafer, H. J., Marek, M. & Reinhard, K. J. (1989). A mimbres burial with associated colon remains from the NAN ranch ruin, New Mexico. *Journal of Field Archaeology* 16, 17-30.
- Sobolik, K. D. (1988a). The importance of pollen concentration values from coprolites: An analysis of southwest Texas samples. *Palynology* 12, 201-214.
- Sobolik, K. D. (1988b). Diet change in the lower Pecos: Analysis of Baker Cave coprolites. *Bulletin of the Texas Archaeological Society* 59, 111-127.
- Sobolik, K. D. & Gerick, D. J. (1992). Prehistoric plant usage: A case study from coprolites. *Journal of Ethnobiology* 12, 203-211.
- Sutton, M. Q. (1993). Midden and coprolite derived subsistence evidence: An analysis of data from the La Quinta site, Salton Basin, California. *Journal of Ethnobiology* 13, 1-15.
- Sullivan, A. P., III (1992). Pinyon nuts and other wild resources in western Anasazi subsistence economies. In (B. L. Isaac, ed.) *Research in Economic Anthropology*. Supplement 6. Greenwich, CT: JAI Press, pp. 195-239.
- Watson, P. J. (1974). Theoretical and methodological difficulties in dealing with paleofecal material. In (P. J. Watson, ed.) *Archaeology of the Mammoth Cave Area*. New York, NY: Academic Press, pp. 239-241.
- Williams-Dean, G. (1956). Pollen analysis of human coprolites. In (D. P. Morris, ed.) *Archaeological Investigations at Antelope House*. Washington, DC: National Park Service, pp. 189-205.
- Williams-Dean, G. & Bryant, V. M., Jr. (1975). Pollen analysis of human coprolites from Antelope House. *The Kiva* 41, 97-111.